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(54) **SYSTEMS AND METHODS FOR MONITORING ATHLETIC PERFORMANCE**

SYSTEME UND VERFAHREN ZUR ÜBERWACHUNG DER SPORTLICHEN LEISTUNG

SYSTÈMES ET MÉTHODES DE SURVEILLANCE DE PERFORMANCES ATHLÉTIQUES

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Description

FIELD OF THE INVENTION

[0001] The present invention relates generally to the field of athletic equipment, and more particularly to systems and methods for providing training information to a runner.

BACKGROUND OF THE INVENTION

[0002] A number of devices exist for providing a runner with basic training information. For example, systems for measuring and recording the heart rate, speed, distance, and/or stride rate of a runner using a sensor that may be clipped, for example, to workout apparel has been manufactured by adidas AG of Herzogenaurach, Germany. Similarly, Nike Inc., of Beaverton, Oregon, has produced devices that measure and record the distance and pace of a walk or run. Such devices often consist of small accelerometers attached to or embedded in a shoe, which communicate with a receiving device (e.g., a sportband or a receiver plugged into of embedded within a mobile phone). The device and receiver allow a user to track the distance, time, and pace of a training run, with the information provided to a user through audio feedback during the training run and/or recorded for later analysis. Systems also exist for measuring and recording training information such as distance, time, and pace of a training run through utilization of a mobile phone of GPS ("Global Positioning System") device without the need for a sensor in a shoe.

[0003] However, these systems only provide basic training information related, for example, to the speed and distance travelled by a runner, and cannot provide any detailed biofeedback information that may be used to improve the actual running form and technique of the runner. As a result, there still exists a need for a system and method capable of providing detailed training information to an athlete during and after a training session to assist in improving their running form.

[0004] US 5955667 A discloses a motion analysis system.

[0005] US 2007/260421 A1 discloses athletic or other performance sensing systems.

[0006] US 2008/214360 A1 discloses a method and apparatus for estimating a motion parameter.

[0007] US 2010/063779 A1 discloses footwear having a sensor system.

[0008] EP 1707065 A1 discloses a pod for mounting electronic device to footwear.

SUMMARY OF THE INVENTION

[0009] Aspects of the present invention are set out in the independent claims. Optional features are included in the dependent claims.

[0010] The present invention is directed towards novel systems, methods and devices for monitoring one or more athletic performance characteristic of a user and/or providing biofeedback information to the user to assist in training the user to run with better form and, for example, with an improved foot strike.

[0011] One aspect of the invention includes an apparatus for monitoring one or more athletic performance characteristic of a user, the apparatus including the features of claim 1.

[0012] In one embodiment the apparatus also includes receiving means for receiving the data package transmitted from the sensing unit and communicating information representative of the performance characteristic to the user. The means for communicating information to the user may include, or consist essentially of, at least one of a visual signal, an auditory signal, and/or a tactile signal (e.g., a vibration). The information may be communicated to the user in substantially real-time and/or be stored, for example within the sensing unit and/or the receiving means, for communicating to the user at a later time and /or for further analysis.

[0013] The receiving means may include one or more remote user feedback devices, such as, but not limited to, a watch, a detachable strap, a mobile phone, an earpiece, a hand-held feedback device, a laptop computer, head-mounted feedback device (e.g., a visor or hat), and/or a desktop personal computer. Alternatively, or in addition, the receiving means may include a software application and/or hardware (e.g., a dongle) for controlling at least one function of a remote user feedback device, such as a mobile phone.

[0014] In one embodiment, the sensing unit includes a housing unit adapted to house the first sensor, the processing means, and the transmitting means. The housing unit may be adapted to be releasably attachable to a sole and/or upper of the shoe of the user, or be fixedly attached to, or embedded within, an upper and/or sole of the shoe. In one embodiment the housing unit is releasably attachable to at least one of a fastening portion (e.g., the lacing portion) of a shoe or a heel portion of the shoe.

[0015] The apparatus may include means for determining at least one second performance characteristic of the user, which can be based upon an output from the first sensor and/or be based upon an output from one or more second sensor(s). The second sensor(s) may include, or consist essentially of, one or more accelerometers, pressure sensors, force sensors, temperature sensors, chemical sensors, global positioning systems, piezoelectric sensors, rotary position sensors, gyroscopic sensors, heart-rate sensors, and/or goniometers. Other sensors, such as, but not limited to, electrocardiograph sensors, electrodermograph sensors, electroencephalograph sensors, electromyography sensors, feedback thermometer sensors, photoplethysmograph sensors, and/or pneumograph sensors may also be utilized in various embodiments of the invention. The at least one second performance characteristic may include, or consist essentially of, at least one of a cadence, a posture, a lean, a speed, a distance travelled, and/or a heart rate of the user.

[0016] The processing means includes a comparison of a localized maximum angular velocity measurement and a localized minimum angular velocity measurement during a foot strike event (e.g., during a brief period immediately before, at, and/or after initial contact between a foot and the ground). For example, processing the measured data may include, or consist essentially of, dividing the localized minimum angular velocity measurement during a foot strike event by the localized maximum angular velocity measurement during a foot strike event, and comparing the resulting calculated value with at least one predetermined comparison value to determine whether a heel strike, a midfoot strike, or a forefoot strike has occurred. In addition, the processing means may include integration of measured angular velocity data during a foot strike event and comparison of the integrated positive angular velocity results and the integrated negative angular velocity results during a foot strike event.

[0017] Another aspect of the invention includes a method for monitoring one or more athletic performance characteristic of a user, the method including the features of claim 13. In one embodiment, the method allows for the communication of the information to the user in substantially real-time.

[0018] These and other objects, along with advantages and features of the present invention herein disclosed, will become more apparent through reference to the following description, the accompanying drawings, and the claims. Furthermore, it is to be understood that the features of the various embodiments described herein are not mutually exclusive and can exist in various combinations and permutations within the scope of the claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0019] In the drawings, like reference characters generally refer to the same parts throughout the different views. Also, the drawings are not necessarily to scale, emphasis instead generally being placed upon illustrating the principles of the invention. In the following description, various embodiments of the present invention are described with reference to the following drawings, in which:

FIG. 1 is a schematic perspective view of a biofeedback system as worn by a runner, in accordance with one embodiment of the invention;

FIG. 2 is a schematic side view of a shoe with forefoot and heel sensors embedded therein, in accordance with one embodiment of the invention;

FIG. 3 is a schematic side view of a shoe with a midfoot sensor embedded therein, in accordance with one embodiment of the invention;

FIG. 4 is a schematic side view of a shoe with a plurality of sensors embedded therein, in accordance with one embodiment of the invention;

FIG. 5 is a schematic plan view of a shoe with an array of sensors embedded therein, in accordance with one embodiment of the invention;

FIG. 6 is a schematic plan view of another shoe with an array of sensors embedded therein, in accordance with one embodiment of the invention;

FIG. 7 is a schematic plan view of a shoe with an sensor holding insert inserted within the sole, in accordance with one embodiment of the invention;

FIG. 8 is a schematic plan view of a shoe sole having midfoot and heel sensor pads, in accordance with one embodiment of the invention;

FIG. 9 is a schematic plan view of a shoe sole having forefoot, midfoot, and heel sensor pads, in accordance with one embodiment of the invention;

FIG. 10 is a schematic side view of a shoe with a sensor holding insert coupled to the shoe at a lacing portion, in accordance with one embodiment of the invention;

FIG. 11 is a schematic side view of a shoe with a sensor coupled to the upper, in accordance with one embodiment of the invention;

FIG. 12 is a schematic view of a system for providing biofeedback information for an athlete, in accordance with one embodiment of the invention;

FIG. 13 is a schematic view of another system for providing biofeedback information for an athlete, in accordance with one embodiment of the invention;

FIG. 14 is a schematic view of yet another system for providing biofeedback information for an athlete, in accordance with one embodiment of the invention;

FIGS. 15 to 19 are schematic views of various biofeedback systems as worn by a runner, in accordance with one embodiment of the invention;

FIG. 20 is a schematic perspective view of a hand held feedback device for a biofeedback system, in accordance with one embodiment of the invention;

FIG. 21 is a schematic side view of a sensor pod for a biofeedback system positioned on a lacing portion of a shoe, in accordance with one embodiment of the invention;

FIG. 22 is a perspective view of the pod of FIG. 21;

FIG. 23 is a schematic side view of a sensor pod for a biofeedback system positioned on a heel portion of a shoe, in accordance with one embodiment of the invention;

FIG. 24 is a perspective view of the pod of FIG. 23;

FIG. 25 is a schematic perspective view of axes of orientation for a gyroscopic sensor for a biofeedback system, in accordance with one embodiment of the invention;

FIG. 26 is a graph of angular velocity data from a gyroscopic sensor for a heel striking running style, in accordance with one embodiment of the invention;

FIG. 27 is a graph of angular velocity data from a gyroscopic sensor for a midfoot striking running style, in accordance with one embodiment of the invention;

FIG. 28 is a graph of data for a reset trigger for a gyroscopic sensor, in accordance with one embodiment of the invention;

FIG. 29 is a schematic representation of various data presentation means for foot strike location of a runner, in accordance with one embodiment of the invention; and

FIGS. 30a to 33c are schematic views of various attachment mechanisms for a sensor pod for a biofeedback system, in accordance with one embodiment of the invention.

DETAILED DESCRIPTION

[0020] The invention described herein relates generally to improved biofeedback systems, and related methods, for use in training users (e.g., runners or other athletes) to run with an improved running form or technique. The invention may be utilized by runners or other athletes of all levels of skill from professional athletes through to beginners and occasional joggers. By placing one or more sensors on the body of a runner (e.g., on or in one or more shoe and/or piece of apparel), the systems and methods described herein may be used as a coaching tool to provide substantially instantaneous feedback and coaching during athletic activity, and also store information for evaluation and further processing after the run.

[0021] Promoting better running form may be beneficial to a runner for a number of reasons such as, but not limited to, improving running efficiency (thereby increasing performance) and reducing the risk of injury. In general, coaching can be an important way to promote proper running form and keep runners injury free. However the majority of runners (including many collegiate and even some elite runners) have never been given any or significant training on how to run with proper form. As a result, many runners are unaware of problems with their running form (e.g., an improper foot strike position or a running style wherein a runner's right foot contacts the ground differently than their left foot) that may significantly affect their running efficiency and leave them more prone to injury.

[0022] The utilization of high-speed cameras during coaching may provide a runner with some feedback to assist in improving running form. However, not only do the majority of athletes not have sufficient access to professional coaching utilizing such technology to provide any substantive guidance to train them to run with an improved running form, but such coaching, even if available, can be expensive and time consuming. In addition, watching video of an athlete running does not provide instantaneous feedback that can be used by the athlete during a run. While technology has been utilized to provide some instantaneous feedback to a runner, such as the speed, distance travelled, heart rate, and calories burned during a run, the information provided by these systems does not produce biofeedback information that may be used to give a runner substantive training on proper running form. The inventions described herein address this issue by providing improved systems, and related methods, for measuring, transmitting, storing, analyzing, and/or communicating substantive biofeedback data that may be utilized instantaneously, or substantially instantaneously, to promote good running form in an athlete during and/or after a run.

[0023] Biofeedback information of use in training an athlete to run with proper running form includes, but is not limited to, foot strike position, cadence, posture, and lean information. Such information may be used to analyze a runner's technique and running traits, and identify parameters that can be adjusted by a runner during training to improve one or more performance characteristic. Good running form for an athlete may include elements such as, but not limited to, quick strides, a midfoot foot strike location, and good posture. These elements may increase the efficiency and ease of running while reducing stresses on the runner that could result in strains and other injuries. In contrast, poor running form, which is common in untrained athletes, may include elements such as overstriding, aggressive heel-striking, and bad posture. These poor running elements may, for example, produce excessive stresses to the knee, potentially resulting in Runner's Knee/Petellofemoral Pain Syndrome or other injuries.

