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Moore et al.

(54) **WEARABLE EARPIECE FOR PROVIDING SOCIAL AND ENVIRONMENTAL AWARENESS**

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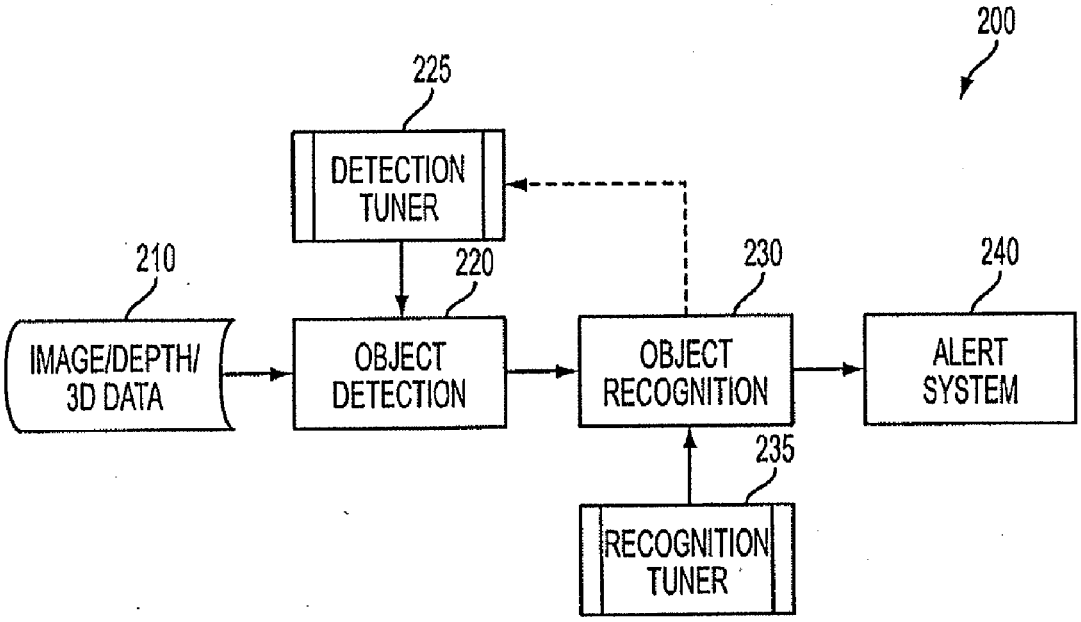
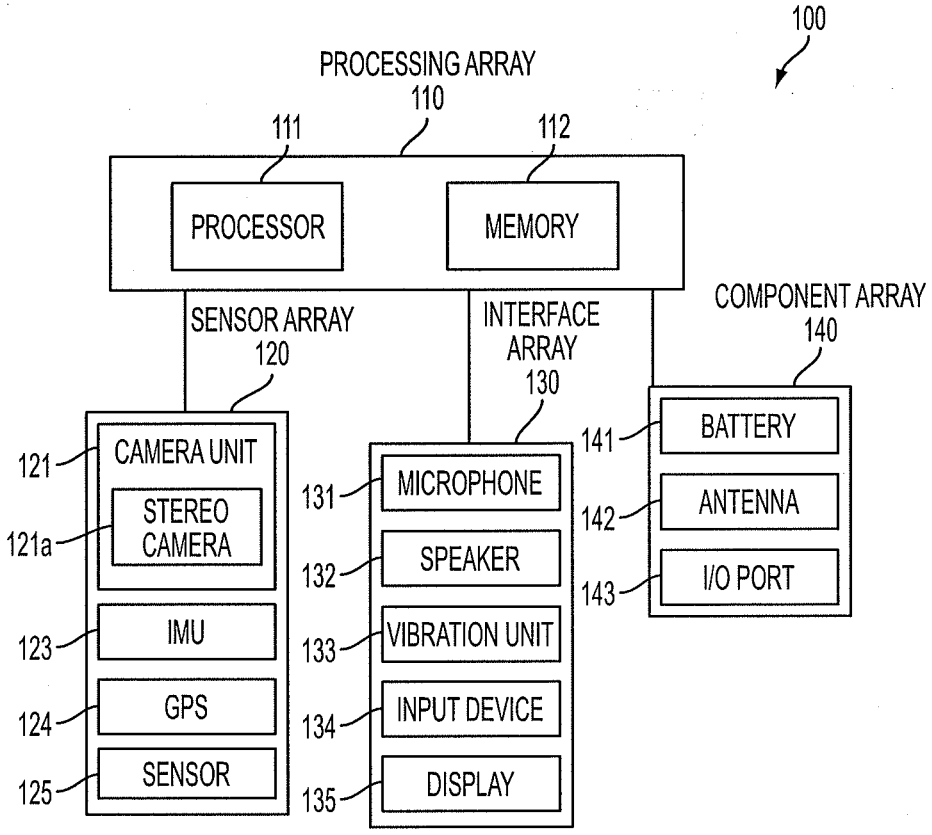
(57) **ABSTRACT**

An intelligent earpiece to be worn over an ear of a user is described. The earpiece includes a processor connected to the IMU, the GPS unit and the at least one camera. The processor can recognize an object in the surrounding environment by analyzing the image data based on the stored object data and at least one of the inertial measurement data or the location data. The processor can determine a desirable event or action based on the recognized object, the previously determined user data, and a current time or day. The processor can determine a destination based on the determined desirable event or action. The processor can determine a navigation path for navigating the intelligent guidance device to the destination based on the determined destination, the image data, the inertial measurement data or the location data. The processor can determine output data based on the determined navigation path.

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PROCESSING ARRAY
110
111
112
PROCESSOR
MEMORY
SENSOR ARRAY
120
INTERFACE ARRAY
130
COMPONENT ARRAY
140
121
CAMERA UNIT
121a
STEREO CAMERA
123
IMU
124
GPS
125
SENSOR
131
MICROPHONE
132
SPEAKER
133
VIBRATION UNIT
134
INPUT DEVICE
135
DISPLAY
141
BATTERY
142
ANTENNA
143
I/O PORT

FIG. 1A

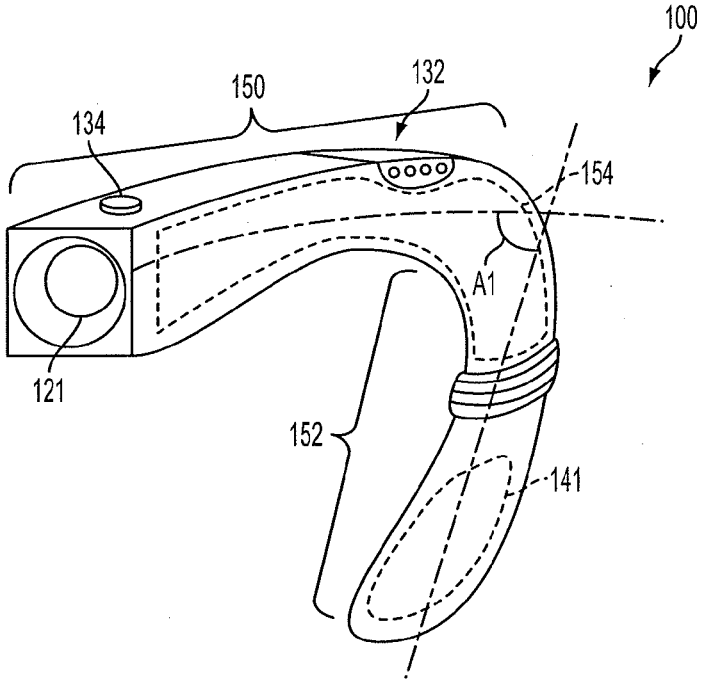

100
150
132
134
154
A1
121
152
141

FIG. 1B

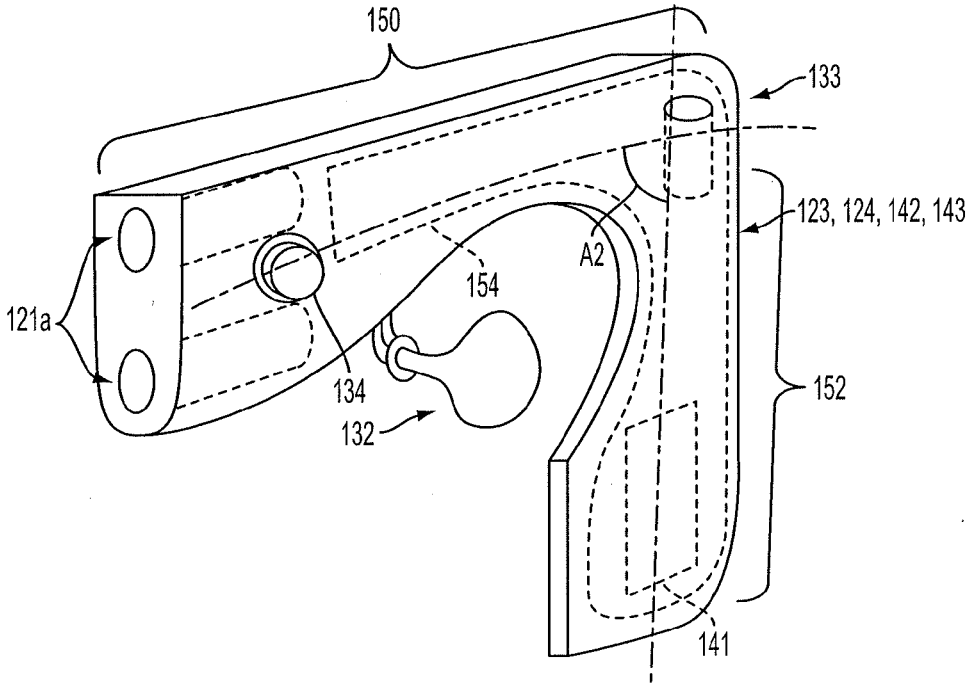

150
133
123, 124, 142, 143
A2
154
121a
134
132
152
141

FIG. 1C

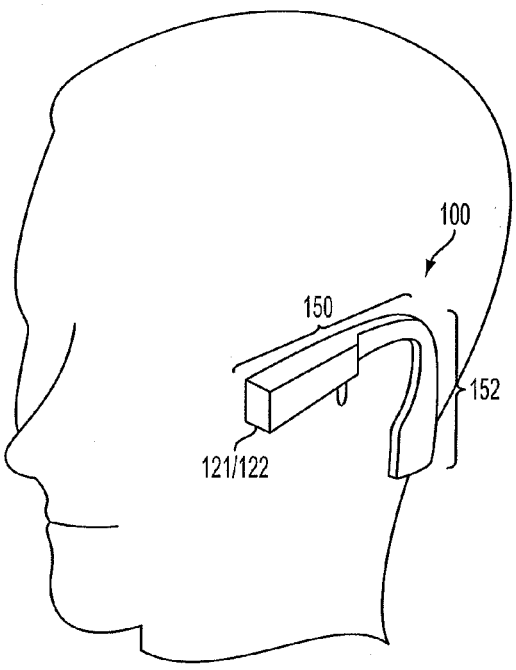


FIG. 1D

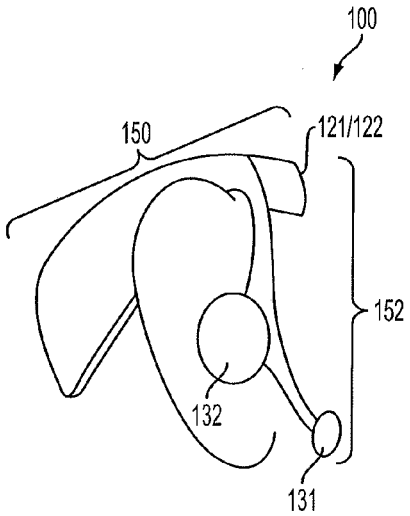


FIG. 1E

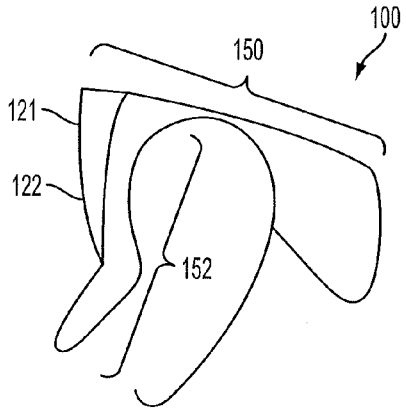


FIG. 1F

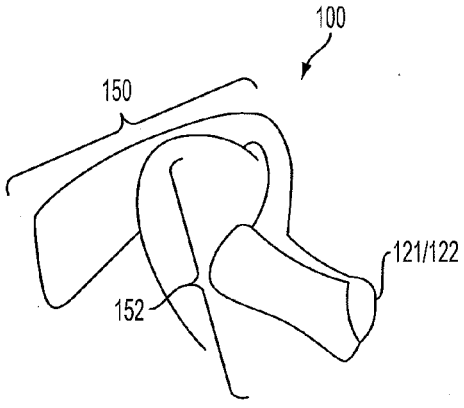


FIG. 1G

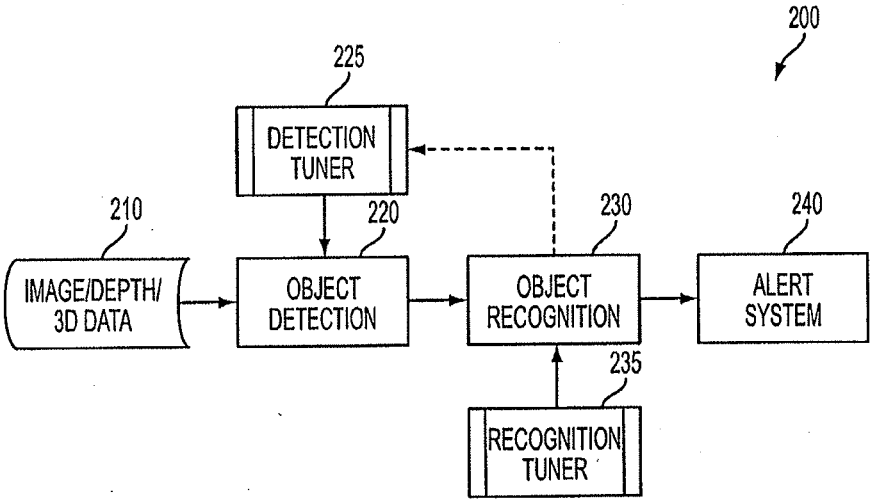

200
225
DETECTION TUNER
210
220
230
240
IMAGE/DEPTH/ 3D DATA
OBJECT DETECTION
OBJECT RECOGNITION
ALERT SYSTEM
235
RECOGNITION TUNER

FIG. 2

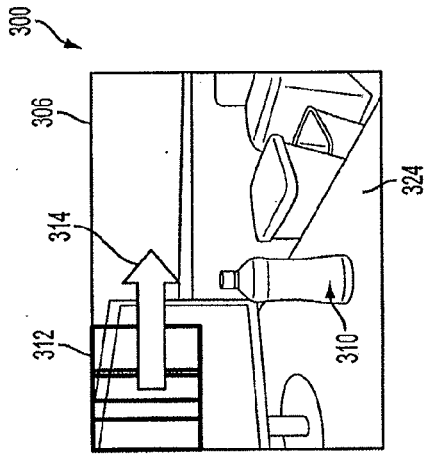


FIG. 3B

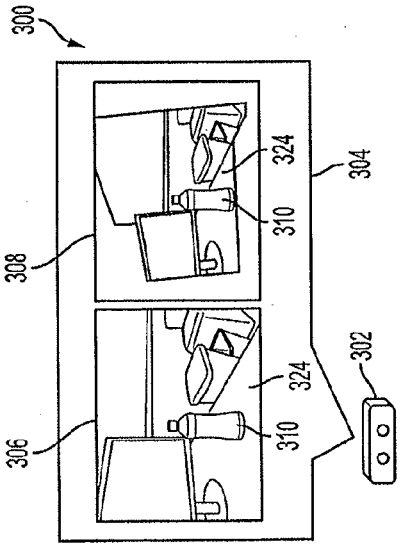


FIG. 3A

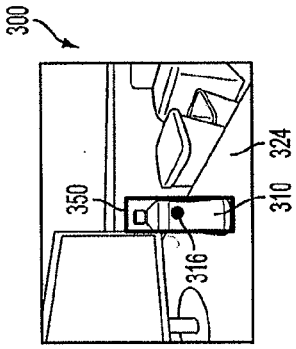


FIG. 3C

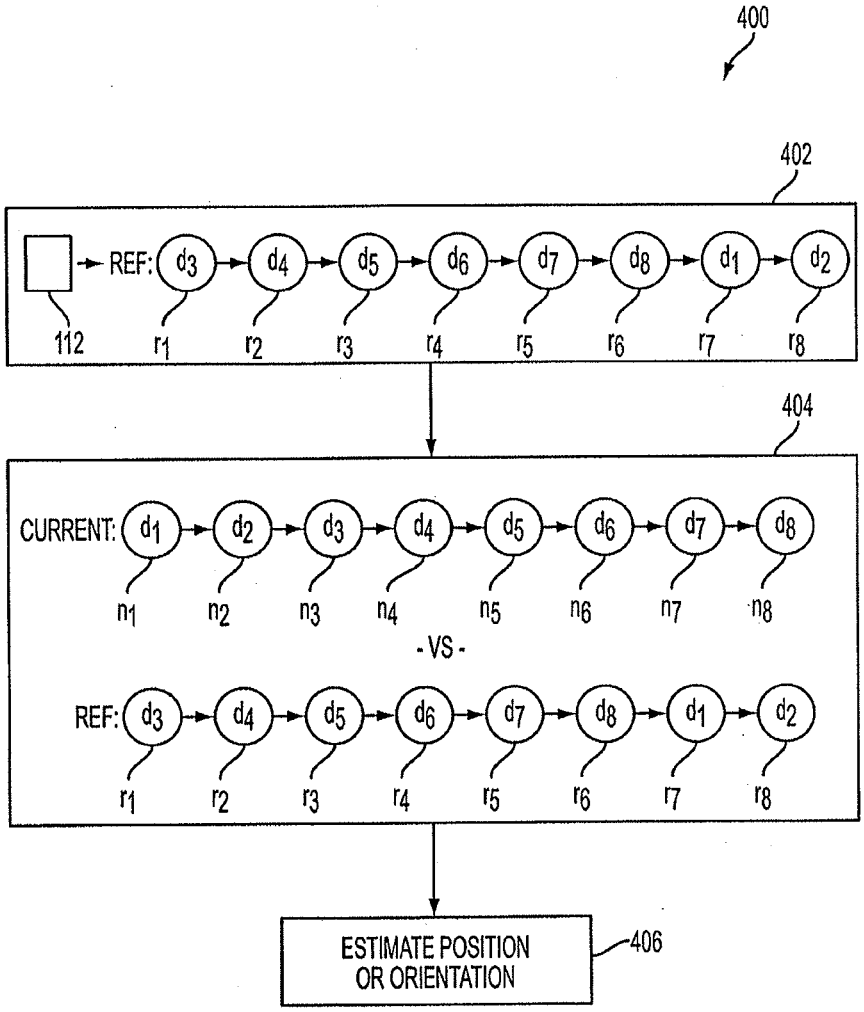

400
402
REF:
d3
d4
d5
d6
d7
d8
d1
d2
112
r1
r2
r3
r4
r5
r6
r7
r8
404
CURRENT:
d1
d2
d3
d4
d5
d6
d7
d8
n1
n2
n3
n4
n5
n6
n7
n8
- VS -
REF:
d3
d4
d5
d6
d7
d8
d1
d2
r1
r2
r3
r4
r5
r6
r7
r8
ESTIMATE POSITION OR ORIENTATION
406

