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(54) **DISPLAY METHOD, SWING ANALYSIS APPARATUS, SWING ANALYSIS SYSTEM, SWING ANALYSIS PROGRAM, AND RECORDING MEDIUM**

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(73) Assignee: **SEIKO EPSON CORPORATION**, Tokyo (JP)

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(30) **Foreign Application Priority Data**

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(51) **Int. Cl.**

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A63B 69/36	(2006.01)
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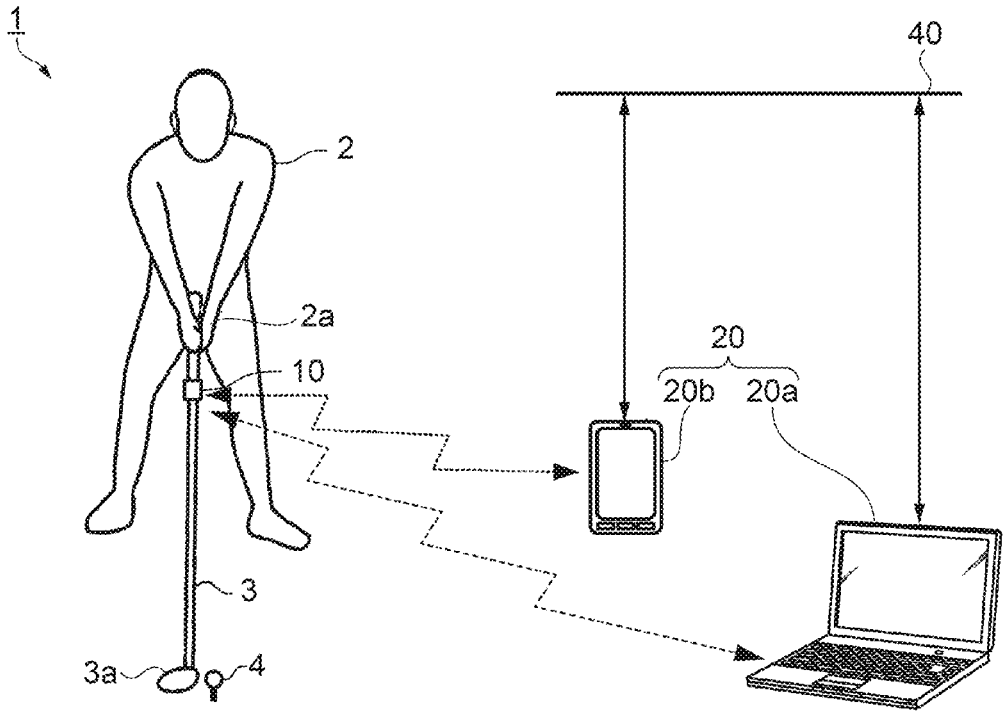
A63B 60/46	(2006.01)
A63B 71/06	(2006.01)
A63B 102/32	(2006.01)
A63B 24/00	(2006.01)

(52) **U.S. Cl.**

CPC ***A63B 24/0006*** (2013.01); ***A63B 60/46*** (2015.10); ***A63B 69/36*** (2013.01); ***A63B 71/0622*** (2013.01); ***G09B 19/0038*** (2013.01); *A63B 2024/0012* (2013.01); *A63B 2102/32* (2015.10); *A63B 2220/803* (2013.01); *A63B 2220/833* (2013.01); *A63B 2220/836* (2013.01); *A63B 2220/62* (2013.01)

(57) **ABSTRACT**

A display method includes generating first analysis information on the basis of a plurality of pieces of data related to a plurality of swings, output from an inertial sensor which is attached to a user or an exercise appliance swung by the user and measures the plurality of swings performed by the user, generating a first region image including a plurality of time-series region images on the basis of the first analysis information, and displaying the plurality of time-series region images in a coordinate system having at least two indexes as axes.



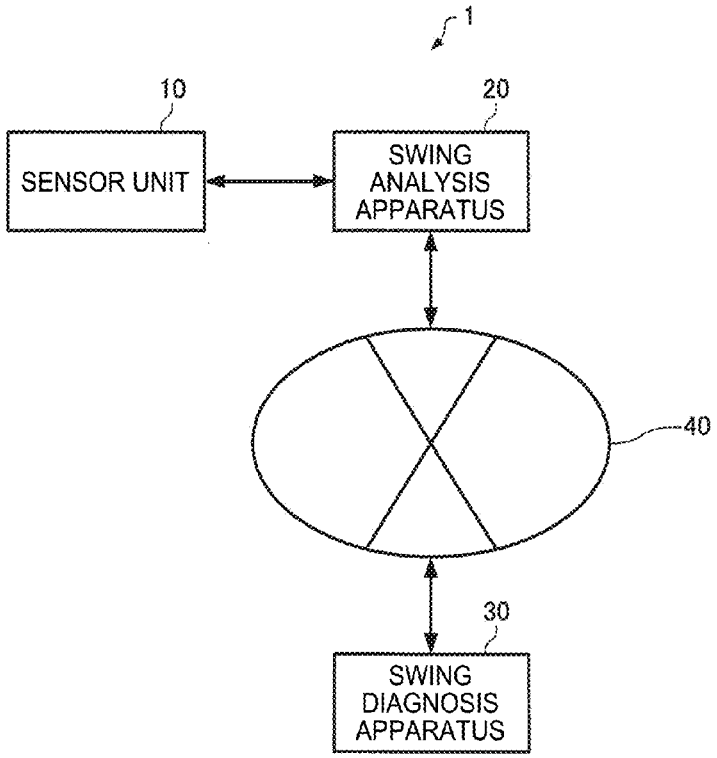

1
10
20
SENSOR UNIT
SWING ANALYSIS APPARATUS
40
30
SWING DIAGNOSIS APPARATUS

FIG. 1

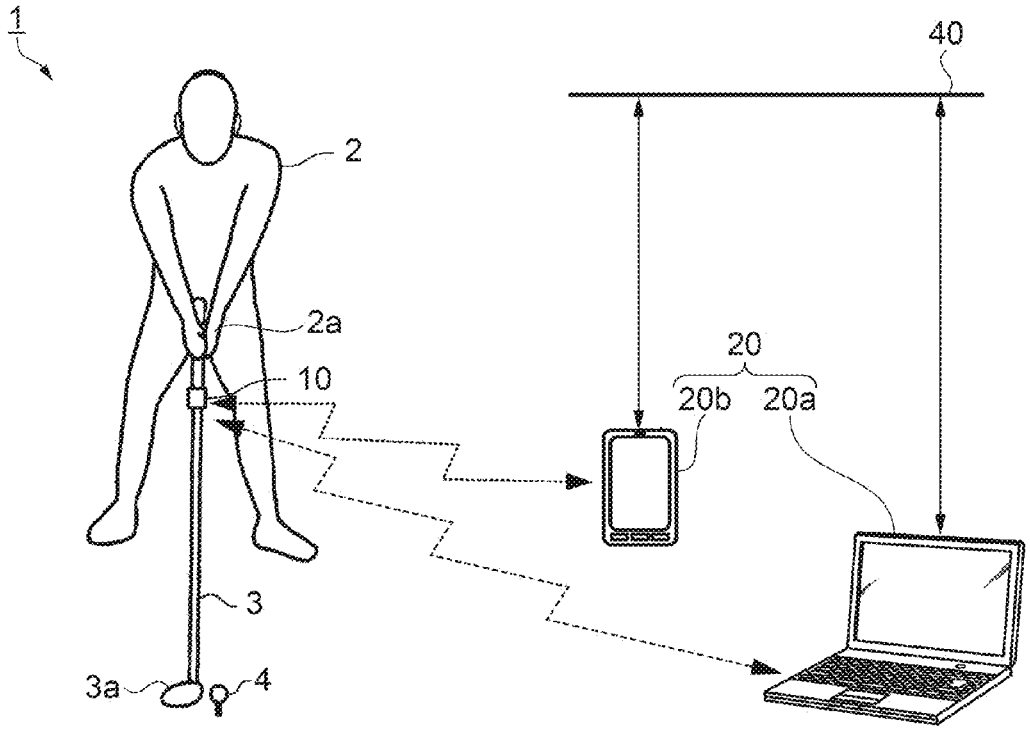

1
40
2
2a
10
20
20b
20a
3
3a
4

FIG. 2

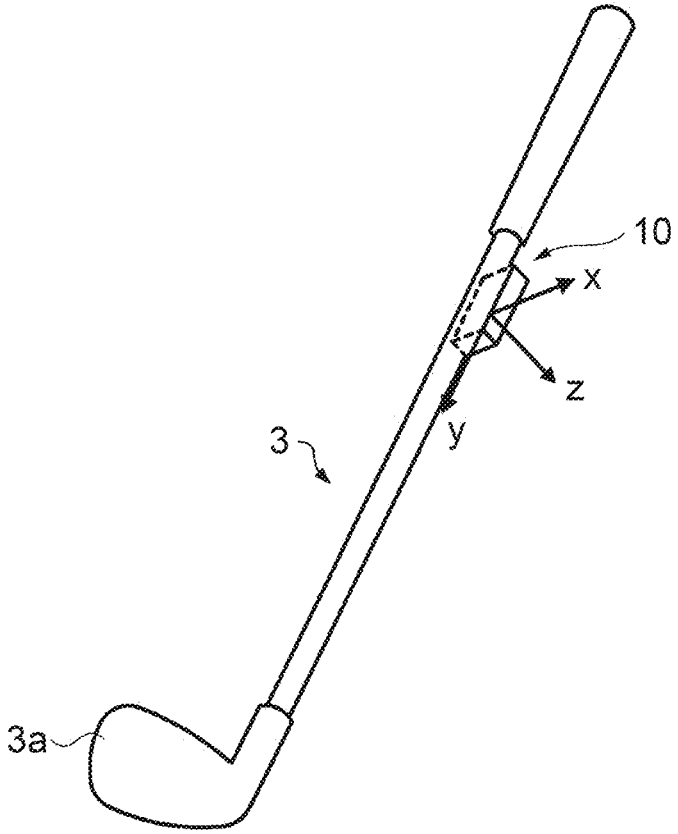


FIG. 3

FIG. 4

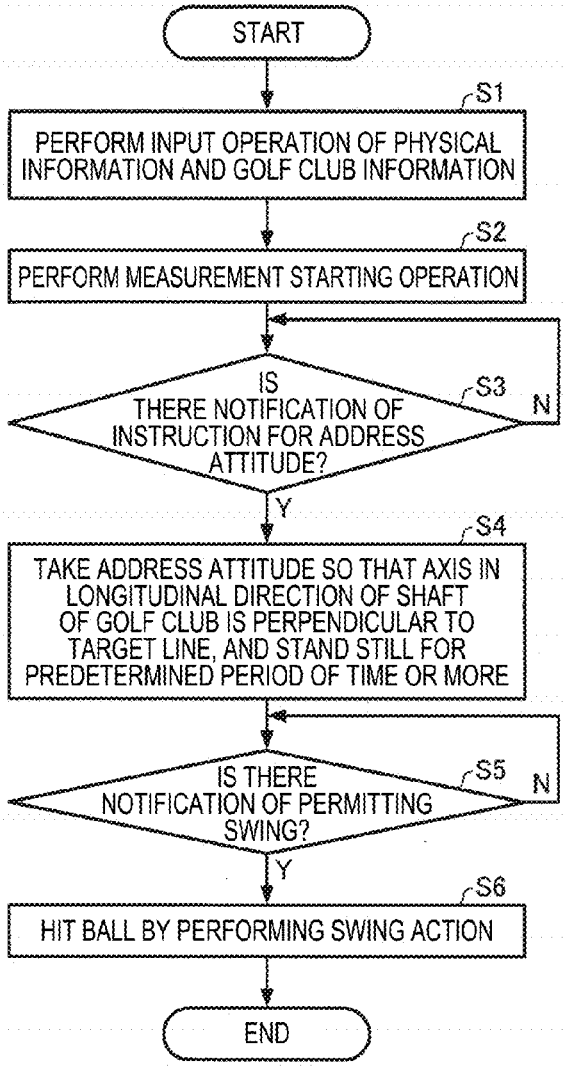
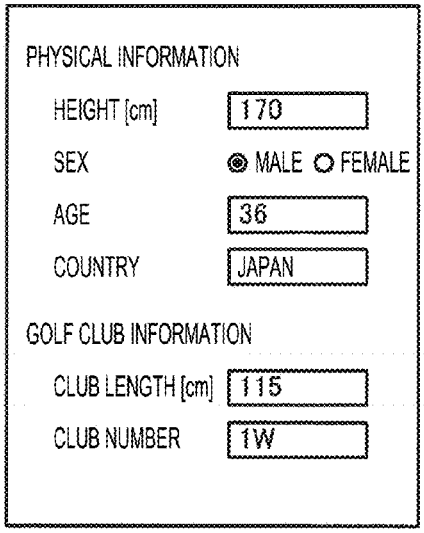

START
S1
PERFORM INPUT OPERATION OF PHYSICAL INFORMATION AND GOLF CLUB INFORMATION
S2
PERFORM MEASUREMENT STARTING OPERATION
S3
IS THERE NOTIFICATION OF INSTRUCTION FOR ADDRESS ATTITUDE?
N
Y
S4
TAKE ADDRESS ATTITUDE SO THAT AXIS IN LONGITUDINAL DIRECTION OF SHAFT OF GOLF CLUB IS PERPENDICULAR TO TARGET LINE, AND STAND STILL FOR PREDETERMINED PERIOD OF TIME OR MORE
S5
IS THERE NOTIFICATION OF PERMITTING SWING?
N
Y
S6
HIT BALL BY PERFORMING SWING ACTION
END

FIG. 5


PHYSICAL INFORMATION
HEIGHT [cm]
170
SEX
MALE
FEMALE
AGE
36
COUNTRY
JAPAN
GOLF CLUB INFORMATION
CLUB LENGTH [cm]
115
CLUB NUMBER
1W

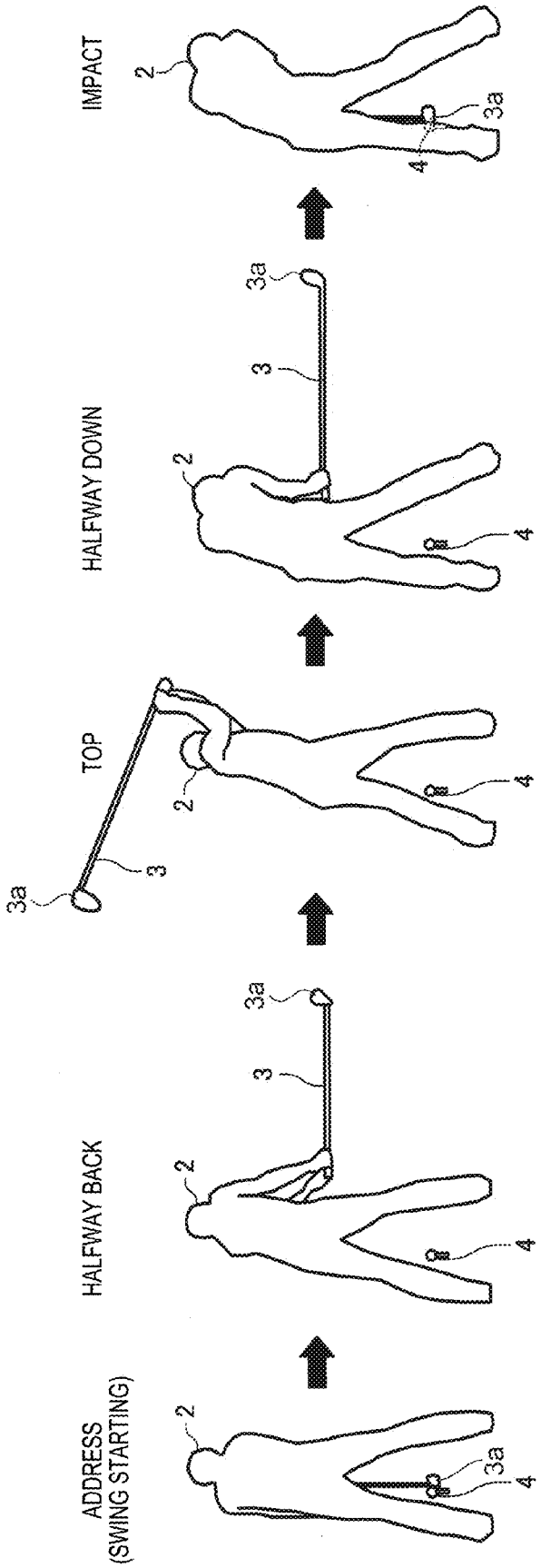

ADDRESS
(SWING STARTING)
HALFWAY BACK
TOP
HALFWAY DOWN
IMPACT
2
3
3a
4

FIG. 6

	DATE AND TIME	GOLF CLUB	HEAD SPEED	FACE ANGLE	CLUB PATH (INCIDENCE ANGLE)	SHAFT AXIS ROTATION ANGLE (TOP)	GRIP DECELERATION RATIO	GRIP DECELERATION TIME RATIO
☑	2015/07/01 00:01:00 PM	1W	40.0 m/s	4.0 deg	−1.0 deg	70.0 deg	30.0 %	14.0 %
☐	2015/07/01 00:59:00 PM	1W	39.0 m/s	3.9 deg	−0.9 deg	69.0 deg	29.0 %	13.0 %
☐	2015/07/01 00:58:00 PM	1W	41.0 m/s	4.1 deg	−1.1 deg	71.0 deg	31.0 %	15.0 %
☐	2015/07/01 00:57:00 PM	7I	38.0 m/s	3.8 deg	−0.8 deg	68.0 deg	28.0 %	12.0 %
☐	2015/07/01 00:56:00 PM	7I	37.0 m/s	3.7 deg	−0.7 deg	67.0 deg	27.0 %	11.0 %

OK →

FIG. 7

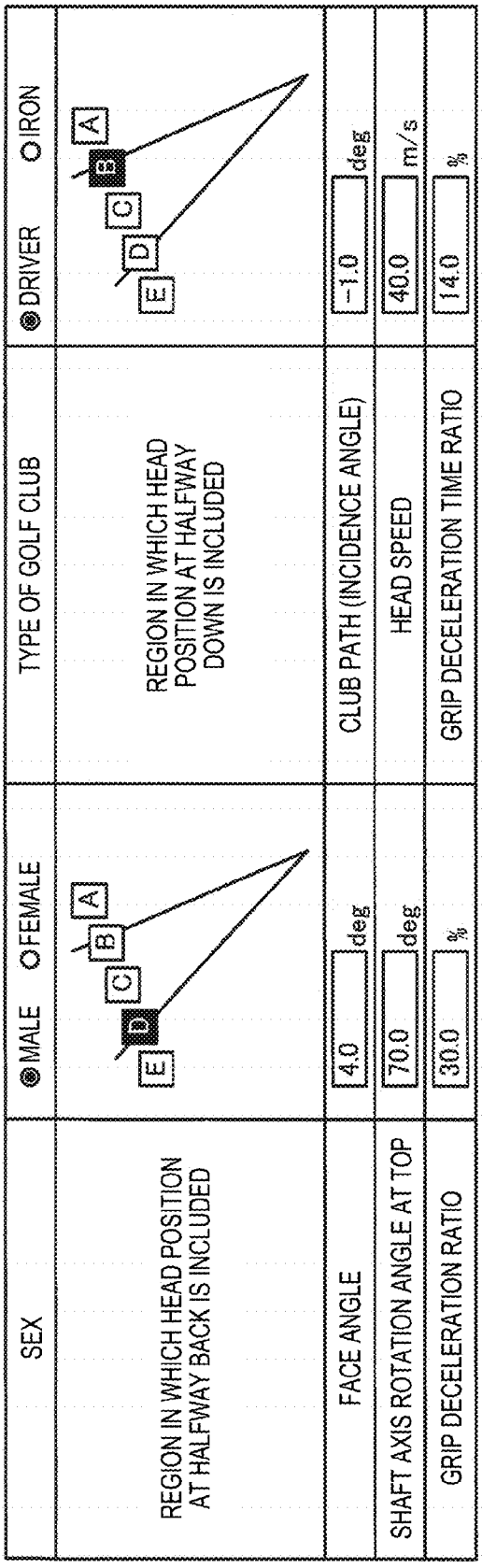
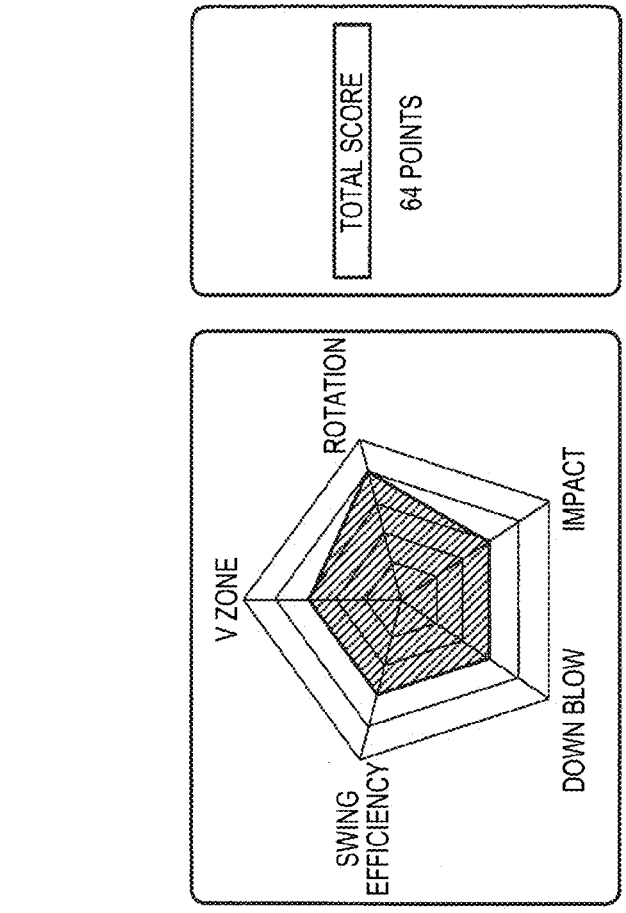

SEX
◉MALE ○FEMALE
TYPE OF GOLF CLUB
◉DRIVER ○IRON
REGION IN WHICH HEAD POSITION AT HALFWAY BACK IS INCLUDED
A
B
C
D
E
REGION IN WHICH HEAD POSITION AT HALFWAY DOWN IS INCLUDED
A
B
C
D
E
FACE ANGLE
4.0 deg
CLUB PATH (INCIDENCE ANGLE)
−1.0 deg
SHAFT AXIS ROTATION ANGLE AT TOP
70.0 deg
HEAD SPEED
40.0 m/s
GRIP DECELERATION RATIO
30.0 %
GRIP DECELERATION TIME RATIO
14.0 %
DIAGNOSIS STARTING

FIG. 8



INPUT DATA

SEX	MALE
TYPE OF GOLF CLUB	DRIVER
REGION IN WHICH HEAD POSITION AT HALFWAY BACK IS INCLUDED	D
REGION IN WHICH HEAD POSITION AT HALFWAY DOWN IS INCLUDED	B
FACE ANGLE	4.0deg
CLUB PATH (INCIDENCE ANGLE)	−1.0deg
SHAFT AXIS ROTATION ANGLE AT TOP	70.0deg
HEAD SPEED	40.0m/s
GRIP DECELERATION RATIO	30.0%
GRIP DECELERATION TIME RATIO	14.0%

FIG. 9

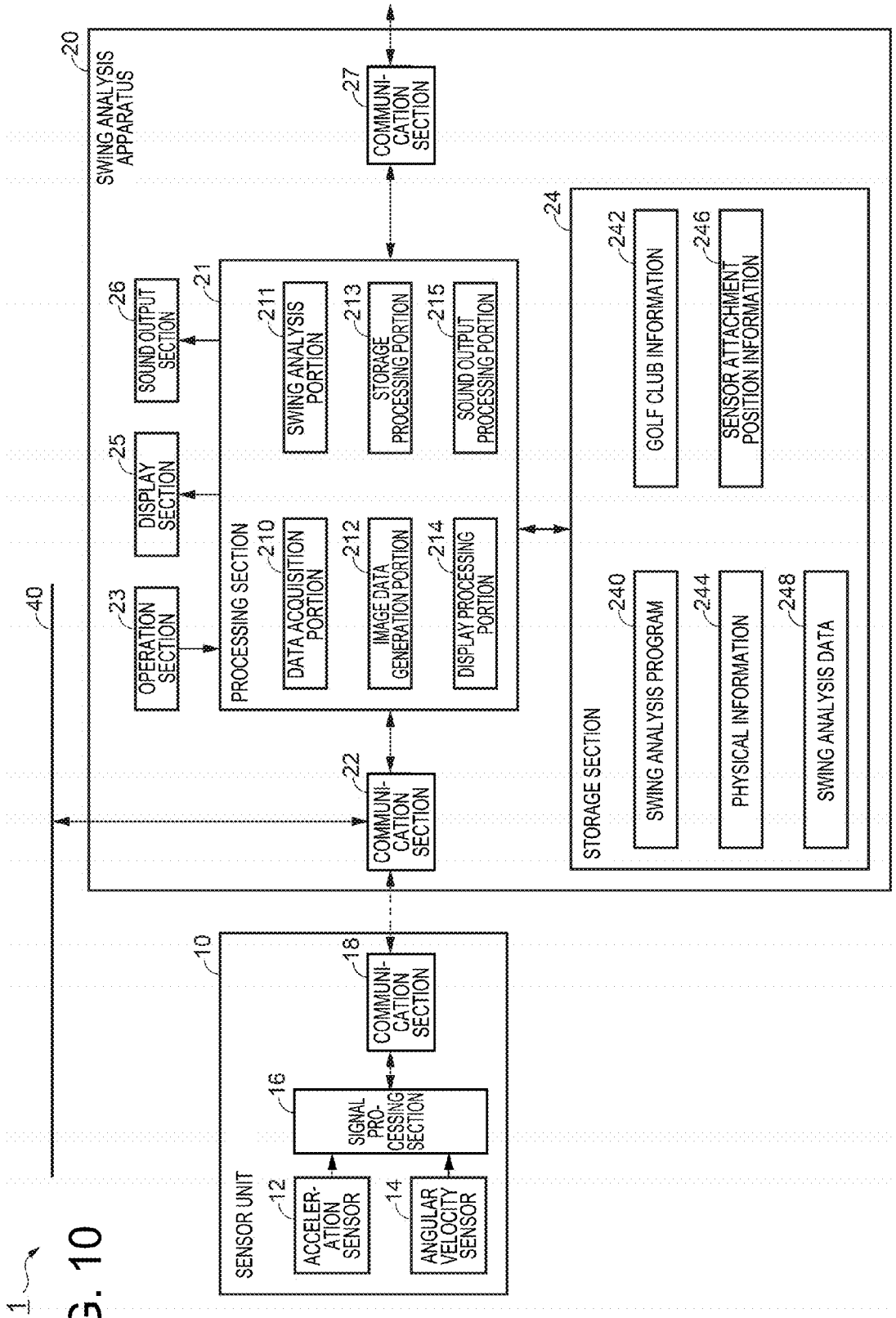

1
40
20
SWING ANALYSIS APPARATUS
27
COMMUNI-CATION SECTION
26
SOUND OUTPUT SECTION
25
DISPLAY SECTION
23
OPERATION SECTION
21
PROCESSING SECTION
211
SWING ANALYSIS PORTION
213
STORAGE PROCESSING PORTION
215
SOUND OUTPUT PROCESSING PORTION
210
DATA ACQUISITION PORTION
212
IMAGE DATA GENERATION PORTION
214
DISPLAY PROCESSING PORTION
22
COMMUNI-CATION SECTION
24
STORAGE SECTION
242
GOLF CLUB INFORMATION
246
SENSOR ATTACHMENT POSITION INFORMATION
240
SWING ANALYSIS PROGRAM
244
PHYSICAL INFORMATION
248
SWING ANALYSIS DATA
10
SENSOR UNIT
18
COMMUNI-CATION SECTION
16
SIGNAL PRO-CESSING SECTION
12
ACCELER-ATION SENSOR
14
ANGULAR VELOCITY SENSOR

FIG. 10

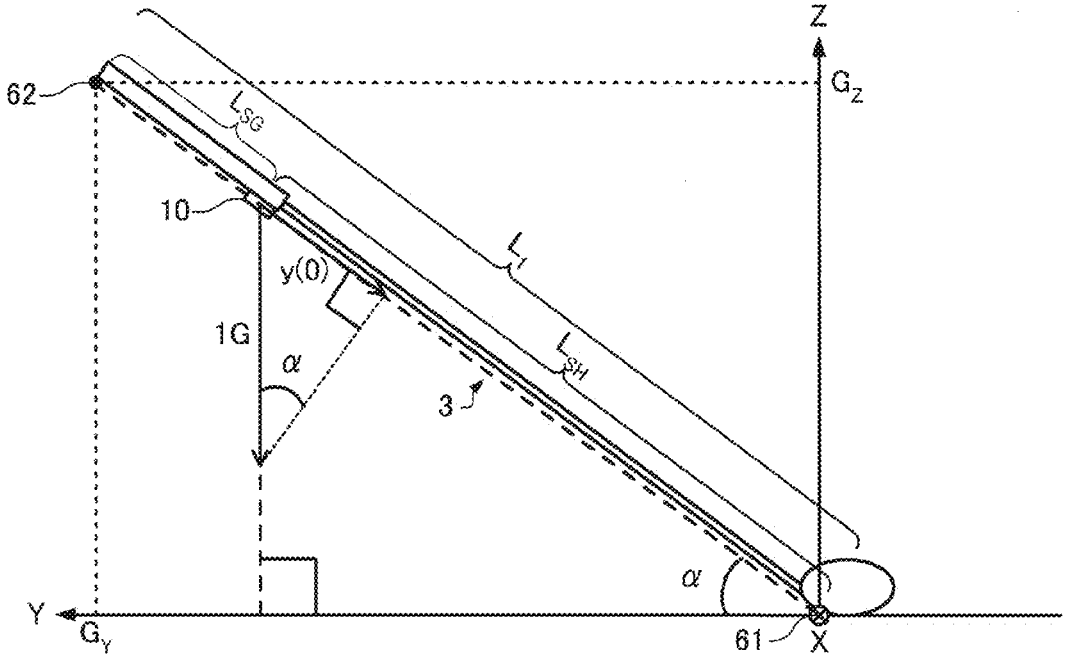

Z
G_Z
62
L_{SG}
10
L_1
y(0)
1G
α
L_{SH}
3
α
Y
G_Y
61
X

FIG. 11

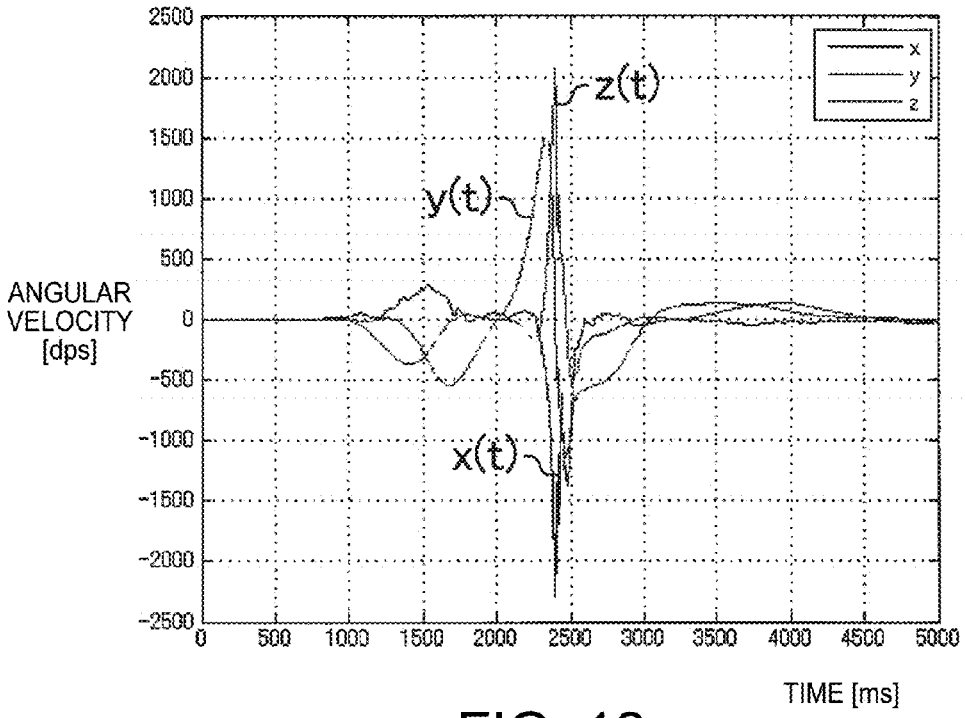

2500
2000
1500
1000
500
0
-500
-1000
-1500
-2000
-2500
ANGULAR VELOCITY [dps]
z(t)
y(t)
x(t)
x
y
z
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
TIME [ms]

FIG. 12

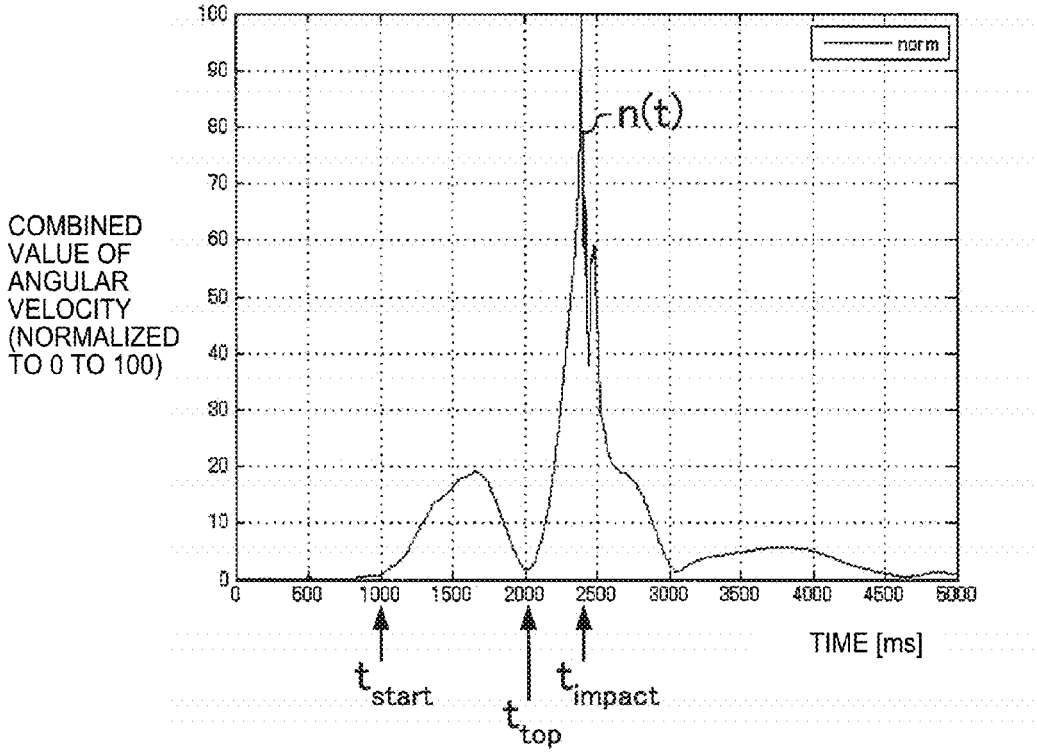

COMBINED VALUE OF ANGULAR VELOCITY (NORMALIZED TO 0 TO 100)
norm
n(t)
TIME [ms]
t_{start}
t_{top}
t_{impact}

FIG. 13

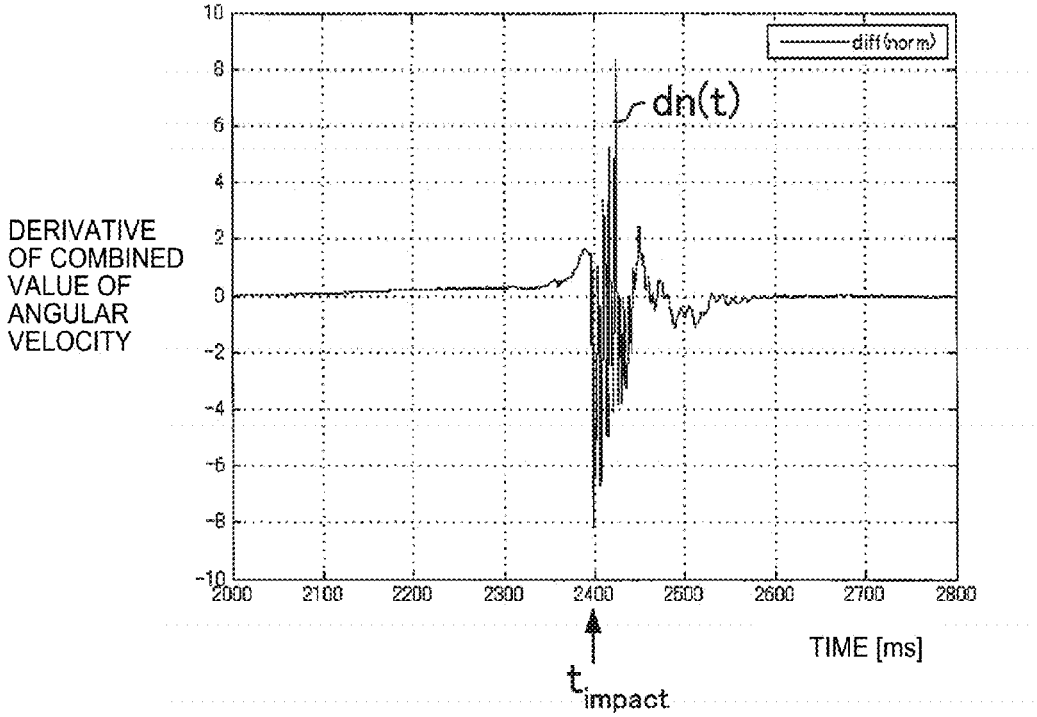

DERIVATIVE OF COMBINED VALUE OF ANGULAR VELOCITY
diff(norm)
dn(t)
TIME [ms]
t_{impact}

FIG. 14

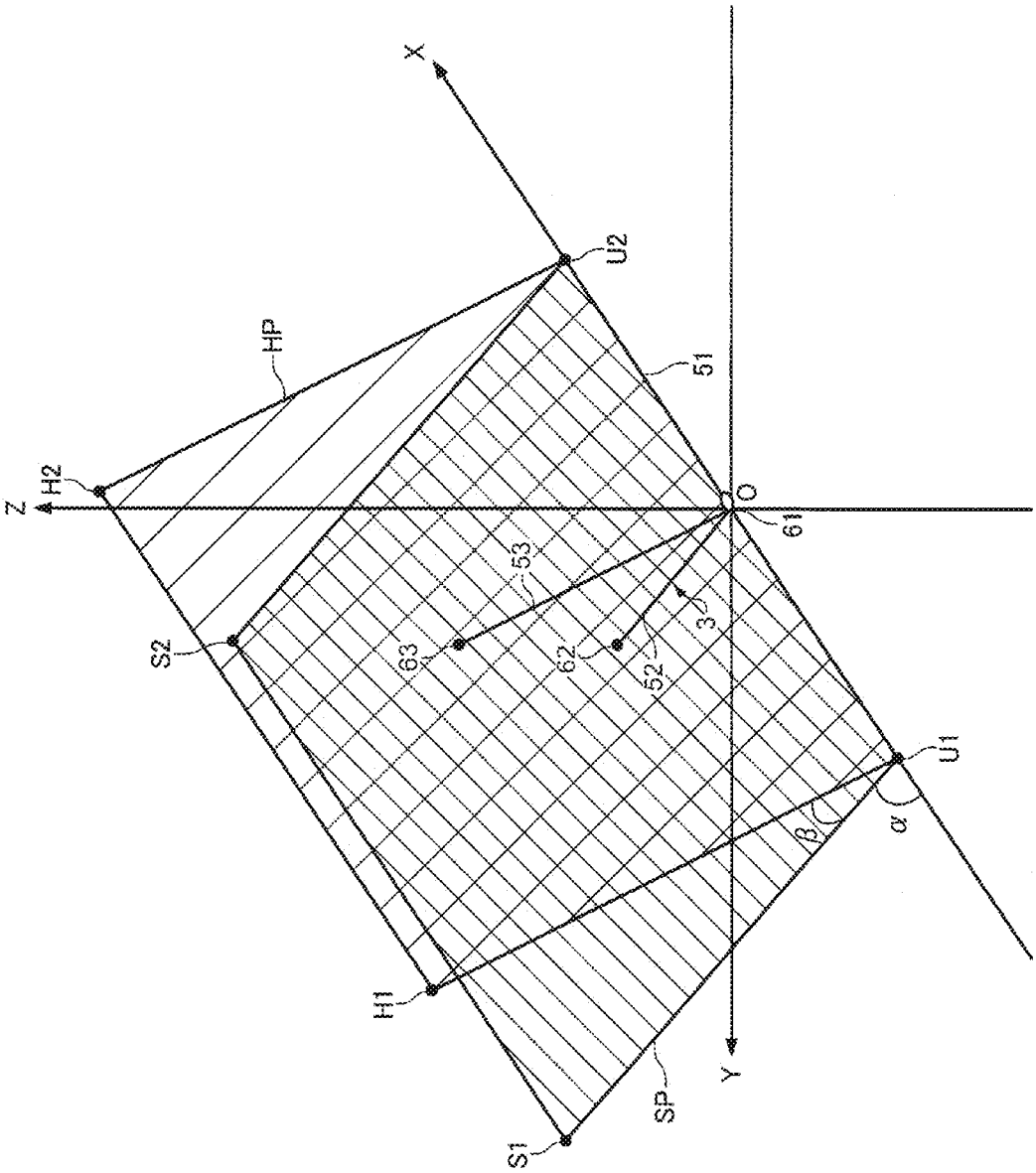


FIG. 15

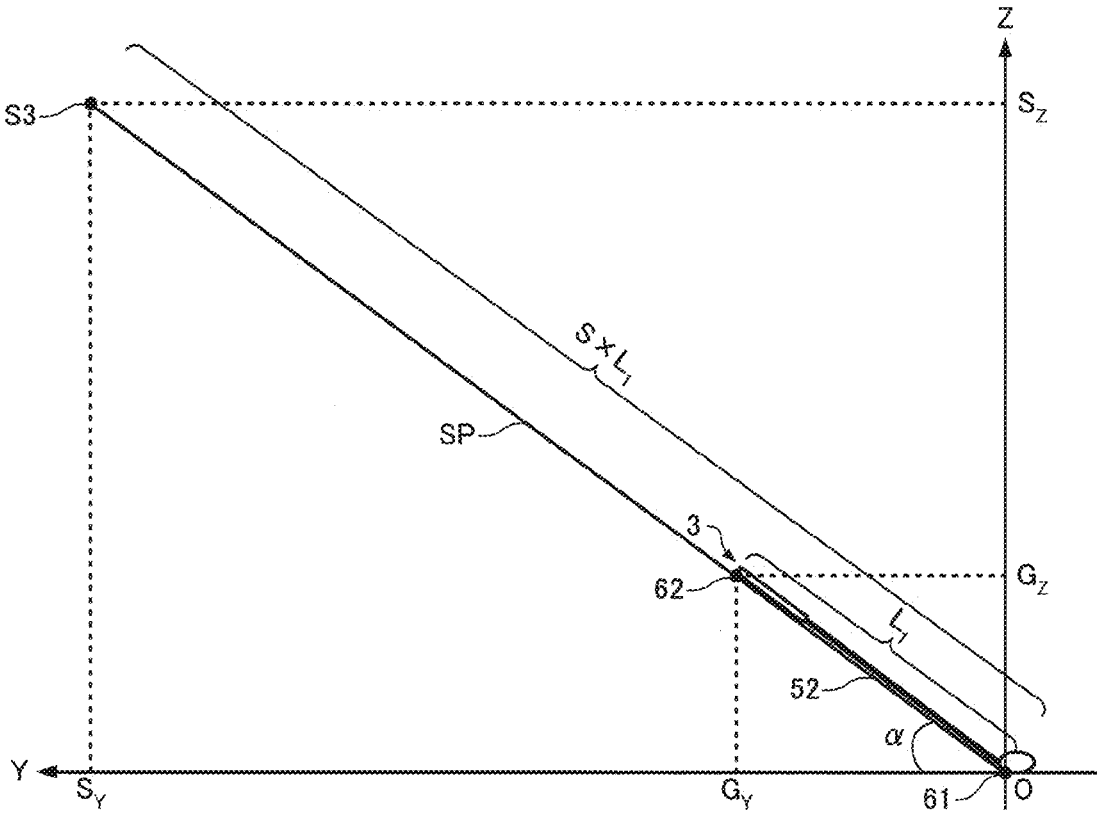


FIG. 16

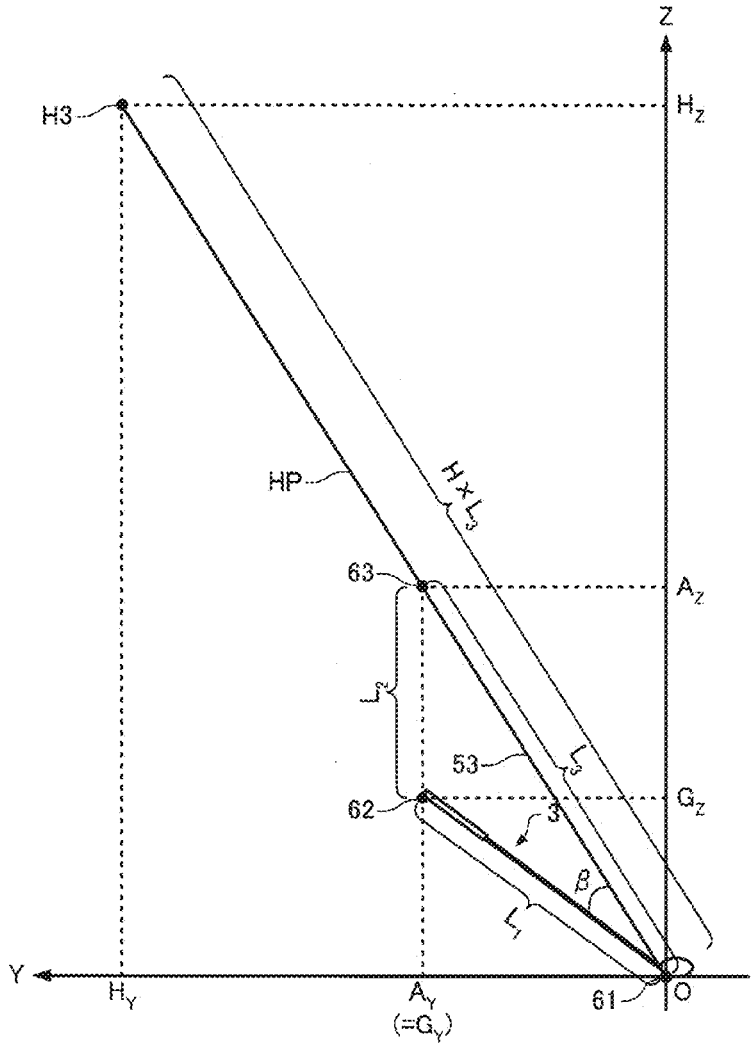

Z
H3
H_Z
HP
$H \times L_3$
63
A_Z
L_2
53
L_3
62
G_Z
3
β
L_1
Y
H_Y
A_Y
(=G_Y)
61
O