[0024] The posture of a runner relates to the carriage of the body of the runner during running. Good posture (generally an up-right posture) may be achieved, for example, by standing tall and running with your head up and with your gaze directed straight ahead.

[0025] The cadence of a runner (i.e., the number of foot strikes per minute) may be important in ensuring good running form. In one embodiment, a cadence of about 180 foot strikes per minute may be optimal to prevent over-striding and to ensure proper running form regardless of the pace of the runner. In alternative embodiments higher or lower cadences may be used depending, for example, on the specific physiology, age, and/or goals of the user.

[0026] The lean of a runner may be utilized to reduce the need for excessive muscle force by advantageously utilizing gravity to assist in forward motion. In one embodiment, improved lean may be achieved by utilizing a running style including a forward lean over the whole length of the body without bending at the waist and by flexing at the ankle to reduce unnecessary muscle strain caused by toeing-off.

[0027] The foot strike location (i.e., the location, on the sole of the foot, of initial impact with a ground surface during each step) can be extremely important in promoting a good running form. Runners with a midfoot striking gait distribute pressure across the foot during a running gait cycle differently than runners employing a heel striking gait. In addition, the mechanical work performed by the lower extremity of a runner using a midfoot striking gait is distributed across the joints differently than a runner employing a heel striking gait. Runners with a midfoot striking gait primarily have pressure distributed in the lateral midfoot and forefoot region of the foot at initial impact and exhibit more ankle flexion (dorsiflexion) subsequent to the initial impact. Runners with a heel striking gait primarily have pressure distributed in the lateral heel at initial impact and generally do not exhibit as much ankle flexion after impact. As a result, heel strikers tend to have larger stresses placed on their knee which can lead to injuries such as Runner's Knee/Patellofemoral Pain Syndrome. Consequently, rearfoot/heel strikers potentially have a less efficient running gait than midfoot strikers, with heel striking and overstriding often causing braking. An example shoe conducive to a midfoot striking gait is described in U.S. Patent Publication No. 2009-0145005. In addition, a midfoot striking gait may provide a superior running form than a pronounced forefoot running gait (which may, for example, cause calf-strain and Achilles strain). One embodiment of the invention may include the use of one or more sensors to determine the location, on the sole of the foot, of initial impact with a ground surface during each step, and/or determine that angle of the foot with respect to the ground surface at initial impact (which may be used to determine foot strike location).

[0028] One embodiment of the invention includes a system **100** for providing biofeedback information to a runner **115** for use in improving running form. The system **100**, as shown in FIG. 1, includes one or more sensors **105** attached to (e.g., embedded within, fixedly coupled to, or releasably coupled to) a portion of a shoe **110** of a runner **115** to measure one or more data conditions/performance characteristics during athletic activity (e.g., a run). The system **100** also includes one or more remote receiving systems **120** for receiving data from the sensor(s) **105** and communicating information to the runner based on an analysis of the gathered data. The analysis of the gathered data may be carried out in a processor located in the shoe **110**, the remote receiving system **120**, and/or a separate analyzing unit (e.g., a personal computer). One or more sensors **105** can be placed in each shoe **110** of the runner **115**, or in only a single shoe **110** of the runner **115.**

[0029] The sensor(s) may be integrally embedded within the shoe and, for example, within one or more portions of a sole (e.g., an outsole, midsole, or insole) of a shoe. One or more sensors may also be integrally embedded within one or more portions of an upper of a shoe. In another embodiment, one or more sensors may be releasably attachable to a portion of the sole and/or upper of a shoe. For example, a sensor unit may be adapted to clip to a portion of an upper of a shoe (e.g., an outer mesh layer of the shoe or a lacing section of the shoe), and/or be releasably attached to a portion of a sole of the shoe. The sensor(s) may be releasably attached through any appropriate attaching elements including, but not limited to, a hook and loop fastening (e.g., Velcro®), a clip, a pin, lacing, magnetic elements, and/or an adhesive.

[0030] Various sensors may be utilized to measure one or more data conditions during athletic activity. Example sensors include, but are not limited to, mechanical feedback devices (e.g., retractable pins that retract upon contact with the ground to measure and indicate a ground contact and/or a force associated therewith, or pins or other structures that provide a tactile sensation to a user during foot strike), accelerometers, piezoelectric sensors, rotary position sensors, gyroscopic sensors, temperature sensors, chemical sensors (e.g., sensors for measuring oxygen levels), GPS devices, pressure sensors (e.g., pressure transducers), force sensors (e.g., load cells, force transducers, or stress/strain sensors), and/or goniometers. Example pressure/force sensors include, but are not limited to, resistive, capacitive, impedance based, and/or piezoelectric sensors. The sensors may measure data conditions at a localized position or be strips or pads adapted to measure data conditions (e.g., pressure and/or force) over an extended area. In various embodiments other electromagnetic, mechanical, and/or optical sensors may be used in addition to, or in place of, the sensors listed above.

[0031] One or more sensors may be placed at any appropriate location on the shoe and, for example, within a forefoot portion, a midfoot portion, and/or a heel portion of a shoe sole and/or upper. In one embodiment, as shown in FIG. 2, a shoe **110** includes a forefoot sensor **105** located in a forefoot portion **117** of the shoe **110**, and a heel sensor **105** located within a heel portion **122** of the shoe **110**. Sensors may be placed at other locations on the shoe **110** in addition to, or in place of, the forefoot portion **117** and heel portion **122**. For example, one or more midfoot sensors **105** may be located at a midfoot portion **125** of a shoe **110,** as shown in FIG. 3. The various sensors **105** may be positioned within or above a sole **130** of the shoe **110** (e.g., within a cavity in the midsole of the shoe or in an insole place within the shoe) and/or be positioned within or on an upper **135** of a shoe **110.**

[0032] In one embodiment, a plurality of sensors **105** (i.e., a sensor array) are positioned at various locations along a length of the shoe **110**, or a portion thereof, as shown in FIG. 4. These sensors **105** may be positioned at a number of locations substantially along a central axis **140** of the sole **130**, as shown in FIG. 5, or at a number of locations along a medial side **145** and/or a lateral side **150** of the sole **130**, as shown in FIG. 6. Any appropriate number of sensors **105** may be positioned at any appropriate locations over the length and width of the sole **130** of the shoe **110**, with the sensors **105** embedded within, or releasably attached to, an outsole, midsole, and/or insole of the sole **130**, depending upon the specific data and running traits being measured. In one embodiment, one or more of the sensors **105** may be exposed on an outer surface of the sole **130**. Alternatively, or in addition, one or more of the sensors **105** may be embedded within the sole **130**.

[0033] In one embodiment, one or more sensors **105** may be placed in a removable insert that may be positioned inside a shoe, for example as a removable insole or as an insert adapted to fit within a cavity or pocket formed within a portion of the shoe sole or upper (e.g., in a heel pocket of tongue pocket). For example, a shoe **110** may be formed with a sole portion **130** having a cavity **170** adapted to releasably receive an insert **175** holding one or more sensors **105** therein, as shown in FIG. 7. The cavity may include a covering portion adapted to cover and protect the insert during operation. The cavity **170**, or cavities, may be placed at any location within the forefoot portion **117**, midfoot portion **125**, and/or heel portion **122** of the shoe **110**. In various embodiments the cavity **170** may be accessed from the interior of the shoe, as shown in FIG. 7, or through an opening in an outer surface of the outsole **130** of the shoe **110**.

[0034] In one embodiment, one or more sensor pads or strips may be affixed to, or embedded in, a sole **130** of a shoe **110.** For example, FIG. 8 shows a sole **130** having a heel sensor pad **180** located at a heel portion **122** along a lateral side **150** of the sole **130,** with a midfoot sensor pad **185** located at a midfoot portion **125** along the lateral side **150** of the sole **130.** Sensor pads or strips can be positioned along a medial side, lateral side, and/or central portion of the sole, or span across a width of the shoe, or a portion thereof. For example, FIG. 9 shows a sole **130** having a midfoot sensor pad **185** located at a midfoot portion **125** along the lateral side **150** of the sole **130,** but also having a heel sensor pad **190** spanning across the width of the heel portion **122** and a forefoot sensor pad **195** spanning across the width of forefoot portion **117**.

[0035] In various embodiments sensor pads and/or strips may be positioned on any portion of the shoe sole. The sensor pads or strips can be embedded within an outsole, midsole, and/or insole, or be positioned between adjoining layers of the sole. Alternatively, the sensor pads or strips can be located in a removable insert (e.g., a removable insole) that can be placed into the shoe, or attached to an exterior, ground contacting, surface of the sole.

[0036] Alternatively, one or more sensors **105** may be placed within an insert **160** that may be releasably attached to the shoe **110** at a lacing portion **165,** as shown in FIG. 10, or on one or more portions of an upper **135** of the shoe **110**, as shown in FIG. 11.

[0037] The sensors **105** may be used to measure the location and distribution of each foot strike of each foot on the ground during running and/or the force and/or pressure applied to various portions of the foot during running. The measured data may be processed to produce biofeedback information that may be used to train a runner to run with a more efficient and safer foot strike location, such as with a midfoot strike. The data may be processed and communicated to a runner instantaneously, or substantially instantaneously, to give the runner immediate feedback during a run. The data may also be stored and used to generate both mean and time dependent results after the run is completed, thereby providing a runner and/or a coach with a full analysis of the runner's performance over the course of the run.

[0038] The sensors **105** may also be used to measure the cadence of the runner during a run, in addition to the foot strike information, by recording the time between each foot strike. Again, the measured data may be processed and communicated to a runner instantaneously, or substantially instantaneously, to give the runner immediate feedback during a run and/or be stored and used to generate both mean and time dependent results after the run is completed.

[0039] In one example embodiment, a shoe **110** may include a sensor **105** comprising a mechanical feedback device (e.g., a pin) located in a sole of a shoe **110** and, for example at the heel portion. Data measured and transmitted from the sensor **105** can be used to determine when a runners heel is in contact with the ground, thereby producing information that can be used to provide the runner with a better awareness of their gait.

[0040] One embodiment of the invention includes one or more sensors **205** positioned either in or on the upper **135** or sole **130** of a shoe **110** (as described hereinabove for the sensors **105**) to measure data that can be utilized to determine a runner's posture and/or lean during a run. For example, one or more sensors **205** (e.g., goniometers) can be fixedly embedded or releasably attached to an upper **135** of a shoe **110** to measure data that can be processed to provide biofeedback information related to a runners posture and/or lean, as shown in FIG. 11. The sensors **205** may operate independently from, or in concert with, sensors **105** for measuring foot strike and/or cadence. In one embodiment, the sensors **205** can communicate data to a remote receiver using the same transmitter as utilized by the sensors **105**. Alternatively, the sensors **205** may utilize a separate transmitter. In an alternative embodiment, sensors for measuring the posture and/or lean of the user may be positioned at other locations on a body of a user (e.g., on an ankle, leg, waist, arm, or chest of the user).

[0041] In one embodiment, one or more sensors can be embedded within, or releasably attachable to, an item of apparel wearable by a runner. Alternatively, or in addition, one or more sensors can be mounted on a strap that may be worn by a runner, or removably affixed to a portion of a runner by a skin sensitive adhesive or tape. These sensors can be used in addition to, or in place of, sensors on a shoe to provide biofeedback information related to a performance characteristic of a runner.

