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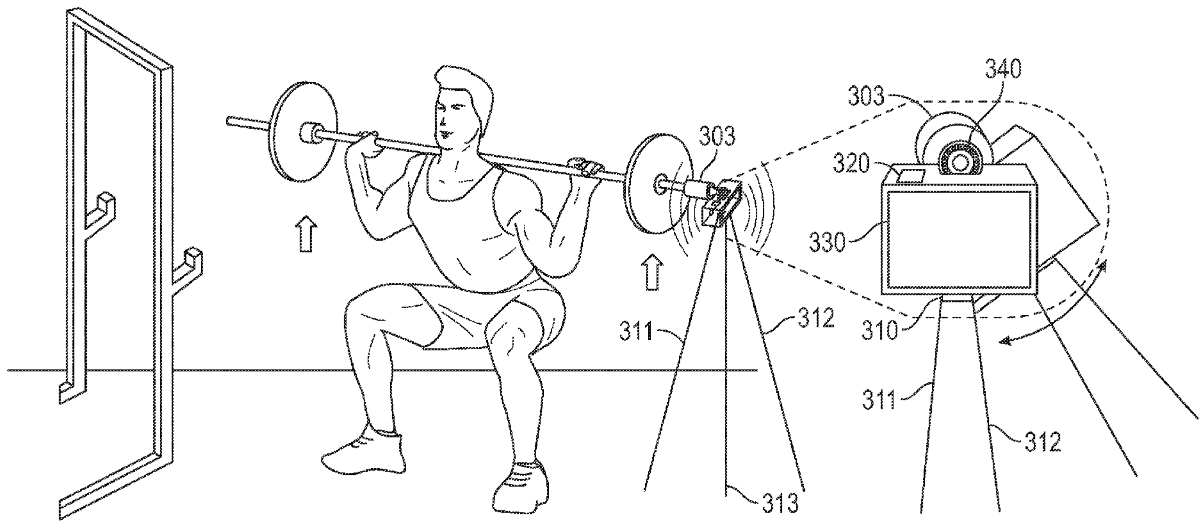

FIG. 5C

(57) Abstract: Provided is a system for measuring velocity associated with a weight lifting activity including a housing; a single time-of-flight sensor positioned within the housing; an accelerometer positioned within the housing; a processor positioned within the housing and in communication with the time-of-flight sensor and the accelerometer; and a ball bearing mechanism associated with the housing. The ball bearing mechanism allows the housing to reorient so as orient the single time-of-flight sensor toward ground. Also provided are a subassembly including such a system mounted to a barbell and a method for measuring velocity associated with a weight lifting activity utilizing such a subassembly.

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VELOCITY BASED TRAINING SYSTEM AND METHODS OF USE THEREOF

CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims priority benefit to U.S. Provisional Patent Application Serial No. 63/436,711 filed on January 3, 2023, the contents of which are hereby incorporated by reference in its entirety.

BACKGROUND

1. Technical Field

The present disclosure is directed to a velocity-based training system for use in conjunction with a barbell and associated method. The disclosed system is designed to measure the speed at which a user completes a repetition of a certain movement, the system including a single time-of-flight sensor on a rotating body to measure the speed at which the user finishes the movement. Examples of movements that the disclosed system may be used to measure include squats, deadlifts, bench presses (flat, decline and incline) and overhead presses. Of note, the design and operation of the disclosed system substantially reduces the cost relative to conventional devices based on the limited componentry required to make the requisite measurements, without sacrificing accuracy and/or simplicity of use.

2. Background Art

Existing devices for measuring velocity-related performance do not meet current user needs because they are too expensive – based on the complexity and cost of electronics used for measurement collection – and/or deliver unacceptable variable results. A need exists for improved velocity measurement devices, systems and methods of use that are more cost effective and that may be relied upon to provide accurate and reproducible performance results.

SUMMARY

The present disclosure is directed towards a velocity-based training system for use in conjunction with a barbell and associated method. The disclosed system advantageously makes velocity measurements for barbell-based activities both simple and effective. The disclosed system addresses a fundamental need in the training field because athletes are interested in measuring their speed and power output curves which allow these athletes to determine what load on a barbell creates the highest power output for exercises such as squats, dead lifts, bench presses (flat, decline, incline), and the like, thereby providing valuable feedback to track or modify a training regimen. In exemplary embodiments the disclosed system may beneficially output sound, e.g., for every repetition an athlete performs based on a velocity threshold an individual would like to reach. The immediate aural feedback provides a beneficial training function while also providing motivational reinforcement.

The main components of the disclosed system may generally include, a time-of-flight sensor for measuring velocity, an accelerometer for angular changes in device, a touch screen or other input device for user interface/feedback, a buzzer or other aural element(s) for delivering aural feedback to the user, a ball bearing mechanism for maintaining position of operative components relative to a reference surface, e.g., the ground.

The disclosed system measures the speed at which a user completes a repetition of a certain movement based in part on a single time-of-flight sensor that is mounted relative to a rotatable body to measure the speed at which the user finishes the movement. The rotational functionality of the disclosed system is facilitated by a ball bearing mechanism that allows the housing structure that encompasses the time-of-flight sensor to reorient itself so that the time-of-flight sensor can remain oriented toward the desired reference surface, i.e., the ground, floor, field or the like. Thus, when mounted relative to a barbell, the disclosed

system maintains rotational functionality that allows reorientation of the housing and associated time-of-flight sensor relative to the barbell. The desired rotational orientation of the housing/time-of-flight sensor may be affected in various ways. In exemplary embodiments, the weight of the housing is selected to bias the housing/time-of-flight sensor into a desired rotational orientation relative to the barbell such that the time-of-flight sensor maintains a desired orientation toward the desire reference surface, e.g., the ground.

The disclosed system has wide ranging applicability and may be used to measure movements associated with training activities such as squats, dead lifts, bench presses (flat, incline, decline) and overhead presses. Additional features, functions, and benefits of the disclosed system will be apparent from the following description.

BRIEF DESCRIPTION OF THE DRAWINGS

To assist those of skill in the art in making and using the subject matter of the present disclosure, reference is made to the appended figures, wherein:

Fig. 1 shows a block diagram overview of the components in an embodiment of a training system.

Fig. 2 shows a flow diagram depicting a method for undertaking measurement(s) using an embodiment of a training system.

Fig. 3 shows a graphical representation of an embodiment of a training system.

Figs. 4A-E show graphical representations of the display of an embodiment of a training system.

Figs. 5A-D show graphical representations of an embodiment of a training system in use.

Fig. 6 shows a block diagram of a network-based embodiment of a training system.

Fig. 7 shows a block diagram of an embodiment of a mobile communication device.

DESCRIPTION OF EXEMPLARY EMBODIMENTS

A description of one or more embodiments of the disclosed apparatus and method are presented herein by way of exemplification and not limitation with reference to the Figures.

Referring now to Fig. 1, shown is a block diagram of the components associated with an exemplary embodiment of the disclosed training system. As illustrated in Fig. 1, the disclosed training system 100 may include components for taking a velocity measurement 101 using primary measuring components 103 of the training system 100. The training system 100 may combine mechanical elements 105 and electronic elements 104.

With reference to mechanical element(s) 105 associated with the disclosed system, the disclosed system may generally include a housing that supports a ball bearing mechanism 107. A conventional mounting structure may be generally provided that allows the housing of the disclosed system to be detachably mounted relative to a barbell. Alternative mounting structure(s) may be provided to accommodate detachable securement relative to different barbell structures. Once mounted relative to a barbell, the ball bearing mechanism 107 associated with the housing of the disclosed system supports rotational/pivotal motion as between the barbell and the housing of the disclosed system. The rotational/pivotal motion may be manually effectuated by the user, automatically effectuated based on weight distribution associated with the housing, automatically effectuated based on one or more measurements of the system, or a combination thereof.

With reference to electrical element(s) 104, the disclosed training system 100 may include a time-of-flight sensor 106 and an accelerometer 108. The accelerometer 108 may act as a gyroscope. The time-of-flight sensor 106 collects sensing data that is translated to velocity measurements of the system – and, therefore, the associated barbell – relative to a reference surface, e.g., the ground. At the same time, the accelerometer 108 measures the change in angle of the housing/time-of-flight sensor 106 relative to the reference surface, e.g., the ground, to allow corrective adjustments to the measurements of the time-of-flight sensor 106, thereby ensuring that changes in the angular orientation of the housing/time-of-flight sensor 106 at various instances of time – based on the barbell's movements during the user's actions -- do not distort the velocity measurements of the disclosed system 100.

With further reference to Fig. 1, exemplary embodiments of the disclosed system 100 may also include/provide user interactive functionalities. Thus, the disclosed system 100 may include a processor positioned within or otherwise associated with the housing. The processor receives measurement data from the time-of-flight sensor 106 and the accelerometer 108, and is programmed to calculate velocities based on that measurement data, e.g., average velocities and peak velocities. Moreover, the disclosed processor may be generally programmed to generate user feedback 109 based on user performance, including specifically calculated velocities associated with user activities. The user feedback 109 may take one or more forms but, in exemplary embodiments, includes sound-based feedback 111, e.g., aural signals generated by piezo buzzer(s) 113 or other aural signal devices. The sound-based feedback 111 generated by the processor may be advantageously programmed based on a communicative protocol, e.g., two high pitched sounds in relatively rapid sequence reflecting velocity-based performance satisfying pre-set performance criteria and two low-pitched sounds in relatively rapid sequence reflecting velocity-based performance failing to satisfy pre-set performance criteria. The communicative protocol may be preset or may be programmed by the user. Alternative and/or additional sound-based feedback 111 may be implemented according to the present disclosure, e.g., alternative sound generation components/systems may be provided (i.e., other than piezo buzzers), e.g., pre-recorded voice communications. Sound-based feedback 111 may be disabled by the user, e.g., based on user adjustment in the system settings, as may be desired by the user.