FIG. 17

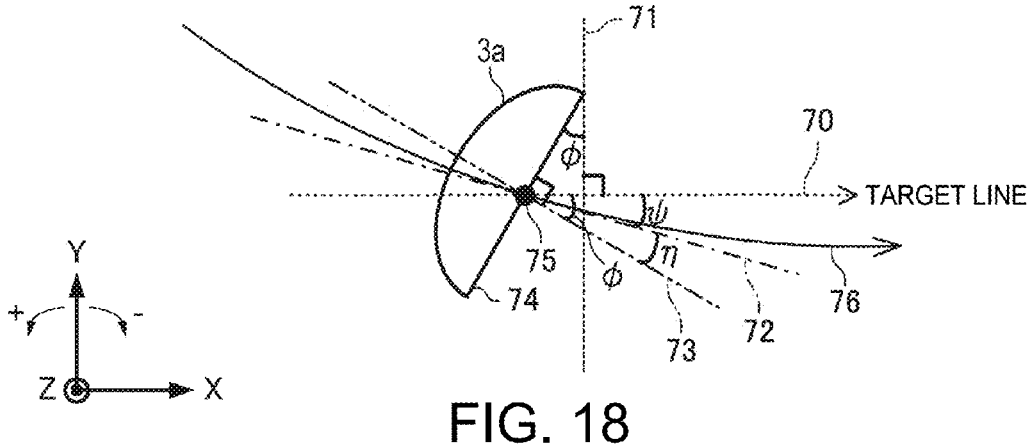

71
3a
70
TARGET LINE
ϕ
ψ
η
75
74
73
72
76
Y
+
-
Z
X

FIG. 18

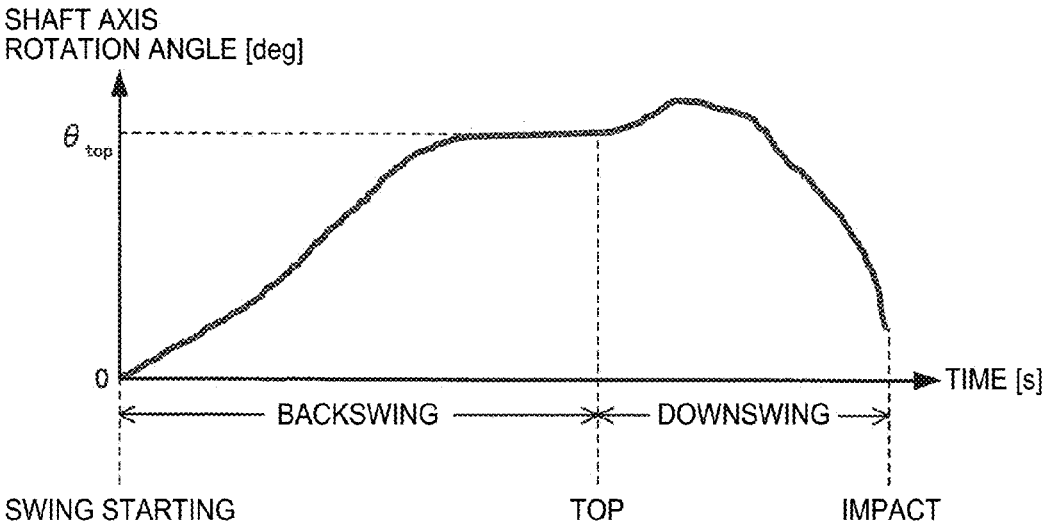

SHAFT AXIS
ROTATION ANGLE [deg]
θ top
0
TIME [s]
BACKSWING
DOWNSWING
SWING STARTING
TOP
IMPACT

FIG. 19

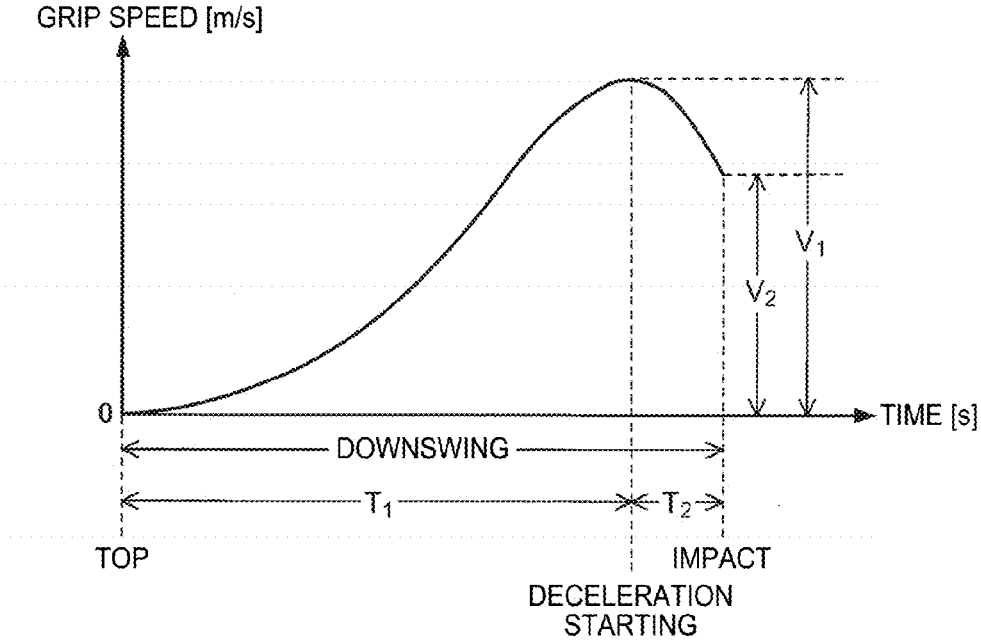

GRIP SPEED [m/s]
V1
V2
0
TIME [s]
DOWNSWING
T1
T2
TOP
IMPACT
DECELERATION
STARTING

FIG. 20

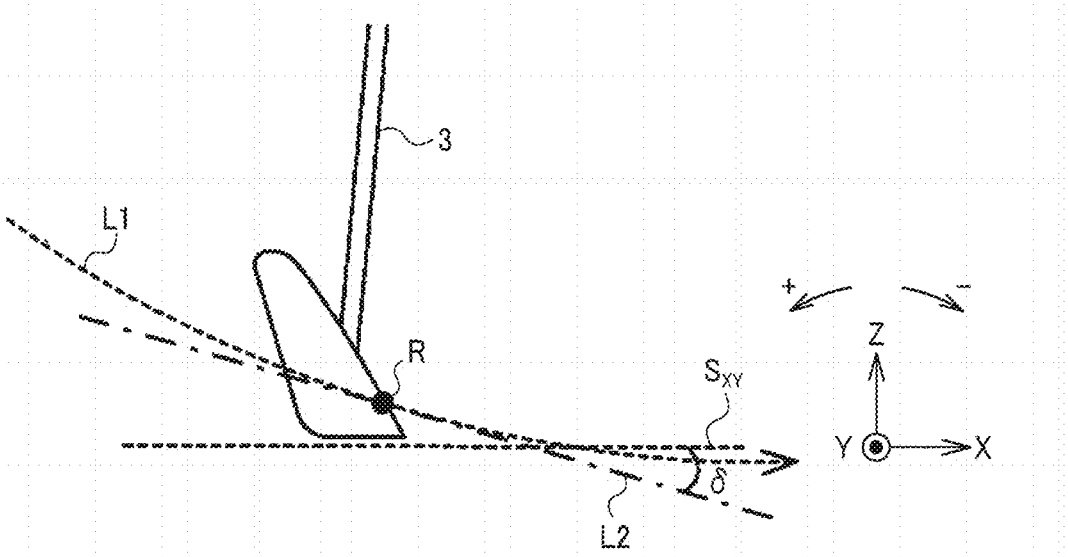


FIG. 21

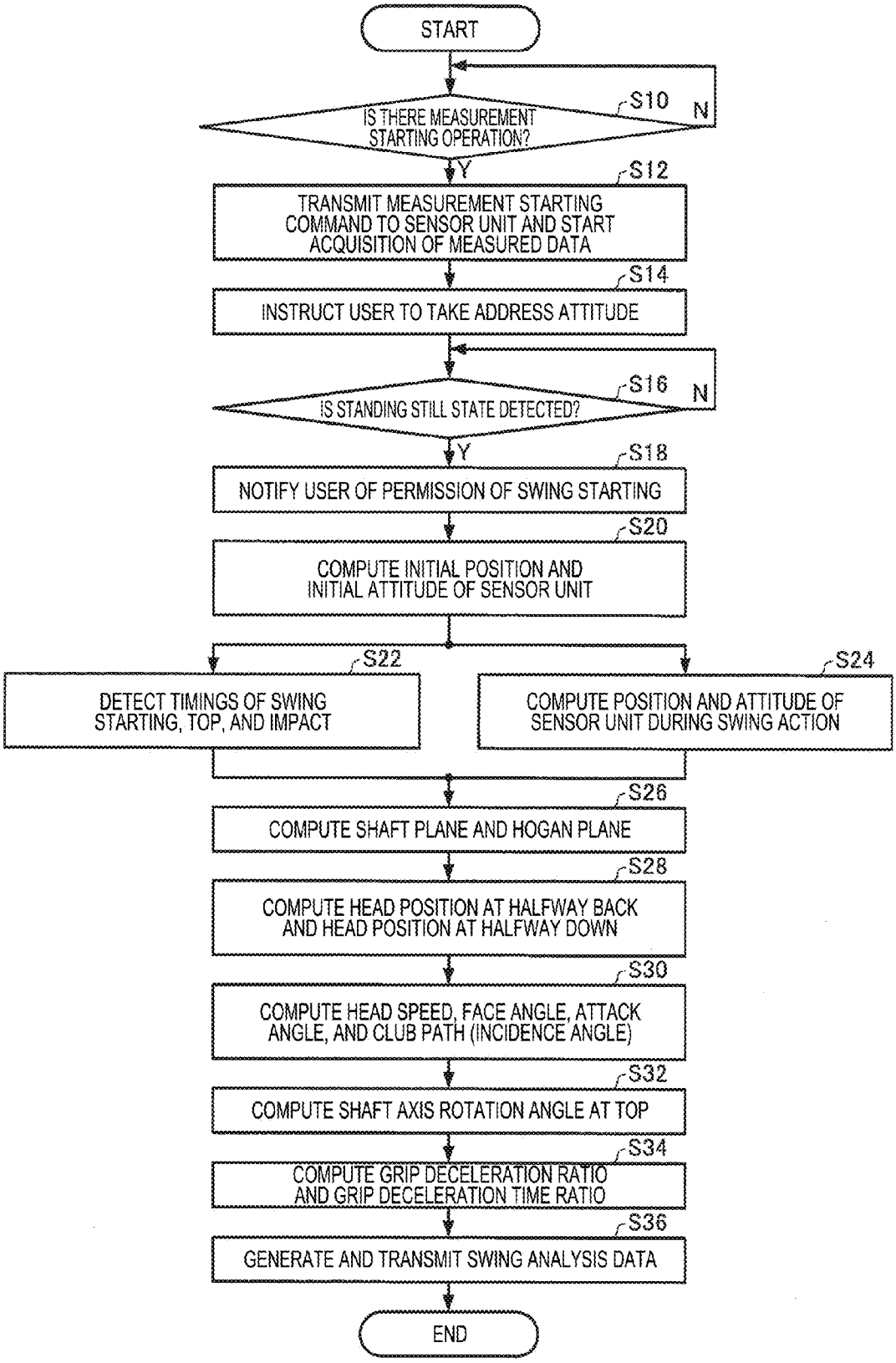

START
S10
IS THERE MEASUREMENT STARTING OPERATION?
N
Y
S12
TRANSMIT MEASUREMENT STARTING COMMAND TO SENSOR UNIT AND START ACQUISITION OF MEASURED DATA
S14
INSTRUCT USER TO TAKE ADDRESS ATTITUDE
S16
IS STANDING STILL STATE DETECTED?
N
Y
S18
NOTIFY USER OF PERMISSION OF SWING STARTING
S20
COMPUTE INITIAL POSITION AND INITIAL ATTITUDE OF SENSOR UNIT
S22
DETECT TIMINGS OF SWING STARTING, TOP, AND IMPACT
S24
COMPUTE POSITION AND ATTITUDE OF SENSOR UNIT DURING SWING ACTION
S26
COMPUTE SHAFT PLANE AND HOGAN PLANE
S28
COMPUTE HEAD POSITION AT HALFWAY BACK AND HEAD POSITION AT HALFWAY DOWN
S30
COMPUTE HEAD SPEED, FACE ANGLE, ATTACK ANGLE, AND CLUB PATH (INCIDENCE ANGLE)
S32
COMPUTE SHAFT AXIS ROTATION ANGLE AT TOP
S34
COMPUTE GRIP DECELERATION RATIO AND GRIP DECELERATION TIME RATIO
S36
GENERATE AND TRANSMIT SWING ANALYSIS DATA
END

FIG. 22

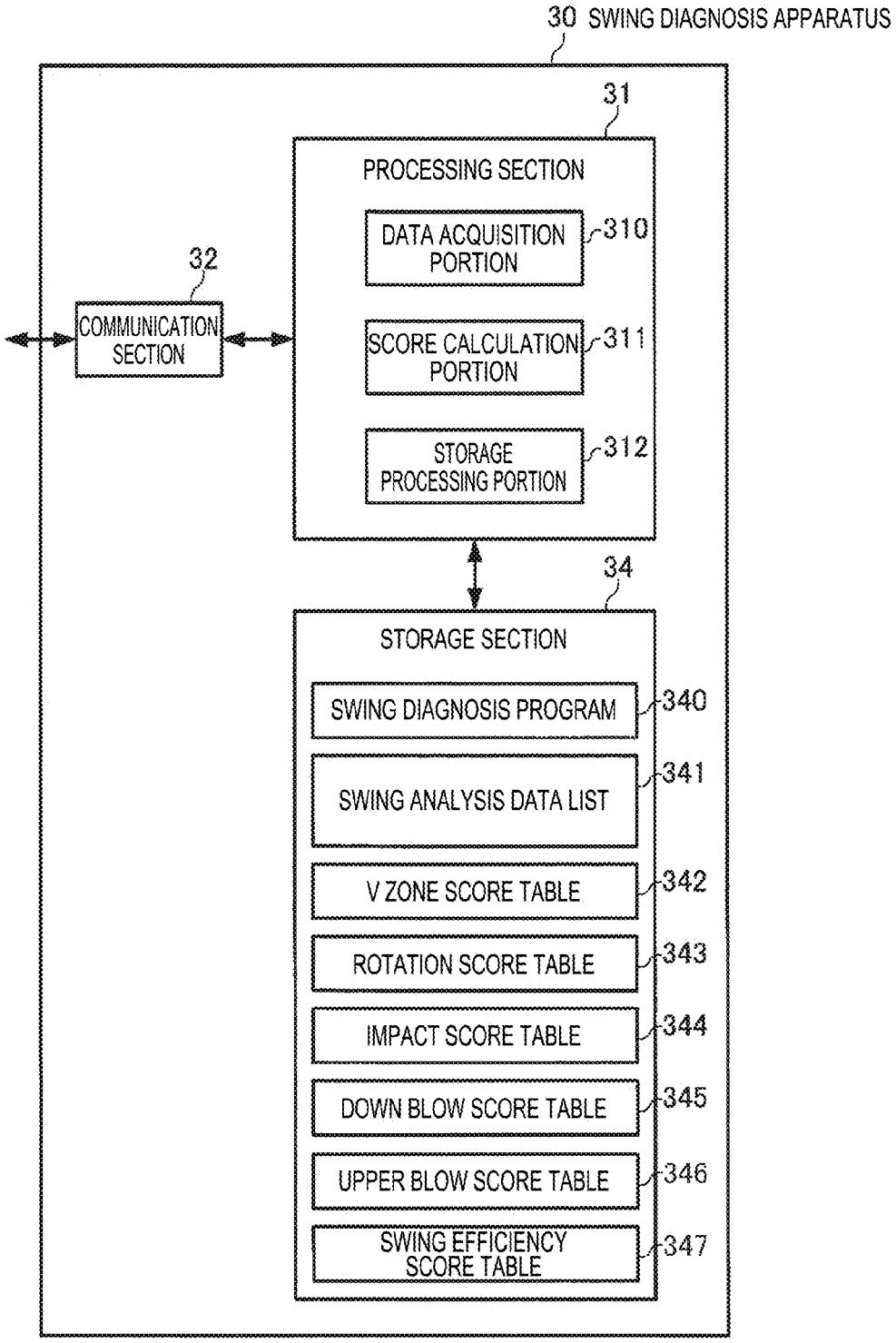

30 SWING DIAGNOSIS APPARATUS
31
PROCESSING SECTION
DATA ACQUISITION PORTION
310
32
COMMUNICATION SECTION
SCORE CALCULATION PORTION
311
STORAGE PROCESSING PORTION
312
34
STORAGE SECTION
SWING DIAGNOSIS PROGRAM
340
SWING ANALYSIS DATA LIST
341
V ZONE SCORE TABLE
342
ROTATION SCORE TABLE
343
IMPACT SCORE TABLE
344
DOWN BLOW SCORE TABLE
345
UPPER BLOW SCORE TABLE
346
SWING EFFICIENCY SCORE TABLE
347

FIG. 23

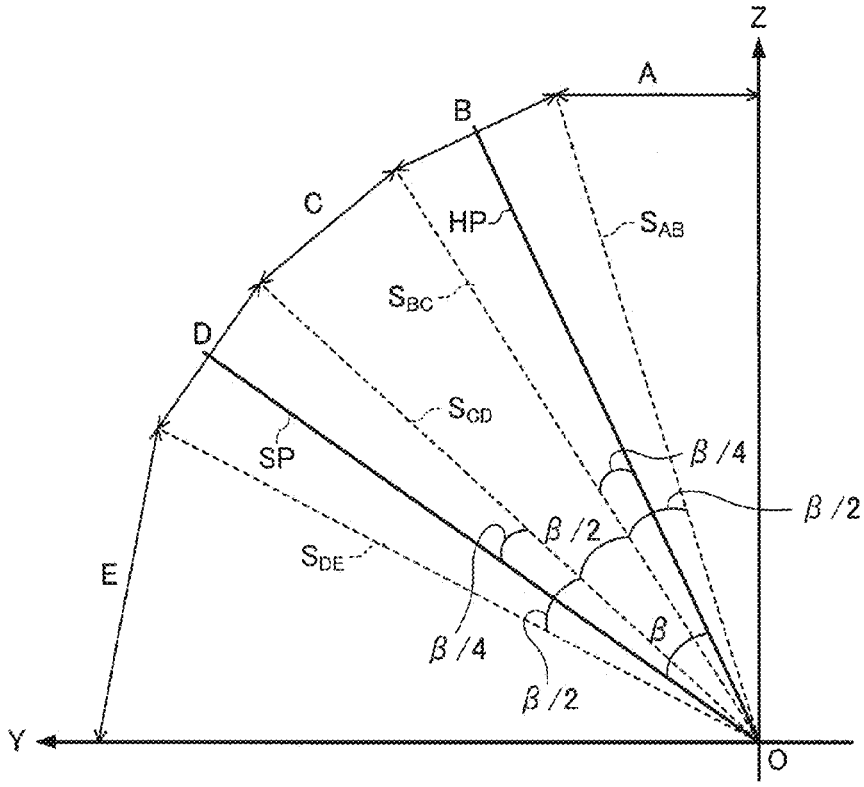


FIG. 24A

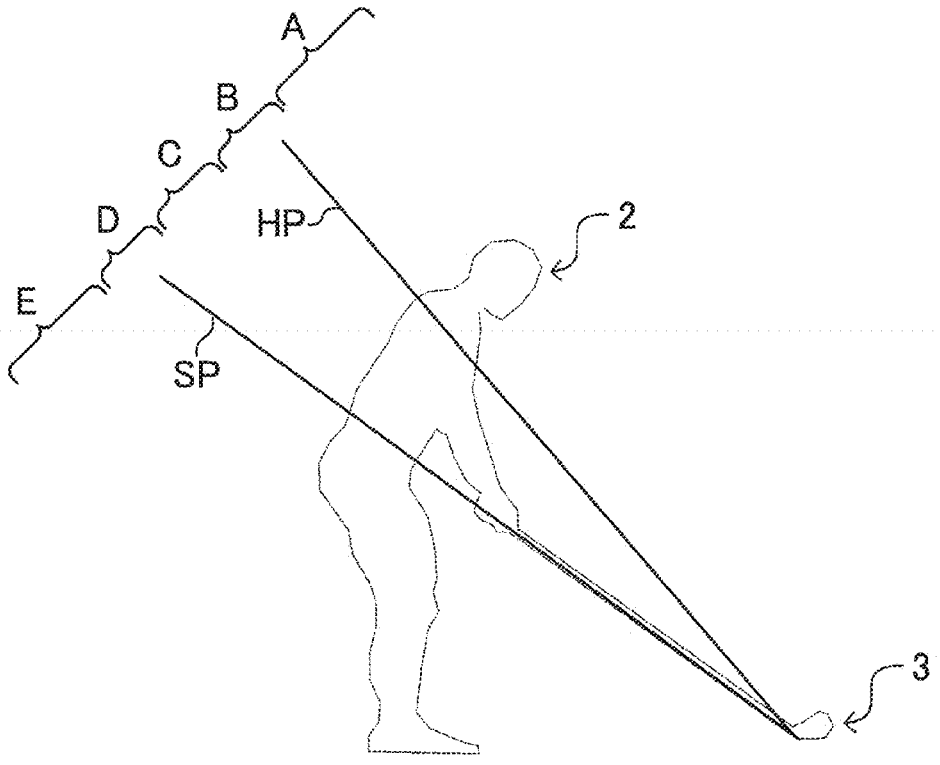


FIG. 24B

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V ZONE SCORE TABLE		HEAD POSITION AT HALFWAY DOWN				
		A	B	C	D	E
HEAD POSITION AT HALFWAY BACK	A	pv1	pv2	pv3	pv4	pv5
	B	pv6	pv7	pv8	pv9	pv10
	C	pv11	pv12	pv13	pv14	pv15
	D	pv16	pv17	pv18	pv19	pv20
	E	pv21	pv22	pv23	pv24	pv25

FIG. 25

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ROTATION SCORE TABLE		FACE ANGLE ϕ [deg]						
		CLOSED			SQUARE	OPEN		
		LESS THAN $\phi 1$	$\phi 1 \sim \phi 2$	$\phi 2 \sim \phi 3$	$\phi 3 \sim \phi 4$	$\phi 4 \sim \phi 5$	$\phi 5 \sim \phi 6$	$\phi 6$ OR MORE
SHAFT AXIS ROTATION ANGLE θ_{top} AT TOP [deg]	LESS THAN $\theta 1$	pr1	pr2	pr3	pr4	pr5	pr6	pr7
	$\theta 1 \sim \theta 2$	pr8	pr9	pr10	pr11	pr12	pr13	pr14
	$\theta 2 \sim \theta 3$	pr15	pr16	pr17	pr18	pr19	pr20	pr21
	$\theta 3 \sim \theta 4$	pr22	pr23	pr24	pr25	pr26	pr27	pr28
	$\theta 4$ OR MORE	pr29	pr30	pr31	pr32	pr33	pr34	pr35

FIG. 26

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IMPACT SCORE TABLE		CLUB PATH (INCIDENCE ANGLE) ψ [deg]				
		LESS THAN ψ1	ψ1～ψ2	ψ2～ψ3	ψ3～ψ4	ψ4 OR MORE
RELATIVE FACE ANGLE η [deg]	η1 OR MORE	pi1	pi2	pi3	pi4	pi5
	η1～η2	pi6	pi7	pi8	pi9	pi10
	η2～η3	pi11	pi12	pi13	pi14	pi15
	η3～η4	pi16	pi17	pi18	pi19	pi20
	LESS THAN η4	pi21	pi22	pi23	pi24	pi25

FIG. 27

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DOWN BLOW SCORE TABLE			ATTACK ANGLE δ [deg]				
			DOWN BLOW			LEVEL BLOW	UPPER BLOW
FACE ANGLE φ [deg]			LESS THAN -δ1	-δ1～-δ2	-δ2～-δ3	-δ3～0	+δ4 OR MORE
	CLOSED	LESS THAN -φ1	Pd1	Pd2	Pd3	Pd4	Pd5
	SQUARE	-φ1～0	Pd6	Pd7	Pd8	Pd9	Pd10
		0～+φ1	Pd11	Pd12	Pd13	Pd14	Pd15
	OPEN	+φ1～+φ2	Pd16	Pd17	Pd18	Pd19	Pd20
		+φ2 OR MORE	Pd21	Pd22	Pd23	Pd24	Pd25

FIG. 28

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UPPER BLOW SCORE TABLE			ATTACK ANGLE δ [deg]				
			UPPER BLOW			LEVEL BLOW	DOWN BLOW
FACE ANGLE ϕ [deg]			δ1 OR MORE	+δ1～+δ2	+δ2～+δ3	+δ3～0	-δ4 OR MORE
	CLOSED	LESS THAN -ϕ1	Pu1	Pu2	Pu3	Pu4	Pu5
	SQUARE	−ϕ1～0	Pu6	Pu7	Pu8	Pu9	Pu10
		0～+ϕ1	Pu11	Pu12	Pu13	Pu14	Pu15
	OPEN	+ϕ1～+ϕ2	Pu16	Pu17	Pu18	Pu19	Pu20
		+ϕ2 OR MORE	Pu21	Pu22	Pu23	Pu24	Pu25

FIG. 29

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SWING EFFICIENCY SCORE TABLE		GRIP DECELERATION TIME RATIO R_T [%]					
		nup1 OR MORE	nup1～nup2	nup2～nup3	nup3～nup4	nup4～nup5	LESS THAN nup5
GRIP DECELERATION RATIO R_V [%]	nu1 OR MORE	ps1	ps2	ps3	ps4	ps5	ps6
	nu1～nu2	ps7	ps8	ps9	ps10	ps11	ps12
	nu2～nu3	ps13	ps14	ps15	ps16	ps17	ps18
	nu3～nu4	ps19	ps20	ps21	ps22	ps23	ps24
	nu4～nu5	ps25	ps26	ps27	ps28	ps29	ps30
	LESS THAN nu5	ps31	ps32	ps33	ps34	ps35	ps36

FIG. 30

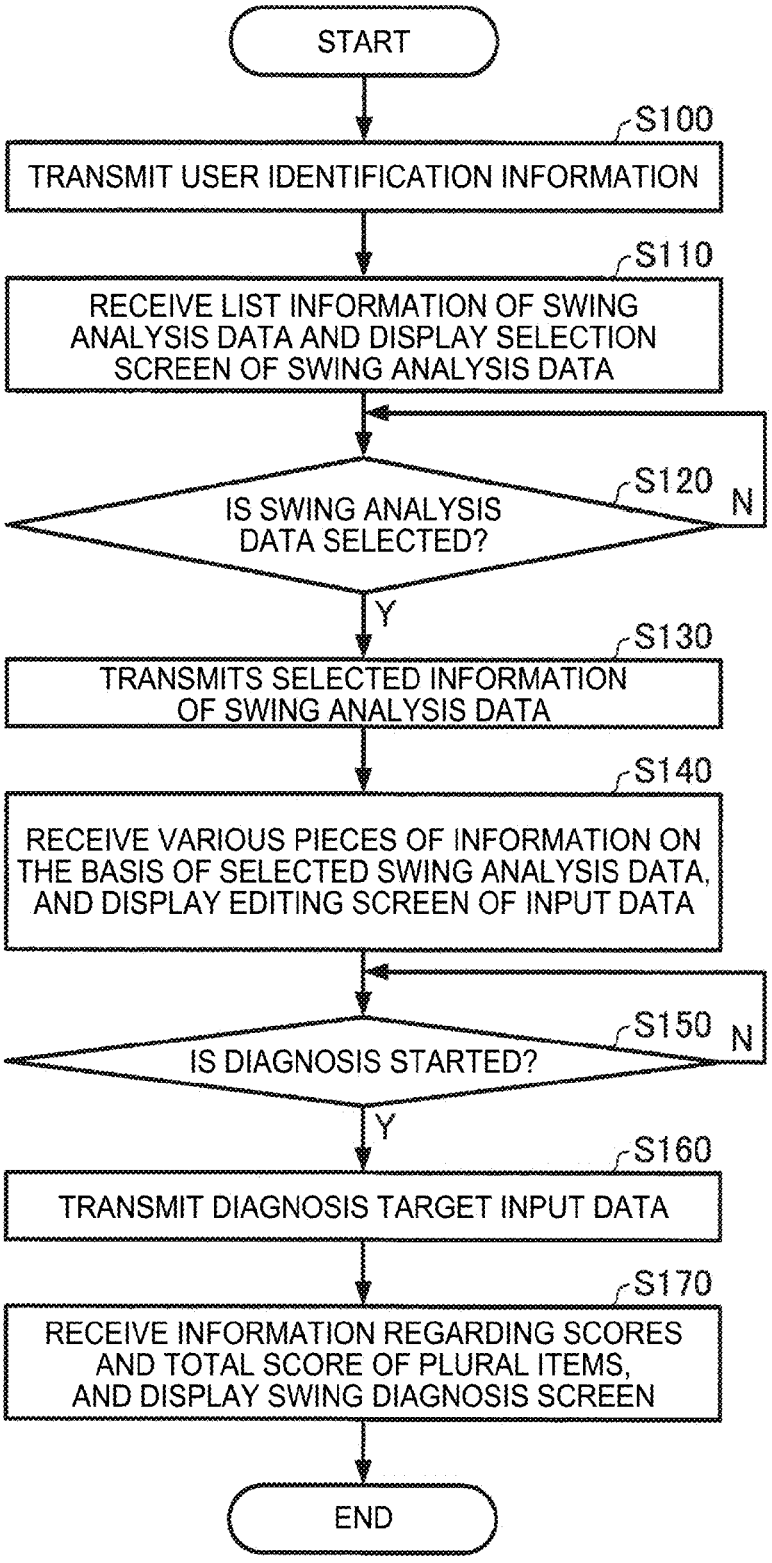

START
S100
TRANSMIT USER IDENTIFICATION INFORMATION
S110
RECEIVE LIST INFORMATION OF SWING ANALYSIS DATA AND DISPLAY SELECTION SCREEN OF SWING ANALYSIS DATA
S120
IS SWING ANALYSIS DATA SELECTED?
N
Y
S130
TRANSMITS SELECTED INFORMATION OF SWING ANALYSIS DATA
S140
RECEIVE VARIOUS PIECES OF INFORMATION ON THE BASIS OF SELECTED SWING ANALYSIS DATA, AND DISPLAY EDITING SCREEN OF INPUT DATA
S150
IS DIAGNOSIS STARTED?
N
Y
S160
TRANSMIT DIAGNOSIS TARGET INPUT DATA
S170
RECEIVE INFORMATION REGARDING SCORES AND TOTAL SCORE OF PLURAL ITEMS, AND DISPLAY SWING DIAGNOSIS SCREEN
END

FIG. 31

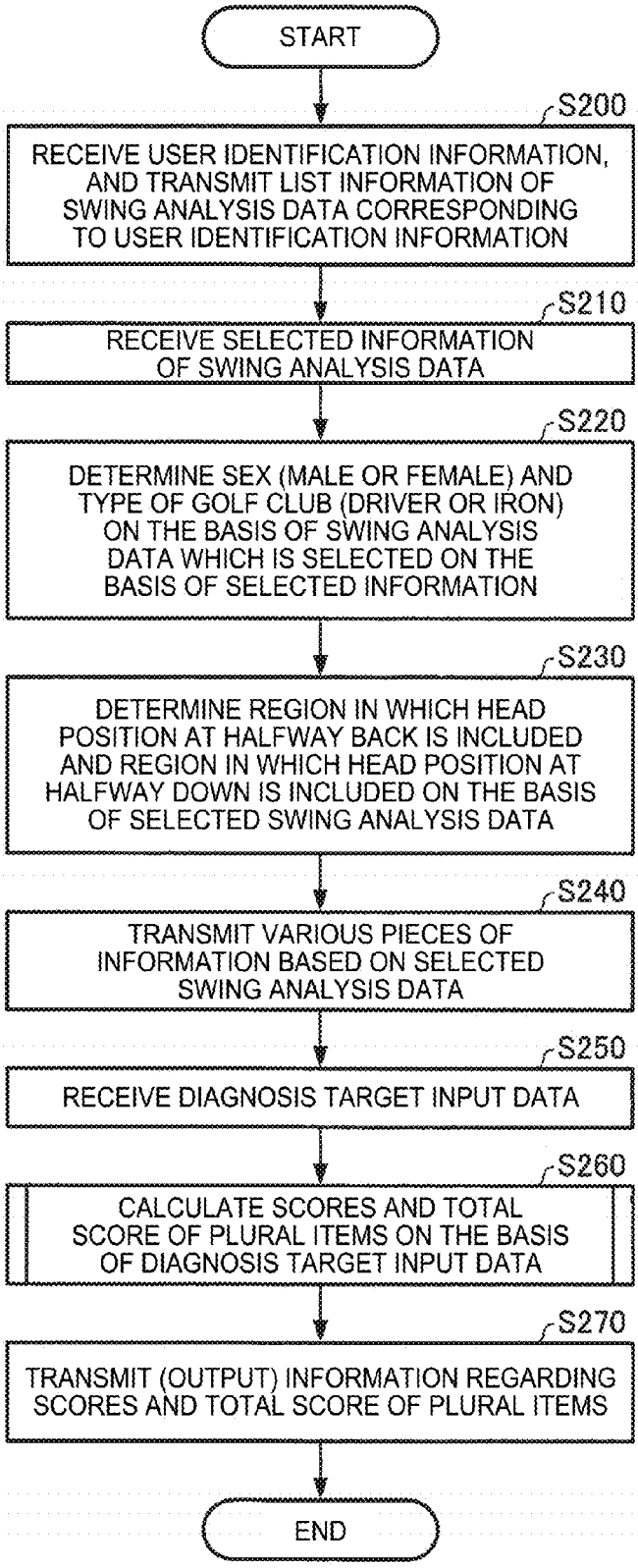

START
S200
RECEIVE USER IDENTIFICATION INFORMATION, AND TRANSMIT LIST INFORMATION OF SWING ANALYSIS DATA CORRESPONDING TO USER IDENTIFICATION INFORMATION
S210
RECEIVE SELECTED INFORMATION OF SWING ANALYSIS DATA
S220
DETERMINE SEX (MALE OR FEMALE) AND TYPE OF GOLF CLUB (DRIVER OR IRON) ON THE BASIS OF SWING ANALYSIS DATA WHICH IS SELECTED ON THE BASIS OF SELECTED INFORMATION
S230
DETERMINE REGION IN WHICH HEAD POSITION AT HALFWAY BACK IS INCLUDED AND REGION IN WHICH HEAD POSITION AT HALFWAY DOWN IS INCLUDED ON THE BASIS OF SELECTED SWING ANALYSIS DATA
S240
TRANSMIT VARIOUS PIECES OF INFORMATION BASED ON SELECTED SWING ANALYSIS DATA
S250
RECEIVE DIAGNOSIS TARGET INPUT DATA
S260
CALCULATE SCORES AND TOTAL SCORE OF PLURAL ITEMS ON THE BASIS OF DIAGNOSIS TARGET INPUT DATA
S270
TRANSMIT (OUTPUT) INFORMATION REGARDING SCORES AND TOTAL SCORE OF PLURAL ITEMS
END

FIG. 32

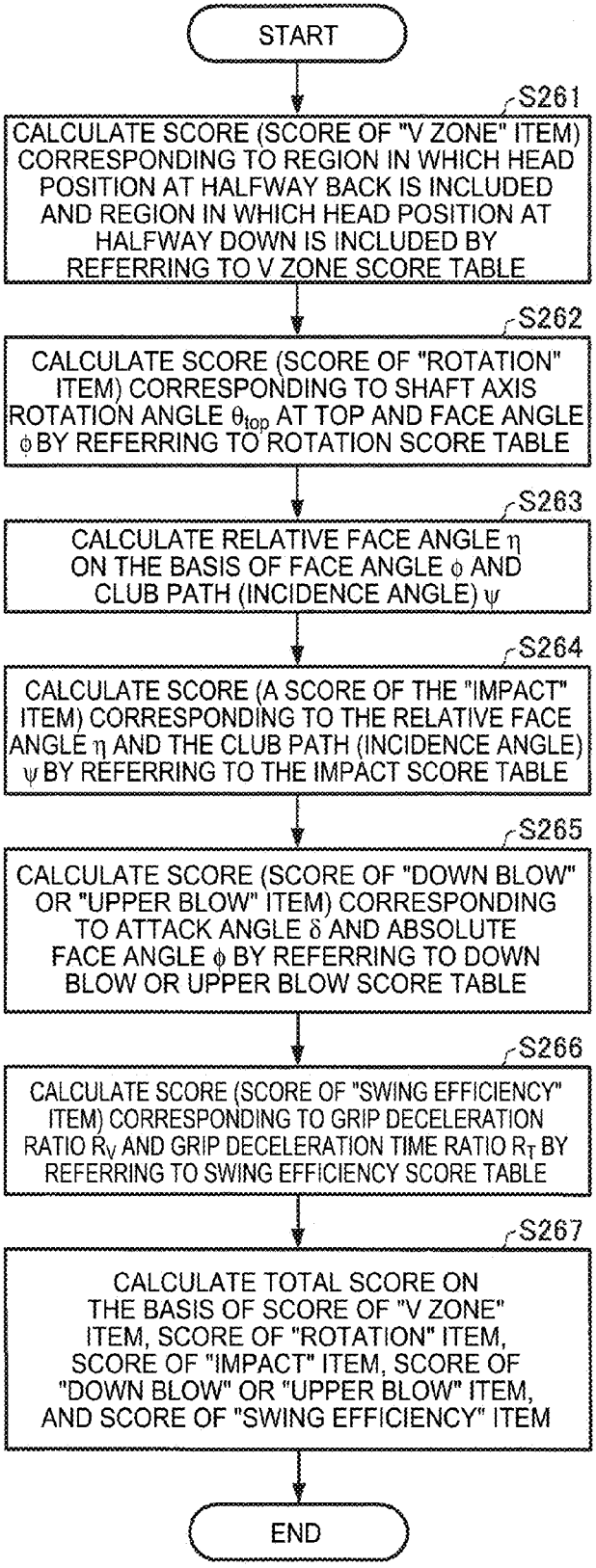

START
S261
CALCULATE SCORE (SCORE OF "V ZONE" ITEM) CORRESPONDING TO REGION IN WHICH HEAD POSITION AT HALFWAY BACK IS INCLUDED AND REGION IN WHICH HEAD POSITION AT HALFWAY DOWN IS INCLUDED BY REFERRING TO V ZONE SCORE TABLE
S262
CALCULATE SCORE (SCORE OF "ROTATION" ITEM) CORRESPONDING TO SHAFT AXIS ROTATION ANGLE θ_{top} AT TOP AND FACE ANGLE ϕ BY REFERRING TO ROTATION SCORE TABLE
S263
CALCULATE RELATIVE FACE ANGLE η ON THE BASIS OF FACE ANGLE ϕ AND CLUB PATH (INCIDENCE ANGLE) ψ
S264
CALCULATE SCORE (A SCORE OF THE "IMPACT" ITEM) CORRESPONDING TO THE RELATIVE FACE ANGLE η AND THE CLUB PATH (INCIDENCE ANGLE) ψ BY REFERRING TO THE IMPACT SCORE TABLE
S265
CALCULATE SCORE (SCORE OF "DOWN BLOW" OR "UPPER BLOW" ITEM) CORRESPONDING TO ATTACK ANGLE δ AND ABSOLUTE FACE ANGLE ϕ BY REFERRING TO DOWN BLOW OR UPPER BLOW SCORE TABLE
S266
CALCULATE SCORE (SCORE OF "SWING EFFICIENCY" ITEM) CORRESPONDING TO GRIP DECELERATION RATIO R_V AND GRIP DECELERATION TIME RATIO R_T BY REFERRING TO SWING EFFICIENCY SCORE TABLE
S267
CALCULATE TOTAL SCORE ON THE BASIS OF SCORE OF "V ZONE" ITEM, SCORE OF "ROTATION" ITEM, SCORE OF "IMPACT" ITEM, SCORE OF "DOWN BLOW" OR "UPPER BLOW" ITEM, AND SCORE OF "SWING EFFICIENCY" ITEM
END

