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(54) **IMAGE PROCESSING APPARATUS, IMAGE PROCESSING METHOD, AND PROGRAM**

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G06F 3/01 (2006.01)
G06F 3/00 (2006.01)

(52) **U.S. Cl.**
CPC ***G06F 3/011*** (2013.01); ***G06F 3/005*** (2013.01); ***G06T 19/20*** (2013.01); *G06T 2219/2004* (2013.01)

(58) **Field of Classification Search**
CPC ... G06F 3/00; G06F 3/01; G06F 3/005; G06F 3/011; G06T 19/20
See application file for complete search history.

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(57) **ABSTRACT**

Disclosed herein is an image processing apparatus including: a nearness computation block configured to compute a nearness between a representative position representative of a user and a position of an object; a movement determination block configured to determine a movement of the object in a virtual space with an accuracy corresponding to the computed nearness; and a drawing block configured to draw an image on the basis of the determined movement.

4 Claims, 8 Drawing Sheets

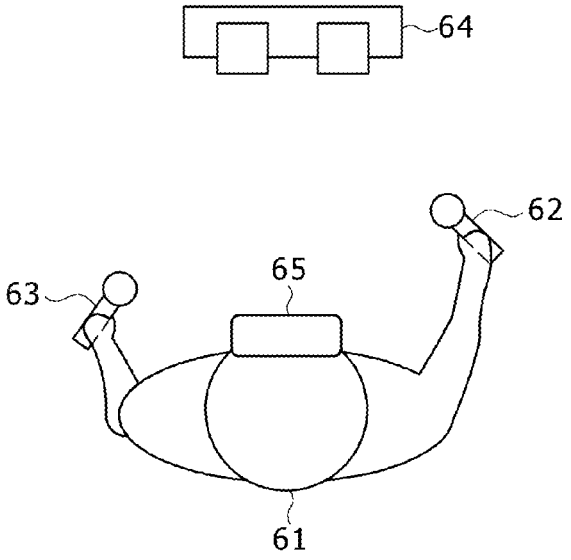

FIG. 1

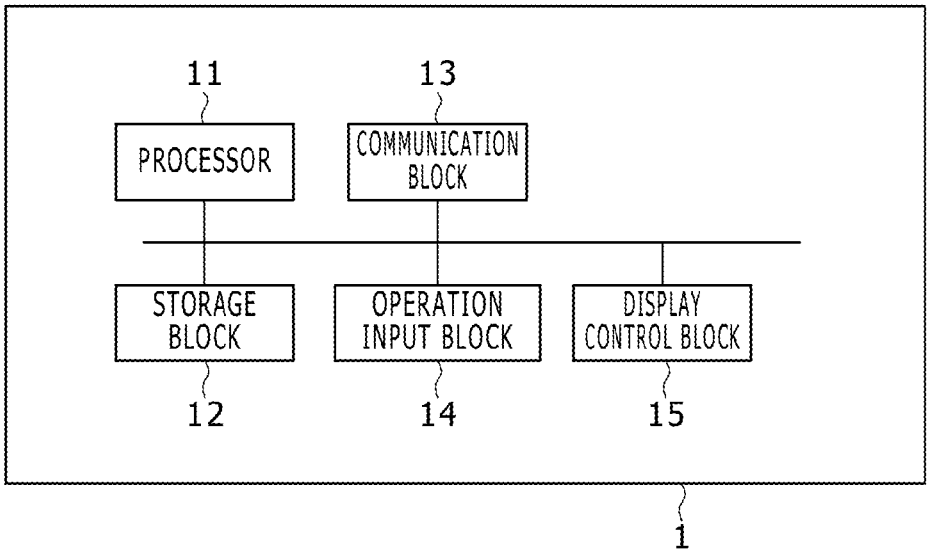
11
13
PROCESSOR
COMMUNICATION BLOCK
STORAGE BLOCK
OPERATION INPUT BLOCK
DISPLAY CONTROL BLOCK
12
14
15
1