[0042] In addition to providing biofeedback information related to a runners proper running form (e.g., foot strike, cadence, posture, and/or lean information), the systems described herein may include sensors for measuring other parameters related to a runners performance including, but not limited to, distance, pace, time, calories burned, heart rate, breaths per minute, blood lactate level, and/or muscle activity (EMG). For example, measuring blood lactate levels may be of use in determining lactate threshold data in long-distance runners and other athletes.

[0043] In various embodiments, the sensors **105**, **205** may be powered by one or more battery elements coupled to the sensors **105**, **205**. The batteries may be single use, replaceable batteries or be rechargeable batteries. The rechargeable batteries may be recharged by any appropriate means. Alternatively, the sensors **105**, **205** may utilize the biomechanical action of a runner for power.

[0044] The sensors **105**, **205** may be coupled to one or more transmitters for transmitting measured data to a remote receiver. The transmitter may include, or consist essentially of, a wireless transmitter and, more particularly, a radio frequency transmitter and/or an infrared transmitter. For example, the transmitter may be a radio transmitter adapted to transmit short wavelength radio transmissions via Bluetooth®, Bluetooth® Low Energy, and/or ANT or ANT+ protocols. In one embodiment the system may include a transmitting system capable of transmitting over a plurality of transmission protocols, thereby allowing the device to communicate with multiple different receiving systems. The transmitter may also, in one embodiment, be capable of receiving information transmitted from a remote source. This information may be utilized, for example, to turn on/off the sensors, calibrate the sensors, and/or control one or more function of the sensing system.

[0045] The data measured by the sensors in or on the shoe(s) can be transmitted to a remote receiving system for recording and/or analysis. An example system **300** for providing biofeedback information including both a sensing unit **305** and a receiving/analyzing unit **310** is shown in FIG. 12. The sensing unit **305** can include elements such as, but not limited to, one or more sensors **315**, a power source **320**, and a transmitting/receiving element **325**. The sensing unit **305** can be positioned in or on a shoe and/or piece of apparel (as described herein). The remote receiving unit **310** can include elements such as, but not limited to, a transmitting/receiving element **330** for receiving the transmitted data from the sensing unit **305**, a remote user feedback element **335** for receiving the data, a storage unit **340** for storing raw and/or analyzed data, a communication element **345** (e.g., a visual display such as a graphical user interface (GUI), an auditory communication element, and/or a tactile user interface) for communicating biofeedback information determined from the analyzed data to an athlete, and a power source **350**. The transmitting/receiving element **330** can also be used to communicate with a remote database, such as an online database for an online running/coaching community, thereby allowing biofeedback information to be transmitted to the remote database and allowing biofeedback information, training instructions, software updates, or other digital information to be transmitted from the remote database to the receiving/analyzing unit **310**.

[0046] Another example system **300** for providing biofeedback information is shown in FIG. 13. In this embodiment, the sensing unit **305** additionally includes an analyzing element **355** and a storage unit **360**. Including an analyzing element **355** and a storage unit **360** in the sensing unit **305** allows for initial processing of the raw data from the one or more sensors **315** to be carried out in the sensing unit **305**, with the raw and/or analyzed data stored in the storage **360** within the sensing unit **305**. As a result, only the processed data, or a small package of information representative of the processed data, need be transmitted from the sensing unit **305** to the remote user feedback element **355**, thereby reducing the quantity of information that needs to be transmitted between devices in order to provide real-time feedback to a user. This in turn reduces the drain on the power sources **320**, 3**50**, thereby extending the run-time and efficiency of the system **300**. In addition, storing raw and/or processed data within the sensing unit **305** allows the data to be downloaded into an analyzing device (e.g., a computer) for further processing after the run is completed, regardless of whether the data was received by a remote user feedback element **355** during the run.

[0047] The remote receiving unit **310** may, for example, be a watch, a portable media player (such as, but not limited to, an Apple Inc. iPod®), a customized receiving unit adapted to be worn by the user (e.g., attached to a detachable strap or adapted to fit in a pocket of the user's garments), a mobile phone or smart phone (such as, but not limited to, an Apple Inc. iPhone® or a Research In Motion Ltd. Blackberry®), a portable GPS device, an earpiece, and/or an item of headgear (e.g., a hat, visor, sunglasses, etc). Alternatively, or in addition, the remote receiver may be a laptop computer, a tablet computer, a desktop personal computer, and/or an athletic training system (e.g., a treadmill). In one embodiment the transmitting/receiving element **330** can be a separate unit (for example, a dongle- i.e., a hardware or software "key" allowing two remote devices to communicate) that is adapted to plug into a smart phone or computer to allow communication between the sensing unit **305** and receiving/analyzing unit **310**.

[0048] The biofeedback information could be communicated to the runner through an auditory, optical, and/or tactile (e.g., vibratory) signal. Auditory signals can, for example, be communicated through a speaker (e.g., a small speaker within the shoe, the sensing unit, and/or receiving device) and/or in an earpiece or headphones worn by the athlete. Optical signals can, for example, be communicated through a visual display on a receiving device (e.g., a visual display on a smart phone screen) or through one or more optical transmitters such as, but not limited to, a light-emitting diode (LED) light source, coupled to the runners shoe and/or to an optical transmitter attached to a piece of apparel or strap worn by the runner. Vibratory signals may be communicated to the runner through a vibration inducing element within the receiver and/or within or attached to the shoe.

[0049] The biofeedback information generated through analysis of the measured data from the sensor(s) can be relayed back to the athlete either in any appropriate auditory form such as, but not limited to, a voice command and/or a warning signal. For example, the information may be communicated via a software generated spoken communication providing information and/or instructions to a runner (e.g., "You are now running on your heel"; "Your cadence is too low"; etc). Alternatively, or in addition, the auditory signal may include a click, beep, or other simple signal that can provide a runner with a warning if their running form does not meet a certain requirement and/or provide a positive signal if their running form does meet the required parameters. Such simple auditory signals can also be used to provide timing information (similar to a metronome) to give a runner a target cadence during a run. In addition, or alternatively, the auditory signal may include a change in a pitch, or speed of a musical composition being played to a user depending upon the actual cadence of a user with respect to a target cadence). By providing this practically real-time feedback, the athlete is able to make quick adjustments to their gait during the run.

[0050] In various embodiments the biofeedback information may be automatically communicated to the athlete, be communicated upon prompting from the runner (e.g., by initiating a communication command in the receiver), and/or be communicated as a summarized report at set periods (e.g., at the end of a set distance or period covered the athlete could receive summarized biofeedback information relating to his/her performance over the last mile covered and/or the entire distance covered - e.g. "You spent 20% of your time on your heel over the last mile").

[0051] One embodiment of the invention can include a system having one or more sensors that are placed inside a shoe of a runner to record foot strike. This information is converted to an auditory signal that is made through a small speaker embedded within, or attached to, the shoe of the runner. As a result, in this embodiment a separate receiving/communicating unit would not be needed to provide feedback to the runner.

[0052] In addition to, or instead of, providing real-time biofeedback information, the information may be stored by the system for later analysis by the athlete and/or a coach. This information may be used, for example, to provide an athlete with a history of their runs and their performance during each run. In one embodiment the biofeedback system merely stores data from the sensor(s) as simple raw data, with the processing and analysis of the data being performed by a processing unit upon completion of the run by downloading the raw data to the processing unit. This may be advantageous, for example, in minimizing the size, weight, and/or cost of the actual biofeedback system being carried by the athlete during a run, while still allowing for detailed analysis of the data to be communicated to the athlete and/or coach upon completion of the run.

[0053] The processed data may also be uploaded to a shared computer drive or a storage drive (e.g., a cloud computing system) for an online community, thereby allowing the information, or portions thereof, to be reviewed remotely by a coach and/or fellow athlete. In one embodiment, processing and analysis of the data transmitted from the sensors can be carried out by one or more application software programs ("Apps") that may be downloaded onto a smart phone or other electronic device. Such "Apps" can be programmed to analyze data and present biofeedback information in any appropriate way, depending upon the specific training requirements of an athlete.

[0054] An example system **400** for monitoring one or more athletic performance characteristic of a user, providing real-time biofeedback information relating to the performance characteristic(s), and/or downloading data associated with the performance characteristic to a computer **455** is shown in FIG. 14. In this embodiment, a sensing unit **405** is adapted to be releasably or fixedly attached to a body portion of a user and, for example, a shoe of a user. The sensing unit **405** can include one or more sensing elements (e.g., a gyroscopic sensor, an accelerometer, etc) for monitoring one or more athletic performance characteristics of the user during an athletic activity such as running. The sensing unit **405** can also include elements such as, but not limited to, one or more power sources (e.g., a rechargeable or replaceable battery), a processing/analyzing unit (e.g., a microprocessor), a memory, an RF transmitting and/or receiving unit, and/or one or more dock contacts **460** for allowing the sensing unit **405** to dock with another device. Docking with another device may, for example, allow for the transferring of measured data (raw and/or processed) from the sensing unit **405** to an analyzing device (e.g., a computer), the transmission of software applications, instructions, upgrades, or settings (e.g., firmware pushes) to the sensing unit **405** from the analyzing device, and/or the recharging of the power source of the sensing unit **405.** The dock contacts **460** may include a USB port or other appropriate port for connecting the sensing unit **405** to a receiving/analyzing device.

[0055] Data related to the one or more performance characteristics can be transmitted **430** from the sensing unit **405** to one or more remote real-time feedback (RTF) receiving devices **410** and/or to a remote analyzing and storing device **455** (e.g., a computer) for later analysis and long-term storage. The RTF unit **410** may be any of the devices described herein. FIG. 14 shows a system wherein a smart phone **420** and/or a watch **415** can be used to provide real-time feedback to the user. The data associated with the performance characteristic(s) of the user can be transmitted through any appropriate RF signal such as, but not limited to, Bluetooth®, Bluetooth® Low Energy, and/or ANT or ANT+ protocols. In one embodiment the RTF **410** (e.g., the smart phone **420**) can communicate directly with the sensing unit **405** without the need for any additional hardware or software. In an alternative embodiment, a dongle **450** may be used to facilitate communication between the RTF **410** and the sensing unit **405**.

[0056] In one embodiment, the RTF **410** can receive and analyze information from one or more sensing unit **405** and receive and analyze data from other sensors or sources in addition to the sensing unit **405** (e.g., one or more sensors embedded within or directly attached to the RTF **410** and/or one or more additional remote sensor units communicating wirelessly with the RTF **410**), thereby allowing for the simultaneous processing of information associated with multiple performance characteristics of the user. For example, the RTF **410** can include, or can communicate with, performance measuring devices such as heart-rate monitors, GPS monitors, speed/distance/time monitors, oxygen level monitors, breathing rate monitors, energy usage monitors, etc.

[0057] In various embodiments the RTF **410** can communicate remotely with a computer **455** or other processing/storage device (e.g., a cloud computing system) through a wireless connection, and/or dock with a docking port **460** on the processing/storage device to allow for direct communication therebetween after a run is complete. The RTF **410** may, for example, be adapted to allow for either one or two-way wireless or direct "docked" connection between the RTF **410** and the sensing unit **405**, thereby allowing the RTF **410** to download software application, instructions, upgrades, or settings to the sensing unit **405** and/or upload raw and/or processed data from the sensing unit **405** after a run is complete. For example, the sensing unit **405** can send small data packages representative of the performance characteristic (e.g., a foot strike location of a user) to the RTF **410** wirelessly during a run, with the raw data being stored on the sensing unit **405** and downloaded to the RTF **410** and/or to a remote analyzing receiving device **455** through a physical wired connection for further processing after the user's run is complete. The raw and/or processed data can then be stored in the RTF **410** and/or communicated **425** to an analyzing/storage device **455** or facility from the RTF **410**.

