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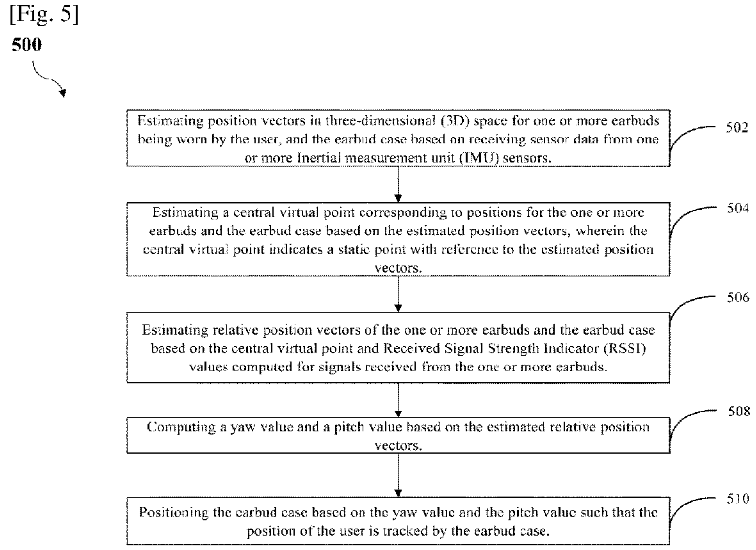
(54) Title: METHOD AND SYSTEM FOR TRACKING A USER

[Fig. 5]



(57) Abstract: A method and a system for tracking a position of a user by an earbud case are disclosed. The method includes estimating position vectors in 3D space and the earbud case based on receiving sensor data. The method includes estimating a central virtual point corresponding to positions for the earbuds and the earbud case based on the estimated position vectors. The method includes estimating relative position vectors of the earbuds and the earbud case based on the central virtual point and RSSI values for signals received from the earbuds. The method includes computing a yaw value and a pitch value. The method includes positioning the earbud case based on the yaw value and the pitch value such that the position of the user is tracked by the earbud case.

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Description

Title of Invention: METHOD AND SYSTEM FOR TRACKING A USER

Technical Field

[1] The present disclosure relates to tracking systems, and more particularly, to a method and a system for tracking a position of a user by an earbud case.

Background Art

[2] The information in this section merely provides background information related to the present disclosure and may not constitute prior art(s) for the present disclosure.

[3] Unmanned aerial vehicles (UAV), commonly known as drones, are aerial aircraft that may be flown without a presence of a pilot onboard, instead using operating equipment such as a remote. Further, the UAV flies autonomously by utilizing one of many pre-programmed sets of instructions, as well as a number of built-in sensors and navigation systems.

[4] The drones may also include tanking systems that are used for tracking and capturing objects such as users. However, these conventional drones are bulky and heavy. Thus, a user faces difficulty in carrying and setting up conventional drones.

[5] Further, conventional drones utilize a camera-based tracking is the loss of tracking when a face is not detected or is no longer visible or requires some initial registration of the face that needs to be tracked.

[6] More specifically, current tracking systems heavily rely on detecting and continuously identifying a user's face. If the face of the user is obscured, turned away, or not within the camera's view, the drones lose track of the targeted object, disrupting the tracking functionality.

[7] Further, interruptions in tracking due to the absence or obstruction of a visible face can lead to frustration among users, impacting the overall usability and satisfaction with the drone.

[8] Furthermore, the current tracking systems use face detection and tracking algorithms that struggle to adapt to varying environmental conditions, lighting changes, or rapid movements, further complicating reliable tracking.

[9] Moreover, the existing camera-based tracking systems consume significant battery power, reducing the overall flight time of compact drones. This limits the duration users can utilize tracking features before needing to recharge or replace batteries.

[10] Therefore, there is a need for an alternative solution that may overcome above discussed limitations.

[11] The drawbacks/difficulties/disadvantages/limitations of the conventional techniques explained in the background section are just for exemplary purposes and the disclosure would never limit its scope only such limitations. A person skilled in the art would understand that this disclosure and below mentioned description may also solve other problems or overcome the other drawbacks/disadvantages.

Disclosure of Invention

Solution to Problem

[12] This summary is provided to introduce a selection of concepts, in a simplified format, that are further described in the detailed description of the invention. This summary is neither intended to identify essential inventive concepts of the invention nor is it intended for determining the scope of the invention.

[13] According to an aspect of the present disclosure, a method for tracking a position of a user by an earbud case is disclosed. The method includes estimating position vectors in three-dimensional (3D) space for one or more earbuds being worn by the user, and the earbud case based on receiving sensor data from one or more Inertial Measurement Unit (IMU) sensors. Further, the method includes estimating a central virtual point corresponding to positions for the one or more earbuds and the earbud case based on the estimated position vectors, wherein the central virtual point indicates a static point with reference to the estimated position vectors. Furthermore, the method includes estimating relative position vectors of the one or more earbuds and the earbud case based on the central virtual point and Received Signal Strength Indicator (RSSI) values computed for signals received from the one or more earbuds. The method further includes computing a yaw value and a pitch value based on the estimated relative position vectors. Moreover, the method includes positioning the earbud case based on the yaw value and the pitch value such that the position of the user is tracked by the earbud case.

[14] According to another aspect of the present disclosure, a system for tracking a position of a user by an earbud case is disclosed. The system includes a memory. The system further includes at least one processor in communication with the memory. The at least one processor is configured to estimate position vectors in three-dimensional (3D) space for one or more earbuds being worn by the user and the earbud case based on receiving sensor data from one or more Inertial Measurement Unit (IMU) sensors. Further, the at least one processor is configured to estimate a central virtual point corresponding to positions for the one or more earbuds and the earbud case based on the estimated position vectors, wherein the central virtual point indicates a static point with reference to the estimated position vectors. Furthermore, the at least one processor is configured to estimate the relative position vectors of the one or more

earbuds and the earbud case based on the central virtual point and Received Signal Strength Indicator (RSSI) values computed for signals received from the one or more earbuds. The at least one processor is further configured to compute a yaw value and a pitch value based on the estimated relative position vectors. Moreover, the at least one processor is configured to position the earbud case based on the yaw value and the pitch value such that the position of the user is tracked by the earbud case.

[15] In yet another aspect, an earbud case capable of flying is disclosed. The earbud case includes a body that includes a shell adapted to retain one or more earbuds. The earbud case further includes one or more arms mounted on the body. Each of the one or more arms includes a proximal end coupled to the body and a distal end that includes a propulsion unit adapted to generate thrust. Further, the earbud case includes one or more actuating units operably coupled to each of the one or more arms and the propulsion unit. The one or more actuating units adapted to drive each of the one or more arms and the propulsion unit. Furthermore, the earbud case includes a control unit in communication with the one or more actuating units. The control unit is configured to generate one or more instructions based on receiving input from a user. The one or more instructions are indicative of commands to operate the one or more actuating units for unfolding the one or more arms. The unfolding indicates extension of the one or more arms from the body. Further, the one or more instructions are indicative of commands to operate the one or more actuating units for operating the propulsion unit upon unfolding the one or more arms, thereby enabling the earbud case to fly.

[16] In yet another aspect, a method for enabling an earbud case capable of flying. The method includes receiving input from a user. The input indicates a command for enabling a flying mode for the earbud case. The method further includes generating one or more instructions based on the received input. The one or more instructions are indicative of commands for operating one or more actuation units for unfolding one or more arms. The unfolding indicates extension of the one or more arms from a body of the earbud case. The one or more instructions are indicative of commands for operating one or more actuation units for operating a propulsion unit associated with one or more arms upon unfolding the one or more arms, thereby enabling the earbud case capable of flying.

[17] To further clarify the advantages and features of the present invention, a more particular description of the invention will be rendered by reference to specific embodiments thereof, which are illustrated in the appended drawings. It is appreciated that these drawings depict only typical embodiments of the invention and are therefore not to be considered limiting of its scope. The invention will be described and explained with additional specificity and detail in the accompanying drawings.

Brief Description of Drawings

[18] These and other features, aspects, and advantages of the present invention will become better understood when the following detailed description is read with reference to the accompanying drawings in which like characters represent like parts throughout the drawings, wherein:

[19] Figure 1 illustrates a schematic block diagram depicting an environment for the implementation of a system for tracking a position of a user, in accordance with an embodiment of the present disclosure;

[20] Figure 2a illustrates a top view of an earbud case when the earbud case gets unfolded, in accordance with an embodiment of the present disclosure;

[21] Figure 2b illustrates an isometric view of the earbud case when the earbud case gets unfolded, in accordance with an embodiment of the present disclosure;

[22] Figure 2c illustrates an isometric view of the earbud case when the earbud case gets folded, in accordance with an embodiment of the present disclosure;

[23] Figure 2d illustrates a bottom view of the earbud case when the earbud case gets folded, in accordance with an embodiment of the present disclosure;

[24] Figure 3 illustrates a flowchart depicting an exemplary method for enabling the earbud case capable of flying, in accordance with an embodiment of the present disclosure;

[25] Figure 4 illustrates a schematic block diagram of the system for tracking the position of the user, in accordance with an embodiment of the present disclosure;

[26] Figure 5 illustrates a flowchart depicting an exemplary method for tracking the position of the user, in accordance with an embodiment of the present disclosure;

[27] Figure 6 illustrates a flowchart depicting the generation of the raw data stream from the sensor data, in accordance with an embodiment of the present disclosure;

[28] Figure 7 illustrates a schematic diagram depicting blocks for processing raw data stream, in accordance with an embodiment of the present disclosure;

[29] Figure 8 illustrates a flowchart depicting sub-steps for estimating position vectors of one or more earbuds and the earbud case, in accordance with an embodiment of the present disclosure;

[30] Figure 9 illustrates a flowchart depicting sub-steps for estimating a central virtual point corresponding to positions for the one or more earbuds and the earbud case, in accordance with an embodiment of the present disclosure;

[31] Figure 10 illustrates a flowchart depicting a filtration of noise from signals, in accordance with an embodiment of the present disclosure;

[32] Figure 11 illustrates a flowchart depicting sub-steps for modifying the initial relative position vectors for estimating, using the estimating module, the optimized relative position vectors, in accordance with an embodiment of the present disclosure;

[33] Figure 12 illustrates a flowchart depicting steps for obtaining a merged audio, in accordance with an embodiment of the present disclosure;

[34] Figure 13 illustrates an exemplary flow depicting dynamic switching, in accordance with an embodiment of the present disclosure;

[35] Figure 14 illustrates a schematic diagram depicting blocks for synchronization of audio and video, in accordance with an embodiment of the present disclosure; and

[36] Figure 15a illustrates an exemplary use case, in accordance with an embodiment of the present disclosure.

[37] Figure 15b illustrates an exemplary use case, in accordance with an embodiment of the present disclosure.

[38] Figure 15c illustrates an exemplary use case, in accordance with an embodiment of the present disclosure.

[39] Figure 15d illustrates an exemplary use case, in accordance with an embodiment of the present disclosure.

[40] Figure 15e illustrates an exemplary use case, in accordance with an embodiment of the present disclosure.

[41] Further, skilled artisans will appreciate that elements in the drawings are illustrated for simplicity and may not have necessarily been drawn to scale. For example, the flow charts illustrate the method in terms of the most prominent steps involved to help improve understanding of aspects of the present invention. Furthermore, in terms of the construction of the device, one or more components of the device may have been represented in the drawings by conventional symbols, and the drawings may show only those specific details that are pertinent to understanding the embodiments of the present invention so as not to obscure the drawings with details that will be readily apparent to those of ordinary skill in the art having the benefit of the description herein.

Mode for the Invention

[42] For the purpose of promoting an understanding of the principles of the invention, reference will now be made to the various embodiments and specific language will be used to describe the same. It should be understood at the outset that although illustrative implementations of the embodiments of the present disclosure are illustrated below, the present invention may be implemented using any number of techniques, whether currently known or in existence. The present disclosure is not necessarily limited to the illustrative implementations, drawings, and techniques

illustrated below, including the exemplary design and implementation illustrated and described herein, but may be modified within the scope of the present disclosure.

[43] It will be understood by those skilled in the art that the foregoing general description and the following detailed description are explanatory of the invention and are not intended to be restrictive thereof.

[44] Reference throughout this specification to "an aspect", "another aspect" or similar language means that a particular feature, structure, or characteristic described in connection with the embodiment is included in at least one embodiment of the present invention. Thus, appearances of the phrase "in an embodiment", "in another embodiment" and similar language throughout this specification may, but do not necessarily, all refer to the same embodiment.

[45] It is to be understood that as used herein, terms such as, "includes," "comprises," "has," etc. are intended to mean that the one or more features or elements listed are within the element being defined, but the element is not necessarily limited to the listed features and elements, and that additional features and elements may be within the meaning of the element being defined. In contrast, terms such as, "consisting of" are intended to exclude features and elements that have not been listed.