The disclosed processor also may generally include a graphical user interface, i.e., display 110, that may take the form of a touchscreen display 112 associated with the housing of the system 100 and/or a voice-recognition functionality. The user may interact with the disclosed system by way of the user interface 110, e.g., by making desired selections through interaction(s) with the touchscreen display 112. Thus, the user may set (and modify) pre-set performance criteria for the user's velocity-based training. The user may also access historical performance data and performance trends through interaction with the touchscreen display 112 and view the information delivered to the display by the processor. Additional features and functions of the disclosed system may be accessed by and modified through user interactions with the disclosed user interface functionality.

Referring now to Fig. 2, shown is flow diagram of a method for taking measurements using the disclosed training system according to an embodiment. As illustrated in Fig. 2, process(es) for use of the disclosed measuring system 200 to obtain velocity-based performance measurements 201 and/or feedback may generally include mechanical processing elements 203, i.e., physical processes, and electrical processing elements 202. With reference to the mechanical element(s) 203, the disclosed system 200 may be mounted 205 with respect to a barbell by or on behalf of the user. Electrically, the device is activated 204 and the user interface may display 206 and/or receive input of target velocity and repetitions 208 for the user's workout activities. While the display is illustrated as being a touch screen it is understood that the display need not be a touchscreen and may be another display, e.g., an LCD or LED display with associated inputs, although not limited thereto. As previously noted, the applicable performance targets 208 are preset for assessment of user performance using the disclosed system, and review and modification to those performance targets 208 on a periodic basis, e.g., before each workout program and/or between individual repetitions sets, is accommodated by the disclosed system.

Of note, the user's target performance metrics 208 will generally differ based on the nature of the physical training to be undertaken, e.g., squats vs. bench presses, and may be influenced by the barbell weights to be used. It is also considered that the disclosed system may be used by multiple users, e.g., different members of a family or individuals being trained by an athletic trainer. In such circumstance, the user interface 206 of the disclosed system may generally allow the appropriate individual's profile to be accessed, thereby ensuring that the appropriate performance targets 208 are utilized and the performance data is properly saved to the relevant user's performance history.

In an embodiment, as further illustrated in Fig. 2, once the target velocity/repetitions 208 are entered and/or confirmed, the measurement process 209 commences according to an embodiment. As the user engages in exercises using the barbell to which the disclosed system is secured, the housing is adapted to rotate/pivot to maintain downward orientation 211 of the time-of-flight sensor 210. In exemplary embodiments, the rotational/pivotal movement is caused by weighting of the housing in a manner that causes the "bottom" of the housing to maintain a downward orientation 211 as the barbell moves relative to ground. The ball bearing mechanism associated with the housing accommodates the noted rotational/pivotal movement of the housing of the disclosed system relative to the barbell as the user engages in his/her use of the barbell, i.e., repetitions are performed 213.

In an embodiment, as illustrated in Fig. 2, as the user's activities proceed, the time-of-flight sensor 210 associated with the disclosed system obtains distance measurement(s) relative to ground and the accelerometer obtains angular orientation measurement(s) relative to ground at points in time during the user's activity. The distance and angular orientation measurement(s) are converted to velocity measurement(s) by programming associated with the processor. The disclosed system may advantageously provide real time feedback to the user concerning his/her performance, e.g., based on buzzer-generated sounds 212 that are generated each time a repetition is completed. The results of the user's activities are typically stored by the processor in association with the user's profile, thereby allowing ongoing and future consideration/review of the user's performance and progress.

Once the user's activity is complete 215 – typically on an exercise-by-exercise and barbell-by-barbell basis – the user interface is programmed to display the results 217 and the user may elect to commence a new set of repetitions 218, with the same or different barbell. For each newly commenced set of repetitions, the user (or his trainer) typically interacts with the user interface as need to initiate the new activity, i.e., by selecting/confirming the desired performance metrics, the applicable user profile and the barbell weight/exercise to be undertaken by the user. When the user has completed all sets of repetitions the device/system is turned off 219.

In an embodiment, as illustrated in Fig. 3, the disclosed device/system 300 may include a housing 301 that is detachably mounted relative to a barbell 303. The housing 301 may be mounted relative to the barbell 303 by way of a ball bearing mechanism 340, which may be typically fabricated from a durable but light weight plastic, metal, or other material used in ball bearing mechanisms. As illustrated in Fig. 3, ball bearing mechanism 340 may be positioned on an upper face of the housing 301, but alternative arrangements are contemplated, e.g., an internally positioned ball bearing mechanism that is accessible through an opening in a side face of the housing 301.

The system 300 may also include a time-of-flight sensor 310 and an accelerometer 320, supported by and associated with the housing 301. As previously noted, accelerometer 320 may function as a gyroscope taking angular orientation measurement(s) relative to ground according the present disclosure. The time-of-flight sensor 310 measures the distance orthogonally from the housing 301 and time-of-flight sensor 310 to the ground along and/or between the time-of-flight paths 311, 312. As the system 300 moves up and down in direction D while the user is performing repetitions, the time-of-flight sensor 310 and the accelerometer 320 may be taking discrete or continuous measurements. A distance to ground 313 may be calculated using the distance measurements of the time-of-flight sensor 310 and the angular orientation measurements of the accelerometer 320, which in turn may be used to calculate instantaneous, peak, and average velocity, although not limited thereto.

Although not shown in Fig. 3, the housing 301 may include feature(s) that rotationally/pivotally bias the housing 301 into an orientation whereby the time-of-flight sensor 310 is directed downward toward ground. For example, the housing 301 may be fabricated such that the lower face is heavier/thicker than other aspects of the housing 301, thereby causing the housing 301 to rotate/pivot relative to the barbell 303 so as to position the lower face in a downward orientation. In another example, a weighted element may be secured relative to the lower face, whether internal, external or a combination thereof, to bias the lower face into a downward orientation. Alternative techniques may be employed to bias the lower face into a downward orientation, as will be apparent to persons skilled in the art. For example, the lower face of the housing may be biased into a downward orientation (to direct the time-of-flight sensor 310 in a downward or substantially downward orientation) is using a damping effect on the rotational motion of the ball bearing mechanism 340, e.g., based on friction between the device body and the ball bearing, to limit relative movement and/or speed of re-orientation therebetween.

A touchscreen 330 may be associated with and supported by the housing 301. As illustrated in an exemplary embodiment, the touchscreen 330 is positioned relative to an outer face of the housing 301, e.g., the outward face opposite the barbell 303 mounting position.

Alternative locations for the touchscreen 330 may be provided, as will be apparent to persons skilled in the art. While a touchscreen 330 is used in exemplary embodiments it is understood and contemplated that the touchscreen 330 may be augmented and/or replaced by an LCD, LED display, or other display, input buttons, and/or a combination thereof.

The system 300 may also include a buzzer mechanism 350 attached to or in a position internal to the housing 301. Alternative sound-producing mechanisms may be used, whether in place of the buzzer mechanism 350 or in combination with the buzzer mechanism 350. In exemplary embodiments the system 300 may also include tactile mechanisms. The tactile mechanisms may cause a slight vibration providing feedback to the user via the barbell 303, similar to the buzzer mechanism 350. The tactile mechanism may also provide aural feedback to the user, e.g., via a hum or other movement causing a noise. In an embodiment the system 300 may include a buzzer mechanism 350, a tactile mechanism, or a combination thereof.

Each of the electronic components, e.g., the time-of-flight sensor 310, the accelerometer 320, the touchscreen 330 and the buzzer mechanism 350, may be in communication with a processor (not shown) that provides processing functionality to the disclosed system. Thus, the time-of-flight sensor 310, the accelerometer 320, the touchscreen 330 and the buzzer mechanism 350 are typically in communication with the processor, whether to deliver measurements to the processor or receive commands from the processor. A power source, e.g., a battery, is typically associated with the processor and the other electronic components. The processor may be provided with external communication capabilities, e.g., Bluetooth-type communication functionality, that allows the processor to receive and deliver data/communications to external devices/systems.

Exemplary implementations of the disclosed system may include use of a Teensyduino microprocessor, a VL53L0X time-of-flight sensor and a ILI9341 touchscreen.

These exemplary components are only provided for illustrative purposes. The present disclosure is not limited by or to such exemplary implementation(s).

In an embodiment, as illustrated in Figs. 4A-E, side views of an exemplary embodiment of the training system 300 are provided in which the touchscreen display 330 is positioned relative to the side face opposite the barbell 303, an on/off switch 360 is also visible. As illustrated in Fig. 4A, shown is an exemplary embodiment where the touchscreen display 330 provides an initial menu of options, e.g., “leaderboard”, “exercise” and “settings”. If selected, the “leaderboard” option may display performance data relative to users of the disclosed system, e.g., as a motivational tool. The data accessed for purposes of the “leaderboard” display may be limited to users of the specific device, i.e., data collected by the specific device, or may include data from users based on use of other physical devices, such data being communicated to the processor associated with this specific device through conventional communication means, e.g., Bluetooth communication.

If selected, the “exercise” option may display various exercise options, e.g., bench press, squat, etc., and various weights, e.g., 10 lbs, 50 lbs, etc., and various repetition sets, e.g., 5 repetitions, 10 repetitions, etc. These options may be presets or may be custom entries by a user.

If selected, the “settings” option may display various performance thresholds/targets for the various exercises, e.g., a target velocity for a squat, bench press, etc. Thus, for example as illustrated in Fig. 4B, the side view shows an exemplary “velocity threshold” of “0.80 m/s” and provides functionality for increasing or decreasing the velocity threshold by interacting with the “-” or “+” buttons on the touchscreen display 330. In an embodiment the “-” or “+” may be associated with a physical button on the housing 301. In an alternate embodiment the touchscreen display 330 may display a full or partial keyboard to input specific values. As illustrated in Fig. 4C, shown is a further exemplary settings option, namely a setting for the number of "reps", i.e., repetitions. Shown is an initial setting of "3 reps" that may be adjusted using the -/+ buttons.