[0058] In one embodiment, a software application ("App") can be provided to an RTF **410** (e.g., a smart phone **420**) to control various functions of the RTF **410** and facilitate the receiving of performance characteristic information from the sensing unit **405** and the communication of the associate performance information to the user.

[0059] The RTF **410** device (e.g., the smart phone **410** or the watch **415**) can communicate information to the user in a variety of ways including, but not limited to, through a visual display screen, through audio signals emitted directly from the RTF **410** or communicated to the user though a wired or wireless (e.g., Bluetooth®) headphone connection, and/or through a vibration emitted by the RTF **410**. Such information can be communicated constantly in real-time or at selected intervals. In one embodiment foot strike location information (e.g., a heel strike, a midfoot strike, or a forefoot strike) is communicated to the user, while additional performance characteristics information (e.g., cadence, heart rate, speed, distance travelled, time, etc) can be communicated at the same time, or substantially at the same time, as the foot strike information, or be communicated independently from the foot strike information.

[0060] The sensing unit **405** and RTF **410** may be attached to the user in various manners, depending upon the particular performance characteristics being monitored, the particular RTF **410** being used, and the particular real-time feedback being provided to the user. For example, one or more RTFs **410** can be mounted to a wrist, arm, waist, hip, shoulder, head, chest, or leg of a user **435**, or be placed in a pocket of a garment of the user **435** or in a bag carried by the user **435**. Example configurations of sensing unit **405** and RTF **410** can be seen in FIGS. 15-19. In FIGS. 15-19 the sensing unit **405** is mounted on a fastening portion of the shoe (e.g., releasably attached to the laces of a laced shoe). The biofeedback system **400** may utilize a single sensing unit **405** attached to only one foot of a user, as shown in FIGS. 15-16 and 18-19, or utilize sensing units **405** attached to both feet of the user, as shown in FIG. 17.

[0061] Using a sensing unit **405** on both feet allows the system **400** to accurately monitor performance characteristics such as foot strike location on both feet during a run. However, as running gait is often reasonably symmetric (i.e., it is rare for a runner to heel-strike with one foot while midfoot striking with the other foot), valuable training information and biofeedback can be obtained from the use of only one sensing unit pod **405**, with the user able to switch the foot on which the sensing unit **405** is mounted between runs (or even during a break in a run) to ensure that feedback relating to the foot strike location on both feet can be provided over time. In addition, additional performance characteristics such as cadence can be obtained through use of only a single sensing unit **405** (as the cadence will be related to twice the number of foot strikes recorded by the sensing unit **405** on only one foot).

[0062] In the embodiment of FIG. 15, the RTF **410** is a wrist-based device **465** (e.g., a watch **415** or other appropriate RTF device such as a custom device specifically adapted to receiving information from the sensing unit **405** and communicating that information to a user) strapped to a wrist of the user **435** by a releasable strap or band **440**. The wrist-based device **465** can include a visual display to provide a visual indication of the information, include a tactile device to provide a tactile sensation (e.g., a vibration) to the wrist if an event (e.g., a heel strike) occurs, and/or include a speaker to provide an auditory signal if an event (e.g., a heel strike) occurs.

[0063] The embodiment of FIG. 16 uses a smart phone **420** including a software application for controlling functionality of the smart phone **420** to allow it to act as an RTF **410**. The smart phone **420** is releasably attached to the upper arm of the user **435** by a strap or band **440**. As with the watch **415**, the smart phone **420** can communicate information to the user **435** through a visual display, a vibration, and/or an auditory signal. For example, the smart phone **420** may output an auditory signal that may be communicated to the user **435** through a pair of headphones **445**, as shown in FIG. 17. Utilizing an RTF **410** having two-way communication functionality (such as, but not limited to, a smart phone **420**) allows the RTF **410** to both receive information from the sensing unit **405** and transmit information to another remote device (e.g., a computer **455**) and/or back to the sensing unit **405**.

[0064] In various embodiments other devices or garments may be used as an RTF **410** for receiving information from the sensing unit **405** and communicating information to the user **435**. In the embodiment of FIG. 18, for example, a user **435** may wear a visor **470** that has a receiving element embedded therein or attached thereto. The receiving element may then process the data, if necessary, and communicate information to the user **435** through a visual display element 475 mounted to the visor **470.** The visor can also include an auditory feedback element (e.g., a speaker or a headphone connection) and/or a vibratory feedback element in addition to, or instead of, the visual display **475.**

[0065] In the embodiment of FIG. 19, the RTF **410** may include, or consist essentially of, a hand-held device **480**, which can be held in a hand of a user **435** during a run. An example hand-held device **480** is shown in FIG. 20. As with other RTFs **410**, the hand-held device **480** can include a variety features such as, but not limited to, user communication elements, controls, and communication ports. As shown in FIG. 20, the hand-held device **480** can include a visual display screen **485** to provide visual information to the user **435,** a headphone jack **490** to allow for auditory signals to be sent to the user **435**, and a handle **495** having a vibration element held therein to provide tactile feedback to the user **435**. Alternatively, or in addition, the hand-held device **480** can include one or more speakers to communicate an auditory signal to the user **435** without the need for headphones. The hand-held device **480** can also include control buttons **500** to allow the user to control one or more function of the hand-held device **480** and one or more communication ports **505** (e.g., a USB port) to allow for the downloading and uploading of information between the hand-held device **480** and another device (e.g., a computer **455**), and to provide a charging port for the hand-held device **480**.

[0066] According to the invention, the sensing unit **405** includes a gyroscopic sensor that is adapted to measure an angular velocity of the shoe during athletic activity. Analysis of this angular velocity data can then be used to determine foot strike information relating to the user's running style, thereby allowing the user to be informed of whether a particular foot strike was a heel strike, a midfoot strike, or a forefoot strike. This information can be communicated to the user in real-time, at set intervals, and/or be stored in the sensing unit **405** for later analysis and processing. In addition, data from a gyroscopic sensor can be used to determine when a foot strike occurs, thereby allowing for the measurement of cadence (i.e., number of foot strikes per minute) information for the user. For example, foot strike location information (e.g., a heel strike, a midfoot strike, or a forefoot strike), cadence information, and/or other performance characteristic information can be communicated to the user upon every foot strike. In addition, compiled and/or averaged performance characteristic information can be communicated to the user upon the completion of a preset or user selected number of foot strikes, upon the completion of a preset or user selected distance travelled or time travelled, upon request from the user, and/or at the end of a run.

[0067] In one embodiment, a sensing unit including a gyroscopic sensor can be releasably mounted to an upper of a shoe at a fastening portion (such as a lacing portion or hook-and-loop fastening portion) located centrally, or substantially centrally, on the top of the shoe. An example gyroscopic sensor unit **510** mounted to the lacing portion **520** of a shoe **515** is shown in FIGS. 21 and 22. Alternatively, the gyroscopic sensor unit **510** can be mounted to a heel portion **525** of a shoe **515,** as shown in FIGS. 23 and 24, or to any other appropriate location on the upper or sole of the shoe **515,** depending upon the shoe, the specific mounting arrangement required, and/or the measurement and calibration requirements of the sensor.

[0068] The gyroscopic sensor may be a one-axis sensor, a two-axis sensor, or even a three-axis sensor, allowing for the measurement of angular velocity (x', y', z') about any axis (X,Y,Z), as shown in FIG. 25, and thereby allowing for the measurement of a variety of performance parameters associated with a foot strike. For example, careful analysis of an angular velocity measurement z' about the Z-axis allows for the identification of a foot strike location (i.e., a heel strike, a midfoot strike, or a forefoot strike) of a user during a stride, and thereby also provides information as to whether a user's foot is dorsiflexed (heel strike), plantarflexed (forefoot strike), or neutral (midfoot strike) upon impact with a ground surface. Similarly, careful analysis of an angular velocity measurement x' about the X-axis allows the system to identify whether a user's foot is pronating (wherein the ankle caves inwards towards the other foot) or supinating (wherein the ankle caves outwards away from the other foot) at impact with a ground surface. In addition, analysis of an angular velocity measurement y' about the Y-axis allows the system to identify whether a user's foot is abducting (wherein the forefoot rotates outwards away from the other foot) or adducting (wherein the forefoot rotates inwards towards the other foot) at impact with a ground surface.

[0069] In general, the goal of an algorithm processing raw z' angular velocity data from the gyroscopic sensor(s) is to accurately detect the direction and speed of the foot's rotation at the moment of impact with a ground surface, and to determine from this the type of foot strike (i.e., forefoot, midfoot, or heel strike) and the severity of the foot strike (e.g., severe heel strike, intermediate heel strike, mild heel strike, midfoot strike at rear of midfoot, midfoot strike at center of midfoot, midfoot strike at front of midfoot, mild forefoot strike, intermediate forefoot strike, or sever forefoot strike). An example method of calculating foot strike location information from a gyroscopic sensor reading is discussed below. In this embodiment, only data from one single-axis of a gyroscopic sensor is required to measure foot strike location and cadence.

[0070] The data recorded from the gyroscopic sensor may be considered to be periodic, with each gait cycle being one period. During a normal gait cycle, the foot often has a positive rotation just before the foot strike (see, for example, FIGS. 26 and 27). After the foot strike, during the stance phase of the gait, the foot is flat on the ground and is relatively motionless. The foot strike occurs during a short time period (e.g., between about 10ms to 50ms and, for example, about 30ms or so) between the end of the swing phase and the start of the stance phase, with the angular velocity data (z') about the Z-axis during that period providing information that can be analyzed to determine the type of foot strike.

[0071] During a heel striking event the heel touches the ground first, followed by a rapid rotation of the foot forwards until the sole is flat against the ground. As a result, a large positive rotational velocity during a foot strike event, accompanied by little or no negative rotational velocity, is measured for a heel strike. In contrast, midfoot striking is indicated by a smaller positive rotational velocity followed by a clearly defined negative rotational velocity, while a forefoot strike shows a larger negative velocity than that observed for a midfoot strike. Thus, there is a clear qualitative difference in the gyroscopic sensor data about the Z-axis between heel striking and forefoot/midfoot striking. It is often found that the maximum localized rotational velocity occurs close to, but slightly after, the initial impact during a foot strike event.

[0072] In one embodiment, raw data from the gyroscopic sensor can be analyzed to determine foot strike location for a foot strike event. In an alternative embodiment, preprocessing of the data (for example through amplification and/ or low-pass, high-pass, band-pass, band-stop, and/or butterworth filtering) may be carried out prior to analyzing the data to determine foot strike information. The sample rate of the gyroscopic sensor can also be set at any appropriate rate to ensure that the sample rate is sufficient to obtain accurate information without sampling at a rate that would draw too much power and/or take up too much storage space. The sample rate may be set, for example, at between 500 to 5000Hz or between 500 and 2000Hz or, more particularly, between 800 and 1500Hz and, for example, at about 900Hz. In one embodiment, a sample rate of about 900Hz may be set to ensure that at least about 300 samples are taken per stride.

[0073] Example gyroscopic sensor data for a heel strike is shown in FIG. 26, while example raw gyroscopic sensor data for a midfoot strike is shown in FIG. 27. Three foot strike events are shown in each graph. As shown, the midfoot strike exhibits a positive spike **550** followed by a negative spike **555**, with the negative component showing that the foot is rotating "backwards" (i.e., the heel is coming down relative to the toe) after initial impact. Conversely, the heel strike has a positive spike **550** but does not have a negative component (i.e., the local minimum **575** is never less than zero), showing that the foot is rotating "forwards" (i.e., the toe is moving down relative to the heel). A forefoot strike is characterized by having a small positive peak **550** relative to the negative peak **555**, showing that the foot is rotating backwards more severely than for a midfoot strike. Cadence can be determined simply by counting the number of foot strike events over a specified time.