FIG. 4

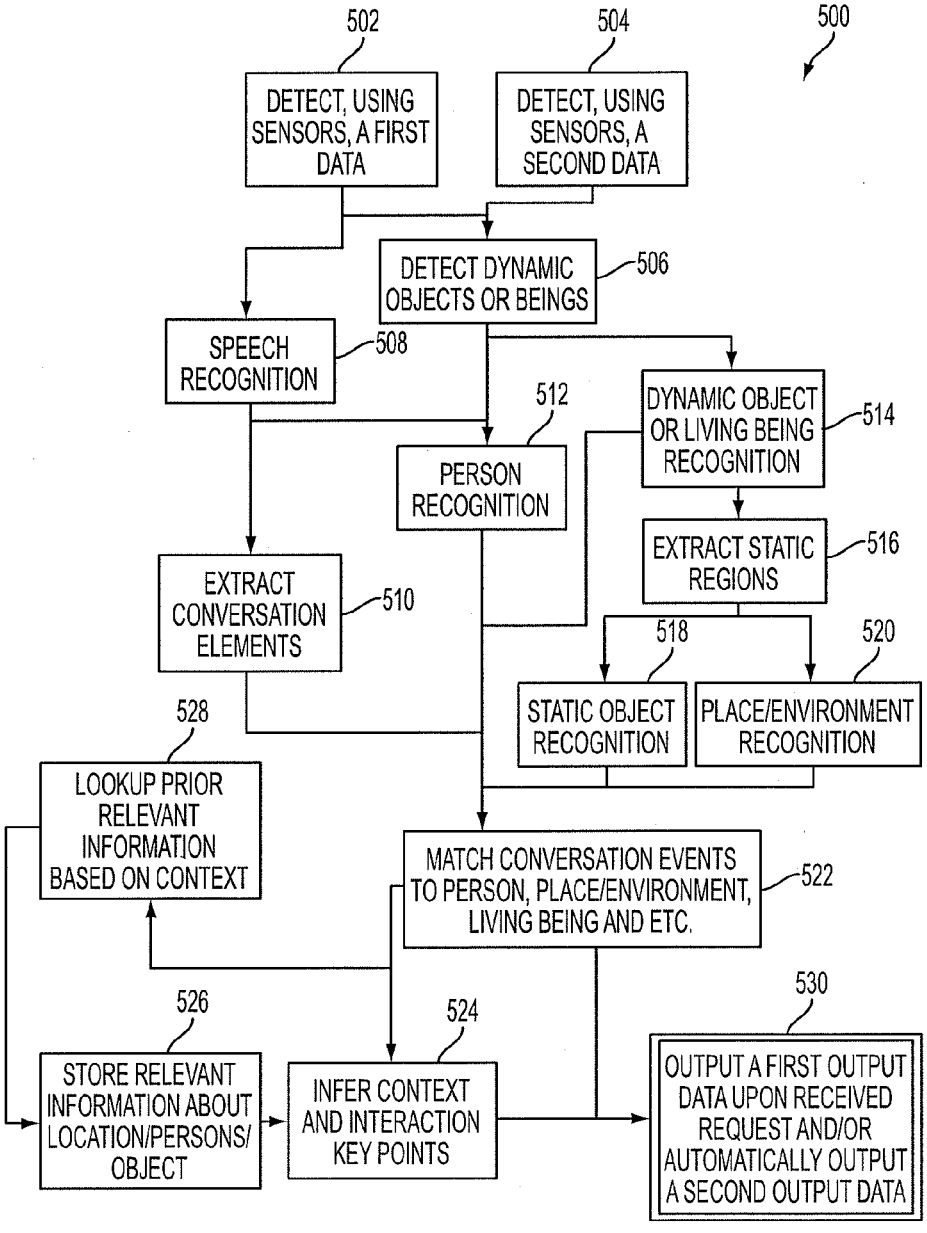

502
504
500
DETECT, USING SENSORS, A FIRST DATA
DETECT, USING SENSORS, A SECOND DATA
DETECT DYNAMIC OBJECTS OR BEINGS
506
SPEECH RECOGNITION
508
512
DYNAMIC OBJECT OR LIVING BEING RECOGNITION
514
PERSON RECOGNITION
EXTRACT STATIC REGIONS
516
EXTRACT CONVERSATION ELEMENTS
510
518
520
STATIC OBJECT RECOGNITION
PLACE/ENVIRONMENT RECOGNITION
528
LOOKUP PRIOR RELEVANT INFORMATION BASED ON CONTEXT
MATCH CONVERSATION EVENTS TO PERSON, PLACE/ENVIRONMENT, LIVING BEING AND ETC.
522
526
524
530
STORE RELEVANT INFORMATION ABOUT LOCATION/PERSONS/ OBJECT
INFER CONTEXT AND INTERACTION KEY POINTS
OUTPUT A FIRST OUTPUT DATA UPON RECEIVED REQUEST AND/OR AUTOMATICALLY OUTPUT A SECOND OUTPUT DATA

FIG. 5

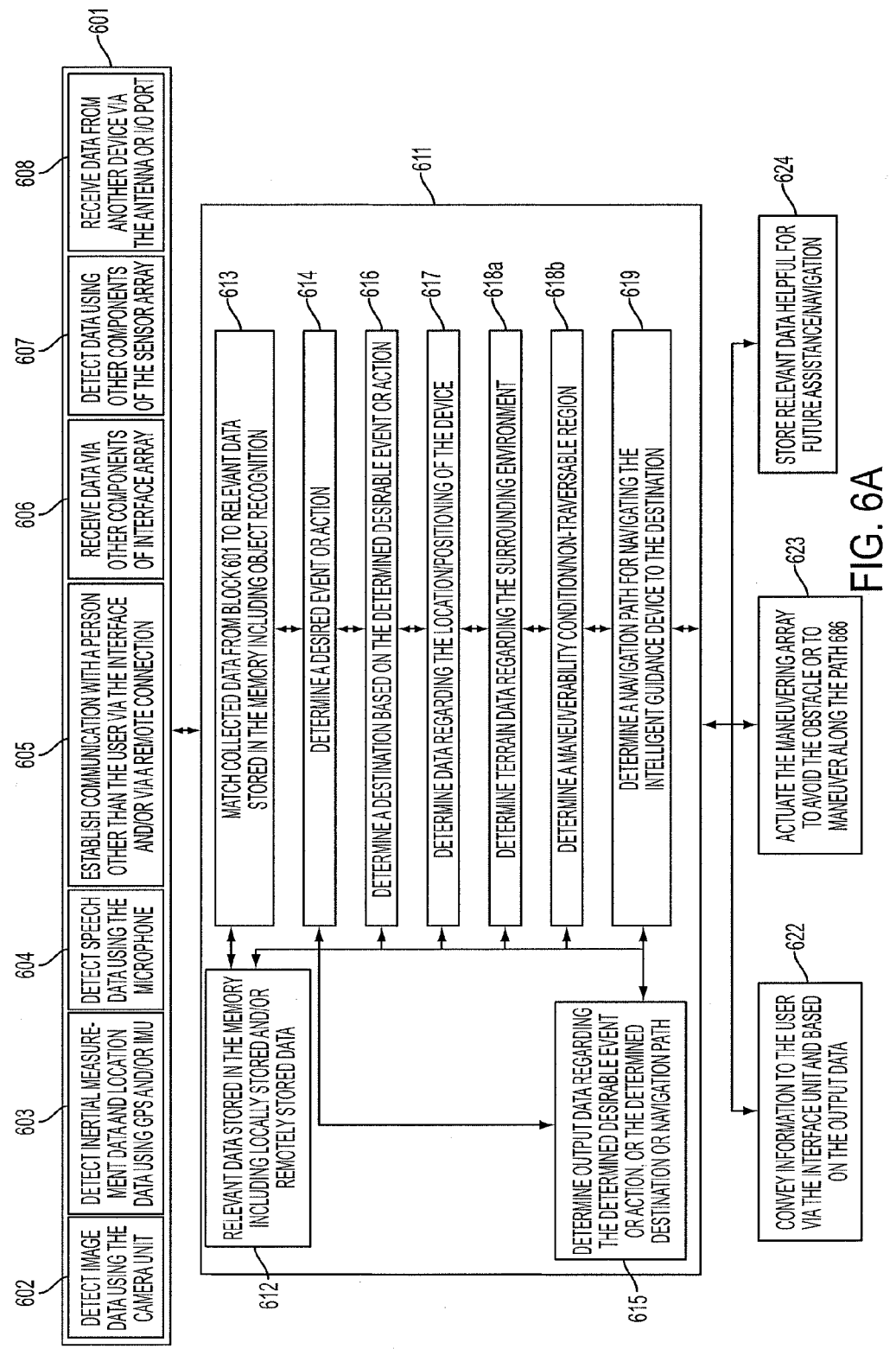

601
602
DETECT IMAGE DATA USING THE CAMERA UNIT
603
DETECT INERTIAL MEASUREMENT DATA AND LOCATION DATA USING GPS AND/OR IMU
604
DETECT SPEECH DATA USING THE MICROPHONE
605
ESTABLISH COMMUNICATION WITH A PERSON OTHER THAN THE USER VIA THE INTERFACE AND/OR VIA A REMOTE CONNECTION
606
RECEIVE DATA VIA OTHER COMPONENTS OF INTERFACE ARRAY
607
DETECT DATA USING OTHER COMPONENTS OF THE SENSOR ARRAY
608
RECEIVE DATA FROM ANOTHER DEVICE VIA THE ANTENNA OR I/O PORT
611
612
RELEVANT DATA STORED IN THE MEMORY INCLUDING LOCALLY STORED AND/OR REMOTELY STORED DATA
613
MATCH COLLECTED DATA FROM BLOCK 601 TO RELEVANT DATA STORED IN THE MEMORY INCLUDING OBJECT RECOGNITION
614
DETERMINE A DESIRED EVENT OR ACTION
616
DETERMINE A DESTINATION BASED ON THE DETERMINED DESIRABLE EVENT OR ACTION
617
DETERMINE DATA REGARDING THE LOCATION/POSITIONING OF THE DEVICE
618a
DETERMINE TERRAIN DATA REGARDING THE SURROUNDING ENVIRONMENT
618b
DETERMINE A MANEUVERABILITY CONDITION/NON-TRAVERSABLE REGION
619
DETERMINE A NAVIGATION PATH FOR NAVIGATING THE INTELLIGENT GUIDANCE DEVICE TO THE DESTINATION
615
DETERMINE OUTPUT DATA REGARDING THE DETERMINED DESIRABLE EVENT OR ACTION, OR THE DETERMINED DESTINATION OR NAVIGATION PATH
622
CONVEY INFORMATION TO THE USER VIA THE INTERFACE UNIT AND BASED ON THE OUTPUT DATA
623
ACTUATE THE MANEUVERING ARRAY TO AVOID THE OBSTACLE OR TO MANEUVER ALONG THE PATH 686
624
STORE RELEVANT DATA HELPFUL FOR FUTURE ASSISTANCE/NAVIGATION

FIG. 6A

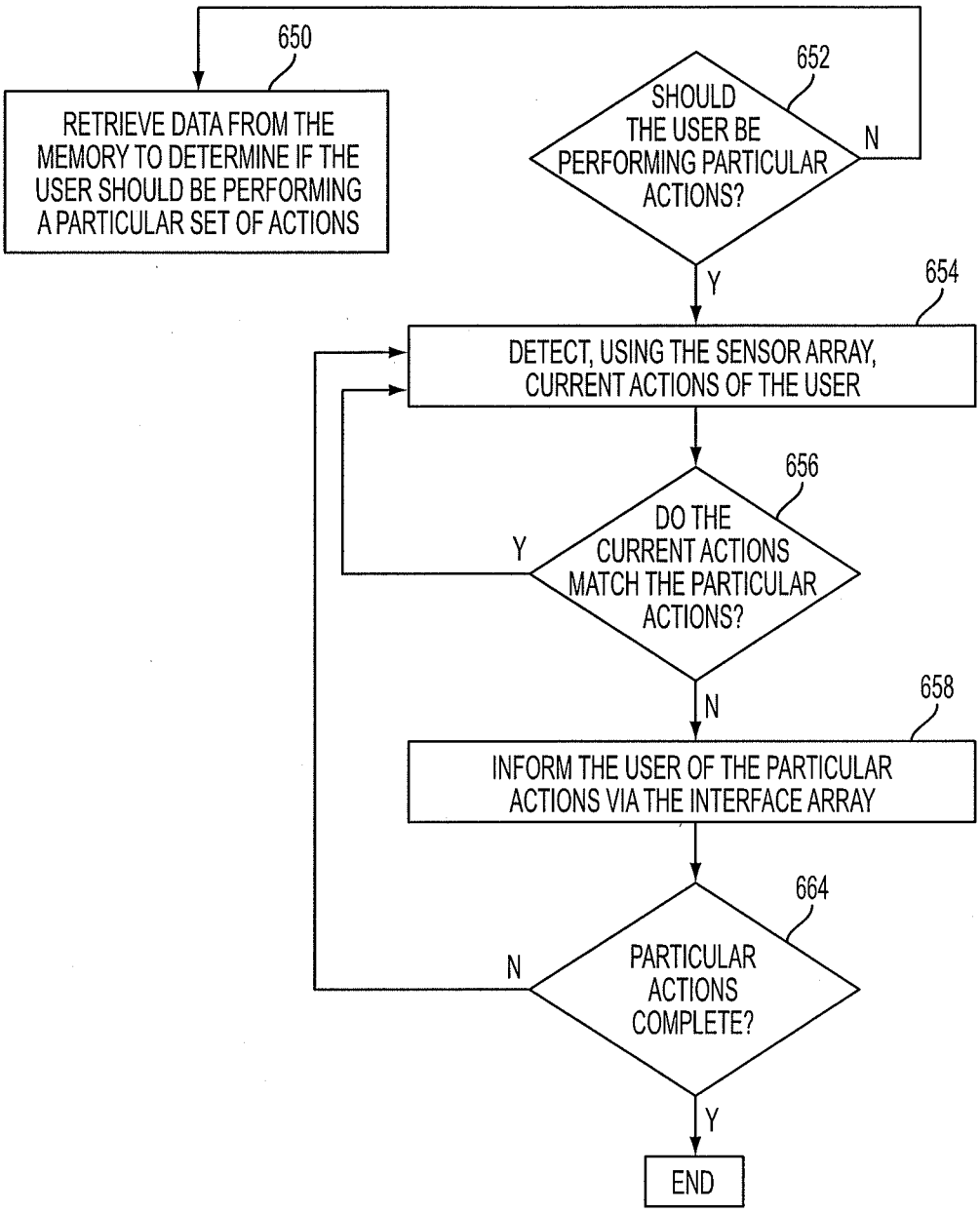

650
RETRIEVE DATA FROM THE MEMORY TO DETERMINE IF THE USER SHOULD BE PERFORMING A PARTICULAR SET OF ACTIONS
652
SHOULD THE USER BE PERFORMING PARTICULAR ACTIONS?
N
Y
654
DETECT, USING THE SENSOR ARRAY, CURRENT ACTIONS OF THE USER
656
DO THE CURRENT ACTIONS MATCH THE PARTICULAR ACTIONS?
Y
N
658
INFORM THE USER OF THE PARTICULAR ACTIONS VIA THE INTERFACE ARRAY
664
PARTICULAR ACTIONS COMPLETE?
N
Y
END

FIG. 6B

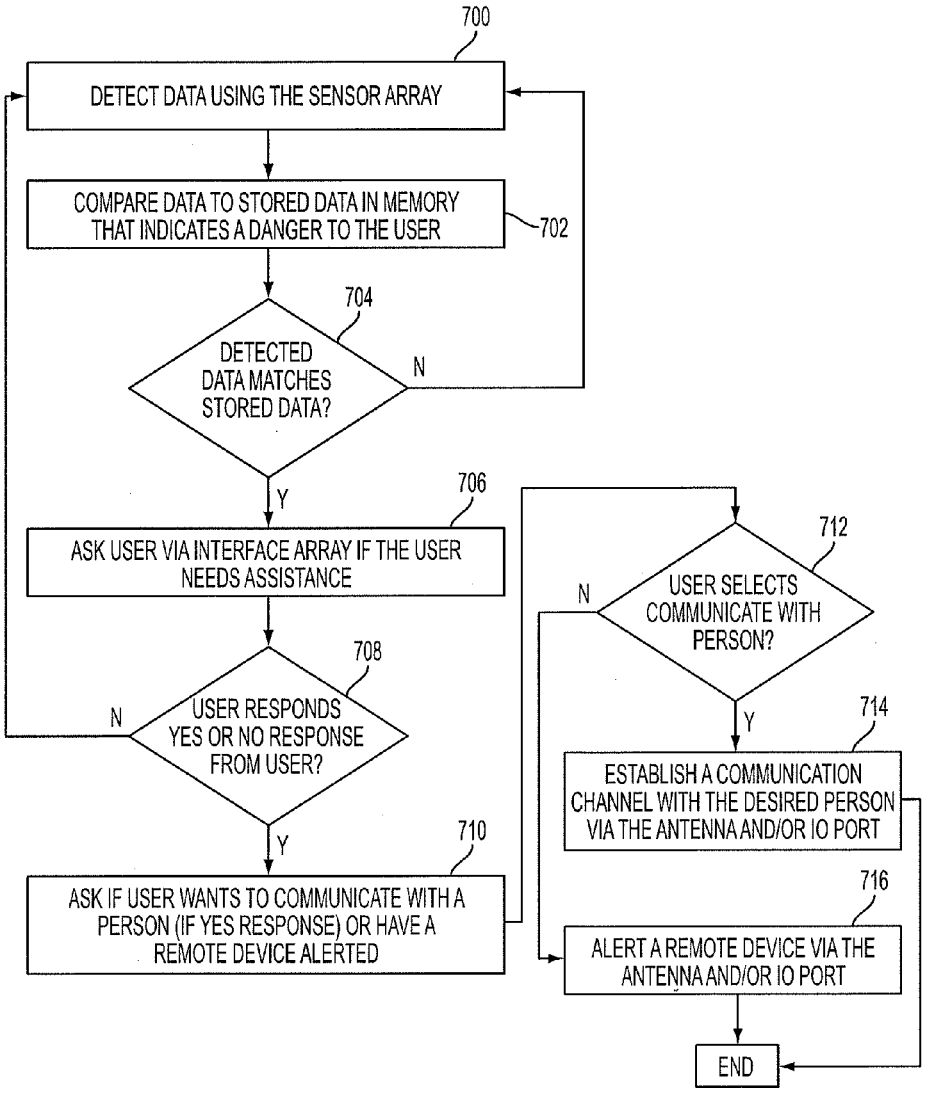

700
DETECT DATA USING THE SENSOR ARRAY
COMPARE DATA TO STORED DATA IN MEMORY THAT INDICATES A DANGER TO THE USER
702
704
DETECTED DATA MATCHES STORED DATA?
N
Y
706
ASK USER VIA INTERFACE ARRAY IF THE USER NEEDS ASSISTANCE
708
USER RESPONDS YES OR NO RESPONSE FROM USER?
N
Y
710
ASK IF USER WANTS TO COMMUNICATE WITH A PERSON (IF YES RESPONSE) OR HAVE A REMOTE DEVICE ALERTED
712
USER SELECTS COMMUNICATE WITH PERSON?
N
Y
714
ESTABLISH A COMMUNICATION CHANNEL WITH THE DESIRED PERSON VIA THE ANTENNA AND/OR IO PORT
716
ALERT A REMOTE DEVICE VIA THE ANTENNA AND/OR IO PORT
END