FIG. 33

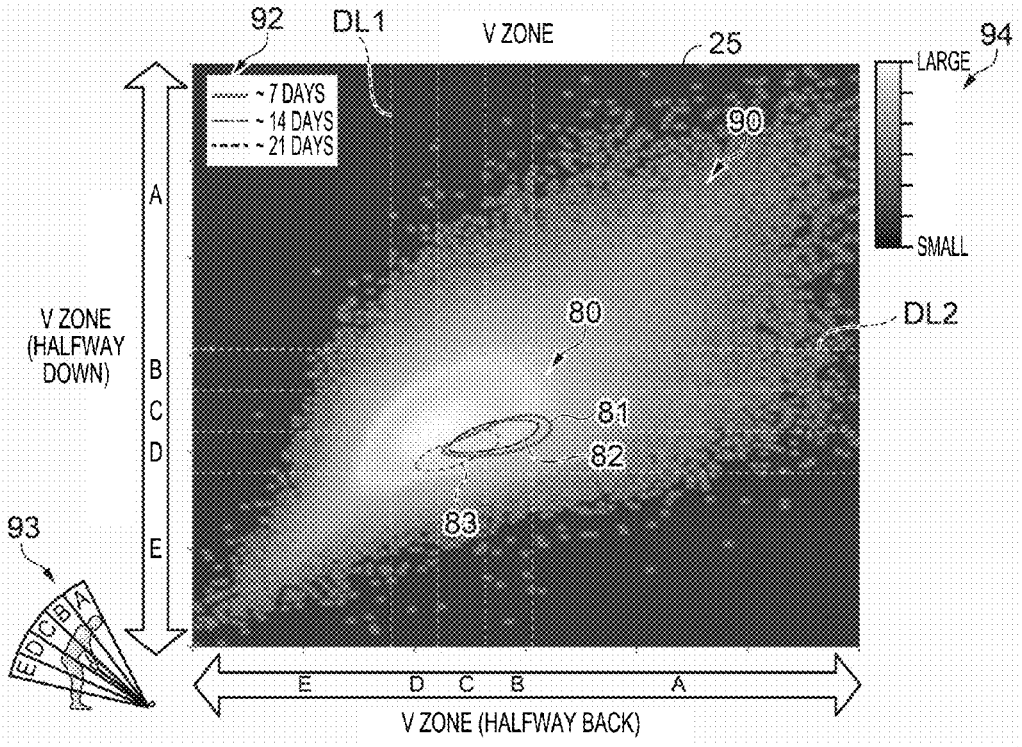

92
DL1
V ZONE
25
94
LARGE
~7 DAYS
~14 DAYS
~21 DAYS
90
SMALL
V ZONE (HALFWAY DOWN)
A
B
C
D
E
80
DL2
81
82
83
93
E D C B A
E D C B A
V ZONE (HALFWAY BACK)

FIG. 34

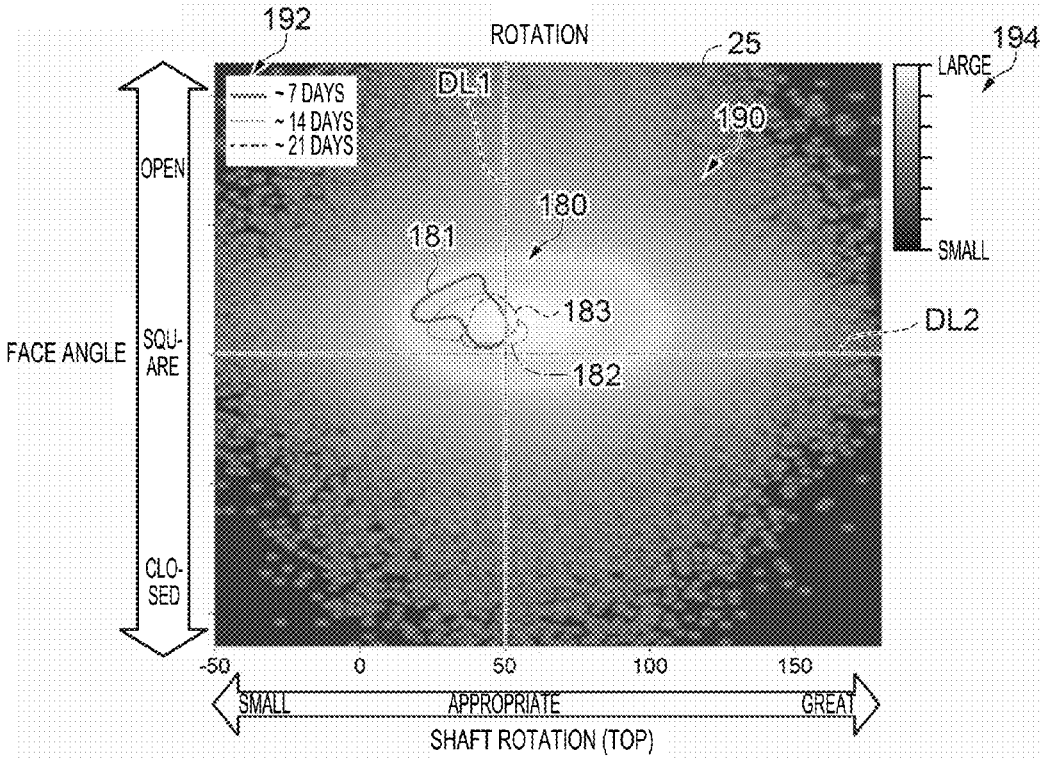

192
ROTATION
25
194
LARGE
DL1
~7 DAYS
~14 DAYS
~21 DAYS
190
180
181
SMALL
OPEN
FACE ANGLE
SQU-ARE
CLO-SED
183
DL2
182
-50
0
50
100
150
SMALL
APPROPRIATE
GREAT
SHAFT ROTATION (TOP)

FIG. 35

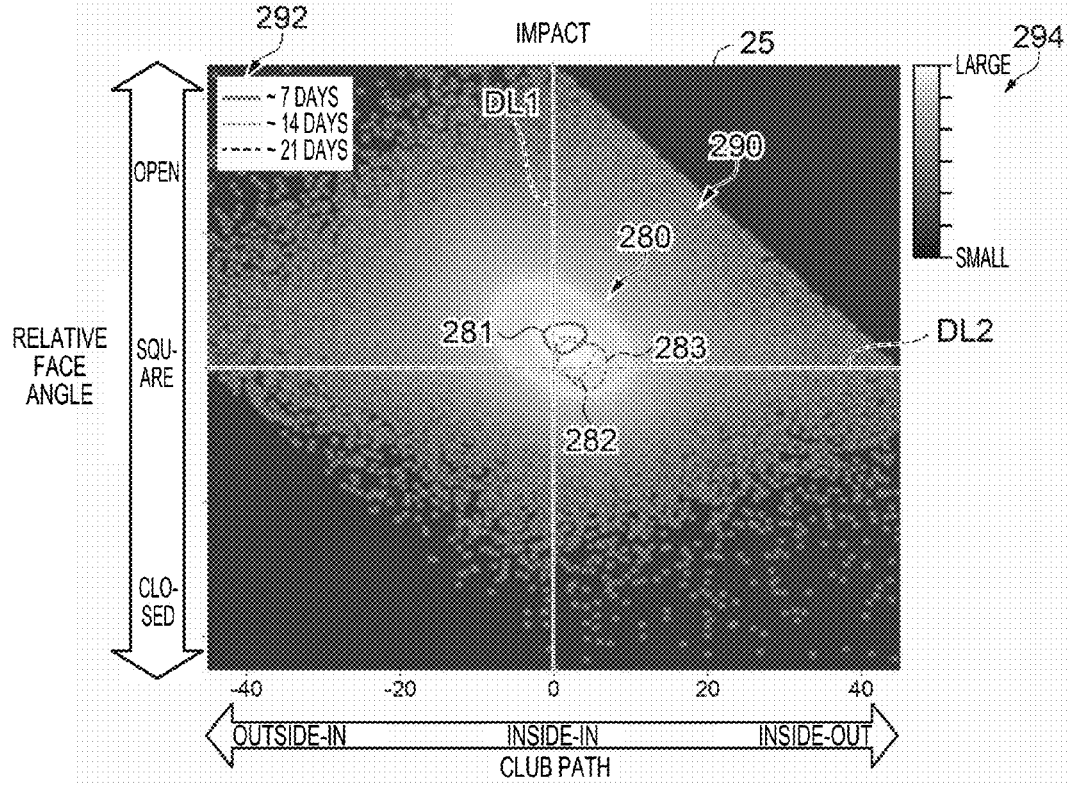

292
IMPACT
25
294
LARGE
SMALL
~ 7 DAYS
~ 14 DAYS
~ 21 DAYS
DL1
290
280
281
283
DL2
282
OPEN
SQU-ARE
CLO-SED
RELATIVE FACE ANGLE
-40
-20
0
20
40
OUTSIDE-IN
INSIDE-IN
INSIDE-OUT
CLUB PATH

FIG. 36

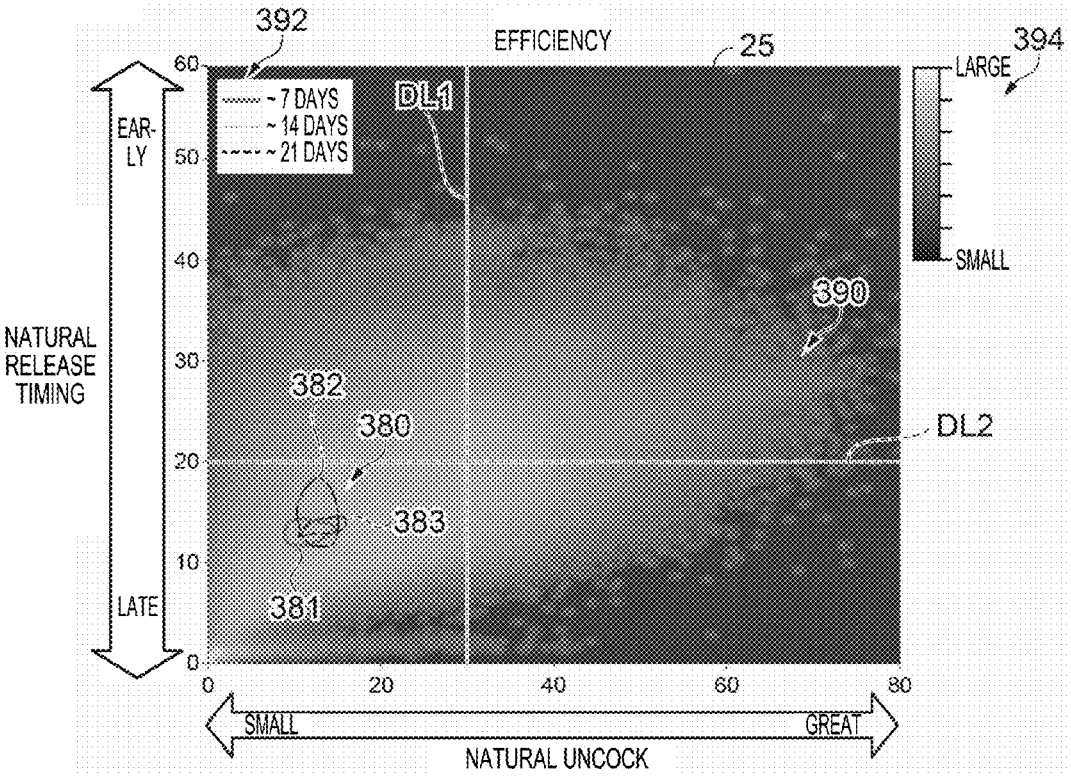

392
EFFICIENCY
25
394
LARGE
SMALL
~ 7 DAYS
~ 14 DAYS
~ 21 DAYS
DL1
390
382
380
383
381
DL2
EAR-LY
LATE
NATURAL RELEASE TIMING
60
50
40
30
20
10
0
0
20
40
60
80
SMALL
GREAT
NATURAL UNCOCK

FIG. 37

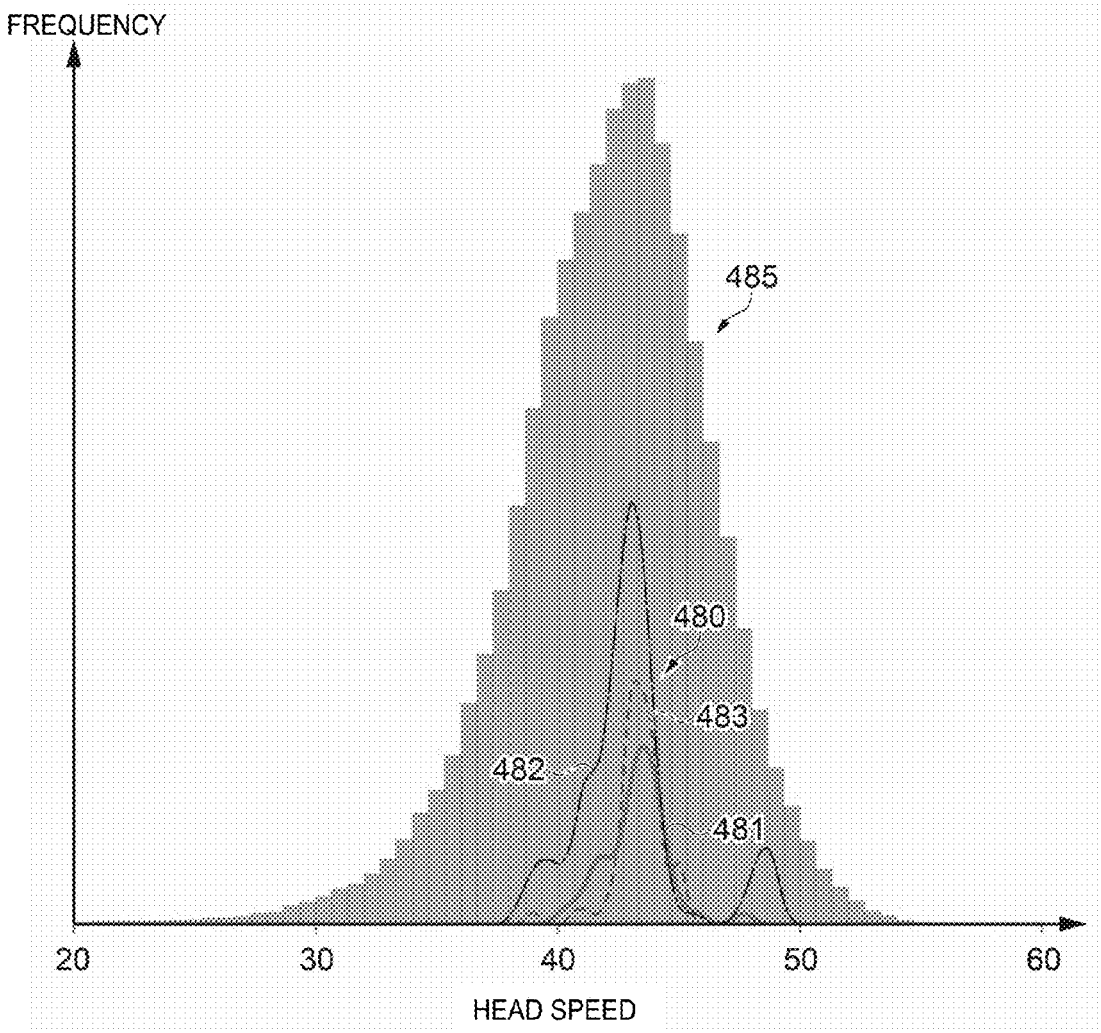


FIG. 38

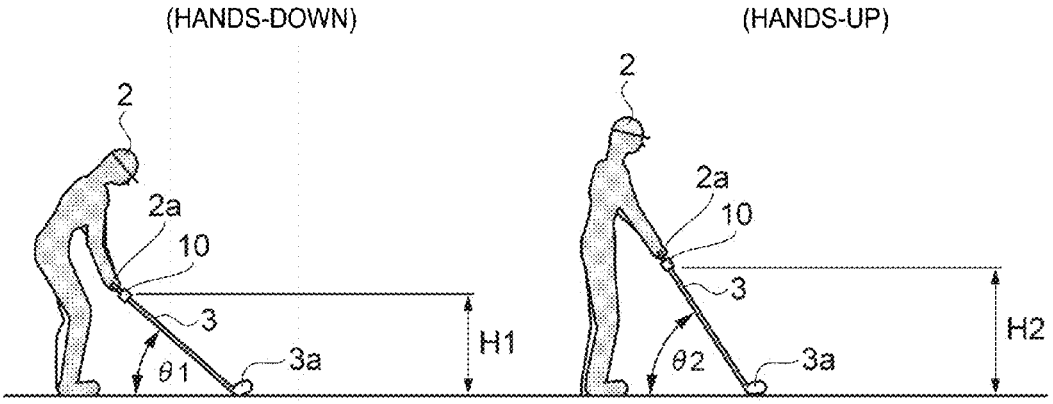


FIG. 39A

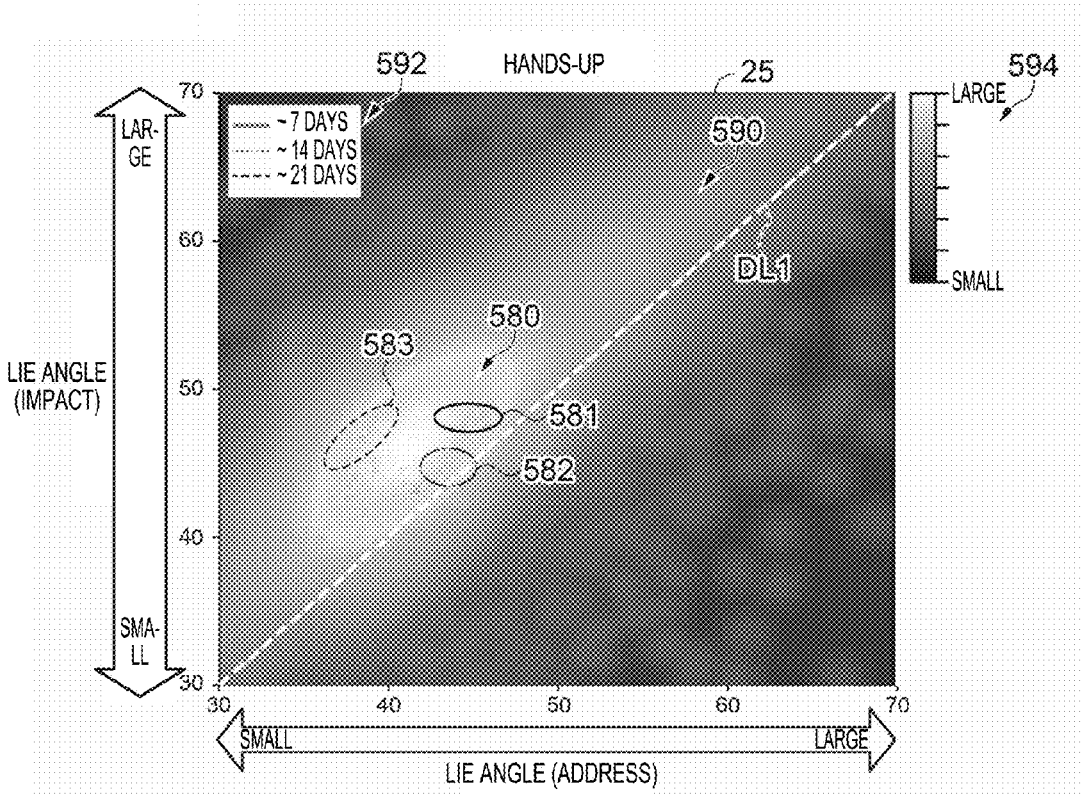


FIG. 39B

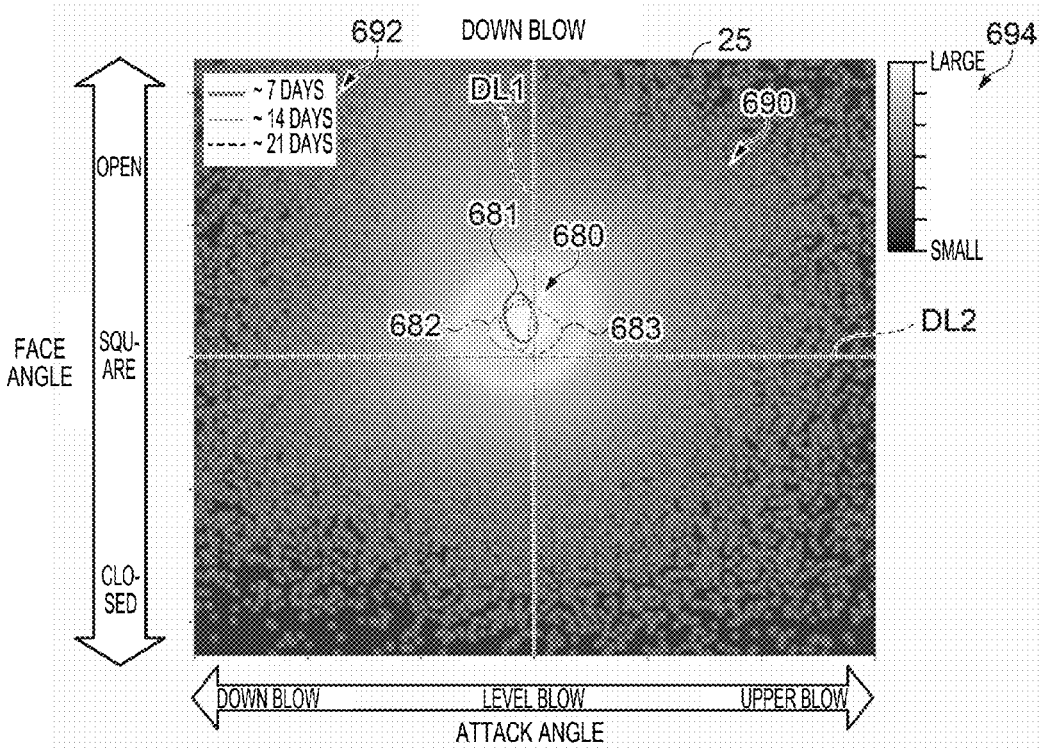

692
DOWN BLOW
25
694
LARGE
~ 7 DAYS
~ 14 DAYS
~ 21 DAYS
DL1
690
681
680
682
683
DL2
SMALL
OPEN
FACE ANGLE
SQU-ARE
CLO-SED
DOWN BLOW
LEVEL BLOW
UPPER BLOW
ATTACK ANGLE

FIG. 40

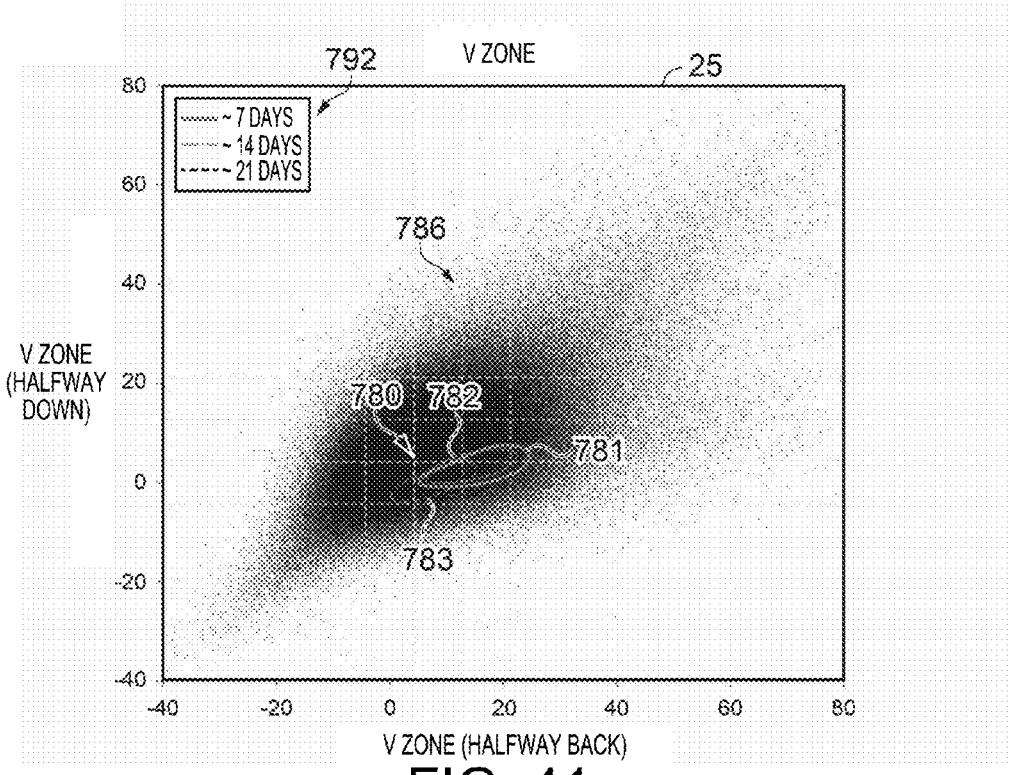

792
V ZONE
25
~ 7 DAYS
~ 14 DAYS
~ 21 DAYS
786
780
782
781
783
V ZONE (HALFWAY DOWN)
80
60
40
20
0
-20
-40
-40
-20
0
20
40
60
80
V ZONE (HALFWAY BACK)

FIG. 41

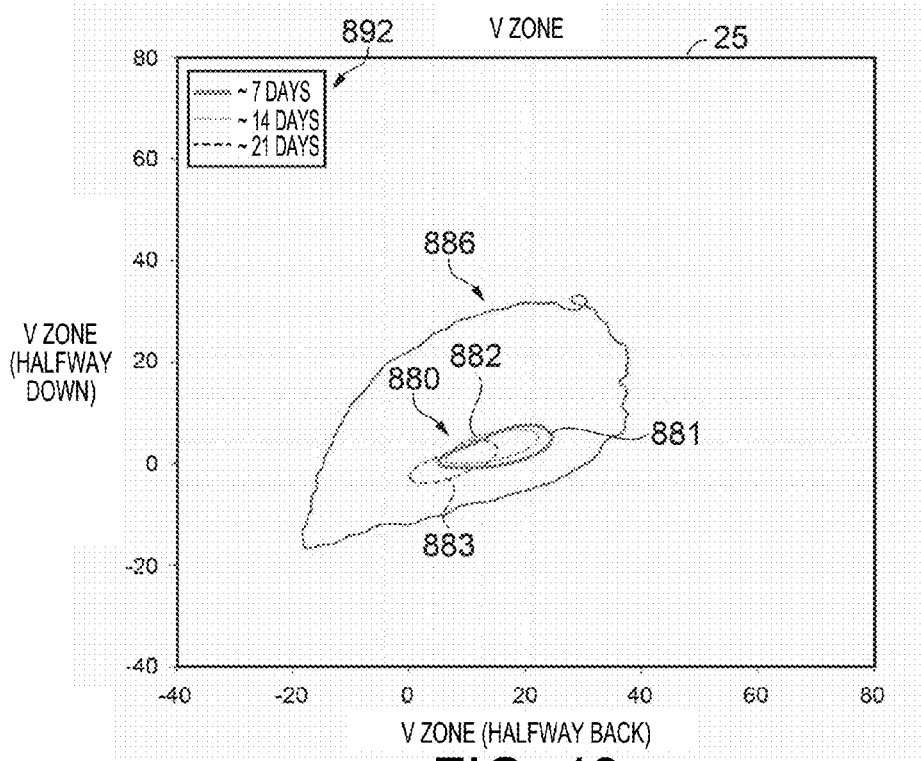

892
V ZONE
25
~ 7 DAYS
~ 14 DAYS
~ 21 DAYS
886
882
880
881
883
V ZONE (HALFWAY DOWN)
V ZONE (HALFWAY BACK)
80
60
40
20
0
-20
-40
-40
-20
0
20
40
60
80

FIG. 42

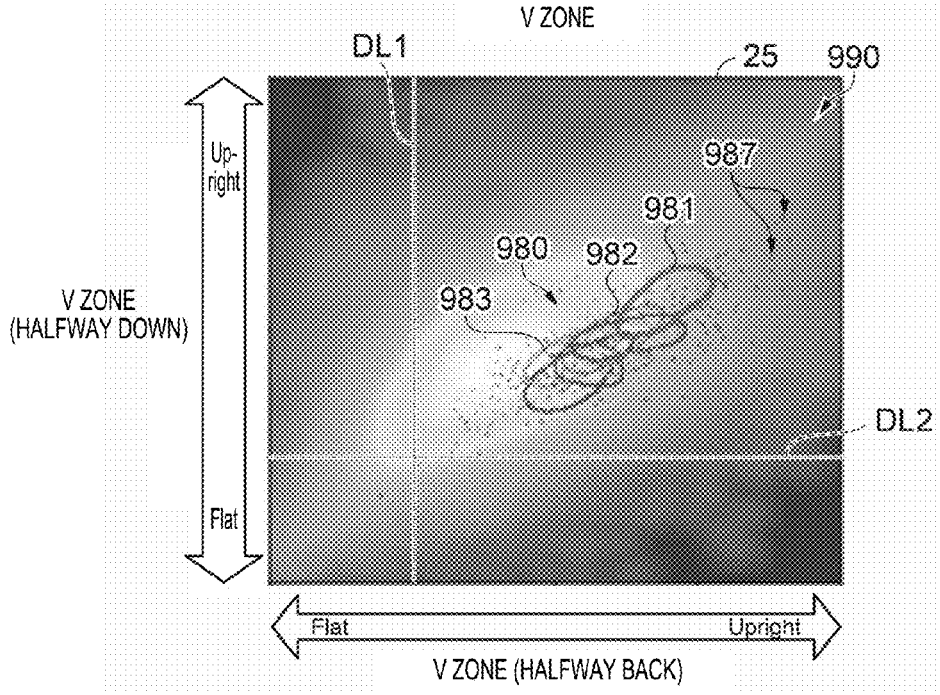

V ZONE
DL1
25
990
987
981
980
982
983
DL2
Up-right
Flat
V ZONE (HALFWAY DOWN)
Flat
Upright
V ZONE (HALFWAY BACK)

FIG. 43

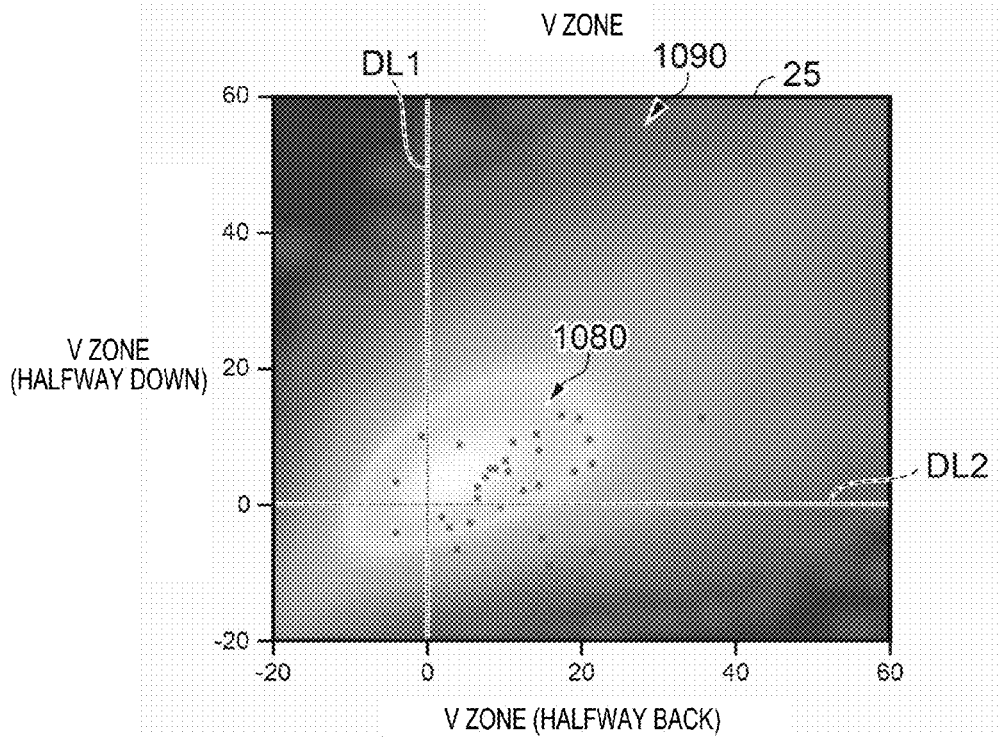


FIG. 44A

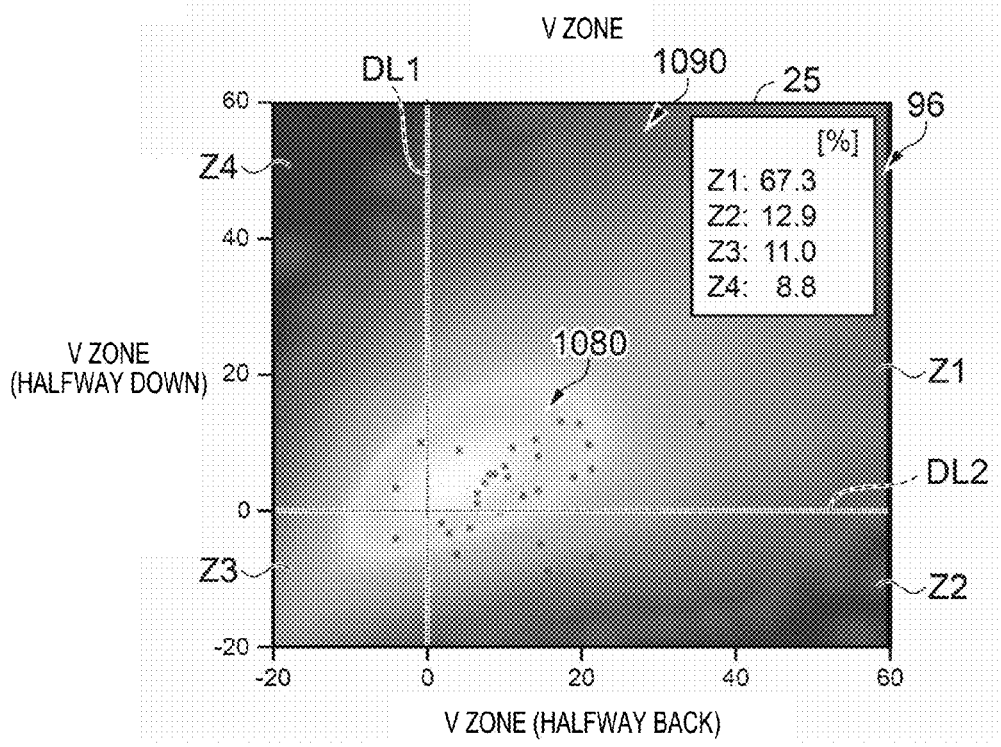


FIG. 44B

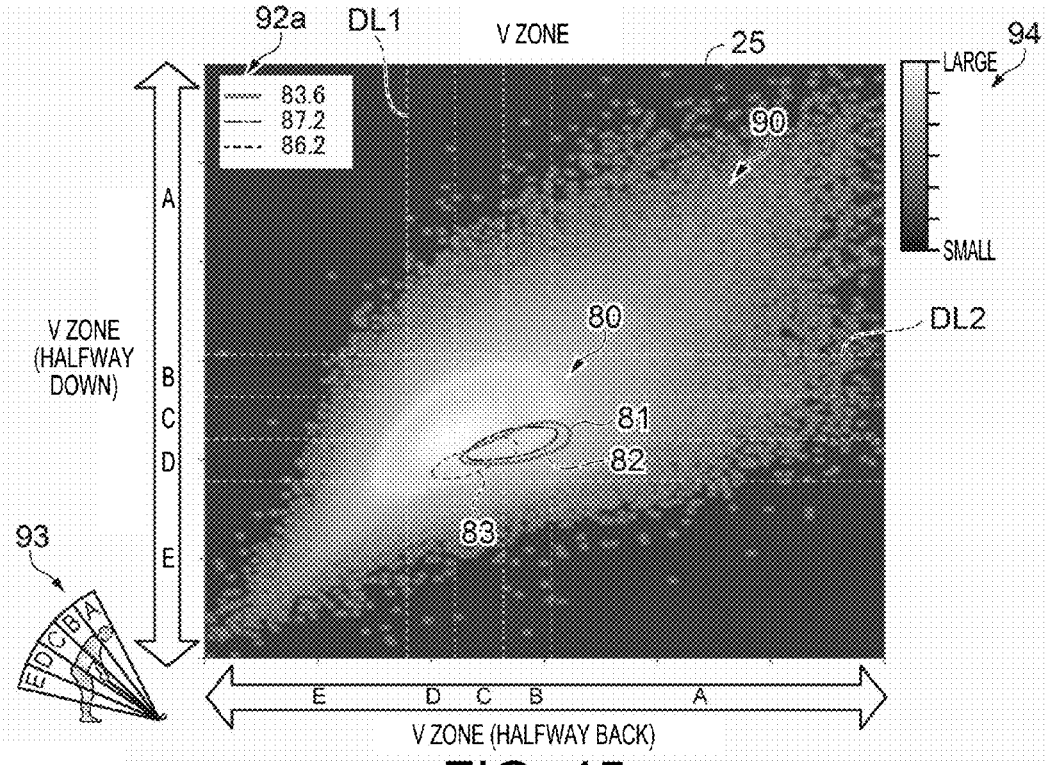

92a
DL1
V ZONE
25
94
LARGE
SMALL
83.6
87.2
86.2
90
80
DL2
81
82
83
V ZONE (HALFWAY DOWN)
A
B
C
D
E
93
E D C B A
V ZONE (HALFWAY BACK)

FIG. 45

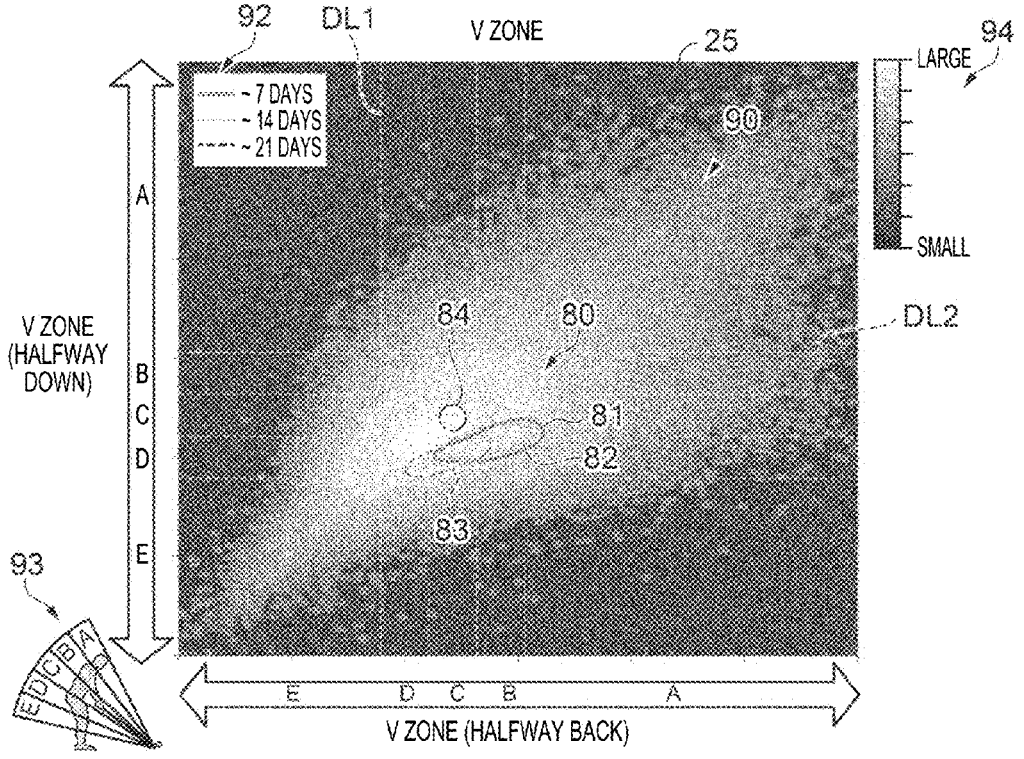

92
DL1
V ZONE
25
94
LARGE
SMALL
~ 7 DAYS
~ 14 DAYS
~ 21 DAYS
90
84
80
DL2
81
82
83
V ZONE (HALFWAY DOWN)
A
B
C
D
E
93
E D C B A
V ZONE (HALFWAY BACK)