With reference to Fig. 4D, the touchscreen display 330 provides a screen for displaying a user's performance. In the exemplary embodiment, the display 330 contemplates three repetitions (consistent with the setting in Fig. 4C) and is at-the-ready to display velocity performance for each repetition based on the user's performance.

With reference with Fig. 4E, shown are velocity measurements for a set of three repetitions (consistent with the setting in Fig. 4C and display in Fig. 4D). Exemplary measurements of "0.81 m/s", "0.79 m/s", and "0.78 m/s" are shown. As noted previously, the touchscreen display 330 may advantageously display the velocities for the respective repetitions and, in exemplary embodiments, may further include an indicia as to whether the performance met or failed to meet the preset threshold/target (e.g., a check mark for repetitions that meet the preset threshold/target, and an X-mark for repetitions that failed to meet the preset threshold/target).

Referring now to Figs. 5A-D shown, in an exemplary embodiment, is the training system used to measure a user's squat exercise. As illustrated in Fig. 5A, the user removes the barbell 303 with the training system configured to begin measuring the squat-based performance of the user. A squat exercise is used by way of illustration and not limitation, it is understood that the disclosed training system may be used to measure any exercise using a barbell or like equipment. Once the velocity threshold and rep count have been entered/confirmed by a user, the disclosed system may provide the user with a signal that the system is ready for the user to commence his/her exercise. Thus, for example, the system may generate sound(s) signifying that the user may start performing the requisite movement. Alternative and/or additional signals may be provided, e.g., tactile vibration, light signals, etc. to signify that the user may start performing the requsite movement.

As illustrated in Figs. 5B-C, the time-of-flight sensor associated may make distance measurements for the barbell 303 relative to ground as the user completes each repetition of his/her exercise. The ball bearing mechanism 340 may allow the housing of the system to rotationally/pivotally reorient so as to maintain a direct path for the time-of-flight 310 sensor to measure the distance relative to ground, e.g., as shown in Fig. 5C. The accelerometer 320 takes measurements that allow a determination of the change in angle of the time-of-flight sensor 310 relative to ground as the exercise proceeds. The time-of-flight sensor 310 and accelerometer 320 measurements are fed to the processor, where velocity calculations are made based on the measured data. User feedback may be provided, e.g., based on a buzzer mechanism. For example, the buzzer mechanism may provide feedback for every repetition that is completed, e.g., as shown in Fig. 5D. The buzzer mechanism may provide a "good" sound for a repetition that is completed over the preset/target velocity (e.g., high-pitched sound(s)), and a "bad" sound for a repetition that is completed below the preset/target velocity (e.g., low-pitched sound(s)).

Network Communications

The disclosed system and associated method may be implemented so as to allow/support communications across a network, e.g., as shown in Fig. 6. Fig. 6 illustrates an example environment 600 to facilitate communications and/or the transfer of data between communication devices, e.g., a first device/system 610 and a second device/system 620, whereby at least one the devices 610, 620 is adapted for mounting relative to a barbell. As a non-limiting example, a first user of a first mobile communication device/system or handset 610 can communicate with a second user of a second mobile communication device/system or handset 620 via a communication channel established by a network 630 between the first mobile communication device 610 and the second mobile communication device 620. The network 130 may include, for example, one or more base stations 632, routers 634, switches 636, and/or servers 638.

In an embodiment the first mobile communication device 610 may be the training system 300 and the second mobile communication device 620 may be a smart phone or other computing device. The first device 610 may transmit measurements from a user's workout to the second device 620 for storage, comparison with historic data, and/or to calculate an adjustment to the user's work out, although not limited thereto. For example the first device 610 may measure a user's exercise velocity and compare it to the target velocity threshold over the target repetitions, sending the data to the second device 620. The second device 620 may store this information in a database, e.g., a leaderboard, and/or send a training adjustment in the target velocity threshold or repetitions back to the first device 610. In this way, for example, if the user is meeting/exceeding the target velocity threshold over the target repetitions the target velocity/repetitions may be increased. Similarly if the user is not meeting/exceeding the target velocity threshold over the target repetitions the target velocity/repetitions may be decreased. The second device 620 may automatically calculate and transmit a training adjustment to the first device 610 or the user/ trainer may manually input or approve/confirm a training adjustment.

While the above exemplary embodiment is illustrated with the first mobile communication device 610 being the training system 300 and the second mobile communication device 620 being a smart phone or other computing device, it is understood that the environment 600 may include a plurality of first devices 610 and a plurality of second devices 620. In this way, in an embodiment, multiple training systems 300 may be in communication with each other and multiple computing devices, e.g., smart phones or personal computers. This configuration may be advantageous in a sports team environment whereby multiple users exercising with the training system 300. The plurality of training systems 300 may be comparing target velocity threshold and target repetitions with each other and the training data may be transmitted to one or more devices used by, for example, a trainer, coach, and/or team captain to track/adjust overall team progress/training regimes.

The (first) mobile communication device 610 can encode (e.g., with LDPC codes) and modulate a radiofrequency (RF) signal and transmit the RF signal which can be routed through the network 630 and transmitted to the (second) communication device 620, which can demodulate and decode the received RF signal to extract the voice data. In an exemplary embodiment, the first mobile communication device 610 can use LDPC codes for channel coding on the traffic channel. When the second mobile communication device 620 receives the RF signal, the second mobile communication device can extract the LDPC codes from the RF signal and use the extracted LDPC codes to correct channel errors by maintaining parity bits for data bits transmitted via the traffic channel. When a parity check failure is detected by the second mobile communication device 620 for one or more data bits, information from the multiple parity bits of the LDPC codes associated with the one or more data bits can be used by the second mobile communication device 620 to determine the original/correct value for the one or more data bits.

Referring now to Fig. 7, shown is a block diagram of an example of an embodiment of a mobile communication device 700 in accordance with embodiments of the present disclosure. In an embodiment, the mobile communication device 700 may be one of the first device 610, the second device 620, or the training system 300. The mobile communication device 700 can be a smartphone, tablet, subnotebook, laptop, personal digital assistant (PDA), and/or any other suitable mobile communication device that includes or can be programmed and/or configured to communicate with other communication devices via a communication network (e.g., network 630). The mobile communication device 700 can include one or more processing and/or logic devices 704, such as digital signal processors

(DSP), microprocessors, microcontrollers, and/or graphical processing units (GPUs), field programmable gate arrays (FPGAs), application specific circuits (ASICs), and the like. The mobile communication device 700 can also include memory/storage 706 in the form a non-transitory computer-readable medium, a display unit 708, a battery 712, and a radio frequency circuitry 714. The camera 710 can be programmed and/or configured to capture images of scenes. Some embodiments of the mobile communication device 700 can also include other components, such as sensors 716 (e.g., accelerometers, gyroscopes, piezoelectric sensors, light sensors, LIDAR sensors), subscriber identity module (SIM) card 718, audio components 720 and 722 (e.g., microphones and/or speakers), and power management circuitry 724.

The memory 706 can include any suitable, non-transitory computer-readable storage medium, e.g., read-only memory (ROM), erasable programmable ROM (EPROM), electrically-erasable programmable ROM (EEPROM), random access memory (RAM), flash memory, and the like. In exemplary embodiments, an operating system 726 and an embodiment of the LDPC decoder 728 can be embodied as computer-readable/executable program code stored on the non-transitory computer-readable memory 706 and implemented using any suitable, high or low-level computing language, scripting language, or any suitable platform, such as, e.g., Java, C, C++, C#, assembly code, machine-readable language, Python, Rails, Ruby, and the like. The memory 706 can also store data to be used by and/or that is generated by the LDPC decoder 728. While memory 706 is depicted as a single component, those skilled in the art will recognize that the memory can be formed using multiple components and that separate non-volatile and volatile memory devices can be used.

One or more processing and logic devices 704 can be programmed and/or configured to facilitate an operation of the mobile communication device 700 and enable RF communications with other communication devices via a network (e.g., network 630). The processing and/or logic devices 704 can be programmed and/or configured to execute the operating system 726 and the LDPC decoder 728 to implement one or more processes to perform one or more operations (de-coding of LDPC codes, error detection and correction). As an example, a microprocessor, micro-controller, central processing unit (CPU), or graphical processing unit (GPU) can be programmed to execute the LDPC decoder 728. As another example, the LDPC decoder 728 can be embodied and executed by an application-specific integrated circuit (ASIC). The processing and/or logic devices 704 can retrieve information/data from and store information/data to the memory 706. For example, the processing device 704 can retrieve and/or store LDPC codes and/or any other suitable information/data that can be utilized by the mobile communication device to perform error detection and correction using LDPC codes.

The LDPC decoder 728 can include a reinforcement learning (RL) software agent that can sequentially decode the low-density parity-check (LDPC) codes included in the RF signal via reinforcement learning (RL). The sequential decoding process implemented by the software agent can be trained to schedule all check nodes (CNs) in a cluster, and all clusters in every iteration, such that in each RL step, the software agent of the LDPC decoder 728 learns to schedule CN clusters sequentially depending on the reward associated with the outcome of scheduling a particular cluster.

The RF circuitry 714 can include an RF transceiver, one or more modulation circuits, one or more demodulation circuits, one or more multiplexers, one or more demultiplexers. The RF circuitry 714 can be configured to transmit and/or receive wireless communications via an antenna 715 pursuant to, for example, the 3rd Generation Partnership Project (3GPP) for 5G NR and/or the International Telecommunications Union (ITU) IMT-2020.