[0074] According to the invention, a microprocessor analyzes each angular velocity sample from the gyroscopic sensor and determines whether or not a foot strike has occurred. To find the moment of foot strike, the microprocessor first needs to distinguish one stride from another with a periodic trigger, as shown in FIG. 28. When the foot is swinging forward, the toe is moving up and the rotational velocity is negative. When the rotational velocity is negative, the microprocessor adds each sample to a sum. When the sum reaches a preset level, a flag is set and the sum resets **560**. This happens once for each stride, just before the moment of the foot strike. After the flag is set, the microprocessor starts looking for a maximum value **550**. Once found, it finds the minimum value **555** within a set window. It is the ratio of this maximum and minimum value that determines the rating for the foot strike.

[0075] The window during which the maximum and minimum angular velocity measurements are taken for the foot strike location analysis may be set to any appropriate size and starting point to ensure that the required maximum and minimum peaks are captured without additional, non-relevant, data contaminating the calculation. For example, the window may be set to capture and analyze data starting at, and/or ending at, a particular identifying event during the periodic data cycle or a specific time period or specific number of samples prior to or after a particular identifying event during the periodic data cycle, and/or be set to cover a specific time period or a specific number or samples from a set starting point, as appropriate.

[0076] In one embodiment the window may begin from the moment of initial impact, or the moment of the first local maximum angular velocity after the initial impact, and continue until a point at or after a first local minimum angular velocity measurement is observed. Alternatively, the window may be set to review data captured within a specific time window (e.g., between lams to 50 ms and, for example, about 30ms) or sample size starting at the moment of initial impact, or at the moment of the first maximum rotational value peak after initial impact, or at any other appropriate time prior to, at, or after the instant of initial impact. In another embodiment, the window for analysis may open at the time at which the angular velocity is zero prior to initial impact, and close at the time at which the angular velocity transitions from negative to positive after the local minimum angular velocity is observed.

[0077] In one embodiment, a determination of the foot strike location can be calculated by comparing the maximum value with the minimum value within the sample window in accordance with the following equation:

$$\text{Foot strike Location Rating (F)} = \left|(\text{Local Minimum value} * 100)/\text{Local Maximum Value})\right|$$

[0078] The results of this calculation produce a non-dimensional value from F_{min} to F_{max} (for example, a value of between $F_{min} = 0$ and $F_{max} = 100$), with F_{min} indicating a severe heel strike, F_{max} indicating a severe forefoot strike, and values in the middle of the range indicating a midfoot strike. The specific values identifying each range may, for one example user, be:

X_1 to X_2 = heel strike (with "X_1" indicating a sever heel strike and values closer to X_2 indicating a more mild heel strike)
X_2 to X_3 = midfoot strike
X_3 to X_4 = forefoot strike (with "X_4" indicating a sever forefoot strike and values closer to X_3 indicating a more mild forefoot strike)

[0079] The values for X_3 and X_4 may be either preset or be calibrated and/or selected to ensure accuracy for a specific user. Example ranges for the values of X_2 may be about 15-40 or, more particularly, about 20-30 or 20-25 or, more particularly, about 20. Example ranges for the values of X_3 may be about 60-80 or, more particularly, about 65-75 or 65-70 or, more particularly, about 70.

[0080] Additional processing may be carried out to provide accurate foot strike position information, if appropriate. For example, a Gaussian multiplier or other appropriate 2nd order multiplier may be applied to assist in analyzing the results. Additionally, or in the alternative, results outside a set results window (e.g., outside the ranges F_{min} to F_{max}) may be either discarded or shifted to a preset default value. For example, any result greater than F_{max} can either be shifted to indicate a value "F_{max}" or be discarded entirely.

[0081] In an alternative embodiment which is not part of the invention, a ratio of the integral of the negative portion of the curve **565** against the integral of the positive portion of the curve **570** (i.e., from calculations of the area under the negative portion of the curve **565** and the positive portion of the curve **570**) may be utilized to produce the foot strike location rating, rather than ratios of the absolute values of the minimum and maximum local peaks. The data to be integrated may be taken over any appropriate window size. Utilization of integrated results may be useful, for example, in producing accurate readings in situations where the sample rate of the gyroscopic sensor is insufficient to ensure that accurate local maximum and minimum peak values can be obtained. In addition, the integral of rotational velocity relates to a change in angle of the foot, which may produce valuable performance characteristic information relating to the foot strike of a user. Where beneficial, various other embodiments may utilize other appropriate algorithms for processing the data to determine the foot strike information.

[0082] In one embodiment, the sensor unit may be set to go into a "sleep-mode" (i.e., a reduced power consumption mode) during periods of inactivity. This sleep-mode may be set to turn on (when a sensor remains at rest for a given period) and off (when the sensor is moved) automatically. Alternatively, or in addition, the sensor unit may include a user interface (e.g., a hardware switch or a software "switch" initiated by a wireless signal from an RTF) allowing a user to turn the power to the sensor on and off manually.

[0083] In one embodiment, the gyroscopic sensor takes data continuously throughout an entire gait cycle. However, in an alternative embodiment, the gyroscopic sensor can be turned on and off during a gait cycle so that it only takes data during the foot strike event phase of the gait cycle. This may, for example, reduce power consumption by the sensor unit and/or reduce the amount of raw data being stored and/or processed by the sensor unit. For example, a separate sensor (e.g., an accelerometer) may be used in the sensor unit in addition to the gyroscopic sensor, with the accelerometer being used to indicate when a foot strike event is taking place and the gyroscopic sensor only capturing angular velocity data upon triggering by the system when the accelerometer data indicates that a foot strike event is occurring. Additionally, or alternatively, the accelerometer data may be used to calculate the cadence information (with the gyroscopic sensor data only being used for foot strike location calculations), and/or the accelerometer may be used to determine whether a user is standing still, walking, or running, with the gyroscopic sensor only being activated when the user is running. The accelerometer can, for example, determine whether a foot strike event is a walking foot strike or running foot strike based on the magnitude of the acceleration measured at impact (with, for example, a running foot strike indicated by a higher magnitude acceleration measurement).

[0084] The performance characteristic information (e.g., the foot strike location information) can be processed and communicated to the user in a number of ways. For example, in one embodiment, as shown in FIG. 29(A), the raw data can be processed to produce a foot strike location rating value of between F_{min} and F_{max} (e.g., between 0 and 100), with that value being stored and communicated to the user. In this example, the user would be provided with an accurate calculation of exactly where on the foot the centre of the initial foot strike impact occurred, with a further indication of whether this value represented a heel strike, a midfoot strike, or a forefoot strike being calculated based on the set values for X_2 and X_3.

[0085] In one embodiment, as shown in FIG. 29(B), the foot strike location rating value can be placed into one of a number of "bins", with the system communicating to the user which bin a particular foot strike (or an average foot strike) fell. In the embodiment of FIG. 29(B) the foot strike information is divided into nine bins (severe heel strike **605**, intermediate heel strike **610**, mild heel strike**615**, midfoot strike at rear of midfoot **620**, midfoot strike at center of midfoot **625,** midfoot strike at front of midfoot **630,** mild forefoot strike **635**, intermediate forefoot strike **640**, or sever forefoot strike **645**), although a greater or lesser number of bins may be used where appropriate. In a further alternative embodiment, the foot strike location rating value can be used to merely indicate whether a heel strike **650**, a midfoot strike **655**, or a forefoot strike **660** has occurred, as shown in FIG. 29(C).

[0086] By performing the analysis described hereinabove with a microprocessor within the sensor unit the performance characteristic data transmitted to a receiving unit can be limited to merely a small package or data representing the foot strike location rating value or the appropriate "bin" into which a given value falls. The cadence information can also be transmitted along with the foot strike information, or may be determined inherently from the time at which each foot strike value is transmitted. Minimizing the data that needs to be sent from the sensing unit to the RTF can reduce the power required by the system and thereby extend the running time of the system.

[0087] In various embodiments this information may be communicated to the user through a visual signal, an auditory signal, and/or a tactile signal. For example, an RTF could generate a sound (e.g., a buzz), cause a vibration, and/or flash a visual indicator only when a certain event occurs (e.g., a heel strike). Alternatively, different sounds, visual signals, and/or vibrations could be assigned to different events, thereby providing a different indicator to the user depending upon the event occurring. The severity of an event (e.g., a severe, intermediate, or mild heel strike) may be indicated, for example, by different sounds or by changes in the volume, pitch, tone, or other acoustic parameter of a given sound. Similarly, variations in the intensity or color and/or variations in the intensity of a vibration can be used to differentiate between different severities of a given foot strike event. In one embodiment the auditory, visual, and/or tactile signals associated with a specific foot strike position may be preset, or be selected by the user depending upon his/her particular preferences and the functionality of the RTF being used.

[0088] The sensing unit can, in one embodiment, include a housing unit adapted to house the sensor, a power source, a processor, and/or a transmitter. The housing unit may, for example, provide a protective casing for the sensor and other electronics and/or provide a mounting means by which the sensor can be mounted to the shoe of the user. The housing unit may be adapted to be releasably attachable to a sole and/or upper of the shoe of the user, or be fixedly attached to, or embedded within an upper and/or sole of the shoe. In one embodiment the housing unit is releasably attachable to at least one of a fastening portion (e.g., the lacing portion or a hook-and-loop fastening portion) of a shoe or a heel portion of the shoe. The housing unit may have an integrated mounting element for mounting the device to a shoe. Alternatively, the housing unit and mounting unit may be separate, attachable, elements that can be coupled together to mount the sensor package to the shoe. Example housing units **700** and mounting elements **705** are shown in FIGS. 30a to 33c.

[0089] The embodiment shown in FIG. 30a includes a housing unit **700** that is either fixedly or detachably attached to an elastic or inelastic mounting element **705** that includes hooked ends **710** for engaging the laces of a shoe. FIG. 30b includes a housing unit **700** having a plurality of elastic or inelastic hooks **715** extending from the housing unit **700** for engaging the laces or the eyelets of a shoe. FIG. 30c includes a housing unit **700** having a flexible or inflexible base unit **720** that can be placed under the laces of a shoe and be fixedly or detachably connected to the housing unit **700**.

[0090] FIGS. 30d and 30e include a flexible or inflexible base unit **725** that can be slid over the heel of a shoe or slid into a pocket on the heel of the shoe (as shown in FIG. 30d), or slid under the laces of a shoe (a shown in FIG. 30e). The base unit **725** may include pins for pinning the base unit **725** into one or more layers of the upper the shoe. Again, the base unit **725** can be fixedly or detachably attached to the housing unit **700**. FIGS. 30f and 30g show a similar configuration but with a latching element **730** allowing the end of the base unit **725** to latch onto the housing unit **700** to lock it in place when mounted to the shoe.

[0091] In one embodiment, as shown in FIG. 31a, magnetic elements **730** can be used to releasably attach a housing unit **700** to the upper of a shoe **735**, while in FIG. 31b pins **740** may be inserted through the upper of the shoe **735** to releasably or fixedly hold the housing unit **700** thereto. In another embodiment a detachable mounting unit **745** having a plurality of latching elements **750** can be placed below the laces **755** of a shoe, as shown in FIG. 32a and 32b, thereby allowing the housing unit **700** to be detachably mounted to the lacing portion of the shoe.