FIG. 46

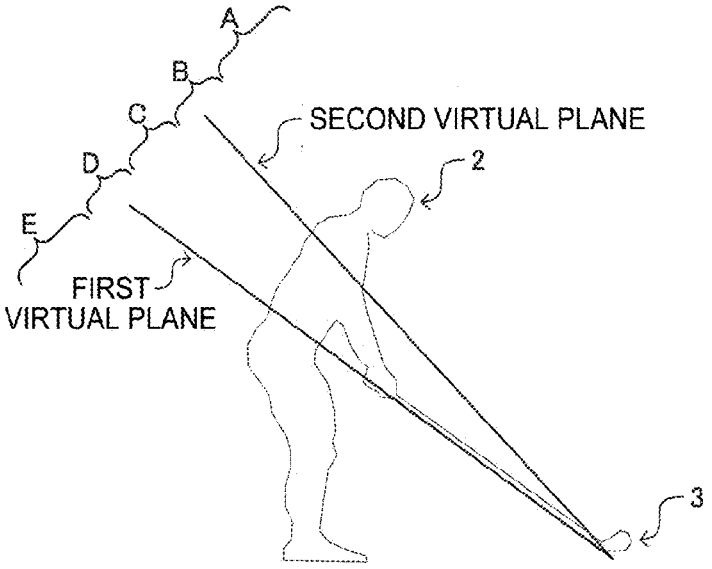


FIG. 47A

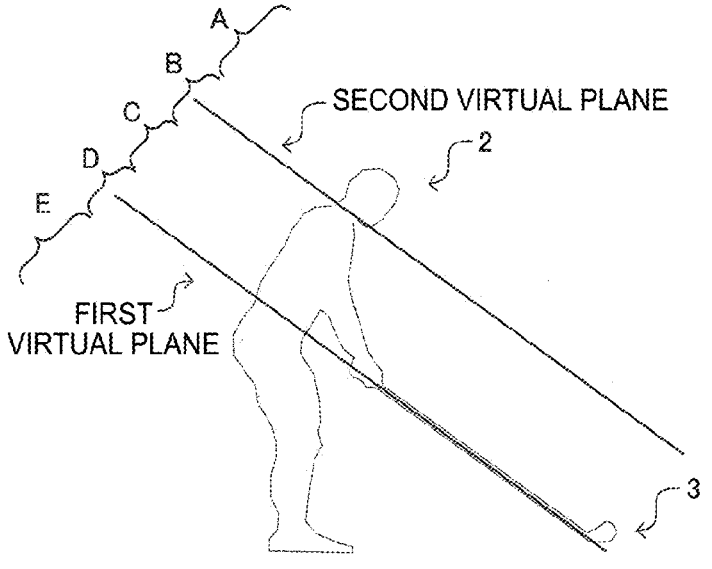


FIG. 47B

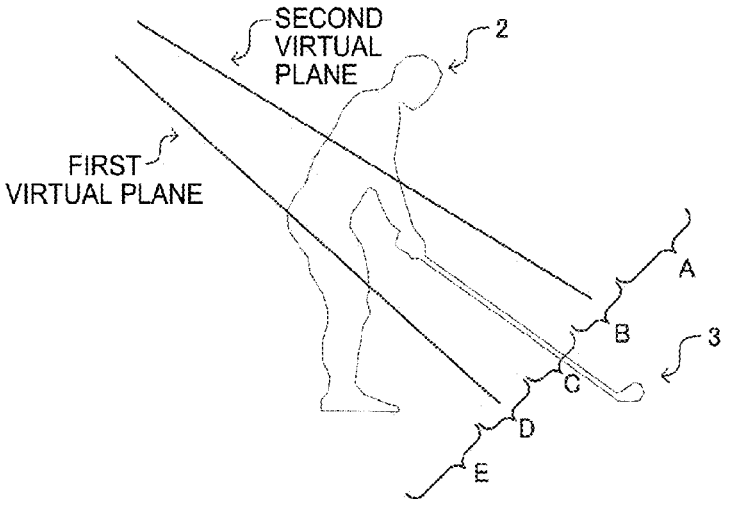


FIG. 47C

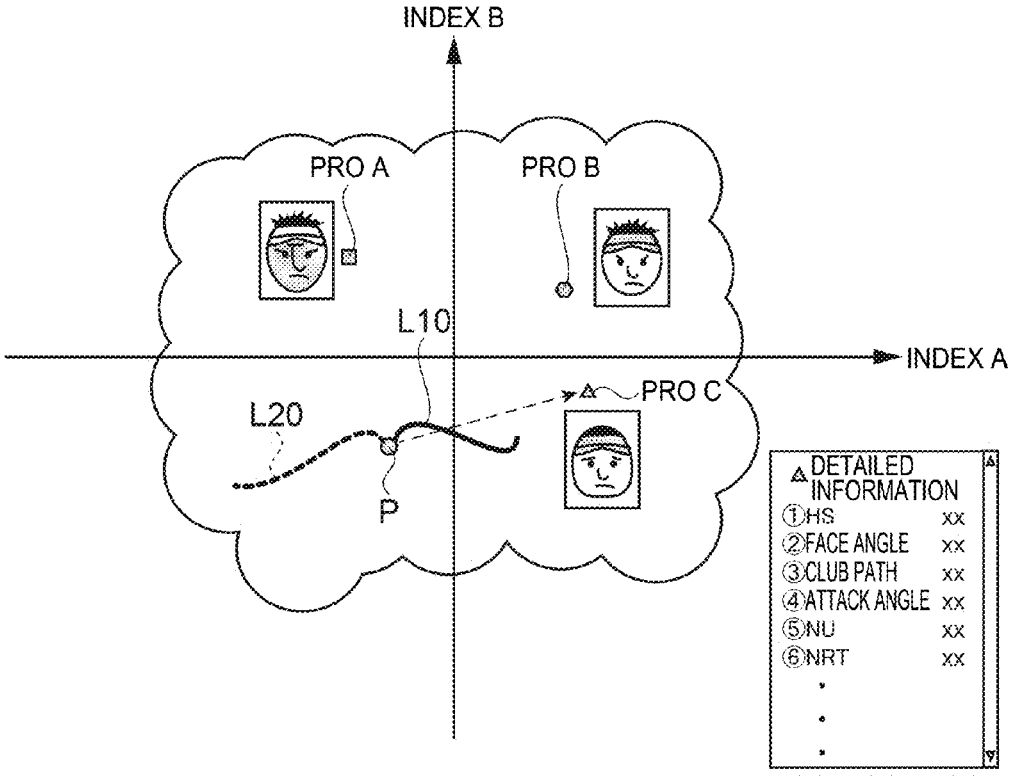


FIG. 48

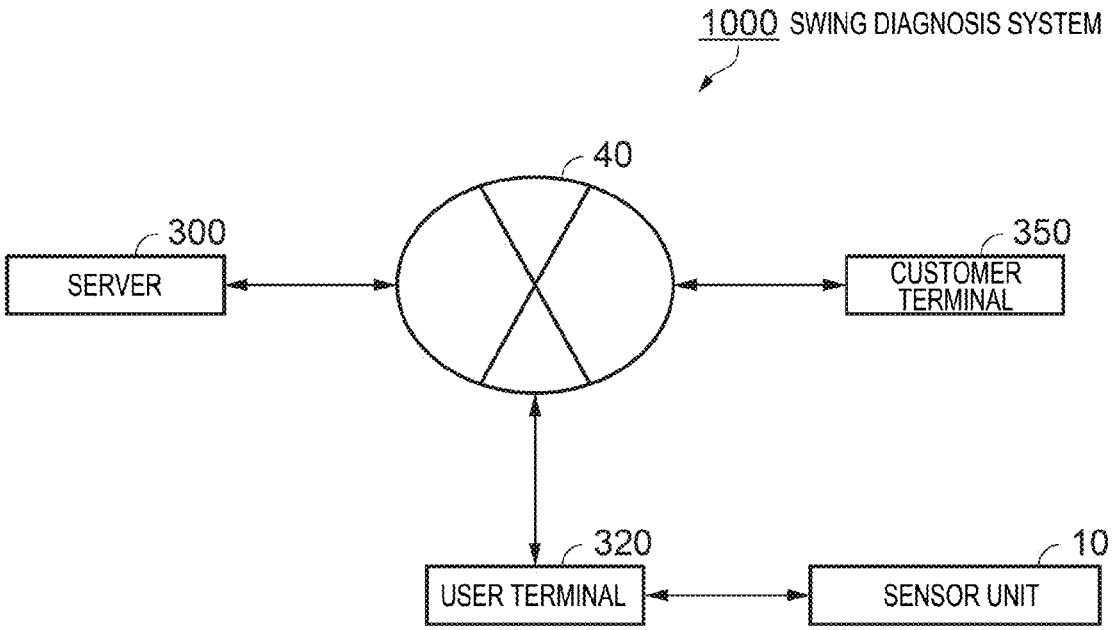
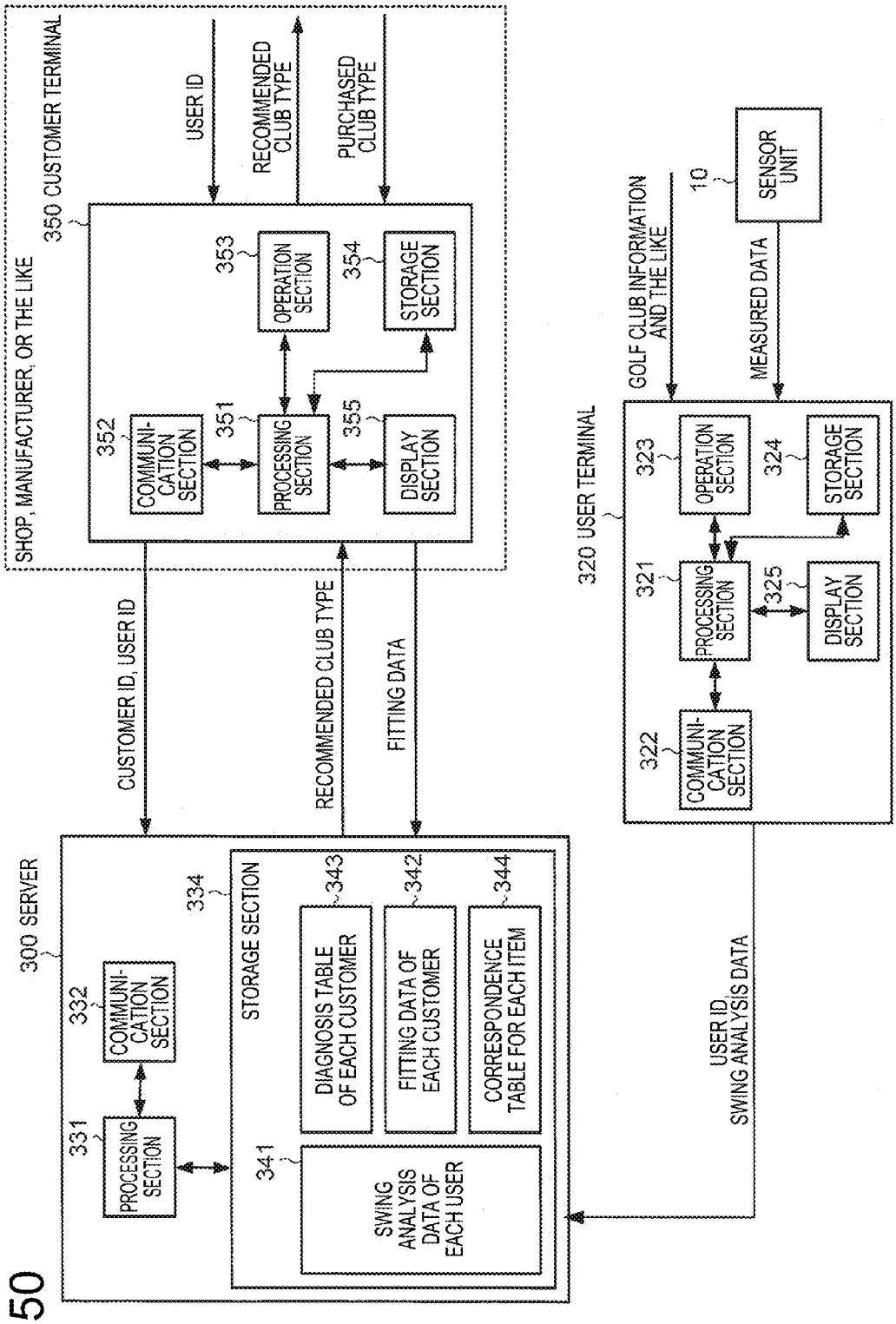

1000 SWING DIAGNOSIS SYSTEM
40
300
SERVER
350
CUSTOMER TERMINAL
320
USER TERMINAL
10
SENSOR UNIT

FIG. 49

FIG. 50


300 SERVER
331
PROCESSING SECTION
332
COMMUNI-CATION SECTION
334
STORAGE SECTION
341
SWING ANALYSIS DATA OF EACH USER
343
DIAGNOSIS TABLE OF EACH CUSTOMER
342
FITTING DATA OF EACH CUSTOMER
344
CORRESPONDENCE TABLE FOR EACH ITEM
SHOP, MANUFACTURER, OR THE LIKE
350 CUSTOMER TERMINAL
352
COMMUNI-CATION SECTION
351
PROCESSING SECTION
355
DISPLAY SECTION
353
OPERATION SECTION
354
STORAGE SECTION
USER ID
RECOMMENDED CLUB TYPE
PURCHASED CLUB TYPE
CUSTOMER ID, USER ID
RECOMMENDED CLUB TYPE
FITTING DATA
320 USER TERMINAL
322
COMMUNI-CATION SECTION
321
PROCESSING SECTION
325
DISPLAY SECTION
323
OPERATION SECTION
324
STORAGE SECTION
GOLF CLUB INFORMATION AND THE LIKE
MEASURED DATA
10
SENSOR UNIT
USER ID, SWING ANALYSIS DATA

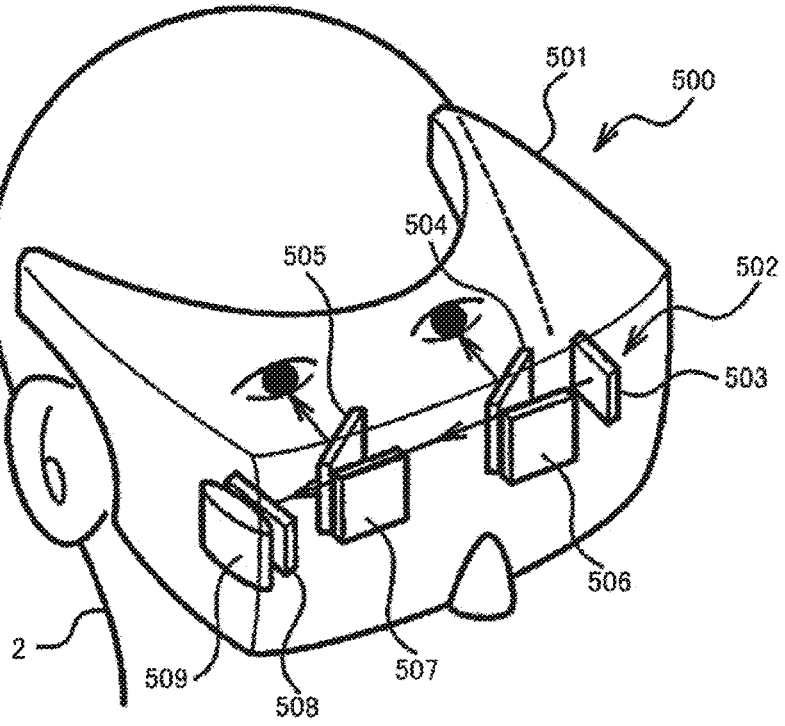

501
500
504
505
502
503
506
2
509
508
507

FIG. 51

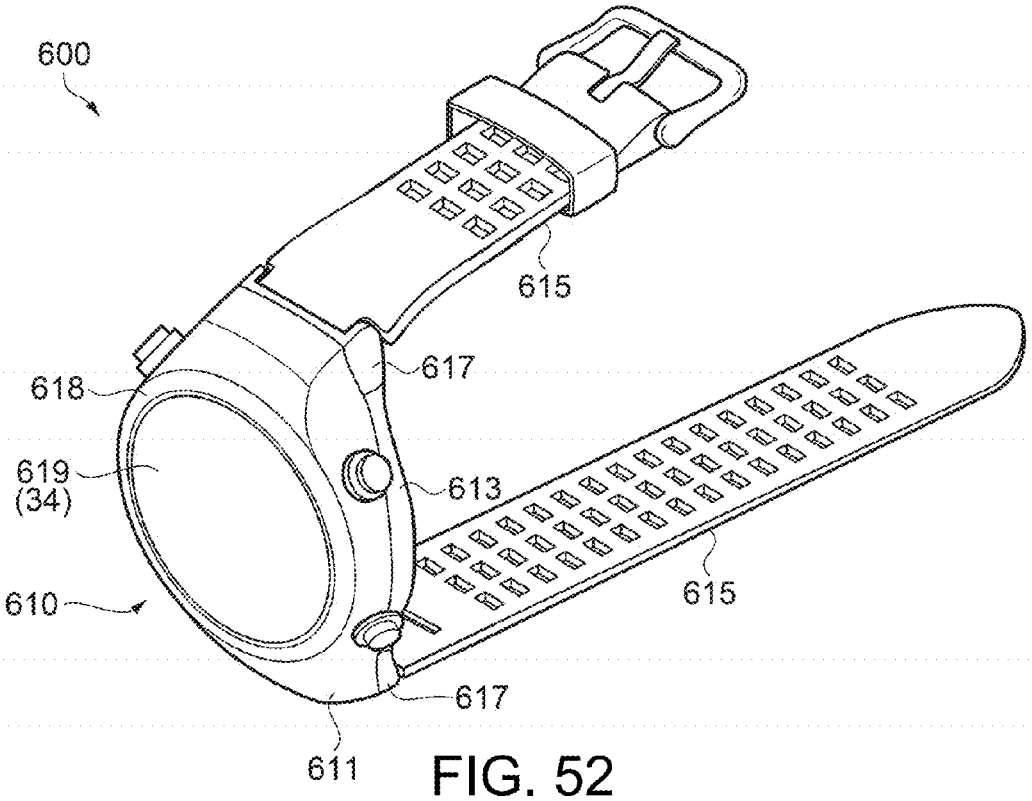

600
615
617
618
619
(34)
613
610
615
617
611

FIG. 52

DISPLAY METHOD, SWING ANALYSIS APPARATUS, SWING ANALYSIS SYSTEM, SWING ANALYSIS PROGRAM, AND RECORDING MEDIUM

BACKGROUND

1. Technical Field

[0001] The present invention relates to a display method, a swing analysis apparatus, a swing analysis system, a swing analysis program, and a recording medium.

2. Related Art

[0002] In the related art, there is a technique in which a swing trajectory of a golf club, a racket, or a bat as an exercise appliance in sports such as golf, tennis, or baseball is analyzed, and an athletic ability of a player is enhanced by improving a swing trajectory. As an example of such a technique, for example, JP-A-2015-123206 discloses a technique in which a swing is imaged with a video camera, and analysis is performed by using captured moving images. For example, JP-A-2014-64125 discloses a technique in which a swing is analyzed on the basis of multi-motion images obtained by superimposing and combining a plurality of continuously captured images of the swing. For example, JP-A-2014-100341 discloses a technique in which an impact timing, that is, a ball hitting timing during a swing is detected by using a motion sensor, and then the swing is analyzed.

[0003] However, in the techniques disclosed in JP-A-2015-123206 and JP-A-2014-64125, a size of a device capturing moving images or consecutive images (multi-motion images) is large, and thus there is a problem in that it is hard for a user to easily measure a swing. On the other hand, in the technique disclosed in JP-A-2014-100341, swing analysis can be easily performed by using a motion sensor attached to an exercise appliance (golf club), but there is a problem in that it is hard for a user to objectively recognize variations in a plurality of swings.

SUMMARY

[0004] An advantage of some aspects of the invention is to solve at least a part of the problems described above, and the invention can be implemented as the following forms or application examples.

Application Example 1

[0005] A display method according to this application example includes generating first analysis information on the basis of a plurality of pieces of data related to a plurality of swings, output from an inertial sensor which is attached to a user or an exercise appliance swung by the user and measures the plurality of swings performed by the user; generating a first region image including a plurality of time-series region images on the basis of the first analysis information; and displaying the plurality of time-series region images in a coordinate system having at least two indexes as axes.

[0006] According to the display method of this application example, a first region image including a plurality of time-series region images is generated on the basis of first analysis information which is generated on the basis of a plurality of pieces of data related to a plurality of swings, and the plurality of time-series region images are displayed in a coordinate system having at least two indexes as axes. Since such display is performed, the user can visually recognize transition of the first analysis information related to a plurality of swings as the plurality of time-series region images. Consequently, the user can objectively recognize the extent of the present ability (level) of the user related to a plurality of swings in addition to a variation.

Application Example 2

[0007] In the display method of the application example, it is preferable that a display aspect differs for each of the time-series region images.

[0008] According to this application example, since the respective time-series region images are displayed in different display aspects (for example, colors or the types of lines) in the first region image, the user can easily identify a transition state from the past to the present with respect to the ability (level) related to a plurality of swings.

Application Example 3

[0009] In the display method of the application example, it is preferable that an area of each of the time-series region images is the magnitude corresponding to variations between the plurality of pieces of data related to the plurality of swings.

[0010] According to this application example, the user can easily and objectively recognize variations between a plurality of pieces of data related to a plurality of swings.

Application Example 4

[0011] In the display method of the application example, it is preferable that a predetermined target region is displayed in the coordinate system.

[0012] According to this application example, since the predetermined target region is displayed in the coordinate system, the user can objectively recognize to what extent there is a gap with the target related to a swing, or to what extent the present ability (level) is improved with respect to the target in addition to a variation.

Application Example 5

[0013] In the display method of the application example, it is preferable that a second region image corresponding to the first region image in relation to a plurality of swings performed by another user who is different from the user is displayed in the coordinate system along with the first region image.

[0014] According to this application example, since the second region image corresponding to the first region image in relation to a plurality of swings performed by another user who is different from the user is displayed in the coordinate system, the user can perform comparison with the second region image related to swings performed by another person, and can thus perform more objective evaluation.

Application Example 6

[0015] In the display method of the application example, it is preferable that the coordinate system is divided into a plurality of regions, and a proportion of the second region image occupying each of the plurality of separate regions is displayed.

[0016] According to this application example, the second region image corresponding to the first region image in relation to a plurality of swings performed by another user who is different from the user, included in each of the regions into which the coordinate system is divided, is displayed, and thus the user can understand a swing state of another person (another user). The user can objectively recognize biasing or the like in analysis results of a plurality of swings performed by the user while performing comparison with swings performed by another person.

Application Example 7

[0017] In the display method of the application example, it is preferable that the coordinate system is divided into a plurality of regions, and a proportion of the first region image occupying each of the plurality of separate regions is displayed.

[0018] According to this application example, since a proportion of the first region image related to respective swings, included in each of the separate regions into which the coordinate system is divided, that is, a proportion of each swing is displayed, the user can objectively recognize biasing or the like in analysis results of a plurality of swings.

Application Example 8

[0019] In the display method of the application example, it is preferable that the first analysis information includes information related to at least one of impact, a V zone, efficiency, rotation, a head speed, hands-up, and a down blow.

[0020] According to this application example, the user can obtain information related to at least one of impact, a V zone, efficiency, rotation, a head speed, hands-up, and a down blow as detailed analysis data of an important index indicating ability (level) regarding a plurality of swings. Consequently, the user can more efficiently understand swing ability (level).

Application Example 9

[0021] In the display method of the application example, it is preferable that diagnosis information is displayed on the basis of the first region image.

[0022] According to this application example, since diagnosis information based on the first region image is displayed, the user can easily understand a swing state, and can thus take appropriate measures to improve a swing.

Application Example 10

[0023] In the display method of the application example, it is preferable that a practice method is displayed on the basis of the diagnosis information.

[0024] According to this application example, a practice method based on diagnosis information is displayed, and thus the user can perform an efficient practice.

Application Example 11

[0025] A swing analysis apparatus according to this application example includes an analysis section that generates first analysis information on the basis of a plurality of pieces of data related to a plurality of swings, output from an inertial sensor which is attached to a user or an exercise appliance swung by the user and measures the plurality of swings performed by the user; a processing section that generates a first region image including a plurality of time-series region images on the basis of the first analysis information; and a display section that displays the plurality of time-series region images in a coordinate system having at least two indexes as axes.

[0026] According to the swing analysis apparatus of this application example, the processing section generates a first region image including a plurality of time-series region images on the basis of first analysis information which is generated by the analysis section on the basis of a plurality of pieces of data related to a plurality of swings. The display section displays the plurality of time-series region images in a coordinate system having at least two indexes as axes. Since such display is performed, the user can visually recognize transition of the first analysis information related to a plurality of swings as the plurality of time-series region images. Consequently, the user can objectively recognize the extent of the present ability (level) of the user related to a plurality of swings in addition to a variation.

Application Example 12

[0027] In the swing analysis apparatus of the application example, it is preferable that a display aspect differs for each of the time-series region images.

[0028] According to this application example, since the respective time-series region images are displayed in different display aspects (for example, colors or the types of lines) in the first region image, the user can easily identify a transition state from the past to the present with respect to the ability (level) related to a plurality of swings.

Application Example 13

[0029] In the swing analysis apparatus of the application example, it is preferable that an area of each of the time-series region images is the magnitude corresponding to variations between the plurality of pieces of data related to the plurality of swings.

[0030] According to this application example, the user can easily and objectively recognize variations between a plurality of pieces of data related to a plurality of swings.

Application Example 14

[0031] In the swing analysis apparatus of the application example, it is preferable that a predetermined target region is displayed in the coordinate system.

[0032] According to this application example, since the predetermined target region is displayed in the coordinate system, the user can objectively recognize to what extent there is a gap with the target related to a swing, or to what extent the present ability (level) is improved with respect to the target in addition to a variation.

Application Example 15

[0033] In the swing analysis apparatus of the application example, it is preferable that a second region image corresponding to the first region image in relation to a plurality of swings performed by another user who is different from the user is displayed in the coordinate system along with the first region image.

[0034] According to this application example, since the second region image corresponding to the first region image in relation to a plurality of swings performed by another user

who is different from the user is displayed in the coordinate system, the user can perform comparison with the second region image related to swings performed by another person, and can thus perform more objective evaluation.

Application Example 16

[0035] In the swing analysis apparatus of the application example, it is preferable that the coordinate system is divided into a plurality of regions, and a proportion of the second region image occupying each of the plurality of separate regions is displayed.

[0036] According to this application example, the second region image corresponding to the first region image in relation to a plurality of swings performed by another user who is different from the user, included in each of the regions into which the coordinate system is divided, is displayed, and thus the user can understand a swing state of another person (another user). The user can objectively recognize biasing or the like in analysis results of a plurality of swings performed by the user while performing comparison with swings performed by another person.

Application Example 17

[0037] In the swing analysis apparatus of the application example, it is preferable that the coordinate system is divided into a plurality of regions, and a proportion of the first region image occupying each of the plurality of separate regions is displayed.

[0038] According to this application example, since a proportion of the first region image related to respective swings, included in each of the separate regions into which the coordinate system is divided, that is, a proportion of each swing is displayed, the user can objectively recognize biasing or the like in analysis results of a plurality of swings.

Application Example 18

[0039] In the swing analysis apparatus of the application example, it is preferable that the first analysis information includes information related to at least one of impact, a V zone, efficiency, rotation, a head speed, hands-up, and a down blow.

[0040] According to this application example, the user can obtain information related to at least one of impact, a V zone, efficiency, rotation, a head speed, hands-up, and a down blow as detailed analysis data of an important index indicating ability (level) regarding a plurality of swings. Consequently, the user can more efficiently understand swing ability (level).

Application Example 19

[0041] In the swing analysis apparatus of the application example, it is preferable that diagnosis information is displayed on the basis of the first region image.

[0042] According to this application example, since diagnosis information based on the first region image is displayed, the user can easily understand a swing state, and can thus take appropriate measures to improve a swing.

Application Example 20

[0043] In the swing analysis apparatus of the application example, it is preferable that a practice method is displayed on the basis of the diagnosis information.

[0044] According to this application example, a practice method based on diagnosis information is displayed, and thus the user can perform an efficient practice.

Application Example 21

[0045] A swing analysis system according to this application example includes the swing analysis apparatus according to any one of the application examples; and an inertial sensor.

[0046] According to the swing analysis system of this application example, the processing section generates a first region image including a plurality of time-series region images on the basis of first analysis information which is generated by the analysis section on the basis of a plurality of pieces of data related to a plurality of swings, output from an inertial sensor. The display section displays the plurality of time-series region images in a coordinate system having at least two indexes as axes. Since such display is performed, the user can visually recognize transition of the first analysis information related to a plurality of swings as the plurality of time-series region images. Consequently, the user can specifically and objectively recognize and check the extent of the present ability (level) of the user related to a plurality of swings in addition to a variation. Therefore, the user can perform an efficient practice by using the swing analysis system.

Application Example 22

[0047] An swing analysis program according to this application example causes a computer to execute generating first analysis information on the basis of a plurality of pieces of data related to a plurality of swings, output from an inertial sensor which is attached to a user or an exercise appliance swung by the user and measures the plurality of swings performed by the user; generating a first region image including a plurality of time-series region images on the basis of the first analysis information; and displaying the plurality of time-series region images together in a coordinate system having at least two indexes as axes.

[0048] According to the swing analysis program of this application example, a first region image including a plurality of time-series region images is generated on the basis of first analysis information which is generated on the basis of a plurality of pieces of data related to a plurality of swings, and the plurality of time-series region images are displayed together in a coordinate system having at least two indexes as axes. Since such display is performed, the user can visually recognize transition of the first analysis information related to a plurality of swings as the plurality of time-series region images. Consequently, the user can specifically and objectively recognize the extent of the present ability (level) of the user related to a plurality of swings in addition to a variation.

Application Example 23

[0049] A recording medium according to this application example records a program causing a computer to execute generating first analysis information on the basis of a plurality of pieces of data related to a plurality of swings, output from an inertial sensor which is attached to a user or an exercise appliance swung by the user and measures the plurality of swings performed by the user; generating a first region image including a plurality of time-series region

images on the basis of the first analysis information; and displaying the plurality of time-series region images together in a coordinate system having at least two indexes as axes.

[0050] According to the recording medium of this application example, by executing a computer on the basis of the recorded program, a first region image including a plurality of time-series region images is generated on the basis of first analysis information which is generated on the basis of a plurality of pieces of data related to a plurality of swings, and the plurality of time-series region images are displayed together in a coordinate system having at least two indexes as axes. Since such display is performed, the user can visually recognize transition of the first analysis information related to a plurality of swings as the plurality of time-series region images. Consequently, the user can objectively recognize the extent of the present ability (level) of the user related to a plurality of swings in addition to a variation.

BRIEF DESCRIPTION OF THE DRAWINGS

[0051] The invention will be described with reference to the accompanying drawings, wherein like numbers reference like elements.

[0052] FIG. **1** is a diagram illustrating a configuration example of a motion analysis system of the present embodiment.

[0053] FIG. **2** is a diagram illustrating a sensor unit and a swing analysis apparatus.

[0054] FIG. **3** is a diagram illustrating examples of a position at which and a direction in which the sensor unit is attached.

[0055] FIG. **4** is a diagram illustrating procedures of actions performed by a user until the user hits a ball.

[0056] FIG. **5** is a diagram illustrating an example of an input screen of physical information and golf club information.

[0057] FIG. **6** is a diagram illustrating a swing action.

[0058] FIG. **7** is a diagram illustrating an example of a selection screen of swing analysis data.

[0059] FIG. **8** is a diagram illustrating an example of an editing screen of input data which is a swing diagnosis target.

[0060] FIG. **9** is a diagram illustrating an example of a swing diagnosis screen.

[0061] FIG. **10** is a diagram illustrating configuration examples of the sensor unit and a swing analysis apparatus.

[0062] FIG. **11** is a plan view in which a golf club and the sensor unit are viewed from a negative side of an X axis during standing still of the user.

[0063] FIG. **12** is a graph illustrating examples of temporal changes of three-axis angular velocities.

[0064] FIG. **13** is a graph illustrating a temporal change of a combined value of the three-axis angular velocities.

[0065] FIG. **14** is a graph illustrating a temporal change of a derivative of the combined value.

[0066] FIG. **15** is a diagram illustrating a shaft plane and a Hogan plane.

[0067] FIG. **16** is a view in which a sectional view of the shaft plane which is cut in a YZ plane is viewed from the negative side of the X axis.

[0068] FIG. **17** is a view in which a sectional view of the Hogan plane which is cut in the YZ plane is viewed from the negative side of the X axis.

[0069] FIG. **18** is a diagram for explaining a face angle and a club path (incidence angle).

[0070] FIG. **19** is a diagram illustrating an example of a temporal change of a shaft axis rotation angle from swing starting (backswing starting) to impact.

[0071] FIG. **20** is a diagram illustrating an example of a temporal change of a speed of a grip in a downswing.

[0072] FIG. **21** is a diagram for explaining definition of an attack angle (first angle) of a ball hitting portion at impact.

[0073] FIG. **22** is a flowchart illustrating examples of procedures of a swing analysis process (swing analysis method).

[0074] FIG. **23** is a diagram illustrating a configuration example of a swing diagnosis apparatus.

[0075] FIG. **24**A is a diagram illustrating relationships among the shaft plane and the Hogan plane, and a plurality of regions.

[0076] FIG. **24**B is a diagram schematically illustrating an example of the shaft plane, the Hogan plane, and a user's attitude.

[0077] FIG. **25** is a diagram illustrating an example of a V zone score table.

[0078] FIG. **26** is a diagram illustrating an example of a rotation score table.

[0079] FIG. **27** is a diagram illustrating an example of an impact score table.

[0080] FIG. **28** is a diagram illustrating an example of a down blow score table.

[0081] FIG. **29** is a diagram illustrating an example of an upper blow score table.

[0082] FIG. **30** is a diagram illustrating an example of a swing efficiency score table.

[0083] FIG. **31** is a flowchart illustrating examples of procedures of a process performed by the swing analysis apparatus in relation to a swing diagnosis process.

[0084] FIG. **32** is a flowchart illustrating examples of procedures of the swing diagnosis process (swing diagnosis method).

[0085] FIG. **33** is a flowchart illustrating examples of procedures of a process of calculating scores and a total score of a plurality of items.

[0086] FIG. **34** is a diagram illustrating a display example (V zone) including a first region image (time-series region images).

[0087] FIG. **35** is a diagram illustrating a display example (rotation) including a first region image (time-series region images).

[0088] FIG. **36** is a diagram illustrating a display example (impact) including a first region image (time-series region images).

[0089] FIG. **37** is a diagram illustrating a display example (efficiency) including a first region image (time-series region images).

[0090] FIG. **38** is a diagram illustrating a display example (head speed) including a first region image (time-series region images).

[0091] FIG. **39**A is a diagram for explaining hands-up.

[0092] FIG. **39**B is a diagram illustrating a display example (hands-up) including a first region image (time-series region images).

[0093] FIG. **40** is a diagram illustrating a display example (down blow) including a first region image (time-series region images).

[0094] FIG. **41** is a diagram illustrating Modification Example 1 (V zone) related to a display method.

[0095] FIG. **42** is a diagram illustrating Modification Example 2 (V zone) related to a display method.

[0096] FIG. **43** is a diagram illustrating Modification Example 3 (V zone) related to a display method.

[0097] FIG. **44**A is a diagram illustrating Modification Example 4 (V zone) related to a display method.

[0098] FIG. **44**B is a diagram illustrating Modification Example 5 (V zone) related to a display method.

[0099] FIG. **45** is a diagram illustrating Modification Example 6 (V zone) related to a display method.

[0100] FIG. **46** is a diagram illustrating Modification Example 7 (V zone) related to a display method.

[0101] FIG. **47**A is a diagram for explaining a V zone (a first virtual plane and a second virtual plane).

[0102] FIG. **47**B is a diagram illustrating a modification example of the first virtual plane and the second virtual plane.

[0103] FIG. **47**C is a diagram illustrating another modification example of the first virtual plane and the second virtual plane.

[0104] FIG. **48** is a diagram illustrating Modification Example 8 related to another display method.

[0105] FIG. **49** is a diagram illustrating a configuration example of a motion analysis system related to a modification example.

[0106] FIG. **50** is a diagram illustrating an arrangement example of a sensor unit and a swing analysis apparatus related to a modification example.

[0107] FIG. **51** is a diagram illustrating an example in which the motion analysis apparatus is configured by using a head mounted display.

[0108] FIG. **52** is a diagram illustrating an example in which the motion analysis apparatus is configured by using a wrist type terminal.

DESCRIPTION OF EXEMPLARY EMBODIMENTS

[0109] Hereinafter, preferred embodiments of the invention will be described with reference to the drawings. The embodiments described below are not intended to improperly limit the content of the invention disclosed in the appended claims. In addition, all constituent elements described below are not essential constituent elements of the invention.

1. Motion Analysis System

1-1. Configuration of Motion Analysis System

[0110] Hereinafter, analysis of a golf swing will be described as an example of motion analysis. FIG. **1** is a diagram illustrating a configuration example of a motion analysis system of the present embodiment. As illustrated in FIG. **1**, a motion analysis system (swing analysis system) **1** of the present embodiment is configured to include a sensor unit (an example of an inertial sensor) **10**, and a swing analysis apparatus (an example of a motion analysis apparatus) **20**. Communication between the sensor unit **10** and the swing analysis apparatus **20** may be wireless communication, and may be wired communication. As illustrated in FIG. **2**, the swing analysis apparatus **20** is implemented by various information terminals (client terminals) including not only a personal computer **20***a*, but also a portable apparatus **20***b* such as a smart phone or a tablet PC, or a wearable terminal such as head mounted display (HMD) or a wrist apparatus.

[0111] The motion analysis system (swing analysis system) **1** may be configured to include a swing diagnosis apparatus **30** separately from the swing analysis apparatus **20**. However, the swing diagnosis apparatus **30** may be included in the swing analysis apparatus **20**. The swing diagnosis apparatus **30** may be implemented by a server which processes a request from the swing analysis apparatus **20**. The swing analysis apparatus **20** and the swing diagnosis apparatus **30** may be connected to each other via a network **40**. The network **40** may be a wide area network (WAN) such as the Internet, and may be a local area network (LAN). The swing analysis apparatus **20** and the swing diagnosis apparatus **30** may communicate with each other through, for example, near field communication or wired communication, without using the network **40**.

[0112] As illustrated in FIG. **2**, the sensor unit **10** can measure, for example, acceleration in each axial direction of three axes orthogonal to each other and, for example, angular velocity about each of the three axes orthogonal to each other, and is attached to, for example, a golf club **3** as an exercise appliance.

[0113] As illustrated in FIG. **3**, the sensor unit **10** is attached to the golf club **3** (an example of an exercise appliance) so as to match three detection axes (an x axis, a y axis, and a z axis) intersecting (ideally, orthogonal to) each other. In FIG. **3**, the sensor unit **10** is attached to a part of a shaft so that, for example, the y axis matches a longitudinal direction of the shaft of the golf club **3** (a longitudinal direction of the golf club **3**), and, for example, the x axis matches a target direction of a hit ball (target hitting direction). Preferably, the sensor unit **10** is attached to a position close to a grip to which impact during ball hitting is hardly forwarded and a centrifugal force is not applied during a swing. The shaft is a shaft portion other than a head (ball hitting portion) **3***a* of the golf club **3** and also includes the grip. However, the sensor unit **10** may be attached to a part (for example, the hand or a glove) of a user **2**, and may be attached to an accessory such as a wristwatch.

[0114] The user **2** performs a swing action for hitting a golf ball **4** or a swing action through a practice swing according to predefined procedures. FIG. **4** is a diagram illustrating procedures of actions performed by the user **2** until the user hits the ball. As illustrated in FIG. **4**, first, the user **2** performs an input operation of physical information of the user **2**, information (golf club information) regarding the golf club **3** used by the user **2**, and the like via the swing analysis apparatus **20** (step S**1**).

[0115] FIG. **5** is a diagram illustrating an example of an input screen of physical information and golf club information, displayed on a display section **25** (refer to FIG. **10**) of the swing analysis apparatus **20**. In step S**1** in FIG. **4**, the user **2** inputs physical information such as a height, sex, age, and country, and inputs golf club information such as a club length (a length of the shaft), and a club number on the input screen illustrated in FIG. **5**. Information included in the physical information is not limited thereto, and, the physical information may include, for example, at least one of information regarding a length of the arms and a length of the legs instead of or along with the height. Similarly, information included in the golf club information is not

limited thereto, and, for example, the golf club information may not include at least one of information regarding the club length and the club number, and may include other information.

[0116] Next, the user **2** performs a measurement starting operation (an operation for starting measurement in the sensor unit **10**) via the swing analysis apparatus **20** (step S**2**). After receiving a notification (for example, a notification using a voice) of giving an instruction for taking an address attitude (a basic attitude before starting a swing) from the swing analysis apparatus **20** (Y in step S**3**), the user **2** takes an address attitude so that the axis in the longitudinal direction of the shaft of the golf club **3** is perpendicular to a target line (target hit ball direction), and stands still (step S**4**). Next, the user **2** receives a notification (for example, a notification using a voice) of permitting a swing from the swing analysis apparatus **20** (Y in step S**5**), and then hits the golf ball **4** by performing a swing action (step S**6**). The present embodiment is not necessarily limited to ball hitting, and is also applicable to a practice swing, and may have a function of detecting a timing corresponding to ball hitting.

[0117] If the user **2** performs the measurement starting operation in step S**2** in FIG. **4**, the swing analysis apparatus **20** transmits a measurement starting command to the sensor unit **10**, and the sensor unit **10** receives the measurement starting command and starts measurement of three-axis accelerations and three-axis angular velocities. The sensor unit **10** measures three-axis accelerations and three-axis angular velocities in a predetermined cycle (for example, 1 ms), and sequentially transmits the measured data to the swing analysis apparatus **20**.

[0118] The swing analysis apparatus **20** notifies the user **2** of permission of swing starting, shown in step S**5** in FIG. **4**, and then analyzes the swing action (step S**6** in FIG. **4**) in which the user **2** has hit the ball by using the golf club **3** on the basis of measured data from the sensor unit **10**.

[0119] As illustrated in FIG. **6**, the swing action performed by the user **2** in step S**6** in FIG. **4** includes an action reaching impact (ball hitting) at which the golf ball **4** is hit from an address attitude (standing still state) through respective states of halfway back at which the shaft of the golf club **3** becomes horizontal during a backswing after starting a swing (backswing), a top at which the swing changes from the backswing to a downswing, and halfway down at which the shaft of the golf club **3** becomes horizontal during the downswing. The swing analysis apparatus **20** generates swing analysis data including information regarding a time point (date and time) at which the swing is performed, identification information or the sex of the user **2**, the type of golf club **3**, and an analysis result of the swing action, and transmits the swing analysis data to the swing diagnosis apparatus **30** via a network **40** (refer to FIG. **1**).

[0120] The swing diagnosis apparatus **30** receives the swing analysis data transmitted by the swing analysis apparatus **20** via the network **40**, and preserves the swing analysis data. Therefore, when the user **2** performs a swing action according to the procedures illustrated in FIG. **4**, the swing analysis data generated by the swing analysis apparatus **20** is preserved in the swing diagnosis apparatus **30**, and thus a swing analysis data list is built.

[0121] In the present embodiment, if the user **2** activates a swing diagnosis application via an operation section **23** (refer to FIG. **10**) of the swing analysis apparatus **20**, the swing analysis apparatus **20** performs communication with the swing diagnosis apparatus **30**, and, for example, a selection screen of swing analysis data as illustrated in FIG. **7** is displayed on the display section **25** of the swing analysis apparatus **20**. The selection screen includes a time point (date and time), the type of golf club which has been used, and some index values as analysis results of a swing, with respect to each item of swing analysis data regarding the user **2** included in the swing analysis data list preserved in the swing diagnosis apparatus **30**.