[46] The embodiments herein and the various features and advantageous details thereof are explained more fully with reference to the non-limiting embodiments that are illustrated in the accompanying drawings and detailed in the following description. Descriptions of well-known components and processing techniques are omitted to not unnecessarily obscure the embodiments herein. Also, the various embodiments described herein are not necessarily mutually exclusive, as some embodiments can be combined with one or more other embodiments to form new embodiments. The term "or" as used herein, refers to a non-exclusive or unless otherwise indicated. The examples used herein are intended merely to facilitate an understanding of ways in which the embodiments herein can be practiced and to further enable those skilled in the art to practice the embodiments herein. Accordingly, the examples should not be construed as limiting the scope of the embodiments herein.

[47] As is traditional in the field, embodiments may be described and illustrated in terms of blocks that carry out a described function or functions. These blocks, which may be referred to herein as units or modules or the like, are physically implemented by analog or digital circuits such as logic gates, integrated circuits, microprocessors, microcontrollers, memory circuits, passive electronic components, active electronic components, optical components, hardwired circuits, or the like, and may optionally be driven by firmware and software. The circuits may, for example, be embodied in one or more semiconductor chips, or on substrate supports such as printed circuit boards and the like. The circuits constituting a block may be implemented by dedicated

hardware, by a processor (e.g., one or more programmed microprocessors and associated circuitry), or by a combination of dedicated hardware to perform some functions of the block and a processor to perform other functions of the block. Each block of the embodiments may be physically separated into two or more interacting and discrete blocks without departing from the scope of the invention. Likewise, the blocks of the embodiments may be physically combined into more complex blocks without departing from the scope of the invention.

[48] The accompanying drawings are used to help easily understand various technical features and it should be understood that the embodiments presented herein are not limited by the accompanying drawings. As such, the present disclosure should be construed to extend to any alterations, equivalents, and substitutes in addition to those which are particularly set out in the accompanying drawings. Although the terms first, second, etc. may be used herein to describe various elements, these elements should not be limited by these terms. These terms are generally only used to distinguish one element from another.

[49] Figure 1 illustrates a schematic block diagram depicting an environment 1000 for the implementation of a system 102 for tracking a position of a user 200, in accordance with an embodiment of the present disclosure. In an embodiment, the environment 1000 may include an earbud case 100 that is capable of flying. The environment 1000 may include one or more earbuds 300 that may be worn by the user 200. In an embodiment, the one or more earbuds 300 may be retained in the earbud case 100. In an embodiment, the system 102 may be implemented in the earbud case 100 and may be capable of tracking the position of the user 200. In various embodiments, the system 102 may interchangeably be termed as a vision-less tracking system (VTS) within the scope of the present disclosure.

[50] In an embodiment, construction details of the earbud case 100 may be discussed in conjunction with figures 2a, 2b, 2c, and 2d.

[51] Figure 2a illustrates a top view of the earbud case 100 when the earbud case 100 gets unfolded, in accordance with an embodiment of the present disclosure. Figure 2b illustrates an isometric view of the earbud case 100 when the earbud case 100 gets unfolded, in accordance with an embodiment of the present disclosure. Figure 2c illustrates an isometric view of the earbud case 100 when the earbud case 100 gets folded, in accordance with an embodiment of the present disclosure. Figure 2d illustrates a bottom view of the earbud case 100 when the earbud case 100 gets folded. The earbud case 100 may include but is not limited to a body 10, one or more arms 14, one or more actuating units, and a control unit. In an embodiment, the body 10 may include a shell 12 (as illustrated in figures 2a and 2b) that may be adapted to retain the one or more earbuds 300 (not shown in figures 2a, 2b, 2c, and 2d). In an embodiment,

the body 10 may include a battery retaining unit (not shown in figures) that may be adapted to retain one or more batteries. In an embodiment, the one or more batteries may be adapted to power various components of the earbud case 100 such as the one or more earbuds 300 case or the one or more actuating units.

[52] Further, the earbud case 100 may include the one or more arms 14 that may be mounted on the body 10. In an embodiment, each of the one or more arms 14 may include a proximal end 20 and a distal end 22 as illustrated in figure 2a.

[53] In an embodiment, the proximal end 20 may be coupled to the body 10. The proximal end 20 may be provided with a rotary device 18 adapted to couple a corresponding arm to the body 10. In an exemplary embodiment, the rotary device 18 may herein refer to a hinge within the scope of the present disclosure.

[54] In one embodiment, each of the one or more arms 14 may include but is not limited to a first telescopic cylinder 14a and a second telescopic cylinder 14b. In an embodiment, the first telescopic cylinder 14a may be coupled to a corresponding rotary device 18. In an embodiment, the first telescopic cylinder 14a may have a cavity to receive the second telescopic cylinder 14b. In various implementations, the second telescopic may be adapted to slide inside the first telescopic cylinder 14a, thereby enabling extension and retraction of the corresponding arm.

[55] In an embodiment, the first telescopic cylinder 14a may include a locking through-hole at a circumferential surface that engages with a protruded part of the second telescopic cylinder 14b when the second telescopic device extends to a predefined range. Thus, may enable a locking of the second telescopic cylinder 14b with the first telescopic cylinder 14a when the one or more arms 14 get unfolded.

[56] In an embodiment, the distal end 22 may be provided with a propulsion unit 16 that may be adapted to generate thrust as illustrated in Figure 2a. In one embodiment, the propulsion unit 16 may be coupled to the distal end 22 in such a manner that the propulsion unit 16 may also get detached as illustrated in Figure 2a. In an embodiment, the propulsion unit 16 may include a propeller that may be coupled to the one or more actuating units.

[57] In one embodiment, the one or more actuating devices (not shown in figures) may be operably coupled to the one or more arms 14 and the propulsion unit 16. In an embodiment, the one or more actuating units may be adapted to drive each of the one or more arms 14, and the propulsion unit 16. More specifically, the one or more actuating units may be adapted to provide a rotational force to drive the propeller.

[58] In one embodiment, the one or more actuating units may be adapted to drive the rotary device 18 to enable rotation of the corresponding arm such that the corresponding arm extends from the body 10.

[59] In one embodiment, the earbud case 100 may further include a control unit that may be operably in communication with the one or more actuating units. In an embodiment, the control unit may be configured to generate one or more instructions based on receiving input from the user 200. In an exemplary embodiment, the input may indicate a voice command from the user 200 for folding the one or more arms 14 or unfolding the one or more arms 14.

[60] In an embodiment, the one or more instructions may be indicative of commands to operate the one or more actuating units to perform one or more functions. In an embodiment, the one or more functions may include unfolding the one or more arms 14. Throughout the disclosure, the unfolding may indicate an extension of the one or more arms 14 from the body 10. The one or more functions may further include operating the propulsion unit 16 upon unfolding the one or more arms 14, thereby enabling the earbud case 100 to fly.

[61] In one embodiment, the one or more actuating units may be adapted to drive the rotary device 18 to enable rotation of the corresponding arm such that the corresponding arm extends from the body 10.

[62] In one embodiment, the one or more actuating units may be adapted to drive the rotary device 18 to enable rotation of the corresponding arm such that the corresponding arm gets folded under the body 10 as illustrated in figure 2d.

[63] In one embodiment, the earbud case 100 may include one or more cameras 24 that may be mounted on the body 10. In an embodiment, the one or more cameras 24 may be adapted to capture videos/images.

[64] In various embodiments, the earbud case 100 and the one or more earbuds 300 may be installed with one or more Inertial Measurement Unit (IMU) sensors.

[65] In one embodiment, the earbud case 100 may be capable of tracking the position of the user 200.

[66] In another aspect, a method 250 for enabling the earbud case 100 capable of flying is discussed in conjunction with figure 3. Figure 3 illustrates a flowchart depicting an exemplary method 250 for enabling an earbud case 100 capable of flying, in accordance with an embodiment of the present disclosure.

[67] At step 302, the method 250 may include receiving input from the user 200. In an embodiment, the input indicates a command for enabling a flying mode for the earbud case 100.

[68] At step 304, the method 250 may include generating the one or more instructions based on the received input. In an embodiment, the one or more instructions are indicative of commands for operating one or more actuation units for at least one of unfolding one or more arms 14 and operating a propulsion unit 16 associated with one

or more arms 14 upon unfolding the one or more arms 14. Thus, may enable the earbud case 100 capable of flying.

[69] In an embodiment, the method 250 may include driving, by the one or more actuating units, the rotary device 18 associated with each of the one or more arms 14 to enable rotation of the corresponding arm such that the corresponding arm extends from the body 10, thereby unfolding of the one or more arms 14.

[70] In one embodiment, the method 250 may include providing, by the one or more actuating units, the rotational force to the propeller associated with the propulsion unit 16 for generating thrust, thereby enabling flight.

[71] Figure 4 illustrates a schematic block diagram of the system 102 for tracking the position of the user 200, in accordance with an embodiment of the present disclosure.

[72] In an embodiment, the system 102 may include a memory 104 including a database 106. In an embodiment, the system 102 may include a processor 108 communicatively coupled with the memory 104, an Input/Output (I/O) interface 110, and a plurality of modules 120. In an embodiment, the system 102 may be implemented by the earbud case 100.

[73] In another embodiment, the system 102 may be implemented by a cloud-based system, which may include the server, specifically a cloud server that may be in communication with the earbud case 100 and the one or more earbuds 300.

[74] In yet another embodiment, the system 102 may be implemented by user equipment (UE) that may be in communication with the earbud case 100 and the one or more earbuds 300. In a non-limiting example, the UE may be a smartphone, a laptop computer, a desktop computer, a Personal Computer (PC), a notebook, a tablet, or a smartwatch.

[75] In one embodiment, the memory 104 is configured to store instructions executable by the processor 108. In one embodiment, the memory 104 communicates via a bus within the system 102. The memory 104 includes but is not limited to, a non-transitory computer-readable storage media, such as various types of volatile and non-volatile storage media including, but not limited to, random access memory, read-only memory, programmable read-only memory, electrically programmable read-only memory, electrically erasable read-only memory, flash memory, magnetic tape or disk, optical media and the like. In one example, the memory includes a cache or random-access memory (RAM) for the processor 108. In alternative examples, the memory 104 is separate from the processor 108 such as a cache memory of a processor, the system memory, or other memory. The memory 104 is an external storage device and the memory 104 is for storing data. The memory 104 is operable to store instructions executable by the processor 108. The functions, acts, or tasks illustrated in the figures or described are performed by the programmed processor

for executing the instructions stored in the memory 104. The functions, acts, or tasks are independent of the particular type of instruction set, storage media, processor, or processing strategy and may be performed by software, hardware, integrated circuits, firmware, micro-code, and the like, operating alone or in combination. Likewise, processing strategies include multiprocessing, multitasking, parallel processing, and the like.

[76] As a non-limiting example, the processor 108 may be a single processing unit or a set of units each including multiple computing units. The processor 108 may be implemented as one or more microprocessors, microcomputers, microcontrollers, digital signal processors, central processing units, state machines, logic circuitries, and/or any devices that manipulate signals based on operational instructions (computer-readable instructions) stored in the memory 104. Among other capabilities, the processor 108 may be configured to fetch and execute computer-readable instructions and data stored in the memory 104. The processor 108 includes one or a plurality of processors. The plurality of processors is further implemented as a general-purpose processor, such as a Central Processing Unit (CPU), an Application Processor (AP), or the like, a graphics-only processing unit, such as a Graphics Processing Unit (GPU), a Visual Processing Unit (VPU), and/or an AI-dedicated processor such as a Neural Processing Unit (NPU). The plurality of processors controls the processing of the input data in accordance with a predefined operating rule or an Artificial Intelligence (AI) model stored in the memory 104. The predefined operating rule or the AI model is provided through training or learning.

[77] The processor 108 may be disposed of in communication with one or more Input/Output (I/O) devices via the Input/Output (I/O) interface 110. The I/O interface 110 employs Communication Code-Division Multiple Access (CDMA), High-Speed Packet Access (HSPA+), Global System for Mobile communications (GSM), Long-Term Evolution (LTE), WiMax, and the like, etc. In another embodiment of the present invention, the I/O interface 110 employs ethernet, industrial wireless Local Area Network (LAN), Process Field Bus (PROFIBUS), Actuator Sensor (AS) Interface, and the like.

[78] In various embodiments, the processor 108 may interchangeably be termed as the control unit within the scope of the present disclosure.

[79] The system 102 may further include a plurality of modules 120 that may include the one or more instructions that may be executed to cause the system 102, in particular, the processor 108 of the system 102, to execute the one or more instructions.

[80] The plurality of modules 120 may include an estimating module 122, a computing module 124, a positioning module 126, a modifying module 128, a capturing module 130, an active noise cancelling (ANC) module 132, a switching module 134, and

a synchronizing module 136. In an embodiment, the estimating module 122, the computing module 124, the positioning module 126, the modifying module 128, the capturing module 130, the active noise cancelling (ANC) module 132, the switching module 134, and the synchronizing module 136 may be in communication with each other. In an embodiment, the plurality of modules 120 may be configured to perform various operations or steps that may be discussed and explained in detail in conjunction with figures 5 to 14.