FIG. 2

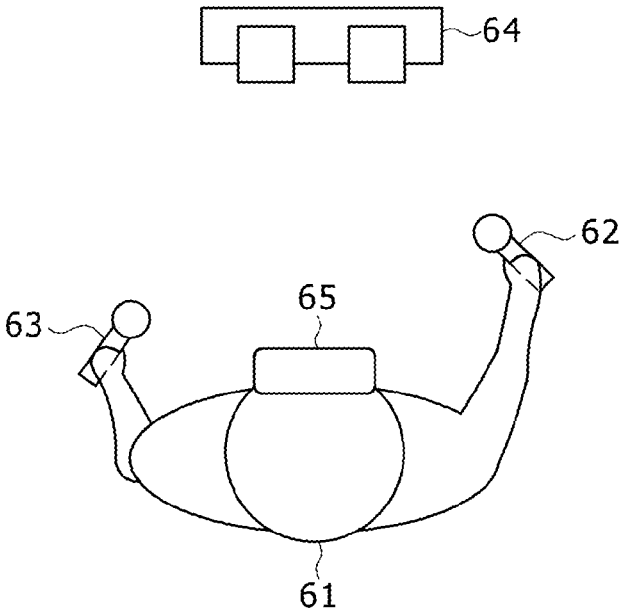
64
62
63
65
61

FIG. 3

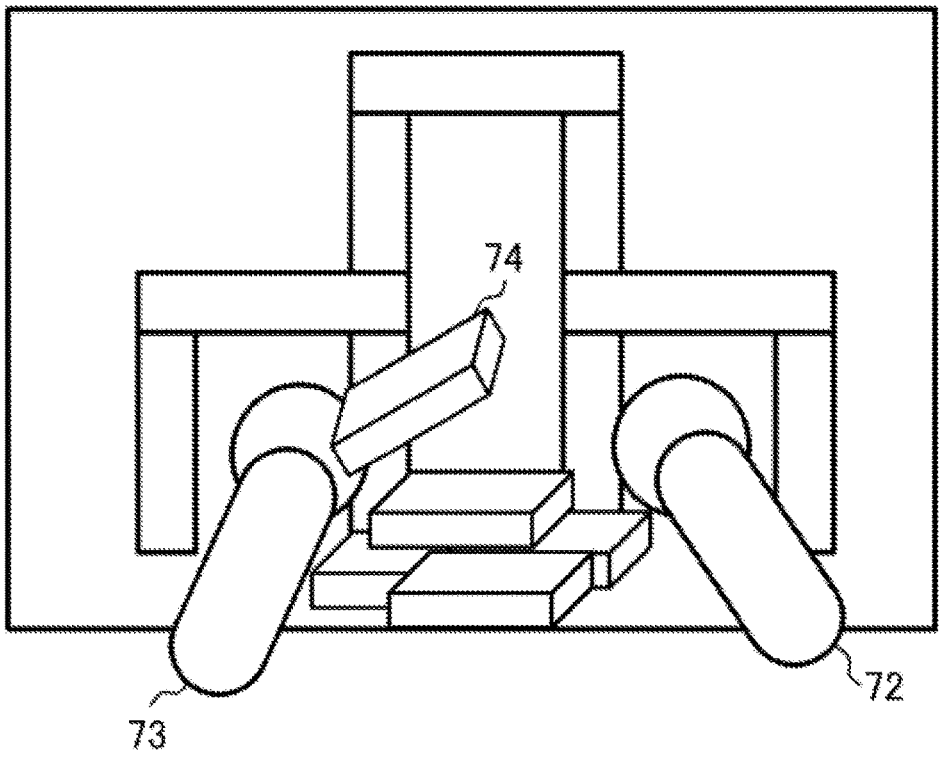

FIG. 4

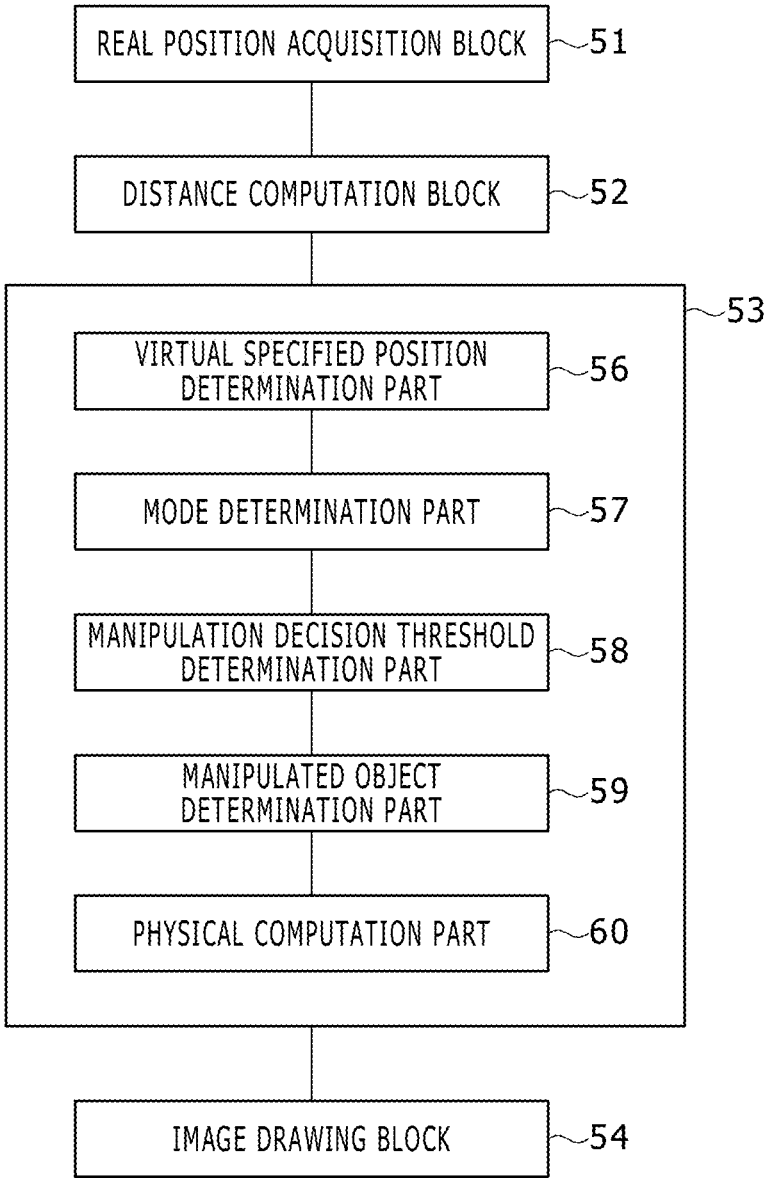
REAL POSITION ACQUISITION BLOCK
51
DISTANCE COMPUTATION BLOCK
52
53
VIRTUAL SPECIFIED POSITION DETERMINATION PART
56
MODE DETERMINATION PART
57
MANIPULATION DECISION THRESHOLD DETERMINATION PART
58
MANIPULATED OBJECT DETERMINATION PART
59
PHYSICAL COMPUTATION PART
60
IMAGE DRAWING BLOCK
54