FIG. 7

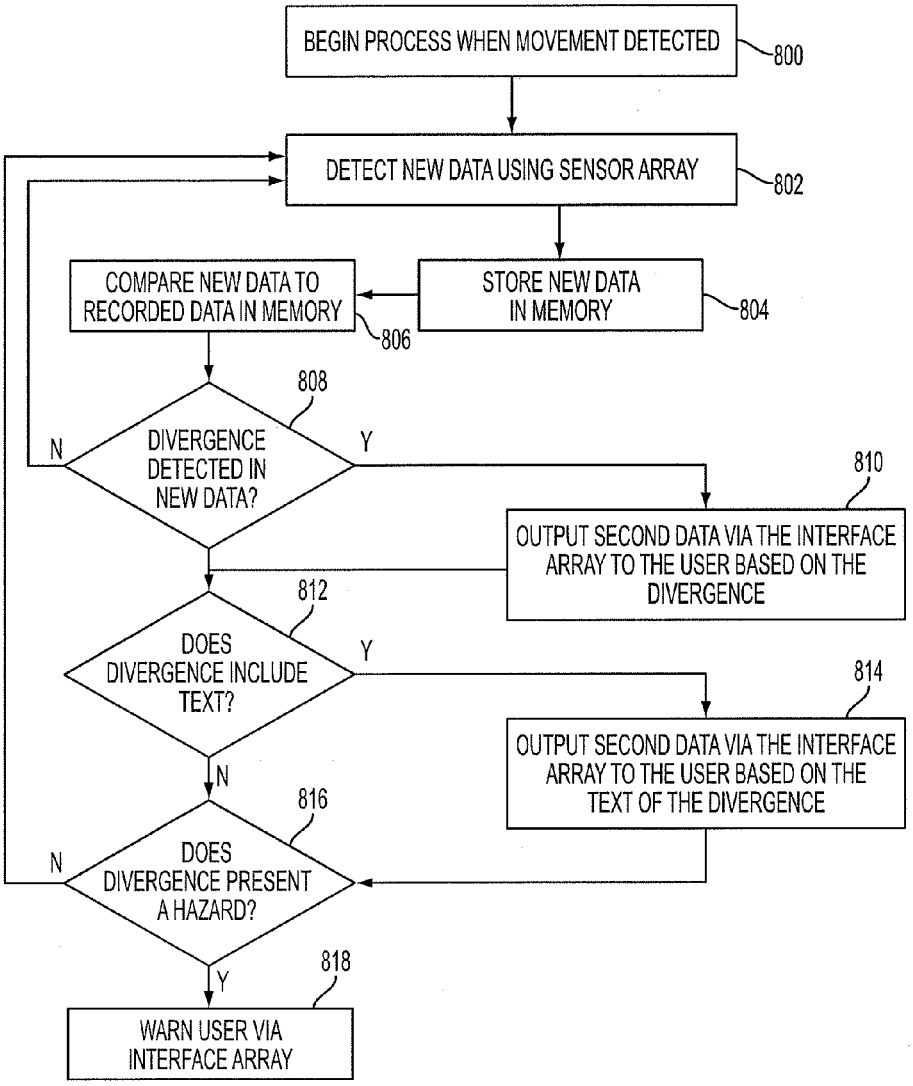

BEGIN PROCESS WHEN MOVEMENT DETECTED
800
DETECT NEW DATA USING SENSOR ARRAY
802
STORE NEW DATA IN MEMORY
804
COMPARE NEW DATA TO RECORDED DATA IN MEMORY
806
808
DIVERGENCE DETECTED IN NEW DATA?
N
Y
810
OUTPUT SECOND DATA VIA THE INTERFACE ARRAY TO THE USER BASED ON THE DIVERGENCE
812
DOES DIVERGENCE INCLUDE TEXT?
Y
814
OUTPUT SECOND DATA VIA THE INTERFACE ARRAY TO THE USER BASED ON THE TEXT OF THE DIVERGENCE
N
816
DOES DIVERGENCE PRESENT A HAZARD?
N
Y
818
WARN USER VIA INTERFACE ARRAY

FIG. 8A

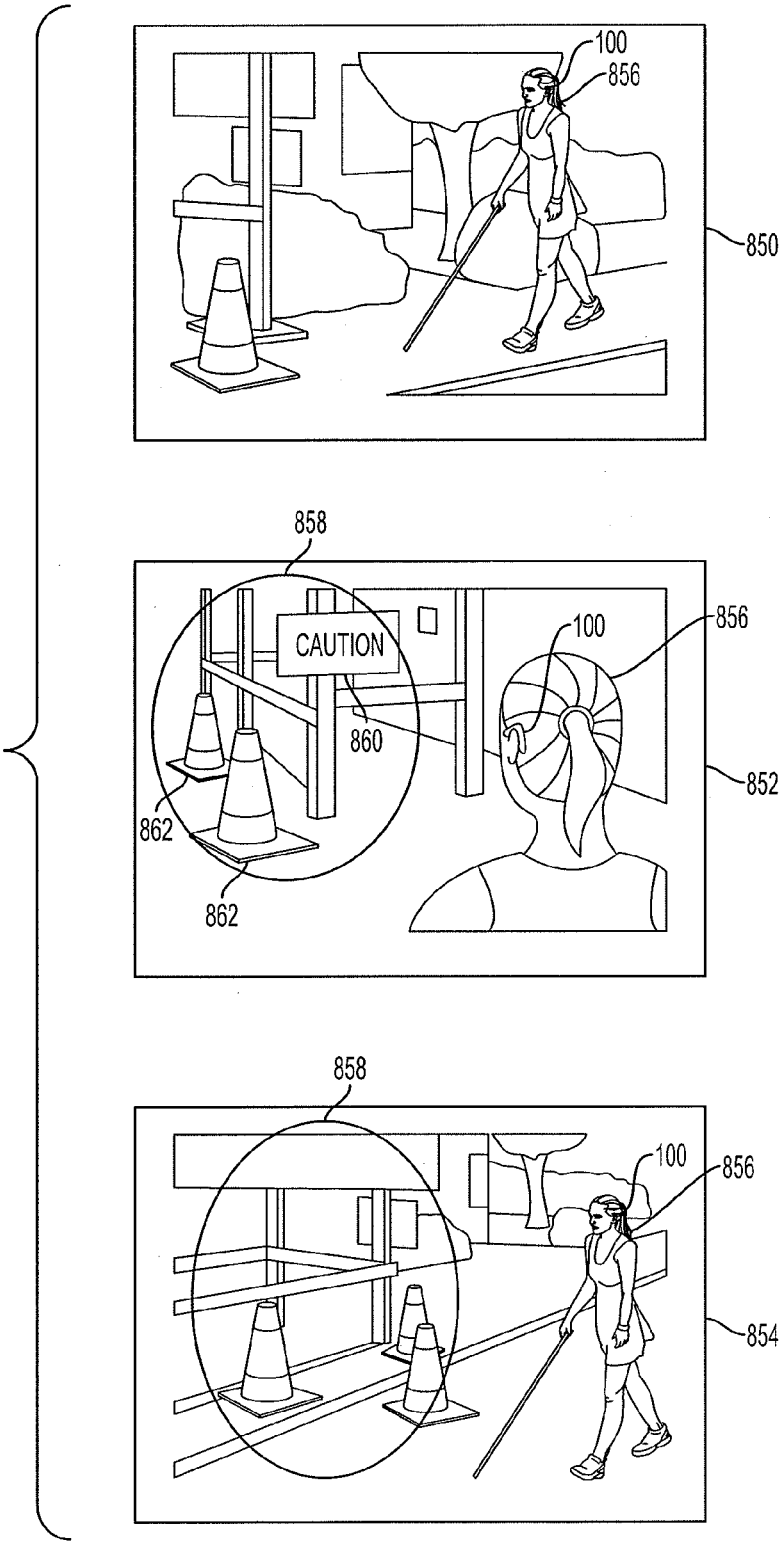


FIG. 8B

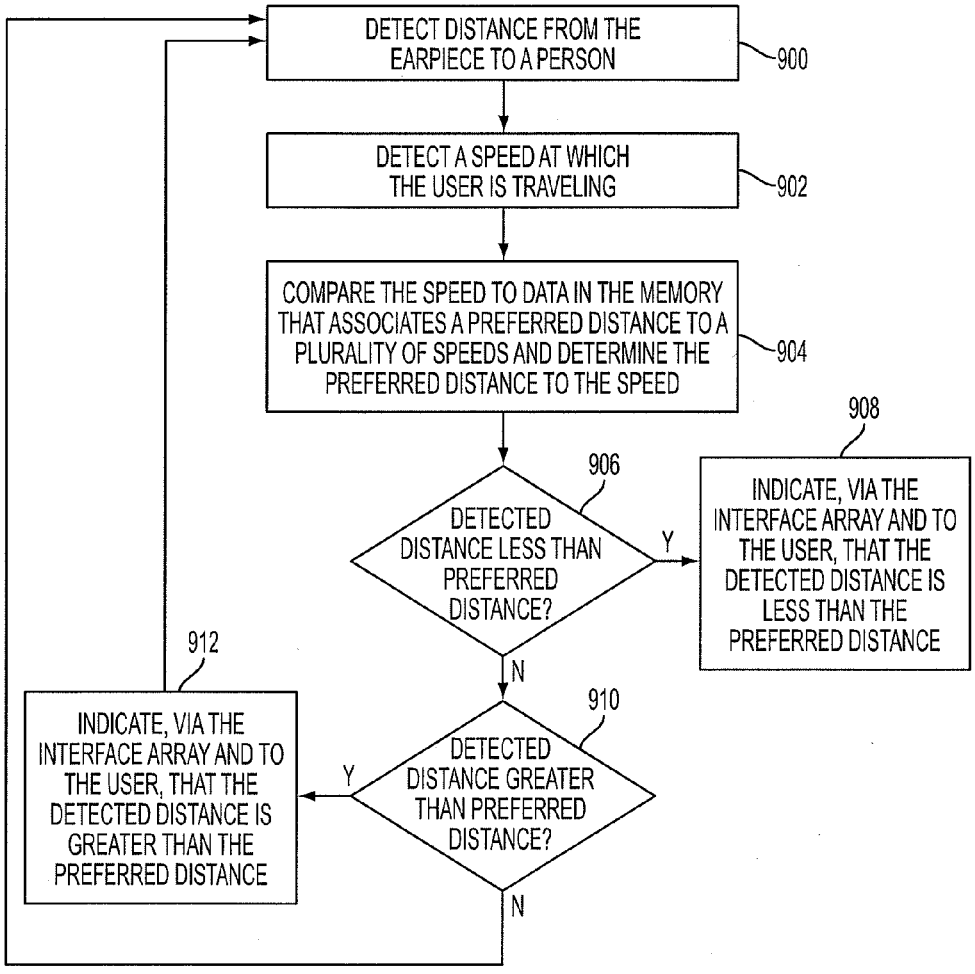

DETECT DISTANCE FROM THE EARPIECE TO A PERSON
900
DETECT A SPEED AT WHICH THE USER IS TRAVELING
902
COMPARE THE SPEED TO DATA IN THE MEMORY THAT ASSOCIATES A PREFERRED DISTANCE TO A PLURALITY OF SPEEDS AND DETERMINE THE PREFERRED DISTANCE TO THE SPEED
904
906
DETECTED DISTANCE LESS THAN PREFERRED DISTANCE?
Y
908
INDICATE, VIA THE INTERFACE ARRAY AND TO THE USER, THAT THE DETECTED DISTANCE IS LESS THAN THE PREFERRED DISTANCE
N
910
DETECTED DISTANCE GREATER THAN PREFERRED DISTANCE?
Y
912
INDICATE, VIA THE INTERFACE ARRAY AND TO THE USER, THAT THE DETECTED DISTANCE IS GREATER THAN THE PREFERRED DISTANCE
N

FIG. 9A

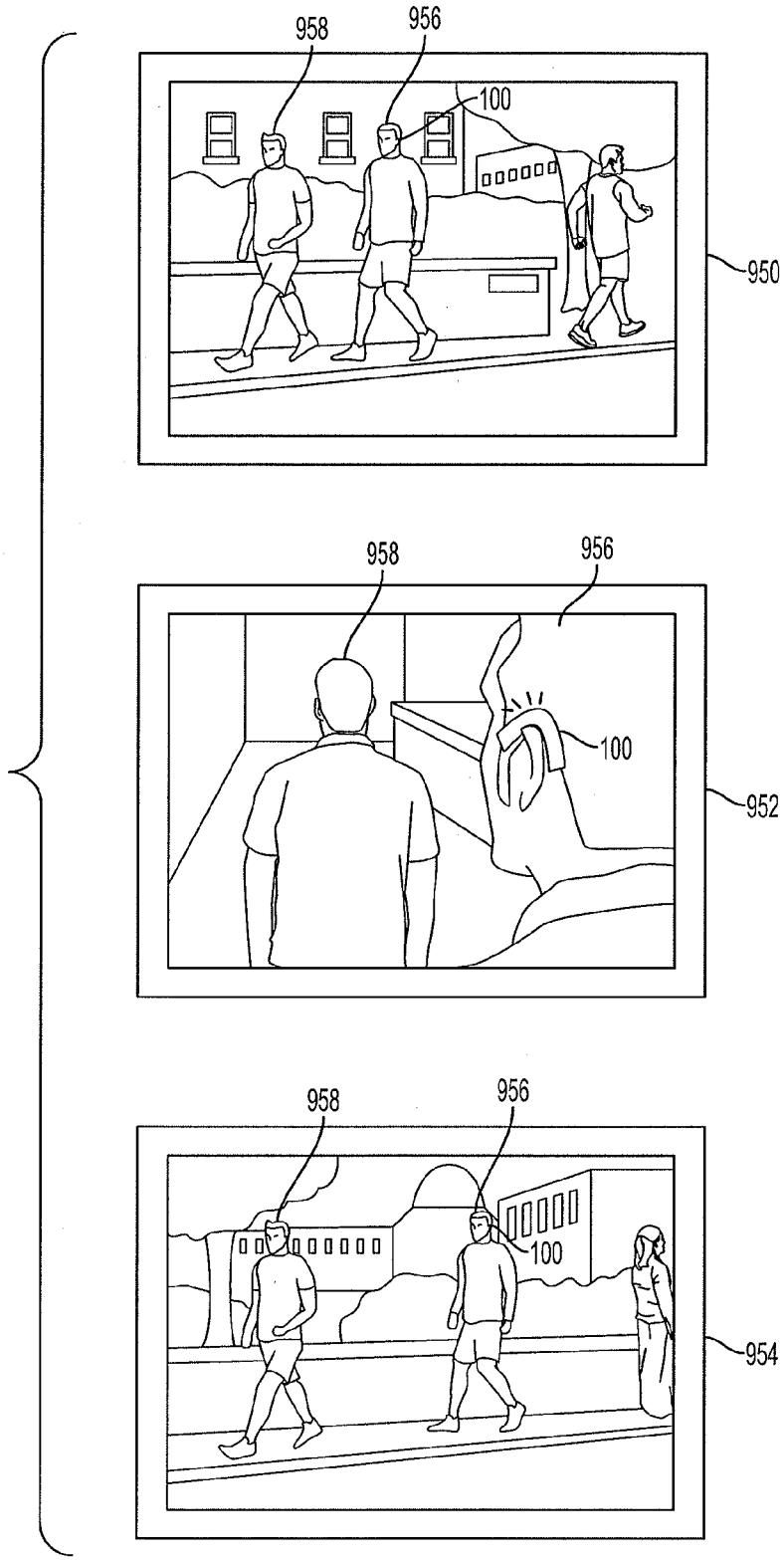
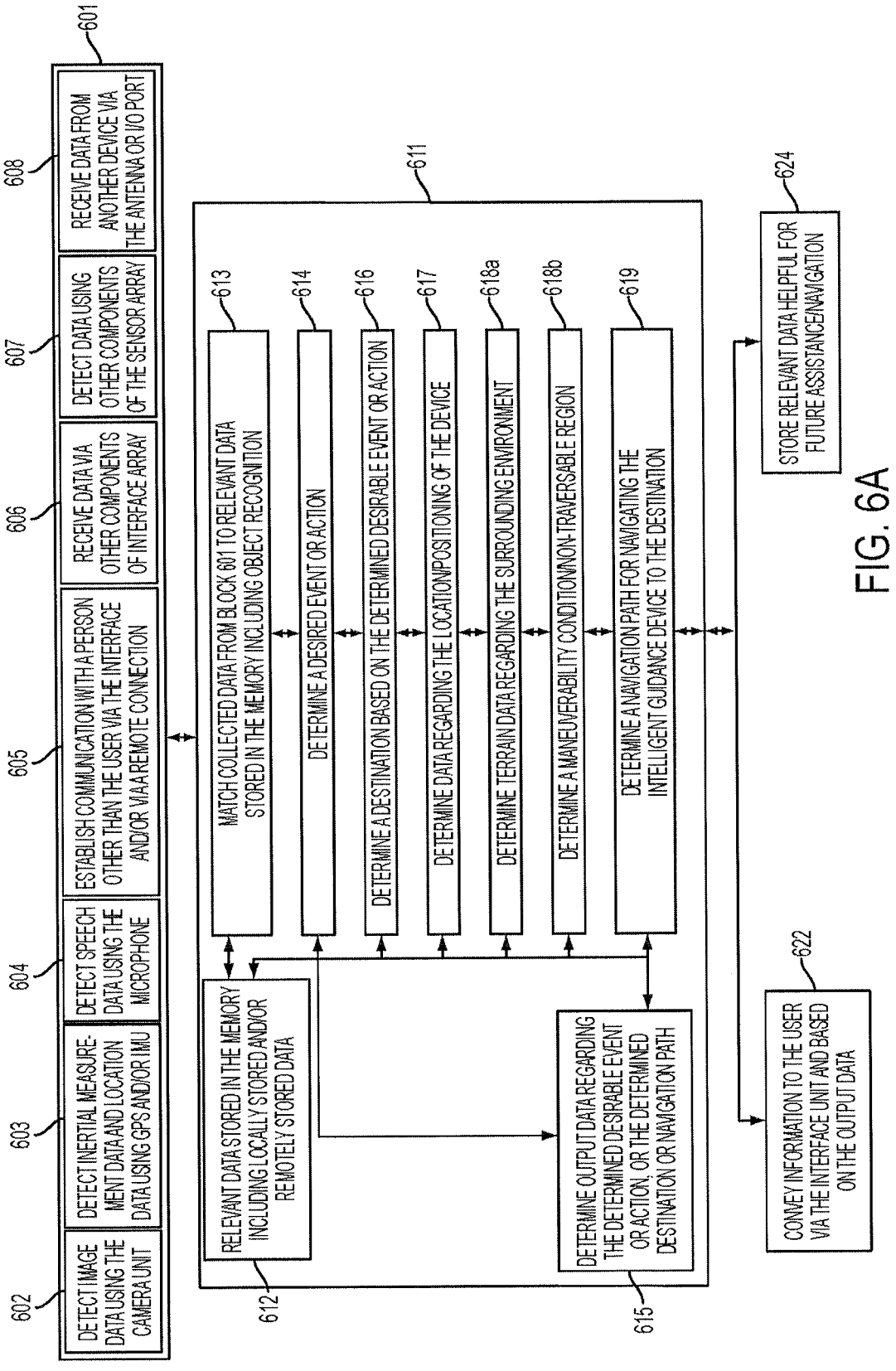


FIG. 9B


601
602
DETECT IMAGE DATA USING THE CAMERA UNIT
603
DETECT INERTIAL MEASUREMENT DATA AND LOCATION DATA USING GPS AND/OR IMU
604
DETECT SPEECH DATA USING THE MICROPHONE
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606
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607
DETECT DATA USING OTHER COMPONENTS OF THE SENSOR ARRAY
608
RECEIVE DATA FROM ANOTHER DEVICE VIA THE ANTENNA OR I/O PORT
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DETERMINE A DESIRED EVENT OR ACTION
615
DETERMINE OUTPUT DATA REGARDING THE DETERMINED DESIRABLE EVENT OR ACTION, OR THE DETERMINED DESTINATION OR NAVIGATION PATH
616
DETERMINE A DESTINATION BASED ON THE DETERMINED DESIRABLE EVENT OR ACTION
617
DETERMINE DATA REGARDING THE LOCATION/POSITIONING OF THE DEVICE
618a
DETERMINE TERRAIN DATA REGARDING THE SURROUNDING ENVIRONMENT
618b
DETERMINE A MANEUVERABILITY CONDITION/NON-TRAVERSABLE REGION
619
DETERMINE A NAVIGATION PATH FOR NAVIGATING THE INTELLIGENT GUIDANCE DEVICE TO THE DESTINATION
622
CONVEY INFORMATION TO THE USER VIA THE INTERFACE UNIT AND BASED ON THE OUTPUT DATA
624
STORE RELEVANT DATA HELPFUL FOR FUTURE ASSISTANCE/NAVIGATION

FIG. 6A

WEARABLE EARPIECE FOR PROVIDING SOCIAL AND ENVIRONMENTAL AWARENESS

BACKGROUND

[0001] 1. Field

[0002] The present disclosure relates to a wearable device, which provides haptic and audio feedback based on various sensors and user input.