[81] Preferably, a detailed explanation of various functions of the processor 108, and/or the plurality of modules 120 may be explained in view of figures 5 to 14.

[82] Figure 5 illustrates a flowchart depicting an exemplary method 500 for tracking the position of the user 200, in accordance with an embodiment of the present disclosure. In an embodiment, the method 500 is a computer-implemented method 400 that is explained in detail in the below paragraphs.

[83] Referring to Figure 5, the method 500 may begin with step 502 which may include estimating, via the estimating module 122, position vectors in Three-Dimensional (3D) space for the one or more earbuds 300 being worn by the user 200, and the earbud case 100. In an exemplary embodiment, the one or more earbuds 300 herein refer to a pair of earbuds, i.e., a left earbud and a right earbud within the scope of the present disclosure.

[84] In an embodiment, the position vectors may be estimated using sensor data that may be received from the one or more Inertial Measurement Unit (IMU) sensors. In an embodiment, the sensor data may include accelerometer data, gyroscope data, and magnetometer data. In an embodiment, the IMU sensors may be installed on the one or more earbuds 300 and the earbud case 100.

[85] In one embodiment, the method 500 may also include receiving input from the one or more cameras 24 integrated with the earbud case 100, in a flying state of the earbud case 100. The input indicates image and video data associated with the user 200.

[86] In one embodiment, prior to estimating the position vectors, the sensor data may be processed to generate a raw data stream which may be discussed in conjunction with figure 6.

[87] Figure 6 illustrates a flowchart 600 depicting the generation of the raw data stream from the sensor data, in accordance with an embodiment of the present disclosure.

[88] At block 602, a data fetching module may fetch the sensor data from the one or more IMU sensors of each of the one or more earbuds 300 and the earbud case 100. The data fetching model may further analyze the sensor data at a specified sampling rate or on-demand basis.

[89] Further, at block 604, a data integration model may integrate the analyzed sensor data received from the IMU sensors associated with each of the one or more earbuds

300 and the earbud case 100. The integration may include aligning timestamps, handling any sensor-specific calibration or normalization, and ensuring data consistency across the sensor data.

[90] Furthermore, at block 606, a transformation model may process the integrated sensor data and transform the integrated sensor data into the raw data stream. The raw data stream may include numerical values representing sensor readings at discrete time intervals. In an exemplary embodiment, the numerical values may include acceleration values (in the x, y, and z axes), angular velocities, and possibly magnetic field strengths associated with the one or more earbuds 300 and the earbud case 100.

[91] Figure 7 illustrates a schematic diagram 700 depicting blocks for processing the raw data stream, in accordance with an embodiment of the present disclosure.

[92] At block 702, a data pre-processing and feature extraction model may parse the raw data stream to separate data received from the one or more IMU sensors. Further, the data pre-processing and feature extraction model may normalize the separated data to a common scale to extract relevant features from the parsed and normalized data.

[93] At block 704, an outlier detection and correction model may identify outliers in the position vectors using statistical methods and learned patterns from training data and apply corrections to the identified outliers to produce a refined data stream.

[94] Again, referring to step 502, one or more sub-steps for estimating the position vectors are discussed in conjunction with Figure 8.

[95] Figure 8 illustrates a flowchart depicting sub-steps for estimating the position vectors of the one or more earbuds 300 and the earbud case 100, in accordance with an embodiment of the present disclosure.

[96] At sub-step 502a, the step 502 may include computing, via the computing module 124, a velocity v(t) of the one or more earbuds 300 and the earbud case 100 based on integrating the acceleration data over time using math figure 1 as illustrated below:

[97] [Math.1]

$$(t) = v\,(t-1) + (t).\Delta t$$

[98] where (t) is acceleration data over time and Δt is a change in time.

[99] At sub-step 502b, the step 502 may include computing integrated position data of the one or more earbuds 300 and the earbud case 100 based on integrating the velocity over time using math figure 2 as below:

[100] [Math.2]

$$p(t) = p(t-1) + v(t).\Delta t$$

[101] where v(t) corresponds to computed velocity over time.

[102] At sub-step 502c, the step 502 may include computing an orientation (γ) of the one or more earbuds 300 and the earbud case 100 based on integrating an angular velocity of the earbuds and the earbud case 100 obtained from the gyroscope data using math figure 3 as below:

[103] [Math.3]

$$\gamma gyro(t) = \gamma gyro(t-1) + \omega gyro(t).\Delta t$$

[104] where $\omega_{gyro}(t)$ corresponds to angular frequency over time.

[105] At sub-step 502d, the step 502 may include modifying, via the modifying module 128, the computed orientation based on the magnetometer data corresponding to the respective axes of the one or more earbuds 300 and the earbud case 100 using math figure 4 as below:

[106] [Math.4]

$$\gamma_{corr}(t) = \alpha\, \gamma_{gyro}(t) + (1-\alpha)\, \gamma_{mag}(t)$$

[107] where $\gamma_{mag}(t)$ is arctan(B_1, B_2), α corresponds to a constant ranging from 0 to 1, and B_1, B_2 are the magnetic field components corresponding to the respective axes.

[108] At sub-step 502e, the step 502 may include estimating the position vectors based on correlating the modified orientation with the integrated position data. In an embodiment, the position vectors (P) may be computed by applying the orientation correction to the integrated positions using math figure 5 as below:

[109] [Math.5]

$$\mathrm{P}(t) = R(\gamma_{corr}(t)).p(t)$$

[110] where $R(\gamma_{corr}(t))$ corresponds to the rotation matrix over time derived from the orientation data.

[111] In an embodiment, the rotation matrix associated with the one or more earbuds 300 and the earbud case 100 may be computed using math figure 6 as below:

[112] [Math.6]

$$R(\gamma_{corr}(t)) = R_x(\varphi).Ry(\theta).Rz(\psi)$$

[113] where Rx(φ) corresponds to the rotation matrix for Roll(φ) represented using math figure 7 as below:

[114] [Math.7]

$$R_x(\varphi) = \begin{bmatrix} 1 & 0 & 0 \\ 0 & \cos(\varphi) & -\sin(\varphi) \\ 0 & \sin(\varphi) & \cos(\varphi) \end{bmatrix}$$

[115] where $R_y(\theta)$ corresponds to the rotation matrix for Pitch(θ) represented using math figure 8 as below:

[116] [Math.8]

$$Ry(\theta) = \begin{bmatrix} \cos(\theta) & 0 & \sin(\theta) \\ 0 & 1 & 0 \\ -\sin(\theta) & 0 & \cos(\theta) \end{bmatrix}$$

[117] and where Rz(ψ) corresponds to the rotation matrix for Yaw(ψ) represented using math figure 9 as below:

[118] [Math.9]

$$Rz(\psi) = \begin{bmatrix} \cos(\psi) & -\sin(\psi) & 0 \\ \sin(\psi) & \cos(\psi) & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

[119] Again, referring to Figure 5, at step 504, the method 500 may include estimating, via the estimating module 122, a central virtual point corresponding to positions for the one or more earbuds 300 and the earbud case 100 based on the estimated position vectors. In an embodiment, the central virtual point indicates a static point with reference to the estimated position vectors.

[120] In an embodiment, the estimation of the central virtual point may be discussed in conjunction with Figure 9.

[121] Figure 9 illustrates a flowchart depicting sub-steps for estimating the central virtual point corresponding to positions for the one or more earbuds 300 and the earbud case 100, in accordance with an embodiment of the present disclosure.

[122] At sub-step 504a, the step 504 may include computing a centroid of the position vectors of the one or more earbuds 300 and the earbud case 100 based on estimated position vectors.

[123] At sub-step 504b, the step 504 may include estimating the central virtual point based on the computed centroid using math figure 10 as below:

[124] [Math.10]

$$\vec{V} = (XA + XB + XC)/3$$

[125] where XA corresponds to a position vector corresponding to the left earbud in the 3D space, XB corresponds to a position vector corresponding to the right earbud in the 3D space, and XC corresponds to a position vector corresponding to the earbud case 100 in the 3D space.

[126] Again, referring to Figure 5, at step 506, the method 500 may include estimating, via the estimating module 122, relative position vectors of the one or more earbuds

300 and the earbud case 100 based on the central virtual point and Received Signal Strength Indicator (RSSI) values computed for signals received from the one or more earbuds 300.

[127] In one embodiment, the computing module 124 may be configured to compute the RSSI value based on filtering noise from the signals received from the one or more earbuds 300 using an Artificial Intelligence (AI) model such as a machine learning model.

[128] In one embodiment, a signal fine tuner may be used to filter noise for the signals received from the one or more earbuds 300, specifically from each of the left earbud and the right earbud.

[129] Figure 10 illustrates a flowchart depicting the filtration of noise from the signals, in accordance with an embodiment of the present disclosure.

[130] Firstly, at block 1002, the signals may pass from a signal reception model. In an embodiment, the signal reception model may continuously monitor and receive signals from the one or more earbuds 300. In an embodiment, the signal reception model may obtain data corresponding to an environment that may affect signal strength. In an exemplary scenario, the data may include interference levels, obstacles, user movement, or the like.

[131] Thereafter, at step 1004, the signals received from the left earbud and the right earbud may pass to a signal analysis model. In an embodiment, the signal analysis model may filter the signals to remove fluctuations from the signals. Further, the signals are analyzed to determine the quality of the signals and identify any issues associated with the signals such as weak signals or interference in the signals.

[132] Further, at step 1006, the analyzed signals may be passed to a signal adjustment model. In an embodiment, the signal adjustment model may dynamically adjust one or more parameters associated with the analyzed signals.

[133] At step 1008, the signals may be passed to a signal optimization model for computing the RSSI values for signals associated with the one or more earbuds 300. In an embodiment, the RSSI values computed are enhanced and stable. In an embodiment, the optimized signals may adapt to changing environmental conditions and user movements to maintain optimal signal strength.

[134] Referring to step 506, the estimating module 122 may be configured to estimate initial relative position vectors corresponding to the one or more earbuds 300 and the earbud case 100 based on the estimated central virtual point.

[135] Further, the initial relative position vectors may be modified based on the computed RSSI values, thereby estimating the relative position vectors of the one or more earbuds 300 and the earbud case 100. More specifically, the estimated relative position

vectors herein refer to optimized relative position vectors associated with the one or more earbuds 300 and the earbud case 100.

[136] Figure 11 illustrates a flowchart depicting sub-steps for modifying the initial relative position vectors for estimating, using the estimating module 122, the optimized relative position vectors, in accordance with an embodiment of the present disclosure.

[137] At sub-step 506a, the step 506 may include estimating a distance (d) between a centroid vector and an initial relative position vector of the earbud case 100 based on the computed RSSI values. In an embodiment, the centroid vector indicates a mid-point of the one or more earbuds 300, i.e., the leaf earbud and the right earbud. The distance may be estimated using math figure 11 as below:

[138] [Math.11]

$$\mathrm{d} = d_o \ * \ 10^{\left(RSSI_o - RSSI / 10 * n\right)}$$

[139] where d_o is reference distance kept 1m, n is path loss component, $RSSI_o$ is RSSI values at reference distance, and RSSI = measured RSSI values at d distance.

[140] In one embodiment, the centroid vector

$$\vec{P}_{\text{centroid}}$$

may be computed based on the initial position vectors of the one or more earbuds 300 using math figure 12 as below:

[141] [Math.12]

$$\vec{P}_{\text{centroid}} = \frac{\overrightarrow{(P_{\text{AV}} + \vec{P}_{\text{BV}})}}{2}$$

[142] where

$$\vec{P}_{AV}$$

corresponds to initial position vector of the left earbud and

$$\vec{P}_{\text{BV}}$$

corresponds to initial position vector of the right earbud.

[143] In one embodiment, the computing module 124 may be configured to compute a directional centroid vector

$$\vec{\mathrm{d}}_{\text{centroid}}$$

based on normalizing the first centroid using math figure 13 as below:

[144] [Math.13]

$$\vec{\mathrm{d}}_{\mathrm{centriod}} = \frac{\vec{P}_{\mathrm{centroid}}}{|\vec{P}_{\mathrm{centroid}}|}$$

[145] Again, referring to Figure 5, at step 508, the method 500 may include computing, via the computing module 124, a yaw value and a pitch value based on the estimated relative position vectors.

[146] In one embodiment, firstly, an initial yaw value and an initial value may be computed using the directional centroid vector. More specifically, yaw indicates a rotation around the Z-axis. The initial yaw value may be computed using the X and Y components of the directional centroid vector. Further, Pitch is the rotation around the Y-axis. The initial pitch value may be computed using the Z component of the directional centroid vector.

[147] Again, referring to Figure 11, at sub-step 506b, the step 506 may include computing an error function (E) based on estimating the distance using at least squares method. In an embodiment, the error function (E) indicates a difference between the estimated distance and an actual distance obtained from the estimated position vectors.