FIG. 5

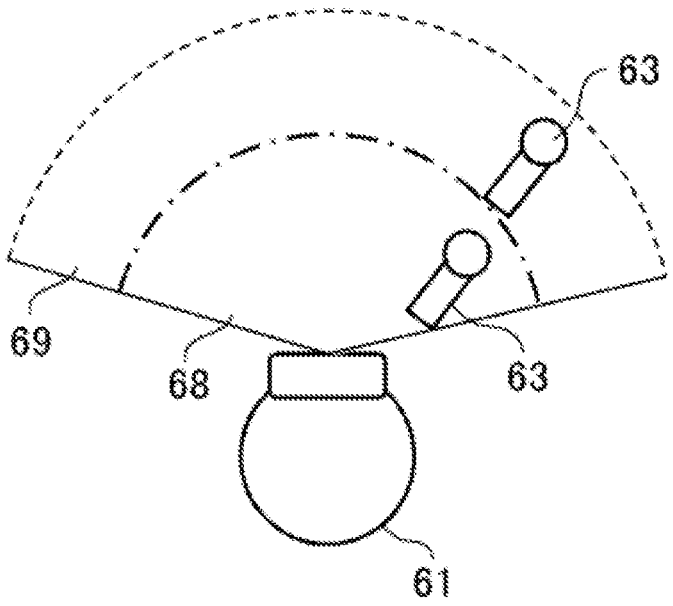

FIG. 6

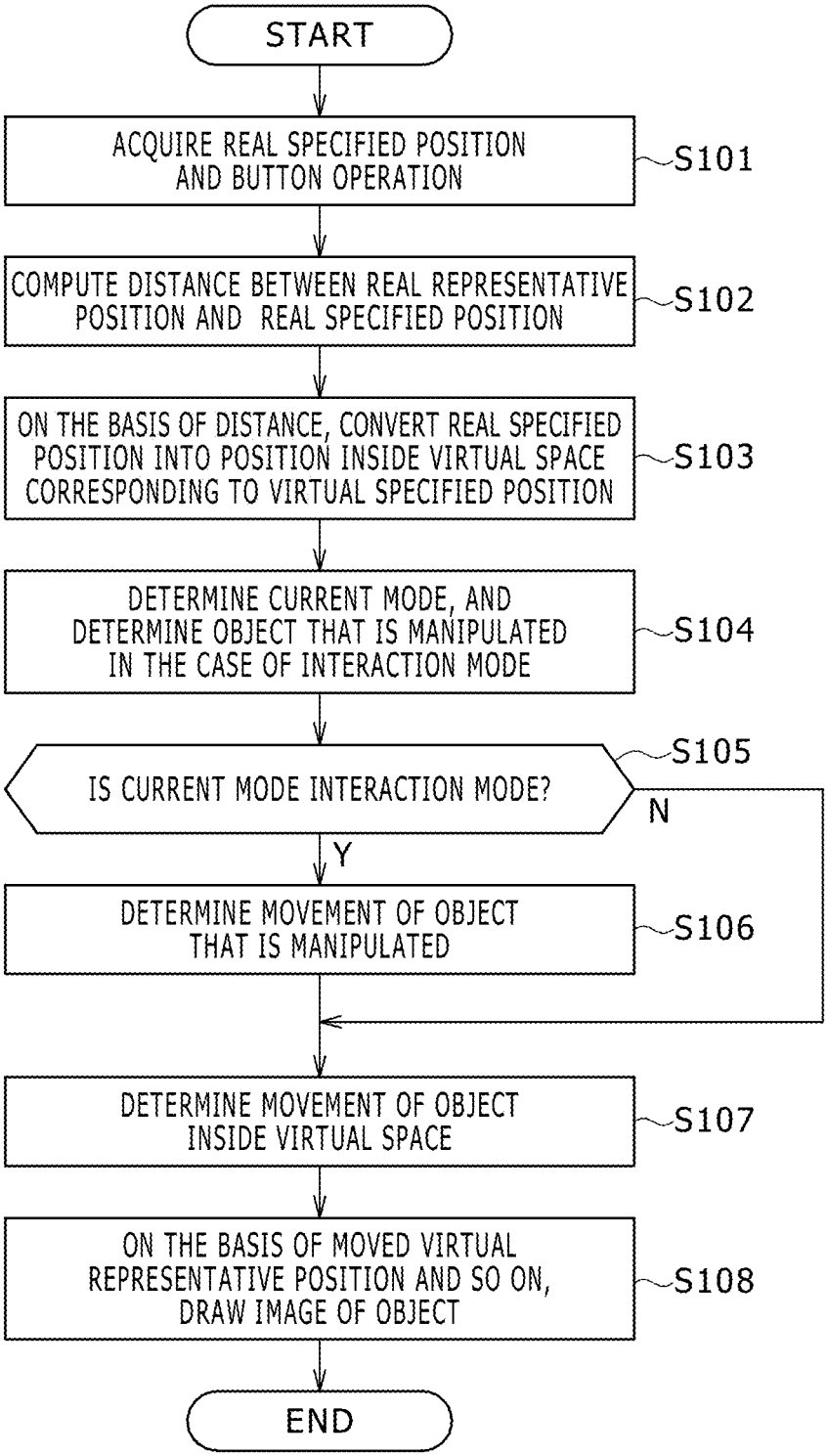
START
ACQUIRE REAL SPECIFIED POSITION AND BUTTON OPERATION
S101
COMPUTE DISTANCE BETWEEN REAL REPRESENTATIVE POSITION AND REAL SPECIFIED POSITION
S102
ON THE BASIS OF DISTANCE, CONVERT REAL SPECIFIED POSITION INTO POSITION INSIDE VIRTUAL SPACE CORRESPONDING TO VIRTUAL SPECIFIED POSITION
S103
DETERMINE CURRENT MODE, AND DETERMINE OBJECT THAT IS MANIPULATED IN THE CASE OF INTERACTION MODE
S104
IS CURRENT MODE INTERACTION MODE?
S105
N
Y
DETERMINE MOVEMENT OF OBJECT THAT IS MANIPULATED
S106
DETERMINE MOVEMENT OF OBJECT INSIDE VIRTUAL SPACE
S107
ON THE BASIS OF MOVED VIRTUAL REPRESENTATIVE POSITION AND SO ON, DRAW IMAGE OF OBJECT
S108
END

FIG. 7

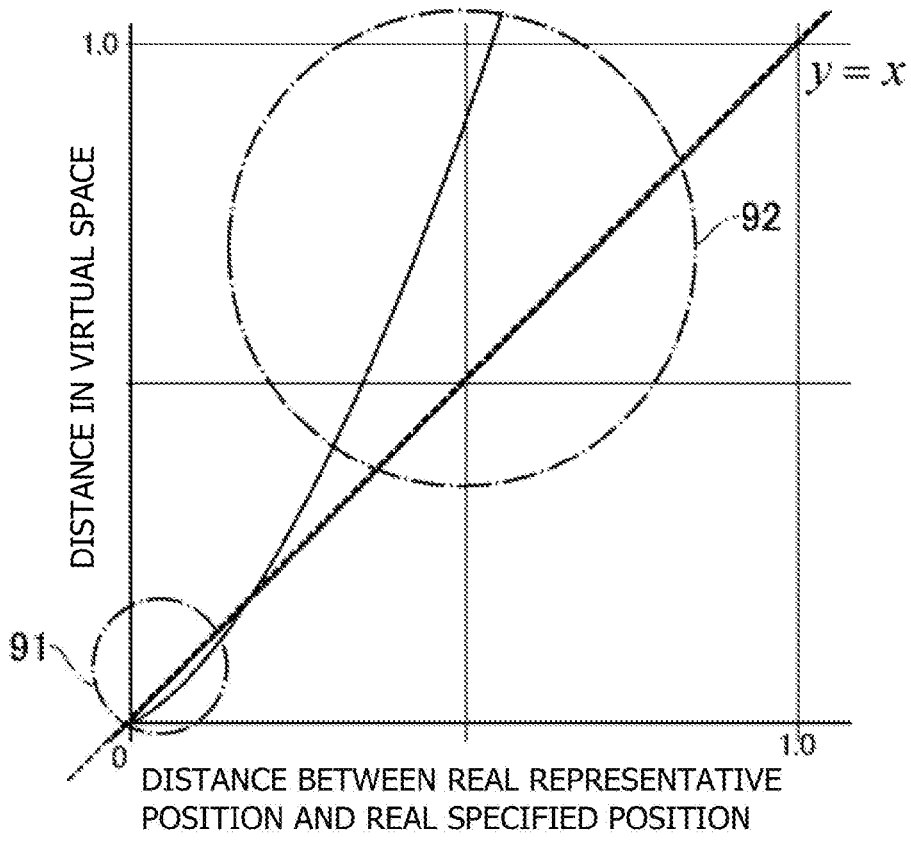
1.0
y = x
92
DISTANCE IN VIRTUAL SPACE
91
0
1.0
DISTANCE BETWEEN REAL REPRESENTATIVE POSITION AND REAL SPECIFIED POSITION