[0003] 2. Description of the Related Art

[0004] Wearable devices currently exist in the art which have an input, such as a camera, an output, such as a speaker, and a processor. However, these devices are not optimized to assist users having certain physical disabilities. For example, they do not proactively collect data regarding the user and the environment of the user to achieve an understanding of the user and the user's environment. These devices also do not proactively provide helpful information or assistance to the user. In other words, the devices known in the art do not proactively aid the user in navigation, environmental awareness, and social interactions.

[0005] Thus, there is a need for a wearable device that actively collects data about the user and the his/her surrounding information, draws helpful inferences based on the collected data, and actively aids the user in navigation, environmental awareness, and social interactions.

SUMMARY

[0006] An intelligent earpiece to be worn over an ear of a user is described. The earpiece contains an inertial measurement unit (IMU) coupled to the intelligent earpiece. The IMU is configured to detect inertial measurement data that corresponds to a positioning, velocity, or acceleration of the intelligent earpiece. The earpiece also contains a global positioning system (GPS) unit coupled to the earpiece that is configured to detect location data corresponding to a location of the intelligent earpiece. At least one camera is coupled to the intelligent earpiece and is configured to detect image data corresponding to a surrounding environment of the intelligent guidance device. The earpiece includes a memory configured to store object data regarding previously determined objects. The memory also stores previously determined user data associated with the user. The earpiece also includes a processor connected to the IMU, the GPS unit and the at least one camera. The processor is configured to recognize an object in the surrounding environment. This is done by analyzing the image data based on the stored object data and at least one of the inertial measurement data or the location data. The processor is also configured to determine a desirable event or action based on the recognized object, the previously determined user data, and a current time or day. The processor is also configured to determine a destination based on the determined desirable event or action. The processor is also configured to determine a navigation path for navigating the intelligent guidance device to the destination. This is determined based on the determined destination, the image data, and at least one of the inertial measurement data or the location data. The processor is also configured to determine output data based on the determined navigation path. A speaker is included that is configured to provide audio information to the user based on at least one of the recognized object, determined desirable event or action, or navigation path.

[0007] Also described is a method for providing continuous social and environmental awareness by an earpiece. The method comprises detecting, via an inertial measurement unit (IMU), a global position system unit (GPS) or a camera, inertial measurement data corresponding to a positioning, velocity, or acceleration of the earpiece. Location data corresponding to a location of the earpiece or image data corresponding to a surrounding environment of the earpiece is also determined. The method also includes storing, in a memory, object data regarding previously determined objects and previously determined user data regarding the user. The method also includes recognizing, by a processor, an object in the surrounding environment by analyzing the image data based on the stored object data and at least one of the inertial measurement data or the location data. The method further includes determining, by the processor, a desirable event or action based on the recognized object, the previously determined user data, and a current time or day. The processor also determines a destination based on the determined desirable event or action. The processor may determine a navigation path for navigating the intelligent guidance device to the destination based on the determined destination, the image data, and at least one of the inertial measurement data or the location data. The processor may determine output data based on the determined navigation path. The method further includes providing, via a speaker or a vibration unit, audio or haptic information to the user based on at least one of the recognized object, the determined desirable event or action, or the navigation path.

[0008] An intelligent earpiece to be worn over an ear of a user is described. The earpiece includes an inertial measurement unit (IMU) coupled to the intelligent earpiece and configured to detect inertial measurement data corresponding to a positioning, velocity, or acceleration of the intelligent earpiece. The earpiece also includes a global positioning system (GPS) unit coupled to the intelligent earpiece and configured to detect location data corresponding to a location of the intelligent earpiece. The earpiece also includes at least one camera coupled to the intelligent earpiece configured to detect image data corresponding to a surrounding environment of the intelligent guidance device. The earpiece also includes a memory configured to store object data regarding previously determined objects and for storing previously determined user data associated with the user. The earpiece also includes an antenna configured to transmit the image data, the inertial measurement data, the location data and the object data to a remote processor and to receive processed data from the remote processor. The remote processor is configured to recognize an object in the surrounding environment by analyzing the image data based on the stored object data and at least one of the inertial measurement data or the location data. The remote processor is also configured to determine a desirable event or action based on the recognized object, the previously determined user data, and a current time or day. The remote processor is also configured to determine a destination based on the determined desirable event or action. The remote processor is also configured to determine a navigation path for navigating the intelligent guidance device to the destination based on the determined destination, the image data, and at least one of the inertial measurement data or the location data. The remote processor is further configured to determine output data based on the determined navigation path. The earpiece also includes a speaker config-

ured to provide audio information to the user based on at least one of the recognized object, determined desirable event or action, or navigation path.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] Other systems, methods, features, and advantages of the present invention will be or will become apparent to one of ordinary skill in the art upon examination of the following figures and detailed description. It is intended that all such additional systems, methods, features, and advantages be included within this description, be within the scope of the present invention, and be protected by the accompanying claims. Component parts shown in the drawings are not necessarily to scale, and may be exaggerated to better illustrate the important features of the present invention. In the drawings, like reference numerals designate like parts throughout the different views, wherein:

[0010] FIG. **1**A is a block diagram of an earpiece according to an embodiment of the present invention;

[0011] FIG. **1**B illustrates an earpiece according to an embodiment of the present invention;

[0012] FIG. **1**C illustrates an earpiece according to an embodiment of the present invention;

[0013] FIG. **1**D illustrates an earpiece positioned on a user's ear according to an embodiment of the present invention;

[0014] FIG. **1**E illustrates an earpiece positioned on a user's ear according to an embodiment of the present invention;

[0015] FIG. **1**F illustrates an earpiece positioned on a user's ear according to an embodiment of the present invention;

[0016] FIG. **1**G illustrates an earpiece positioned on a user's ear according to an embodiment of the present invention;

[0017] FIG. **2** is a flowchart of an object recognition logic according to an embodiment of the present invention;

[0018] FIG. **3**A illustrates an object recognition logic applied to a visual data set according to an embodiment of the present invention;

[0019] FIG. **3**B illustrates the object recognition logic shown in FIG. **3**A according to an embodiment of the present invention;

[0020] FIG. **3**C illustrates the object recognition logic shown in FIG. **3**A according to an embodiment of the present invention;

[0021] FIG. **4** is a flowchart illustrating a method of estimating a position or orientation based on slice descriptors according to an embodiment of the present invention;

[0022] FIG. **5** is a flowchart for outputting first and/or second output data for providing assistance to a user of the earpiece according to an embodiment of the present invention;

[0023] FIG. **6**A illustrates an exemplary method for navigating a mobility aid device and/or providing helpful information to a user of the mobility aid device based on detected data according to an embodiment of the present invention;

[0024] FIG. **6**B illustrates an exemplary method for navigating a mobility aid device and/or providing assistance to a user of the mobility aid device based on a determined desirable event action, and/or destination according to an embodiment of the present invention;

[0025] FIG. **7** illustrates an exemplary method for danger assistance by the earpiece according to an embodiment of the present invention;

[0026] FIG. **8**A illustrates an exemplary method for safety monitoring and alerting using the earpiece according to an embodiment of the present invention;

[0027] FIG. **8**B illustrates an example of the method of FIG. **8**A according to an embodiment of the present invention;

[0028] FIG. **9**A illustrates an exemplary method for providing navigation assistance to the user of the earpiece according to an embodiment of the present invention; and

[0029] FIG. **9**B illustrates an exemplary use of the method of FIG. **9**A according to an embodiment of the present invention.

DETAILED DESCRIPTION

[0030] Apparatus, systems and methods that implement the implementations of the various features of the present application will now be described with reference to the drawings. The drawings and the associated descriptions are provided to illustrate some implementations of the present application and not to limit the scope of the present application. Throughout the drawings, reference numbers are re-used to indicate correspondence between referenced elements.

[0031] The wearable intelligent earpiece for providing social and environmental awareness provides several advantages over the current state of the art. The selection and placement of inputs on the wearable earpiece has been optimized. This provides the advantage of more accurate output being provided to the user. Also, the selection and placement of outputs has been optimized in order to provide information to the user in a more integrated and easier to understand fashion.

[0032] Additionally, the earpiece can continuously observe the user and his surroundings as well as store preference information, such as calendars and schedules, and access remote databases. Based on this observed data, the earpiece can proactively provide feedback to the user. Proactive functions can, for example, remind a user where he should be, inform the user of the name of a person he is speaking with, warn the user when the user may be approaching a hazardous situation, etc. This is advantageous over the state of the art because the user of the earpiece can be provided information without having to request it. This can result in the user being provided feedback that he may not have known he could receive. Additionally, it allows the user to receive feedback without wasting extra time or effort. In some circumstances, this proactive feedback can prevent potential embarrassment for the user (for example, he need not ask the earpiece the name of a person he is speaking with).

[0033] The on board stereo camera of the device (when included) provides useful depth and distance information to the device. The device can then use this information to better determine social and environmental elements around the user. The combination of the global positioning system (GPS), the inertial measurement unit (IMU) and the camera is advantageous as the combination can provide more accurate feedback to the user.

[0034] FIG. **1**A is a block diagram of an intelligent earpiece (earpiece) **100** according to an embodiment of the present invention. The earpiece **100** includes an onboard processing array **110**, which communicates with a sensor array **120**, an interface array **130** and a component array **140**.

[0035] The arrays **110**, **120**, **130** and **140** are exemplary groupings to visually organize the components of the earpiece **100** in the block diagram of FIG. **1**A and are not limiting or necessarily representative of any physical groupings. In addi-

tion, certain embodiments may have more or less components illustrated in FIG. **1**A. The embodiments shown in FIGS. **1**B-**1**G are examples physical designs of the earpiece **100**. The components can be arranged differently based on design concerns. Not all features and components described herein are shown in FIGS. **1**B-**1**G. Furthermore, the structure in FIGS. **1**B-**1**G may be modified or another earpiece can be designed to include additional features described herein.

[0036] Referring to FIG. **1**B, the earpiece **100** is designed such that it fits over a user's ear. As such, the design may be optimized by using contour shapes as illustrated in FIGS. **1**B through **1**G. These shapes allow the earpiece **100** to more easily and comfortably remain on the user's ear. The design may also be optimized by utilizing light-weight and small components. Light-weight components allow the earpiece **100** to remain light and comfortable for the user. Small components allow the earpiece **100** to remain small, so that it does not feel bulky to the user. Connectivity to another device to perform certain functions is beneficial as it allows the earpiece **100** to remain light while still providing higher power computations.

[0037] The onboard processing array **110** includes a processor **111** and a memory **112**. The processor **111** may be a computer processor such as an ARM processor, DSP processor, distributed processor, or other form of central processing. The memory **112** may be a RAM or other volatile or nonvolatile memory used by the processor **111**. The memory **112** may be a non-transitory memory or a data storage device, such as a hard disk drive, a solid state disk drive, a hybrid disk drive, or other appropriate data storage, and may further store machine-readable instructions, which may be loaded and executed by the processor **111**.

[0038] The sensor array **120** includes a camera unit **121**, an inertial measurement unit (IMU) **123**, a global positioning system (GPS) **124**, and a sensor **125**.

[0039] In one embodiment, the camera unit **121** may include a pair of stereo cameras **121***a* having at least two cameras offset by a stereo distance and/or a non-stereo camera **121**. The stereo distance may be optimized for the two cameras. When discussed herein, camera **121** may refer to any pair of stereo cameras **121***a* and/or any non-stereo camera **121**. Because of the size of the earpiece **100** and the desire to keep the surface are and weight low, it may be optimal for the earpiece to include only one pair of stereo cameras **121***a* or one other type of camera **121**.

[0040] Stereo cameras provide depth information in both indoor and outdoor environments. The pair of stereo cameras **121***a* may face forward, in front of a user, to establish a field of view (FOV). The pair of stereo cameras **121***a* may have, for example, an FOV of around 90 degrees. The pair of stereo cameras **121***a* provides 3D information such as depth in front of the user. Additional cameras, such as a wide angle lens camera, which may be placed to the sides of the pair of stereo cameras **121***a* or used in place of the pair of stereo cameras **121***a*, may increase the FOV to, for example, around 120 degrees. Although the cameras **121** may be monocular, they can provide simple recognition, even without depth or distance information. For example, the cameras **121** can detect moving objects in the user's periphery. The stereo cameras **121***a* and/or the cameras **121** continuously recognize objects in the environment. Working in conjunction with the other sensors in the sensor array **120**, the earpiece **100** provides the user with guidance and navigation commands by way of audio and haptic feedback.

[0041] For example, instead of or in addition to a pair of stereo cameras **121***a*, the earpiece **100** may include a wide-lens camera to increase the field of view. Although additional cameras may be monocular, they can provide simple recognition, even without depth or distance information. For example, the cameras can detect moving objects in the user's periphery. The stereo cameras **122***a* and the additional cameras continuously recognize objects in the environment. Working in conjunction with the other sensors in the sensor array **120**, the earpiece **100** provides the user with guidance and navigation commands by way of audio and haptic feedback.

[0042] In some embodiments, the camera **121** may include a plurality of cameras. Adding multiple cameras might be beneficial as it may capture a view that may be obstructed by the device itself if a single camera is utilized. For example, a single camera's view may be blocked by a physical component of the earpiece **100**. To obtain a greater field of view, cameras may be positioned at different vantage points. The multiple images can be fit together via image processing to capture a broader spectrum of the surrounding environment. Because of the size of the earpiece **100**, it may be difficult to position more cameras. However, it may still be possible to position multiple cameras on the earpiece **100**. Additionally, if the user is taking advantage of two earpieces **100**, then each earpiece may have at least one, or a combination of, cameras **121**.

[0043] The earpiece **100** assists the user in environmental awareness, navigation, social interactions, and obstacle avoidance through real-time feedback. The earpiece **100** is capable of recognizing objects around the user, in order to alert the user. For example, the earpiece **100** may be used by a blind person to aid in environmental awareness and navigate safely around obstacles. The earpiece **100** provides the user audio and haptic feedback through the speaker **132** and the vibration unit **133**, based upon camera input from the sensor array **120** (and input from the interface array **130**, such as audio input from a microphone **131** and/or user input from the input device **134**).

[0044] In certain embodiments, the earpiece **100** is designed to accommodate blind or partially blind users. In such embodiments, a low-light viewing or night-vision camera (e.g., infrared camera) may also be utilized. For example, a camera may be directed to normal lighting and another directed to night vision. For example, a blind user may be more likely to turn off the lights because he/she does not depend on the lighting. The earpiece **100** would still function properly by processing images of the night-vision camera. The image processed may be limited in night-vision. For example, facial recognition may not be feasible, but the presence of another person can be detected. As a result, helpful information can be given to the user.

[0045] In addition to uses for blind or partially blind users, the earpiece **100** may be applied to other uses of daily life. For example, it can be used to record life events (i.e., weddings, sporting events, etc.). It may also be utilized to aid peace officers, such as by recording arrests, traffic stops, etc. It may also be used by workers, for example, by visually identifying hazardous items in the environment and alerting the worker.

[0046] The IMU **123** may comprise one or more of an accelerometer, a gyroscope, a magnetometer and/or an acceleration or positioning sensor. The GPS **124** may be one or

more GPS units. The IMU **123** and/or the GPS **124** may be utilized to determine the location and/or positioning of the user and/or the earpiece **100**.

[0047] The GPS **124** provides location information, which works with the inertial guidance information, including velocity and orientation information, provided by the IMU **123** to help direct the user. The memory **112** may store, for example, map information or data to help locate and provide navigation commands to the user. The map data may be preloaded, downloaded wirelessly through the antenna **142**, or may be visually determined, such as by capturing a building map posted near a building's entrance, or built from previous encounters and recordings. The map data may be abstract, such as a network diagram with edges, or a series of coordinates with features. The map data may contain points of interest to the user, and as the user walks, the stereo cameras **121***a* and/or cameras **121** may recognize additional points of interest and update the map data as they enter into the field of view of the camera **121**.

[0048] For example, the user may give a voice command, "Take me to building X in Y campus." The earpiece **100** may then download a relevant map if not already stored, or may navigate based on perceived images from the stereo cameras **121***a* and the cameras **121**. As the user follows the navigation commands from the earpiece **100**, the user may walk by a coffee shop in the morning, and the earpiece **100** would recognize the coffee shop and the time of day, along with the user's habits, and appropriately alert the user. The earpiece **100** may verbally alert the user through the speaker **132**. The user may use the input device **134** to adjust settings, which for example may control the types of alerts, what details to announce, and other parameters which may relate to object recognition or alert settings. The user may turn on or off certain features as needed.

[0049] When navigating indoors, the GPS **124** may not provide enough information to a blind user to navigate around obstacles and reach desired locations or features. The earpiece **100** may recognize, for instance, stairs, exits, and restrooms and appropriately store them in the memory **112**.

[0050] The sensor **125** may be one or more sensors which provide further information about the environment in conjunction with the rest of the sensor array **120**. The sensor **125** may be, for example, one or more of a temperature sensor, an air pressure sensor, a moisture or humidity sensor, a gas detector or other chemical sensor, a sound sensor, a pH sensor, a smoke detector, a metal detector, an actinometer, an altimeter, a depth gauge, a compass, a radiation sensor, a motion detector, or other sensor.

[0051] The interface array **130** includes the microphone **131**, a speaker **132**, a vibration unit **133**, an input device **134**, and a display **135**.

[0052] The microphone **131** may be a microphone or other device capable of receiving sounds, such as voice activation/commands or other voice actions from the user, and may be integrated with or external to the earpiece **100**. The microphone **131** may also provide input as part of the sensor array **120**.

[0053] The microphone **131** may provide additional environmental data, such as sounds of moving cars or other possible hazards. The microphone **131** may work in conjunction with the speaker **132**, and may be placed away from the speaker **132** to prevent interference. The microphone **131** may alternatively work in conjunction with an attached audio device, such as bone conduction devices, to provide the user with audio feedback without broadcasting the audio feedback.

[0054] The speaker **132** may be one or more speakers or other devices capable of producing sounds and/or vibrations.

[0055] The vibration unit **133** may be a vibration motor or actuator capable of providing haptic and tactile output. In certain embodiments, the vibration unit **133** may also be capable of producing sounds, such that the speaker **132** and the vibration unit **133** may be the same or integrated. Because of the size of the earpiece **100**, the vibration unit **133** should be small in size. In some embodiments, a user may wear an earpiece **100** in each ear such that the earpieces **100** work in concert with each other. In these embodiments, each earpiece **100** may include a vibration unit **133** so the earpiece **100** may provide stereo vibration data. Vibration patterns on one earpiece **100** can be outputted that are different than vibration patterns on the other earpiece **100**. In this manner, different combination of left/right vibration patterns can convey useful information to the user. For example, certain vibration patterns on the left that are lacking on the right may be used to signal to the user that the user should turn left.

[0056] The input device **134** may be an input device such as a touch sensor and/or one or more buttons. For example, the input device **134** may be a touch sensor used as a slider to adjust settings as well as act as a button for making selections, similar to a touchpad.

[0057] The display **135** may be a display, wirelessly connected to the earpiece **100**. For example, the display **135** may be a display on a connected cellular telephone. The display **135** may be capable of displaying visual data from the camera **121**. In embodiments, the display **135** may be another visual alert device, such as one or more LEDs or similar light source.

[0058] The display **135** can appropriately remind the user with memory retention difficulties. For example, the display **135** may display an image indicating information about activities of the user to remind the user. For example, the displayed information may be based on the task that the user is currently performing, and the destination that the user is travelling towards. The displayed information may further correspond to the surrounding environment. For example, the information may correspond to identity, location and movement of others currently around the user. For example, a user with Alzheimer's may not recognize the people around the user. The processor may determine identity of the nearby person using facial recognition based on data detected by the camera unit **121**. The display **135** may further indicate current events.

[0059] The component array **140** includes a battery **141**, an antenna **142**, and an input/output (I/O) port **143**. The battery **141** may be a battery or other power supply capable of powering the earpiece **100**. The battery **141** may have a connection port for recharging, or may be wirelessly recharged, such as through induction charging.

[0060] The battery **141** can be connected to an external power source or outlet via a power cord. Alternatively or in addition, the battery **141** can be charged via wireless charging. Battery size and capacity may differ based on design concerns such as the required computation. Additional capacity may be required based on the average operation time.