[0122] A checkbox correlated with each item of swing analysis data is located at a left end of the selection screen illustrated in FIG. **7**, and the user **2** checks any one of the checkboxes by operating the swing analysis apparatus **20**, and then presses an OK button located on a lower part of the selection screen. Consequently, the swing analysis apparatus **20** performs communication with the swing diagnosis apparatus **30**, and, thus, for example, an editing screen of input data which is a swing diagnosis target, as illustrated in FIG. **8**, is displayed on the display section **25** of the swing analysis apparatus **20**, with respect to the swing analysis data correlated with the checked checkbox on the selection screen illustrated in FIG. **7**.

[0123] The input data editing screen illustrated in FIG. **8** includes values obtained on the basis of the selected swing analysis data as initial values with respect to the sex, the type of golf club (either of a driver or an iron), and each index of a swing. Meanings or calculation methods of the respective indexes (a region in which a position of a head **3***a* at halfway back is included, a region in which a position of the head **3***a* at halfway down is included, a face angle, a club path (incidence angle), a shaft axis rotation angle at top, a head speed, a grip deceleration ratio, and a grip deceleration time ratio) included in the selection screen illustrated in FIG. **7** will be described later.

[0124] The input data formed of the sex, the type of golf club, and the respective index values in the input data editing screen illustrated in FIG. **8** can be edited. The user **2** does not edit the input data or edits the input data via the operation section **23** (refer to FIG. **10**) of the swing analysis apparatus **20**, and then presses a diagnosis starting button located on a lower part of the input data editing screen. Consequently, the swing analysis apparatus **20** transmits the input data at the time of the diagnosis starting button being pressed to the swing diagnosis apparatus **30**.

[0125] The swing diagnosis apparatus **30** receives the input data, and performs calculation of levels of a plurality of items by using the input data. For example, the swing diagnosis apparatus **30** may calculate a level of each of five items such as a "V zone", "rotation", "impact", a "down blow" or an "upper blow", and "swing efficiency (efficiency)" illustrated in the radar chart of FIG. **9**, as 5 points maximum. Meanings or calculation methods of the five items will be described later. The swing diagnosis apparatus **30** may calculate a total score of a swing by using the respective levels of the five items. The swing diagnosis apparatus **30** transmits information regarding the calculated levels and total score of the plurality of items to the swing analysis apparatus **20**. The "levels" may be represented by, for example, "1, 2, 3, . . . ", "A, B, C, . . . ", "○, Δ, X, . . . ", and may be represented by scores.

[0126] The swing analysis apparatus **20** receives the information regarding levels and total score of the plurality of items, and displays, for example, a swing diagnosis screen as illustrated in FIG. **9** on the display section **25**. The swing

diagnosis screen illustrated in FIG. **9** includes input data information on a left part thereof. The input data information is input data at the time of the diagnosis starting button being pressed in the input data editing screen illustrated in FIG. **8**, that is, data information used for diagnosis of the swing (that is, calculation of the levels and the total score of the five items) in the swing diagnosis apparatus **30**. The swing diagnosis screen illustrated in FIG. **9** includes a radar chart indicating scores as the levels of the five items on the central part thereof, and includes information regarding the total score on a right part thereof.

[0127] The user **2** can understand levels and a total score of the plurality of items as diagnosis results for the input data on the left part on the basis of the swing diagnosis screen illustrated in FIG. **9**. Particularly, if the user **2** presses the diagnosis starting button without editing the input data on the input data editing screen illustrated in FIG. **8**, the user can understand a strong point or a weak point in the user's swing on the basis of the swing diagnosis screen illustrated in FIG. **9**. On the other hand, if the user **2** edits the input data and presses the diagnosis starting button on the input data editing screen illustrated in FIG. **8**, the user can understand which index is improved to what extent in order to overcome the weak point. Hereinafter, a description will be made of an example in which "levels" of a plurality of items are represented by "scores", but, needless to say, the example can be easily replaced with an example of the levels being expressed by "1, 2, 3, . . . ", "A, B, C, . . . ", "○, Δ, X, . . . ", or the like.

[0128] The swing analysis apparatus **20** receives analysis information regarding levels and a total score of the plurality of items related to a plurality of swings, generates first analysis information on the basis of such a plurality of pieces of information (data), and generates a first region image including a plurality of time-series region images on the basis of the first analysis information. The swing analysis apparatus **20** displays the plurality of time-series region images (which will be described later in FIGS. **34** to **40**) together in a coordinate system having at least two indexes as axes. In the plurality of time-series region images, a size of a region surrounded by an outer circumferential line indicating the region indicates the magnitude corresponding to variations among a plurality of pieces of data related to a plurality of swings.

[0129] Since the time-series region images are displayed, the user **2** can visually recognize transition of the first analysis information related to a plurality of swings as a plurality of time-series region images. Consequently, the user can specifically and objectively recognize the extent of the present ability (level) of the user related to a plurality of swings in addition to variations.

1-2. Configurations of Sensor Unit and Swing Analysis Apparatus

[0130] FIG. **10** is a diagram illustrating configuration examples of the sensor unit **10** and the swing analysis apparatus **20**. As illustrated in FIG. **10**, in the present embodiment, the sensor unit **10** is configured to include an acceleration sensor **12**, an angular velocity sensor **14**, a signal processing section **16**, and a communication section **18**. However, the sensor unit **10** may have a configuration in which some of the constituent elements are deleted or changed as appropriate, or may have a configuration in which other constituent elements are added thereto.

[0131] The acceleration sensor **12** measures respective accelerations in three axial directions which intersect (ideally, orthogonal to) each other, and outputs digital signals (acceleration data) corresponding to magnitudes and directions of the measured three-axis accelerations.

[0132] The angular velocity sensor **14** measures respective angular velocities in three axial directions which intersect (ideally, orthogonal to) each other, and outputs digital signals (angular velocity data) corresponding to magnitudes and directions of the measured angular velocities in the three axial directions.

[0133] The signal processing section **16** receives the acceleration data and the angular velocity data from the acceleration sensor **12** and the angular velocity sensor **14**, respectively, adds time information thereto, stores the data in a storage portion (not illustrated), adds time information to the stored measured data (acceleration data and angular velocity data) so as to generate packet data conforming to a communication format, and outputs the packet data to the communication section **18**.

[0134] Ideally, the acceleration sensor **12** and the angular velocity sensor **14** are provided in the sensor unit **10** so that the three axes thereof match three axes (an x axis, a y axis, and a z axis) of an orthogonal coordinate system (sensor coordinate system) defined for the sensor unit **10**, but, actually, errors occur in installation angles. Therefore, the signal processing section **16** performs a process of converting the acceleration data and the angular velocity data into data in the xyz coordinate system by using a correction parameter which is calculated in advance according to the installation angle errors.

[0135] The signal processing section **16** may perform a process of correcting the temperatures of the acceleration sensor **12** and the angular velocity sensor **14**. Alternatively, the acceleration sensor **12** and the angular velocity sensor **14** may have a temperature correction function.

[0136] The acceleration sensor **12** and the angular velocity sensor **14** may output analog signals, and, in this case, the signal processing section **16** may A/D convert an output signal from the acceleration sensor **12** and an output signal from the angular velocity sensor **14** so as to generate measured data (acceleration data and angular velocity data), and may generate communication packet data by using the data.

[0137] The communication section **18** performs a process of transmitting packet data received from the signal processing section **16** to the swing analysis apparatus **20**, or a process of receiving a control command from the swing analysis apparatus **20** and sending the control command to the signal processing section **16**. The signal processing section **16** performs various processes corresponding to control commands.

[0138] As illustrated in FIG. **10**, in the present embodiment, the swing analysis apparatus **20** is configured to include a processing section **21**, a communication section **22**, an operation section **23**, a storage section **24**, a display section **25**, a sound output section **26**, and a communication section **27**. However, the swing analysis apparatus **20** may have a configuration in which some of the constituent elements are deleted or changed as appropriate, or may have a configuration in which other constituent elements are added thereto.

[0139] The communication section **22** performs a process receiving packet data transmitted from the sensor unit **10**

and sending the packet data to the processing section **21**, or a process of transmitting a control command from the processing section **21** to the sensor unit **10**.

[0140] The operation section **23** performs a process of acquiring operation data from the user **2** and sending the operation data to the processing section **21**. The operation section **23** may be, for example, a touch panel type display, a button, a key, or a microphone.

[0141] The storage section **24** is constituted of, for example, various IC memories such as a read only memory (ROM), a flash ROM, and a random access memory (RAM), or a recording medium such as a hard disk or a memory card. The storage section **24** stores a program for the processing section **21** performing various calculation processes or a control process, or various programs or data for realizing application functions.

[0142] In the present embodiment, the storage section **24** stores a swing analysis program **240** which is read by the processing section **21** and executes a swing analysis process. The swing analysis program **240** may be stored in a non-volatile recording medium (computer readable recording medium) in advance, or the swing analysis program **240** may be received from a server (not illustrated) or the swing diagnosis apparatus **30** by the processing section **21** via the network **40**, and may be stored in the storage section **24**.

[0143] In the present embodiment, the storage section **24** stores golf club information **242**, physical information **244**, sensor attachment position information **246**, and swing analysis data **248**. For example, the user **2** may operate the operation section **23** so as to input specification information regarding the golf club **3** (for example, at least some information such as information regarding a length of the shaft, a position of the centroid thereof, a lie angle, a face age, a loft angle, and the like) from the input screen illustrated in FIG. **5**, and the input specification information may be used as the golf club information **242**. Alternatively, in step S**1** in FIG. **4**, the user **2** may sequentially input type numbers of the golf club **3** (alternatively, selects a type number from a type number list) so that specification information for each type number is stored in the storage section **24** in advance. In this case, specification information of an input type number may be used as the golf club information **242**.

[0144] For example, the user **2** may input physical information by operating the operation section **23** from the input screen illustrated in FIG. **5**, and the input physical information may be used as the physical information **244**. For example, in step S**1** in FIG. **4**, the user **2** may input an attachment position of the sensor unit **10** and a distance to the grip end of the golf club **3** by operating the operation section **23**, and the input distance information may be used as the sensor attachment position information **246**. Alternatively, the sensor unit **10** may be attached at a defined predetermined position (for example, a distance of 20 cm from the grip end), and thus information regarding the predetermined position may be stored as the sensor attachment position information **246** in advance.

[0145] The swing analysis data **248** is data including information regarding a swing action analysis result in the processing section **21** (swing analysis portion **211**) along with a time point (date and time) at which a swing was performed, identification information or the sex of the user **2**, and the type of golf club **3**.

[0146] The storage section **24** is used as a work region of the processing section **21**, and temporarily stores data which is input from the operation section **23**, results of calculation executed by the processing section **21** according to various programs, and the like. The storage section **24** may store data which is required to be preserved for a long period of time among data items generated through processing of the processing section **21**.

[0147] The display section **25** displays a processing result in the processing section **21** as text, a graph, a table, animation, and other images. The display section **25** may be, for example, a CRT, an LCD, a touch panel type display, and a head mounted display (HMD). A single touch panel type display may realize functions of the operation section **23** and the display section **25**.

[0148] The first analysis information displayed on the display section **25** preferably includes information related to at least one of impact based on a relative face angle and a club path (incidence angle); efficiency based on an deceleration amount and timing in the grip of the golf club **3**; a rotation angle of the shaft axis and a face angle at top; a head speed based on a speed of the golf club **3** at ball hitting; hands-up based on lie angles at ball hitting and at address; and a down blow based on a face angle and an attack angle.

[0149] Consequently, the user **2** can obtain information related to at least one of impact, a V zone, efficiency, rotation, a head speed, hands-up, and a down blow as analysis data of an important index indicating ability (level) regarding a plurality of swings and detailed data. Consequently, the user **2** can more efficiently understand swing ability.

[0150] The display section **25** displays a plurality of time-series region images **81**, **82** and **83** included in a first region image **80** together in a coordinate system having at least two indexes as axes, for example, as illustrated in FIG. **34**. As illustrated in FIG. **34**, the display section **25** displays a second region image **90**, related to a plurality of swings performed by another user who is different from the user **2**, corresponding to the first region image **80**, together. Detailed description of display examples will be made later, and thus description thereof will be omitted.

[0151] Regarding a function of the operation section **23** in the display section **25**, the display content can be switched or enlarged or reduced by touching (screen touching) the display section **25**. As mentioned above, designation of the display content is performed on the operation section **23** of the display section **25**, and thus it is possible to directly perform an indication, and also to reliably and easily perform an indication.

[0152] The sound output section **26** outputs a processing result (analysis information) in the processing section **21** so as to present the processing result as a sound such as a voice or a buzzer sound. The sound output section **26** may be, for example, a speaker or a buzzer.

[0153] The communication section **27** performs data communication with a communication section **32** (refer to FIG. **23**) of the swing diagnosis apparatus **30** via the network **40**. For example, the communication section **27** performs a process of receiving the swing analysis data **248** from the processing section **21** after a swing analysis process is completed, and transmitting the swing analysis data to the communication section **32** of the swing diagnosis apparatus **30**. For example, the communication section **27** performs a process of receiving information required to display the

selection screen illustrated in FIG. **7** from the communication section **32** of the swing diagnosis apparatus **30** and transmitting the information to the processing section **21**, and a process of receiving selected information on the selection screen illustrated in FIG. **7** from the processing section **21** and transmitting the selected information to the communication section **32** of the swing diagnosis apparatus **30**. For example, the communication section **27** performs a process of receiving information required to display the input data editing screen illustrated in FIG. **8** from the communication section **32** of the swing diagnosis apparatus **30**, and transmitting the information to the processing section **21**. For example, the communication section **27** performs a process of receiving input data at the time of the diagnosis starting button on the input data editing screen illustrated in FIG. **8** from the processing section **21**, and transmitting the input data to the communication section **32** of the swing diagnosis apparatus **30**. For example, the communication section **27** performs a process of receiving information (diagnosis result information (scores or a total score of a plurality of items) based on the input data) required to display the swing diagnosis screen illustrated in FIG. **9** from the communication section **32** of the swing diagnosis apparatus **30**, and transmitting the information to the processing section **21**.

[0154] The processing section **21** performs a process of transmitting a control command to the sensor unit **10** via the communication section **22**, or various computation processes on data which is received from the sensor unit **10** via the communication section **22**, according to various programs. The processing section **21** performs a process of reading the swing analysis data **248** from the storage section **24**, and transmitting the swing analysis data to the swing diagnosis apparatus **30** via the communication section **27**, according to various programs. The processing section **21** may perform a process of transmitting various pieces of information to the swing diagnosis apparatus **30** via the communication section **27**, and forming first region image data corresponding to the first region image **80** (for example, refer to FIG. **34**) as display data of the first analysis information on the basis of the information received from the swing diagnosis apparatus **30**, according to various programs. The processing section **21** performs other various control processes.

[0155] By executing the swing analysis program **240**, the processing section **21** functions as a data acquisition portion **210**, a swing analysis portion **211** as an analysis portion, an image data generation portion **212**, a storage processing portion **213**, a display processing portion **214**, and a sound output processing portion **215**. The processing section **21** functions as a computer.

[0156] Particularly, in the present embodiment, by executing the swing analysis program **240**, the processing section **21** functions as the data acquisition portion **210**, the swing analysis portion **211**, the image data generation portion **212**, the storage processing portion **213**, the display processing portion **214**, and the sound output processing portion **215**, and performs a process (swing analysis process) of analyzing a swing action of the user **2**.

[0157] The data acquisition portion **210** performs a process of receiving packet data which is received from the sensor unit **10** by the communication section **22**, acquiring time information and measured data in the sensor unit **10** from the received packet data, and sending the time information and the measured data to the storage processing portion **213**. The data acquisition portion **210** performs a process of receiving the information required to display the various screens (the respective screens illustrated in FIGS. **7**, **8** and **9**), received from the swing diagnosis apparatus **30** by the communication section **27**, and transmitting the information to the image data generation portion **212**.

[0158] The storage processing portion **213** performs read/write processes of various programs or various data for the storage section **24**. The storage processing portion **213** performs a process of storing the time information and the measured data received from the data acquisition portion **210** in the storage section **24** in correlation with each other, or a process of storing various pieces of information calculated by the swing analysis portion **211**, the swing analysis data **248**, or the like in the storage section **24**.

[0159] The swing analysis portion **211** as an analysis portion performs a process of analyzing a swing action (a plurality of swings) of the user **2** by using the measured data (the measured data stored in the storage section **24**) output from the sensor unit **10**, the data from the operation section **23**, or the like, so as to generate the swing analysis data **248** as first analysis information including a time point (date and time) at which the swing was performed, identification information or the sex of the user **2**, the type of golf club **3**, and information regarding a swing action analysis result. Particularly, in the present embodiment, the swing analysis portion **211** calculates a value of each index of the swing as at least some of the information regarding the swing action analysis result. The swing analysis data **248** as the first analysis information includes information regarding at least one of the impact, the V zone, the efficiency (swing efficiency), the rotation, the head speed, the hands-up, and the down blow. By obtaining such information, the user **2** can more efficiently check swing ability.

[0160] The swing analysis portion **211** may calculate at least one virtual plane as an index of the swing. For example, at least one virtual plane includes a shaft plane SP (first virtual plane) which will be described later, and a Hogan plane HP (second virtual plane) which will be described later forming a predetermined angle with the shaft plane SP, and the swing analysis portion **211** may calculate the "shaft plane SP" and the "Hogan plane HP" as the indexes.

[0161] The swing analysis portion **211** may calculate a position of the head **3***a* of the golf club **3** at a first timing during the backswing as an index of the swing. For example, the first timing is the time of halfway back at which the longitudinal direction of the golf club **3** becomes a direction along the horizontal direction during the backswing, and the swing analysis portion **211** may calculate a "position of the head **3***a* at halfway back" which will be described later as the index.

[0162] The swing analysis portion **211** may calculate a position of the head **3***a* of the golf club **3** at a second timing during the downswing as an index of the swing. For example, the second timing is the time of halfway down at which the longitudinal direction of the golf club **3** becomes a direction along the horizontal direction during the downswing, and the swing analysis portion **211** may calculate a "position of the head **3***a* at halfway down" which will be described later as the index.

[0163] The swing analysis portion **211** may calculate an index based on an incidence angle of the head **3***a* of the golf club **3** at impact (at ball hitting), as an index of the swing.

For example, the swing analysis portion **211** may calculate a "club path (incidence angle) ψ" which will be described later as the index.

[0164] The swing analysis portion **211** may calculate an index based on an inclination of the head **3***a* of the golf club **3** at impact (at ball hitting) as an index of the swing.

[0165] The swing analysis portion **211** may calculate an index based on a speed of the golf club **3** (head **3***a*) at impact (at ball hitting) as an index of the swing. For example, the swing analysis portion **211** may calculate the "head speed" which will be described later as the index.

[0166] The swing analysis portion **211** may calculate, as an index of the swing, an index based on a rotation angle about a rotation axis (hereinafter, referred to as about the long axis) of the shaft of the golf club **3** at a predetermined timing between the time of starting a backswing and the time of impact (at ball hitting) with the longitudinal direction of the shaft as the rotation axis. The rotation angle about the long axis of the golf club **3** may be an angle by which the golf club **3** is rotated about the long axis from a reference timing to a predetermined timing. The reference timing may be the time of starting a backswing, and may be the time of address. The predetermined timing may be the time (the time of a top) at which a backswing transitions to a downswing. For example, the swing analysis portion **211** may calculate a "shaft axis rotation angle θ_{top} at top" which will be described later as the index.

[0167] The swing analysis portion **211** may calculate an index based on a deceleration amount of the grip of the golf club **3** during the downswing as an index of the swing. For example, the swing analysis portion **211** may calculate a "grip deceleration ratio R_V" which will be described later as the index. The "grip deceleration ratio R_V" is also referred to as "natural uncock" or a "natural uncock ratio".

[0168] The swing analysis portion **211** may calculate an index based on a deceleration period of the grip of the golf club **3** during the downswing as an index of the swing. For example, the swing analysis portion **211** may calculate a "grip deceleration time ratio R_T" which will be described later as the index.

[0169] The swing analysis portion **211** may calculate an index based on a deceleration timing of the grip of the golf club **3** during the downswing as an index of the swing. For example, the swing analysis portion **211** may calculate a timing of natural uncock ("natural uncock timing") of motion in which the grip side of the golf club **3** is decelerated, and the head **3***a* of the golf club **3** is accelerated as the index. The timing of natural uncock is an index indicating a switching timing in a state in which energy accumulated in a top swing is released and is thus forwarded to the golf club **3**.

[0170] The swing analysis portion **211** may calculate, as indexes of the swing, an index related to a position of the head **3***a* at halfway back (HWB) and an index related to a position of the head **3***a* at halfway down (HWD) in a region (refer to FIGS. **15** and **17**) interposed between the shaft plane SP (first virtual plane) and the Hogan plane HP (second virtual plane) called the "V zone".

[0171] The swing analysis portion **211** may calculate indexes based on a lie angle at ball hitting and a lie angle at address in the head **3***a* of the golf club **3** as indexes of the swing. A correlation diagram (including a first region image **580** and a second region image **590**) of "hands-up" as illustrated in FIG. **39**B may be formed on the basis of the "lie angle at ball hitting" and the "lie angle at address" calculated in the above-described way.

[0172] The swing analysis portion **211** may calculate indexes based on a "face angle" and an "attack angle" in the head **3***a* of the golf club **3** as indexes of the swing.

[0173] However, the swing analysis portion **211** may not calculate values of some of the indexes, and may calculate values of other indexes, as appropriate.

[0174] The image data generation portion **212** performs a process of generating image data corresponding to an image displayed on the display section **25**. For example, the image data generation portion **212** generates image data corresponding to the selection screen illustrated in FIG. **7**, the input data editing screen illustrated in FIG. **8**, and the swing diagnosis screen illustrated in FIG. **9**, on the basis of various pieces of information received by the data acquisition portion **210**.

[0175] The image data generation portion **212** performs, for example, a process of generating image data of a correlation diagram related to an analysis result of the "V zone" illustrated in FIG. **34**, and a process of generating image data of another user corresponding to an image (for example, "V zone") displayed on the display section **25**. For example, the image data generation portion **212** generates image data (second region image data) corresponding to, for example, the second region image **90** illustrated in FIG. **34** on the basis of a plurality of pieces of swing analysis data performed by another user stored in the storage section **24**.

[0176] The display processing portion **214** performs a process of displaying various images (including text, symbols, and the like in addition to an image corresponding to the image data generated by the image data generation portion **212**) on the display section **25**. For example, the display processing portion **214** displays the selection screen illustrated in FIG. **7**, the input data editing screen illustrated in FIG. **8**, the swing diagnosis screen illustrated in FIG. **9**, and the like, on the display section **25**, on the basis of the image data generated by the image data generation portion **212**. For example, the image data generation portion **212** may display an image, text, or the like for notifying the user **2** of permission of swing starting on the display section **25** in step S**5** in FIG. **4**. For example, the display processing portion **214** may display text information such as text or symbols indicating an analysis result in the swing analysis portion **211** on the display section **25** automatically or in response to an input operation performed by the user **2** after a swing action of the user **2** is completed. Alternatively, a display section may be provided in the sensor unit **10**, and the display processing portion **214** may transmit image data to the sensor unit **10** via the communication section **22**, and various images, text, or the like may be displayed on the display section of the sensor unit **10**.

[0177] The display processing portion **214** may display the second region images **90** for another user along with the first region image **80** for the user **2** displayed as images on the display section **25**, in response to an instruction from the user **2**.

[0178] The display processing portion **214** may display, for example, comments along with the first region image **80** or the second region image **90** displayed as images on the display section **25**. The comments may be diagnosis information based on the first region image **80** or information indicating a practice method based on the diagnosis infor-

mation. As mentioned above, the comments are preferably advice information regarding an analysis result.

[0179] As mentioned above, since diagnosis information or a practice method based on the diagnosis information is displayed as comments, the user **2** can easily understand a swing state, and can thus take appropriate measures in relation to improvement of a swing or perform an efficient practice.

[0180] The sound output processing portion **215** performs a process of outputting various sounds (including voices, buzzer sounds, and the like) from the sound output section **26**. For example, the sound output processing portion **215** may output a sound for notifying the user **2** of permission of swing starting from the sound output section **26** in step S**5** in FIG. **4**. For example, the sound output processing portion **215** may output a sound or a voice indicating an analysis result in the swing analysis portion **211** from the sound output section **26** automatically or in response to an input operation performed by the user **2** after a swing action of the user **2** is completed. Alternatively, a sound output section may be provided in the sensor unit **10**, and the sound output processing portion **215** may transmit various items of sound data or voice data to the sensor unit **10** via the communication section **22**, and may output various sounds or voices from the sound output section of the sensor unit **10**.

[0181] A vibration mechanism may be provided in the swing analysis apparatus **20** or the sensor unit **10**, and various pieces of information may be converted into vibration pieces of information by the vibration mechanism so as to be presented to the user **2**.

1-3. Swing Analysis Process

[0182] In the present embodiment, when a position of the head **3***a* of the golf club **3** at address (during standing still) is set to the origin, an XYZ coordinate system (global coordinate system) is defined which has a target line indicating a target hit ball direction as an X axis, an axis on a horizontal plane which is perpendicular to the X axis as a Y axis, and a vertically upward direction (a direction opposite to the gravitational direction) as a Z axis. In order to calculate each index value, the swing analysis portion **211** calculates a position and an attitude of the sensor unit **10** in a time series from the time of the address in the XYZ coordinate system (global coordinate system) by using measured data (acceleration data and angular velocity data) in the sensor unit **10**. The swing analysis portion **211** detects respective timings of the swing starting, the top, and the impact illustrated in FIG. **6**, by using the measured data (acceleration data or angular velocity data) in the sensor unit **10**. The swing analysis portion **211** calculates values of the respective indexes (for example, a V zone, efficiency (swing efficiency), rotation, impact, and a down blow (or an upper blow) illustrated in the radar chart of FIG. **9**) of the swing by using the time series data of the position and the attitude of the sensor unit **10**, and the timings of the swing starting, the top, and the impact, so as to generate the swing analysis data **248**.

1-3-1. Calculation of Position and Attitude of Sensor Unit **10**

[0183] If the user **2** performs the action in step S**4** in FIG. **4**, first, the swing analysis portion **211** determines that the user **2** stands still at an address attitude in a case where an amount of changes in acceleration data measured by the acceleration sensor **12** does not continuously exceed a threshold value for a predetermined period of time. Next, the swing analysis portion **211** computes an offset amount included in the measured data by using the measured data (acceleration data and angular velocity data) for the predetermined period of time. Next, the swing analysis portion **211** subtracts the offset amount from the measured data so as to perform bias correction, and computes a position and an attitude of the sensor unit **10** during a swing action of the user **2** (during the action in step S**6** in FIG. **4**) by using the bias-corrected measured data.

[0184] Specifically, first, the swing analysis portion **211** computes a position (initial position) of the sensor unit **10** during standing still (at address) of the user **2** in the XYZ coordinate system (global coordinate system) by using the acceleration data measured by the acceleration sensor **12**, the golf club information **242**, and the sensor attachment position information **246**.

[0185] FIG. **11** is a plan view in which the golf club **3** and the sensor unit **10** during standing still (at address) of the user **2** are viewed from a negative side of an X axis. The origin O (0,0,0) is set at a position **61** of the head **3***a* of the golf club **3**, and coordinates of a position **62** of a grip end are $(0, G_Y, G_Z)$. Since the user **2** performs the action in step S**4** in FIG. **4**, the position **62** of the grip end or the initial position of the sensor unit **10** has an X coordinate of 0, and is present on a YZ plane. As illustrated in FIG. **11**, the gravitational acceleration of 1G is applied to the sensor unit **10** during standing still of the user **2**, and thus a relationship between a y axis acceleration y(0) measured by the sensor unit **10** and an inclined angle (an angle formed between the longitudinal direction of the shaft and the horizontal plane (XY plane)) a of the shaft of the golf club **3** is expressed by Equation (1).

$$y(0)=1G\cdot\sin\alpha \tag{1}$$

[0186] Therefore, the swing analysis portion **211** can calculate the inclined angle α according to Equation (1) by using any acceleration data between any time points at address (during standing still).

[0187] Next, the swing analysis portion **211** subtracts a distance L_{SG} between the sensor unit **10** and the grip end included in the sensor attachment position information **246** from a length L_1 of the shaft included in the golf club information **242**, so as to obtain a distance L_{SH} between the sensor unit **10** and the head **3***a*. The swing analysis portion **211** sets, as the initial position of the sensor unit **10**, a position separated by the distance L_{SH} from the position **61** (origin O) of the head **3***a* in a direction (a negative direction of the y axis of the sensor unit **10**) specified by the inclined angle α of the shaft.

[0188] The swing analysis portion **211** integrates subsequent acceleration data so as to compute coordinates of a position from the initial position of the sensor unit **10** in a time series.

[0189] The swing analysis portion **211** computes an attitude (initial attitude) of the sensor unit **10** during standing still (at address) of the user **2** in the XYZ coordinate system (global coordinate system) by using acceleration data measured by the acceleration sensor **12**. Since the user **2** performs the action in step S**4** in FIG. **4**, the x axis of the sensor unit **10** matches the X axis of the XYZ coordinate system in terms of direction at address (during standing still) of the user **2**, and the y axis of the sensor unit **10** is present

on the YZ plane. Therefore, the swing analysis portion **211** can specify the initial attitude of the sensor unit **10** on the basis of the inclined angle α of the shaft of the golf club **3**.

[0190] The swing analysis portion **211** computes changes in attitudes from the initial attitude of the sensor unit **10** by performing rotation calculation using angular velocity data which is subsequently measured by the angular velocity sensor **14**. An attitude of the sensor unit **10** may be expressed by, for example, rotation angles (a roll angle, a pitch angle, and a yaw angle) about the X axis, the Y axis, and the Z axis, or a quaternion.

[0191] The signal processing section **16** of the sensor unit **10** may compute an offset amount of measured data so as to perform bias correction on the measured data, and the acceleration sensor **12** and the angular velocity sensor **14** may have a bias correction function. In this case, it is not necessary for the swing analysis portion **211** to perform bias correction on the measured data.

1-3-2. Detection of Swing Starting, Top and Impact Timings

[0192] First, the swing analysis portion **211** detects a timing (impact timing) at which the user **2** hit a ball by using measured data. For example, the swing analysis portion **211** may compute a combined value of measured data (acceleration data or angular velocity data), and may detect an impact timing (time point) on the basis of the combined value.

[0193] Specifically, first, the swing analysis portion **211** computes a combined value $n_0(t)$ of angular velocities at each time point t by using the angular velocity data (bias-corrected angular velocity data for each time point t). For example, if the angular velocity data items at the time point t are respectively indicated by x(t), y(t), and z(t), the swing analysis portion **211** computes the combined value $n_0(t)$ of the angular velocities according to the following Equation (2).

$$n_0(t)\sqrt{x(t)^2+y(t)^2+z(t)^2} \tag{2}$$

[0194] Next, the swing analysis portion **211** converts the combined value $n_0(t)$ of the angular velocities at each time point t into a combined value n(t) which is normalized (scale-conversion) within a predetermined range. For example, if the maximum value of the combined value of the angular velocities in an acquisition period of measured data is max (n_0), the swing analysis portion **211** converts the combined value n_0 (t) of the angular velocities into the combined value n(t) which is normalized within a range of 0 to 100 according to the following Equation (3).

$$n(t) = \frac{100 \times n_0(t)}{\max(n_o)} \tag{3}$$

[0195] Next, the swing analysis portion **211** computes a derivative dn (t) of the normalized combined value n (t) at each time point t. For example, if a cycle for measuring three-axis angular velocity data items is indicated by Δt, the swing analysis portion **211** computes the derivative (difference) dn(t) of the combined value of the angular velocities at the time point t by using the following Equation (4).

$$dn(t)=n(t)-n(t-\Delta t) \tag{4}$$

[0196] FIG. **12** illustrates examples of three-axis angular velocity data items x(t), y(t) and z (t) obtained when the user **2** hits the golf ball **4** by performing a swing. In FIG. **12**, a transverse axis expresses time (msec), and a longitudinal axis expresses angular velocity (dps).

[0197] FIG. **13** is a diagram in which the combined value n_0 (t) of the three-axis angular velocities is computed according to Equation (2) by using the three-axis angular velocity data items x(t), y(t) and z(t) in FIG. **12**, and then the combined value n(t) normalized to 0 to 100 according to Equation (3) is displayed in a graph. In FIG. **13**, a transverse axis expresses time (msec), and a longitudinal axis expresses a combined value of the angular velocity.

[0198] FIG. **14** is a diagram in which the derivative dn(t) is calculated according to Equation (4) on the basis of the combined value n(t) of the three-axis angular velocities in FIG. **13**, and is displayed in a graph. In FIG. **14**, a transverse axis expresses time (msec), and a longitudinal axis expresses a derivative value of the combined value of the three-axis angular velocities. In FIGS. **12** and **13**, the transverse axis is displayed at 0 seconds to 5 seconds, but, in FIG. **14**, the transverse axis is displayed at 2 seconds to 2.8 seconds so that changes in the derivative value before and after impact can be understood.

[0199] Next, of time points at which a value of the derivative do (t) of the combined value becomes the maximum and the minimum, the swing analysis portion **211** specifies the earlier time point as an impact time point t_{impact} (impact timing) (refer to FIG. **14**). It is considered that swing speed is the maximum at the moment of impact in a typical golf swing. In addition, since it is considered that a value of the combined value of the angular velocities also changes according to a swing speed, the swing analysis portion **211** can capture a timing at which a derivative value of the combined value of the angular velocities is the maximum or the minimum (that is, a timing at which the derivative value of the combined value of the angular velocities is a positive maximum value or a negative minimum value) in a series of swing actions as the impact timing. Since the golf club **3** vibrates due to the impact, a timing at which a derivative value of the combined value of the angular velocities is the maximum and a timing at which a derivative value of the combined value of the angular velocities is the minimum may occur in pairs, and, of the two timings, the earlier timing may be the moment of the impact.

[0200] Next, the swing analysis portion **211** specifies a time point of a minimum point at which the combined value n(t) is close to 0 before the impact time point t_{impact}, as a top time point t_{top} (top timing) (refer to FIG. **13**). It is considered that, in a typical golf swing, an action temporarily stops at the top after starting the swing, then a swing speed increases, and finally impact occurs. Therefore, the swing analysis portion **211** can capture a timing at which the combined value of the angular velocities is close to 0 and becomes the minimum before the impact timing, as the top timing.

[0201] Next, the swing analysis portion **211** sets an interval in which the combined value n(t) is equal to or smaller than a predetermined threshold value before and after the top time point t_{top}, as a top interval, and detects a last time point at which the combined value n(t) is equal to or smaller than the predetermined threshold value before a starting time point of the top interval, as a swing starting (backswing starting) time point t_{start} (refer to FIG. **13**). It is hardly considered that, in a typical golf swing, a swing action is

started from a standing still state, and the swing action is stopped till the top. Therefore, the swing analysis portion **211** can capture the last timing at which the combined value of the angular velocities is equal to or smaller than the predetermined threshold value before the top interval as a timing of starting the swing action. The swing analysis portion **211** may detect a time point of the minimum point at which the combined value n(t) is close to 0 before the top time point t_{top} as the swing starting time point t_{start}.

[0202] The swing analysis portion **211** may also detect each of a swing starting timing, a top timing, and an impact timing by using three-axis acceleration data in the same manner.

1-3-3. Calculation of Shaft Plane and Hogan Plane

[0203] The shaft plane is a first virtual plane specified by a target line (target hit ball direction) and the longitudinal direction of the shaft of the golf club **3** at address (standing still state) of the user **2** before starting a swing. The Hogan plane is a second virtual plane specified by a virtual line connecting the vicinity of the shoulder (the shoulder or the base of the neck) of the user **2** to the head **3***a* of the golf club (or the golf ball **4**), and the target line (target hit ball direction), at address of the user **2**.

[0204] FIG. **15** is a diagram illustrating the shaft plane and the Hogan plane. FIG. **15** displays the X axis, the Y axis, and the Z axis of the XYZ coordinate system (global coordinate system).

[0205] As illustrated in FIG. **15**, in the present embodiment, a virtual plane which includes a first line segment **51** as a first axis along a target hit ball direction and a second line segment **52** as a second axis along the longitudinal direction of the shaft of the golf club **3**, and has four vertices such as U**1**, U**2**, S**1**, and S**2**, as the shaft plane SP (first virtual plane). In the present embodiment, the position **61** of the head **3***a* of the golf club **3** at address is set as the origin O (0,0,0) of the XYZ coordinate system, and the second line segment **52** is a line segment connecting the position **61** (origin O) of the head **3***a* of the golf club **3** to the position **62** of the grip end. The first line segment **51** is a line segment having a length UL in which U**1** and U**2** on the X axis are both ends, and the origin O is a midpoint. Since the user **2** performs the action in step S**4** in FIG. **4** at address, and thus the shaft of the golf club **3** is perpendicular to the target line (X axis), the first line segment **51** is a line segment orthogonal to the longitudinal direction of the shaft of the golf club **3**, that is, the second line segment **52**. The swing analysis portion **211** calculates coordinates of the four vertices U**1**, U**2**, S**1**, and S**2** of the shaft plane SP in the XYZ coordinate system.

[0206] Specifically, first, the swing analysis portion **211** computes coordinates $(0,G_Y,G_Z)$ of the position **62** of the grip end of the golf club **3** by using the inclined angle α and the length L_1 of the shaft included in the golf club information **242**. As illustrated in FIG. **11**, the swing analysis portion **211** may compute G_Y and G_Z by using the length L_1 of the shaft and the inclined angle α according to Equations (5) and (6).

$$G_Y=L_1\cdot\cos\alpha \tag{5}$$

$$G_Z=L_1\cdot\sin\alpha \tag{6}$$

[0207] Next, the swing analysis portion **211** multiplies the coordinates $(0,G_Y,G_Z)$ of the position **62** of the grip end of the golf club **3** by a scale factor S so as to compute coordinates $(0,S_Y,S_Z)$ of a midpoint S**3** of the vertex S**1** and the vertex S**2** of the shaft plane SP. In other words, the swing analysis portion **211** computes S_Y and S_Z according to Equations (7) and (8), respectively.

$$S_Y=G_Y\cdot S \tag{7}$$

$$S_Z=G_Z\cdot S \tag{8}$$

[0208] FIG. **16** is a view in which a sectional view of the shaft plane SP in FIG. **15** which is cut in the YZ plane is viewed from the negative side of the X axis. As illustrated in FIG. **16**, a length (a width of the shaft plane SP in a direction orthogonal to the X axis) of a line segment connecting the midpoint S**3** of the vertex S**1** and the vertex S**2** to the origin O is S times the length L_1 of the second line segment **52**. The scale factor S is set to a value at which a trajectory of the golf club **3** during a swing action of the user **2** enters the shaft plane SP. For example, if a length of the arms of the user **2** is indicated by L_2, the scale factor S may be set as in Equation (9) so that the width $S\times L_1$ of the shaft plane SP in the direction orthogonal to the X axis is twice the sum of the length L_1 of the shaft and the length L_2 of the arms.

$$S=\frac{2\cdot(L_1+L_2)}{L_1} \tag{9}$$

[0209] The length L_2 of the arms of the user **2** is associated with a height L_0 of the user **2**. The length L_2 of the arms is expressed by a correlation expression such as Equation (10) in a case where the user **2** is a male, and is expressed by a correlation expression such as Equation (11) in a case where the user **2** is a female, on the basis of statistical information.

$$L_2=0.41\times L_0-45.5\ [\text{mm}] \tag{10}$$

$$L_2=0.46\times L_0-126.9\ [\text{mm}] \tag{11}$$

[0210] Therefore, the swing analysis portion **211** may calculate the length L_2 of the arms of the user according to Equation (10) or Equation (11) by using the height L_0 and the sex of the user **2** included in the physical information **244**.

[0211] Next, the swing analysis portion **211** computes coordinates (−UL/2, 0, 0) of the vertex U**1** of the shaft plane SP, coordinates (UL/2, 0, 0) of a vertex U**2**, coordinates $(-UL/2,S_Y,S_Z)$ of the vertex S**1**, and coordinates $(UL/2,S_Y,S_Z)$ of the vertex S**2** by using the coordinates $(0,S_Y,S_Z)$ of the midpoint S**3** and a width (the length of the first line segment **51**) UL of the shaft plane SP in the X axis direction. The width UL in the X axis direction is set to a value at which a trajectory of the golf club **3** during a swing action of the user **2** enters the shaft plane SP. For example, the width UL in the X axis direction may be set to be same as the width $S\times L_1$ in the direction orthogonal to the X axis, that is, twice the sum of the length L_1 of the shaft and the length L_2 of the arms.

[0212] In the above-described manner, the swing analysis portion **211** can calculate the coordinates of the four vertices U**1**, U**2**, S**1**, and S**2** of the shaft plane SP.

[0213] As illustrated in FIG. **15**, in the present embodiment, a virtual plane which includes a first line segment **51** as a first axis and a third line segment **53** as a third axis, and

has four vertices such as U1, U2, H1, and H2, is used as the Hogan plane HP (second virtual plane). The third line segment **53** is a line segment connecting a predetermined position **63** in the vicinity of a line segment connecting both of the shoulders of the user **2**, to the position **61** of the head **3***a* of the golf club **3**. However, the third line segment **53** may be a line segment connecting the predetermined position **63** to a position of the golf ball **4**. The swing analysis portion **211** calculates respective coordinates of the four vertices U1, U2, H1, and H2 of the Hogan plane HP in the XYZ coordinate system.

[0214] Specifically, first, the swing analysis portion **211** estimates the predetermined position **63** by using the coordinates $(0,G_Y,G_Z)$ of the position **62** of the grip end of the golf club **3** at address (during standing still), and the length L_2 of the arms of the user **2** based on the physical information **244**, and computes coordinates (A_X,A_Y,A_Z) thereof.