FIG. 8

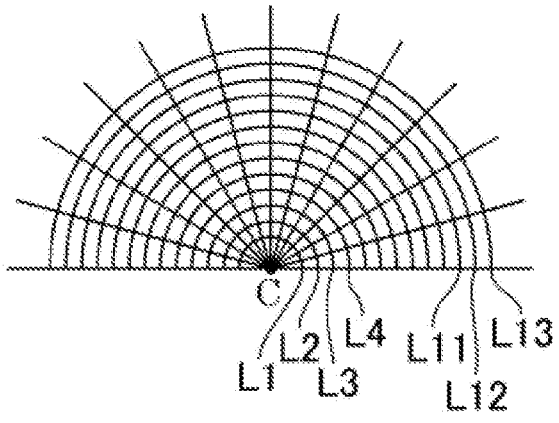
C
L1
L2
L3
L4
L11
L12
L13

FIG. 9

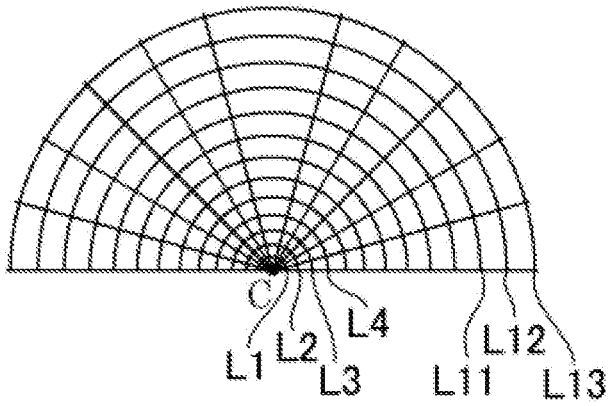

FIG. 10

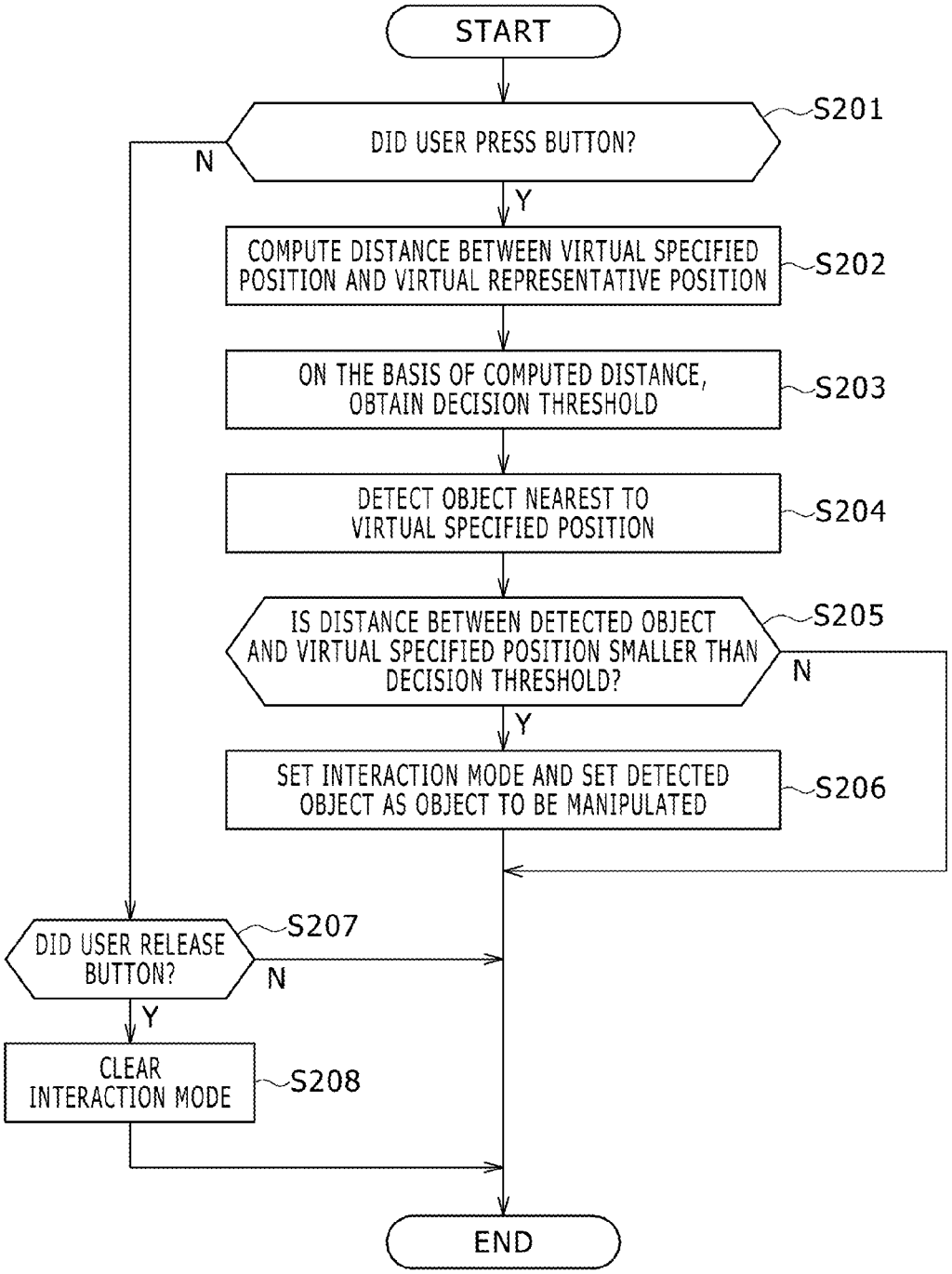
START
DID USER PRESS BUTTON?
S201
N
Y
COMPUTE DISTANCE BETWEEN VIRTUAL SPECIFIED POSITION AND VIRTUAL REPRESENTATIVE POSITION
S202
ON THE BASIS OF COMPUTED DISTANCE, OBTAIN DECISION THRESHOLD
S203
DETECT OBJECT NEAREST TO VIRTUAL SPECIFIED POSITION
S204
IS DISTANCE BETWEEN DETECTED OBJECT AND VIRTUAL SPECIFIED POSITION SMALLER THAN DECISION THRESHOLD?
S205
N
Y
SET INTERACTION MODE AND SET DETECTED OBJECT AS OBJECT TO BE MANIPULATED
S206
DID USER RELEASE BUTTON?
S207
N
Y
CLEAR INTERACTION MODE
S208
END

IMAGE PROCESSING APPARATUS, IMAGE PROCESSING METHOD, AND PROGRAM

BACKGROUND

The present disclosure relates to an image processing apparatus, an image processing method, and a program.