The display unit 708 can render user interfaces, such as graphical user interfaces (GUIs) to a user and in some embodiments can provide a mechanism that allows the user to interact with the GUIs. For example, a user may interact with the mobile communication device 700 through the display unit 708, which may be implemented as a liquid crystal touchscreen (or haptic) dis-play, a light-emitting diode touchscreen display, and/or any other suitable display device, which may display one or more user interfaces that may be provided in accordance with exemplary embodiments.

The power source 712 can be implemented as a battery or capacitive elements configured to store an electric charge and power the mobile communication device 700. In exemplary embodiments, the power source 712 can be a rechargeable power source, such as a battery or one or more capacitive elements configured to be recharged via a connection to an external power supply.

The present disclosure thus provides a device/system and associated method that measures the velocity of a vertical barbell movement or repetition of an exercise by using time-of-flight sensor distance measurements and accelerometer angular measurements to calculate the average and peak velocities that a barbell would reach during an exercise. The time-of-flight sensor faces perpendicularly/orthogonally to the ground during a movement and will stay this way during the duration of a movement to calculate velocities. In exemplary embodiments, a ball bearing system is provided that allows a user to rotate the bar while keeping the single time-of-flight sensor facing towards the ground, or accommodates automatic rotational/pivotal adjustment, e.g., based on the weighting of the disclosed device/system.

The disclosed device/system advantageously uses a combination of a time-of-flight sensor and an accelerometer sensor in order to take average-velocity and peak-velocity measurements during the concentric phase of a repetition of an exercise. The time-of-flight sensor takes distance measurements from the ground over the duration of a repetition to calculate the instantaneous velocity at a point in time while the accelerometer is used to account for any angular change of the time-of-flight sensor's laser to the ground from a perpendicular distance.

In addition, as noted above, the device may rotate about a single axis on a ball bearing system in order to maintain a perpendicular orientation relative to ground.

The device also gives feedback to a user, e.g., via a buzzer making a 'good' or 'bad' sound for every concentric phase of a repetition that an athlete completes with an average velocity higher or lower than a user-input velocity threshold. In addition, when the user initiates the start of an exercise through the user interface, the buzzer gives feedback for every second that passes before the user initiates a repetition.

A touchscreen is utilized which allows an athlete to select an Exercise option on the user interface. When Exercise has been selected, the velocity of each concentric movement of a repetition the user completes is measured. A certain velocity threshold the user would like to reach during the concentric phase of a repetition and the number of repetitions they would like to complete must be entered in order to start the velocity measurement process. Once the velocity threshold and the number of repetitions the user would like to accomplish have been entered, the user may then begin the exercise.

It is further contemplated that selection of the velocity threshold before starting an exercise may be optional so that the user can choose whether the athlete wants to hit a certain velocity during a movement and receive feedback via buzzers.

Throughout the exercise performed by the user, the interface will display the average velocity of the current repetition and once finished, each of the velocities as well as the rep in which they were performed will continue to be displayed to a user.

It is appreciated that the various exemplary embodiments, and the components thereof, discussed herein may be used in combination, alternatively, and/or in addition to each other exemplary embodiment, and the components thereof.

Although the present disclosure has been described with reference to exemplary embodiments, the present disclosure is not limited by or to such exemplary embodiments. Rather, various modifications, refinements and/or adjustments to the disclosed system and/or associated method may be made without departing from the spirit or scope of the present disclosure.

The terminology used herein is for the purpose of describing particular embodiments only and is not intended to be limiting of the present disclosure. As used herein, the singular forms “a”, “an” and “the” are intended to include the plural forms as well, unless the context clearly indicates otherwise. It will be further understood that the terms “comprises” and/or “comprising,” when used in this specification, specify the presence of stated features, integers, steps, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, integers, steps, operations, element components, and/or groups thereof.

While the present disclosure has been described with reference to an exemplary embodiment or embodiments, it will be understood by those skilled in the art that various changes may be made and equivalents may be substituted for elements thereof without departing from the scope of the present disclosure. In addition, many modifications may be made to adapt a particular situation or material to the teachings of the present disclosure without departing from the essential scope thereof. Therefore, it is intended that the present disclosure not be limited to the particular embodiment disclosed as the best mode contemplated for carrying out this present disclosure, but that the present disclosure will include all embodiments falling within the scope of the claims.

CLAIMS

1. A system for measuring velocity associated with a weight lifting activity, comprising:

   a. a housing;

   b. a time-of-flight sensor positioned within the housing;

   c. an accelerometer positioned within the housing;

   d. a processor positioned within the housing and in communication with the time-of-flight sensor and the accelerometer; and

   e. a ball bearing mechanism associated with the housing;

   wherein the ball bearing mechanism biases the housing to orient the time-of-flight sensor orthogonally toward ground.

2. The system according to claim 1, wherein the processor calculates a velocity of the housing based on measurements received from the single time-of-flight sensor and the accelerometer.

3. The system according to claim 1, wherein the housing includes a mounting structure for detachably mounting the housing to a barbell.

4. The system according to claim 1, further comprising a display mounted on the housing and in communication with the processor.

5. The system according to claim 1, wherein the processor is programmed to allow a selection of at least one of a weight lifting activity, a number of repetitions, a target velocity, and a weight.

6. The system according to claim 5, wherein the housing includes a display mounted on the housing and in communication with the processor, and wherein the selection is displayed on the display.

7. The system according to claim 2, further comprising a buzzer in communication with the processor.

8. The system according to claim 7, wherein the buzzer generates a sound based on the velocity of the housing.

9. The system according to claim 8, wherein the sound differs depending on whether the velocity of the housing is above a target velocity.

10. The system according to claim 1, wherein the processor is in communication with a network.

11. The system according to claim 1, further comprising a weight in the housing biasing the time-of-flight sensor orthogonally toward ground.

12. The system according to claim 2, wherein the calculated velocity includes an average velocity and a peak velocity.

13. The system according to claim 4, wherein the weight lifting activity is at least one of flat bench pressing, incline bench pressing, decline bench pressing, squatting, overhead military pressing, and dead lifting.

14. A system according to any of the preceding claims, wherein the housing is mounted to a barbell.

15. A method for measuring velocity associated with a weight lifting activity, comprising:

a. providing a system according to any of claims 1-12,

b. detachably mounting the system relative to a barbell; and

c. completing one or more repetitions of the weight lifting activity;

wherein the system measures velocity based on the activity.

16. The method according to claim 15, further comprising comparing the measured velocity to a preset threshold or target, and providing a signal as to whether the measured velocity exceeds or fails to exceed the preset threshold or target.

17. The method according to claims 15 or 16, wherein the weight lifting activity is selected from the group consisting of flat bench pressing, incline bench pressing, decline bench pressing, squatting, overhead military pressing, and dead lifting.

18. A method for velocity based training, comprising:

measuring a time-of-flight path from a barbell to ground;

measuring changes in the angular orientation of the time-of flight path;

calculating a velocity of the barbell based on the time-of-flight path measurements and the changes in the angular orientation of the time-of flight path;

comparing the velocity of the barbell to a velocity target;

providing a feedback based on the comparison of the velocity of the barbell to the velocity target; and

displaying the feedback on a display.

19. The method according to claim 18, wherein the velocity of the barbell includes an average velocity and a peak velocity.

20. The method according to claim 18, wherein the feedback changes based on whether the velocity of the barbell is more or less than the velocity target.

21. The method according to claim 18, wherein the feedback is one or more of a sound, a vibration, and a light.

22. The method according to claim 18, further comprising transmitting one or more of the time-of-flight path measurements, the changes in the angular orientation of the time-of flight path, the velocity of the barbell, and the comparison of the velocity of the barbell to the velocity target to a network.

23. The method according to claim 18, further comprising adjusting the velocity target based on the comparison of the velocity of the barbell to the velocity target.

24. A method for velocity based training, comprising:

detachably mounting a training system to a barbell, the training system comprising:

a housing;

a time-of-flight sensor positioned within the housing measuring a time-of-flight path from a barbell to ground;

an accelerometer positioned within the housing measuring changes in the angular orientation of the time-of flight path;

a processor positioned within the housing and in communication with the time-of-flight sensor and the accelerometer; and

a ball bearing mechanism attached to the housing and mounted between the training system and the barbell, the ball bearing mechanism biasing the time-of-flight sensor orthogonally to ground;

calculating a velocity of the barbell based on the time-of-flight path measurements and the changes in the angular orientation of the time-of flight path;

comparing the velocity of the barbell to a velocity target;

providing a feedback based on the comparison of the velocity of the barbell to the velocity target.

25. A system for velocity based training, comprising:

a housing;

a time-of flight sensor positioned on a bottom of the housing;

an accelerometer measuring the change in angular orientation of the housing;

a mount having a ball bearing, the housing being detachably mounted to a barbell via the mount;

a feedback device;

a display; and

a processor in communication with the time-of flight sensor, the accelerometer, the feedback device, and a display;

wherein the time-of flight sensor is biased orthogonally to ground via the ball bearing;

wherein the processor calculates a velocity of the barbell based on measurements received from the single time-of-flight sensor and the accelerometer;

wherein the processor displays the velocity of the barbell on the display;

wherein the feedback device provides a feedback based on the velocity of the barbell.