[0215] FIG. **17** is a view in which a sectional view of the Hogan plane HP illustrated in FIG. **15** which is cut in the YZ plane is viewed from the negative side of the X axis. In FIG. **17**, a midpoint of the line segment connecting both of the shoulders of the user **2** is the predetermined position **63**, and the predetermined position **63** is present on the YZ plane. Therefore, an X coordinate A_X of the predetermined position **63** is 0. As illustrated in FIG. **17**, the swing analysis portion **211** estimates, as the predetermined position **63**, a position obtained by moving the position **62** of the grip end of the golf club **3** by the length L_2 of the arms of the user **2** in a positive direction along the Z axis. Therefore, the swing analysis portion **211** sets a Y coordinate A_Y of the predetermined position **63** to be the same as the Y coordinate G_Y of the position **62** of the grip end. The swing analysis portion **211** computes a Z coordinate A_Z of the predetermined position **63** as a sum of the Z coordinate G_Z of the position **62** of the grip end and the length L_2 of the arms of the user **2** as in Equation (12).

$$A_Z=G_Z L_2 \tag{12}$$

[0216] Next, the swing analysis portion **211** multiplies the Y coordinate A_Y and the Z coordinate A_Z of the predetermined position **63** by a scale factor H, so as to compute coordinates $(0,H_Y,H_Z)$ of a midpoint H3 of the vertex H1 and the vertex H2 of the Hogan plane HP. In other words, the swing analysis portion **211** computes H_Y and H_Z according to Equation (13) and Equation (14), respectively.

$$H_Y=A_Y H \tag{13}$$

$$H_Z=A_Z H \tag{14}$$

[0217] As illustrated in FIG. **17**, a length (a width of the Hogan plane HP in a direction orthogonal to the X axis) of a line segment connecting the midpoint H3 of the vertex H1 and the vertex H2 to the origin O is H times the length L_3 of the third line segment **53**. The scale factor H is set to a value at which a trajectory of the golf club **3** during a swing action of the user **2** enters the Hogan plane HP. For example, the Hogan plane HP may have the same shape and size as the shape and the size of the shaft plane SP. In this case, the width $H\times L_3$ of the Hogan plane HP in the direction orthogonal to the X axis matches the width $S\times L_1$ of the shaft plane SP in the direction orthogonal to the X axis, and is twice the sum of the length L_1 of the shaft of the golf club **3** and the length L_2 of the arms of the user **2**. Therefore, the swing analysis portion **211** may compute the scale factor H according to Equation (15).

$$H=\frac{2\cdot(L_1+L_2)}{L_3} \tag{15}$$

[0218] The swing analysis portion **211** may compute the length L_3 of the third line segment **53** according to Equation (13) by using the Y coordinate A_Y and the Z coordinate A_Z of the predetermined position **63**.

[0219] Next, the swing analysis portion **211** computes coordinates $(-UL/2, H_Y, H_Z)$ of the vertex H1 of the Hogan plane HP, and coordinates $(UL/2, H_Y, H_Z)$ of the vertex H2 by using the coordinates $(0, H_Y, H_Z)$ of the midpoint H3 and a width (the length of the first line segment **51**) UL of the Hogan plane HP in the X axis direction. The two vertices U1 and U2 of the Hogan plane HP are the same as those of the shaft plane SP, and thus the swing analysis portion **211** does not need to compute coordinates of the vertices U1 and U2 of the Hogan plane HP again.

[0220] In the above-described manner, the swing analysis portion **211** can calculate the coordinates of the four vertices U1, U2, H1, and H2 of the Hogan plane HP.

[0221] A region interposed between the shaft plane SP (first virtual plane) and the Hogan plane HP (second virtual plane) is referred to as a "V zone", and a trajectory of a hit ball (a ball line) may be estimated to some extent on the basis of a relationship between a position of the head **3***a* of the golf club **3** and the V zone during a backswing or a downswing. For example, in a case where the head **3***a* of the golf club **3** is present in a space lower than the V zone at a predetermined timing during a backswing or a downswing, a hit ball is likely to fly in a hook direction. In a case where the head **3***a* of the golf club **3** is present in a space higher than the V zone at a predetermined timing during a backswing or a downswing, a hit ball is likely to fly in a slice direction. In the present embodiment, as is clear from FIG. **17**, an angle β formed between the shaft plane SP and the Hogan plane HP is determined depending on the length L_1 of the shaft of the golf club **3** and the length L_2 of the arms of the user **2**. In other words, since the angle β is not a fixed value, and is determined depending on the type of golf club **3** or physical features of the user **2**, the more appropriate shaft plane SP and Hogan plane HP (V zone) are calculated as an index for diagnosing a swing of the user **2**.

1-3-4. Calculation of Positions of Head **3***a* at Halfway Back and Halfway Down

[0222] A position of the head **3***a* at halfway back is a position of the head **3***a* at the moment of the halfway back, right before the halfway back, or right after the halfway back, and a position of the head **3***a* at halfway down is a position of the head **3***a* at the moment of the halfway down, right before the halfway down, or right after the halfway down.

[0223] First, the swing analysis portion **211** computes a position of the head **3***a* and a position of the grip end at each time point t by using the position and the attitude of the sensor unit **10** at each time point t from the swing start time point t_{start} to the impact time point t_{impact}.

[0224] Specifically, the swing analysis portion **211** uses, as a position of the head **3***a*, a position separated by the distance L_{SH} in the positive direction of the y axis specified by the attitude of the sensor unit **10**, from the position of the sensor unit **10** at each time point t, and computes coordinates of the

position of the head **3***a*. As described above, the distance L_{SH} is a distance between the sensor unit **10** and the head **3***a*. The swing analysis portion **211** uses, as a position of the grip end, a position separated by the distance L_{SG} in the negative direction of the y axis specified by the attitude of the sensor unit **10**, from the position of the sensor unit **10** at each time point t, and computes coordinates of the position of the grip end. As described above, the distance L_{SG} is a distance between the sensor unit **10** and the grip end.

[0225] Next, the swing analysis portion **211** detects a halfway back timing and a halfway down timing by using the coordinates of the position of the head **3***a* and the coordinates of the position of the grip end.

[0226] Specifically, the swing analysis portion **211** computes a difference ΔZ between a Z coordinate of the position of the head **3***a* and a Z coordinate of the position of the grip end at each time point t from the swing start time point t_{start} to the impact time point t_{impact}. The swing analysis portion **211** detects a time point t_{HWB} at which a sign of ΔZ is inverted between the swing start time point t_{start} and the top time point t_{top}, as the halfway back timing. The swing analysis portion **211** detects a time point t_{HWD} at which a sign of ΔZ is inverted between the swing start time point t_{top} and the impact time point t_{impact}, as the halfway down timing.

[0227] The swing analysis portion **211** uses the position of the head **3***a* at the time point t_{HWB} as a position of the head **3***a* at halfway back, and uses the position of the head **3***a* at the time point t_{HWD} as a position of the head **3***a* at halfway down.

1-3-5. Calculation of Head Speed

[0228] A head speed is the magnitude of a speed of the head **3***a* at impact (the moment of the impact, right before the impact, or right after the impact). For example, the swing analysis portion **211** computes a speed of the head **3***a* at the impact time point t_{impact} on the basis of differences between the coordinates of the position of the head **3***a* at the impact time point t_{impact} and coordinates of a position of the head **3***a* at the previous time point. The swing analysis portion **211** computes the magnitude of the speed of the head **3***a* as the head speed.

1-3-6. Calculation of Face Angle and Club Path (Incidence Angle)

[0229] The face angle is an index based on an inclination of the head **3***a* of the golf club **3** at impact, and the club path (incidence angle) is an index based on a trajectory of the head **3***a* of the golf club **3** at impact.

[0230] FIG. **18** is a diagram for explaining the face angle and the club path (incidence angle). FIG. **18** illustrates the golf club **3** (only the head **3***a* is illustrated) on the XY plane viewed from a positive side of the Z axis in the XYZ coordinate system. In FIG. **18**, the reference numeral **74** indicates a face surface (hitting surface) of the golf club **3**, and the reference numeral **75** indicates a ball hitting point. The reference numeral **70** indicates a target line indicating a target hit ball direction, and the reference numeral **71** indicates a plane orthogonal to the target line **70**. The reference numeral **76** indicates a curve indicating a trajectory of the head **3***a* of the golf club **3**, and the reference numeral **72** is a tangential line at the ball hitting point **75** for the curve **76**. In this case, the face angle ϕ is an angle formed between the plane **71** and the face surface **74**, that is, an angle formed between a straight line **73** orthogonal to the face surface **74**, and the target line **70**. The club path (incidence angle) ψ is an angle formed between the tangential line **72** (a direction in which the head **3***a* in the XY plane passes through the ball hitting point **75**) and the target line **70**.

[0231] For example, assuming that an angle formed between the face surface **74** of the head **3***a* and the x axis direction is normally constant (for example, orthogonal), the swing analysis portion **211** computes a direction of a straight line orthogonal to the face surface **74** on the basis of the attitude of the sensor unit **10** at the impact time point t_{impact}. The swing analysis portion **211** uses, a straight line obtained by setting a Z axis component of the direction of the straight line to 0, as a direction of the straight line **73**, and computes an angle (face angle) ϕ formed between the straight line **73** and the target line **70**.

[0232] For example, the swing analysis portion **211** uses a direction of a speed (that is, a speed of the head **3***a* in the XY plane) obtained by setting a Z axis component of a speed of the head **3***a* at the impact time point t_{impact} to 0, as a direction of the tangential line **72**, and computes an angle (club path (incidence angle)) ψ formed between the tangential line **72** and the target line **70**.

[0233] The face angle ϕ indicates an inclination of the face surface **74** with the target line **70** whose direction is fixed regardless of an incidence direction of the head **3***a* to the ball hitting point **75** as a reference, and is thus also referred to as an absolute face angle. In contrast, an angle η formed between the straight line **73** and the tangential line **72** indicates an inclination of the face surface **74** with an incidence direction of the head **3***a* to the ball hitting point **75** as a reference, and is thus referred to as a relative face angle. The relative face angle η is an angle obtained by subtracting the club path (incidence angle) ψ from the (absolute) face angle ϕ.

1-3-7. Calculation of Shaft Axis Rotation Angle at Top

[0234] The shaft axis rotation angle θ_{top} at top is an angle (relative rotation angle) by which the golf club **3** is rotated about a shaft axis from a reference timing to a top timing. The reference timing is, for example, the time of starting a backswing, or the time of address. In the present embodiment, in a case where the user **2** is a right-handed golfer, a right-handed screw tightening direction toward the tip end on the head **3***a* side of the golf club **3** (a clockwise direction when the head **3***a* is viewed from the grip end side) is a positive direction of the shaft axis rotation angle θ_{top}. Conversely, in a case where the user **2** is a left-handed golfer, a left-handed screw tightening direction toward the tip end on the head **3***a* side of the golf club **3** (a counterclockwise direction when the head **3***a* is viewed from the grip end side) is a positive direction of the shaft axis rotation angle θ_{top}.

[0235] FIG. **19** is a diagram illustrating an example of a temporal change of the shaft axis rotation angle from starting of a swing (starting of a backswing) to impact. In FIG. **19**, a transverse axis expresses time (s), and a longitudinal axis expresses a shaft axis rotation angle (deg). FIG. **19** illustrates the shaft axis rotation angle θ_{top} at top with the time of starting a swing (the time of starting a backswing) as a reference timing (at which the shaft axis rotation angle is 0°).

[0236] In the present embodiment, as illustrated in FIG. **3**, the y axis of the sensor unit **10** substantially matches the longitudinal direction of the shaft of the golf club **3** (the longitudinal direction of the golf club **3**). Therefore, for example, the swing analysis portion **211** time-integrates a y axis angular velocity included in angular velocity data from the swing starting (backswing starting) time point t_{start} or the time of address to the top time point t_{top} (at top), so as to compute the shaft axis rotation angle θ_{top}.

1-3-8. Calculation of Grip Deceleration Ratio and Grip Deceleration Time Ratio

[0237] The grip deceleration ratio is an index based on a grip deceleration amount, and is a ratio between a speed of the grip when the grip starts to be decelerated during the downswing, and a speed of the grip at impact. The grip deceleration time ratio is an index based on a grip deceleration period, and is a ratio between a period of time from the time at which the grip starts to be decelerated during the downswing to the time of impact, and a period of time of the downswing. A speed of the grip is preferably a speed of a portion held by the user **2**, but may be a speed of any portion of the grip (for example, the grip end), and may be a speed of a peripheral portion of the grip.

[0238] FIG. **20** is a diagram illustrating an example of a temporal change of a speed of the grip during the downswing. In FIG. **20**, a transverse axis expresses time (s), and a longitudinal axis expresses a speed (m/s) of the grip. In FIG. **20**, if a speed (the maximum speed of the grip) when the grip starts to be decelerated is indicated by V_2, and a speed of the grip at impact is indicated by V_2, a grip deceleration ratio R_V (unit: %) is expressed by the following Equation (16).

$$R_V = \frac{V_1 - V_2}{V_1} \times 100\ (\%) \tag{16}$$

[0239] In FIG. **20**, if a period of time from the time of top to the time at which the grip starts to be decelerated is indicated by T_1, and a period of time from the time at which the grip starts to be decelerated during the downswing to the time of impact is indicated by T_2, a grip deceleration time ratio R_T (unit: %) is expressed by the following Equation (17).

$$R_T = \frac{T_2}{T_1 + T_2} \times 100\ (\%) \tag{17}$$

[0240] For example, the sensor unit **10** may be attached to the vicinity of a portion of the golf club **3** held by the user **2**, and a speed of the sensor unit **10** may be regarded as a speed of the grip. Therefore, first, the swing analysis portion **211** computes a speed of the sensor unit **10** at the time point t on the basis of differences between coordinates of a position of the sensor unit **10** at each time point t from the top time point t_{top} to the impact time point t_{impact} (during the downswing) and coordinates of a position of the sensor unit **10** at the previous time point.

[0241] Next, the swing analysis portion **211** computes the magnitude of the speed of the sensor unit **10** at each time point t, sets the maximum value thereof as V_1, and sets the magnitude of the speed at the impact time point t_{impact} as V_2. The swing analysis portion **211** specifies a time point t_{vmax} at which the magnitude of the speed of the sensor unit **10** becomes the maximum value V_1. The swing analysis portion **211** computes $T_1=t_{vmax}-t_{top}$, and $T_2=t_{impact}-t_{vmax}$. The swing analysis portion **211** computes the grip deceleration ratio R_V and the grip deceleration time ratio R_T according to Equations (16) and (17), respectively.

[0242] The swing analysis portion **211** may regard a speed of the grip end as a speed of the grip, and may compute the speed of the grip end on the basis of coordinates of a position of the grip end at each time point t during the downswing, so as to obtain the grip deceleration ratio R_V and the grip deceleration time ratio R_T through the above-described computation.

1-3-9. Calculation of Attack Angle and Defined of Signs of Attack Angle and Face Angle

[0243] FIG. **21** is a diagram for explaining definition of an attack angle (first angle) δ. In the present embodiment, the XYZ coordinate system is defined which has a target line indicating a target hitting direction as an X axis, an axis on a horizontal plane which is perpendicular to the X axis as a Y axis, and a vertical direction (a direction opposite to the gravitational direction) as a Z axis, and FIG. **21** illustrates the X axis, the Y axis, and the Z axis. The target line indicates, for example, a target direction in which a ball flies straight. In FIG. **21**, a point R is a ball hitting point at which the head **3***a* of the golf club **3** comes into contact with a golf ball **4**, a curve L**1** indicates a part of a trajectory during a swing of the head **3***a* of the golf club **3** in an XZ plane, and a straight line L**2** is a tangential line of the curve L**1** at the hall hitting point R in the XZ plane. As illustrated in FIG. **21**, an attack angle is defined as an angle δ of the straight line L**2** with respect to the XY plane (horizontal plane) S. In FIG. **21**, a rightward direction toward the drawing surface along the X axis which is parallel to the XY plane (horizontal plane) S_{XY} is a target hitting direction. Therefore, the attack angle δ can be said to be an angle formed between a direction of the tangential line (straight line L**2**) which is in contact with the trajectory (curve L**1**) of a swing of the head (ball hitting portion) **3***a* of the golf club (exercise appliance) **3** and a target hitting direction along the X axis.

[0244] The target hitting direction also includes a direction orthogonal to the face surface of the head **3***a* of the golf club **3**, a hitting direction which is set in advance by the user, a direction connecting a direct distance to a hole cup, and the like.

[0245] In the present embodiment, regarding signs of the attack angle (first angle) δ, when the Y axis is a rotation axis, a direction (a clockwise direction in FIG. **21**) in which +Z (vertically upward direction) of the Z axis rotates in the +X direction (rightward direction toward the drawing surface) of the X axis is defined as a first sign, and a sign reverse to the first sign is defined as a second sign. As illustrated in FIG. **21**, the first sign is, for example, negative (−), and the second sign is positive (+). A sign of the attack angle (first angle) δ illustrated in FIG. **21** is the first sign (negative). In other words, the attack angle $\delta<0°$ occurs at the time of a down blow in which the head **3***a* is incident to the ball hitting point R obliquely downwardly toward the drawing surface. The attack angle $\delta=0°$ occurs at the time of a level blow in which the head **3***a* is incident to the ball hitting point R horizontally along the X axis. The attack angle $\delta>0°$ occurs

at the time of an upper blow in which the head **3***a* is incident to the ball hitting point R obliquely upwardly toward the drawing surface.

[0246] On the other hand, regarding signs of the face angle (second angle) Φ illustrated in FIG. **18**, when the Z axis is a rotation axis, a direction (a clockwise direction toward the drawing surface in FIG. **18**) in which +Y of the Y axis rotates in the +X direction of the X axis is defined as a third sign, and a sign reverse to the third sign is defined as a fourth sign. As illustrated in FIG. **18**, the third sign is, for example, negative (−), and the fourth sign is positive (+). A sign of the face angle (second angle) Φ illustrated in FIG. **18** is the third sign (negative). In other words, the face angle $\phi<0°$ occurs when the head **3***a* reaches impact in a closed state with an inside-out trajectory. The face angle $\phi=0°$ occurs when the face surface **74** of the head **3***a* is vertically incident to the target line. The face angle $\phi>0°$ occurs when the head **3***a* reaches impact in an open state with an outside-in trajectory.

[0247] The swing analysis portion **211** illustrated in FIG. **10** may include a first angle calculator which calculates the attack angle (first angle) δ and a second angle calculator which calculates the face angle (second angle) ϕ. The first and second angle calculators respectively calculate the first and second angles δ and ϕ on the basis of the relationships illustrated in FIGS. **21** and **18** by using an output from the data acquisition portion **210** illustrated in FIG. **10**, that is, an output from the sensor unit **10**.

1-3-10. Procedures of Swing Analysis Process (Swing Analysis Method)

[0248] FIG. **22** is a flowchart illustrating examples of procedures of a swing analysis process (swing analysis method) performed by the processing section **21**. The processing section **21** performs the swing analysis process, for example, according to the procedures shown in the flowchart of FIG. **22** by executing the swing analysis program **240** stored in the storage section **24**. Hereinafter, the flowchart of FIG. **22** will be described.

[0249] First, the processing section **21** waits for the user **2** to perform a measurement starting operation (the operation in step S**2** in FIG. **4**) (N in step S**10**), transmits a measurement starting command to the sensor unit **10** if the measurement starting operation is performed (Y in step S**10**), and starts to acquire measured data from the sensor unit **10** (step S**12**).

[0250] Next, the processing section **21** instructs the user **2** to take an address attitude (step S**14**). The user **2** takes the address attitude in response to the instruction, and stands still for a predetermined period of time or more (step S**4** in FIG. **4**).

[0251] Next, if a standing still state of the user **2** is detected by using the measured data acquired from the sensor unit **10** (Y in step S**16**), the processing section **21** notifies the user **2** of permission of swing starting (step S**18**). The processing section **21** outputs, for example, a predetermined sound, or an LED is provided in the sensor unit **10**, and the LED is lighted, so that the user **2** is notified of permission of swing starting. The user **2** confirms the notification and then starts a swing action (the action in step S**6** in FIG. **4**).

[0252] Next, the processing section **21** performs processes in step S**20** and subsequent steps after completion of the swing action of the user **2**, or from before completion of the swing action.

[0253] First, the processing section **21** computes an initial position and an initial attitude of the sensor unit **10** by using the measured data (measured data during standing still (at address) of the user **2**) acquired from the sensor unit **10** (step S**20**).

[0254] Next, the processing section **21** detects a swing starting timing, a top timing, and an impact timing by using the measured data acquired from the sensor unit **10** (step S**22**).

[0255] The processing section **21** computes a position and an attitude of the sensor unit **10** during the swing action of the user **2** in parallel to the process in step S**22**, or before and after the process in step S**22** (step S**24**).

[0256] Next, in steps S**26** to S**34**, the processing section **21** computes values of various indexes regarding the swing by using at least some of the measured data acquired from the sensor unit **10**, the swing starting, top and impact timings detected in step S**22**, and the position and the attitude of the sensor unit **10** computed in step S**24**.

[0257] The processing section **21** computes the shaft plane SP and the Hogan plane HP in step S**26**.

[0258] The processing section **21** computes a position of the head **3***a* at halfway back and a position of the head **3***a* at halfway down in step S**28**.

[0259] The processing section **21** computes a head speed, the face angle ϕ, the attack angle δ, and the club path (incidence angle) ψ in step S**30**.

[0260] The processing section **21** computes the shaft axis rotation angle θ_{top} at top in step S**32**.

[0261] The processing section **21** computes the grip deceleration ratio R_V and the grip deceleration time ratio R_T in step S**34**.

[0262] The processing section **21** generates the swing analysis data **248** by using the various indexes calculated in steps S**26** to S**34**, transmits the swing analysis data to the swing diagnosis apparatus **30** (step S**36**), and finishes the swing analysis process.

[0263] In the flowchart of FIG. **22**, order of the respective steps may be changed as appropriate within an allowable range, some of the steps may be omitted or changed, and other steps may be added thereto.

1-4. Configuration of Swing Diagnosis Apparatus

[0264] FIG. **23** is a diagram illustrating a configuration example of the swing diagnosis apparatus **30**. As illustrated in FIG. **23**, in the present embodiment, the swing diagnosis apparatus **30** is configured to include a processing section **31**, a communication section **32**, and a storage section **34**. However, the swing diagnosis apparatus **30** may have a configuration in which some of the constituent elements are deleted or changed as appropriate, or may have a configuration in which other constituent elements are added thereto.

[0265] The storage section **34** is constituted of, for example, various IC memories such as a ROM, a flash ROM, and a RAM, or a recording medium such as a hard disk or a memory card. The storage section **34** stores a program for the processing section **31** performing various calculation processes or a control process, or various programs or data for realizing application functions.

[0266] In the present embodiment, the storage section **34** stores a swing diagnosis program **340** which is read by the processing section **31** and executes a swing diagnosis process. The swing diagnosis program **340** may be stored in a nonvolatile recording medium (computer readable recording

medium) in advance, or the swing diagnosis program **340** may be received from a server (not illustrated) by the processing section **31** via the network **40**, and may be stored in the storage section **34**.

[0267] In the present embodiment, the storage section **34** stores (preserves) a swing analysis data list **341** including a plurality of pieces of swing analysis data **248** generated by the swing analysis apparatus **20**. In other words, the swing analysis data **248** generated whenever the processing section **21** of the swing analysis apparatus **20** analyzes a swing action of the user **2** is sequentially added to the swing analysis data list **341**.

[0268] In the present embodiment, the storage section **34** stores a V zone score table **342**, a rotation score table **343**, an impact score table **344**, a down blow score table **345**, an upper blow score table **346**, and a swing efficiency score table **347**. The score tables will be described later in detail.

[0269] The storage section **34** is used as a work region of the processing section **31**, and temporarily stores results of calculation executed by the processing section **31** according to various programs, and the like. The storage section **34** may store data which is required to be preserved for a long period of time among pieces of data generated through processing of the processing section **31**.

[0270] The communication section **32** performs data communication with the communication section **27** (refer to FIG. **10**) of the swing analysis apparatus **20** via the network **40**. For example, the communication section **32** performs a process of receiving the swing analysis data **248** from the communication section **27** of the swing analysis apparatus **20**, and transmitting the swing analysis data **248** to the processing section **31**. For example, the communication section **32** performs a process of transmitting information required to display the selection screen illustrated in FIG. **7** to the communication section **27** of the swing analysis apparatus **20**, or a process of receiving selected information on the selection screen illustrated in FIG. **7** from the communication section **27** of the swing analysis apparatus **20** and transmitting the selected information to the processing section **31**. For example, the communication section **32** performs a process of receiving information required to display the input data editing screen illustrated in FIG. **8** from the processing section **31**, and transmitting the information to the communication section **27** of the swing analysis apparatus **20**. For example, the communication section **32** performs a process of receiving input data at the time of the diagnosis starting button on the input data editing screen illustrated in FIG. **8** being pressed from the communication section **27** of the swing analysis apparatus **20**, transmitting the input data to the processing section **31**, receiving diagnosis result information (scores or a total score of a plurality of items indicating features of a swing of the user **2**) based on the input data from the processing section **31**, and transmitting the diagnosis information and the lesson information to the communication section **27** of the swing analysis apparatus **20**. For example, the communication section **32** performs a process of receiving information required to display the swing diagnosis screen illustrated in FIG. **9** from the processing section **31**, and transmitting the information to the communication section **27** of the swing analysis apparatus **20**.

[0271] The processing section **31** performs a process of receiving the swing analysis data **248** from the swing analysis apparatus **20** via the communication section **32** and storing the swing analysis data **248** in the storage section **34** (adding the swing analysis data to the swing analysis data list **341**), according to various programs. The processing section **31** performs a process of receiving various pieces of information from the swing analysis apparatus **20** via the communication section **32**, and transmitting information required to display various screens (the respective screens illustrated in FIGS. **7**, **8** and **9**) to the swing analysis apparatus **20**, according to various programs. The processing section **31** performs other various control processes.

[0272] Particularly, in the present embodiment, the processing section **31** functions as a data acquisition portion **310**, a score calculation portion **311**, and a storage processing portion **312** by executing the swing diagnosis program **340**, and performs a diagnosis process (swing diagnosis process) on the swing analysis data **248** selected from the swing analysis data list **341**.

[0273] The data acquisition portion **310** performs a process of receiving the swing analysis data **248** received from the swing analysis apparatus **20** by the communication section **32** and transmitting the swing analysis data **248** to the storage processing portion **312**. The data acquisition portion **310** performs a process of receiving various pieces of information received from the swing analysis apparatus **20** by the communication section **32** and transmitting the information to the score calculation portion **311**.

[0274] The storage processing portion **312** performs read/write processes of various programs or various data for the storage section **34**. For example, the storage processing portion **312** performs a process of receiving the swing analysis data **248** from the data acquisition portion **310** and storing the swing analysis data **248** in the storage section **34** (adding the swing analysis data to the swing analysis data list **341**), a process of reading the swing analysis data **248** from the swing analysis data list **341** stored in the storage section **34**, or the like. For example, the storage processing portion **312** performs a process of reading the V zone score table **342**, the rotation score table **343**, the impact score table **344**, the down blow score table **345**, the upper blow score table **346**, and the swing efficiency score table **347** stored in the storage section **34**.

[0275] The score calculation portion **311** (level calculation unit) performs a process of calculating scores (levels) of a plurality of items on the basis of data regarding a swing. In the present embodiment, the data regarding a swing may be input data at the time of the diagnosis starting button on the input data editing screen illustrated in FIG. **8** being pressed, may be the swing analysis data **248** selected on the selection screen illustrated in FIG. **7**, and may include both of the data.

[0276] For example, in a case where the sex, the type of golf club, and each index of a swing are not edited in a state of being initial values, and the diagnosis starting button is pressed on the input data editing screen illustrated in FIG. **8**, the score calculation portion **311** performs a process of calculating scores on the basis of the swing analysis data **248** selected from the swing analysis data list **341**. On the other hand, in a case where at least one of the sex, the type of golf club, and each index of a swing is edited, and then the diagnosis starting button is pressed on the input data editing screen illustrated in FIG. **8**, the score calculation portion **311** performs a process of calculating scores on the basis of data (pseudo-data) in which at least a part of the selected swing analysis data **248** is edited.

[0277] A plurality of items which are score calculation targets include a first item regarding at least one of a backswing and a downswing. The first item may include an item indicating a relationship among at least one virtual plane, a position of the head **3***a* (an example of a ball hitting portion) of the golf club **3** (an example of an exercise appliance) at a first timing during the backswing, and a position of the head **3***a* at a second timing during the downswing. For example, the first timing may be the time at which the longitudinal direction of the golf club **3** becomes a direction along the horizontal direction during the backswing. For example, the second timing may be the time at which the longitudinal direction of the golf club **3** becomes a direction along the horizontal direction during the downswing.

[0278] At least one virtual plane may include the shaft plane SP which is a first virtual plane specified on the basis of the first line segment **51** which is a first axis along a target hit ball direction (target line) in the XY plane as a reference plane, and the second line segment **52** which is a second axis along the longitudinal direction of the golf club **3** before starting a backswing. The time before starting a backswing may be the time of address (when the user **2** takes an address attitude and stands still).

[0279] At least one virtual plane may include the Hogan plane HP which is a second virtual plane (that is, the second virtual plane which forms a first angle β with the first virtual plane) specified on the basis of the first line segment **51** which is a first axis along a target hit ball direction (target line) in the XY plane as a reference plane, and the third line segment **53** which is a third axis forming the first angle β with the longitudinal direction of the golf club **3** before starting a backswing.

[0280] At least one virtual plane may include only one of the shaft plane SP and the Hogan plane HP. At least one virtual plane may include other virtual planes (for example, a plane interposed between the shaft plane SP and the Hogan plane HP, a plane outside the shaft plane SP and the Hogan plane HP, and a plane intersecting at least one of the shaft plane SP and the Hogan plane HP) instead of the shaft plane SP or the Hogan plane HP.

[0281] Hereinafter, the first item is assumed to include an item (hereinafter, this item will be referred to as a "V zone" item) indicating a relationship among four indexes of a swing, that is, the "shaft plane SP", the "Hogan plane HP", a "position of the head **3***a* at halfway back", and a "position of the head **3***a* at halfway down".

[0282] The first item may include an item regarding swing efficiency. The item regarding swing efficiency may be an item indicating a relationship between a deceleration amount and a deceleration period of the grip of the golf club **3** in a downswing. Hereinafter, the first item is assumed to include an item (hereinafter, this item will be referred to as a "swing efficiency" item) indicating a relationship between a "grip deceleration ratio" which is an index based on the deceleration amount of the grip and a "grip deceleration time ratio" which is an index based on the deceleration period of the grip, as the item regarding swing efficiency.

[0283] The plurality of items which are score calculation targets also include a second item regarding impact (at ball hitting). The second item may include an item indicating a relationship between an incidence angle of the head **3***a* of the golf club **3** and an inclination of the head **3***a* at impact (at ball hitting). Hereinafter, the second item is assumed to include an item (hereinafter, this item will be referred to as an "impact" item) indicating a relationship between the "club path (incidence angle) ψ" which is an index based on the incidence angle of the head **3***a* of the golf club **3** at impact and the "relative face angle π" which is an index based on the inclination of the head **3***a* at impact.

[0284] The second item may include an item indicating a relationship between an attack angle of the head **3***a* of the golf club **3** and an absolute face angle at impact (at ball hitting). Hereinafter, the second item is assumed to include an item (hereinafter, this item will be referred to as a "down blow" item or an "upper blow" item) indicating a relationship between the "attack angle δ" which depends on a position of the head **3***a* of the golf club **3** and the lowest point thereof at impact and the "absolute face angle φ" which is an index based on the inclination of the head **3***a* at impact.

[0285] The plurality of items which are score calculation targets may also include a third item regarding the time at which a swing transitions from a backswing to a downswing, and the time of impact (the time of ball hitting). The third item may include an item indicating a relationship between a rotation angle about the long axis of the golf club **3** at the time (at top) at which a swing transitions from a backswing to a downswing and an inclination of the head **3***a* of the golf club **3** at impact (at ball hitting). Hereinafter, the third item is assumed to include an item (hereinafter, this item will be referred to as a "rotation" item) indicating a relationship between the "shaft axis rotation angle θ_{top} at top" which is an index based on the rotation angle about the long axis of the golf club **3** at the top timing, and the "(absolute) face angle φ" which is an index based on the inclination of the head **3***a* at impact.

[0286] The score calculation portion **311** performs a process of calculating a total score on the basis of the scores of the plurality of items. The processing section **31** transmits information regarding the scores or the total score of the plurality of items, calculated by the score calculation portion **311**, to the swing analysis apparatus **20** via the communication section **32**. In other words, the processing section **31** also functions as an output section which outputs the information regarding the scores (levels) or the total score of the plurality of items.

1-5. Swing Diagnosis Process

[0287] In the present embodiment, the processing section **31** of the swing diagnosis apparatus **30** performs a process of calculating scores and a total score of a plurality of items indicating features of a swing as a swing analysis process.

[0288] A detailed description will be made of a method of calculating a score of each item and a method of calculating a total score in the score calculation portion **311** of the processing section **31**.

1-5-1. Calculation of Score of "V Zone" Item

[0289] The score calculation portion **311** calculates a score of the "V zone" item depending on in which regions positions of the head **3***a* at halfway back and halfway down are included among a plurality of regions determined based on the shaft plane SP and the Hogan plane HP (V zone).

[0290] FIGS. **24**A and **24**B are diagrams illustrating examples of relationships among the shaft plane SP and the Hogan plane HP (V zone), and a plurality of regions. FIG. **24**A illustrates relationships among the shaft plane SP, the

Hogan plane HP, and five regions A to E when viewed from a negative side of the X axis (when projected onto the YZ plane). FIG. **24**B is a diagram schematically illustrating an example of the shaft plane SP, the Hogan plane HP, and an attitude of the user **2**. The region B is a predetermined space including the Hogan plane HP, and the region D is a predetermined space including the shaft plane SP. The region C is a region interposed between the region B and the region D (a space between an interface S_{BC} with region B and an interface S_{CD} with the region D). The region A is a space in contact with the region B in an interface S_{AB} on an opposite side to the region C. The region E is a space in contact with the region D in an interface S_{DE} on an opposite side to the region C.

[0291] There may be various methods of setting the interface S_{AB}, the interface S_{BC}, the interface S_{CD}, and the interface S_{DE}. As an example, the interfaces may be set so that, on the YZ plane, the Hogan plane HP is located exactly at the center of the interface S_{AB} and the interface S_{BC}, the shaft plane SP is located exactly at the center of the interface S_{CD} and the interface S_{DE}, and angles of the region B, the region C, and the region D about the origin O (X axis) are the same as each other. In other words, with respect to the first angle β formed between the shaft plane SP and the Hogan plane HP, if each of angles formed between the Hogan plane HP, and the interface S_{AB} and the interface S_{BC} is set to β/4, and each of angles formed between the shaft plane SP, and the interface S_{CD} and the interface S_{DE} is set to β/4, angles of the region B, the region C, and the region D are all set to β/2.

[0292] Since a swing that causes a Y coordinate of a head **3***a* position at halfway back or halfway down to be negative cannot be expected, an interface of the region A opposite to the interface S_{AB} is set in the XZ plane in FIG. **24**A. Similarly, a swing that causes a Z coordinate of a position of the head **3***a* at halfway back or halfway down to be negative cannot be expected, and an interface of the region E opposite to the interface S_{DE} is set in the XY plane. Of course, an interface of the region A or the region E may be set so that an angle of the region A or the region E about the origin O (X axis) is the same as angles of the region B, the region C, and the region D.

[0293] Specifically, first, the score calculation portion **311** sets the interface S_{AB}, the interface S_{BC}, the interface S_{CD}, and the interface S_{DE} of the regions A to E on the basis of coordinates of each of the four vertices U**1**, U**2**, S**1**, and S**2** of the shaft plane SP and coordinates of each of the four vertices U**1**, U**2**, H**1**, and H**2** of the Hogan plane HP, included in data (selected swing analysis data **248**) regarding a swing. Next, the score calculation portion **311** determines in which region of the regions A to E coordinates of a position of the head **3***a* at halfway back and coordinates of a position of the head **3***a* at halfway down included in the data (selected swing analysis data **248**) regarding the swing are included.

[0294] Information regarding a determination result thereof is transmitted to the swing analysis apparatus **20**, and is used as the information regarding the "sex" and the "region in which a position of the head **3***a* at halfway down is included" in the input data editing screen illustrated in FIG. **8**. Thereafter, the score calculation portion **311** calculates a score corresponding to the determination result by referring to the V zone score table **342** and by using information regarding a "region in which a position of the head **3***a* at halfway back is included" and a "region in which a position of the head **3***a* at halfway down is included", included in the data (diagnosis target input data) regarding the swing.

[0295] In the present embodiment, as illustrated in FIG. **25**, the V zone score table **342** defines a score for each combination of the region in which a position of the head **3***a* at halfway back is included and the region in which a position of the head **3***a* at halfway down is included. For example, in a case where a position of the head **3***a* at halfway back is included in the region A, and a position of the head **3***a* at halfway down is included in the region A, a score is pv1. Each of scores pv1 to pv25 illustrated in FIG. **25** is any one of, for example, 1 point to 5 points.

[0296] The score calculation portion **311** may calculate a lower score as a hit ball predicted on the basis of a relationship among the shaft plane SP, the Hogan plane HP, the position of the head **3***a* at halfway back, and the position of the head **3***a* at halfway down becomes more easily curved. The term. "easily curved" may indicate that a trajectory after ball hitting is easily curved (easily sliced or hooked), and may indicate that a hit ball direction is easily deviated relative to a target direction (target line). Alternatively, the score calculation portion **311** may calculate a higher score as a hit ball more easily flies straight. The term "easily flies straight" may indicate that a trajectory after ball hitting is hardly curved (easily straightened), and may indicate that a hit ball direction is hardly deviated relative to a target direction (target line).

[0297] For example, in a case where a position of the head **3***a* at halfway back is included in the region E, and a position of the head **3***a* at halfway down is included in the region A, it is expected that a hit ball is easily curved, and thus the score calculation portion **311** calculates a relatively low score. Therefore, in the example illustrated in FIG. **25**, pv21 may be 1 point which is the lowest score, for example, among 1 point to 5 points.

[0298] For example, in a case where a position of the head **3***a* at halfway back and a position of the head **3***a* at halfway down are all included in the region C, it is expected that a hit ball easily flies straight, and thus the score calculation portion **311** calculates a relatively high score (for example, 5 points maximum). Therefore, in the example illustrated in FIG. **25**, pv13 may be 5 points which is the highest score, for example, among 1 point to 5 points.

1-5-2. Calculation of Score of "Rotation" Item

[0299] The score calculation portion **311** calculates a score of the "rotation" item depending on in which range among a plurality of ranges each of the shaft axis rotation angle θ_{top} at top and the face angle ϕ is included. Specifically, first, the score calculation portion **311** determines whether or not in which range each of the shaft axis rotation angle θ_{top} at top and the face angle ϕ included in data (target diagnosis input data) regarding a swing is included. Next, the score calculation portion **311** calculates a score corresponding to a determination result by referring to the rotation score table **343**.

[0300] In the present embodiment, as illustrated in FIG. **26**, the rotation score table **343** defines a score for each combination of a range in which the shaft axis rotation angle θ_{top} at top is included and a range in which the face angle ϕ is included. In the example illustrated in FIG. **26**, a range in which the shaft axis rotation angle θ_{top} at top is included is

classified into five ranges such as "less than θ1", "θ1 or more and less than θ2", "θ2 or more and less than θ3", "θ3 or more and less than θ4", and "θ4 or more". A range in which the face angle ϕ is included is classified into seven ranges such as "less than ϕ1", "ϕ1 or more and less than ϕ2", "ϕ2 or more and less than ϕ3", "ϕ3 or more and less than ϕ4", "ϕ4 or more and less than ϕ5", "ϕ5 or more and less than ϕ6", and "ϕ6 or more". For example, in a case where the shaft axis rotation angle θ_{top} at top is included in the range of "less than θ1", and the face angle ϕ is included in the range of "less than ϕ1", a score is pr1. Each of scores pr1 to pr35 illustrated in FIG. **26** is any one of, for example, 1 point to 5 points.

[0301] The score calculation portion **311** may calculate a lower score as a hit ball predicted on the basis of a relationship between the shaft axis rotation angle θ_{top} at top and the face angle ϕ becomes more easily curved.

[0302] For example, since the face surface of the golf club **3** is considerably open in a state where the shaft axis rotation angle θ_{top} at top is extremely large, it is expected that the face surface is not completely returned to a square at impact, and thus a hit ball is easily curved. A state in which the face angle ϕ is extremely large is a state in which the face surface at impact is considerably open, and a state in which the face angle ϕ is extremely small (a negative state in which an absolute value thereof is great) is a state in which the face surface at impact is considerably closed. In either state, it is expected that a hit ball is easily curved. In other words, for example, in a case where the shaft axis rotation angle θ_{top} is included in the range of "θ4 or more", and the face angle ϕ is included in the range of "less than ϕ1" or "ϕ6 or more", it is expected that a hit ball is easily curved, and thus the score calculation portion **311** calculates a relatively low score. Therefore, in the example illustrated in FIG. **26**, pr29 or pr35 may be 1 point which is the lowest score, for example, among 1 point to 5 points.

[0303] For example, if the shaft axis rotation angle θ_{top} at top is small, it is expected that the face surface is completely returned to the square at impact, and thus a hit ball easily flies straight. If the face angle ϕ is close to 0°, the face surface at impact is close to the square, and thus it is expected that a hit ball easily flies straight. In other words, in a case where the shaft axis rotation angle θ_{top} is included in the range of "less than θ1", and the face angle ϕ is included in the range of "ϕ3 or more and less than ϕ4", it is expected that a hit ball easily flies straight, and thus the score calculation portion **311** calculates a relatively high score (for example, 5 points maximum). Therefore, in the example illustrated in FIG. **26**, pr4 may be 5 points which is the highest score, for example, among 1 point to 5 points.

1-5-3. Calculation of Score of "Impact" Item

[0304] The score calculation portion **311** calculates a score of the "impact" item depending on in which range among a plurality of ranges each of the club path (incidence angle) ψ and the relative face angle η is included. Specifically, first, the score calculation portion **311** determines whether or not in which range the club path (incidence angle) ψ included in data (target diagnosis input data) regarding a swing is included. The score calculation portion **311** calculates the relative face angle η by subtracting the club path (incidence angle) ψ from the face angle ϕ included in the data (diagnosis target input data) regarding the swing (refer to FIG. **18**), and determines in which range the relative face angle η is included. Next, the score calculation portion **311** calculates a score corresponding to a determination result by referring to the impact score table **344**.

[0305] In the present embodiment, as illustrated in FIG. **27**, the impact score table **344** defines a score for each combination of a range in which the relative face angle η is included and a range in which the club path (incidence angle) ψ is included. In the example illustrated in FIG. **27**, a range in which the relative face angle η is included is classified into five ranges such as "η1 or more", "less than η1 and η2 or more", "less than η2 and η3 or more", "less than η3 and η4 or more", and "less than η4". A range in which the club path (incidence angle) ψ is included is classified into five ranges such as "less than ψ1", "ψ1 or more and less than ψ2", "ψ2 or more and less than ψ3", "ψ3 or more and less than ψ4", and "ψ4 or more". For example, in a case where the relative face angle η is included in the range of "η1 or more", and the club path (incidence angle) ψ is included in the range of "less than ψ1", a score is pi1. Each of scores pi1 to pi25 illustrated in FIG. **27** is any one of, for example, 1 point to 5 points.

[0306] The score calculation portion **311** may calculate a lower score as a hit ball predicted on the basis of the club path (incidence angle) ψ and the relative face angle η becomes more easily curved.