A technology is known in which, when a user enters a three-dimensional position by manipulating a controller or selects an object inside a virtual space to be manipulated, interaction between the manipulation by the user and the object inside the virtual space is realized.

SUMMARY

In order to enhance the reality of interaction, increase in the accuracy of the processing associated with interaction is possible. For example, varying the ratio between a manipulation amount and a movement inside a virtual space or the distance serving as the threshold for use in contact determination allows the enhancement in the reality of interaction and minute manipulations. On the other hand, simply increasing the accuracy forces the user to execute fine manipulations and the like, thereby making it possible that user-expected manipulations cannot be executed.

Therefore, the present disclosure addresses the above-identified and other problems associated with related-art methods and apparatuses, and it is desirable to provide a technology intended to establish both the enhanced processing accuracy and user manipulability.

According to one embodiment of the present disclosure, an image processing apparatus includes: a nearness computation block configured to compute a nearness between a representative position representative of a user and a position of an object; a movement determination block configured to determine a movement of the object in a virtual space with an accuracy corresponding to the computed nearness; and a drawing block configured to draw an image on the basis of the determined movement.

According to another embodiment of the present disclosure, an image processing method includes: computing a nearness between a representative position representative of a user and a position of an object; determining a movement of the object in a virtual space with an accuracy corresponding to the computed nearness; and drawing an image on the basis of the determined movement.

According to a further embodiment of the present disclosure, a program for a computer includes: by a nearness computation block, computing a nearness between a representative position representative of a user and a position of an object; by a movement determination block, determining a movement of the object in a virtual space with an accuracy corresponding to the computed nearness; and by a drawing block, drawing an image on the basis of the determined movement.

According to the embodiments of the present disclosure, the accuracy of processing is enhanced and an operation by a user is facilitated at the same time.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a diagram illustrating one example of a hardware configuration of an image processing apparatus according to one embodiment of the present disclosure;

FIG. **2** is a diagram illustrating a method of using an input/output device when a user uses the image processing apparatus;

FIG. **3** is a diagram illustrating one example of an image to be displayed;

FIG. **4** is a block diagram illustrating functions that are realized by the image processing apparatus;

FIG. **5** is a diagram schematically illustrating a relation between a distance from a user and an accuracy;

FIG. **6** is a diagram illustrating one example of a processing flow of the image processing apparatus;

FIG. **7** is a diagram illustrating a relation between a distance from a user in a real space and a distance in a virtual space;

FIG. **8** is a diagram illustrating a relation between a distance and a position in a real space;

FIG. **9** is a diagram illustrating a relation between a position in a virtual space and a distance in a real space; and

FIG. **10** is a diagram illustrating one example of a processing flow related with a mode determination part, a manipulation decision threshold determination part, and a manipulated object determination part.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

The technology disclosed herein will be described in further detail by way of one embodiment thereof with reference to the accompanying drawings. It should be noted that components having similar functions are denoted by the same reference symbols and the description thereof will be skipped.

Now, referring to FIG. **1**, there is shown a diagram illustrating one example of a hardware configuration of an image processing apparatus **1** according to one embodiment of the present disclosure. The image processing apparatus **1** is a personal computer, a family game machine, or a portable information terminal. The image processing apparatus **1** has a processor **11**, a storage block **12**, a communication block **13**, an operation input block **14**, and a display control block **15**.

The processor **11** operates as instructed by a program stored in the storage block **12**, controlling the communication block **13**, the operation input block **14**, the display control block **15**, and the like. It should be noted that the program mentioned above may be provided in a computer-readable storage medium such as a flash memory or provided via a network such as the Internet.

The storage block **12** includes a memory element such as a dynamic random access memory (DRAM) and a flash memory. The storage block **12** stores the program mentioned above. In addition, the storage block **12** stores information and computation results entered from the processor **11**, the communication block **13**, and the like.

The communication block **13** includes an integrated circuit, a connector, an antenna, and the like configuring a wired local area network (LAN) or a wireless LAN. The communication block **13** has a function of providing communication with other apparatuses via a network. Under the control of the processor **11**, the communication block **13** enters information received from other apparatuses into the processor **11** or the storage block **12** and transmits information to other apparatuses.

The operation input block **14** is a circuit configured to obtain inputs from the hardware that detects operations done by a user. The operation input block **14** obtains inputs from a position input device through which positions for example are entered by the user and an input device such as a keyboard, thereby entering the detected information into the processor **11** or the storage block **12**.

The display control block **15** includes a circuit configured to control a display output device such as a display. Under the control of the processor **11**, the display control block **15** makes a display output device display images.

Referring to FIG. **2**, there is shown one example of a method of using an input device or the like when a user **61** uses the image processing apparatus **1**. In the example shown in FIG. **2**, the user **61** is seen from above. In the present embodiment, motion controllers **62** and **63** and a camera **64** are used as input devices and a head-mounted display **65** is used as a display output device.

Each of the motion controller **62** and the motion controller **63** has a ball section for the camera **64** to recognize a position and a holding section to be grasped by the user **61**. The holding section has a button. When the user **61** operates the button, the motion controller **62** or the motion controller **63** transmits information about the button operation to the operation input block **14** in a wireless manner and the operation input block **14** receives this information. The camera **64** takes images including the ball sections of the motion controller **62** and the motion controller **63** and, on the basis of the position and the size of a ball section within these taken images, detects a real specified position specified in a real space by the motion controller **62** or the motion controller **63**. The operation input block **14** obtains the detected real specified position of the motion controller **62** or the motion controller **63**.

The head-mounted display **65** is a display that is worn on the head of the user **61** so as to display an image just in front of the eyes of the user **61**. If the displayed image is based on parallax, the user **61** is able to recognize an object included in the image in a cubic manner. The head-mounted display **65** can display an image that is high in presence for the user **61**. If parallax is provided, the user **61** is able to correctly recognize the three-dimensional position of an object inside a virtual space, thereby allowing the user **61** to experience good interaction with an object inside a virtual space.