[148] At sub-step 506c, the step 506 may include modifying, via the modifying module 128, the initial relative position vectors based on minimizing the computed error function (E) using optimizing techniques, thereby estimating the relative position vectors, i.e., the optimized relative position vectors. In a non-limiting example, the optimizing techniques may be a gradient descent technique or a Levenberg-Marquard technique. This step refines the relative position vectors to better match the distances indicated by the RSSI values.

[149] In one embodiment, the centroid vector may again be recomputed based on the estimated relative position vectors. Thereafter, the directional centroid vector may again be computed as discussed in the above paragraphs. Further, the yaw value and the pitch value may be computed as discussed in the above paragraphs. The yaw value and the pitch value may be final and refined values.

[150] Again, referring to Figure 5, at step 510, the method 500 may include positioning, via the positioning module 126, the earbud case 100 based on the yaw value and the pitch value such that the position of the user 200 may be tracked by the earbud case 100.

[151] In one embodiment, the method 500 may include capturing, via the capturing module 130, audio. In an embodiment, the audio signals received from the one or more earbuds 300 may be processed using an active noise cancelling (ANC) module to minimize background noise, using a predefined noise cancelation technique from the audio signals received from the one or more earbuds 300 in real-time.

[152] In an exemplary embodiment, the one or more earbuds 300 may include a first earbud that may be worn by the user 200. Further, the one or more earbuds 300 may include a second earbud that may be adapted to retain in the earbud case 100. In an exemplary scenario, the first earbud may be the left earbud and the second earbud may be the right earbud. In another exemplary scenario, the first earbud may be the right earbud and the second earbud may be the left earbud.

[153] In an embodiment, the ANC module 132 may include an adaptive filtering technique such as an LMS (Least Mean Squares) Adaptive Filter for generating anti-noise signals to cancel out unwanted sounds (such as rotor of the one or more actuating units and ambient noise), while preserving important audio signals like the user's voice.

[154] Figure 12 illustrates a flowchart depicting steps for obtaining a merged audio, in accordance with an embodiment of the present disclosure.

[155] At step 1202, the method 500 may include determining one or more characteristics based on analyzing the audio signals received from the first earbud and the second earbud respectively. In an embodiment, the one or more characteristics may include but are not limited to frequency, amplitude, and audio patterns.

[156] At step 1204, the method 500 may include detecting at least one of a user speech or an environmental sound based on the determined one or more characteristics. In embodiment, the user speech is detected from the audio signals corresponding to the first earbud, and environmental sound is detected from the audio signals corresponding to the second earbud.

[157] In an embodiment, the system 102 may utilize a voice activity detection model to detect the user speech from the audio signals of the first earbud as illustrated in Figures 12 and 13. In an embodiment, the audio signals may be noise-less audio signals. More specifically, the voice activity detection model may analyze the audio signals to determine the amplitude associated with the audio signals received from the first earbud. In a case, when the voice activity detection model may detect a sudden increase in signal strength, the voice activity detection model may determine the frequency of a first audio stream associated with the audio signals received from the first earbud. In an embodiment, the voice activity detection model may determine the patterns associated with the audio stream when the determined frequency is within a predefined threshold range. In an embodiment, the predefined threshold range corresponds to a range associated with the user speech.

[158] More specifically, the voice activity detection model may determine temporal patterns like pauses, continuous vocalization, etc., thereby identifying a presence of the user speech.

[159] In one embodiment, the system 102 may utilize an environment sound detection model to detect the environmental sound from the audio signals of the second earbud.

More specifically, the environment sound detection model may analyze the audio signals to determine the frequency of a second audio stream associated with the audio signals received from the second earbud. In an embodiment, the system 102 may filter the rotor (that is associated with the one or more actuating units) noise of the earbud case 100 based on its lower frequency range and may isolate other sounds (such as the user speech or announcements) that occur in different frequency ranges. Further, the environment sound detection model may apply machine learning models that may be trained on environmental sound datasets to classify different sound events (for example-the user speech, animal sounds, nature's sound, and music).

[160] At step 1206, the method 500 may include dynamic switching, via the switching module 134, between the first earbud and the second earbud seamlessly based on the detection of the at least one of the user speech and the environmental sound as illustrated in Figures 12 and 13.

[161] Further, at step 1208, the method 500 may include merging the first audio stream and the second audio stream based on the dynamic switching, thereby obtaining the merged audio as illustrated in Figures 12 and 13.

[162] Figure 14 illustrates a schematic diagram 1400 depicting blocks for synchronization of the merged audio and the captured video, in accordance with an embodiment of the present disclosure; and

[163] In one embodiment, the method 500 may include synchronizing, via the synchronizing module 136, the captured merged audio with the captured video as illustrated in Figure 14. In an embodiment, the synchronizing module may utilize a combination of a latency correction model and a real-time signal processing model to ensure that the captured merged audio is perfectly aligned with the captured video.

[164] Referring to Figure 14, at block 1404, the latency correction model may be configured to compensate for any latency introduced by the ANC or the dynamic switching, so that the captured merged audio is matched frame by frame with the captured video.

[165] At block 1404, the real-time signal processing model may be configured to improve an overall audio-visual experience by ensuring that transitions (like audio switching between earbuds) are smooth and imperceptible to the user 200, The final output is optimized for both audio clarity and video coherence, producing a high-quality, post-processing-free video ready for immediate publication.

[166] Figures 15a to 15e illustrate a plurality of exemplary use cases, in accordance with an embodiment of the present disclosure. In an embodiment, the plurality of exemplary use cases is discussed in the below paragraphs.

[167] In a first exemplary use case, the user 200 is wearing the earbuds and listening to music. In this event, the user 200 provides the voice command "*take my selfie*" via

the earbud's microphone. After receiving the command, the system 102 processes the audio signals and transmits the signals to the earbud case 100 to trigger an event for initiating the camera 24 for clicking the selfie of the user 200.

[168] In a second exemplary use case, the user 200 provides the voice command "*take-off*" via the earbud's microphone. In this event, the earbud case 100 unfolds itself into the drone and takes off. The earbud case 100 starts hovering at a fixed distance from the user 200. Further, the camera 24 is not active and not aligned with the user 200.

[169] In a third exemplary use case, the system 102 is activated which is the vision-less tracking (VTS) and the camera 24 remains inactive VTS estimates the relative positions of the left and the right earbud with respect to the earbud case 100. The accuracy of the system 102 is further enhanced using the RSSI signals received from each of the left earbud and the right earbud. Further, the earbud case 100 automatically starts adjusting its orientation in 3D space in order to align the camera 24 towards the user 200.

[170] In a fourth exemplary use case, the camera 24 is activated, and the selfie of the user 200 is captured and saved in the user's phone's gallery. Further, the camera 24 is deactivated after capturing the selfie and the system 102 remains active.

[171] In a fifth exemplary user case, the system 102 is deactivated, to enable the earbud case 100 for auto landing, and the earbud case 100 gets fold.

[172] In various embodiments, the present disclosure at least provides the following advantages:

[173] The present disclosure uses the RSSI values for enhanced tracking of the position of the user 200, thereby eliminating the need for the installation of the one or more cameras 24. The present disclosure utilizes minimal energy for transmitting and receiving the signals.

[174] Further, the present disclosure minimizes the computational load by avoiding complex image-processing tasks, thus conserving battery power for essential flight operations of the earbud case 100.

[175] Furthermore, the present disclosure enables tracking in various lighting conditions such as both bright and dark environments Thus, enabling the tracking unaffected from the occlusions.

[176] In addition, the present disclosure enables tracking dynamic and cluttered environments. The present disclosure provides enhanced privacy.

[177] Moreover, the present disclosure enables tracking with low power consumption, thereby enabling the earbud case 100 to sustain longer flight times.

[178] The present disclosure uses the ANC to filter out the rotor noise, thereby ensuring clean audio capture without interference from mechanical sounds.

[179] The present disclosure may be adaptive to changing audio environments, switching between the user speech and important environmental sounds, without missing key moments.

[180] The present disclosure provides the synchronized audio video that eliminates the need for post-processing, saving time and effort for content creators and delivering ready-to-publish content.

[181] The present disclosure provides seamless synchronization of the captured merged audio and the captured video, thereby ensuring perfect alignment, even during audio stream switching, providing a smooth viewing experience for audiences.

[182] The present disclosure may be designed for outdoor and indoor vlogging scenarios where the background noise and drone noise may disrupt content quality. The system 102 adjusts dynamically based on real-time audio inputs.

[183] The embodiments disclosed herein can be implemented through at least one software program running on at least one hardware device and performing network management functions to control the elements. The elements can be at least one of a hardware device or a combination of hardware devices and software modules.

[184] It is understood that terms including "unit" or "module" at the end may refer to the unit for processing at least one function or operation and may be implemented in hardware, software, or a combination of hardware and software.

[185] While specific language has been used to describe the disclosure, any limitations arising on account of the same are not intended. As would be apparent to a person in the art, various working modifications may be made to the method in order to implement the inventive concept as taught herein.

[186] The drawings and the forgoing description give examples of embodiments. Those skilled in the art will appreciate that one or more of the described elements may well be combined into a single functional element. Alternatively, certain elements may be split into multiple functional elements. Elements from one embodiment may be added to another embodiment. For example, orders of processes described herein may be changed and are not limited to the manner described herein.

[187] Moreover, the actions of any flow diagram need not be implemented in the order shown; nor do all of the acts necessarily need to be performed. Also, those acts that are not dependent on other acts may be performed in parallel with the other acts. The scope of embodiments is by no means limited by these specific examples. Numerous variations, whether explicitly given in the specification or not, such as differences in structure, dimension, and use of material, are possible. The scope of embodiments is at least as broad as given by the following claims.

[188] Benefits, other advantages, and solutions to problems have been described above with regard to specific embodiments. However, the benefits, advantages, solutions to

problems, and any component(s) that may cause any benefit, advantage, or solution to occur or become more pronounced are not to be construed as a critical, required, or essential feature or component of any or all the claims.

[189] The foregoing description of the specific embodiments will so fully reveal the general nature of the embodiments herein that others can, by applying current knowledge, readily modify and adapt for various applications such specific embodiments without departing from the generic concept, and, therefore, such adaptations and modifications should and are intended to be comprehended within the meaning and range of equivalents of the disclosed embodiments. It is to be understood that the phraseology or terminology employed herein is for the purpose of description and not of limitation. Therefore, while the embodiments herein have been described in terms of at least one embodiment, those skilled in the art will recognize that the embodiments herein can be practiced with modification within the spirit and scope of the embodiments as described herein.

Claims

[Claim 1] A method (500) for tracking a position of a user (200) by an earbud case (100), the method (500) comprising:
estimating position vectors in three-dimensional (3D) space for one or more earbuds (300) being worn by the user (200), and the earbud case (100) based on receiving sensor data from one or more Inertial measurement unit (IMU) sensors;
estimating a central virtual point corresponding to positions for the one or more earbuds (300) and the earbud case (100) based on the estimated position vectors, wherein the central virtual point indicates a static point with reference to the estimated position vectors;
estimating relative position vectors of the one or more earbuds (300) and the earbud case (100) based on the central virtual point and Received Signal Strength Indicator (RSSI) values computed for signals received from the one or more earbuds (300);
computing a yaw value and a pitch value based on the estimated relative position vectors; and
positioning the earbud case (100) based on the yaw value and the pitch value such that the position of the user (200) is tracked by the earbud case (100).

[Claim 2] The method (500) as claimed in claim 1, wherein the IMU sensors are installed on the one or more earbuds (300) and the earbud case (100), and wherein the sensor data comprises accelerometer data, gyroscope data, and magnetometer data.

[Claim 3] The method (500) as claimed in claim 1, wherein computing the RSSI values comprises:
computing the RSSI value based on filtering noise from the signals received from the one or more earbuds (300) using an Artificial Intelligence (AI) model.

[Claim 4] The method (500) as claimed in claim 1, wherein estimating the position vectors comprises:
computing a velocity of the one or more earbuds (300) and the earbud case (100) based on integrating the acceleration data over time;

computing integrated position data of the one or more earbuds (300) and the earbud case (100) based on integrating the velocity over time;
computing an orientation of the one or more earbuds (300) and the earbud case (100) based on integrating an angular velocity of the earbuds (300) and the earbud case (100) obtained from the gyroscope data;
modifying the computed orientation based on the magnetometer data corresponding to respective axes of the one or more earbuds (300) and the earbud case (100); and
estimating the position vectors based on correlating the modified orientation with the integrated position data.

[Claim 5] The method (500) as claimed in claim 1, wherein estimating the central virtual point comprises:
computing a centroid of the position vectors of the one or more earbuds (300) and the earbud case (100) based on the estimated position vectors; and
estimating the central virtual point based on the computed centroid.

[Claim 6] The method (500) as claimed in claim 1, wherein estimating the relative position vectors comprises:
estimating initial relative position vectors corresponding to the one or more earbuds (300) and the earbud case (100) based on the estimated central virtual point; and
modifying the initial relative position vectors based on the computed RSSI value for the signals received from the one or more earbuds (300), thereby estimating the relative position vectors.