[0307] For example, a state in which the relative face angle **11** is extremely large is a state in which the face surface at impact is open, and a state in which the face angle ϕ is extremely small (a negative state in which an absolute value thereof is great) is a state in which the face surface at impact is considerably closed. In either state, it is expected that a hit ball is easily curved. For example, in a state in which the club path (incidence angle) ψ is extremely large, a trajectory of the head **3***a* at impact becomes a considerably inside-out trajectory, and thus it is expected that a hit ball is easily curved. In a state in which the club path (incidence angle) ψ is extremely small (a negative state in which an absolute value thereof is great), a trajectory of the head **3***a* at impact becomes a considerably outside-in trajectory, and thus it is expected that a hit ball is easily curved. In other words, for example, in a case where the relative face angle η is included in the range of "η1 or more" or "less than η4", and the club path (incidence angle) ψ is included in the range of "less than ψ1" or "ψ4 or more", it is expected that a hit ball is easily curved, and thus the score calculation portion **311** calculates a relatively low score. Therefore, in the example illustrated in FIG. **27**, pi1, pi5, pi21, and pi25 may be 1 point which is the lowest score, for example, among 1 point to 5 points.

[0308] For example, in a case where the relative face angle η is close to 0°, and the club path (incidence angle) ψ is close to 0°, the face surface at impact is close to the square, and a trajectory of the head **3***a* at impact is nearly straight. Therefore, it is expected that a hit ball easily flies straight. In other words, in a case where the relative face angle η is included in the range of "less than η2 and η3 or more", and the club path (incidence angle) ψ is included in the range of "ψ2 or more and less than ψ3", it is expected that a hit ball easily flies straight, and thus the score calculation portion **311** calculates a relatively high score (for example, 5 points maximum). Therefore, in the example illustrated in FIG. **27**, pi13 may be 5 points which is the highest score, for example, among 1 point to 5 points.

1-5-4. Calculation of Score of "Down Blow" Item

[0309] The score calculation portion **311** calculates a score of the "down blow" item depending on in which range among a plurality of ranges each of the attack angle δ and the absolute face angle ϕ is included in a case where an iron is selected as the golf club **3**. Specifically, first, the score calculation portion **311** determines whether or not in which range the attack angle δ illustrated in FIG. **21** is included. The score calculation portion **311** determines whether or not in which range the face angle ϕ illustrated in FIG. **18** is included. Next, the score calculation portion **311** calculates a score corresponding to a determination result by referring to the down blow score table **345** as illustrated in FIG. **28**.

[0310] In the present embodiment, as illustrated in FIG. **28**, the down blow score table **345** defines a score for each combination of a range in which the attack angle δ is included and a range in which the absolute face angle ϕ is included. In the example illustrated in FIG. **28**, a range in which the attack angle δ is included is classified into five ranges such as "less than −δ1", "−δ1 or more and less than −δ2", "−δ2 or more and less than −δ3", "−δ3 or more and less than 0", and "+δ4 or more" (where δ1>δ2>δ3 and δ4≅0). A range in which the absolute face angle ϕ is included is classified into five ranges such as "less than −ϕ1", "−ϕ1 or more and 0 or less", "more than 0 and less than +ϕ1", "+ϕ1 or more and less than +ϕ2", and "+ϕ2 or more" (where ϕ1<ϕ2). For example, in a case where the attack angle δ is included in the range of "less than −δ1", and the absolute face angle ϕ is included in the range of "less than −ϕ1", a score is pd1.

[0311] Here, when a sign of the attack angle (first angle) δ is the second sign (positive), scores Pd5, Pd10, Pd15, Pd20, and Pd25 may be the lowest score. In this case, an absolute value of the threshold value δ4 may be infinitely small (δ4≅0). As mentioned above, the second sign (positive) of the attack angle (first angle) δ at impact indicates an upper blow in which the lowest point of the club head **3***a* during a downswing occurs before the impact. In an iron club requiring a down blow, if it is determined that a sign of the attack angle (first angle) δ is the second sign (positive), the lowest score may be calculated, and thus a swing may be evaluated to be bad.

[0312] Next, in a case where a sign of the attack angle (first angle) δ is the first sign (negative), and a sign of the absolute face angle (second angle) ϕ is the fourth sign (positive), if an absolute value of the absolute face angle (second angle) ϕ is equal to or greater than the first threshold value ϕ2, scores Pd21 to Pd24 illustrated in FIG. **28** satisfying this condition may be set to be low. As mentioned above, the first sign (negative) of the attack angle (first angle) δ at impact indicates a down blow in which the lowest point of the club head **3***a* during a downswing occurs after the impact. If the attack angle (first angle) δ is zero, a true level blow occurs, but a level blow may also be regarded to occur in a case where an absolute value of an attack angle having the first sign (negative) is small. Even in this case, in a case where it is determined that the absolute face angle (second angle) ϕ is equal to or more than the first threshold value ϕ2 indicating an excessively open state, a low score may be calculated, and thus a swing may be evaluated to be bad, even if the attack angle (first angle) δ indicates a down blow.

[0313] Next, in a case where a sign of the attack angle (first angle) δ is the first sign (negative), if an absolute value of the attack angle (first angle) δ is smaller than a second threshold value δ2, and an absolute value of the absolute face angle (second angle) ϕ is smaller than the third threshold value ϕ1, scores Pd8, Pd9, Pd13 and Pd14 satisfying this condition may be set to be highest. The case where a sign of the attack angle (first angle) δ is the first sign (negative) indicates a case where a swing using an iron club is an appropriate down blow or a level blow. For example, if an absolute value of the attack angle (first angle) δ is smaller than the second threshold value δ2, it is determined that the attack angle (first angle) δ is in an appropriate range. Similarly, if an absolute value of the absolute face angle (second angle) ϕ is smaller than the third threshold value ϕ1, it is also determined that the absolute face angle (second angle) ϕ is in an appropriate range. In this case, the highest score may be calculated, and thus the swing may be evaluated to be good.

[0314] Next, in a case where a sign of the attack angle (first angle) δ is the first sign (negative), and a sign of the absolute face angle (second angle) ϕ is the fourth sign (positive), if an absolute value of the absolute face angle (second angle) ϕ is equal to or greater than the third threshold value ϕ1 and is smaller than the first threshold value ϕ2, scores Pd16 to Pd19 satisfying this condition may be set as low scores. The case where a sign of the attack angle (first angle) δ is the first sign (negative) indicates a case where a swing using an iron club is an appropriate down blow or a level blow. The case where a sign of the absolute face angle (second angle) ϕ is the fourth sign (positive) corresponds to the time at which the face surface is open. In this case, if an absolute value of the absolute face angle (second angle) ϕ is equal to or greater than the third threshold value ϕ1 and is smaller than the first threshold value ϕ2, low scores are set. The scores Pd21 to Pd24 illustrated in FIG. **28** may be the same as the scores Pd16 to Pd19 illustrated in FIG. **28**.

[0315] Next, in a case where a sign of the attack angle (first angle) δ is the first sign (negative), and a sign of the absolute face angle (second angle) ϕ is the third sign (negative), if an absolute value of the absolute face angle (second angle) ϕ is equal to or greater than the third threshold value ϕ1, scores Pd1, Pd2, Pd3 and Pd4 illustrated in FIG. **28** satisfying this condition may be set as intermediate scores higher than the low scores. The case where a sign of the first angle corresponding to an attack angle is the first sign (negative) indicates a case where a swing using an iron club is an appropriate down blow or a level blow. The case where a sign of the absolute face angle (second angle) ϕ is the third sign (negative) corresponds to the time at which a face angle of the head (ball hitting portion) **3***a* with respect to a target hitting direction at impact indicates a closed state. In this case, even if an absolute value of the absolute face angle (second angle) ϕ is equal to or greater than the third threshold value ϕ1, intermediate scores which are higher than the low scores are set.

[0316] Next, if an absolute value of the attack angle (first angle) δ is equal to or greater than the fourth threshold value δ1 and is smaller than the second threshold value δ2 in a case where a sign of the attack angle (first angle) δ is the first sign (negative), and if an absolute value of the absolute face angle (second angle) ϕ is smaller than the third threshold value ϕ1 in a case where a sign of the absolute face angle (second angle) ϕ is the third sign (negative), a score Pd7 illustrated in FIG. **28** satisfying this condition is set as a

score which is lower than the highest score and is higher than the intermediate score. The case where a sign of the first angle corresponding to an attack angle is the first sign (negative) indicates a case where a swing using an iron club is an appropriate down blow. In this case, if an absolute value of the attack angle (first angle) δ is equal to or greater than the fourth threshold value δ1 and is smaller than second threshold value δ2, it can be said that the attack angle (first angle) δ is in a range similar to an appropriate range. The case where a sign of the absolute face angle (second angle) ϕ is the third sign (negative) corresponds to the time at which a face angle of the head (ball hitting portion) **3***a* with respect to a target hitting direction at impact indicates a closed state. In this case, if an absolute value of the absolute face angle (second angle) ϕ is smaller than the third threshold value ϕ1, a score which is lower than the highest score and is higher than the intermediate score is set.

[0317] Next, if an absolute value of the attack angle (first angle) δ is equal to or greater than the fourth threshold value δ1 and is smaller than the second threshold value δ2 in a case where a sign of the attack angle (first angle) δ is the first sign (negative), and if an absolute value of the absolute face angle (second angle) ϕ is smaller than the third threshold value ϕ1 in a case where a sign of the absolute face angle (second angle) ϕ is the fourth sign (positive), a score Pd12 illustrated in FIG. **28** satisfying this condition is set as a score which is lower than the highest score and is higher than the intermediate score. The case where a sign of the first angle corresponding to an attack angle is the first sign (negative) indicates a case where a swing using an iron club is an appropriate down blow. In this case, if an absolute value of the attack angle (first angle) δ is equal to or greater than the fourth threshold value δ1 and is smaller than second threshold value δ2, it can be said that the attack angle (first angle) δ is in a range similar to an appropriate range. On the other hand, the case where a sign of the absolute face angle (second angle) ϕ is the fourth sign (positive) corresponds to the time at which a face angle of the head (ball hitting portion) **3***a* with respect to a target hitting direction at impact indicates an open state. In this case, if an absolute value of the absolute face angle (second angle) ϕ is smaller than the third threshold value ϕ1, a score which is lower than the highest score and is higher than the intermediate score is set.

[0318] In the present embodiment, in a case where a sign of the attack angle (first angle) δ is the first sign (negative), and a sign of the absolute face angle (second angle) ϕ is the fourth sign (positive), a lower score may be calculated as an absolute value of the second angle becomes greater (for example, Pd6<Pd7<Pd8, Pd9, Pd11<Pd12<Pd13).

[0319] In the present embodiment, in a case where a sign of the attack angle (first angle) δ is the first sign (negative), a higher score may be calculated as an absolute value of the first angle becomes smaller and an absolute value of the second angle becomes smaller (for example, Pd2<Pd7=Pd12<Pd8=Pd13, and Pd7=Pd12>Pd17).

[0320] In the present embodiment, in a case where a sign of the attack angle (first angle) δ is the first sign (negative), and a sign of the absolute face angle (second angle) ϕ is the third sign (negative), a lower score is calculated as an absolute value of the second angle becomes greater (for example, Pd1<Pd6, Pd2<Pd7, Pd3<Pd8, and Pd4<Pd9).

1-5-5. Calculation of Score of "Upper Blow" Item

[0321] The score calculation portion **311** calculates a score of the "upper blow" item depending on in which range among a plurality of ranges each of the attack angle δ and the absolute face angle ϕ is included in a case where a driver (wood) is selected as the golf club **3**. Specifically, the score calculation portion **311** calculates a score corresponding to a determination result by referring to the upper blow score table **346**, for example, as illustrated in FIG. **29**.

[0322] Here, FIG. **29** may be created, for example, by changing signs of the attack angle (first angle) δ illustrated in FIG. **28**. In other words, since a driver (wood) requires an upper blow, if a sign of the attack angle (first angle) δ is the first sign (negative) indicating a down blow, scores pu5, pu10, pu15, pu20 and pu25 satisfying this condition are the lowest score. Also in a case where a sign of the attack angle (first angle) δ is the second sign (positive) indicating an upper blow, if the absolute face angle (second angle) ϕ indicates an excessive open state (ϕ≥+ϕ2), scores pu21 to pu24 satisfying this condition are the lowest score. The scores pu1 to pu25 illustrated in FIG. **29** may be the same as the scores Pd1 to Pd25 illustrated in FIG. **28** in corresponding numbers. For example, in FIG. **29**, the highest score may be set in the range of 0≤δ<δ2 and the range of −ϕ1<ϕ<+ϕ1 (pu8=pu9=pu13=pu14=highest score). In FIGS. **28** and **29**, values of 61 to 64 or values of ϕ1 and ϕ2 may be the same as or different from each other. In FIGS. **28** and **29**, values of Pd1 to Pd25 and values of pu1 to pu25 may be the same as or different from each other.

1-5-6. Calculation of Score of "Swing Efficiency" Item

[0323] The score calculation portion **311** calculates a score of the "swing efficiency" item depending on in which range among a plurality of ranges each of the grip deceleration ratio R_V and the grip deceleration time ratio R_T is included. Specifically, first, the score calculation portion **311** determines whether or not in which range each of the grip deceleration ratio R_V and the grip deceleration time ratio R_T included in data (target diagnosis input data) regarding a swing is included. Next, the score calculation portion **311** calculates a score corresponding to a determination result by referring to the swing efficiency score table **347**.

[0324] In the present embodiment, as illustrated in FIG. **30**, the swing efficiency score table **347** defines a score for each combination of a range in which the grip deceleration ratio R_V is included and a range in which the grip deceleration time ratio R_T is included. In the example illustrated in FIG. **30**, a range in which the grip deceleration ratio R_V is included is classified into six ranges such as "nu1 or more", "less than nu1 and nu2 or more", "less than nu2 and nu3 or more", "less than nu3 and nu4 or more", "less than nu4 and nu5 or more", and "less than nu5". A range in which the grip deceleration time ratio R_T is included is classified into six ranges such as "nup1 or more", "less than nup1 and nup2 or more", "less than nup2 and nup3 or more", "less than nup3 and nup4 or more", "less than nup4 and nup5 or more", and "less than nup5". For example, in a case where the grip deceleration ratio R_V is included in the range of "nu1 or more", and the grip deceleration time ratio R_T is included in the range of "nup1 or more", a score is ps1. Each of scores ps1 to ps36 illustrated in FIG. **30** is any one of, for example, 1 point to 5 points.

[0325] The score calculation portion **311** may calculate a higher score as swing efficiency predicted on the basis of the grip deceleration ratio R_V and the grip deceleration time ratio R_T becomes higher.

[0326] It is considered in a golf swing that, when the head **3***a* is accelerated, the arms are decelerated by reducing forces of the arms in a downswing, and thus natural rotation of the golf club occurs, so that the shaft is accelerated. A tendency for the natural rotation of the golf club to occur can be understood depending on to what extent a speed of the grip is decelerated during a downswing. Therefore, it is expected that a highly efficient swing using natural rotation of the golf club can be realized as the grip deceleration ratio R_V becomes higher. However, if a timing at which natural rotation of the golf club occurs is close to an impact timing, that is, the grip deceleration time ratio R_T is low, impact occurs in a state in which the natural rotation of the golf club cannot be sufficiently used, and thus it cannot necessarily be said that a highly efficient swing is performed. In other words, for example, in a case where the grip deceleration ratio R_V is included in the range of "nu1 or more", and the grip deceleration time ratio R_T is included in the range of "nup1 or more", it is expected that swing efficiency is high, and thus the score calculation portion **311** calculates a relatively high score. For example, in a case where the grip deceleration ratio R_V is included in the range of "less than nu5", and the grip deceleration time ratio R_T is included in the range of "less than nup5", it is expected that swing efficiency is low, and thus the score calculation portion **311** calculates a relatively low score. Therefore, in the example illustrated in FIG. **30**, ps1 may be 5 points which is the highest score, for example, among 1 point to 5 points, and ps36 may be 1 point which is the lowest score, for example, among 1 point to 5 points.

[0327] Here, in the score tables illustrated in FIGS. **25** to **30**, a level is calculated on the basis of the first index and the second index. As mentioned above, a level can be calculated through positioning of a swing in a two-axis coordinate system formed of the first index and the second index, and thus a swing of a golf club (exercise appliance) at impact can be objectively determined.

[0328] A score is added to each region in advance on the basis of a relationship between the first index and the second index, and thus a lookup table can be used. A score can be specified on the basis of the first index and the second index by using the lookup table, and the score can be calculated as a level. As mentioned above, since a swing is calculated as a score on the basis of the first index and the second index by using the lookup table, it is possible to easily and appropriately perform an objective determination on a swing of a golf club (exercise appliance) at impact.

1-5-7. Calculation of Total Score

[0329] The score calculation portion **311** calculates a total score on the basis of the score of the "V zone" item, the score of the "rotation" item, the score of the "impact" item, the score of the "down blow", the score of the "upper blow" item, and the score of the "swing efficiency" item.

[0330] For example, in a case where a score of each item is 5 points maximum, if a maximum of a total score is 100 points, the score calculation portion **311** may multiply the score of each item by 4 so that 20 points maximum is obtained, and may add all the scores together so as to calculate a total score. In the swing diagnosis screen illustrated in FIG. **9**, a score of 5 points maximum of each item is displayed as a radar chart, and the score of each item is multiplied by 4, and 64 points obtained by adding all the scores together is a total score.

[0331] For example, the score calculation portion **311** may increase a weight of a highly important item in diagnosis (evaluation) of a swing and may add scores of the items together so as to calculate a total score.

1-5-8. Procedures of Swing Diagnosis Process (Swing Diagnosis Method)

[0332] FIG. **31** is a flowchart illustrating examples of procedures of a process performed by the processing section **21** of the swing analysis apparatus **20** in relation to the swing diagnosis process. FIG. **32** is a flowchart illustrating examples of procedures of the swing diagnosis process (swing diagnosis method) performed by the processing section **31** of the swing diagnosis apparatus **30**. The processing section **31** (an example of a computer) of the swing diagnosis apparatus **30** performs the swing diagnosis process, for example, according to the procedures of the flowchart of FIG. **32** by executing the swing diagnosis program **340** stored in the storage section **34**. Hereinafter, the flowcharts of FIGS. **31** and **32** will be described.

[0333] First, the processing section **21** of the swing analysis apparatus **20** transmits user identification information allocated to the user **2**, to the swing diagnosis apparatus **30** (step S**100** in FIG. **31**).

[0334] Next, the processing section **31** of the swing diagnosis apparatus **30** receives the user identification information, and transmits list information of the swing analysis data **248** corresponding to the user identification information (step S**200** in FIG. **32**).

[0335] Next, the processing section **21** of the swing analysis apparatus **20** receives the list information of the swing analysis data **248**, and displays a selection screen (FIG. **7**) of the swing analysis data on the display section **25** (step S**110** in FIG. **31**).

[0336] The processing section **21** of the swing analysis apparatus **20** waits for the swing analysis data **248** to be selected on the selection screen of the swing analysis data (N in step S**120** in FIG. **31**), and transmits selected information of the swing analysis data to the swing diagnosis apparatus **30** (step S**130** in FIG. **31**) if the information is selected (Y in step S**120** in FIG. **31**).

[0337] Next, the processing section **31** of the swing diagnosis apparatus **30** receives the selected information of the swing analysis data (step S**210** in FIG. **32**), and determines the sex (a male or a female) and the type of golf club (a driver or an iron) on the basis of the swing analysis data **248** which is selected on the basis of the selected information (step S**220** in FIG. **32**).

[0338] The processing section **31** of the swing diagnosis apparatus **30** determines a region in which a position of the head **3***a* at halfway back is included and a region in which a position of the head **3***a* at halfway down is included on the basis of the selected swing analysis data **248** (step S**230** in FIG. **32**).

[0339] Next, the processing section **31** of the swing diagnosis apparatus **30** transmits various pieces of information based on the selected swing analysis data (step S**240** in FIG. **32**). The various pieces of information based on the selected swing analysis data **248** include the determination result in step S**220**, the determination result in step S**230**, and infor-

mation regarding some index values (the face angle ϕ, the attack angle δ, the club path (incidence angle) ψ, the shaft axis rotation angle θ_{top} at top, the head speed, the grip deceleration ratio R_V, and the grip deceleration time ratio R_T) included in the selected swing analysis data.

[0340] Next, the processing section **21** of the swing analysis apparatus **20** receives the various pieces of information based on the selected swing analysis data **248**, and displays an editing screen (FIG. **8**) of input data on the display section **25** (step S**140** in FIG. **31**).

[0341] The processing section **21** of the swing analysis apparatus **20** waits for a diagnosis starting operation to be performed on the editing screen of input data (N in step S**150** in FIG. **31**), and transmits diagnosis target input data to the swing diagnosis apparatus **30** (step S**160** in FIG. **31**) if the diagnosis starting operation is performed (Y in step S**150** in FIG. **31**).

[0342] Next, the processing section **31** of the swing diagnosis apparatus **30** receives the diagnosis target input data (step S**250** in FIG. **32**), and calculates scores and a total score of a plurality of items on the basis of the diagnosis target input data (step S**260** in FIG. **32**).

[0343] Next, the processing section **31** of the swing diagnosis apparatus **30** transmits (outputs) information regarding the scores and the total score of the plurality of items to the swing analysis apparatus **20** (step S**270** in FIG. **32**), and finishes the swing diagnosis process.

[0344] The processing section **21** of the swing analysis apparatus **20** receives the information regarding the scores and the total score of the plurality of items, displays the swing diagnosis screen (FIG. **9**) on the display section **25** (step S**170** in FIG. **31**), and finishes the process.

[0345] In the flowchart of FIG. **31**, order of the respective steps may be changed as appropriate within an allowable range, some of the steps may be omitted or changed, and other steps may be added thereto. Similarly, in the flowchart of FIG. **32**, order of the respective steps may be changed as appropriate within an allowable range, some of the steps may be omitted or changed, and other steps may be added thereto.

[0346] FIG. **33** is a flowchart illustrating examples of procedures of a process (step S**260** in FIG. **32**) of calculating scores and a total score of a plurality of items in the processing section **31** (score calculation portion **311**) of the swing diagnosis apparatus **30**. Hereinafter, the flowchart of FIG. **33** will be described.

[0347] First, the processing section **31** calculates a score (a score of the "V zone" item) corresponding to a region in which a position of the head **3***a* at halfway back is included and a region in which a position of the head **3***a* at halfway down is included by referring to the V zone score table **342** stored in the storage section **34** (step S**261**).

[0348] Next, the processing section **31** calculates a score (a score of the "rotation" item) corresponding to the shaft axis rotation angle θ_{top} at top and the face angle ϕ by referring to the rotation score table **343** stored in the storage section (step S**262**).

[0349] Next, the processing section **31** calculates the relative face angle η on the basis of the face angle ϕ and the club path (incidence angle) ψ (step S**263**).

[0350] Next, the processing section **31** calculates a score (a score of the "impact" item) corresponding to the relative face angle η and the club path (incidence angle) ψ by referring to the impact score table **344** stored in the storage section **34** (step S**264**).

[0351] Next, if an iron is selected as the golf club **3**, the processing section **31** calculates a score (a score of the "down blow" item) corresponding to the attack angle δ and the absolute face angle ϕ by referring to the down blow score table **345** stored in the storage section **34** (step S**265**). Alternatively, if a driver (wood) is selected as the golf club **3**, the processing section **31** calculates a score (a score of the "upper blow" item) corresponding to the attack angle δ and the absolute face angle ϕ by referring to the upper blow score table **346** stored in the storage section **34** (step S**265**).

[0352] Next, the processing section **31** calculates a score (a score of the "swing efficiency" item) corresponding to the grip deceleration ratio R_V and the grip deceleration time ratio R_T by referring to the swing efficiency score table **347** stored in the storage section **34** (step S**266**).

[0353] Finally, the processing section **31** calculates a total score on the basis of the score of the "V zone" item calculated in step S**261**, the score of the "rotation" item calculated in step S**262**, the score of the "impact" item calculated in step S**264**, the score of the "down blow" or "upper blow" item calculated in step S**265**, and the score of the "swing efficiency" item calculated in step S**266**, or scores of the "ball curving" item and the "ball shooting direction" item (not illustrated) (step S**267**).

[0354] As described above, on the basis of the respective calculated scores (evaluation result), the image data generation portion **212** performs a process of generating image data of the swing analysis data **248** (correlation data) as the first analysis information related to each index, and generating image data related to swing analysis data as the second analysis information for another user corresponding to an image (for example, a "V zone") displayed on the display section **25**. The display processing portion **214** displays various images (including text, symbols, and the like in addition to an image corresponding to the image data generated by the image data generation portion **212**) on the display section **25**.

[0355] Regarding a specific display method on the display section **25**, a correlation diagram of the "V zone" illustrated in FIG. **34** may be formed on the basis of the "position of the head **3***a* at halfway back (HWB)" and the "position of the head **3***a* at halfway down (HWD)". A correlation diagram of the "rotation" as shown in a display example of the second region image illustrated in FIG. **35** may be formed on the basis of the "shaft axis rotation angle θ_{top} at top" and the "(absolute) face angle ϕ". A correlation diagram of the "impact" as shown in a display example of the second region image illustrated in FIG. **36** may be formed on the basis of the "relative face angle η" and the "club path (incidence angle) ψ". A correlation diagram (including the first region image **80** and the second region image **90**) of the "efficiency" as shown in a display example as illustrated in FIG. **37** may be formed on the basis of the "natural uncock" and the "natural release timing". A correlation diagram (histogram) of the "head speed" as illustrated in FIG. **38** may be formed on the basis of the "head speed". A correlation diagram of the "hands-up" as illustrated in FIG. **39**B may be formed on the basis of the "lie angle at impact" and the "lie angle at address". A correlation diagram of the "down blow" illustrated in FIG. **40** may be formed on the basis of the "face angle" and the "attack angle".

1-5-9. Display Examples of Swing Diagnosis Screen and Lesson Screen

[0356] Hereinafter, with reference to FIGS. **34** to **46**, a description will be made of specific display examples of display methods displayed on the display section **25**. FIG. **34** is a diagram illustrating a display example (V zone) including a first region image (time-series region images). FIG. **35** is a diagram illustrating a display example (rotation) including a first region image (time-series region images). FIG. **36** is a diagram illustrating a display example (impact) including a first region image (time-series region images). FIG. **37** is a diagram illustrating a display example (efficiency) including a first region image (time-series region images). FIG. **38** is a diagram illustrating a display example (head speed) including a first region image (time-series region images). FIG. **39**A is a diagram for explaining hands-up. FIG. **39**B is a diagram illustrating a display example (hands-up) including a first region image (time-series region images). FIG. **40** is a diagram illustrating a display example (down blow) including a first region image (time-series region images). FIGS. **41** to **45** are diagrams illustrating modification examples related to a display method, in which FIG. **41** illustrates Modification Example 1 (V zone); FIG. **42** illustrates Modification Example 2 (V zone); FIG. **43** illustrates Modification Example 3 (V zone); FIG. **44**A illustrates Modification Example 4 (V zone); FIG. **44**B illustrates Modification Example 5 (V zone); and FIG. **45** illustrates Modification Example 6 (V zone). FIG. **46** is a diagram illustrating Modification Example 7 (V zone) related to display of the first region image.

Display Example 1

[0357] First, with reference to FIG. **34**, a description will be made of a display method for a display example (V zone) in which the first region image **80** (time-series region images **81**, **82** and **83**) is displayed on the display section **25**.

[0358] As illustrated in FIG. **34**, the "V zone" corresponding to one of detailed analysis data is displayed as the first region image **80** (a plurality of time-series region images) on the display section **25**. Regarding display of the "V zone", a plurality of time-series region images **81**, **82** and **83** included in the first region image **80** are displayed together in a coordinate system having at least two indexes as axes on the display section **25**. In the display example 1, as two indexes related to the "V zone", a transverse axis expresses a position of the head **3***a* at halfway back ("HWB" or "HB"), and a longitudinal axis expresses a position of the head **3***a* at halfway down ("HWD" or "HD"). A region surrounded by an outer circumferential line indicating a variation range of each piece of analysis data is displayed in the first region image **80** with swing analysis data obtained by analyzing the previously performed swing as the plurality of time-series region images **81**, **82** and **83**. In other words, the magnitude of an area of a region surrounded by an outer circumferential line indicating a variation range of each of the plurality of time-series region images **81**, **82** and **83** corresponds to a variation between a plurality of pieces of data related to a plurality of swings. In this example, a large area of the region indicates that a variation is large.

[0359] The plurality of time-series region images **81**, **82** and **83** preferably have different display aspects. Specifically, regarding a plurality of time-series display aspects, the time-series region image **81** is displayed with a solid line, the time-series region image **82** is displayed with a dot chain line, and the time-series region image **83** is displayed with a dotted line (dashed line), as different display aspects. In the display example 1, as an example of display forming the time-series region image **81**, a "set of analysis data in a period from the present to 7 days ago" is displayed, as an example of display forming the time-series region image **82**, a "set of analysis data in a period from 8 days ago to 14 days ago" is displayed, and as an example of display forming the time-series region image **83**, a "set of analysis data in a period from 15 days ago to 21 days ago" is displayed. Such exemplary content is shown in a legend region (checkbox) **92**.

[0360] There is a tendency that, in a golfer (user **2**) having high skill, swing reproducibility is high, and a variation in each index is reduced when a plurality of swings are analyzed, but, on the other hand, in a golfer (user **2**) having low skill, swing reproducibility is low, and a variation in each index is increased when a plurality of swings are analyzed.

[0361] Therefore, as mentioned above, since the respective time-series region images **81**, **82** and **83** are displayed in different display aspects (for example, the types of lines, or colors) in the first region image **80**, the user **2** can easily identify a transition state from the past to the present at first sight with respect to the ability (level) related to a plurality of swings in the "V zone". Reference lines DL**1** and DL**2** are displayed, and thus the user can more easily identify a transition state. The reference lines DL**1** and DL**2** can be moved to any positions. An indicator **93** indicating the plurality of regions (refer to FIG. **24**A) is provided outside the coordinate system, and, in the following description, the same indicator **93** will not be described.

[0362] As illustrated in FIG. **34**, the display section **25** also displays the second region image **90** (cloud data) corresponding to the first region image **80** in relation to a plurality of swings performed by another user who is different from the user **2**. The second region image **90** indicates the concentration extent of analysis data related to a plurality of swings performed by another user through mapping (hit map) display on the background of the first region image **80**. In this example, the concentration extent of analysis data is divided through gradation display represented by color shading, and, as shown in a legend region (checkbox) **94**, a portion where data concentrates is displayed as a portion whose color is light (in FIG. **34**, a white portion).

[0363] In the display example 1, it can be seen that states of a plurality of swings performed by the user **2** are slightly biased toward the lower right in the figure compared with states of a plurality of swings performed by another user (the white portion which is a region where a plurality of pieces of swing data for another user concentrate). Consequently, the user **2** can check that there is a tendency that a shooting direction is a slightly rightward direction with respect to the ability (level) thereof compared with another user (another person). In the following display examples, the same checking can be performed, and thus a description thereof will be omitted in each display example.

Display Example 2

[0364] Next, with reference to FIG. **35**, a description will be made of a display example (rotation) of a first region

image **180** (time-series region images **181**, **182** and **183**) displayed on the display section **25**.

[0365] As illustrated in FIG. **35**, the "rotation" corresponding to one of detailed analysis data is displayed as the first region image **180** (a plurality of time-series region images) on the display section **25**. Regarding display of the "rotation", a plurality of time-series region images **181**, **182** and **183** included in the first region image **180** are displayed together in a coordinate system having at least two indexes as axes on the display section **25**. In the display example 2, as two indexes related to the "rotation", a longitudinal axis expresses an (absolute) face angle, and a transverse axis expresses a shaft axis rotation angle at top. A region surrounded by an outer circumferential line indicating a variation range of each piece of analysis data is displayed in the first region image **180** with swing analysis data obtained by analyzing the previously performed swing as the plurality of time-series region images **181**, **182** and **183**. In other words, the magnitude of an area of a region surrounded by an outer circumferential line indicating a variation range of each of the plurality of time-series region images **181**, **182** and **183** corresponds to a variation between a plurality of pieces of data related to a plurality of swings. In this example, a large area of the region indicates that a variation is large.

[0366] The plurality of time-series region images **181**, **182** and **183** have different display aspects, and, for example, the time-series region image **181** is displayed with a solid line, the time-series region image **182** is displayed with a dot chain line, and the time-series region image **183** is displayed with a dotted line (dashed line), as different display aspects. As shown in a legend region (checkbox) **192**, the time-series region image **181** exemplifies a "set of analysis data in a period from the present to 7 days ago", the time-series region image **182** exemplifies a "set of analysis data in a period from 8 days ago to 14 days ago", and the time-series region image **183** exemplifies a "set of analysis data in a period from 15 days ago to 21 days ago".

[0367] Therefore, as mentioned above, since the respective time-series region images **181**, **182** and **183** are displayed in different display aspects (for example, the types of lines, or colors) in the first region image **180**, the user **2** can easily identify a transition state from the past to the present at first sight with respect to the ability (level) related to a plurality of swings in the "rotation". Reference lines DL**1** and DL**2** are displayed, and thus the user can more easily identify a transition state. The reference lines DL**1** and DL**2** can be moved to any positions.

[0368] As illustrated in FIG. **35**, the display section **25** also displays the second region image **190** corresponding to the first region image **180** in relation to a plurality of swings performed by another user who is different from the user **2**. The second region image **190** indicates the concentration extent of analysis data related to a plurality of swings performed by another user through mapping (hit map) display on the background of the first region image **180**. In this example, the concentration extent of analysis data is divided through gradation display represented by color shading, and, as shown in a legend region (checkbox) **194**, a portion where data concentrates is displayed as a portion whose color is light (white portion).

Display Example 3

[0369] Next, with reference to FIG. **36**, a description will be made of a display example (impact) of a first region image **280** (time-series region images **281**, **282** and **283**) displayed on the display section **25**.

[0370] As illustrated in FIG. **36**, the "impact" corresponding to one of detailed analysis data is displayed as the first region image **280** (a plurality of time-series region images) on the display section **25**. Regarding display of the "impact", a plurality of time-series region images **281**, **282** and **283** included in the first region image **280** are displayed together in a coordinate system having at least two indexes as axes on the display section **25**. In the display example 3, as two indexes related to the "impact", a longitudinal axis expresses a relative face angle, and a transverse axis expresses a club path (incidence angle). A region surrounded by an outer circumferential line indicating a variation range of each piece of analysis data is displayed in the first region image **280** with swing analysis data obtained by analyzing the previously performed swing as the plurality of time-series region images **281**, **282** and **283**. In other words, the magnitude of an area of a region surrounded by an outer circumferential line indicating a variation range of each of the plurality of time-series region images **281**, **282** and **283** corresponds to a variation between a plurality of pieces of data related to a plurality of swings. In this example, a large area of the region indicates that a variation is large.

[0371] The plurality of time-series region images **281**, **282** and **283** have different display aspects, and, for example, the time-series region image **281** is displayed with a solid line, the time-series region image **282** is displayed with a dot chain line, and the time-series region image **283** is displayed with a dotted line (dashed line), as different display aspects. As shown in a legend region (checkbox) **292**, the time-series region image **281** exemplifies a "set of analysis data in a period from the present to 7 days ago", the time-series region image **282** exemplifies a "set of analysis data in a period from 8 days ago to 14 days ago", and the time-series region image **283** exemplifies a "set of analysis data in a period from 15 days ago to 21 days ago".

[0372] Therefore, as mentioned above, since the respective time-series region images **281**, **282** and **283** are displayed in different display aspects (for example, the types of lines, or colors) in the first region image **280**, the user **2** can easily identify a transition state from the past to the present at first sight with respect to the ability (level) related to a plurality of swings in the "impact". Reference lines DL**1** and DL**2** are displayed, and thus the user can more easily identify a transition state. The reference lines DL**1** and DL**2** can be moved to any positions.

[0373] As illustrated in FIG. **36**, the display section **25** also displays the second region image **290** corresponding to the first region image **280** in relation to a plurality of swings performed by another user who is different from the user **2**. The second region image **290** indicates the concentration extent of analysis data related to a plurality of swings performed by another user through mapping (hit map) display on the background of the first region image **280**. In this example, the concentration extent of analysis data is divided through gradation display represented by color shading, and, as shown in a legend region (checkbox) **294**, a portion where data concentrates is displayed as a portion whose color is light (white portion).

Display Example 4

[0374] Next, with reference to FIG. **37**, a description will be made of a display example (efficiency (swing efficiency))

of a first region image **380** (time-series region images **381**, **382** and **383**) displayed on the display section **25**.

[0375] As illustrated in FIG. **37**, the "efficiency (swing efficiency)" corresponding to one of detailed analysis data is displayed as the first region image **380** (a plurality of time-series region images) on the display section **25**. Regarding display of the "efficiency", a plurality of time-series region images **381**, **382** and **383** included in the first region image **380** are displayed together in a coordinate system having at least two indexes as axes on the display section **25**. In the display example 4, as two indexes related to the "efficiency", a longitudinal axis expresses natural release timing, and a transverse axis expresses natural uncock. A region surrounded by an outer circumferential line indicating a variation range of each piece of analysis data is displayed in the first region image **380** with swing analysis data obtained by analyzing the previously performed swing as the plurality of time-series region images **381**, **382** and **383**. In other words, the magnitude of an area of a region surrounded by an outer circumferential line indicating a variation range of each of the plurality of time-series region images **381**, **382** and **383** corresponds to a variation between a plurality of pieces of data related to a plurality of swings. In this example, a large area of the region indicates that a variation is large.

[0376] The plurality of time-series region images **381**, **382** and **383** have different display aspects, and, for example, the time-series region image **381** is displayed with a solid line, the time-series region image **382** is displayed with a dot chain line, and the time-series region image **383** is displayed with a dotted line (dashed line), as different display aspects. As shown in a legend region (checkbox) **392**, the time-series region image **381** exemplifies a "set of analysis data in a period from the present to 7 days ago", the time-series region image **382** exemplifies a "set of analysis data in a period from 8 days ago to 14 days ago", and the time-series region image **383** exemplifies a "set of analysis data in a period from 15 days ago to 21 days ago".

[0377] Therefore, as mentioned above, since the respective time-series region images **381**, **382** and **383** are displayed in different display aspects (for example, the types of lines, or colors) in the first region image **380**, the user **2** can easily identify a transition state from the past to the present at first sight with respect to the ability (level) related to a plurality of swings in the "efficiency". Reference lines DL**1** and DL**2** are displayed, and thus the user can more easily identify a transition state. The reference lines DL**1** and DL**2** can be moved to any positions.

[0378] As illustrated in FIG. **37**, the display section **25** also displays the second region image **390** corresponding to the first region image **380** in relation to a plurality of swings performed by another user who is different from the user **2**. The second region image **390** indicates the concentration extent of analysis data related to a plurality of swings performed by another user through mapping (hit map) display on the background of the first region image **380**. In this example, the concentration extent of analysis data is divided through gradation display represented by color shading, and, as shown in a legend region (checkbox) **394**, a portion where data concentrates is displayed as a portion whose color is light (white portion).

Display Example 5

[0379] Next, with reference to FIG. **38**, a description will be made of a display example (head speed) of a first region image **480** (time-series region images **481**, **482** and **483**) displayed on the display section **25**.

[0380] As illustrated in FIG. **38**, the "head speed" corresponding to one of detailed analysis data is displayed as the first region image **480** (a plurality of time-series region images) on the display section **25**. Regarding display of the "head speed", a polygonal line graph (a plurality of time-series region images **481**, **482** and **483**) as the first region image **480** is displayed in a coordinate system having at least two indexes as axes on the display section **25**. In the display example 5, as two indexes related to the "head speed", a longitudinal axis expresses a frequency, and a transverse axis expresses a head speed. A region surrounded by an outer circumferential line indicating a variation range of each piece of analysis data is displayed in the first region image **480** with swing analysis data obtained by analyzing the previously performed swing as the plurality of time-series region images **481**, **482** and **483**.

[0381] The time-series region image **481** is displayed with a solid line, the time-series region image **482** is displayed with a dot chain line, and the time-series region image **483** is displayed with a dotted line (dashed line), as different display aspects. The time-series region image **481** exemplifies a "set of analysis data in a period from the present to 7 days ago", the time-series region image **482** exemplifies a "set of analysis data in a period from 8 days ago to 14 days ago", and the time-series region image **483** exemplifies a "set of analysis data in a period from 15 days ago to 21 days ago".

[0382] The display section **25** displays the second region image **485** corresponding to the first region image **480** in relation to a plurality of swings performed by another user who is different from the user **2** along with the above-described first region image **480**. The second region image **485** is displayed on the background of the first region image **480**, and indicates a distribution (concentration extent) of analysis data regarding a head speed related to a plurality of swings performed by another user as a frequency distribution based on a histogram.

[0383] Since the respective time-series region images **481**, **482** and **483** are displayed in different display aspects (for example, the types of lines, or colors) in the first region image **480**, the user **2** can easily identify a transition state from the past to the present at first sight with respect to the ability (level) related to a plurality of swings in the "head speed".

Display Example 6

[0384] Next, with reference to FIGS. **39**A and **39**B, a description will be made of a display example (hands-up) of a first region image **580** (time-series region images **581**, **582** and **583**) displayed on the display section **25**. Here, prior to description of the display example, a hands-up angle and a hands-down angle will be described with reference to FIG. **39**A. As illustrated in FIG. **39**A, an attitude (position) of the hands **2***a* of the user **2** holding the golf club **3** has a hands-down state in which a position of the hands **2***a* is low and a hands-up state in which a position of the hands **2***a* is high. In the hands-down state, an inclination angle of the golf club **3** is obtained on the basis of a position (height H**1**)

of the sensor unit **10** interlocking with a position of the hands **2***a*, and a length from an attachment position of the sensor unit **10** to the head **3***a*, and this angle θ1 is used as a hands-down angle. In the hands-up state, in the same manner as described above, an inclination angle of the golf club **3** is obtained on the basis of a position (height H**1**) of the sensor unit **10** interlocking with a position of the hands **2***a*, and a length from an attachment position of the sensor unit **10** to the head **3***a*, and this angle θ2 is used as a hands-up angle.

[0385] As illustrated in FIG. **39**B, the "hands-up" corresponding to one of detailed analysis data is displayed as the first region image **580** (a plurality of time-series region images) on the display section **25**. Regarding display of the "hands-up", a plurality of time-series region images **581**, **582** and **583** included in the first region image **580** are displayed together in a coordinate system having at least two indexes as axes on the display section **25**. In the display example 6, as two indexes related to the "hands-up", a longitudinal axis expresses a lie angle at impact, and a transverse axis expresses a lie angle at address. A region surrounded by an outer circumferential line indicating a variation range of each piece of analysis data is displayed in the first region image **580** with swing analysis data obtained by analyzing the previously performed swing as the plurality of time-series region images **581**, **582** and **583**. In other words, the magnitude of an area of a region surrounded by an outer circumferential line indicating a variation range of each of the plurality of time-series region images **581**, **582** and **583** corresponds to a variation between a plurality of pieces of data related to a plurality of swings. In this example, a large area of the region indicates that a variation is large.

[0386] The plurality of time-series region images **581**, **582** and **583** have different display aspects, and, for example, the time-series region image **581** is displayed with a solid line, the time-series region image **582** is displayed with a dot chain line, and the time-series region image **583** is displayed with a dotted line (dashed line), as different display aspects. As shown in a legend region (checkbox) **592**, the time-series region image **581** exemplifies a "set of analysis data in a period from the present to 7 days ago", the time-series region image **582** exemplifies a "set of analysis data in a period from 8 days ago to 14 days ago", and the time-series region image **583** exemplifies a "set of analysis data in a period from 15 days ago to 21 days ago".