Referring to FIG. **3**, there is shown one example of an image to be displayed. An image to be displayed in the present embodiment is a three-dimensional image relative to the direction of viewpoint at a position (hereafter referred to as "virtual representative position") of the user **61** inside a virtual space. With this image, specified objects **72** and **73** are displayed at positions (hereafter referred to as "virtual specified positions") inside a virtual space equivalent to the real specified positions indicated by the motion controllers **62** and **63**. In addition, a manipulated object **74** that is manipulated by the specified object **73** is displayed. It should be noted that, if, by the operation of the motion controllers **62** and **63**, a virtual representative position is moved, the direction of viewpoint of the user **61** inside a virtual space is changed, or the position or direction of an object inside a range in which an image is drawn inside a virtual space is changed, then the image processing apparatus **1** draws an image with these changes reflected and displays the drawn image onto a display output device such as the head-mounted display **65**.

Referring to FIG. **4**, there is shown a block diagram illustrating functions that are realized by the image processing apparatus **1** related with the present embodiment. The image processing apparatus **1** functionally includes a real position acquisition block **51**, a distance computation block **52**, an operation determination block **53**, and an image drawing block **54**. Further, the operation determination block **53** includes a virtual specified position determination part **56**, a mode determination part **57**, a manipulation decision threshold determination part **58**, a manipulated object determination part **59**, and a physical computation part **60**.

The real position acquisition block **51** is realized by the processor **11** mainly by executing a program stored in the storage block **12**, processing information from the operation input block **14** that obtains information from the motion controller **62** or **63** and the camera **64**, and storing the results of the processing into the storage block **12**. The distance computation block **52** and the operation determination block **53** are realized by the processor **11** mainly by executing a program stored in the storage block **12**, processing the information stored in the storage block **12** and the like, and storing the results of the processing into the storage block **12**. The image drawing block **54** is realized by the processor **11** mainly by executing a program stored in the storage block **12**, processing the information stored in the storage block **12** and the like, and controlling the display control block **15** so as for a display output device to display an image.

The real position acquisition block **51** acquires a real specified position indicated by the user **61** in a real space. In addition, the real position acquisition block **51** acquires the position of the user **61** (referred to as "real representative position") in a real space. The real specified position and the real representative position acquired by the real position acquisition block **51** are positions in a three-dimensional space. In the present embodiment, the real specified position is the position of the ball section of the motion controller **62** or **63**; however, this real specified position may be the position of the hand itself of the user **61**. The real representative position may be the position of the head-mounted display **65** (a position equivalent to the viewpoint of the user **61**) or such a position near the user **61** as a position a bit in front of the chest of the user **61**.

The distance computation block **52** computes the nearness between the representative position representative of the user **61** and the position of an object. To be more specific, the distance computation block **52** computes the nearness between the real representative position of the user **61** and a real specified position and the nearness between a virtual representative position and the position of an object inside a virtual space. In the former, the object for use in computing nearness is an object for the user **61** to specify a position; for example, the motion controller **62** or **63** or the hand of the user **61**.

The operation determination block **53** determines the movement of an object in a virtual space with an accuracy corresponding to the computed nearness. The movement of an object in a virtual space determined with the above-mentioned accuracy by the operation determination block **53** includes a movement of an object other than the user **61** arranged inside a virtual space and the movements of the specified objects **72** and **73** indicated by virtual specified positions.

Referring to FIG. **5**, there is schematically shown a relation between the distance from the user **61** and the accuracy. For example, in FIG. **5**, the operation determination block **53** determines the movement of an object such that, in a high accuracy area **68** that is an area (an area nearer to the user **61** than a dash-dot line) smaller in distance than a predetermined value, the accuracy of the movement of the object is higher than that in a low accuracy area **69** larger in distance than this predetermined value. Also, if the motion controller **63** is found in the high accuracy area **68**, for example, the operation determination block **53** obtains a

virtual specified position with a higher accuracy than in the case where the motion controller **63** is found in the low accuracy area **69**.

The image drawing block **54** draws a three-dimensional image of an object in a virtual space on the basis of the determined movement of the object. In a virtual space, the image drawing block **54** draws an image in the case where the direction of viewpoint of the user **61** is seen from a virtual representative position.

The virtual specified position determination part **56** determines the movement of a virtual specified position on the basis of the nearness between a real representative position and a real specified position and the real specified position.

The mode determination part **57** determines on the basis of a manipulation done by the user **61** whether the current mode is an interaction mode or not. In the interaction mode, the manipulated object **74** in a virtual space may be manipulated by moving a real specified position by the user **61**.

The manipulation decision threshold determination part **58** determines a decision threshold on the basis of the nearness between a representative position and the position of an object. This decision threshold is used to determine whether an object found inside a virtual space is the manipulated object **74** to be manipulated. The nearness between a representative position and the position of an object which nearness is used by the manipulation decision threshold determination part **58** may be the nearness between a virtual representative position and a virtual specified position or may be the nearness between a virtual representative position and the position of an object other than the specified objects **72** and **73** inside a virtual space.

The manipulated object determination part **59** detects the manipulated object **74** on the basis of the decision threshold determined above. To be more specific, from among two or more objects other than the specified objects **72** and **73** and the user **61** inside a virtual space, the manipulated object determination part **59** detects an object smaller in the distance from a virtual specified position than the decision threshold as the manipulated object **74**.

The physical computation part **60** computes the movements of two or more objects such that the movements of the two or more objects including the manipulated object **74** follow physical laws in a virtual space. It should be noted that the physical computation part **60** may compute the movements of the two or more objects with an accuracy corresponding to the nearness between each of the two or more objects and a virtual representative position.

Referring to FIG. **6**, there is shown a diagram illustrating one example of a processing flow of the image processing apparatus **1**. First, the real position acquisition block **51** acquires a real specified position and a button operation (step S**101**). The real position acquisition block **51** detects, as this button operation, whether the button is being pressed at the current point of time, the button has been newly pressed, and the pressed button has been released. In addition, the real position acquisition block **51** acquires a current real specified position and a real representative position that is representative of the user **61**.

Next, the distance computation block **52** computes a distance between the real representative position of the user **61** and the real specified position (step S**102**). The distance computation block **52** may obtain a three-dimensional distance between the real representative position and the real specified position as the nearness between the real representative position of the user **61** and the real specified position or a two-dimensional distance only by using a horizontal component of the real representative position and the real specified position.