[0061] The antenna **142** may be one or more antennas capable of transmitting and receiving wireless communications. For example, the I/O port **143** may be a headphone jack, or may be a data port. For example, the antenna **142** may be a

Bluetooth or WiFi antenna, may be a radio frequency identification (RFID) antenna or reader, mobile telecommunication antenna (e.g., third generation (3G)) and/or a near field communication (NFC) unit. The I/O port **143** may be one or more ports for connecting additional peripherals.

[0062] The processor may wirelessly connect to another processor of a smart phone, tablet, computer, laptop, other computer-based devices or a cloud via the antenna **142**. The connection can be established using, for example, Bluetooth or Wi-Fi. The connection can assist the user in sharing data among various devices in addition to utilizing functionality of the connected devices. The antenna **142** and/or the I/O port **143** allow the earpiece **100** to connect to another device or network for data downloads, such as updates or map information or other relevant information for a particular application, and data uploads, such as status updates. Further, the antenna **142** and/or the I/O port **143** allow the earpiece **100** to communicate with other intelligent earpiece **100***s* **100** for distributed computing or sharing resources. The earpiece **100** described herein is generally a stand-alone device. For example, smartphones, tablets, or other mobile devices may wirelessly connect to the earpiece **100** for shared data and processing. The mobile device may act as an additional or alternative display unit for the earpiece **100**. The earpiece **100** may further have specific protocols for interacting with mobile devices or other intelligent earpiece **100***s* **100**.

[0063] The memory **112** may be positioned on the earpiece **100** or may be accessed remotely, for example, via the antenna **142**. For example, the earpiece **100** may have a memory within it, and the processor **111** may access a remote memory **100** for additional storage capacity. The remote memory **100** may include memory dedicated to the user and/or it may include shared memory, such as a shared database.

[0064] The earpiece **100** may improve social interactions. For example, the earpiece **100** may recognize faces in a room to identify potential friends, and provide the user with audio feedback identifying friends. The stereo cameras **121***a* and/or the camera **121** may be further able to determine additional details about persons, such as moods or expressions, or if they are engaging in physical activities, in order to alert the user. For example, the potential friend may extend a hand for a handshake or a "high five," and the earpiece **100** may use audio or haptic feedback to notify the user. The microphone **131** may recognize voices of other persons to identify and appropriately notify the user, or may recognize a new voice to save for future identification.

[0065] The earpiece **100** may also be used in hazardous environments to provide additional safety warnings. The earpiece **100** can be a memory device to aid persons, such as Alzheimer's patients. The earpiece **100** can aid in shopping or otherwise navigating inventories by helping to keep track of goods. The antenna **142** may be an RFID or NFC reader capable of identifying RFID or NFC tags on goods.

[0066] FIG. **1**B illustrates one embodiment of the earpiece **100**. Because the earpiece **100** is designed to fit over a user's ear, small components should be utilized. For example, use of a small communications processor and access to cloud processing may be preferable over a large, multi-purpose processor. Additionally, the number of components may be limited. For example, in some embodiments, only one of a pair of stereo cameras **121***a* or another camera **121** is utilized.

[0067] Components which produce heat should be positioned in a location where the component will not be in direct contact with the user's skin. This will prevent discomfort and possibility of harm to the user.

[0068] In the embodiment illustrated in FIG. **1**B, only a single camera **121**, such as a camera with a wide-angle lens, is utilized. The earpiece **100** is a curved device including a top portion **150** and a bottom portion **152**. A line substantially parallel to the top portion **150** intersects a line substantially parallel to the bottom portion **152** and creates an angle A**1**. Angle A**1** may be 90 degrees or it may be less than 90 degrees, such that the earpiece **100** cups the user's ear. This allows for the earpiece to remain in place on the user's ear more easily. A front face of the earpiece **100** includes the camera **121** and is substantially square in shape. An input device **134** such as a button may be positioned at the top portion **150** of the earpiece.

[0069] In this embodiment, a speaker **132** is positioned on an end of the top portion **150** of the earpiece that is close to the bottom portion **152** of the earpiece. This speaker **132** is external to the earpiece **100** and positioned such that sound from the speaker **132** is easily heard by the user. An advantage of this placement of the speaker is that the user does not have any object within his ear canal. At the bottom of the bottom portion **152** of the earpiece is the battery **141**. Nearby the battery may be a receiver for inductive charging or a connector, such as a mini-USB connector, for receiving charge.

[0070] Inside of the earpiece **100** may be a circuit board **154**. The circuit board **154** may fill the majority of the earpiece **100** or may only fill a portion of the earpiece **100**. The circuit board **154** may have built onto it or attached to it some of the components referenced in the discussion of FIG. **1**A.

[0071] The top portion **150** of the earpiece **100** may be a three dimensional rectangle which tapers on at least one side as it approaches the end closest to the bottom portion **152**. The top portion **150** may also include curvature for comfort and/or design advantages. The bottom portion **152** may be curved for comfort and/or design advantages. On this end of the earpiece **100**, at least one dimension of the earpiece **100** may reduce such that the earpiece **100** does not protrude very far from the user's head. The bottom portion of the earpiece may also have one dimension smaller than the other two such that the earpiece **100** does not protrude very far from the user's head.

[0072] FIG. **1**C illustrates another embodiment of the earpiece **100**. This embodiment includes a stereo camera **121**. The two lenses of the stereo camera **121** are positioned on top of one another. On a side of the earpiece that is to be facing away from the user is an input device **134**. The earpiece **100** is a partially curved device including a top portion **150** and a bottom portion **152**. A line substantially parallel to the top portion **150** intersects a line substantially parallel to the bottom portion **152** and creates an angle A**2**. Angle A**2** may be 90 degrees or it may be less than 90 degrees, such that the earpiece **100** cups the user's ear. This allows for the earpiece **100** to stay in place on the user's ear more easily. A front face of the earpiece **100** includes the camera **121** and is substantially rectangular or oval in shape. The input can be a haptic strip, a button, a potentiometer or the like.

[0073] The earpiece **100** may include substantially straight lines on the sides of the top portion **150** and the bottom portion **152** facing away from the user's ear. A center portion of the earpiece **100** where the user's ear is to be positioned may be curved such that it will fit around a user's ear comfortably and without corners touching the user's ear. The speaker **132** may be positioned within the center portion of the earpiece **100**. This speaker **132** may be, for example, a

bud-type speaker to be positioned within the user's ear. An advantage of this placement of the speaker **132** is that it is less likely that a non-user will hear the output of the speaker **132**.

[0074] The top portion **150** of the earpiece **100** may be a three dimensional rectangle which tapers on at least one side as it approaches the end closest to the bottom portion **152**. The top portion **150** may also include curvature for comfort and design advantages. On this end of the top portion of the earpiece **100**, at least one dimension of the earpiece **100** may reduce such that the earpiece **100** does not protrude very far from the user's head. The bottom portion **152** of the earpiece **100** may be a substantially three dimensional rectangle. The bottom portion **152** of the earpiece may also have one dimension smaller than the other two such that the earpiece **100** does not protrude very far from the user's head.

[0075] FIG. **1**D illustrates an embodiment of the earpiece **100** positioned on a user's ear. FIG. **1**D shows the top portion **150** of the earpiece positioned on the top of the user's ear and the bottom portion **152** positioned behind the user's ear. In the embodiment illustrated in FIG. **1**D, a stereo camera **121** and/or a camera is positioned on a front end of the top portion **150**.

[0076] FIG. **1**E illustrates another embodiment of the earpiece **100** positioned on a user's ear. In this embodiment, a speaker **132** is positioned directly outside or inside of the user's ear canal and a microphone **131** is positioned at the bottom of the bottom portion **152**. A stereo camera **121** and/or a camera **121** are positioned at the top of the bottom portion **152** and the front of the top portion **150**. In this embodiment, the top portion **150** is much larger than the bottom portion **152**. This means that the majority of the components must be positioned in the top portion **150** of the earpiece **100**.

[0077] FIG. **1**F illustrates another embodiment of the earpiece **100** positioned on a user's ear. In this embodiment, the portion of the earpiece **100** that contains the stereo camera **121** and/or the camera **121** is larger than in the other embodiments. In this embodiment, the stereo camera **121** is positioned at the top of the bottom portion **152** and the camera **121** is positioned underneath the stereo camera **121**. In other embodiments, the position of the stereo camera **121** and the camera **121** may be swapped. This combination of the stereo camera **121** and the camera **121** provides the advantage of allowing a larger field of view because of the wide-angle camera **121** as well as good depth perception because of the stereo camera **121**.

[0078] FIG. **1**G illustrates another embodiment of the earpiece **100** positioned on a user's ear. In this embodiment, a stereo camera **121** and/or a camera **121** are positioned at a front end of the bottom portion **152** and towards the bottom of the bottom portion **152**. As with the embodiment in FIG. **1**E, the top portion **150** is much larger than the bottom portion **152**. This means that the majority of the components must be positioned in the top portion **150** of the earpiece **100**.

[0079] Referring now to FIG. **2**, a flowchart of a method **200** of adjusting object detection parameters, object recognition parameters, or both object detection parameters and object recognition parameters is schematically depicted. In some embodiments, the method **200** may be implemented as logic within the machine readable instructions that, when executed by the processor **111**, automatically adjust object detection parameters, object recognition parameters, or both object detection parameters and object recognition parameters. It is noted that, while the method **200** depicts a specific sequence, additional embodiments of the present invention are not limited to any particular sequence.

[0080] Referring to FIG. **2**, at block **210** the earpiece **100** receives image data representative of the environment. As noted above, in some embodiments, the earpiece **100** is configured to acquire video or image data, which may be video frames, of the FOV of the user from the camera **121** (including for example, the pair of stereo cameras **121***a*), and to then send the acquired image data of the environment to the processor **111** and/or the memory **112** for storage and/or processing. In some embodiments, the earpiece **100** may receive image data from a source external to the earpiece **100**, such as via the antenna **142** through a wireless network.

[0081] The image data received at block **210** may be data of a variety of forms, such as, but not limited to red-green-blue ("RGB") data, depth image data, three dimensional ("3D") point data, and the like. In some embodiments, the earpiece **100** may receive depth image data from an infrared sensor or other depth sensor, such as an infrared sensor or depth sensor integrated with the pair of stereo cameras **121***a* and/or the camera **121**. In other embodiments that include a depth sensor (e.g., an infrared sensor), the depth sensor may be separate from the pair of stereo cameras **121***a* and/or the camera **121**.

[0082] Still referring to FIG. **2**, at block **220**, the machine readable instructions stored in the memory **112**, when executed by the processor **111**, cause the earpiece **100** to detect a candidate object, with the onboard processing array **110**, based on the image data received at block **210**. In some embodiments, the onboard processing array **110** may detect the candidate object by identifying a candidate region of the received image data, such as a region of the image that includes high entropy. For example, the onboard processing array **110** may detect a high entropy region in the acquired target image data that includes a spray bottle. In some embodiments, the onboard processing array **110** may utilize a sliding window algorithm to identify the candidate region of the received image data. In embodiments, the onboard processing array **110** may detect the candidate object by utilizing a feature descriptor algorithm or an image descriptor algorithm, such as scale-invariant feature transform ("SIFT"), speeded up robust feature ("SURF"), histogram of oriented gradients ("HOG"), generalized search tree ("GIST"), fast retina keypoint ("FREAK"), and binary robust invariant scalable keypoints ("BRISK"), and the like. In some embodiments, the onboard processing array **110** may bias detections to one or more spatially located regions of interest based on application, scene geometry and/or prior information.

[0083] The onboard processing array **110** includes at least one object detection parameter to facilitate the detection of the candidate object. In some embodiments, the at least one object detection parameter is a window size, a noise filtering parameter, an estimated amount of light, an estimated noise level, a feature descriptor parameter, an image descriptor parameter, or the like.

[0084] Still referring to FIG. **2**, at block **230**, the machine readable instructions stored in the memory **112**, when executed by the processor **111**, will cause the earpiece **100** to recognize an object, using the onboard processing array **110**, based on the image data received at block **210**. In some embodiments, the object recognition module may recognize the object based on a candidate region identified by the onboard processing array **110**.

[0085] In some embodiments, the onboard processing array **110** may recognize the candidate object by utilizing a feature descriptor algorithm or an image descriptor algorithm, such as scale invariant feature transform ("SIFT"), speeded up

robust feature ("SURF"), histogram of oriented gradients ("HOG"), generalized search tree ("GIST"), fast retina keypoint ("FREAK"), and binary robust invariant scalable keypoints ("BRISK"), and the like. In some embodiments in which the onboard processing array **110** utilizes a feature descriptor or image descriptor algorithm, the onboard processing array **110** may extract a set of features from a candidate region identified by the onboard processing array **110**. The onboard processing array **110** may then access a reference set of features of an object recognition reference model from an object recognition database stored in the memory **112** and then compare the extracted set of features with the reference set of features of the object recognition reference model.

[0086] For example, the onboard processing array **110** may extract a set of features from the high entropy region of the acquired target image data that includes a bottle and compare the extracted set of features to reference sets of features for one or more reference bottle models. When the extracted set of features match the reference set of features, the onboard processing array **110** may recognize an object (e.g., recognizing a bottle when the extracted set of features from the high entropy region of the acquired target image data that includes the bottle match the reference set of features for a reference bottle model). When the extracted set of features does not match the reference set of features, an object recognition error has occurred (e.g., an object recognition error indicating that no object recognition reference model matches the candidate object). When an object recognition error has occurred (e.g., referring to the example, no reference bottle model exists in the memory **112**), the at least one object detection parameter may be adjusted to improve the accuracy of the object detection module, as described below with reference to block **225**.

[0087] In some embodiments, the object recognition module may assign an identifier to the recognized object. For example, the identifier may be an object category identifier (e.g., "bottle" when the extracted set of features match the reference set of features for the "bottle category" or "cup" when the extracted set of features match the reference set of features for the "cup" object category) or a specific object instance identifier (e.g., "my bottle" when the extracted set of features match the reference set of features for the specific "my bottle" object instance or "my cup" when the extracted set of features match the reference set of features for the specific "my cup" object instance).

[0088] The onboard processing array **110** includes at least one object recognition parameter to facilitate the recognition of the object. In some embodiment, the at least one object recognition parameter is a window size, a noise filtering parameter, an estimated amount of light, an estimated noise level, a feature descriptor parameter, an image descriptor parameter, or the like.

[0089] Still referring to FIG. **2**, at block **240**, the machine readable instructions stored in the memory **112**, when executed by the processor **111**, cause the earpiece **100** to send control signals to the vibration unit **133** and/or the speaker **132** to provide appropriate haptic and audio feedback to the user. For example, if the object recognized is categorized as an obstacle, the vibration unit **133** may vibrate at an increasing rate as the intelligent earpiece **100** approaches it. If the object is categorized as a hazard, the speaker **132** may play a warning sound. If the object is categorized as a point of interest, the speaker **132** may play an appropriate notice, or may remain silent. As noted above, when an object recognition error has occurred, the at least one object detection parameter may be adjusted to improve the accuracy of the onboard processing array **110**.

[0090] Still referring to FIG. **2**, at block **225**, the machine readable instructions stored in the memory **112**, when executed by the processor **111**, cause the earpiece **100** to adjust at least one object detection parameter of the processing array **110**, with a detection tuner module, when an object recognition error has occurred. The detection tuner module may be implemented as instructions executed by the processor **111** and data stored on the memory **112**. By way of non-limiting example, in some embodiments, the detection tuner module may adjust the window size utilized by the onboard processing array **110** when an object recognition error has occurred. In some embodiments, the detection tuner module includes a detection tuner model and the detection tuner model adjusts the at least one object detection parameter based on the object recognition error. In some embodiments, the detection tuner model maps the object recognition error to the adjusted at least one object detection parameter. In some embodiments, the detection tuner model is a learned correlation model, such as a support vector machine ("SVM") model.

[0091] Still referring to FIG. **2**, at block **235**, the machine readable instructions stored in the memory **112**, when executed by the processor **111**, cause the earpiece **100** to adjust at least one object recognition parameter of the onboard processing array **110**, with a recognition tuner module, when object recognition error has occurred. The recognition tuner module may be implemented as instructions executed by the processor **111** and data stored on the memory **112**. By way of non-limiting example, in some embodiments, the recognition tuner module may adjust the window size utilized by the onboard processing array **110** when object recognition error has occurred. In some embodiments, the recognition tuner module includes a recognition tuner model and the recognition tuner model adjusts the at least one object recognition parameter based on the object recognition error. In some embodiments, the recognition tuner model maps the object recognition error to the adjusted at least one object recognition parameter. In some embodiments, the recognition tuner model is a learned correlation model, such as a support vector machine ("SVM") model.

[0092] FIGS. **3**A-**3**C present one example of a method of object recognition according to an embodiment of the present invention. In FIG. **3**A, for example, the first visual data **306** corresponds to a 2-D image of the target object **310** positioned on a plane **324** (e.g., a table). The second visual data **308** corresponds to 3-D depth data of the target object **310** positioned on the plane **324**. Category object recognition is performed for analyzing, using the processor **111** and the first visual data **306**. The first visual data **306** is analyzed based on a plurality of object models stored in a database, which may be stored in the memory **112**. For example, the plurality of object models may include primitive shapes such as cylinders, boxes, and the like associated with corresponding parameters defining the primitive shapes. For example, the processor **111** may determine whether any portion of the first visual data **306** corresponds in shape, structure, or in terms of other pose information, to the plurality of object models stored in the database. Each of the plurality of object models may have at least one parameter. For example, an object model may be a cylinder with parameters of a height and a radius. For example, an object model may be a box with three parameters of a width, a height, and a length.

[0093] When the processor **111** searches for an object model of the plurality of object models, more than one object model may be similar in shape or structure to a portion of the first visual data **306**. For example, a body of a bottle (e.g., the target object **310**) may be similar in shape or structure to either a cylinder or a box. The processor **111** is configured to determine which of the plurality of object models has the closest fit for the analyzed portion of the first visual data **306**. For example, the processor **111** may assign a score (for example, a recognition accuracy percentage) as to the degree of similarity between a particular object model of the plurality of object models and the analyzed portion of the first visual data **306**. For example, the processor **111** may choose the object model of the plurality of object models associated with the highest associated score (e.g., recognition accuracy percentage), as the object model that corresponds to the analyzed portion of the first visual data **306**. As such, in one embodiment, the processor **111** determines the parameters of the chosen object model.

[0094] As described below, the plurality of object models are not fixed. The stored object models and their corresponding parameters may be supplemented or modified. In addition or in the alternative, new category object models may be learned and stored in the database based on the recognized target objects. The discussion at this juncture assumes that the method is detecting the target object **310** for the first time, and objects having similar shapes, structure, or pose information to the target object **310** as a whole are not yet encountered and stored.

[0095] Referring to FIG. **3**B, an example of the category object recognition of the method is illustrated. For example, the processor **111** may examine the first visual data **306** adjacent to, around, or within the sliding enclosure **312** from left to right, starting from the top left corner of the 2-D image represented by the first visual data **306** moving right thereafter in the direction **314**. The processor **111** may recognize objects within the first visual data **306** that are similar in shape or structure to an object model of the plurality of object models stored in the database. In other embodiments, instead of the sliding enclosure **312**, the visual data set **304**, the first visual data **306**, the second visual data **308**, or combinations thereof may be examined as a whole to determine whether any portion of the first visual data **306** matches an object model stored in the database.

[0096] FIG. **3**C illustrates a result of the category object recognition. The processor **111** may recognize that the target object **310** is similar to one of the object models. The first enclosure **350** may be a bounding box, a bounding circle, or any other shape without limiting the scope of the invention. The first enclosure **350** has a first center point **316**. When the first enclosure **350** is a bounding box, the first center point **316** is the point with approximately equal distance from each side of the bounding box. When the first enclosure **350** is a bounding circle, the first center point **316** may be the center of the bounding circle. In one embodiment, the processor **111** may determine the first center point **316** such that the first center point **316** is positioned on, corresponds to, or falls within a portion of the visual data set **304** corresponding to the target object **310**. The target object **310** may, for example, be positioned within, around, or adjacent to the first enclosure **350**. The processor **111** determines that a first target data (which is a portion of the first visual data **306**) corresponds to the target object **310** to recognize the target object **310**.