[0387] Therefore, as mentioned above, since the respective time-series region images **581**, **582** and **583** are displayed in different display aspects (for example, the types of lines, or colors) in the first region image **580**, the user **2** can easily identify a transition state from the past to the present at first sight with respect to the ability (level) related to a plurality of swings in the "hands-up". A reference line DL**1** is displayed, and thus the user can more easily identify a transition state. The reference line DL**1** can be moved to any position.

[0388] As illustrated in FIG. **39**B, the display section **25** also displays the second region image **590** corresponding to the first region image **580** in relation to a plurality of swings performed by another user who is different from the user **2**. The second region image **590** indicates the concentration extent of analysis data related to a plurality of swings performed by another user through mapping (hit map) display on the background of the first region image **580**. In this example, the concentration extent of analysis data is divided through gradation display represented by color shading, and, as shown in a legend region (checkbox) **594**, a portion where data concentrates is displayed as a portion whose color is light (white portion).

Display Example 7

[0389] Next, with reference to FIG. **40**, a description will be made of a display example (down blow) of a first region image **680** (time-series region images **681**, **682** and **683**) displayed on the display section **25**.

[0390] As illustrated in FIG. **40**, the "down blow" corresponding to one of detailed analysis data is displayed as the first region image **680** (a plurality of time-series region images) on the display section **25**. Regarding display of the "down blow", a plurality of time-series region images **681**, **682** and **683** included in the first region image **680** are displayed together in a coordinate system having at least two indexes as axes on the display section **25**. In the display example 7, as two indexes related to the "down blow", a longitudinal axis expresses a face angle, and a transverse axis expresses an attack angle. A region surrounded by an outer circumferential line indicating a variation range of each piece of analysis data is displayed in the first region image **680** with swing analysis data obtained by analyzing the previously performed swing as the plurality of time-series region images **681**, **682** and **683**. In other words, the magnitude of an area of a region surrounded by an outer circumferential line indicating a variation range of each of the plurality of time-series region images **681**, **682** and **683** corresponds to a variation between a plurality of pieces of data related to a plurality of swings. In this example, a large area of the region indicates that a variation is large.

[0391] The plurality of time-series region images **681**, **682** and **683** have different display aspects, and, for example, the time-series region image **681** is displayed with a solid line, the time-series region image **682** is displayed with a dot chain line, and the time-series region image **683** is displayed with a dotted line (dashed line), as different display aspects. As shown in a legend region (checkbox) **692**, the time-series region image **681** exemplifies a "set of analysis data in a period from the present to 7 days ago", the time-series region image **682** exemplifies a "set of analysis data in a period from 8 days ago to 14 days ago", and the time-series region image **683** exemplifies a "set of analysis data in a period from 15 days ago to 21 days ago".

[0392] Therefore, as mentioned above, since the respective time-series region images **681**, **682** and **683** are displayed in different display aspects (for example, the types of lines, or colors) in the first region image **680**, the user **2** can easily identify a transition state from the past to the present at first sight with respect to the ability (level) related to a plurality of swings in the "down blow". Reference lines DL**1** and DL**2** are displayed, and thus the user can more easily identify a transition state. The reference lines DL**1** and DL**2** can be moved to any positions.

[0393] As illustrated in FIG. **40**, the display section **25** also displays the second region image **690** corresponding to the first region image **680** in relation to a plurality of swings performed by another user who is different from the user **2**. The second region image **690** indicates the concentration extent of analysis data related to a plurality of swings performed by another user through mapping (hit map) display on the background of the first region image **680**. In this example, the concentration extent of analysis data is

divided through gradation display represented by color shading, and, as shown in a legend region (checkbox) **694**, a portion where data concentrates is displayed as a portion whose color is light (white portion).

[0394] According to the display performed in the above-described display examples 1 to 7, the following effects are achieved. In the following description, effects related to the display example 1 will be described as representative effects, but the other display examples 2 to 7 achieve the same effects.

[0395] According to the display methods as described, a plurality of time-series region images **81**, **82** and **83** included in the first region image **80** based on the first analysis information related to a plurality of swings are displayed together in a coordinate system having at least two indexes (positions of the head **3***a* at halfway back (HWB) and at halfway down (HWD)) as axes. Since such display is performed, the user **2** can visually recognize transition of the first analysis information related to a plurality of swings as the plurality of time-series region images **81**, **82** and **83**. Consequently, the user **2** can specifically and objectively visually recognize and check the extent of the present ability (level) of the user related to a plurality of swings in addition to a variation.

[0396] According to the display method, the second region image **90** corresponding to the first region image **80** in relation to a plurality of swings performed by another user who is different from the user **2** is displayed along with the first region image **80** for the user **2** in a coordinate system having at least two indexes as axes on the display section **25**. Consequently, the user **2** can easily compare the first region image **80** for the user **2** with the second region image **90** related to swings performed by another person, and can thus objectively perform evaluation. For example, if a user who is different from the user **2** is set as a person who has to be a model, for example, a leader or a pro golfer, it is possible to objectively evaluate a difference between the ability of the user **2** and the ability of the leader or the pro golfer.

Modification Example 1 Related to Display Method

[0397] Next, with reference to FIG. **41**, display related to the "V zone" will be described as a representative example with respect to Modification Example 1 related to the display method. In Modification Example 1 related to the display method, data related to the "V zone" in a plurality of swings performed by the user **2** is displayed as set data **786** along with a first region image **780**.

[0398] In Modification Example 1 related to the display method, as illustrated in FIG. **41**, in the same manner as the first region image **80** (time-series region images **81**, **82** and **83**) in the above-described display example 1, the first region image **780** (time-series region images **781**, **782** and **783**) is displayed in a coordinate system having two indexes as axes on the display section **25**. Therefore, detailed description of the first region image **780** (time-series region images **781**, **782** and **783**) will be omitted here.

[0399] In Modification Example 1, data related to the "V zone" in a plurality of swings performed by the user **2**, collected as raw data for generating the first region image **780** (time-series region images **781**, **782** and **783**) is displayed as set data **786** plotted as in a scatter diagram through dot display on the display section **25** along with the first region image **780** (time-series region images **781**, **782** and **783**).

[0400] As mentioned above, since the set data **786** is plotted along with the first region image **780** (time-series region images **781**, **782** and **783**), the user **2** can easily perform comparison with the whole data related to the "V zone" and can identify a transition state from the past to the present, with respect to the present ability (level) in the "V zone". The user **2** can objectively evaluate the present ability (level) in the "V zone".

Modification Example 2 Related to Display Method

[0401] Next, with reference to FIG. **42**, display related to the "V zone" will be described as a representative example with respect to Modification Example 2 related to the display method. In Modification Example 2 related to the display method, a region in which the extent of collected data related to the "V zone" in a plurality of swings performed by the user **2** is equal to or more than a predetermined collection density is displayed, for example, as a region **886** so as to be surrounded by a curve, along with a first region image **880**.

[0402] In Modification Example 2 related to the display method, as illustrated in FIG. **42**, in the same manner as the first region image **80** (time-series region images **81**, **82** and **83**) related to the above-described display example 1, the first region image **880** (time-series region images **881**, **882** and **883**) is displayed in a coordinate system having two indexes as axes on the display section **25**. Therefore, detailed description of the first region image **880** (time-series region images **881**, **882** and **883**) will be omitted here.

[0403] In Modification Example 2, data related to the "V zone" in a plurality of swings performed by the user **2**, collected as raw data for generating the first region image **880** (time-series region images **881**, **882** and **883**) is displayed as the region **886** using a contour with a predetermined collection density as a threshold value on the display section **25** along with the first region image **880** (time-series region images **881**, **882** and **883**).

[0404] As mentioned above, since the region **886** surrounded by the curve with the predetermined collection density as a threshold value is displayed along with the first region image **880** (time-series region images **881**, **882** and **883**), the user **2** can easily perform comparison with the whole data related to the "V zone" and can identify a transition state from the past to the present, with respect to the present ability (level) in the "V zone". The user **2** can objectively evaluate the present ability (level) in the "V zone".

Modification Example 3 Related to Display Method

[0405] Next, with reference to FIG. **43**, display related to the "V zone" will be described as a representative example with respect to Modification Example 3 related to the display method.

[0406] In Modification Example 3 related to the display method, as illustrated in FIG. **43**, in the same manner as the first region image **80** (time-series region images **81**, **82** and **83**) related to the above-described display example 1, the first region image **980** (time-series region images **981**, **982** and **983**) is displayed in a coordinate system having two indexes as two axes on the display section **25**. Therefore, detailed description of the first region image **980** (time-series region images **981**, **982** and **983**) will be omitted here.

[0407] In Modification Example 3, in addition to the time-series region images **981**, **982** and **983**, analysis data (first analysis information **987**) located outside the regions is plotted through dot display on the display section **25**. In other words, on the display section **25** in Modification Example 3, the time-series region images **981**, **982** and **983**, and the analysis data (first analysis information **987**) located outside the regions **981**, **982** and **983** are displayed together on the display section **25**.

[0408] Also in this display, the user **2** can easily perform comparison with the whole data related to the "V zone" and can identify a transition state from the past to the present, with respect to the present ability (level) in the "V zone". The user **2** can objectively evaluate the present ability (level) in the "V zone".

Modification Example 4 Related to Display Method

[0409] Next, with reference to FIG. **44**A, display related to the "V zone" will be described as a representative example with respect to Modification Example 4 related to the display method.

[0410] In Modification Example 4 related to the display method, analysis data **1080** related to the "V zone" in a plurality of swings performed by the user **2** is plotted through dot display in a coordinate system having two indexes as two axes. The concentration extent of analysis data related to a plurality of swings performed by another user is displayed as a second region image **1090** through mapping (hit map) display on the background of the analysis data **1080** displayed in a dot form.

[0411] Also in this display method, in the same manner as described above, the user **2** can objectively evaluate the present ability related to the "V zone" while performing comparison with analysis data related to a plurality of swings performed by another user.

Modification Example 5 Related to Display Method

[0412] Next, with reference to FIG. **44**B, display related to the "V zone" will be described as a representative example with respect to Modification Example 5 related to the display method.

[0413] In Modification Example 5 related to the display method, analysis data **1080** related to the "V zone" in a plurality of swings performed by the user **2** is plotted through dot display in a coordinate system having two indexes as two axes. The coordinate system is divided into a plurality of regions. In Modification Example 5, the coordinate system is divided into four regions including a first quadrant Z**1**, a second quadrant Z**2**, a third quadrant Z**3**, and a fourth quadrant Z**4** by reference lines DL**1** and DL**2**. A proportion of plot points of a first region image (analysis data **1080**) occupying each of the separate four regions (the first quadrant Z**1**, the second quadrant Z**2**, the third quadrant Z**3**, and the fourth quadrant Z**4**) is displayed in a percentage (%) in a display region **96**. The concentration extent of analysis data related to a plurality of swings performed by another user is displayed as a second region image **1090** through mapping (hit map) display on the background of the analysis data **1080** displayed in a dot form.

[0414] According to this display, since a proportion of the first region image related to respective swings, included in each of the separate four regions (the first quadrant Z**1**, the second quadrant Z**2**, the third quadrant Z**3**, and the fourth quadrant Z**4**) into which the coordinate system is divided, that is, a proportion of each swing is displayed, the user **2** can objectively check biasing or the like in analysis results of a plurality of swings. It is possible to perform comparison with analysis data related to a plurality of swings performed by another user.

[0415] A proportion of plot points of a second region image **1090** which is analysis data for another user who is different from the user **2**, occupying each of the separate four regions (the first quadrant Z**1**, the second quadrant Z**2**, the third quadrant Z**3**, and the fourth quadrant Z**4**) obtained by dividing the coordinate system is divided into the first quadrant Z**1**, the second quadrant Z**2**, the third quadrant Z**3**, and the fourth quadrant Z**4** with the reference lines DL**1** and DL**2** may be displayed in a percentage (%) in the display region **96**.

[0416] In the above-described way, the second region image **1090** corresponding to the first region image (analysis data **1080**) in relation to a plurality of swings performed by another user, included in each of the regions (the first quadrant Z**1**, the second quadrant Z**2**, the third quadrant Z**3**, and the fourth quadrant Z**4**) into which the coordinate system is divided, is displayed, and thus the user **2** can understand a swing state of another person.

Modification Example 6 Related to Display Method

[0417] Next, with reference to FIG. **45**, display related to the "V zone" will be described as a representative example with respect to Modification Example 6 related to the display method.

[0418] In Modification Example 6 related to the display method, regarding display of the "V zone", in the same manner as in the above-described display example 1, a plurality of time-series region images **81**, **82** and **83** included in the first region image **80** are displayed together in a coordinate system having at least two indexes as axes on the display section **25**. A region surrounded by an outer circumferential line indicating a variation range of each piece of analysis data is displayed in the first region image **80** with swing analysis data obtained by analyzing the previously performed swing as the plurality of time-series region images **81**, **82** and **83**. In the same manner as in the above-described display example 1, the display section **25** also displays the second region image **90** (cloud data) corresponding to the first region image **80** in relation to a plurality of swings performed by another user who is different from the user **2** through mapping (hit map) along with the first region image **80**.

[0419] In the above-described display example 1 ("V zone") illustrated in FIG. **34**, the legends written in the legend region (checkbox) **92** describe time-series conditions (for example, the set "~7 days" of analysis data in a period from the present to 7 days ago) for the region images **81**, **82** and **83**.

[0420] On the other hand, in the display related to Modification Example 6, legends written in a legend region (checkbox) **92***a* respectively indicate the variation extents of the region images **81**, **82** and **83**, such as "83.6". The variation extents are obtained according to the following Equations (18) to (26). In the following equations, for example, scores ranging from 0 to 100 may be obtained by performing normalization of data on each of a longitudinal axis and a transverse axis using Equations (18) and (19), or calculation of an average value using Equations (20) and

(21). Here, x_i and y_i indicate respectively a transverse axis and a longitudinal axis of a graph related to the display example. A variation is reduced, that is, an area of the region surrounded by the outer circumferential line becomes smaller as a value of the obtained variation extent becomes greater (closer to 100).

$$x_i = x_i / x_{max} \tag{18}$$

$$y_i = y_i / y_{max} \tag{19}$$

$$\tilde{x} = \frac{\Sigma_N x_i}{N} \tag{20}$$

$$\tilde{y} = \frac{\Sigma_N y_i}{N} \tag{21}$$

$$\alpha = \frac{\Sigma_N \sqrt{(x_i - \tilde{x})^2 + (y_i - \tilde{y})^2}}{N} \tag{22}$$

$$\beta = K \times \alpha \tag{23}$$

$$\gamma = (1 - \beta) \times 100 \tag{24}$$

$$\text{if } (\gamma < 0)\ \gamma = 0 \tag{25}$$

$$\text{if } (\gamma > 100)\ \gamma = 100 \tag{26}$$

[0421] Here, N indicates the number of x_i (the number of y_i is the same as that); x_{max} indicates the maximum value of x_i (where i=0, 1, 2, . . . , and N); y_{max} indicates the maximum value of y_i (where i=0, 1, 2, . . . , and N); ~x in Equation (20) indicates an average value of x_i (where i=0, 1, 2, . . . , and N); ~y in Equation (21) indicates an average value of y_i (where i=0, 1, 2, . . . , and N); α indicates an average value of distances from the average value ~x on a transverse axis and the average value ~y on a longitudinal axis; K indicates a coefficient for controlling addition of scores such as 0 to 100 points; β indicates a numerical value which becomes smaller as a variation decreases and which becomes greater as a variation increases; and γ indicates a score (0 to 100).

[0422] As mentioned above, since a variation in each of the region images **81**, **82** and **83** is expressed by using a region (image) and a numerical value, the user **2** can easily identify transition states of ability (level) and the variation extent from the past to the present at first sight.

Modification Example 7 Related to Display Method

[0423] Next, with reference to FIG. **46**, display related to the "V zone" will be described as a representative example with respect to Modification Example 7 related to the display method.

[0424] In Modification Example 7 related to the display method, as illustrated in FIG. **46**, in the same manner as in the above-described display example 1, the first region image **80** (time-series region images **81**, **82** and **83**) is displayed in a coordinate system having at least two indexes as two axes on the display section **25**. In the same manner as in the above-described display example 1, the display section **25** also displays the second region image **90** (cloud data) corresponding to the first region image **80** in relation to a plurality of swings performed by another user who is different from the user **2** through mapping (hit map) along with the first region image **80**. In Modification Example 7 related to the display method, not only the first region image **80** (time-series region images **81**, **82** and **83**) but also a target region **84** indicating a state at which the user **2** aims is displayed in the coordinate system having the two indexes as two axes. The target region **84** may be arbitrarily designated by the user **2**.

[0425] Since the predetermined target region **84** is displayed in the coordinate system, the user **2** can specifically and objectively visually recognize and check to what extent there is a gap with the target related to a swing, or to what extent the present ability (level) is improved with respect to the target in addition to a variation.

[0426] In the embodiment, the swing analysis portion **211** detects impact by using the square root of the square sum as shown in Equation (2) as a combined value of three-axis angular velocities measured by the sensor unit, but, as a combined value of three-axis angular velocities, for example, a square sum of three-axis angular velocities, a sum or an average of three-axis angular velocities, or the product of three-axis angular velocities may be used. Instead of a combined value of three-axis angular velocities, a combined value of three-axis accelerations such as a square sum or a square root of three-axis accelerations, a sum or an average value of three-axis accelerations, or the product of three-axis accelerations may be used.

[0427] In the embodiment, the score calculation portion **311** may calculate scores and a total score of a plurality of items on the basis of the selected swing analysis data **248** without displaying the input data editing screen as illustrated in FIG. **8**. The score calculation portion **311** may calculate scores and a total score of a plurality of items on the basis of input data (for example, all indexes are manually input data) in which all values of indexes indicating features of a swing are pseudo-values.

[0428] In the embodiment, the score calculation portion **311** calculates scores of seven items including the "V zone" item, the "rotation" item, the "impact" item, the "down blow" or "upper blow" item, the "efficiency (swing efficiency)" item, the "head speed" item, and the "hands-up" item, but may not calculate scores of some of the items, and may calculate scores of other items. In the present embodiment, the score calculation portion **311** calculates a total score, but may not calculate a total score.

[0429] In the embodiment, the score calculation portion **311** calculates scores of a plurality of items by using various score tables, but may use equations instead of the score tables.

[0430] In the embodiment, the score calculation portion **311** may also function as the swing analysis portion **211**, and may perform a swing diagnosis process (a swing analysis process and a score calculation process) including the swing analysis process on the basis of measured data (an output signal from an inertial sensor) from the sensor unit **10**, which is data regarding a swing.

[0431] In the above-described embodiment, the concept of the V zone (a region interposed between the shaft plane and the Hogan plane) is introduced in order to define the regions A, B, C, D and E in which the head **3***a* is included. The V zone is a region interposed between the first virtual plane along the longitudinal direction of the golf club **3** and the second virtual plane passing through the vicinity of the shoulder of the user **2** (refer to FIG. **47**A). The first virtual plane is, for example, a so-called shaft plane specified by a first axis along a target hit ball direction and a second axis along the longitudinal direction of the golf club **3** before a

swing is started. The second virtual plane is, for example, a so-called Hogan plane which includes the first axis, and forms a predetermined angle with the first virtual plane. However, the second virtual plane may be a virtual plane (including both of a virtual plane parallel to the first virtual plane and a virtual plane along the first virtual plane) which is parallel to the first virtual plane. A parallel virtual plane may be referred to as a "shoulder plane" (refer to FIG. **47**B). In the above-described embodiment, the second virtual plane may be calculated on the basis of both of the first virtual plane and the physical information **244** of the user **2**, and a plane having a predetermined relationship with the first virtual plane may be the second virtual plane.

[0432] A method of defining the first virtual plane and the second virtual plane is not limited thereto, and, for example, virtual planes as illustrated in FIG. **47**C may be used. Two virtual planes illustrated in FIG. **47**C are virtual planes which are set on the basis of an attitude of the shaft before a swing is started, in which a first plane is a virtual plane passing through the vicinity of the elbow of the user **2**, and a second plane is a virtual plane passing through the vicinity of the knee of the user. The first virtual plane and the second virtual plane are not parallel to each other, and intersect each other on a straight line extending in a grip end direction of the golf club **3**, for example.

Modification Example 8 of Another Display Method

[0433] Next, with reference to FIG. **48**, a description will be made of Modification Example 8 related to another display method of an analysis result. FIG. **48** is a diagram illustrating Modification Example 8 related to another display method of an analysis result.

[0434] In Modification Example 8 related to another display method of an analysis result, as illustrated in FIG. **48**, for example, pieces of record data of pro golfers A, B and C who the user **2** aims to become are displayed as regions. Time-series records are plotted from the previous record value P of the user **2**, and, thus, for example, a line segment L**10** or L**20** can be drawn. For example, in a case where the user **2** aims to become the pro golfer C, if time-series plots are arranged as in the line segment L**10**, it can be seen that the user's attitude comes close to a target attitude. On the other hand, if time-series plots are arranged as in the line segment L**20**, it can be seen that the user's attitude becomes distant from the target attitude, that is, the user's attitude is not directed toward the target attitude.

[0435] As mentioned above, since the record value P indicating a position of the user, the target regions (for example, record data of the pro golfers A, B and C), and the record values which are plotted in a time series from the record value P are displayed, the user **2** can visually understand whether or not the user is directed toward a target related to a swing at first sight.

[0436] The display of the target regions (for example, the record data of the pro golfers A, B and C) may be changed, for example, by tapping a position of a desired target region on a screen.

[0437] As described above, comments on diagnosis information based on the first region image **80** or a practice method based on the diagnosis information may be displayed along with the first region image **80** or the second region image **90** displayed as an image on the display section **25**. Since the comments on the diagnosis information or the practice method based on the diagnosis information are displayed, the user **2** can easily understand a swing state, and can thus take appropriate measures to improve a swing or perform efficient practice.

[0438] In the coordinate system in the above-described display method, for example, a description has been made of an example in which the transverse axis expresses halfway back, and the longitudinal axis expresses halfway down, as two indexes related to the "V zone", but indexes on the transverse axis and the longitudinal axis are not limited thereto, and, for example, indexes on the transverse axis and the longitudinal axis may be replaced with each other, for example, the transverse axis expresses halfway down. In the coordinate system in the above-described display method, a combination with other indexes may be used as necessary.

[0439] In the above-described display method, along with the first region image **80** (for example, the time-series region images **81**, **82** and **83**), switching may occur in a target (for example, the second region image **90**) displayed as the background so that switching occur between meanings indicated by the background. Specifically, the second region image **90** switches between male version cloud data and female version cloud data as a second region image (cloud data) corresponding to the first region image **80** in relation to a plurality of swings performed by another user so that the background is displayed as a meaning indicating the tendency of the user **2**, and thus various display combinations may occur.

1-6. Modification Example of Motion Analysis System

[0440] Next, with reference to FIGS. **49** and **50**, a modification example of the motion analysis system will be described. FIG. **49** is a diagram illustrating a configuration example of a motion analysis system related to a modification example, and FIG. **50** is a diagram illustrating an arrangement example of a sensor unit and a swing analysis apparatus related to the modification example.

[0441] A swing diagnosis system **1000** as a motion analysis system related to the modification example is configured to include a sensor unit (an example of an inertial sensor) **10**, a user terminal **320**, a customer terminal **350**, and a server **300** as illustrated in FIGS. **49** and **50**. Above all, the user terminal **320**, the customer terminal **350**, and the server **300** are connected to the network **40** such as the Internet, and can transmit and receive information to and from each other. A use example of the sensor unit **10** is the same as in the above-described embodiment, and flows of information transmitted and received among the sensor unit **10**, the user terminal **320**, the server **300**, and the customer terminal **350** are the same as illustrated in FIG. **49**.

[0442] A user of the sensor unit **10** is, for example, a purchaser of the sensor unit **10**. The sensor unit **10** is attached to, for example, the golf club **3** owned by the user, and is used for a golf swing practice of the user. An operator of the user terminal **320** is the same as the user. The user terminal **320** is used for the user to operate the sensor unit **10** or to access the server **300**.

[0443] A manager of the customer terminal **350** is a golf goods manufacturer or a golf goods shop dealing in various types of golf clubs (examples of exercise appliances). The manufacturer or the shop is a customer to a manager of the server **300** (hereinafter, referred to as a "customer" as appropriate). A user visits the manufacturer or the shop in order to purchase a golf club.

[0444] An operator of the customer terminal **350** is an employee of a customer (the manufacturer or the shop). In the present modification example, the employee is a person (hereinafter, simply referred to as a "fitter") who allows a user visiting the manufacturer or the shop to try to hit a ball, so as to find a golf club fitted to the user, and prompts the user to purchase the golf club.

[0445] The manager of the server **300** is, for example, a person who made a promise to provide a program or various pieces of information for controlling the sensor unit **10** to the user terminal **320** in advance. The manager of the server **300** is also a person who made a promise to provide information to each of a plurality of customers including the customer (that is, the manufacturer or the shop) of the present modification example.

[0446] A user (not illustrated) attaches the sensor unit **10** to the golf club **3** owned by the user, and inputs physical information of the user, information regarding the golf club (golf club information), sensor attachment position information, and the like to the user terminal **320**. The physical information includes, for example, a height of the user, a length of the arms, a length of the legs, the sex, and other information. The golf club information includes, for example, information regarding a manufacturer name of the golf club **3**, a product number, a club number, a club type (a head type and a shaft type), a specification (a length of the shaft, a position of the centroid thereof, a lie angle, a face age, a loft angle, and the like).

[0447] Next, the user performs a measurement starting operation (an operation for causing the sensor unit **10** to start measurement) via the user terminal **320**. Next, after receiving a notification (for example, a notification using a voice) of giving an instruction for taking an address attitude (a basic attitude before starting a swing) from the user terminal **320**, the user takes an address attitude so that the axis in the longitudinal direction of the shaft of the golf club **3** is perpendicular to a target line (target hit ball direction), and stands still. The attitude of the user **2** illustrated in FIG. **2** is the address attitude.

[0448] Next, the user receives a notification (for example, a notification using a voice) of permitting a swing from the user terminal **320**, and then hits the golf ball **4** by performing a swing action.

[0449] If the user **2** performs the measurement starting operation, the user terminal **320** transmits a measurement starting command to the sensor unit **10**, and the sensor unit starts measurement of three-axis accelerations and three-axis angular velocities and sequentially transmits the measured data to the user terminal **320**. Then, the user terminal **320** analyzes the swing action on the basis of the received measured so as to generate swing analysis data, and transmits the swing analysis data to the server **300**.

[0450] The swing action performed by the user **2** includes an action reaching impact (ball hitting) at which the golf ball **4** is hit through respective states of halfway back at which the shaft of the golf club **3** becomes horizontal during a backswing after starting a swing (backswing), a top at which the swing changes from the backswing to a downswing, and halfway down at which the shaft of the golf club **3** becomes horizontal during the downswing. For example, a swing time point (date and time), user identification information (user ID), the sex of the user **2**, the golf club information, the physical information of the user **2**, and the sensor attachment position information are added to the swing analysis data which is transmitted from the user terminal **320** to the server **300**.

[0451] Here, in a case where a carry is not increased even if the user of the present modification example uses the golf club, the user visits the shop or the manufacturer who is an owner of the customer terminal **350** in order to examine purchase of a new golf club.

[0452] The fitter accesses the server **300** by operating the customer terminal **350**, and calls a home screen (an input screen of the user ID) which is displayed on the customer terminal **350**.

[0453] Next, the fitter prompts the user to input the user ID of the user visiting the shop or the manufacturer to the customer terminal **350**.

[0454] If the user ID is input to the customer terminal **350**, the user ID and a customer ID are transmitted from the customer terminal **350** to the server **300**. Here, a case is assumed in which the customer terminal **350** stores the customer ID in advance. In a case where the customer is not stored, the fitter may input the customer ID to the customer terminal **350**. The fitter may input the user ID to the customer terminal **350** instead of the user.

[0455] Thereafter, a diagnosis result is transmitted from the server **300** to the customer terminal **350**, and is displayed on the customer terminal **350**. The diagnosis result in the present modification example includes a recommended golf club type (recommended club type) which is recommended to the user by the shop or the manufacturer. The recommended club type is expressed by, for example, a combination of a recommended shaft type and a recommended head type.

[0456] Next, the fitter checks the recommended club type displayed on the customer terminal **350**, and picks up one or a plurality of golf clubs included in the recommended club type among a plurality of golf clubs stored in the shop or the manufacturer to which the fitter belongs.

[0457] Next, the fitter allows the user to actually try to hit a ball (swing) with one or a plurality of golf clubs having been picked up, and thus determines whether or not the picked-up golf club is fitted to the user.

[0458] If the fitter determines that the picked-up golf club is not fitted to the user, the fitter picks up another golf club type stored in the shop or the manufacturer, and allows the user to try to hit a ball with the golf club. The fitter repeatedly performs this, and thus searches for a golf club fitted to the user.

[0459] If a golf club type fitted to the user is found, the user purchases the fitted golf club type.

[0460] If the user purchases the golf club, the fitter inputs the club type of purchased golf club (purchased club type) to the customer terminal **350**. The input of fitting data performed by the fitter is performed, for example, by selecting (touching or clicking) a region in which the purchased club type is included.

[0461] As a result, fitting data indicating the recommended club type and the purchased club type is transmitted from the customer terminal **350** to the server **300**.

[0462] In a case where a difference between the recommended club type and the purchased club type is small, the accuracy of swing diagnosis in the server **300** may be regarded to be high (the recommended club type is fitted to the user), and, in a case where a difference between the recommended club type and the purchased club type is great,

the accuracy of swing diagnosis in the server **300** may be regarded to be low (the recommended club type is not fitted to the user).

[0463] Therefore, in the present modification example, the fitting data transmitted to the server **300** is used for correction (feedback correction) of a diagnosis table (an example of a diagnosis reference) in the server **300**. The diagnosis table which is a target of the feedback correction is a diagnosis table dedicated to the customer (the shop or the manufacturer) of the present modification example.

[0464] Therefore, in the present modification example, as the number of times of the fitter using the swing diagnosis system **1000** is increased, the diagnosis table (an example of a customer diagnosis reference) dedicated to the customer (the shop or the manufacturer) is optimized (customized), and thus the accuracy of swing diagnosis is improved. In other words, a probability that a recommended club type may be fitted to a user is improved.

[0465] If the accuracy of swing diagnosis is improved, the fitter belonging to the shop or the manufacturer, even a beginner, can reduce the time required to find a golf club fitted to a user (the time required for fitting). In this case, the time required for a user to purchase a golf club is also reduced.

[0466] Even if the fitter is inexperienced, the fitter performs fitting with confidence on the basis of a recommended club type supported by the swing diagnosis system **1000**, and can thus give a user a sense of security.

[0467] Here, as the fitting data, a "combination of the recommended club type and the purchased club type" is used, but, at least one of "review of a fitter", "pointing-out by a fitter", "improvements from a fitter", and the like may be used instead of the "purchased club type" or along with "purchased club type".

[0468] If the user ID and the customer ID are received from the customer terminal **350**, the server **300** acquires a diagnosis result (recommended club type) for the user and dedicated to the customer on the basis of the swing analysis data of the user and the diagnosis table of the customer stored in the server **300** in advance, and transmits the diagnosis result to the customer terminal **350**.

[0469] If the fitting data (a combination of the recommended club type and the purchased club type) is received from the customer terminal **350**, the server **300** performs feedback correction on the diagnosis table of the customer so that a difference between the recommended club type and the purchased club type is reduced.

[0470] The server **300** adjusts the intensity of the feedback correction (whether or not the feedback is performed, a shift amount of a boundary position, a timing of the feedback reference numeral, and the like) according to the reliability of the received fitting data.

[0471] The server **300** estimates the reliability of the received fitting data on the basis of the fitting data of the customer or the swing analysis data of the user.

[0472] As mentioned above, the swing diagnosis system **1000** may be formed of a manager of the server, a golf goods manufacturer or a golf goods shop which is a customer, and a user visiting the golf goods shop in order to purchase a golf club.

1-7. Application Example of Motion Analysis Apparatus

[0473] Next, with reference to FIG. **51**, a description will be made of an example of using a head mounted display (HMD) as the swing analysis apparatus **20**. FIG. **51** is a perspective view illustrating an example of a head mounted display (HMD) as a motion analysis apparatus.

1-7-1. Application Example 1

[0474] As illustrated in FIG. **51**, a head mounted display (HMD) **500** includes a spectacle main body **501** mounted on the head of the user **2**. The spectacle main body **501** is provided with a display section **502**. The display section **502** integrates a light beam emitted from an image display unit **503** with a light beam directed toward the eyes of the user **2**, and thus overlaps a virtual image on the image display unit **503** with a real image of the external world viewed from the user **2**.

[0475] The display section **502** is provided with, for example, the image display unit **503** such as an liquid crystal display (LCD), a first beam splitter **504**, a second beam splitter **505**, a first concave reflection mirror **506**, a second concave reflection mirror **507**, a shutter **508**, and a convex lens **509**.

[0476] The first beam splitter **504** is disposed on the front side of the left eye of the user **2**, and partially transmits and partially reflects light emitted from the image display unit **503**. The second beam splitter **505** is disposed on the front side of the right eye of the user **2**, and partially transmits and partially reflects light which is partially transmitted from the first beam splitter **504**.

[0477] The first concave reflection mirror **506**, which is disposed in front of the first beam splitter **504**, partially reflects the partially reflected light from the first beam splitter **504** so as to transmit the light through the first beam splitter **504**, and thus guides the light to the left eye of the user **2**. The second concave reflection mirror **507**, which is disposed in front of the second beam splitter **505**, partially reflects the partially reflected light from the second beam splitter **505** so as to transmit the light through the second beam splitter **505**, and thus guides the light to the right eye of the user **2**.

[0478] The convex lens **509** guides partially transmitted light from the second beam splitter **505** to the outside of the head mounted display (HMD) **500** when the shutter **508** is opened.

[0479] The analysis information (refer to FIGS. **34** to **46**) in a series of swing actions of the user **2**, the swing information such as a swing trajectory (not illustrated) approximating the swing actions, and the like, as described in the display examples, are displayed on the head mounted display (HMD) **500**. The display content is the same as in the above-described display examples, and a detailed description thereof will be omitted.

[0480] According to the head mounted display (HMD) **500**, since the head mounted display (HMD) is mounted on the head and displays information, the user **2** can understand swing analysis information of the user or attitude (position) information of the hands **2***a* without holding the swing analysis apparatus (motion analysis apparatus) **20** including the display section **25** displaying information with the hands.

[0481] The head mounted display (HMD) **500** may have the functions of the swing analysis apparatus **20** and may display swing analysis or swing information based on measured data from the sensor unit **10**, and may be used as a display section displaying image data transmitted from the separate swing analysis apparatus **20**. The functions of the

swing analysis apparatus (motion analysis apparatus) **20** include the processing section **21** (an example of a processing section), the communication section **22**, the operation section **23**, the storage section **24**, the display section **25**, and the sound output section **26** as described above.

1-7-2. Application Example 2

[0482] Next, with reference to FIG. **52**, a description will be made of an example of using an arm mounted analysis display apparatus as an example of a wearable apparatus, as the motion analysis display apparatus. FIG. **52** is a perspective view illustrating an arm mounted motion analysis display apparatus as an example of a wearable apparatus.

[0483] As illustrated in FIG. **52**, a wearable (arm mounted) analysis display apparatus **600** is mounted on a predetermined part (the wrist in this example) of the user (subject) **2** (refer to FIG. **2**) and displays swing analysis or swing information based on measured data from the sensor unit **10** (refer to FIG. **2**). The analysis display apparatus **600** includes an apparatus main body **610** which is worn by the user **2** and displays swing analysis information such as swing analysis or attitude information of the hands **2***a* (refer to FIG. **2**) of the user **2**, and a band portion **615** which is attached to the apparatus main body **610** and allows the apparatus main body **610** to be mounted on the user **2**.

[0484] The apparatus main body **610** of the analysis display apparatus **600** is provided with a bottom case **613** on the side mounted on the user **2**, and a top case **611** on an opposite side to the side mounted on the user **2**. A bezel **618** is provided on a top side (top case **611**) of the apparatus main body **610**, and a glass plate **619** as a top plate portion (outer wall) which is disposed inside the bezel **618** and protects inner structures is also provided. A pair of band attachment portions **617** which is a connection portion with the band portion **615** are provided on both sides of the bottom case **613**.

[0485] The apparatus main body **610** is provided with a display portion such as a liquid crystal display (LCD **634**) directly under the glass plate **619**. The user **2** can view swing analysis information, attitude information of the hands **2***a* of the user **2**, or the like, displayed on the liquid crystal display (LCD **634**) via the glass plate **619**. The apparatus main body **610** may include the processing section **21**, the communication section **22**, the operation section **23**, the storage section **24**, the display section **25**, and the sound output section **26** in the same manner as the swing analysis apparatus **20** described with reference to FIG. **10**. The display section **25** corresponds to a display portion such as the liquid crystal display (LCD **634**) in this example.

[0486] The analysis information (refer to FIGS. **34** to **46**) in a series of swing actions of the user **2**, the swing information such as a swing trajectory (not illustrated) approximating the swing actions, and the like, as described in the display examples, are displayed on the display portion of the liquid crystal display (LCD **634**). The display (presentation) content is the same as in the above-described display examples, and a detailed description thereof will be omitted.

[0487] Other advice information based on swing analysis results, for example, a text image representing a swing type of the user **2** or a text image representing advice (practice method or the like) suitable for the swing type of the user **2** may be displayed on the display portion of the liquid crystal display (LCD **634**). Moving images as video pictures may be displayed on the display portion of the liquid crystal display (LCD **634**).

[0488] In the above description, an example in which the top plate portion of the apparatus main body **610** is implemented by the glass plate **619** has been described, but the top plate portion may be formed by using materials other than glass, such as transparent plastic, as long as a member is transparent so as to allow the LCD **634** to be viewed, and has the rigidity of being capable of protecting constituent elements included in the top case **611** and the bottom case **613**, such as the LCD **634**. A configuration example in which the bezel **618** is provided has been described, but the bezel **618** may not be provided.

[0489] According to the wearable (arm mounted) analysis display apparatus **600**, since analysis display apparatus is mounted on the arm and displays information, the user **2** can understand swing information of the user or attitude (position) information of the hands **2***a* without holding the display portion (liquid crystal display (LCD **634**)) displaying information with the hands.

[0490] The wearable (arm mounted) analysis display apparatus **600** may have the functions of the swing analysis apparatus **20** and may display swing analysis or swing information based measured data from the sensor unit **10**, and may be used as a display section displaying image data transmitted from the separate swing analysis apparatus **20**. The functions of the swing analysis apparatus (motion analysis apparatus) **20** include the processing section **21** (an example of a processing section), the communication section **22**, the operation section **23**, the storage section **24**, the display section **25**, and the sound output section **26**, as described in the swing analysis apparatus **20** of the above-described embodiment.

[0491] For example, the invention includes substantially the same configuration (for example, a configuration in which functions, methods, and results are the same, or a configuration in which objects and effects are the same) as the configuration described in the embodiment. The invention includes a configuration in which an inessential part of the configuration described in the embodiment is replaced with another part. The invention includes a configuration which achieves the same operation and effect or a configuration capable of achieving the same object as in the configuration described in the embodiment. The invention includes a configuration in which a well-known technique is added to the configuration described in the embodiment.

[0492] The entire disclosure of Japanese Patent Application No. 2016-081823 filed Apr. 15, 2016 is expressly incorporated by reference herein.

What is claimed is:

1. A display method comprising:

generating first analysis information on the basis of a plurality of pieces of data related to a plurality of swings, output from an inertial sensor which is attached to a user or an exercise appliance swung by the user and measures the plurality of swings performed by the user;

generating a first region image including a plurality of time-series region images on the basis of the first analysis information; and

displaying the plurality of time-series region images in a coordinate system having at least two indexes as axes.

2. The display method according to claim 1,
wherein a display aspect differs for the time-series region images.
3. The display method according to claim 1,
wherein an area of the time-series region images is the magnitude corresponding to variations between the plurality of pieces of data related to the plurality of swings.
4. The display method according to claim 1,
wherein a predetermined target region is displayed in the coordinate system.
5. The display method according to claim 1,
wherein a second region image corresponding to the first region image in relation to a plurality of swings performed by another user who is different from the user is displayed in the coordinate system along with the first region image.
6. The display method according to claim 5,
wherein the coordinate system is divided into a plurality of regions, and
wherein a proportion of the second region image occupying the plurality of separate regions is displayed.
7. The display method according to claim 5,
wherein the coordinate system is divided into a plurality of regions, and
wherein a proportion of the first region image occupying the plurality of separate regions is displayed.
8. The display method according to claim 1,
wherein the first analysis information includes information related to at least one of impact, a V zone, efficiency, rotation, a head speed, hands-up, and a down blow.
9. The display method according to claim 1,
wherein diagnosis information is displayed on the basis of the first region image.
10. The display method according to claim 9,
wherein a practice method is displayed on the basis of the diagnosis information.
11. A swing analysis apparatus comprising:
an analysis section that generates first analysis information on the basis of a plurality of pieces of data related to a plurality of swings, output from an inertial sensor which is attached to a user or an exercise appliance swung by the user and measures the plurality of swings performed by the user;
a processing section that generates a first region image including a plurality of time-series region images on the basis of the first analysis information; and
a display section that displays the plurality of time-series region images in a coordinate system having at least two indexes as axes.
12. The swing analysis apparatus according to claim 11,
wherein a display aspect differs for the time-series region images.
13. The swing analysis apparatus according to claim 11,
wherein an area of the time-series region images is the magnitude corresponding to variations between the plurality of pieces of data related to the plurality of swings.
14. The swing analysis apparatus according to claim 11,
wherein a predetermined target region is displayed in the coordinate system.
15. The swing analysis apparatus according to claim 11,
wherein a second region image corresponding to the first region image in relation to a plurality of swings performed by another user who is different from the user is displayed in the coordinate system along with the first region image.
16. The swing analysis apparatus according to claim 15,
wherein the coordinate system is divided into a plurality of regions, and
wherein a proportion of the second region image occupying the plurality of separate regions is displayed.
17. The swing analysis apparatus according to claim 15,
wherein the coordinate system is divided into a plurality of regions, and
wherein a proportion of the first region image occupying the plurality of separate regions is displayed.
18. The swing analysis apparatus according to claim 11,
wherein the first analysis information includes information related to at least one of impact, a V zone, efficiency, rotation, ahead speed, hands-up, and a down blow.
19. A swing analysis system comprising:
the swing analysis apparatus according to claim 11; and
an inertial sensor.
20. A recording medium recording a program causing a computer to execute:
generating first analysis information on the basis of a plurality of pieces of data related to a plurality of swings, output from an inertial sensor which is attached to a user or an exercise appliance swung by the user and measures the plurality of swings performed by the user;
generating a first region image including a plurality of time-series region images on the basis of the first analysis information; and
displaying the plurality of time-series region images in a coordinate system having at least two indexes as axes.

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