On the basis of the computed distance between the real representative position and the real specified position, the virtual specified position determination part **56** converts the real specified position into a position inside a virtual space corresponding to a virtual specified position (step S**103**). In addition, on the basis of the virtual specified position at the current point of time and the converted position inside a virtual space, the virtual specified position determination part **56** determines a moving speed and a rotational speed of the virtual specified position. If there is no collision or the like between an object inside the virtual space and the specified objects **72** and **73**, then the virtual specified position moved by the determined moving speed and the converted position inside a virtual space are the same. To be more specific, if there is no collision or the like, the virtual specified position determination part **56** determines the movement of a virtual specified position such that a ratio of a distance between a virtual representative position and a virtual specified position to a distance between a real representative position and a real specified position gets larger as the real representative position is nearer to the real specified position. From a different point of view, the virtual specified position determination part **56** determines the movement of a virtual specified position such that a ratio of the amount of movement of the virtual specified position to the amount of movement of the real specified position gets larger as a real representative position is nearer to a real specified position.

Referring to FIG. **7**, there is shown a diagram illustrating a relation between a distance from the user **61** in a real space and a distance in a virtual space. With the graph shown in FIG. **7**, the horizontal axis (the x axis) is indicative of a distance (a real distance) between a real representative position and a real specified position and the vertical axis (the y axis) is indicative of a distance (a virtual distance) between a virtual representative position and a virtual specified position in a virtual space. The solid line in the graph is indicative of a relation between a real distance and a virtual distance, the relation being indicated by a polynomial function such as a 1.5-degree function for example. The dashed line in the graph is indicative of a related-art relation between a real distance and a virtual distance in the case where the real distance is equal to the virtual distance in order to make comparison with the solid line. In accordance with the relation shown in FIG. **7**, the virtual specified position determination part **56** converts the real distance into the virtual distance, thereby computing a virtual specified position on the basis of a direction in the real space, a virtual distance, and the representative position and viewpoint direction of the user **61** in the virtual space. For example, in an area **91**, the virtual distance in a virtual space is smaller than the real distance indicated by the user **61**, so that the movements of such objects as the specified objects **72** and **73** are determined with an accuracy higher than that provided by related-art techniques. On the other hand, in an area **92**, a virtual distance inside the virtual space is larger than the real distance indicated by the user **61**, so that the movements of such objects as the specified objects **72** and **73** are determined with an accuracy lower than that provided by related-art techniques.

Referring to FIG. **8**, there is shown a diagram illustrating a relation between distances and positions in a real space. Referring to FIG. **9**, there is shown a diagram illustrating a relation between positions in a virtual space and distances in

a real space. FIG. **8** shows arcs L**1** through L**13** in an ascending order of distances from a representative position C. The arcs L**1** through L**13** are each a curve connecting the points at which distances from the representative position C are equal to each other. An interval between two adjacent arcs of the arcs L**1** through L**13** is constant in a real space. On the other hand, in the virtual space shown in FIG. **9**, the arcs L**1** through L**13** are written at the positions corresponding to the arcs L**1** through L**13** in the real space shown by FIG. **8**. In FIG. **9**, for two adjacent arcs of the arcs L**1** through L**13**, the interval between the two adjacent arcs gets smaller as these two arcs get nearer to the representative position C and larger as these two arcs get farther from the representative position C. Therefore, the nearer to the representative position C, the change of a virtual specified position for the movement of the real specified position gets smaller, thereby determining the virtual specified position with a higher accuracy. Consequently, the movement of objects (the specified objects **72** and **73** and the manipulated object **74**, for example) inside a virtual space associated with the virtual specified position is determined in accordance with the distance from the representative position C.

Next, on the basis of a button operation by the user **61** and a real specified position, the mode determination part **57** determines a current mode and, if an interaction mode is determined, the manipulated object determination part **59** determines the manipulated object **74** (step S**104**). To be more specific, on the basis of a decision threshold determined by the manipulation decision threshold determination part **58**, the mode determination part **57** determines whether the current operation mode is the interaction mode or not. A decision threshold is determined on the basis of the nearness between the virtual representative position and the virtual specified position obtained by the distance computation block **52**. In addition, if the interaction mode is determined, the manipulated object determination part **59** selects the manipulated object **74** from among two or more objects found inside a virtual space.

The following further describes the processing of step S**104**. Referring to FIG. **10**, there is shown a diagram illustrating one example of a processing flow associated with the mode determination part **57**, the manipulation decision threshold determination part **58**, and the manipulated object determination part **59**. First, on the basis of inputs from the motion controllers **62** and **63**, the mode determination part **57** detects whether a button included in any one of the motion controllers **62** and **63** has been newly pressed by the user **61** (step S**201**). If a button is found newly pressed (Y of step S**201**), then the distance computation block **52** computes a three-dimensional or horizontal distance between a virtual representative position and a virtual specified position (step S**202**). Here, of the motion controllers **62** and **63**, the one for which the button has been pressed is referred to as a target controller. Then, on the basis of the computed distance between the virtual specified position and virtual representative position, the manipulation decision threshold determination part **58** obtains a decision threshold (step S**203**). To be more specific, the manipulation decision threshold determination part **58** obtains a decision threshold such that the decision threshold gets larger as the computed distance is larger. For example, if the computed distance is smaller than a certain constant value, then the manipulation decision threshold determination part **58** may determine a first value as a decision threshold and, if the computed distance is larger than the certain constant value, may determine a second value larger than the first value as a decision threshold. In addition, the manipulation decision threshold determination part **58** may compute a decision threshold by a function that monotonously increases for the computed distance.

When a decision threshold has been obtained, the manipulated object determination part **59** computes distances between a virtual specified position indicated by the target controller for which the button has been pressed and each of two or more objects, thereby detecting the object nearest to this virtual specified position (step S**204**). Next, the manipulated object determination part **59** determines whether the distance between the detected object and the virtual specified position is smaller than the decision threshold (step S**205**). If the distance between the detected object and the virtual specified position is found smaller than the decision threshold (Y of step S**205**), then the mode determination part **57** sets the current mode to the interaction mode and the manipulated object determination part **59** sets the detected object as the manipulated object **74** (step S**206**), and the mode determination part **57** stores in the storage block **12** the information indicative of the target controller for which the button was pressed as target controller information. On the other hand, if the distance between the detected object and the virtual specified position is found larger than the decision threshold (N of step S**205**), it indicates that there is no manipulated object **74**, so that step S**206** is skipped.

Here, if the button was not newly pressed by the user **61** in step S**201** (N of step S**201**) and the button for the target controller indicated by the target controller information was released by the user **61** (Y of step S**207**), then the mode determination part **57** sets the current mode to a mode other than the interaction mode, thereby clearing the interaction mode (step S**208**). On the other hand, if this button is kept pressed by the user **61** (N of step S**207**), then the mode determination part **57** does not change the operation mode.