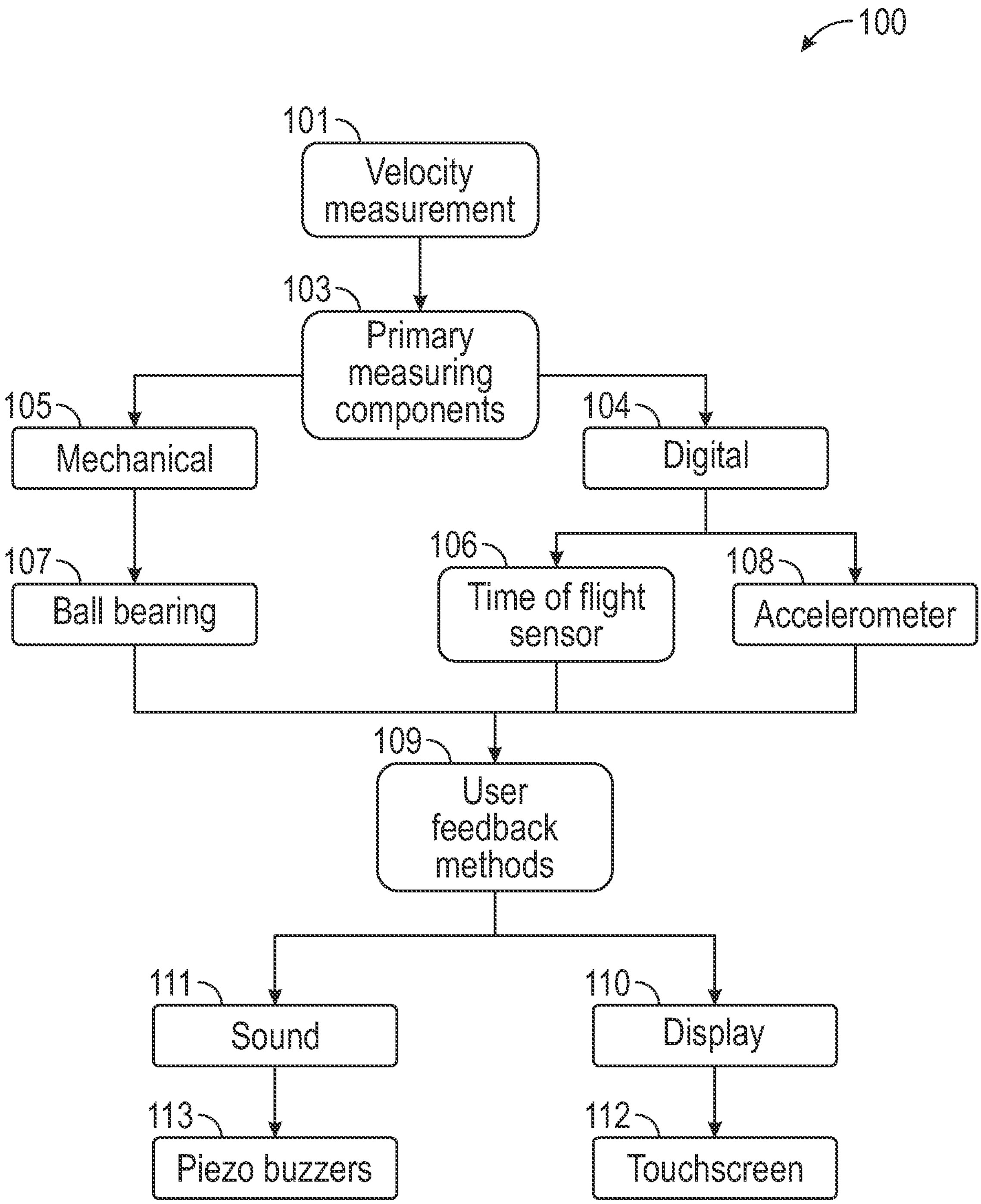
100
101
Velocity measurement
103
Primary measuring components
105
Mechanical
104
Digital
107
Ball bearing
106
Time of flight sensor
108
Accelerometer
109
User feedback methods
111
Sound
110
Display
113
Piezo buzzers
112
Touchscreen

FIG. 1

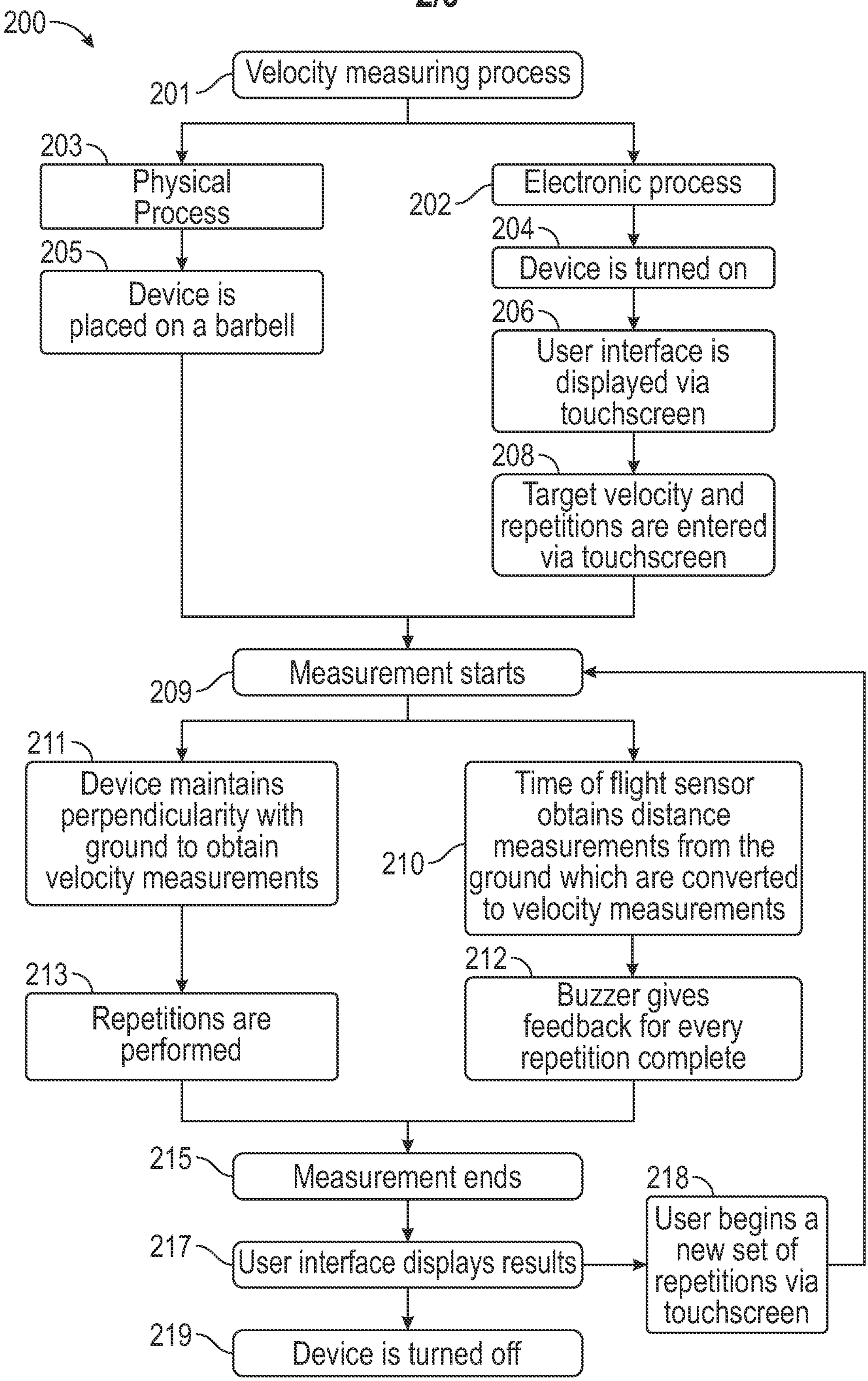
200
201
Velocity measuring process
203
Physical Process
202
Electronic process
205
Device is placed on a barbell
204
Device is turned on
206
User interface is displayed via touchscreen
208
Target velocity and repetitions are entered via touchscreen
209
Measurement starts
211
Device maintains perpendicularity with ground to obtain velocity measurements
210
Time of flight sensor obtains distance measurements from the ground which are converted to velocity measurements
213
Repetitions are performed
212
Buzzer gives feedback for every repetition complete
215
Measurement ends
218
User begins a new set of repetitions via touchscreen
217
User interface displays results
219
Device is turned off