[0092] In one embodiment, as shown in FIG. 33a, a housing unit **700** can be slideably connectable with a mounting unit **760.** The mounting unit **760** may include flexible arms **765**, that can be pinched in to allow the ends **770** of the arms **765** to be hooked under the laces of the shoe or the sides of the lacing portion of the upper of the shoe. The arms **765** may alternatively be fixedly mounted to the housing unit **700**. In another embodiment, as shown in FIG. 33b, the housing unit **700** may be formed from a flexible elongate length of material with the sensor, a power source, a processor, and/or a transmitter held within. This flexible housing could, for example, be slid below the laces and held in place by the closing force applied by the laces to the shoe. In yet another embodiment a housing unit **700** may be releasably or fixedly mounted to a clip **775** that can be clipped onto the upper of a shoe at a heel portion (as shown in FIG. 33c) or over a lacing portion of a shoe, or be attached to the upper of a shoe through an adhesive attachment, a hook-and-ioop attachment, a pinned attachment, or any other appropriate attachment means.

[0093] In one embodiment data from a gyroscopic sensor coupled, for example, to an upper body of a user can be used to provide posture and/or lean information during a run. For example, a gyroscopic sensor in a smart phone or other RTF strapped to the upper body of the user (e.g., on the torso or upper arm of the user) can be used to measure posture and/or lean information that can be coupled with the foot strike and cadence information to provide the runner with a more complete analysis of their running form. The smart phone may then act as both a sensor unit and an RTF. In one embodiment, the user can calibrate the gyroscopic sensor within the smart phone or other RTF prior to use, for example by simply strapping the smart phone to their person and then standing upright (e.g., against a wall) to "zero" the sensor prior to the run.

[0094] In one embodiment, the foot strike position information may be supported by GPS data, or other appropriate data, that can be used to determine the altitude, and more particularly the change in altitude, of the user for a particular foot strike. More particularly, the altitude data can be used to determine whether a runner was running on a flat or substantially flat stretch of ground, or was running uphill or downhill, for each foot strike. This may be beneficial in providing context for each foot strike to ensure that accurate data and instructions are communicated to the runner, as even runners with good running for will tend to heel strike when running down a substantial incline and forefoot strike when running up a substantial incline.

[0095] In one embodiment, a shoe may have one or more control elements embedded therein to adjust an element of the shoe. For example, control elements may be embedded in the sole of a shoe to adjust a stiffness, flexibility, and/or thickness of the sole in response to a signal received from a remote source. As such, a biofeedback system can be adapted to send biofeedback information measured by one or more sensors in a shoe to a remote receiver, analyze the data to determine one or more performance characteristic of the runner during a run, and send a control signal to control elements in the shoe to adjust a characteristic of the shoe to compensate for shortcomings in the runners technique and/or to assist in training the runner to run with proper form. In an alternative embodiment the analyzing and controlling steps may be carried out by a control element embedded within, or attached to, the shoe, without the need for a remote receiver.

[0096] While the discussions hereinabove relate to the use of sensors to measure an provide feedback relating to a runners form during jogging or running, in alternative embodiments the systems and methods described herein may be used to measure one or more performance characteristics related to athletic activities other than running. For example, the systems and methods described herein may be useful for training purposes in sports that require an athlete to make rapid changes of direction (e.g., soccer, football, basketball, baseball, softball, tennis, squash, badminton, volleyball, lacrosse, field hockey, ultimate Frisbee, etc), where analysis of the athlete's foot striking during a turn or "cut" may provide valuable performance information. Similarly, sports that require good jumping form when jumping (e.g., hurdling, basketball, volleyball, etc) may also benefit from devices and methods that provide accurate information relating to the position of the athlete's foot during push of and/or landing. In addition, devices that provide accurate information about the position and rotation of the feet of a user may provide valuable training information for a golfer during a swing, for a bowler during a throwing action, for a baseball pitcher during a throw, or for other athletic motions requiring a high degree of repeatability.

[0097] The invention may be embodied in other specific forms without departing from the scope of the invention. The foregoing embodiments, therefore, are to be considered in all respects illustrative rather than limiting the invention described herein. Scope of the invention is thus indicated by the appended claims, rather than by the foregoing description, and all changes that come within the scope of the claims are intended to be embraced therein.

Claims

1. An apparatus for monitoring one or more athletic performance characteristic of a user, the apparatus comprising: a sensing unit (405) adapted to be attachable to a shoe of a user, the sensing unit (405) comprising:

    (i) a first sensor adapted to monitor a movement of a foot of the user while the user is in motion, the first sensor comprising a gyroscopic sensor (510) adapted to measure an angular velocity of the foot of the user;

(ii) processing means (335) for determining a first performance characteristic of the user based upon an output from the first sensor, the first performance characteristic comprising a foot strike location of a foot of the user upon striking a ground surface, the processing means (335) being configured to use a periodic trigger to determine whether or not a foot strike has occurred, the periodic trigger being determined by the processing means (335) adding measured angular velocity samples to a sum when the rotational velocity is negative and, when the sum reaches a preset level, setting a flag and resetting the sum, the processor being configured to start looking for a maximum value after the flag is set and, once found, to find the minimum value within a set window, the processing means (335) being configured to determine a ratio of the maximum and minimum values and to determine whether the resulting calculated value lies in a range indicating a heel strike, in a range indicating a midfoot strike, or in a range indicating a forefoot strike; and
(iii) transmitting means (325) for transmitting a data package representative of the performance characteristic to a remote receiver, the data package indicating whether a heel strike, a midfoot strike, or a forefoot strike has occurred.

2. The apparatus of claim 1, further comprising receiving means for: (i) receiving the data package transmitted from the sensing unit (405), and (ii) communicating information representative of the performance characteristic to the user.

3. The apparatus of claim 2, wherein the means for communicating information to the user comprises at least one of a visual signal, an auditory signal, or a tactile signal.

4. The apparatus of claim 1, wherein at least one of:

the information is communicated to the user in substantially real-time;
the receiving means comprises at least one remote user feedback device, optionally wherein the remote user feedback device is selected from the group consisting of: a watch, a detachable strap, a mobile phone, an earpiece, a hand-held feedback device, a laptop computer, a head-mounted feedback device, or a desktop personal computer.

5. The apparatus of claim 1, wherein the receiving means comprises means for controlling at least one function of a remote user feedback device.

6. The apparatus of claim 1, wherein at least one of the sensing unit (405) and the receiving means comprises means for storing data related to the first performance characteristic.

7. The apparatus of claim 1, wherein at least one of:

the means (335) for determining a performance characteristic of the user comprises a microprocessor;
the sensing unit (405) comprises a housing unit (700) adapted to house the first sensor, the processing means (335), and the transmitting means; the housing unit (700) is adapted to be releasably attachable to the shoe of the user, for example to at least one of a fastening portion or a heel portion of the shoe.

8. The apparatus of claim 1, further comprising means for determining at least one second performance characteristic of the user, optionally wherein the at least one second performance characteristic comprises at least one of a cadence, a posture, a lean, a speed, a distance travelled, or a heart rate of the user.

9. The apparatus of claim 8, wherein at least one of:

the determination of the at least one second performance characteristic is based upon an output from the first sensor;
the determination of the at least one second performance characteristic is based upon an output from at least one second sensor, optionally wherein the at least one second sensor is selected from the group consisting of: an accelerometer, a pressure sensor, a force sensor, a temperature sensor, a chemical sensor, a global positioning system, a piezoelectric sensor, a rotary position sensor, a gyroscopic sensor, a heart-rate sensor, and a goniometer.

10. The apparatus of claim 1, wherein the processing means (335) comprises comparison of a localized maximum angular velocity measurement and a localized minimum angular velocity measurement during a foot strike event.

11. The apparatus of claim 10, wherein the processing means (335) comprises dividing the localized minimum angular velocity measurement during a foot strike event by the localized maximum angular velocity measurement during a foot strike event, and comparing the resulting calculated value with at least one predetermined comparison value.

12. The apparatus of claim 1, wherein the processing means (335) comprises integration of measured angular velocity data during a foot strike event.

13. A method for monitoring one or more athletic performance characteristic of a user, the method comprising the steps of:

providing a sensing unit (405) adapted to be attachable to a shoe of a user, the sensing unit (405) comprising:

(i) a first sensor adapted to monitor a movement of a foot of the user while the user is in motion, the first sensor comprising a gyroscopic sensor (510) adapted to measure an angular velocity of the foot of the user;
(ii) processing means (335) for determining a first performance characteristic of the user based upon an output from the first sensor, the first performance characteristic comprising a foot strike location of a foot of the user upon striking a ground surface, the processing means (335) being configured to use a periodic trigger to determine whether or not a foot strike has occurred, the periodic trigger being determined by the processing means (335) adding measured angular velocity samples to a sum when the rotational velocity is negative and, when the sum reaches a preset level, setting a flag and resetting the sum, the processor being configured to start looking for a maximum value after the flag is set and, once found, to find the minimum value within a set window, the processing means (335) being configured to determine a ratio of the maximum and minimum values and to determine whether the resulting calculated value lies in a range indicating a heel strike, in a range indicating a midfoot strike, or in a range indicating a forefoot strike; and
(iii) transmitting means for transmitting a data package representative of the performance characteristic to a remote receiver; and

providing receiving means for receiving a data package transmitted from the sensing unit (405) and communicating information representative of the performance characteristic to the user.

14. The method of claim 13, wherein the information is communicated to the user in substantially real-time.

Patentansprüche

1. Vorrichtung zum Überwachen von einer oder mehreren athletischen Leistungscharakteristiken eines Benutzers, wobei die Vorrichtung Folgendes umfasst:
eine Sensoreinheit (405), ausgelegt zum Anbringen an einem Schuh eines Benutzers, wobei die Sensoreinheit (405) Folgendes umfasst:

(i) einen ersten Sensor, ausgelegt zum Überwachen einer Bewegung eines Fußes des Benutzers, während der Benutzer in Bewegung ist, wobei der erste Sensor einen gyroskopischen Sensor (510) umfasst, ausgelegt zum Messen einer Winkelgeschwindigkeit des Fußes des Benutzers;
(ii) Verarbeitungsmittel (335) zum Bestimmen einer ersten Leistungscharakteristik des Benutzers auf der Basis eines Ausgangs vom ersten Sensor, wobei die erste Leistungscharakteristik eine Fußauftrittsstelle eines Fußes des Benutzers beim Auftreten auf eine Bodenfläche umfasst, wobei das Verarbeitungsmittel (335) zum Benutzen eines periodischen Triggers konfiguriert ist, um festzustellen, ob ein Fußauftritt erfolgt ist oder nicht, wobei der periodische Trigger dadurch bestimmt wird, dass das Verarbeitungsmittel (335) gemessene Winkelgeschwindigkeitsproben zu einer Summe addiert, wenn die Drehgeschwindigkeit negativ ist, und wenn die Summe ein voreingestelltes Niveau erreicht, einen Flag setzt und die Summe zurücksetzt, wobei der Prozessor zum Starten der Suche nach einem Höchstwert nach dem Setzen des Flag und, wenn einer gefunden ist, zum Finden des Mindestwertes innerhalb eines Einstellfensters konfiguriert ist, wobei das Verarbeitungsmittel (335) zum Bestimmen eines Verhältnisses der Höchst- und Mindestwerte und zum Feststellen konfiguriert ist, ob der resultierende berechnete Wert in einem Bereich liegt, der das Auftreten einer Ferse anzeigt, in einem Bereich liegt, der das Auftreten eines Mittelfußes anzeigt, oder in einem Bereich liegt, der das Auftreten eines Vorderfußes anzeigt; und
(iii) Sendemittel (325) zum Senden eines die Leistungscharakteristik repräsentierenden Datenpakets zu einem fernen Empfänger, wobei das Datenpaket anzeigt, ob ein Auftreten einer Ferse, ein Auftreten eines Mittelfußes oder ein Auftreten eines Vorderfußes erfolgt ist.