[Claim 7] The method (500) as claimed in claim 6, wherein modifying the initial relative position vectors of the one or more earbuds (300) and the earbud case (100) comprises:
estimating a distance between a centroid vector and an initial relative position vector of the earbud case (100) based on the computed RSSI values, wherein the centroid vector indicates a mid-point of the one or more earbuds (300);
computing an error function based on estimating the distance, wherein the error function indicates a difference between the

estimated distance and an actual distance obtained from the estimated position vectors; and
modifying the initial relative position vectors based on minimizing the computed error function using optimizing techniques, thereby estimating the relative position vectors.

[Claim 8] The method (500) as claimed in claim 7 comprising:
computing the centroid vector based on initial relative position vectors of the one or more earbuds (300); and
computing a directional centroid vector based on normalizing the centroid vector.

[Claim 9] The method (500) as claimed in claim 8 comprising computing a modified centroid vector based on the estimated relative position vectors.

[Claim 10] The method (500) as claimed in claim 1 comprising:
receiving input from one or more cameras (24) integrated with the earbud case (100) in a flying state of the earbud case (100) for capturing video, wherein input indicates image and video data associated with the user (200).

[Claim 11] The method (500) as claimed in claim 1 comprising:
capturing an audio based on minimizing background noise, using a predefined noise cancelation technique, from the audio signals received from the one or more earbuds (300) in real-time.

[Claim 12] The method (500) as claimed in claim 11, wherein for capturing the audio, the one or more earbuds (300) comprise a first earbud and a second earbud, wherein the first earbud is worn by the user (200) and the second earbud is adapted to be retained in the earbud case (100).

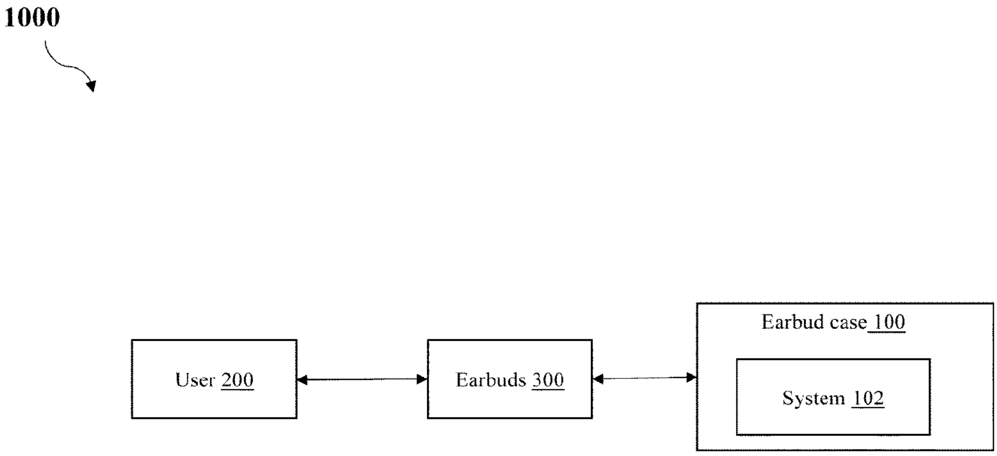
[Claim 13] The method (500) as claimed in claim 12, comprising:
determining one or more characteristics associated with based on analyzing audio signals received from the one or more earbuds (300), wherein the one or more characteristics comprises frequency, amplitude, and patterns associated with the audio signals;
detecting at least one of a user speech and an environmental sound based on the determined one or more characteristics, wherein the user speech is detected from the audio signals corresponding to the first earbud and environmental sound is detected from the audio signals corresponding to the second earbud;

dynamic switching between the first earbud and the second earbud based on the detection of the at least one of the user speech and the environmental sound; and
merging a first audio stream associated with the first earbud and the second audio stream associated with the second earbud based on the dynamic switching, thereby obtaining the merged audio.

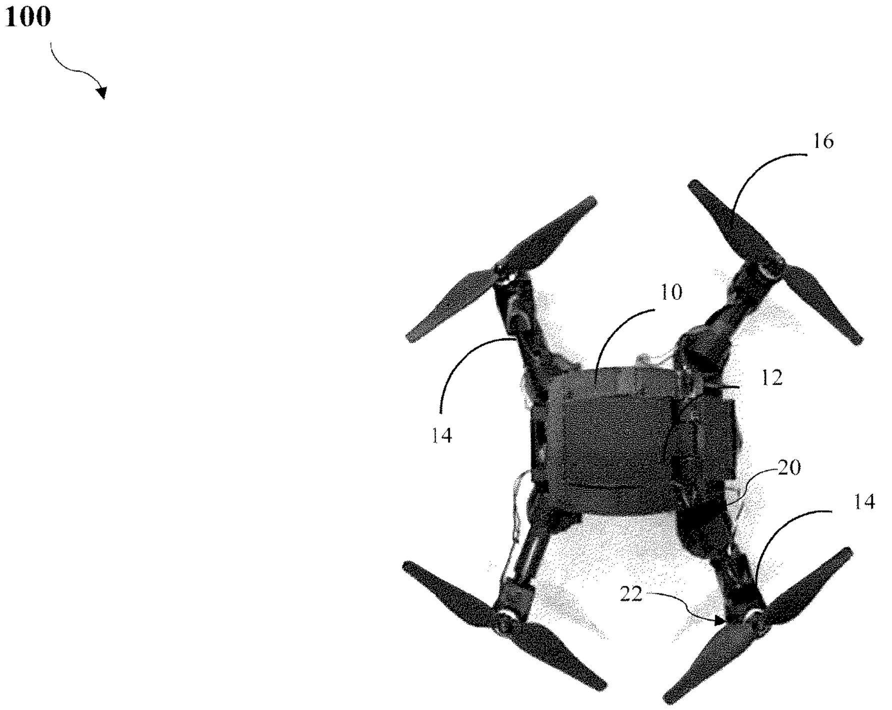
[Claim 14] The method (500) as claimed in claim 13 comprising synchronizing the merged audio and the captured video using a latency correction model and a real-time signal processing model.

[Claim 15] A system (102) for tracking a position of a user (200) by an earbud case (100), the system (102) comprising:
a memory (104); and
at least one processor (108) in communication with the memory (104), wherein the at least one processor (108) configured to:
estimate position vectors in three-dimensional (3D) space for one or more earbuds (300) being worn by the user (200) and the earbud case (100) based on receiving sensor data from one or more Inertial measurement unit (IMU) sensors;
estimate a central virtual point corresponding to positions for the one or more earbuds (300) and the earbud case (100) based on the estimated position vectors, wherein the central virtual point indicates a static point with reference to the estimated position vectors;
estimate relative position vectors of the one or more earbuds (300) and the earbud case (100) based on the central virtual point and a Received Signal Strength Indicator (RSSI) value computed for signals received from the one or more earbuds (300);
compute a yaw value and a pitch value based on the estimated relative position vectors; and
position the earbud case (100) based on the yaw value and the pitch value such that the position of the user (200) is tracked by the earbud case (100).

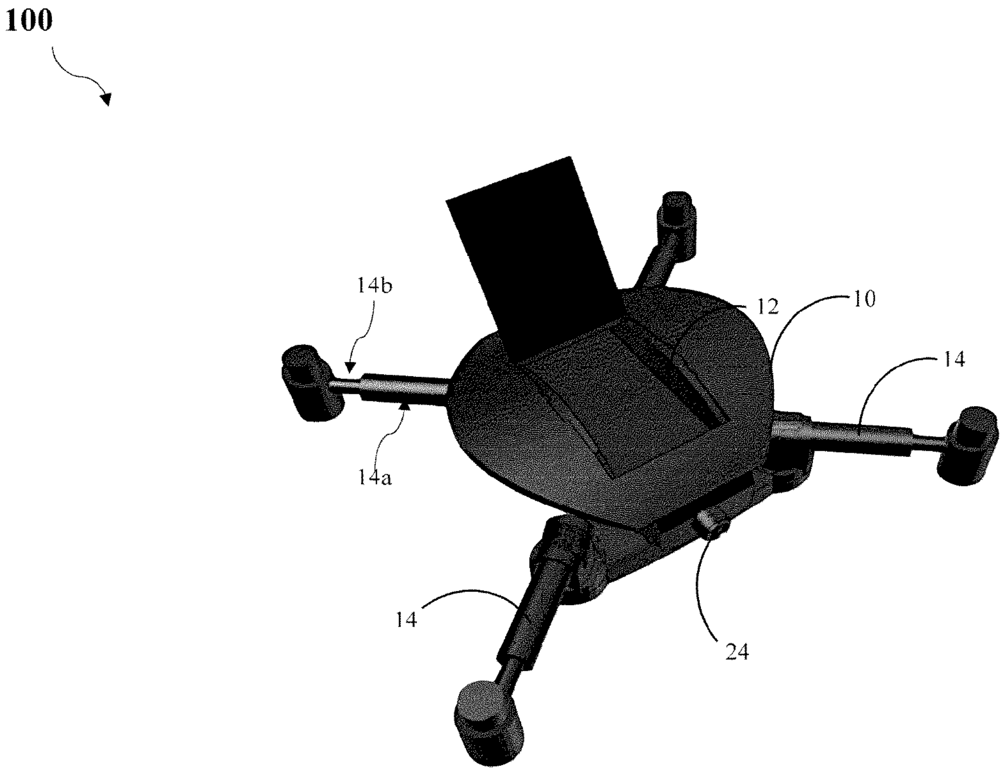
[Fig. 1]


1000
User 200
Earbuds 300
Earbud case 100
System 102

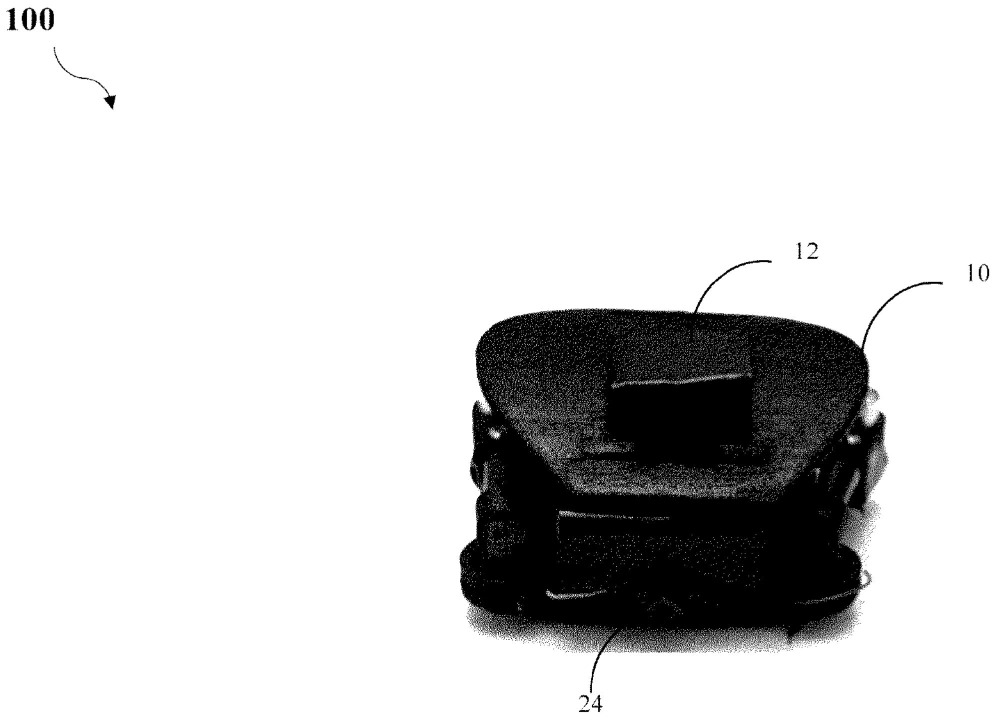
[Fig. 2a]


100
16
10
12
14
20
14
22

[Fig. 2b]

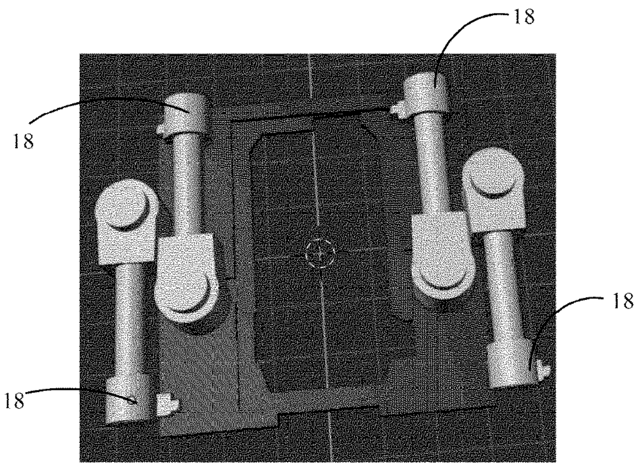


[Fig. 2c]