When the processing of step S**104** is executed, the physical computation part **60** determines, if the current mode is the interaction mode (step S**105**), the movement of the manipulated object **74** on the basis of the moving speed of the specified object **72** or **73** at the virtual specified position and a positional relation between this specified object **72** or **73** and the manipulated object **74** (step S**106**). For example, the physical computation part **60** may determine the movement of the manipulated object **74** such that the manipulated object **74** sucks the specified object **72** or **73** and the sucking position of the manipulated object **74** moves in the same manner as the specified object **72** or **73**.

As seen from the description made above, a decision threshold is set on the basis of the distance between a virtual specified position and a virtual representative position and an object to be manipulated is determined by this decision threshold. For example, if a virtual specified position is near the user **61**, then, as compared with the case where it is remote from the user **61**, it is necessary to make the virtual specified position approach to an object at the time of manipulating the object. From a different point view, if a virtual specified position is near the user **61**, then the possibility for an unintended object to become the manipulated object **74** gets lower, thereby enabling the decision of the movement of an object with a higher accuracy. On the other hand, if a virtual specified position is remote from the user **61**, then the user **61** is able to determine the manipulated object **74** with a less clear operation at the cost of a lower accuracy. For example, the user **61** is able to also grasp an object at a position not reachable by the specified object **72** or **73**. It should be noted that the interval between an object equivalent to a decision threshold and a virtual specified position is much smaller than the distance between a virtual

representative position and a virtual specified position and therefore the position of the object to be manipulated is sufficiently near the virtual specified position. Therefore, it may be said that the operation of an object to be manipulated is determined on the basis of the nearness between the object to be manipulated and a virtual representative position.

Further, the physical computation part **60** determines movements of two or more objects inside a virtual space on the basis of movements of the determined specified objects **72** and **73**, movements of the determined object to be manipulated, and predetermined movements of two or more objects (step S**107**). The movements of two or more objects to be determined are moving speed and rotational speed. The physical computation part **60** also computes the positions and angles of two or more objects in a frame to be next drawn by the image drawing block **54**. The physical computation part **60** also determines the positions of the specified objects **72** and **73** to be drawn by the image drawing block **54**, namely, virtual specified positions. Here, if the specified objects **72** and **73** collide with another object (an obstacle) when the specified objects **72** and **73** move at the moving speed and rotational speed determined by the virtual specified position determination part **56**, the positions of the specified objects **72** and **73** to be computed by the physical computation part **60** are the positions at which the collision is taken into consideration such as positions at which the collision with this obstacle occurred. Therefore, the virtual specified position at the time of drawing by the image drawing block **54** is based on a position inside a virtual space obtained by converting a real specified position in the virtual specified position determination part **56** but does not necessarily match this position. Thus, determination of the positions of the specified objects **72** and **73** prevents the specified objects **72** and **73** from crushing into an obstacle, thereby allowing the realization of a natural interaction that does not give the sense of incongruity.

The physical computation part **60** obtains the speeds of two or more objects and, on the basis of the obtained speeds, executes collision decision. In addition, if there are constraint conditions on mutual positions and so on of two or more objects, the physical computation part **60** computes, by the processing of a constraint solver, the positions and so on that satisfy the constraint conditions for these two or more objects. The constraint solver computes the position and so on of each object that satisfy the constraint conditions by known iterative solutions such as an impulse method.

Upon determination of the movements of two or more objects, the image drawing block **54** draws the three-dimensional images of the objects on the basis of the determined positions and angles of the objects, the virtual representative position, and the direction of viewpoint (step S**108**).

The present disclosure contains subject matter related to that disclosed in Japanese Priority Patent Application JP 2015-209834 filed in the Japan Patent Office on Oct. 26, 2015, the entire content of which is hereby incorporated by reference.

It should be understood by those skilled in the art that various modifications, combinations, sub-combinations and alterations may occur depending on design requirements and other factors insofar as they are within the scope of the appended claims or the equivalents thereof.

What is claimed is:

1. An image processing apparatus comprising:

a nearness computation block configured to compute a nearness between a representative position representative of a user and a position of an object;

a movement determination block configured to determine a movement of the object in a virtual space with an accuracy corresponding to the computed nearness;

a drawing block configured to draw an image on the basis of the determined movement; and

a real specified position acquisition block configured to acquire a real specified position indicated by the user in a real space as the position of the object;

the representative position being a position of the user in the real space;

the movement determination block determining the movement of the object by determining a movement of a virtual specified position that is a specified position in the virtual space with the accuracy corresponding to the nearness,

wherein the movement determination block determines the movement of the virtual specified position such that, as the representative position is closer to the real specified position, a ratio of a distance between a virtual representative position representative of the user in the virtual space and the virtual specified position gets larger to a distance between the representative position and the real specified position.

2. The image processing apparatus according to claim **1**, wherein

the movement determination block determines a decision threshold in accordance with the nearness, detects an object in the virtual space which is smaller in distance than the determined decision threshold, and determines a movement of the detected object.

3. An image processing method comprising:

computing a nearness between a representative position representative of a user and a position of an object;

determining a movement of the object in a virtual space with an accuracy corresponding to the computed nearness;

drawing an image on the basis of the determined movement;

acquiring a real specified position indicated by the user in a real space as the position of the object,

the representative position being a position of the user in the real space;

determining the movement of the object by determining a movement of a virtual specified position that is a specified position in the virtual space with the accuracy corresponding to the nearness; and

determining the movement of the virtual specified position such that, as the representative position is closer to the real specified position, a ratio of a distance between a virtual representative position representative of the user in the virtual space and the virtual specified position gets larger to a distance between the representative position and the real specified position.

4. A non-transitory computer-readable storage medium storing a program for a computer, comprising:

by a nearness computation block, computing a nearness between a representative position representative of a user and a position of an object;

by a movement determination block, determining a movement of the object in a virtual space with an accuracy corresponding to the computed nearness;

by a drawing block, drawing an image on the basis of the determined movement; and

by a real specified position acquisition block, acquiring a real specified position indicated by the user in a real space as the position of the object;

the representative position being a position of the user in the real space;

the movement determination block determining the movement of the object by determining a movement of a virtual specified position that is a specified position in the virtual space with the accuracy corresponding to the nearness,

wherein the movement determination block determines the movement of the virtual specified position such that, as the representative position is closer to the real specified position, a ratio of a distance between a virtual representative position representative of the user in the virtual space and the virtual specified position gets larger to a distance between the representative position and the real specified position.

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