2. Vorrichtung nach Anspruch 1, die ferner Empfangsmittel umfasst zum: (i) Empfangen des von der Sensoreinheit (405) gesendeten Datenpakets, und (ii) Übermitteln von die Leistungscharakteristik repräsentierenden Informationen zum Benutzer.

3. Vorrichtung nach Anspruch 2, wobei das Mittel zum Übermitteln von Informationen zum Benutzer wenigstens eines aus einem visuellen Signal, einem hörbaren Signal oder einem taktilen Signal umfasst.

4. Vorrichtung nach Anspruch 1, wobei wenigstens eines der Folgenden erfolgt:

die Informationen werden dem Benutzer im Wesentlichen in Echtzeit übermittelt;
das Empfangsmittel umfasst wenigstens eine ferne Benutzerrückmeldevorrichtung, wobei die ferne Benutzerrückmeldevorrichtung optional ausgewählt ist aus der Gruppe bestehend aus einer Uhr, einem abnehmbaren Riemen, einem Mobiltelefon, einer Hörmuschel, einer Handheld-Rückmeldevorrichtung, einem Laptop-Computer, einer kopfmontierten Rückmeldevorrichtung und einem Desktop-PC.

5. Vorrichtung nach Anspruch 1, wobei das Empfangsmittel Mittel zum Steuern wenigstens einer Funktion einer fernen Benutzerrückmeldevorrichtung umfasst.

6. Vorrichtung nach Anspruch 1, wobei die Sensoreinheit (405) und/oder das Empfangsmittel Mittel zum Speichern von Daten in Bezug auf die erste Leistungscharakteristik umfasst/umfassen.

7. Vorrichtung nach Anspruch 1, wobei wenigstens eines der Folgenden gilt:

das Mittel (335) zum Bestimmen einer Leistungscharakteristik des Benutzers umfasst einen Mikroprozessor;
die Sensoreinheit (405) umfasst eine Gehäuseeinheit (700), die zum Aufnehmen des ersten Sensors, des Verarbeitungsmittels (335) und des Übertragungsmittels ausgelegt ist; die Gehäuseeinheit (700) ist zum lösbaren Anbringen am Schuh des Benutzers ausgelegt, zum Beispiel an einem Befestigungsteil und/oder an einem Fersenteil des Schuhs.

8. Vorrichtung nach Anspruch 1, die ferner Mittel zum Bestimmen von wenigstens einer zweiten Leistungscharakteristik des Benutzers umfasst, wobei die wenigstens eine zweite Leistungscharakteristik optional wenigstens eines aus Rhythmus, Haltung, Neigung, Geschwindigkeit, zurückgelegter Entfernung oder Herzfrequenz des Benutzers umfasst.

9. Vorrichtung nach Anspruch 8, wobei wenigstens eines der Folgenden gilt:

die Bestimmung der wenigstens einen zweiten Leistungscharakteristik basiert auf einem Ausgang vom ersten Sensor;
die Bestimmung der wenigstens einen zweiten Leistungscharakteristik basiert auf einem Ausgang von wenigstens einem zweiten Sensor, wobei der wenigstens eine zweite Sensor optional ausgewählt ist aus der Gruppe bestehend aus einem Beschleunigungsmesser, einem Drucksensor, einem Kraftsensor, einem Temperatursensor, einem chemischen Sensor, einem globalen Positionierungssystem, einem piezoelektrischen Sensor, einem Drehpositionssensor, einem gyroskopischen Sensor, einem Herzfrequenzsensor, und einem Goniometer.

10. Vorrichtung nach Anspruch 1, wobei das Verarbeitungsmittel (335) einen Vergleich einer lokalisierten maximalen Winkelgeschwindigkeitsmessung und einer lokalisierten minimalen Winkelgeschwindigkeitsmessung während eines Fußauftrittsereignisses umfasst.

11. Vorrichtung nach Anspruch 10, wobei das Verarbeitungsmittel (335) das Dividieren des lokalisierten minimalen Winkelgeschwindigkeitsmesswertes bei einem Fußauftrittsereignis durch den lokalisierten maximalen Winkelgeschwindigkeitsmesswert bei einem Fußauftrittsereignis und das Vergleichen des resultierenden berechneten Wertes mit wenigstens einem vorbestimmten Vergleichswert beinhaltet.

12. Vorrichtung nach Anspruch 1, wobei das Verarbeitungsmittel (335) die Integration von gemessenen Winkelgeschwindigkeitsdaten während eines Fußauftrittsereignisses umfasst.

13. Verfahren zum Überwachen von einer oder mehreren athletischen Leistungscharakteristiken eines Benutzers, wobei das Verfahren die folgenden Schritte beinhaltet:

Bereitstellen einer Sensoreinheit (405), ausgelegt zum Anbringen an einem Schuh eines Benutzers, wobei die Sensoreinheit (405) Folgendes umfasst:

(i) einen ersten Sensor, ausgelegt zum Überwachen einer Bewegung eines Fußes des Benutzers, während der Benutzer in Bewegung ist, wobei der erste Sensor einen gyroskopischen Sensor (510) umfasst, ausgelegt zum Messen einer Winkelgeschwindigkeit des Fußes des Benutzers;
(ii) Verarbeitungsmittel (335) zum Bestimmen einer ersten Leistungscharakteristik des Benutzers auf der Basis eines Ausgangs vom ersten Sensor, wobei die erste Leistungscharakteristik eine Fußauftrittsstelle eines Fußes des Benutzers beim Auftreten auf eine Bodenfläche umfasst, wobei das Verarbeitungsmittel (335) zum Benutzen eines periodischen Triggers konfiguriert ist, um festzustellen, ob ein Fußauftritt erfolgt ist oder nicht, wobei der periodische Trigger dadurch bestimmt wird, dass das Verarbeitungsmittel (335) gemessene Winkelgeschwindigkeitsproben zu einer Summe addiert, wenn die Drehgeschwindigkeit negativ ist, und wenn die Summe ein voreingestelltes Niveau erreicht, einen Flag setzt und die Summe zurücksetzt, wobei der Prozessor zum Starten der Suche nach einem Höchstwert nach dem Setzen des Flag und, wenn einer gefunden ist, zum Finden des Mindestwertes innerhalb eines Einstellfensters konfiguriert ist, wobei das Verarbeitungsmittel (335) zum Bestimmen eines Verhältnisses der Höchst- und Mindestwerte und zum Feststellen konfiguriert ist, ob der resultierende berechnete Wert in einem Bereich liegt, der das Auftreten einer Ferse anzeigt, in einem Bereich liegt, der das Auftreten eines Mittelfußes anzeigt, oder in einem Bereich liegt, der das Auftreten eines Vorderfußes anzeigt; und
(iii) Sendemittel zum Senden eines die Leistungscharakteristik repräsentierenden Datenpakets zu einem fernen Empfänger; und

Bereitstellen von Empfangsmitteln zum Empfangen eines von der Sensoreinheit (405) übertragenen Datenpakets und zum Übermitteln von die Leistungscharakteristik repräsentierenden Informationen zu dem Benutzer.

14. Verfahren nach Anspruch 13, wobei die Informationen dem Benutzer im Wesentlichen in Echtzeit übermittelt werden.

Revendications

1. Appareil de surveillance d'une ou plusieurs caractéristiques de performances athlétiques d'un utilisateur, l'appareil comprenant :
une unité de détection (405), conçue pour pouvoir être fixée à une chaussure d'un utilisateur, l'unité de détection (405) comprenant :

(i) un premier capteur, conçu pour surveiller un mouvement d'un pied de l'utilisateur pendant que l'utilisateur est en mouvement, le premier capteur comprenant un capteur gyroscopique (510) conçu pour mesurer une vitesse angulaire du pied de l'utilisateur ;
(ii) un moyen de traitement (335) pour déterminer une première caractéristique de performances de l'utilisateur sur la base d'une sortie du premier capteur, la première caractéristique de performances comprenant un emplacement de pose de pied d'un pied de l'utilisateur au moment de sa pose sur une surface au sol, le moyen de traitement (335) étant configuré pour utiliser un déclencheur périodique pour déterminer si une pose de pied s'est produite ou non, le déclencheur périodique étant déterminé par le moyen de traitement (335) qui ajoute des échantillons de vitesse angulaire mesurés à une somme quand la vitesse de rotation est négative et qui définit un indicateur et réinitialise la somme quand la somme atteint un niveau prédéfini, le processeur étant configuré pour démarrer la recherche d'une valeur maximale après la définition de l'indicateur, et une fois la valeur maximale trouvée, pour trouver la valeur minimale dans une fenêtre définie, le moyen de traitement (335) étant configuré pour déterminer un rapport entre la valeur maximale et la valeur minimale et pour déterminer si la valeur calculée résultante se trouve dans une plage indiquant une pose de talon, dans une plage indiquant une pose de mi-pied ou dans une plage indiquant une pose d'avant-pied ; et
(iii) un moyen d'émission (325) pour émettre un paquet de données représentatif de la caractéristique de performances vers un récepteur distant, le paquet de données indiquant si une pose de talon, une pose de mi-pied ou une pose d'avant-pied s'est produite.

2. Appareil selon la revendication 1, comprenant en outre un moyen de réception pour : (i) recevoir le paquet de données émis par l'unité de détection (405), et (ii) communiquer une information représentative de la caractéristique de performances à l'utilisateur.

3. Appareil selon la revendication 2, dans lequel le moyen permettant de communiquer une information à l'utilisateur comprend au moins un signal parmi un signal visuel, un signal audible ou un signal tactile.

4. Appareil selon la revendication 1, dans lequel :

l'information est communiquée à l'utilisateur en temps sensiblement réel ;
le moyen de réception comprend au moins un dispositif distant de retour d'utilisateur, le dispositif distant de retour d'utilisateur étant sélectionné dans le groupe constitué de : une montre, une bride amovible, un téléphone mobile, un écouteur, un dispositif de retour portatif, un ordinateur portable, un dispositif de retour de type casque, ou un ordinateur personnel de bureau.

5. Appareil selon la revendication 1, dans lequel le moyen de réception comprend un moyen permettant de contrôler au moins une fonction d'un dispositif distant de retour d'utilisateur.

6. Appareil selon la revendication 1, dans lequel l'unité de détection (405) et/ou le moyen de réception comprennent un moyen permettant de stocker des données relatives à la première caractéristique de performances.

7. Appareil selon la revendication 1, dans lequel :

le moyen (335) permettant de déterminer une caractéristique de performances de l'utilisateur comprend un microprocesseur ;
l'unité de détection (405) comprend une unité boîtier (700) conçue pour loger le premier capteur, le moyen de traitement (335) et le moyen d'émission ; l'unité boîtier (700) est conçue pour pouvoir être fixée amovible à la chaussure de l'utilisateur, par exemple à au moins une partie parmi une partie de fixation ou une partie talon de la chaussure.

8. Appareil selon la revendication 1, comprenant en outre un moyen permettant de déterminer au moins une seconde caractéristique de performances de l'utilisateur, éventuellement l'au moins une seconde caractéristique de performances comprenant au moins une information parmi une cadence, une position, un appui, une vitesse, une distance parcourue, ou une fréquence cardiaque de l'utilisateur.

9. Appareil selon la revendication 8, dans lequel :

la détermination de l'au moins une seconde caractéristique de performances est basée sur une sortie du premier capteur ;
la détermination de l'au moins une seconde caractéristique de performances est basée sur une sortie d'au moins un second capteur, éventuellement l'au moins un second capteur étant sélectionné dans le groupe constitué de : un accéléromètre, un capteur de pression, un capteur de force, un capteur de température, un capteur chimique, un système de positionnement global, un capteur piézoélectrique, un capteur de position de rotation, un capteur gyroscopique, un capteur de fréquence cardiaque, et un goniomètre.