FIG. 2

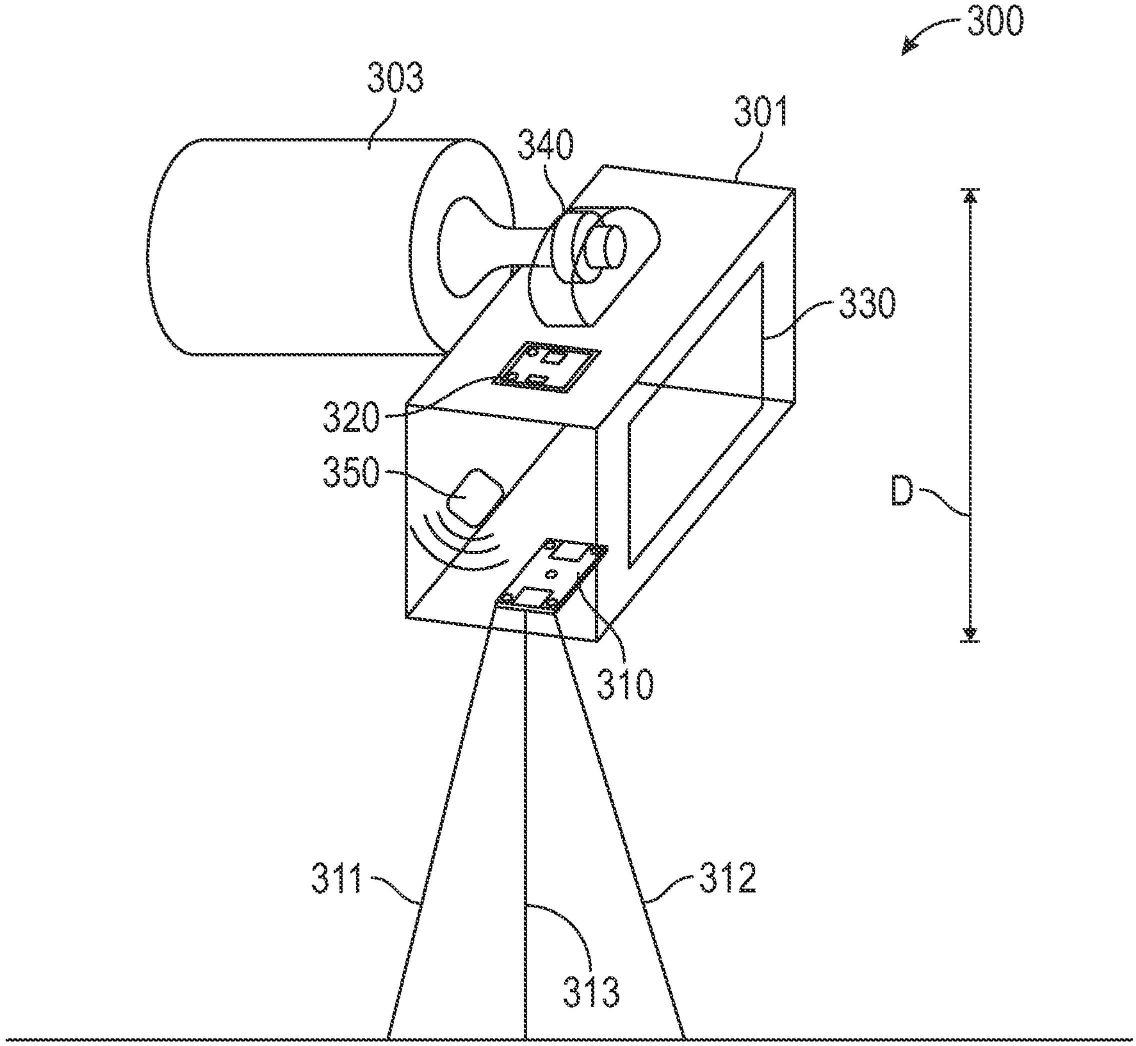

FIG. 3

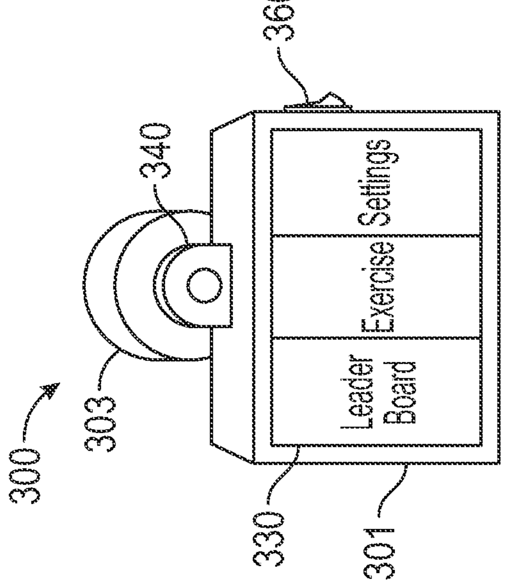

FIG. 4A

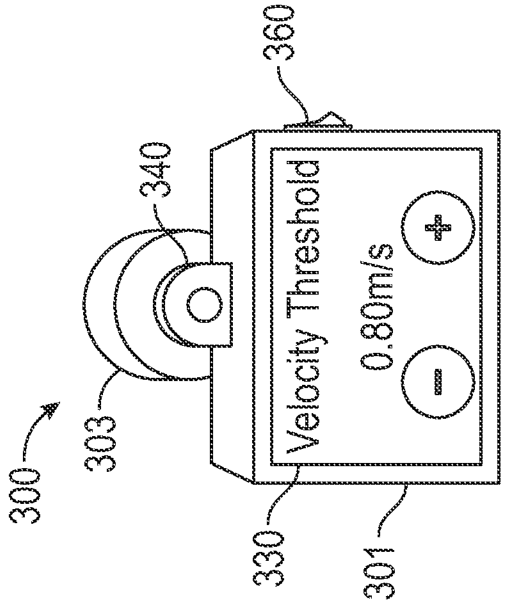

FIG. 4B

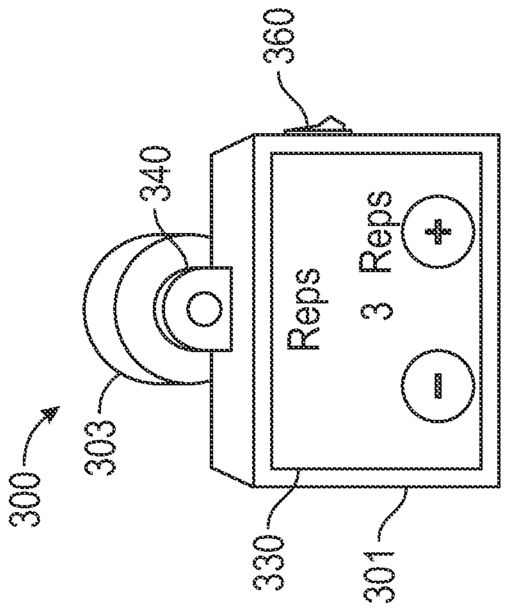

FIG. 4C

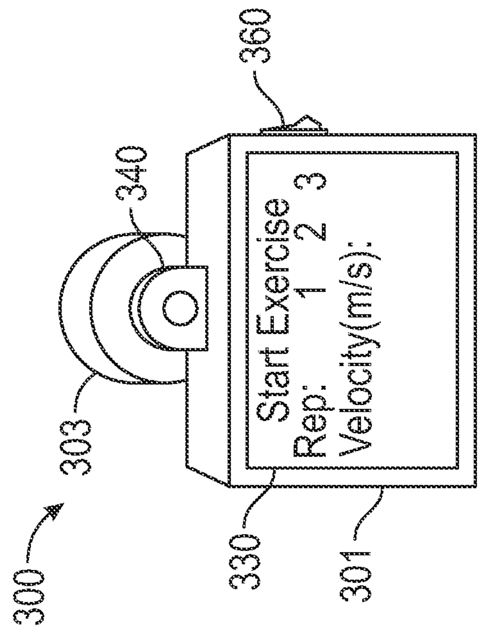

FIG. 4D

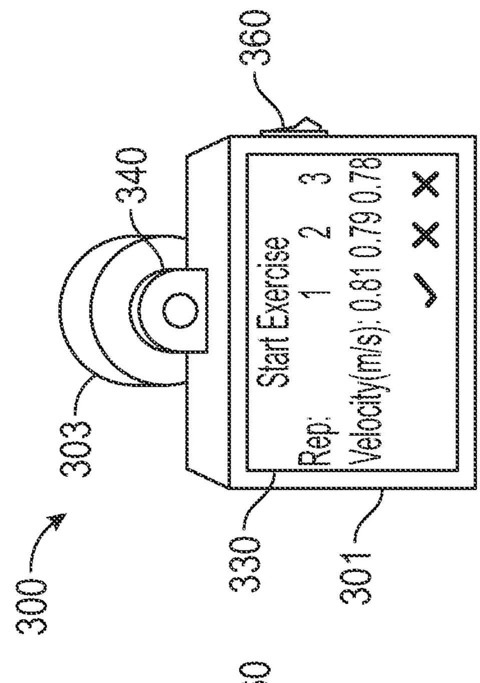

FIG. 4E

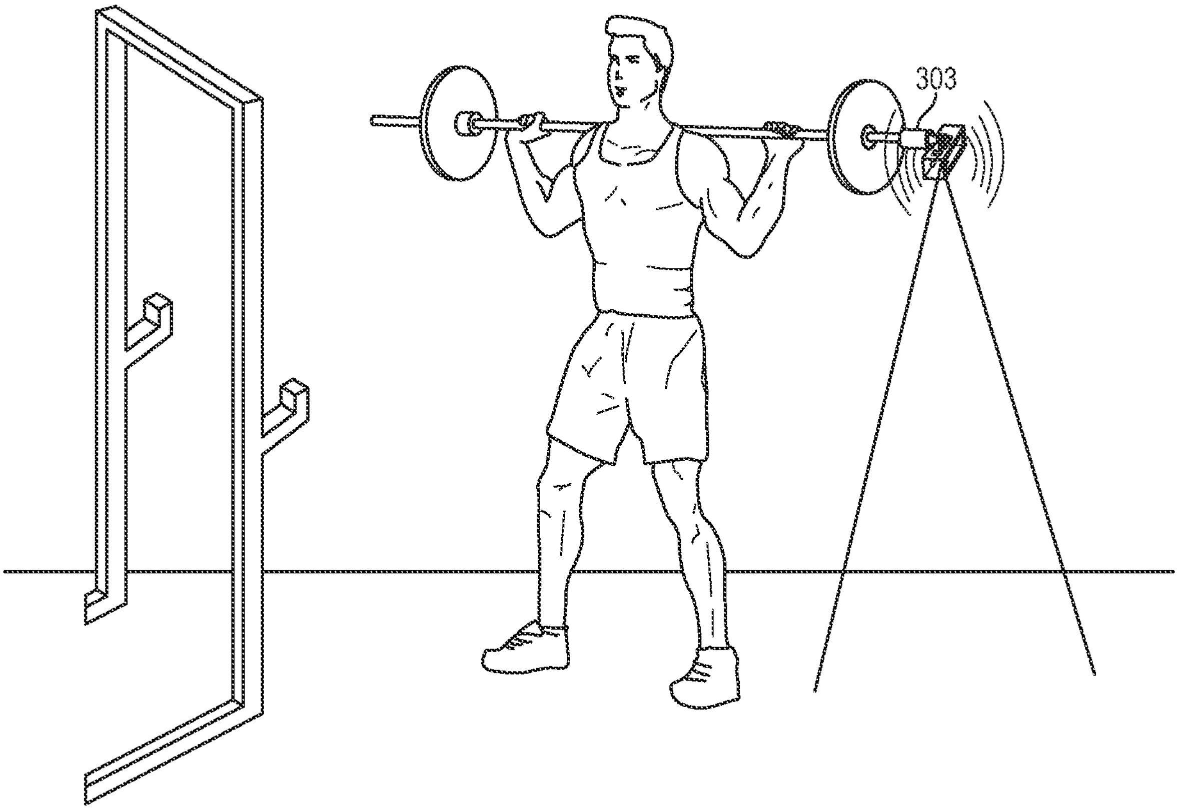

FIG. 5A

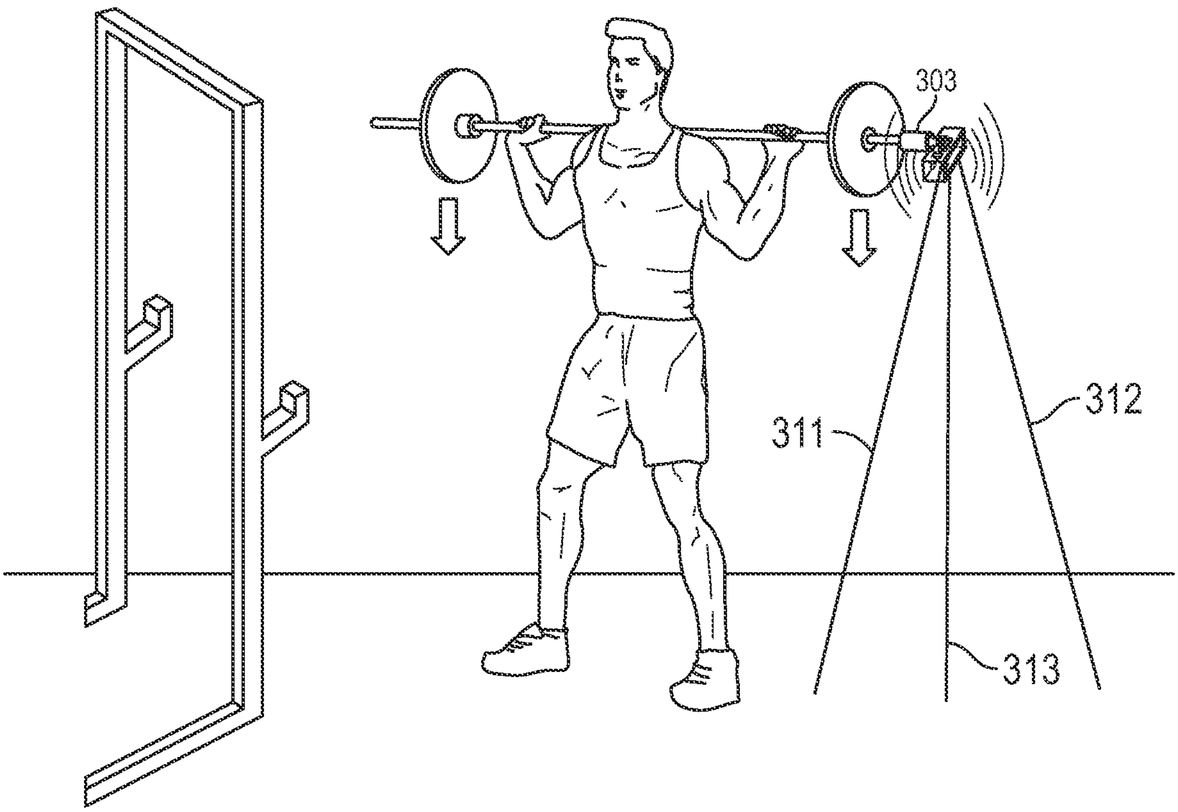

FIG. 5B

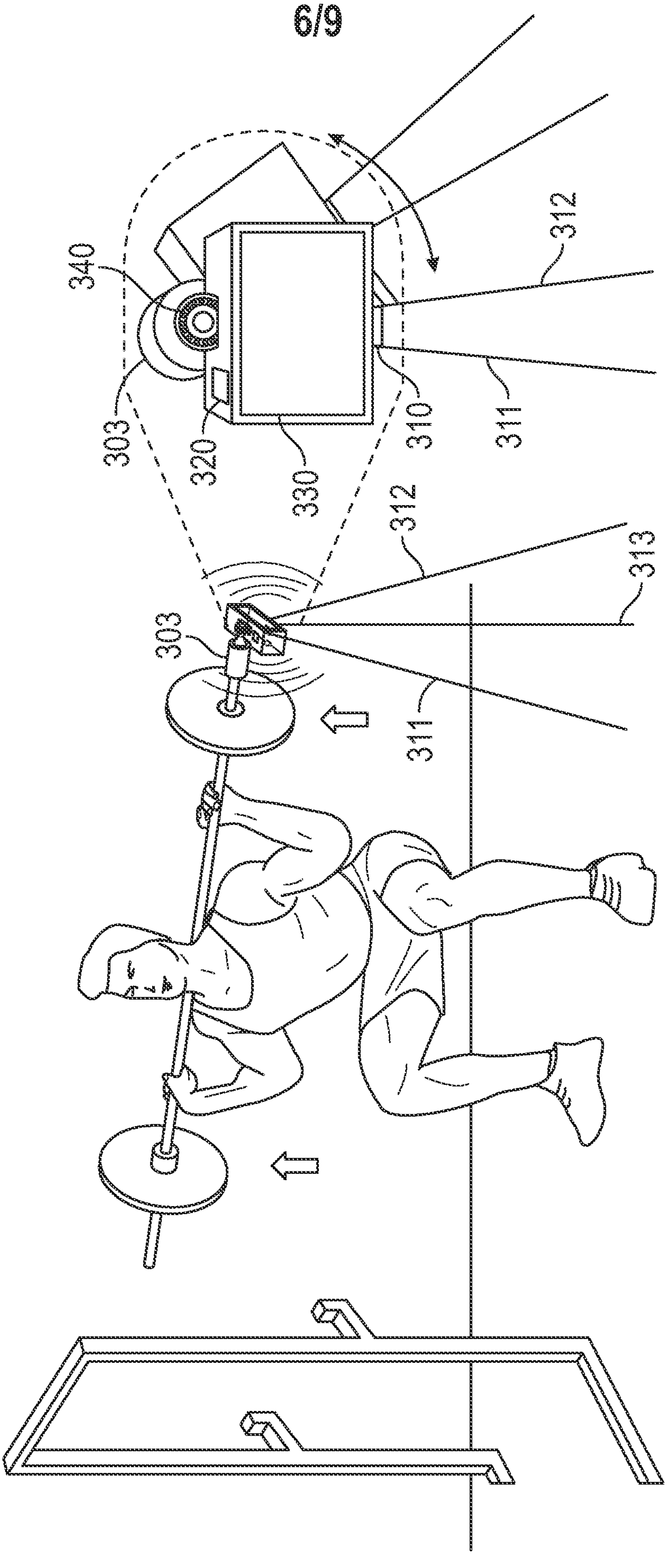

FIG. 5C

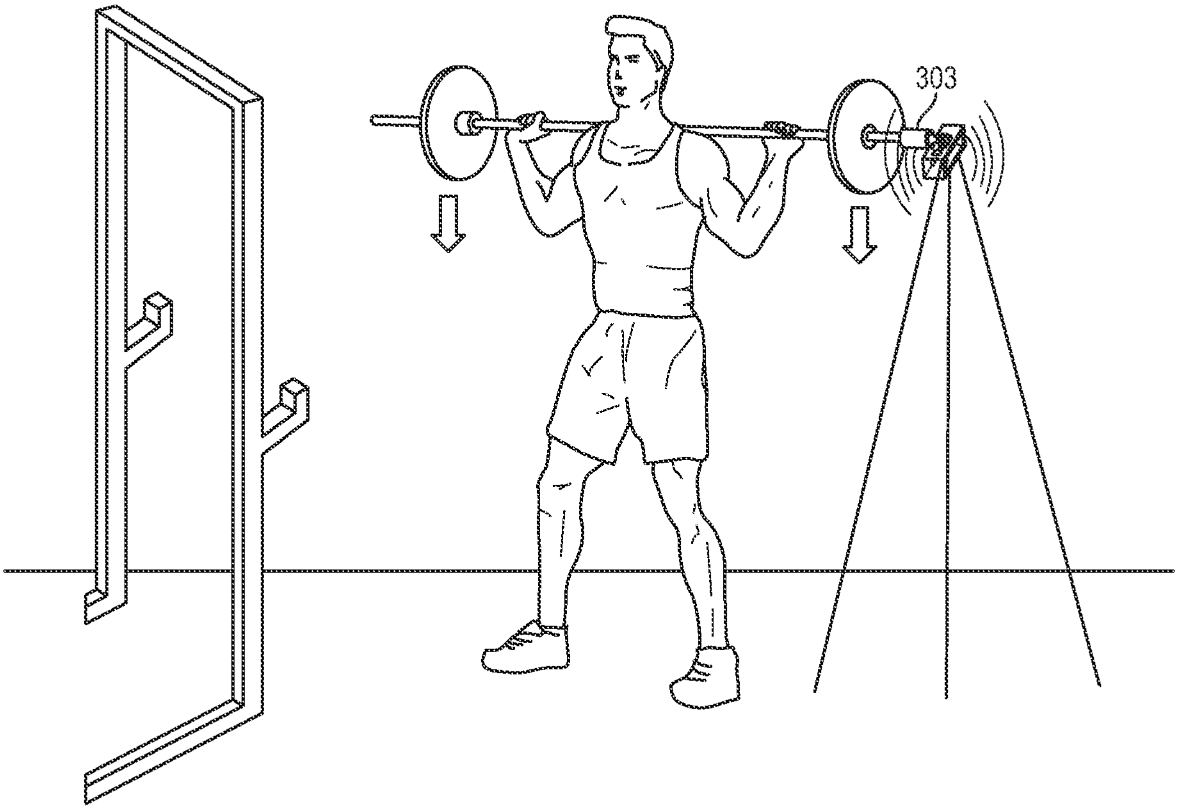

FIG. 5D

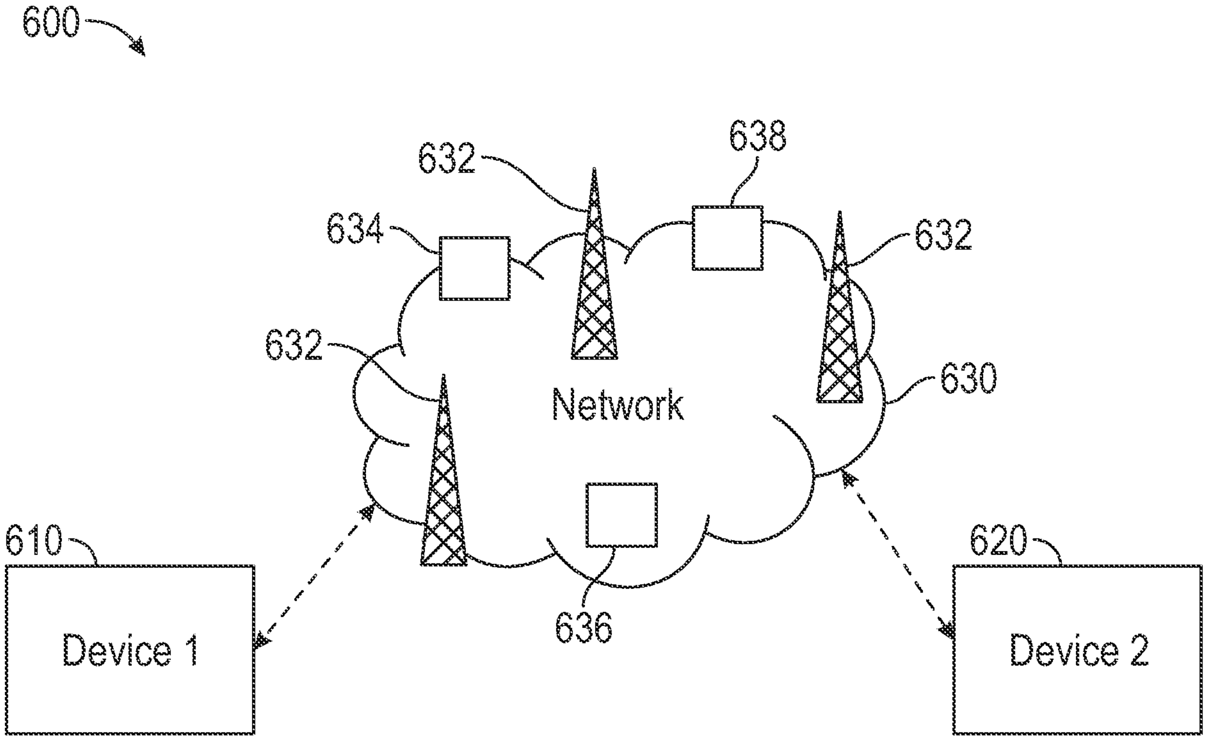
600
632
638
634
632
632
630
Network
610
620
636
Device 1
Device 2

FIG. 6

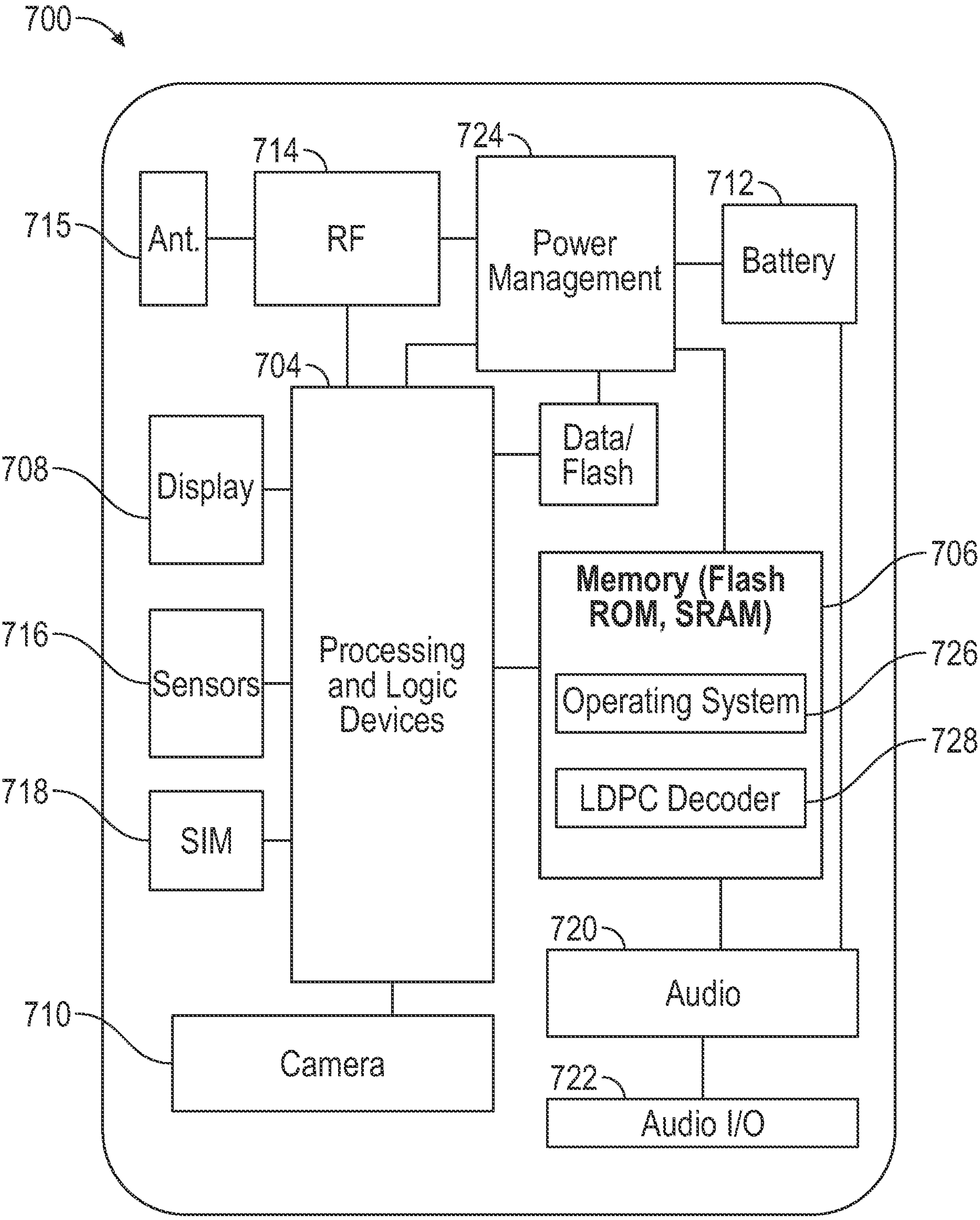
700
715
Ant.
714
RF
724
Power Management
712
Battery
704
Data/ Flash
708
Display
706
Memory (Flash ROM, SRAM)
716
Sensors
Processing and Logic Devices
726
Operating System
718
SIM
728
LDPC Decoder
720
Audio
710
Camera
722
Audio I/O

FIG. 7

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US 24/10071