[0097] Although the method described above uses a bottle as an exemplary object, the method may be used to recognize points of interest and other features, such as stairs, empty seats or buildings. For example, the object recognition may be utilized to determine an empty seat without presence of a person. A seat can be recognized as a collection of category objects that make up an empty chair. For example, a seat can be recognized as a substantially horizontally positioned surface positioned on 4 legs recognized by straight vertical lines with a back rest positioned on the surface (which is detected as a collection of primitive shapes that make up a seat). The components of the seat and the relative positioning of the components can be compared to stored objects in the database to recognize the seat.

[0098] For example, a person could be represented by a circular shape at the top of his head, a straight line that represents the torso and two other segments which represent the legs. The camera **121** (e.g., pair of stereo cameras **121***a*) may be utilized to determine edge features, contours and depth information. An empty seat can be recognized as having a recognized chair without recognizing a person positioned on top of the horizontal surface of the chair.

[0099] The earpiece **100** can navigate the user to the empty seat. For example, the intelligent mobility aid earpiece **100** may direct the user to an empty seat, or may remember the user's specific seat in order to navigate away and subsequently return to the same seat.

[0100] FIG. **4** shows a flowchart **400** of a method of estimating position or orientation based on slice descriptors. The onboard processing array **110** receives image data representative of a FOV from the camera **121**. In some embodiments, the camera **121** can operate within a physical environment and is configured to acquire wide-angle image data, and then send the acquired wide-angle image data of the physical environment to the onboard processing array **110** for storage and/or processing. In some embodiments, the onboard processing array **110** may receive omnidirectional image data from a source external to the intelligent mobility aid earpiece **100**, such as via the antenna **142**. The acquired omni-directional image data may be in the form of digital video and/or one or more digital photographs.

[0101] The onboard processing array **110** segments the omni-directional image data into a plurality of image slices. In one exemplary embodiment, the received omni-directional image is segmented into eight slices (S**1**, S**2**, S**3**, S**4**, S**5**, S**6**, S**7**, and S**8**). In some embodiments, the omni-direction image may be segmented into any number of slices. The number of slices may be between 8 and 36. However, it should be understood that the number of slices may be less than 8 or greater than 36.

[0102] Each of the plurality of slices is representative of at least a portion of the panoramic field of view of the omni-directional image data or the partially panoramic field of view of the omni-directional image data. In some embodiments, the plurality of image slices includes a middle image slice (e.g., slice S**2**), a preceding image slice (e.g., slice S**1**), and a subsequent image slice (e.g., slice S**3**), such that a field of view of the middle image slice (e.g., slice S**2**) is adjacent to or overlaps a preceding field of view of the preceding image slice (e.g., slice S**1**) and the middle field of view of the middle image slice (e.g., slice S**2**) is adjacent to or overlaps a subsequent view of the subsequent image slice (e.g., slice S**3**).

[0103] In some embodiments, each image slice of the plurality of image slices is representative of an equal portion of

the panoramic field of view of the omni-directional image data and the collective fields of view of the plurality of image slices is the same as the panoramic field of view of the omni-directional image data. For example, each of the eight slices captures an eighth of the full panoramic view of the omnidirectional image data and the collective field of view of the eight image slices is the same as the panoramic field of view of the omni-directional image data. In some embodiments, the field of view of a first slice of the plurality of views may be greater than a field of view of a second slice of the plurality of slices. In some embodiments, the collective fields of view of the plurality of slices may be smaller than the full panoramic field of view. In some embodiments, the field of views of neighboring slices may overlap.

[0104] The onboard processing array **110** calculates a slice descriptor for each image slice of the plurality of image slices. As used herein, "slice descriptor" refers to a description of the visual features (e.g., color, texture, shape, motion, etc.) of the image data of a particular slice of the omni-directional image data. For example, a slice descriptor d**1** is calculated for slice S**1**, a slice descriptor d**2** is calculated for slice S**2**, a slice descriptor d**3** is calculated for slice S**3**, a slice descriptor d**4** is calculated for slice S**4**, a slice descriptor d**5** is calculated for slice S**5**, a slice descriptor d**6** is calculated for slice S**6**, a slice descriptor d**7** is calculated for slice S**7**, and a slice descriptor d**8** is calculated for slice S**8**.

[0105] In some embodiments, the slice descriptor may be calculated using an algorithm, such as scale-invariant feature transform ("SIFT"), speeded up robust feature ("SURF"), histogram of oriented gradients ("HOG"), generalized search tree ("GIST"), fast retina keypoint ("FREAK"), and binary robust invariant scalable keypoints ("BRISK"), and the like. However, it should be understood that other algorithms may be used to calculate the slice descriptor. In some embodiments, the slice descriptor may include a decimal vector. In some embodiments, the slice descriptor may include a binary vector. In other embodiments, the slice descriptor may be represented in a format other a binary vector or a decimal vector. Depth information resulting from the application of stereo algorithms may also be used to calculate the slice descriptor.

[0106] The onboard processing array **110** generates a current sequence of slice descriptors for the omni-directional image data received. The current sequence of slice descriptors includes the calculated slice descriptor for each image slice of the plurality of image slices. For example, node n**1** includes the slice descriptor d**1** corresponding to slice S**1**, node n**2** includes the slice descriptor d**2** corresponding to slice S**2**, node n**3** includes the slice descriptor d**3** corresponding to slice S**3**, node n**8** includes the slice descriptor d**8** corresponding to slice S**8**, etc.

[0107] In some embodiments, the current sequence of slice descriptors may be structured such that a middle node (e.g., node n**2**) corresponds to a middle image slice (e.g., slice S**2**), a preceding node (e.g., node n**1**) corresponds to a preceding image slice (e.g., slice S**1**), and a subsequent node (e.g., node n**3**) corresponds to a subsequent image slice (e.g., slice S**3**). The preceding node (e.g., node n**1**) is linked to the middle node (e.g., node n**2**), and the middle node (e.g., node n**2**) is linked to the subsequent node (e.g., node n**3**).

[0108] In some embodiments, the current sequences of slice descriptors are stored in the memory **112**. In some embodiments, the memory **112** may include a database of reference sequences of slice descriptors, each of which corresponds to a previously processed omni-directional image encountered by the onboard processing array **110**.

[0109] In some embodiments, the current sequence of slice descriptors may be stored in the memory **112** as a current linked list of slice descriptors. In embodiments in which the current sequence of slice descriptors is stored in the memory **112** as a current linked list of slice descriptors, each node of the linked list may be linked to the subsequent node of the linked list (e.g., node n**1** is linked to node n**2**, node n**2** is linked to node n**3**, etc.). In some embodiments, the current sequence of slice descriptors may be stored in the memory **112** as a circular linked list of slice descriptors, such that the first node is linked to the second node (e.g., node n**1** is linked to node n**2**), the second node is linked to the third node (e.g., node n**2** is linked to node n**3**), . . . , and the last node is linked back to the first node (e.g., node n**8** is linked to node n**1**). In some embodiments, the current sequence of slice descriptors may be stored in the memory **112** as a current doubly linked list of slice descriptors. It should be understood that in other embodiments, the current sequence of slice descriptors may be stored in the memory **112** using a data structure other than a linked list, such as an array, and the like.

[0110] While the omni-directional image received was not unwarped prior to segmenting the omni-directional image, in other embodiments, the omni-directional image may be unwarped prior to segmentation.

[0111] Returning to FIG. **4**, at block **402**, the machine readable instructions stored in the memory **112**, when executed by the processor **111**, may cause the onboard processing array **110** to access a reference sequence of slice descriptors in the memory **112**. For example, in the embodiment depicted in FIG. **4**, the reference sequence of slice descriptors includes a reference slice descriptor d**3** corresponding to a reference node r**1**, a reference slice descriptor d**4** corresponding to a reference node r**2**, a reference slice descriptor d**5** corresponding to a reference node r**3**, a reference slice descriptor d**6** corresponding to a reference node r**4**, a reference slice descriptor d**7** corresponding to a reference node r**5**, a reference slice descriptor d**8** corresponding to a reference node r**6**, a reference slice descriptor d**1** corresponding to a reference node r**7**, and a reference slice descriptor d**2** corresponding to a reference node r**8**.

[0112] Still referring to FIG. **4**, at block **404**, the machine readable instructions stored in the memory **112**, when executed by the processor **111**, may cause the onboard processing array **110** to determine whether the current sequence of slice descriptors matches the reference sequence. In some embodiments, whether the current sequence of slice descriptors matches the reference sequence of slice descriptors is determined by determining a current order of slice descriptors, determining a reference order of slice descriptors, and comparing the current order of slice descriptors to the reference order of slice descriptors. For example, a current order of slice descriptors in the embodiment depicted in FIG. **4** may be determined as {d**1**, d**2**, d**3**, d**4**, d**5**, d**6**, d**7**, d**8**}. A reference order of slice descriptors in the embodiment depicted in FIG. **4** may be determined as {d**3**, d**4**, d**5**, d**6**, d**7**, d**8**, d**1**, d**2**}. The current order of slice descriptors {d**1**, d**2**, d**3**, d**4**, d**5**, d**6**, d**7**, d**8**} may be compared to the reference order of slice descriptors {d**3**, d**4**, d**5**, d**6**, d**7**, d**8**, d**1**, d**2**} in order to determine whether the current order of slice descriptors matches the reference order of slice descriptors.

[0113] In some embodiments, the current sequence of slice descriptors is a current circular linked list of slice descriptors

and the reference sequence of slice descriptors is a reference circular linked list of slice descriptors. In such embodiments, the current order of slice descriptors may be determined by traversing the current circular linked list of slice descriptors starting at a current starting node (e.g., the current order of slice descriptors may be determined to be {d**1**, d**2**, d**3**, d**4**, d**5**, d**6**, d**7**, d**8**} by traversing the current circular linked list starting from node n**1** of the current circular linked list of slice descriptors).

[0114] The reference order of slice descriptors may be determined by traversing the reference circular linked list of slice descriptors starting at a reference starting node (e.g., the reference order of slice descriptors may also be determined to be {d**1**, d**2**, d**3**, d**4**, d**5**, d**6**, d**7**, d**8**} by traversing the reference circular linked list starting from node r**7** of the reference circular linked list of slice descriptors). The current sequence of slice descriptors matches the reference sequence of slice descriptors when the current order of slice descriptors is the same as the reference order of slice descriptors. In the embodiment depicted in FIG. **4**, the current sequence of slice descriptors may be determined to match the reference sequence of slice descriptors because the reference order of slice descriptors when traversing the reference circular linked list of slice descriptors starting from node r**7** is the same as the current order of slice descriptors when traversing the current circular linked list of slice descriptors starting from node n**1**.

[0115] Still referring to FIG. **4**, at block **406**, the machine readable instructions stored in the memory **112**, when executed by the processor **111**, may cause the onboard processing array **110** to estimate an orientation or position based on the current sequence of slice descriptors and the reference sequence of slice descriptors. For example, differences between the current sequence of slice descriptors and the reference sequence of slice descriptors may be used to determine a current position or orientation with reference to a known position or orientation associated with the reference sequence of slice descriptors. In some embodiments, standard filtering techniques, such as the extended Kalman filter, the particle filter, and the like may be used to determine the current position or orientation based on the comparison between the current sequence of slice descriptors and the reference sequence of slice descriptors.

[0116] FIG. **5** illustrates an exemplary method **500** for human interaction using the earpiece **100**. The method **500** is only an example of the detection and analysis or processing of the first detected data and/or the second detected data. The blocks of method **500** may be performed simultaneously or in various combinations of orders. In blocks **502** and **504**, the first data and the second data are detected using the camera **121** and/or sensor **125**. The degree to which data can be collected regarding the surrounding environment of the user and matters therein may depend on what or which camera **121** and/or sensor **125** are available, as well as the processing limitations of the processor **111** and/or the external device and/or cloud. As such, the method **500** may be adjusted accordingly in real time by monitoring such limitations.

[0117] The processor **111** may work in concert with the camera **121** and/or sensor **125** for improving collection of the first detected data and/or the second detected data. The processor **111** may also consider whether the user or a person is requesting or attempting to convey information. For example, if a user is making a facial expression without speech to communicate with the earpiece **100**, the processor **111** can direct the speaker **132** to pose follow-up questions or inquiries in order to supplement or clarify the detected data. For example, the method **500** may direct an output speech to be generated, thereby asking the user to clarify the facial expression. The user may then respond in a voice command clarifying the conveyed information. In other embodiments, this facial expression recognition setup may be performed by a person other than the user.

[0118] In block **506**, the method **500** detects dynamic objects or beings. In one embodiment, the method **500** may detect movement, changes in a scene or other dynamic regions as observed by cameras in order to focus the camera **121** and/or sensor **125** on the detected dynamic regions. The processor **111** classifies the detected dynamic region as described below.

[0119] For example, detection of a person, living being, and/or a dynamic object may be performed by looking for changes in data detected by the camera **121** and/or the sensor **125**. Changes in data received from the camera **121** and/or sensor **125** may be identified by first estimating the motion of the earpiece **100** using the GPS **124**, the IMU **123** or techniques such as visual odometry which allow estimation of the motion of a camera by tracking corner or blob features between two camera frames. As such, the earpiece **100** may identify motion in the surrounding environment of the user which does not correspond to the motion of the earpiece **100**.

[0120] Upon identifying the changing parts of the scene within the first detected data and the second detected data, the earpiece **100** seeks to recognize the changing elements, using techniques such as "eigenfaces" and "skeletal recognition" to recognize persons and faces. Additionally, standard techniques like Support Vector Machines, Deformable Parts Model and dynamic programming can be used to learn different models for various object/person classes. The types of features that can be used in these recognition tasks can be any combination of features like SIFT (Scale-Invariant Feature Transform), SURF (Speeded Up Robust Features), Gist modeling, Sobel, Fast, and other features and/or techniques that enable the method **500** to recognize a person, object, living being, or place/environment within a proximity of the user.

[0121] Thus, by detecting the dynamic regions, a new person entering the environment within the proximity of the user may be detected in block **512** and a dynamic object or being can be detected in block **506** and classified by the processor **111** accordingly. Simultaneously or thereafter, the earpiece **100** extracts the remaining static regions in block **516**. In one embodiment, in block **516** additional second detected data are collected from static objects in block **518** and from an environment or place within a proximity of the user in block **520**.

[0122] The microphone **131** may communicate with a speech recognition module to detect speech, conversation or interaction as shown in block **508**. The earpiece **100** may further extract conversation elements containing useful data in block **510**. In block **522**, the processor **111** matches extracted conversation or speech elements from block **510** to the detected person, object, living being, place/environment, or combinations thereof.

[0123] In block **528**, the method **500** looks up prior relevant information or learned data based on context and based on the matched conversation events from block **522** regarding the person, object, living being, place/environment, or combinations thereof. In block **526**, the processor **111** stores in the memory **112** relevant information for later use based on prior relevant information. For example, if the processor **111** detects facial features of a person entering the environment

and also detects that the new person is speaking, the speech elements can be matched with the new person.

[0124] Speech data related to the person may be stored in the memory **112** for later use. A 3-D microphone or a microphone array may also be utilized to localize the origin of the sound or voice. The earpiece **100** can track and log data related to the person in order to supplement the first detected data. The method **500** may actively and automatically output a second output data in block **350** based on the matched conversation events to the corresponding person, place/environment, living beings, or combinations thereof of block **522** and further based on the inferred context and interaction key points from block **524**.

[0125] The processing of data (e.g., in blocks **506-350**) can be performed by continuously analyzing data gathered by the camera **121** and/or sensor **125** in real time. The external device and/or cloud may be utilized due to restraints on the information storage capacity of the memory **112**, energy capacity challenges associated with processing using solely the processor **111**, and processing power limits of the processor **111**. However, in one embodiment, both on-board and off-board processing capabilities are utilized to prepare for events in which the on-board processing may be preferable (e.g., a poor connection in cloud communications) to ensure a minimal level of capability. For example, if the device does not have sufficient capacity to perform the blocks of method **500**, the external device and/or cloud can provide assistance in sharing the load of the processing.

[0126] In block **530**, the processor **111** may passively output, using the speaker **132**, a first output data upon an input/request received by the processor **111** or a predetermined or scheduled event stored in the memory **112**.

[0127] The processor **111** may further actively and automatically output, using the speaker **132**, a second output data based on the first detected data and/or the second detected data, the previously detected, processed, and stored first and/or second data, the pre-programmed algorithm stored in the memory **112**, or combinations thereof.

[0128] As discussed above, the interface array **130** communicates with the user or another person based on the detected data. The interface array **130** may communicate via the display **135** or a projection system in communication with the processor **111**. The display **135** or projection system may be positioned on a remote device, such as a cellular telephone wirelessly connected to the earpiece **100**. The interface array may also communicate via the speaker **132**.

[0129] The output images/videos may be displayed using an LCD, an organic light emitting display, a plasma display, light-emitting diodes, or any other display mechanism for displaying the output images/videos.

[0130] Flow charts illustrating exemplary methods of the invention will now be disclosed. The earpiece **100** may be configured to operate in different modes. The mode may be selected, for example, using the input device **134**. Depending on the mode, the earpiece **100** may perform all of the functions, some of the functions or none of the functions described herein. Different functions are illustrated using the flow charts. The functions represented by the flow charts do not always require all of the blocks, some additional blocks may be utilized, and the blocks are not necessarily performed in any given order.

[0131] All of the methods described below may cause the earpiece **100** to perform actions based on determining a divergence between stored data and detected data. For example, the process of FIG. **7** relates to a method for determining and responding to a danger to a user. As an example, if a user falls down, the camera **121** may detect data that the user is facing upwards. The previously detected and stored data may indicate that the user was previously facing in a direction parallel to the floor. The earpiece **100** may then take an action based on the divergence of data between the stored data (facing forward) and the detected data (facing upwards).

[0132] FIG. **6**A illustrates an exemplary method for navigating an earpiece **100** and/or providing helpful information to a user of the earpiece **100** based on detected data.

[0133] Block **601** refers to various methods of data collection using the earpiece **100**.

[0134] In block **602**, the earpiece **100** may detect image data using the camera **121**. The image data may correspond to the surrounding environment, objects or living beings therein, the user, and/or other surrounding elements. For example, the image data may be associated with the shape of a room or objects within the room. As another example, the earpiece **100** may detect image data including facial recognition data.

[0135] In block **603**, an IMU **123** is coupled to the platform and configured to detect inertial measurement data corresponding to a positioning, velocity, or acceleration of the intelligent navigation device. A GPS unit (GPS) **124** is configured to detect location data corresponding to a location of the intelligent navigation device.

[0136] In block **604**, speech data or audio data is detected using the microphone **131**. This information may be information associated with the user, with the environment, with other people, actions, events, and various other items regarding social interaction and the surrounding environment. For example, when in a particular room, the earpiece **100**, via the interface array **130**, may receive information from the user or another person, such as the type of room (i.e., "this is the living room"). As another example, a user may want to name or add information regarding a particular person. In this instance, the earpiece **100**, via the interface array **130**, may receive information from the user such as to name the person (i.e., "he is Johnny"). Alternatively, the processor **111** may actively infer this information by parsing a conversation with the other person, without a user input that is directed to the earpiece **100**.

[0137] Referring to another example, the user may provide input to the earpiece **100** that the user is performing a particular action, such as going to lunch. As another example, the user may provide input to the device that a hazard exists at the current position and a description of the hazard. Alternatively, the processor **111** may actively infer this information by parsing conversations, analyzing detected image data, etc. as discussed above with respect to FIG. **5** and as discussed further below.

[0138] The data may further include a request. This request may be, for example, a request to identify a person, identify a room, identify an object, identify any other place, navigate to a certain location such as an address or a particular room in a building, to remind the user of his current action, what color an object is, if an outfit matches, where another person is pointing or looking, etc. The output of block **614** (determining a desirable event or action) or of block **616** (determining a destination) can be based on the requested information. Although speech data is discussed with respect to block **604**, the information can be gathered using any combination of components of the interface array **130** and/or the sensor array **120**.