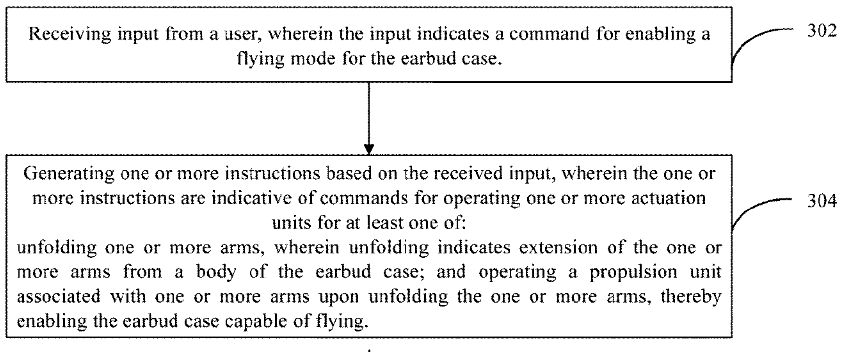
[Fig. 2d]

100

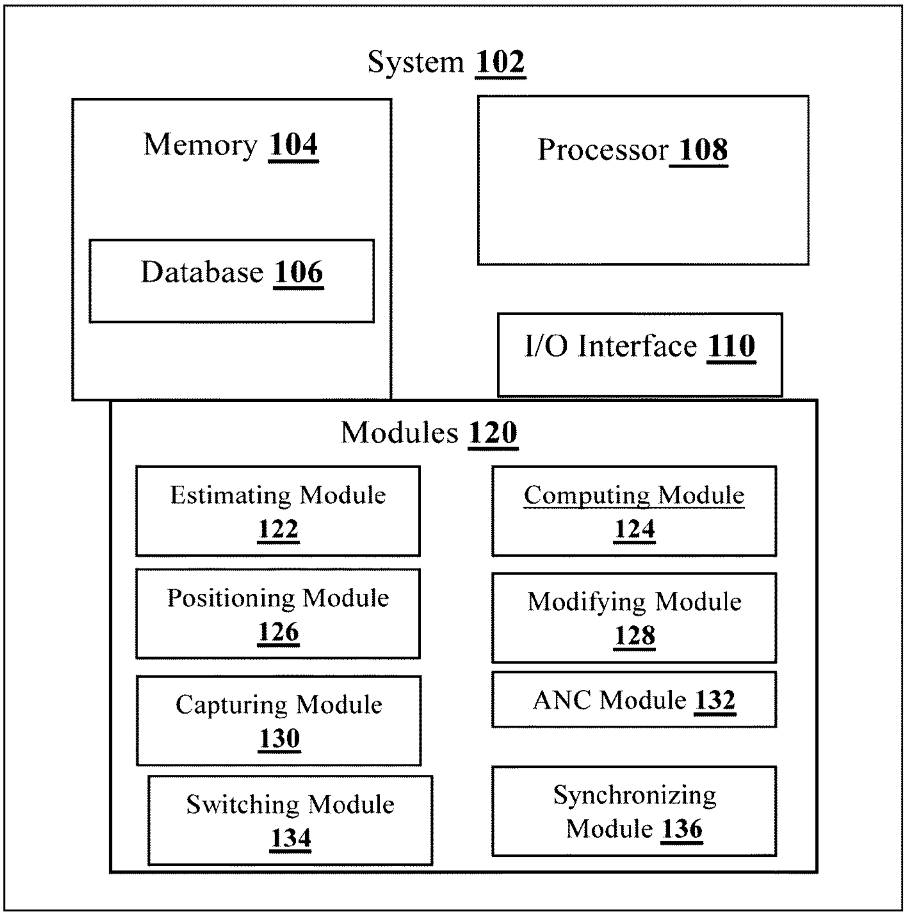


[Fig. 3]

250



[Fig. 4]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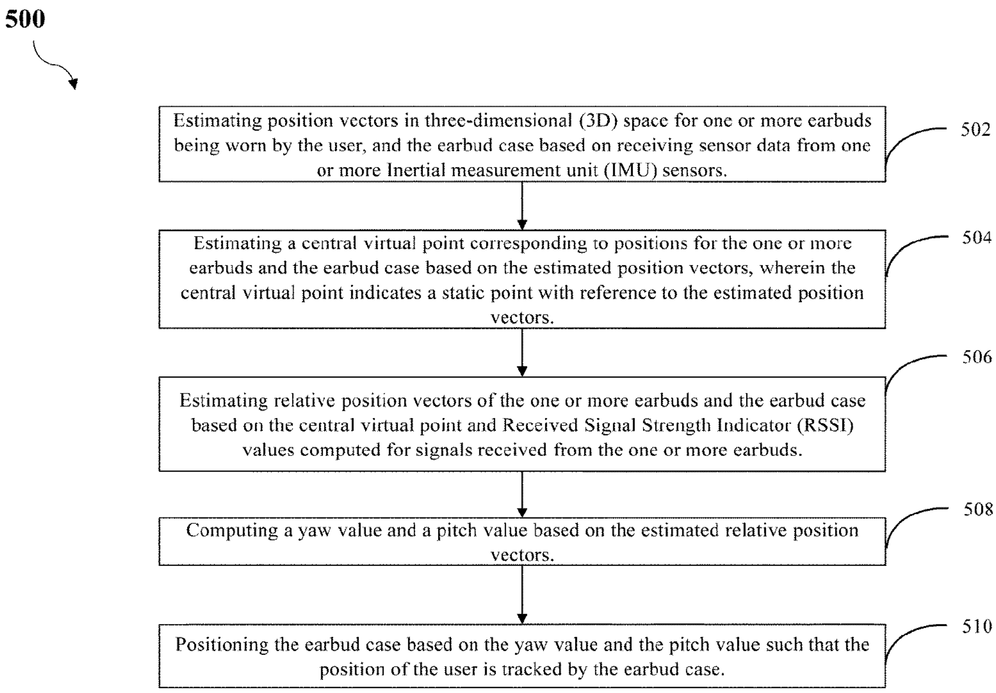
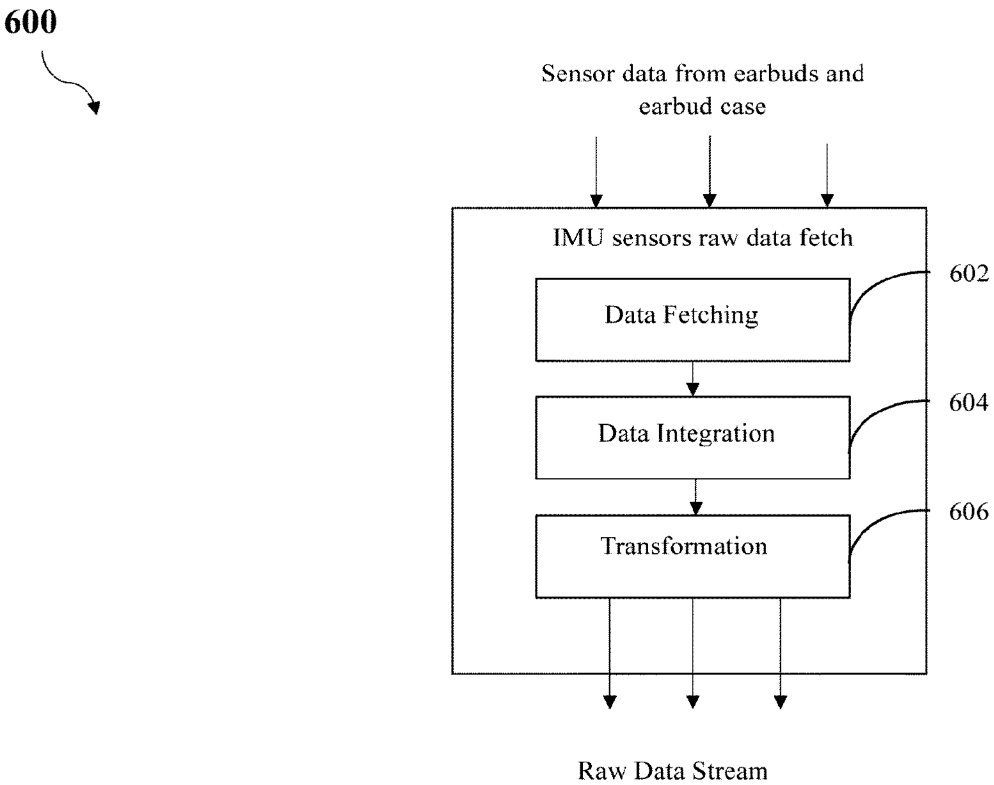
Memory 104
Database 106
Processor 108
I/O Interface 110
Modules 120
Estimating Module 122
Computing Module 124
Positioning Module 126
Modifying Module 128
Capturing Module 130
ANC Module 132
Switching Module 134
Synchronizing Module 136

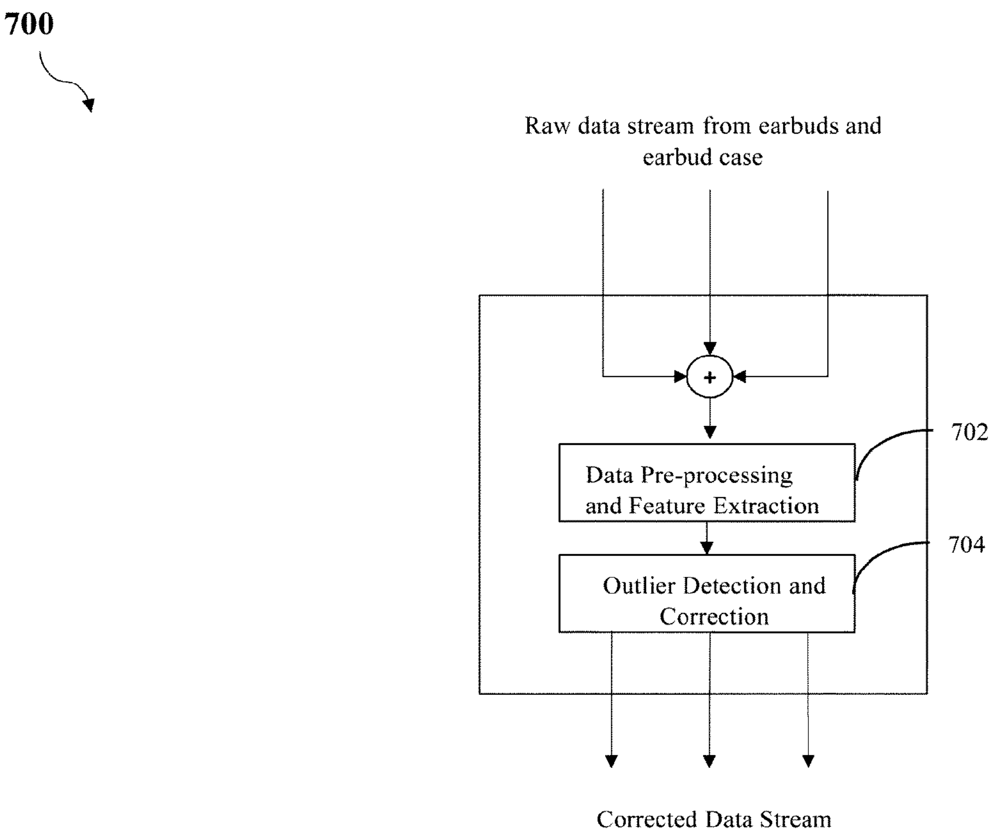
[Fig. 5]


500
Estimating position vectors in three-dimensional (3D) space for one or more earbuds being worn by the user, and the earbud case based on receiving sensor data from one or more Inertial measurement unit (IMU) sensors.
502
Estimating a central virtual point corresponding to positions for the one or more earbuds and the earbud case based on the estimated position vectors, wherein the central virtual point indicates a static point with reference to the estimated position vectors.
504
Estimating relative position vectors of the one or more earbuds and the earbud case based on the central virtual point and Received Signal Strength Indicator (RSSI) values computed for signals received from the one or more earbuds.
506
Computing a yaw value and a pitch value based on the estimated relative position vectors.
508
Positioning the earbud case based on the yaw value and the pitch value such that the position of the user is tracked by the earbud case.
510

[Fig. 6]