A. CLASSIFICATION OF SUBJECT MATTER

IPC - INV. A63B 21/072, A63B 21/06 (2024.01)
ADD. A63B 24/00 (2024.01)

CPC - INV. A63B 21/0724, A63B 21/0726

ADD. A63B 24/00, A63B 2220/13, A63B 2220/16, A63B 2220/30, A63B 2220/40, A63B 2244/09

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)
See Search History document

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

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X --- Y	WO 2020/019041 A1 (Evan Lawton) 30 January 2020 (30.01.2020) Entire document especially pages 6-11 and figs. 1-7	18-23 ----- 1-16, 24-25
Y	US 11,135,477 B1 (Kneknas) 5 October 2021 (05.10.2021) Entire document especially col 3, ln 66 - col 4, ln 40; col 5, ln 7-20, 40 - col 6, ln 12 and figs. 1-7	1-16, 24-25
A	US 2009/0267783 A1 (Vock et al.) 29 October 2009 (29.10.2009) Entire document	1-16, 18-25
A	US 2021/0308524 A1 (Cernasov et al.) 7 October 2021 (07.10.2021) Entire document	1-16, 18-25
A	US 10,878,952 B1 (Patel et al.) 29 December 2020 (29.12.2020) Entire document	1-16, 18-25
A	US 2018/0050234 A1 (Smartweights, Inc.) 22 February 2018 (22.02.2018) Entire document	1-16, 18-25
A	US 2017/0216665 A1 (Mahr) 3 August 2017 (03.08.2017) Entire document	1-16, 18-25

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

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"D" document cited by the applicant in the international application
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
14 March 2024	APR 12 2024
Name and mailing address of the ISA/US Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-8300	Authorized officer Kari Rodriquez Telephone No. PCT Helpdesk: 571-272-4300

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 24/10071

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☒ Claims Nos.: 17
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☐ No protest accompanied the payment of additional search fees.