[0139] In block **605**, the processor **111** may establish communication with a person other than the user via the interface array **130** and/or via a connection with a remote device. The remote connection may be established via a wireless communication antenna **142**, as discussed further below.

[0140] The processor **111** may determine whether communication with a person other than the user is desirable or requested. For example, when the detected data suggests that the user requires an opinion of another person, a communication channel may be established with a device of another person. For example, when the detected speech regarding an outfit of the user, facial recognition data regarding the user being indecisive or wondering about what to wear, and/or perceived action of a user in front of a mirror indicate that the user needs fashion advice from another person, a video teleconference between the user and a friend of the user may be established. From prior conversations/interactions, the processor **111** may have previously stored a user's friend's contact information. The processor **111** may categorize types of friends of the user and recognize that this communication needs to be with a friend that the user is comfortable with. The processor **111** may output data to the user letting the user know that a video conference or teleconference will be established with the friend. The earpiece **100** may provide a video connection to a friend of the user or send a picture of the outfit to a friend of the user. In this example, the friend may provide a response as to whether or not the outfit matches. The friend may also assist the user in finding an alternate outfit that matches.

[0141] In block **606**, data is received from the user, the environment, and/or other objects/beings via the interface array **130**. For example, data may be detected from a touchscreen display **135**, from a keyboard or buttons of an input device **134**, or other devices capable of interfacing with the user or another person to receive input data.

[0142] In block **607**, data may be detected using other components of the sensor array **120**. For example, data may be detected from the other sensors **125** as discussed above. This information may be information associated with the user, with the environment, objects within the environment, and/or with other living beings/people.

[0143] In block **608**, the earpiece **100** may also receive data from another device using the antenna **142** or the I/O port, such as data regarding a map of a building, or any other data. Data may be shared among the earpiece **100**, other devices of the user (for example, a portable electronic device of the user such as a smart phone or tablet), a remote server, or devices of others connected and with permission to access (for example, devices of the friends of the user).

[0144] In block **608**, data is retrieved via the antenna **142** and/or I/O port **143**. This data may be information indicating to the earpiece **100** that the user should be performing a particular set of actions. For example, the user may be in a hospital. The received information may be processed real time or stored for later use in the memory **112**. The information may relate to mealtimes of the user. The earpiece **100** may then know that the user is to eat lunch at 12:00 pm in the cafeteria every day. As another example, the earpiece **100** may access the user's cellular phone and download the user's schedule.

[0145] In block **611**, the processor **111** matches collected data from block **601** to relevant data stored in the memory. This includes object recognition. The processor **111** recognizes an object in the surrounding environment by analyzing the detected data based on the stored object data and at least one of the inertial measurement data or the location data. The object data stored in the memory **112** can be obtained from block **612**.

[0146] In block **612**, the memory **112** stores relevant data locally and/or remotely. For example, locally stored data may be data stored in a memory coupled to the earpiece **100**. Remotely stored data may include data accessed from a remote server or another device via the antenna **142** and/or I/O port **143**. A schedule of the user may be periodically transmitted to the earpiece **100** via the antenna **142**.

[0147] In block **613**, the processor **111** matches data collected in block **601** to relevant data stored in the memory. This includes object recognition as discussed above. The processor **111** recognizes an object in the surrounding environment by analyzing the detected data based on the stored object data and at least one of the inertial measurement data or the location data. The retrieved data can include data stored in the cloud or the internet. The processor **111** determines what information is desirable to process the request. For example, if the user requested to be navigated to the living room, the earpiece **100** may need to know where the living room is, a layout of an entire route from the user to the living room and any hazards that may be present. As another example, if the user asked if his clothes match, then the earpiece **100** may need to know what type of clothes match, what colors match and what the user is wearing.

[0148] The processor **111** accesses the memory **112** to retrieve the information desired to process the request. For example, if the user requested to be navigated to the living room, the earpiece **100** may retrieve the location of the living room, a layout of the route from the user to the living room and any known hazards.

[0149] The processor **111** may determine whether or not the memory **112** has sufficient helpful information regarding the detected data. For example, when the user requests walking directions between two points, and a layout of a route is not available in the memory **112**, the earpiece **100** may access the internet or the cloud via the antenna **142** and/or the I/O port **143** to retrieve this missing information.

[0150] In block **614**, the processor **111** determines a desirable event or action. The processor **111** may determine a desirable event or action based on the recognized object, the previously determined user data and a current time or day. Current day or time is relevant for determining the current desirable event, action, destination, speech, etc. as discussed below.

[0151] The earpiece **100** may determine whether or not the user should be at a particular location and/or performing a particular action at any given time. For example, the processor **111** may match a previously stored lunch event to a current date/time (i.e., noon). The processor **111** may also match the previously stored lunch event to a time before the event. For example, if the user is to have lunch at noon somewhere that is 30 minutes away, the processor may determine a match at 11:30 am. As another example, a desirable action may be to wear certain clothes with other matching items. A desirable event may be to go to lunch if the current day/time indicates that the user in a nursing home should attend a lunch gathering event.

[0152] In block **615**, the earpiece **100**, via the interface array **130**, may output data based on the inferred current desirable event, action/destination, etc. For example, if the inferred action is to find matching clothes, the processor may

determine whether or not the outfit matches. As another example, if a destination is inferred, the processor may determine a viable navigation route for the user. The output may be, for example, a series of verbal phrases (i.e., step-by-step walking directions) via the speaker **132**. The output may also be, for example, vibrations informing the user of the data. For example, a vibration in a left earpiece **100** may signify to turn left, a vibration in a right earpiece **100** may signify to turn right, a vibration in both a right and a left earpiece **100** may signify to stop, a continuous vibration in both the right and the left earpiece **100** may signify to slow down, or any other combination of vibrations may indicate any of these or any other command.

[0153] Discussion now turns to navigation features of the earpiece **100**. In order to provide navigation information to the user, the processor **111** at least determines two sets of data: (I) data regarding positioning and/or location of the earpiece **100** and/or the user and (II) data regarding the surrounding environment, persons, objects, living beings, etc.

[0154] Referring back to block **602**, data regarding the surrounding terrain of the earpiece **100** is detected using the camera **121**. As discussed above, the blocks in FIG. **6**A are not necessarily performed in the order shown. The processor **111** may determine, for example, that further image data is required to learn about the terrain after a destination is determined. When navigating indoors, the standalone GPS units may not provide enough information to a blind user to navigate around obstacles and reach desired locations or features. The intelligent earpiece **100** may recognize, for instance, stairs, exits, and restrooms and appropriately store them in the memory **112**.

[0155] For example, the stereo cameras **121***a* may provide depth information of the surrounding environment and obstacles. Alternatively or in addition, one or more other cameras **121** may be utilized to provide information regarding the surrounding environment.

[0156] Referring back to block **603**, data using the GPS **124** and/or the IMU **123** is detected. This data can be used along with data obtained from the camera **121** to gain an understanding of the terrain.

[0157] In blocks **617**, **618***a*, and **618***b*, the processor **111** analyzes data obtained using the camera **121** based on the data obtained from the GPS **124** and/or the IMU **123**, and vice versa. In block **617**, information set (II) can be used to gain a better/more accurate understanding of the information set (I) and vice versa.

[0158] In block **617**, the processor determines data regarding the location or positioning of the earpiece **100** using at least one of image data, inertial measurement data obtained using the IMU **123**, location data obtained using the GPS unit **124**, and relevant stored data (for example, map data stored in the memory **112**).

[0159] In block **618***a*, the processor **111** may analyze features of images collected using the camera **121** and recognize the environment objects using object recognition. For example, data collected by the IMU **123** can be used to determine the amount and speed of movement to improve accuracy of detection using data collected by the camera **121**. In addition, the IMU **123** may indicate a direction in which the collected information is located. For example, if the IMU **123** indicates that the information is regarding objects from a direction above the earpiece **100***a*, the processor **111** can determine that the surface is more likely to be ceiling than ground.

[0160] In addition, data collected using the GPS **124** can enhance identification of data collected by the camera **121**. For example, if the camera **121** provides an image of the building, the processor **111** can determine if the building is detected correctly by utilizing data regarding the location of the user in the world, because building types differ in different parts of the world.

[0161] The GPS information may be inadequate because it may not provide sufficiently detailed information about the surrounding environment. However, the GPS information can be utilized along with visual data from the camera **121** to draw inferences that are helpful to the user. For example, if the GPS information indicates that the earpiece **100** is currently inside a building, and the camera **121** provides information regarding an object, the processor **111** can limit its search to objects that would rationally be inside the building. For example, if an image provided by the camera **121** appears like a truck, the processor **111** can rule out the possibility that the object is a truck based on the GPS information. In other words, it is more likely to be an image of a poster of a truck, because the poster can rationally be within a building and a truck cannot. The GPS **124** provides location information, which along with the inertial guidance information, including velocity and orientation information provided by the IMU **123**, allows the processor **111** to help direct the user.

[0162] The memory **112** may store, for example, map information or data to help locate and provide navigation commands to the user. The map data may be preloaded, downloaded wirelessly through the antenna **142**, or may be visually determined, such as by capturing a building map posted near a building's entrance, or built from previous encounters and recordings. The map data may be abstract, such as a network diagram with edges, or a series of coordinates with features. The map data may contain points of interest to the user, and as the user walks, the camera **121** may passively recognize additional points of interest and update the map data.

[0163] In block **616**, the processor **111** determines a desired destination based on the determined desirable action or event.

[0164] For example, the earpiece **100** may direct the user to an empty seat, or may remember the user's specific seat in order to navigate the user away and subsequently return to the same seat. Other points of interest may be potential hazards, descriptions of surrounding structures, alternate routes, and other locations. Additional data and points of interest can be downloaded and/or uploaded to mobile devices and other devices, social networks, or the cloud, through Bluetooth or other wireless networks.

[0165] In block **618***b*, based on the analyzed data, a maneuverability condition/non-traversable region is detected. For example, a non-traversable region may be a region where the user cannot safely travel, such as a tar pit.

[0166] In block **619**, the processor **111** determines a path over which the user can travel. The path excludes the detected non-traversable regions in block **618***b*. The intelligent earpiece **100** may determine paths for navigation, which may be further modified for the user's needs. For example, a blind person may prefer routes that follow walls. Using the IMU **123** and/or the GPS **124** and other sensors, the intelligent earpiece **100** can determine the user's location and orientation to guide them along the path, avoiding obstacles.

[0167] For example, the path may be towards a desired object (empty chair) as discussed above. The earpiece **100** may identify obstacles or paths for the user, and based on either the speed of the traveler or the intended direction of the

traveler, be able to filter down what the significant obstacles or potential paths are. The earpiece **100** may then guide the user based on those significant obstacles or paths. Guidance may be, for example, auditory feedback or vibratory feedback, for either the path or objects to avoid.

[0168] In block **622**, the output data from block **615** may be conveyed to the user using various outputs of the interface array **130**. Multimode feedback is provided to the user to guide the user on the path. This feedback is also provided to guide the user towards the desired destination/object and is presented via a combination of speech, vibration, mechanical feedback, electrical stimulation, display, etc. With blind users, the processor **111** may keep the range of vision in mind when outputting information. A blind or partially blind person can identify most of the things that are less than three feet away using a cane. Objects and other items of interest more than 30 feet away may not be of utmost importance because of the distance.

[0169] While travelling along the path, the earpiece **100** may inform the user about signs or hazards along the path. The vibration unit **133** and/or the speaker **132** provide audio and haptic cues to help guide the user along the path. For example, the speaker **132** may play a command to move forward a specified distance. Then, special audio tones or audio patterns can play when the user is at a waypoint, and guide the user to make a turn by providing additional tones or audio patterns. A first tone, audio pattern or vibration can alert the user to the start of a turn. For example, a single tone or a vibration from a left intelligent mobility aid device may indicate a left turn. A second tone, audio pattern or vibration can alert the user that the turn is complete. For example, two tones may be provided, or the vibration may stop so that a left device ceases to vibrate, when the turn is complete. Different tones or patterns may also signify different degrees of turns, such as a specific tone for a 45 degree turn and a specific tone for a 90 degree turn. Alternatively or in addition to tones and vibrations, the intelligent earpiece **100** may provide verbal cues, similar to a car GPS navigation command. High level alerts may also be provided through audio feedback. For example, as the intelligent earpiece **100** reaches a predetermined distance—such as a foot or other value which may be stored in the memory **112** and may be adjusted—from an obstacle or hazard, the speaker **132** and/or the vibration unit **133** may provide audible alerts. As the intelligent earpiece **100** gets closer to the obstacle, the audible alerts and/or vibrations may increase in intensity or frequency.

[0170] As an example of the method illustrated in FIG. **6**A, the user may give a voice command, "Take me to building X in Y campus." The intelligent earpiece **100** may then download or retrieve from memory a relevant map, or may navigate based on perceived images from the camera **121**. As the user follows the navigation commands from the intelligent earpiece **100**, the user may walk by a coffee shop in the morning, and the intelligent earpiece **100** would recognize the coffee shop. The earpiece **100** may use this recognition and the time of day, along with the user's habits, and appropriately alert the user that the coffee shop is nearby. The intelligent earpiece **100** may verbally alert the user through the speaker **132**. The user may use the input device **134** to adjust settings, which for example may control the types of alerts, what details to announce, and other parameters which may relate to object recognition or alert settings. The user may turn on or off certain features as needed.

[0171] FIG. **6**B illustrates an exemplary method for providing assistance to a user of the earpiece **100** based on an inferred current desirable event, action, destination, etc. In block **650**, data is retrieved from the memory **112** and/or via the antenna **142** and/or the I/O port **143**. This data may be information indicating to the earpiece **100** that the user should be performing a particular set of actions. For example, the user may be in a hospital. In this example, let's assume that the memory **112** includes information related to mealtimes of the user. The device may then know that the user is to eat lunch at 12:00 pm in the cafeteria every day. As another example, the user may inform the earpiece **100** of his/her schedule. For example, the user may inform the device that he/she has a meeting at 5:00 PM this Friday at 600 Anton Blvd.

[0172] In block **652**, the earpiece **100** may determine whether or not the user should be at a particular location and/or performing a particular action at any given time. If not, the process may return to block **650**. If so, the process may proceed to block **654**.

[0173] In block **654**, data associated with the current actions of the user is detected by the sensor array **120**. For example, the GPS **124** and/or the IMU **123** may sense that the earpiece **100** is traveling towards the cafeteria or towards 600 Anton Blvd. As another example, the microphone **131** may detect data indicating that the user is busy talking to another person.

[0174] In block **656**, it is determined whether the current actions of the user match the particular set of actions from block **650**. For example, if the user is not moving towards the cafeteria and he is supposed be at lunch in 5 minutes, the current actions do not match the particular actions. If the current actions do match the particular actions from block **650**, then the process returns to block **654** to ensure that the user continues to perform the particular actions.

[0175] In block **658**, the user is informed of the particular actions via the interface array **130**. For example, if the device is travelling away from the cafeteria, the earpiece **100** may provide data to the user that he should be going to lunch now. If the user does not begin the particular set of actions retrieved in block **650**, then the earpiece **100** may again notify the user after a predetermined amount of time. However, the earpiece **100** may have learned when the user does not want to be interrupted. For example, the user may not want to be interrupted during a conversation. If the microphone **131** detects that the user is having a conversation, the earpiece **100** may wait until after the conversation to inform the user.

[0176] The earpiece **100** may determine, via the interface array **130**, whether or not the user needs more information. The earpiece **100** may have previously learned preferences of the user, such as if he is wobbling back and forth, he requires directions. The earpiece **100** may also request navigational information. For example, the user may request directions to the cafeteria. The user can provide data to the earpiece **100** via the interface array **130** that he does or does not need more information. If the user does not require additional information, the process proceeds to block **664**.

[0177] In block **664**, the processor **111** determines whether or not the particular set of actions from block **650** is complete. If the particular actions are complete, then the process ends. If the particular actions are not complete, then the process returns to block **654**.

[0178] An example of the process in FIG. **6**B will now be provided. Assume that the user is supposed to be in the caf-

eteria for lunch. The earpiece **100** may determine that the user is supposed to be in the cafeteria and that the user is not moving towards the cafeteria. The earpiece **100** may then, via the interface array **130**, provide feedback to the user, such as audio feedback that says, "time to go to lunch." The user may then return feedback to the earpiece **100**, such as "I'm not ready yet" or "let's go." If the user is not yet ready, the earpiece **100** may remind the user again that it is lunch time after a predetermined amount of time. When he is ready, the user may provide data to the earpiece **100** that he is ready to go.

[0179] The earpiece **100** may then request feedback from the user to determine whether he needs directions or not. If the user responds no, then the earpiece **100** may not provide any current information. However, if the user responds yes, then the earpiece **100** may navigate the user to the cafeteria. The earpiece **100** may also be configured so that it communicates with another device. For example, the earpiece **100** may provide data to a terminal in the cafeteria that the user is on his way for lunch, so that his food can be prepared and a seat ready for him when he arrives. As the user arrives, the earpiece **100** may provide additional data to the user such as where his table is and who he is sitting with.

[0180] In some embodiments, the earpiece **100** may learn preferences of the user. For example, it may learn what chair the user normally sits at for lunch. In this example, the earpiece **100** may determine where the user's normal lunchtime chair is To do so, it may use sensed visual data from the camera **121**, position data from the GPS **124**, the IMU **123** and/or any other detected data, as well as shape analysis as described above in regards to FIG. **2**. Once the earpiece **100** determines where the chair is, it may guide the user to the chair so that the user can safely get to the chair and sit down.

[0181] FIG. **7** illustrates an exemplary method of danger assistance by the earpiece **100**. In block **700**, data is detected by the sensor array **120**. This data may be visual data, position data, or any other data that the sensor array can sense. For example, the IMU **123** may detect data indicating that the user has fallen down or that the user is in an upside down position. The camera **121** may detect visual data such as a large object extremely close to the lens. The sensor array **120** may detect any other information such as data indicating a fire or a flood.

[0182] In block **702**, the detected data is compared to data indicative of danger stored in the memory **112**. This data in the memory **112** may be, for example, data associated with a falling motion of a user. The data may also be, for example, data associated with an object falling on the user. The processor **111** compares the data indicative of danger from the memory **112** to the detected data to determine if there is a match. For example, if detected data matches data indicating that a large object has fallen on the user, then a match exists.

[0183] In block **704**, if no match exists between the data indicative of danger and the detected data, then the process returns to block **700** where data continues to be detected. If, however, a match does exist, then the process proceeds to block **706**. In block **706**, the earpiece **100** requests that the user provide information such as whether the user is ok. The user may provide this information via the interface array **130**. This information may be, for example, a spoken "yes, I am ok," or "no, I am not ok."

[0184] In block **708**, it is determined whether the user responded that he needs assistance, responded that he does not need assistance, or did not respond at all. If the user responded that he does not need assistance, then the process returns to block **700**. If the user responded that he does need assistance or if the user did not respond to the inquiry, then the process proceeds to block **710**.

[0185] In block **710**, the earpiece **100** may, via the interface array **130**, request that the user provide information about whether the user wants to communicate with a person or to have a remote device alerted.

[0186] In block **712**, it is determined whether or not the user selected to communicate with a person. If the user selected to communicate with a person, then in block **714**, a communication channel may be established between the user and the desired people/person. Additionally, the user may select whom he wants to speak with. For example, he may wish to contact his personal physician, the police, a friend, or any other person or service. The earpiece **100** may also have learned with whom to open a communication channel. For example, if fire data is detected, the earpiece **100** may open a communication with a fire department or "911" call center.

[0187] The communication may be established, for example, by connecting the earpiece to a cellular device via the antenna **142** and/or the I/O port **143**. After the connection is established, the earpiece **100** may cause the cellular device to place a video call or a voice call to the requested person or institution. The microphone **131** of the earpiece **100** may act as the microphone for the cellular device and the speaker **132** of the earpiece **100** may act as the speaker of the cellular device. Once the communication is established, the user may communicate with the requested person and provide information. The earpiece **100** may also provide information to a device on the other end of the communication, such as any data associated with the danger, any location data, etc. Any information may also be communicated via a Wi-Fi, Bluetooth, etc. element of the earpiece **100**. For example, the earpiece **100** may establish a VoIP connection via Wi-Fi.