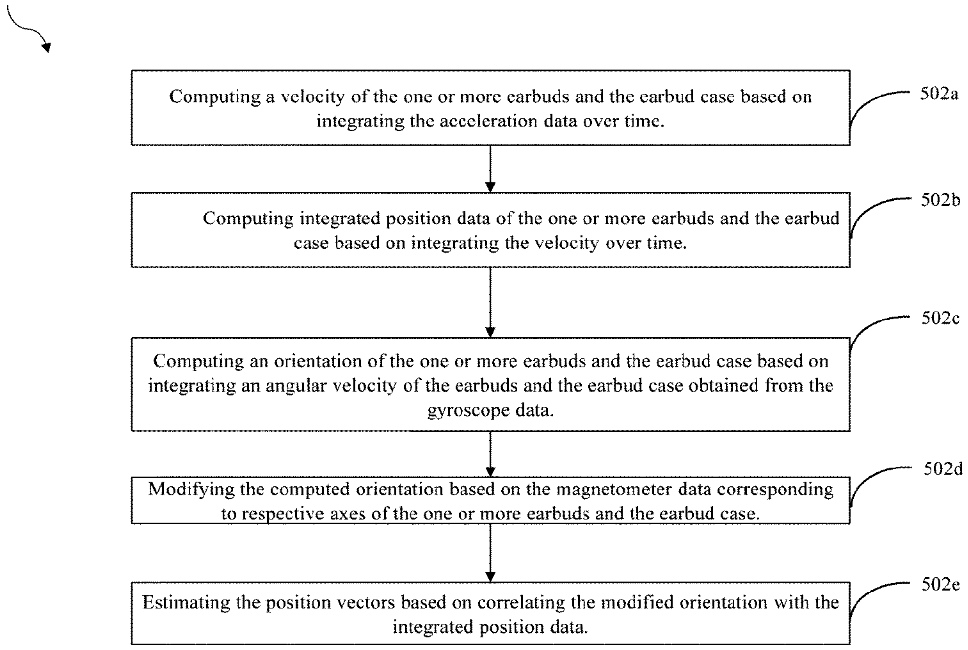

600
Sensor data from earbuds and earbud case
IMU sensors raw data fetch
Data Fetching
602
Data Integration
604
Transformation
606
Raw Data Stream

[Fig. 7]


700
Raw data stream from earbuds and earbud case
+
Data Pre-processing and Feature Extraction
702
Outlier Detection and Correction
704
Corrected Data Stream

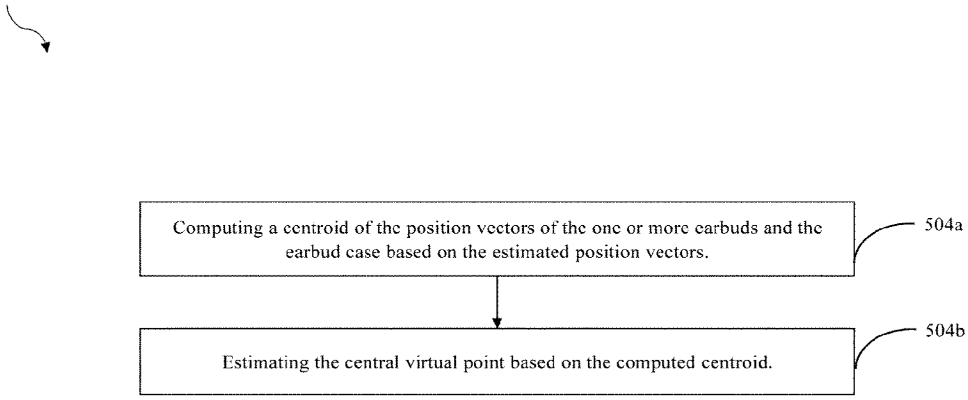
[Fig. 8]

502

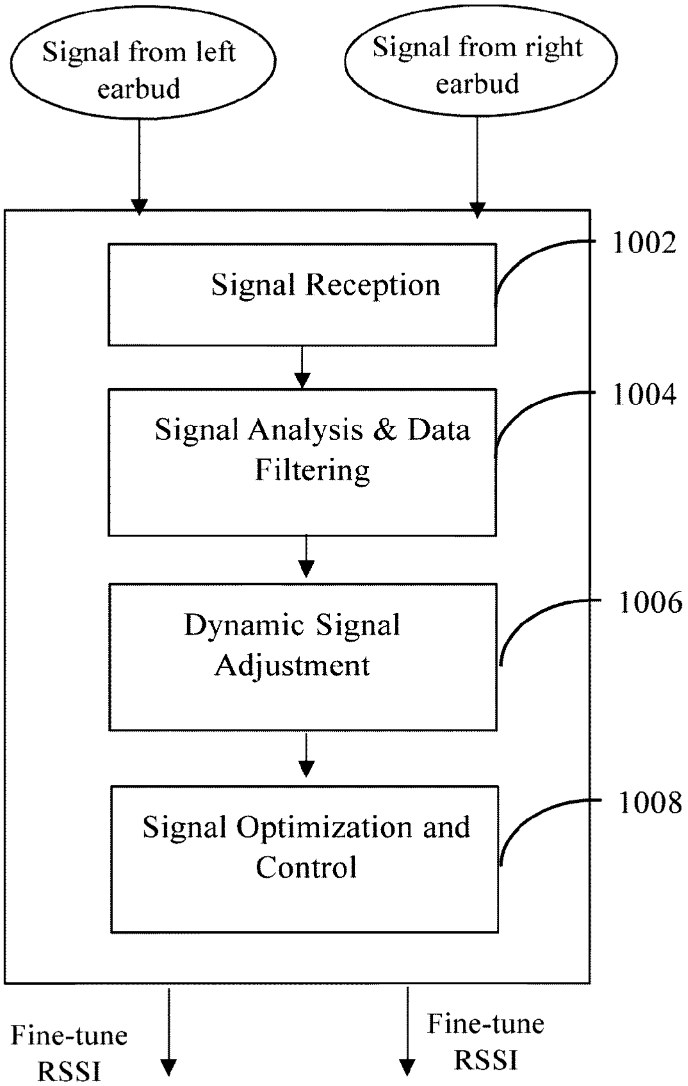


[Fig. 9]

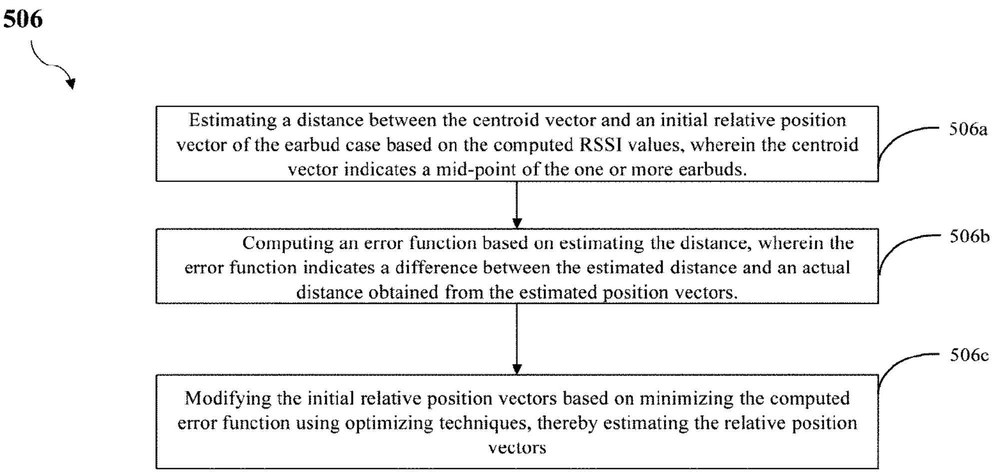
504



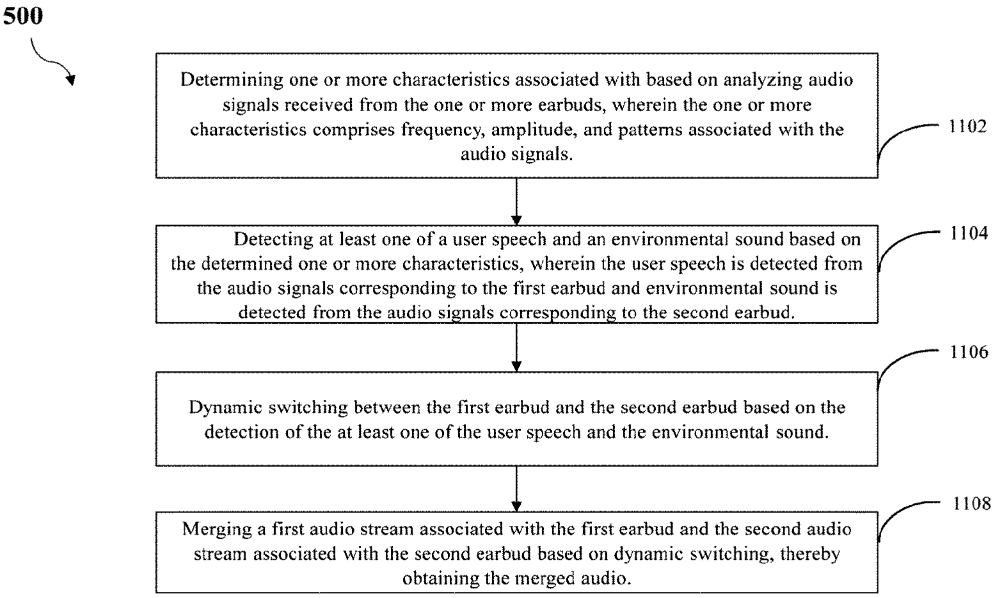
[Fig. 10]


Signal from left earbud
Signal from right earbud
Signal Reception
1002
Signal Analysis & Data Filtering
1004
Dynamic Signal Adjustment
1006
Signal Optimization and Control
1008
Fine-tune RSSI
Fine-tune RSSI

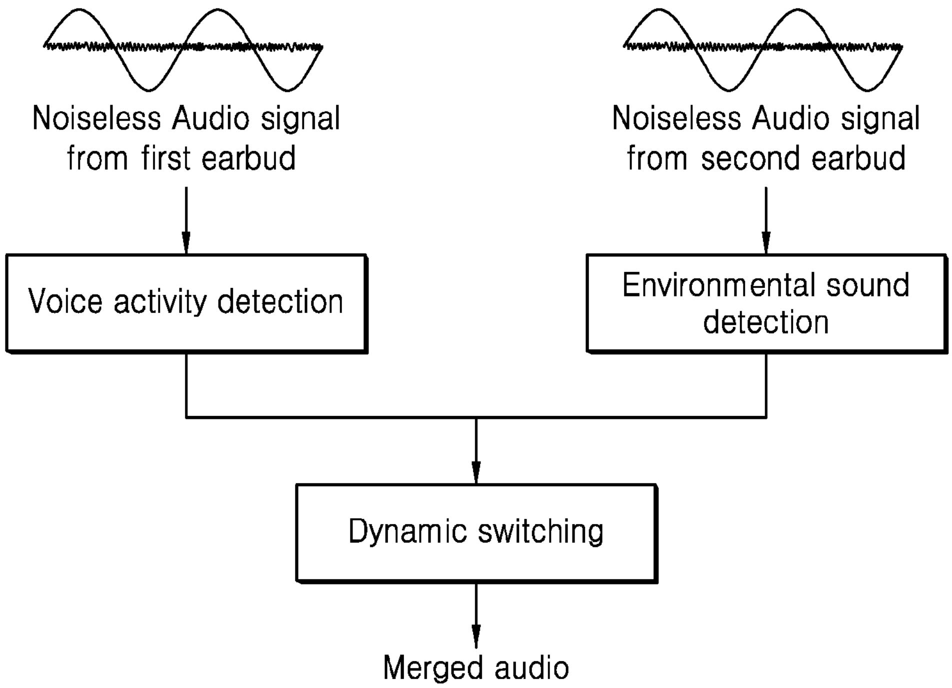
[Fig. 11]


506
Estimating a distance between the centroid vector and an initial relative position vector of the earbud case based on the computed RSSI values, wherein the centroid vector indicates a mid-point of the one or more earbuds.
506a
Computing an error function based on estimating the distance, wherein the error function indicates a difference between the estimated distance and an actual distance obtained from the estimated position vectors.
506b
Modifying the initial relative position vectors based on minimizing the computed error function using optimizing techniques, thereby estimating the relative position vectors
506c

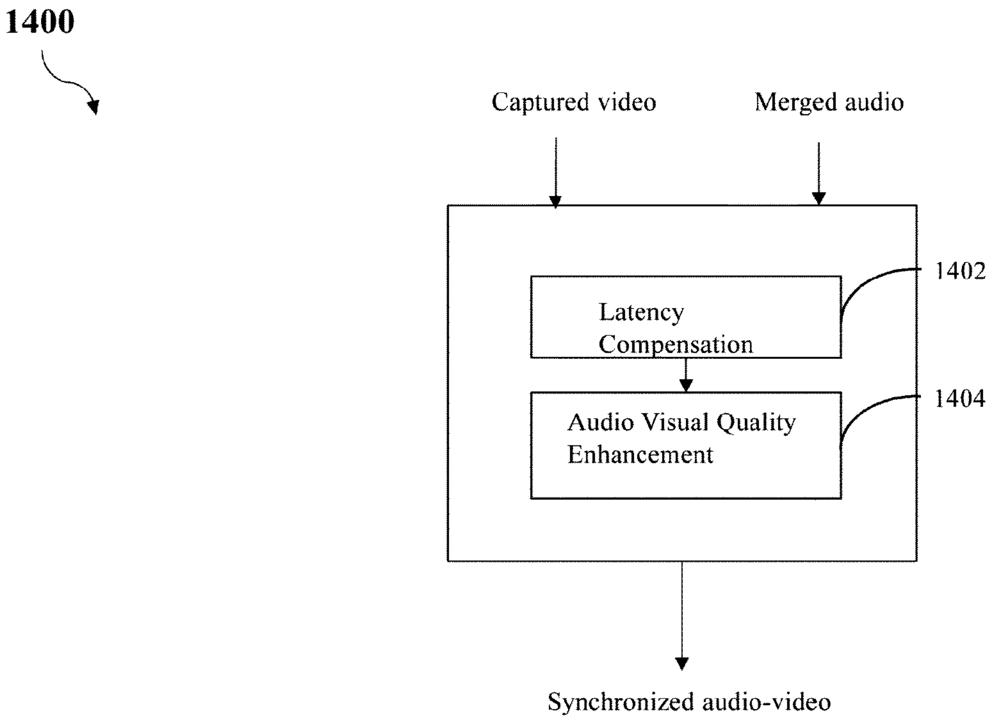
[Fig. 12]


500
Determining one or more characteristics associated with based on analyzing audio signals received from the one or more earbuds, wherein the one or more characteristics comprises frequency, amplitude, and patterns associated with the audio signals.
1102
Detecting at least one of a user speech and an environmental sound based on the determined one or more characteristics, wherein the user speech is detected from the audio signals corresponding to the first earbud and environmental sound is detected from the audio signals corresponding to the second earbud.
1104
Dynamic switching between the first earbud and the second earbud based on the detection of the at least one of the user speech and the environmental sound.
1106
Merging a first audio stream associated with the first earbud and the second audio stream associated with the second earbud based on dynamic switching, thereby obtaining the merged audio.
1108

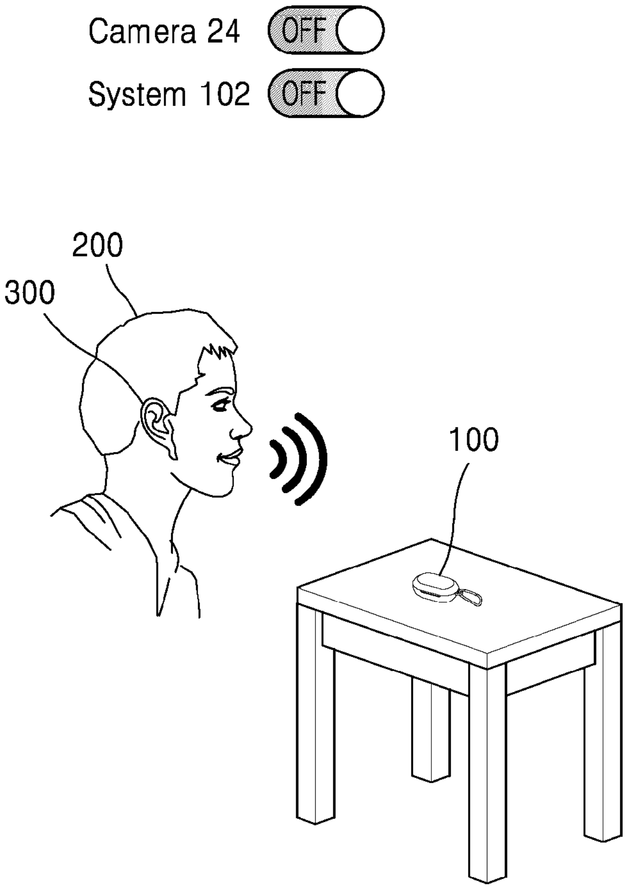
[Fig. 13]


Noiseless Audio signal from first earbud
Noiseless Audio signal from second earbud
Voice activity detection
Environmental sound detection
Dynamic switching
Merged audio

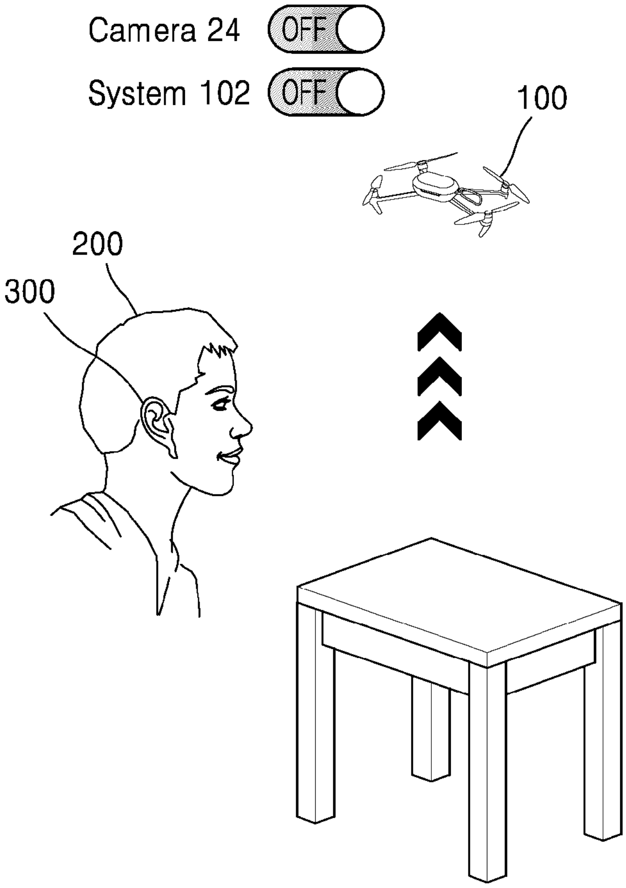
[Fig. 14]



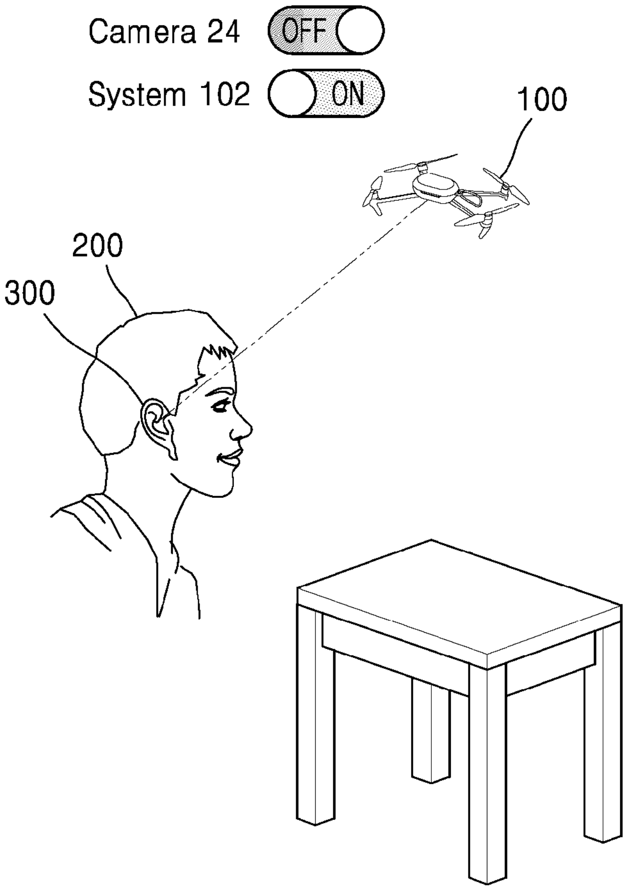
[Fig. 15a]



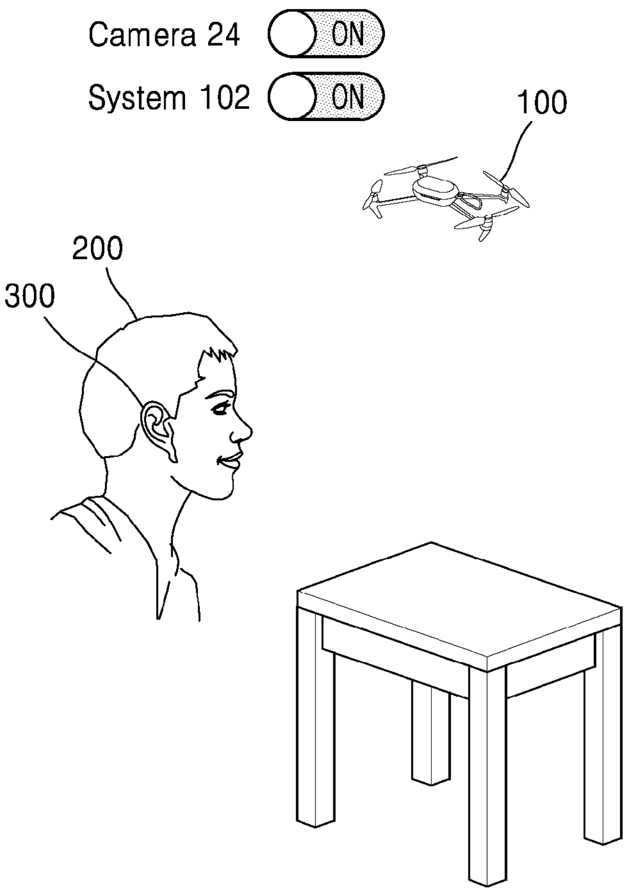
[Fig. 15b]



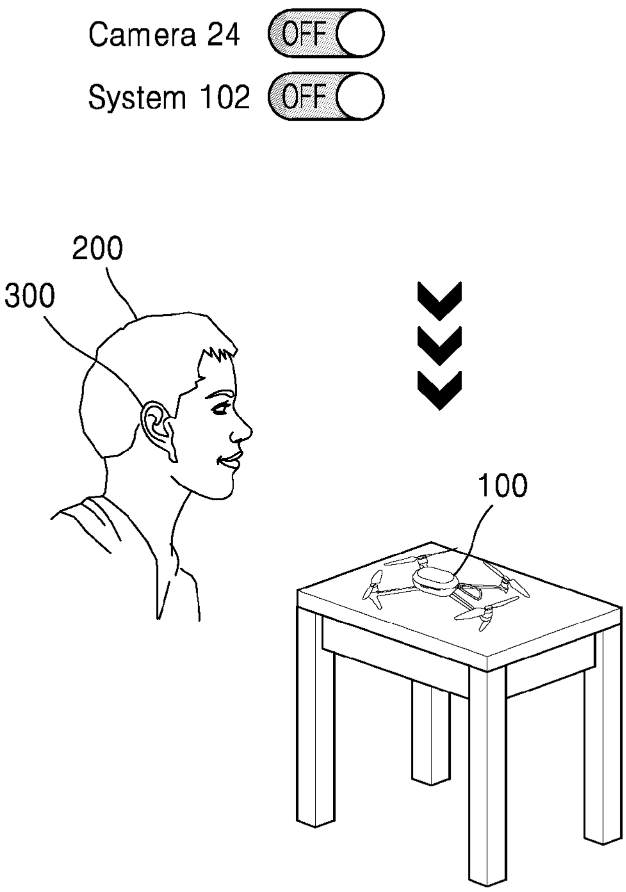
[Fig. 15c]



[Fig. 15d]



[Fig. 15e]



INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR2024/015230

A. CLASSIFICATION OF SUBJECT MATTER

G01S 5/02(2010.01)i; **G01C 21/16**(2006.01)i; **G01S 11/06**(2006.01)i; **G10K 11/16**(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

G01S 5/02(2010.01); G01C 21/36(2006.01); G01S 19/51(2010.01); G06Q 50/10(2012.01); G06Q 50/26(2012.01); G10L 19/22(2013.01); H04R 1/10(2006.01); H04R 25/00(2006.01); H04W 4/80(2018.01); H04W 76/14(2018.01)

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Korean utility models and applications for utility models
Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

eKOMPASS(KIPO internal) & Keywords: tracking, earbuds, position, intertial measurement unit, received signal strength indicator

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	KR 10-2020-0064615 A (KIM JOO HUN) 08 June 2020 (2020-06-08) paragraphs [0028], [0043], claim 9 and figure 2	1-15
A	US 2016-0327405 A1 (UNIST (ULSAN NATIONAL INSTITUTE OF SCIENCE AND TECHNOLOGY)) 10 November 2016 (2016-11-10) claim 1	1-15
A	US 2021-0120607 A1 (GUANGDONG OPPO MOBILE TELECOMMUNICATIONS CORP., LTD.) 22 April 2021 (2021-04-22) paragraphs [0033]-[0034] and figures 1-3	1-15
A	US 2017-0094396 A1 (APPLE INC.) 30 March 2017 (2017-03-30) paragraphs [0290]-[0292] and figures 50-51	1-15
A	US 2018-0234777 A1 (SONOVA AG) 16 August 2018 (2018-08-16) claim 1 and figures 1-9	1-15

☐ Further documents are listed in the continuation of Box C. ☑ See patent family annex.

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- "O" document referring to an oral disclosure, use, exhibition or other means
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Date of the actual completion of the international search	Date of mailing of the international search report
13 January 2025	**13 January 2025**

Name and mailing address of the ISA/KR

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Authorized officer

JUNG, Jong Han

Telephone No. **+82-42-481-5642**

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/KR2024/015230

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