[0188] If, in block **712**, the user did not select to communicate with a person, or the user did not respond, the process may proceed to block **716**. In block **716**, a remote device is alerted of the danger via the antenna and/or the I/O port. This alert may consist of any data captured around the time of the incident, any location data, etc. The alert may be communicated by a connection to a cellular device via the antenna **142** and/or the I/O port **143**, Wi-Fi, Bluetooth, etc.

[0189] FIG. **8**A illustrates an exemplary method for safety monitoring and alerting. The process begins in block **800** when movement is detected by the earpiece **100**. This movement may be detected, for example, by the IMU **123** or the GPS **124**. After the process begins, in block **802**, new data is detected by the earpiece using the sensor array **120**. This data may include any data detected by the sensor array **120**, such as visual data (streets, sidewalks, people), position data (location of the user, direction of travel), audio data (such as a moving car sound, a siren, an alarm), or any other data. In block **806**, this new data is stored in the memory **112**.

[0190] In block **806**, this new data is compared to data recorded in the memory **112**. The data recorded in the memory **112** may include data captured at the same location at a previous time. The data recorded in the memory **112** may also include data captured at the same location or nearby at a time prior to the current time, such as milliseconds, seconds, or minutes prior to the current time. The processor may make this comparison using the object recognition method of FIG. **2**.

[0191] In block **808**, it is determined whether or not a divergence is detected between the new data and the data

recorded in the memory **112**. This divergence may include, for example, data indicating that a new object is in the field of view of the earpiece **100** that was not previously detected. A divergence may also include, for example, that a previously-present object is no longer in the field of view. The divergence may also include, for example, a new sound, such as a police siren.

[0192] In block **810**, if a divergence is detected in the new data, a second data may be output to the user via the interface array **130** based on this divergence. As an example, let's assume that a divergence includes a boulder in the middle of the sidewalk. In this example, the earpiece **100** may provide data to the user indicating the divergence. For example, the earpiece **100** may, using the speaker **132**, inform the user that an object matching the shape of a boulder is 10 feet directly ahead of the user. Alternately or additionally, the earpiece **100** may provide haptic feedback to the user based on the divergence.

[0193] In block **812**, it is determined whether or not the divergence includes text. For example, the divergence may be a sign or police tape including text. The processor **111** may make this determination by comparing the new detected data to data indicating the shape of text characters to determine if any matches exist.

[0194] In block **814**, if is determined that the divergence includes text, then the earpiece **100** may output data to the user via the interface array **130** based on the text of the divergence. For example, the data may include audio data indicating the content of the text of the divergence.

[0195] In block **816**, it is determined whether or not the divergence presents a hazard. The memory **112** may have stored data which can be compared to detected data in order to determine if a divergence is hazardous. For example, the memory **112** may have stored therein visual data associated with a bobcat and an indicator that a bobcat is hazardous. As another example, the memory **112** may have stored therein visual data associated with the shape of a caution sign and the word caution, and that this data is an indicator of a hazard.

[0196] As another example, instead of having data representing a dangerous object, the memory **112** may store situational data. An example of situational data is that the earpiece **100** may recognize that if a large object is in the middle of a sidewalk that the user is walking along, the object may present a hazard. Another example of situational data is that the earpiece may recognize that if visual data of an area had been previously sensed and stored, and the visual data of the area is significantly different in the present sensing of the area, then a danger may exist.

[0197] In block **818**, if it is determined that the divergence does present a hazard, the earpiece **100** may warn the user via the interface array **130**. The warning may include, for example, an output via the speaker **132** informing the user that a hazard exists and the location of the hazard. The earpiece **100** may also output, for example, the type of hazard. If the earpiece **100** detected a caution sign that read "potholes in the sidewalk," then the earpiece **100** may output data to the user informing the user that potholes exist in the sidewalk. The earpiece **100** may also inform the user of the locations of the potholes as the earpiece **100** detects them. In some embodiments, the earpiece **100** may provide vibrational data to the user via the vibration unit **133**. For example, as the user approaches a hazard, the vibration unit **133** may produce increasingly frequent vibrations.

[0198] Next, it is determined whether or not more movement of the earpiece **100** is detected. If no more movement is detected, then the user is standing still and the process may end. If movement is detected, then the process may return to block **802**. If the process ends because of a lack of movement, it can restart at any time by detection of movement of the earpiece **100**.

[0199] FIG. **8**B illustrates an example of the method of claim **8**A. In frame **850** of FIG. **8**B, a user **856** is walking along a sidewalk. Let's assume that the user has previously walked along the sidewalk and the memory **112** has stored therein data detected by the sensor array **120** during the previous trips along the sidewalk.

[0200] In frame **852**, a hazard **858** is present on the sidewalk in the direction of travel of the user. The hazard includes a caution sign **860** as well as two caution cones **862**. When the hazard is in the field of view of the earpiece **100**, the earpiece **100** may compare the detected data to stored data. The processor **111** may then determine that the hazard is a divergence and it may provide data to the user **856** based on the divergence. The data may include, for example, a description of the two cones **862**, the fact that a sign is present and any other large diversions. The earpiece **100** may also detect that the diversion includes text. The earpiece **100** may provide the user **856** data based on the text, such as reading the text to the user.

[0201] The earpiece **100** may have learned that a caution sign **860** or a caution cone **862** presents a hazard, and determine that the caution sign **860** and/or the caution cone **862** present a hazard. The earpiece **100** may also determine this by identifying that the divergence is significant. The earpiece **100** may use the fact that the caution sign **860** and/or cones **862** are positioned in a direction of travel of the user **856** to determine that they present a hazard. The earpiece **100** may then provide data to the user **856** indicating that the hazard **858** is present. The earpiece **100** may, for example, output the type and/or location of the hazard **858** to the user **856** using the speaker **132**. The earpiece **100** may also, for example, vibrate with increasing frequency as the user approaches the hazard **858**.

[0202] For example, in frame **854**, the user may utilize the output from the earpiece **100** to navigate around the hazard **858**. If the user **856** is wearing two earpieces **100**, then the earpiece **100** may vibrate more on one side than another to indicate the location of the hazard **858**. In frame **854**, the hazard is more to the right side of the user **856** than the left side. So, the earpiece **100** on the right ear of the user **856** may vibrate more than the earpiece **100** on the left ear of the user **856**, indicating that the hazard is on the right. Alternately, the earpiece **100** on the right ear may vibrate less than the earpiece **100** on the left ear, indicating that it is safer on the left side.

[0203] FIG. **9**A illustrates an exemplary method for providing navigation assistance to the user. This method may be used, for example, to inform a user when he should move forward in line. It may also be used, for example, to inform a user of when he should slow down or speed up based on a another walker. This method may also be used, for example, to inform a user of when he should slow down or speed up so that he can walk at the same pace as his friends.

[0204] In block **900**, the earpiece **100**, using the sensor array **120**, detects a distance from the earpiece to a moving object, such as a person. The object can be in any relative position to the user so long as it is in the field of view of the

camera **121**. The earpiece may also, in some embodiments, determine a speed at which the object is moving.

[0205] In block **902**, the earpiece **100** may determine a speed at which the user is traveling, using the sensor array **120**. This speed may include a walking or running speed, or it may be a zero speed. Using the speed data, as well as other data, the processor **111** may determine a set of actions that the user is performing. For example, the user could be walking with friends. He also could be waiting in a line, or walking down the street in a hurry to get to a meeting. The processor may utilize the detected data to determine the action of the user.

[0206] In block **904**, the processor **111** compares the speed and other data to data in the memory **112**. The data in the memory **112** may, for example, associate speed and other data to a preferred distance of the user to an object. For example, if the user is walking with friends, the preferred distance may be relatively short. As another example, if the user is rushing to a meeting, the preferred distance may be relative long so that the user does not accidentally run into the object.

[0207] In block **906**, it is determined whether or not the detected distance is less than the preferred distance. This may be useful, for example, when the user is walking down the street faster than another walker, or has prematurely started walking forward when waiting in a line.

[0208] If the detected distance is less than the preferred distance, then the method proceeds to block **908**. In block **908**, the earpiece **100** outputs data to the user, via the interface array **130**, indicating that the detected distance is less than the preferred distance. This data may include, for example, audio data or haptic data. For example, the earpiece **100** may vibrate with increasing frequency as the user approaches the object.

[0209] In block **910**, it is determined whether the detected distance is greater than the preferred distance. This may be useful, for example, if the user is walking with friends and is moving at a faster pace.

[0210] If the detected distance is greater than the preferred distance, then the process proceeds to block **912**. In block **912**, the earpiece **100** outputs data to the user, via the interface array **130**, indicating that the detected distance is greater than the preferred distance. This data may include, for example, audio data or haptic data. For example, the earpiece **100** may vibrate with increasing intensity as the distance between the user and the object grows. In some embodiments, there are only certain situations in which the earpiece **100** will alert the user that the distance is greater than the preferred distance. For example, if the user is walking alone, he will not care if he is far away from other walkers and the earpiece may not provide any data.

[0211] FIG. **9**B illustrates an exemplary use of the method of FIG. **9**A. In frame **950**, the user **956** is walking down a sidewalk. The user is behind a walker **958**. At first, the user **956** and the walker **958** may be traveling at the same speed. Initially, because of the same speeds, the distance from the user **956** to the walker **958** may be the preferred distance.

[0212] As illustrated in frame **952**, eventually the walker **958** may slow down. In this situation, the detected distance from the user **956** to the walker **958** may become less than the preferred distance. The earpiece **100** may provide data to the user **956** including information that the detected distance is shorter than the preferred distance. The user **956** may then slow down based on the data from the earpiece **100**. By receiving the data from the earpiece **100**, the user **956** may slow until he is at the preferred distance from the walker **958**, as illustrated in frame **954**.

[0213] As used herein, the term "network" includes any cloud, cloud computing system or electronic communications system or method which incorporates hardware and/or software components. Communication among the parties may be accomplished through any suitable communication channels, such as, for example, a telephone network, an extranet, an intranet, Internet, point of interaction device, point of sale device, personal digital assistant (e.g., an Android device, iPhone®, Blackberry®), cellular phone, kiosk, etc.), online communications, satellite communications, off-line communications, wireless communications, transponder communications, local area network (LAN), wide area network (WAN), virtual private network (VPN), networked or linked devices, keyboard, mouse and/or any suitable communication or data input modality. Specific information related to the protocols, standards, and application software utilized in connection with the Internet is generally known to those skilled in the art and, as such, need not be detailed herein.

[0214] "Cloud" or "Cloud computing" includes a model for enabling convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction. Cloud computing may include location-independent computing, whereby shared servers provide resources, software, and data to computers and other devices on demand.

[0215] Systems, methods and computer program products are provided. References to "various embodiments", in "some embodiments", "one embodiment", "an embodiment", "an example embodiment", etc., indicate that the embodiment described may include a particular feature, structure, or characteristic, but every embodiment may not necessarily include the particular feature, structure, or characteristic. Moreover, such phrases are not necessarily referring to the same embodiment. Further, when a particular feature, structure, or characteristic is described in connection with an embodiment, it is submitted that it is within the knowledge of one skilled in the art to affect such feature, structure, or characteristic in connection with other embodiments whether or not explicitly described. After reading the description, it will be apparent to one skilled in the relevant art(s) how to implement the disclosure in alternative embodiments.

[0216] The steps of a method or algorithm described in connection with the examples disclosed herein may be embodied directly in hardware, in a software module executed by the processor **111**, or in a combination of the two. A software module may reside in RAM memory, flash memory, ROM memory, EPROM memory, EEPROM memory, registers, hard disk, a removable disk, a CD-ROM, or any other form of storage medium known in the art. An exemplary storage medium, such as the memory **112**, is coupled to the processor **111** such that the processor **111** can read information from, and write information to, the storage medium. In the alternative, the storage medium may be integral to the processor **111**. The processor **111** and the storage medium may reside in an Application Specific Integrated Circuit (ASIC).

[0217] The methods/systems may be described herein in terms of functional block components, screen shots, optional

selections and various processing steps. It should be appreciated that such functional blocks may be realized by any number of hardware and/or software components configured to perform the specified functions. For example, the methods/systems may employ various integrated circuit components, e.g., memory elements, processing elements, logic elements, look-up tables, and the like, which may carry out a variety of functions under the control of one or more microprocessors or other control devices. Similarly, the software elements of the methods/systems may be implemented with any programming or scripting language such as, VPL, C, C++, C#, Java, JavaScript, VBScript, Macromedia Cold Fusion, COBOL, Microsoft Active Server Pages, assembly, PERL, PHP, awk, Python, Visual Basic, SQL Stored Procedures, PL/SQL, any UNIX shell script, and XML with the various algorithms being implemented with any combination of data structures, objects, processes, routines or other programming elements. Further, it should be noted that the methods/systems may employ any number of conventional techniques for data transmission, signaling, data processing, network control, and the like.

[0218] As will be appreciated by one of ordinary skill in the art, the methods/systems may be embodied as a customization of an existing system, an add-on product, upgraded software, a stand-alone system, a distributed system, a method, a data processing system, a device for data processing, and/or a computer program product. Furthermore, the methods/systems may take the form of a computer program product on a non-transitory computer-readable storage medium having computer-readable program code means embodied in the storage medium. Any suitable computer-readable storage medium may be utilized, including hard disks, CD-ROM, optical storage devices, magnetic storage devices, and/or the like.

[0219] Exemplary embodiments of the methods/systems have been disclosed in an illustrative style. Accordingly, the terminology employed throughout should be read in a non-limiting manner. Although minor modifications to the teachings herein will occur to those well versed in the art, it shall be understood that what is intended to be circumscribed within the scope of the patent warranted hereon are all such embodiments that reasonably fall within the scope of the advancement to the art hereby contributed, and that that scope shall not be restricted, except in light of the appended claims and their equivalents.

What is claimed is:

1. An intelligent earpiece to be worn over an ear of a user, comprising:

an inertial measurement unit (IMU) coupled to the intelligent earpiece and configured to detect inertial measurement data corresponding to a positioning, velocity, or acceleration of the intelligent earpiece;

a global positioning system (GPS) unit coupled to the intelligent earpiece and configured to detect location data corresponding to a location of the intelligent earpiece;

at least one camera coupled to the intelligent earpiece configured to detect image data corresponding to a surrounding environment of the intelligent guidance device;

a memory configured to store object data regarding previously determined objects and for storing previously determined user data associated with the user;

a processor connected to the IMU, the GPS unit and the at least one camera and configured to:

recognize an object in the surrounding environment by analyzing the image data based on the stored object data and at least one of the inertial measurement data or the location data,

determine a desirable event or action based on the recognized object, the previously determined user data, and a current time or day,

determine a destination based on the determined desirable event or action,

determine a navigation path for navigating the intelligent guidance device to the destination based on the determined destination, the image data, and at least one of the inertial measurement data or the location data, and

determine output data based on the determined navigation path; and

a speaker configured to provide audio information to the user based on at least one of the recognized object, determined desirable event or action, or navigation path.

2. The intelligent earpiece of claim **1**, further comprising:

a vibratory motor coupled to the intelligent earpiece configured to provide first haptic information to the user based on the determined output data.

3. The intelligent earpiece of claim **1**, wherein the memory is configured to store map data and the processor is configured to determine the navigation path based on the image data, the map data, and at least one of the location data or the inertial measurement data.

4. The intelligent earpiece of claim **1**, further comprising:

a wireless communication antenna for establishing an audio or video communication with another portable electronic device or computer used by another person,

wherein the processor is further configured to establish the audio or video communication based on the determined desirable event or action.

5. The intelligent earpiece of claim **1**, further comprising an antenna configured for wireless communication.

6. The intelligent earpiece of claim **1**, further comprising a microphone configured to detect a speech of the user or another person, wherein the processor is further configured to:

parse a conversation of the user or the another person into speech elements,

analyze the speech elements based on the previously determined user data, and

determine the desirable event or action further based on the analyzed speech elements.

7. The intelligent earpiece of claim **1**, further comprising a pair of stereo cameras configured to detect depth information regarding the surrounding environment.

8. The intelligent earpiece of claim **1**, further comprising a wide angle camera configured to detect image data within a 120 degree field of view.

9. A method for providing continuous social and environmental awareness by an earpiece comprising:

detecting, via an inertial measurement unit (IMU), a global position system unit (GPS) or a camera, inertial measurement data corresponding to a positioning, velocity, or acceleration of the earpiece, location data corresponding to a location of the earpiece or image data corresponding to a surrounding environment of the earpiece;

storing, in a memory, object data regarding previously determined objects and previously determined user data regarding the user;

recognizing, by a processor, an object in the surrounding environment by analyzing the image data based on the stored object data and at least one of the inertial measurement data or the location data;

determining, by the processor:

a desirable event or action based on the recognized object, the previously determined user data, and a current time or day,

a destination based on the determined desirable event or action,

a navigation path for navigating the intelligent guidance device to the destination based on the determined destination, the image data, and at least one of the inertial measurement data or the location data, and

output data based on the determined navigation path; and

providing, via a speaker or a vibration unit, audio or haptic information to the user based on at least one of the recognized object, the determined desirable event or action, or the navigation path.

10. The method of claim **9** wherein:

detecting data includes detecting, by the camera, image data corresponding to a surrounding environment of the earpiece,

determining divergence data includes determining divergence data between the object data and the image data, and

providing audio or haptic information to the user further includes providing audio or haptic information based on the divergence data.

11. The method of claim **9** wherein determining a navigation path includes determining the navigation path based on the image data, the map data, and at least one of the location data or the inertial measurement data.

12. The method of claim **9** further including transmitting, via an antenna, the image data and at least one of the inertial measurement data or the location data to a remote device, where the processor is located on the remote device.

13. The method of claim **9** further comprising storing, in the memory, map data and determining, by the processor, the navigation path based on the image data, the map data, and at least one of the location data or the inertial measurement data.

14. The method of claim **9** wherein storing object data includes storing object data in a remote database that can be accessed by other intelligent devices.

15. An intelligent earpiece to be worn over an ear of a user, comprising:

an inertial measurement unit (IMU) coupled to the intelligent earpiece and configured to detect inertial measurement data corresponding to a positioning, velocity, or acceleration of the intelligent earpiece;

a global positioning system (GPS) unit coupled to the intelligent earpiece and configured to detect location data corresponding to a location of the intelligent earpiece;

at least one camera coupled to the intelligent earpiece configured to detect image data corresponding to a surrounding environment of the intelligent guidance device;

a memory configured to store object data regarding previously determined objects and for storing previously determined user data associated with the user;

an antenna configured to transmit the image data, the inertial measurement data, the location data and the object data to a remote processor and to receive processed data from the remote processor, the remote processor configured to:

recognize an object in the surrounding environment by analyzing the image data based on the stored object data and at least one of the inertial measurement data or the location data,

determine a desirable event or action based on the recognized object, the previously determined user data, and a current time or day,

determine a destination based on the determined desirable event or action,

determine a navigation path for navigating the intelligent guidance device to the destination based on the determined destination, the image data, and at least one of the inertial measurement data or the location data, and

determine output data based on the determined navigation path; and

a speaker configured to provide audio information to the user based on at least one of the recognized object, determined desirable event or action, or navigation path.

16. The intelligent earpiece of claim **15**, further comprising:

a vibratory motor coupled to the earpiece configured to provide first haptic information to the user based on the determined output data.

17. The intelligent earpiece of claim **15**, wherein the memory is configured to store map data and the processor is configured to determine the navigation path based on the image data, the map data, and at least one of the location data or the inertial measurement data.

18. The intelligent earpiece of claim **15**, further comprising:

a wireless communication antenna for establishing an audio or video communication with another portable electronic device or computer used by another person,

wherein the processor is further configured to establish the audio or video communication based on the determined desirable event or action.

19. The intelligent earpiece of claim **15**, further comprising a microphone configured to detect a speech of the user or another person, wherein the processor is further configured to:

parse a conversation of the user or the another person into speech elements,

analyze the speech elements based on the previously determined user data, and

determine the desirable event or action further based on the analyzed speech elements.

20. The intelligent earpiece of claim **15**, further comprising a pair of stereo cameras configured to detect depth information regarding the surrounding environment.

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