10. Appareil selon la revendication 1, dans lequel le moyen de traitement (335) comprend la comparaison d'une mesure de vitesse angulaire maximale localisée à une mesure de vitesse angulaire minimale localisée pendant un événement de pose de pied.

11. Appareil selon la revendication 10, dans lequel le moyen de traitement (335) comprend la division de la mesure de vitesse angulaire minimale localisée pendant un événement de pose de pied par la mesure de vitesse angulaire maximale localisée pendant un événement de pose de pied, et la comparaison de la valeur calculée résultante à au moins une valeur de comparaison prédéterminée.

12. Appareil selon la revendication 1, dans lequel le moyen de traitement (335) comprend l'intégration de données de vitesse angulaire mesurées pendant un événement de pose de pied.

13. Procédé de surveillance d'une ou plusieurs caractéristiques de performances athlétiques d'un utilisateur, le procédé comprenant les étapes consistant à :

fournir une unité de détection (405), conçue pour pouvoir être fixée à une chaussure d'un utilisateur, l'unité de détection (405) comprenant :

(i) un premier capteur, conçu pour surveiller un mouvement d'un pied de l'utilisateur pendant que l'utilisateur est en mouvement, le premier capteur comprenant un capteur gyroscopique (510) conçu pour mesurer une vitesse angulaire du pied de l'utilisateur ;
(ii) un moyen de traitement (335) pour déterminer une première caractéristique de performances de l'utilisateur sur la base d'une sortie du premier capteur, la première caractéristique de performances comprenant un emplacement de pose de pied d'un pied de l'utilisateur au moment de sa pose sur une surface au sol, le moyen de traitement (335) étant configuré pour utiliser un déclencheur périodique pour déterminer si une pose de pied s'est produite ou non, le déclencheur périodique étant déterminé par le moyen de traitement (335) qui ajoute des échantillons de vitesse angulaire mesurés à une somme quand la vitesse de rotation est négative et qui définit un indicateur et réinitialise la somme quand la somme atteint un niveau prédéfini, le processeur étant configuré pour démarrer la recherche d'une valeur maximale après la définition de l'indicateur, et une fois la valeur maximale trouvée, pour trouver la valeur minimale dans une fenêtre définie, le moyen de traitement (335) étant configuré pour déterminer un rapport entre la valeur maximale et la valeur minimale et pour déterminer si la valeur calculée résultante se trouve dans une plage indiquant une pose de talon, dans une plage indiquant une pose de mi-pied ou dans une plage indiquant une pose d'avant-pied ; et
(iii) un moyen d'émission pour émettre un paquet de données représentatif de la caractéristique de performances vers un récepteur distant ; et

fournir un moyen de réception pour recevoir un paquet de données émis par l'unité de détection (405) et communiquer une information représentative de la caractéristique de performances à l'utilisateur.

14. Procédé selon la revendication 13, dans lequel l'information est communiquée à l'utilisateur en temps sensiblement réel.

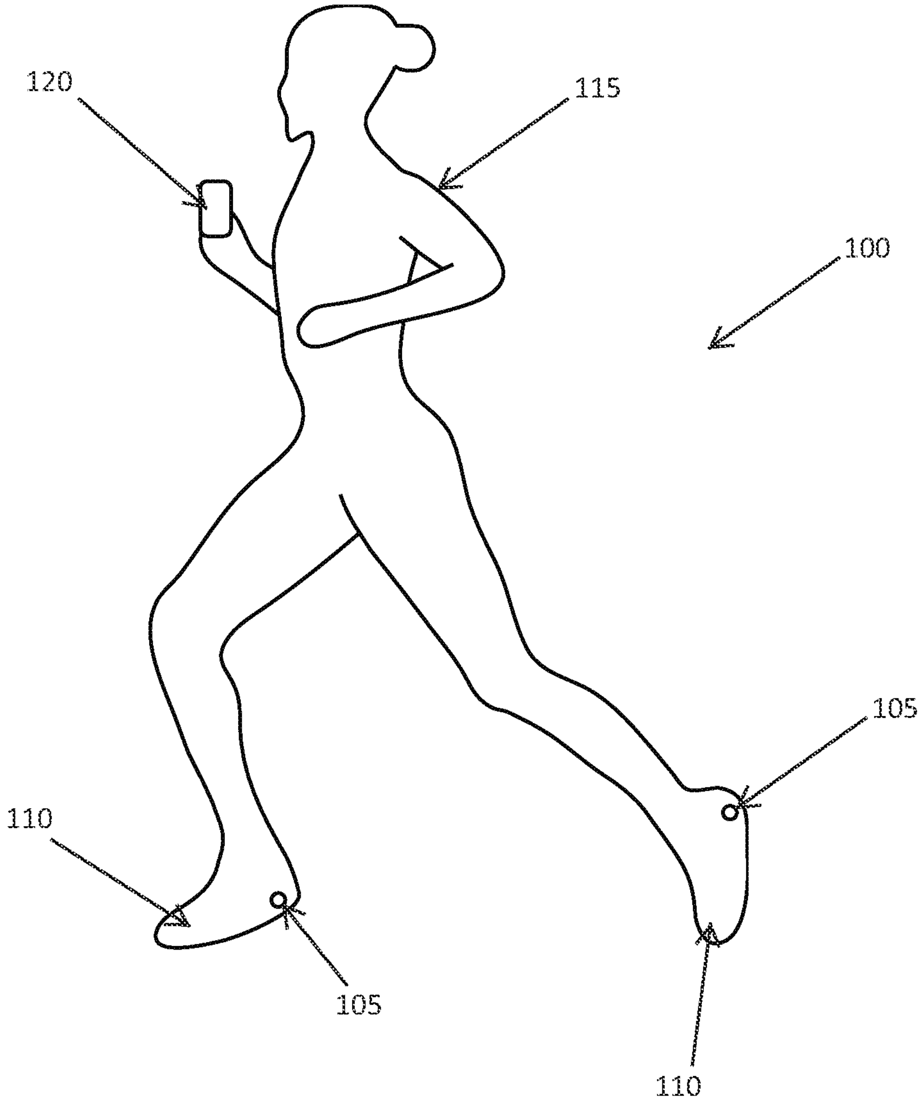


FIG. 1

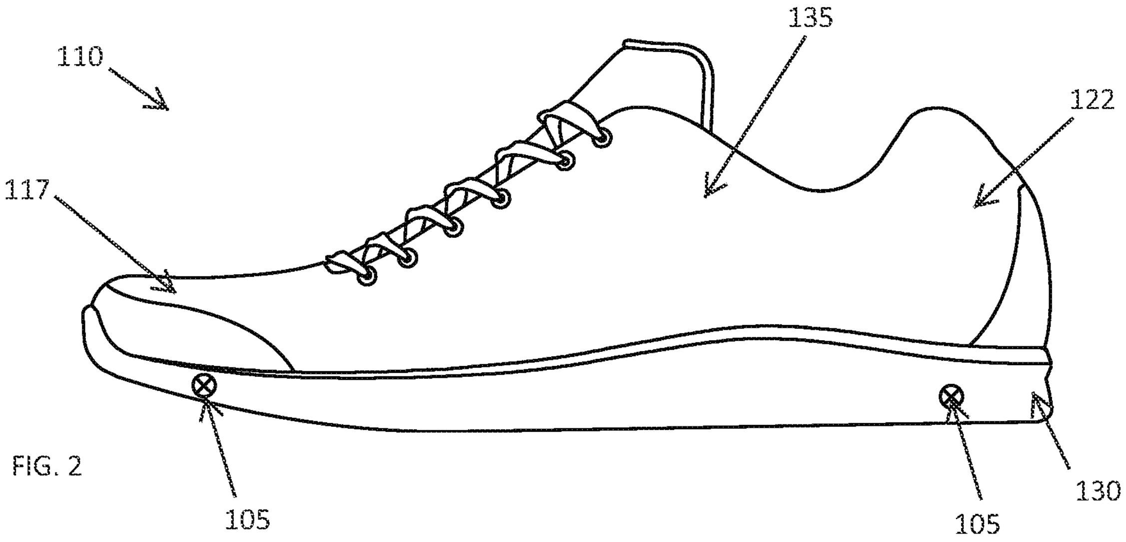


FIG. 2

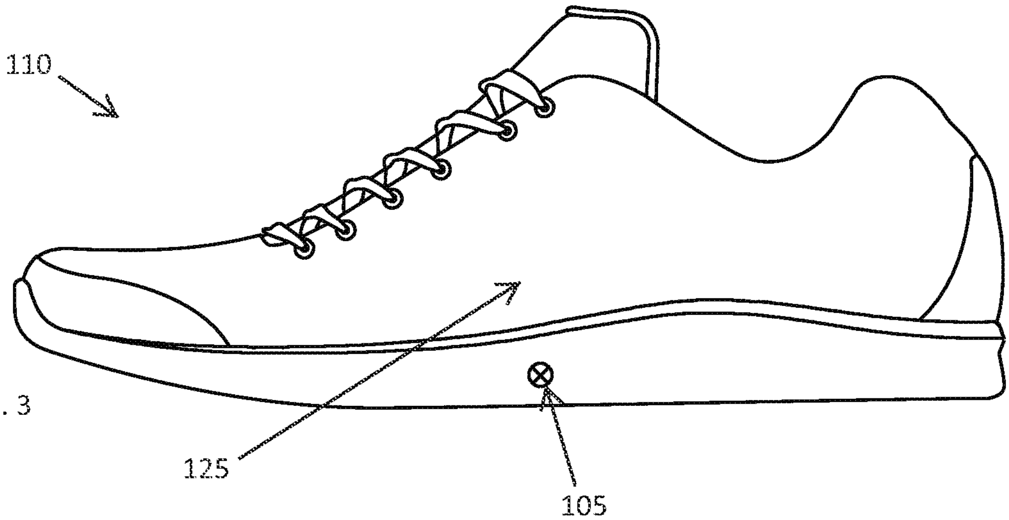


FIG. 3

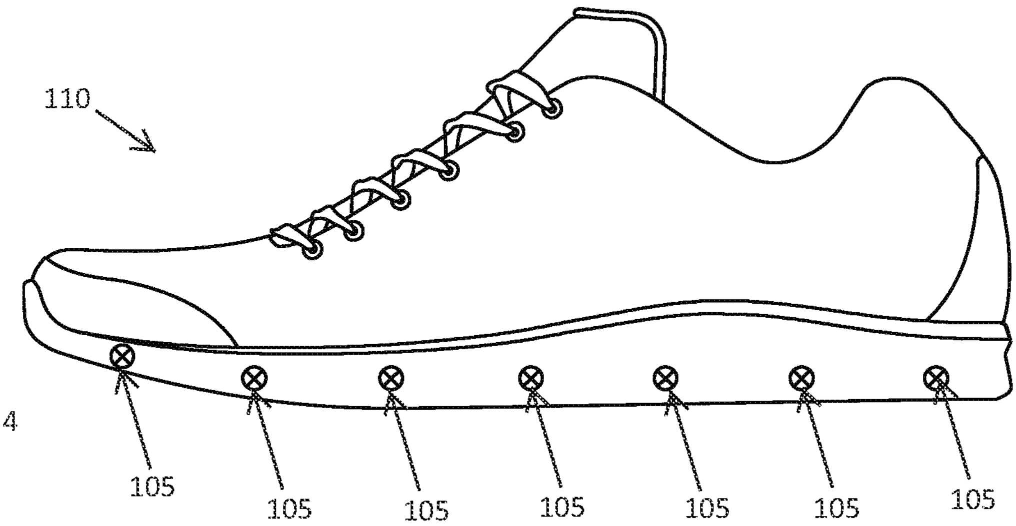


FIG. 4

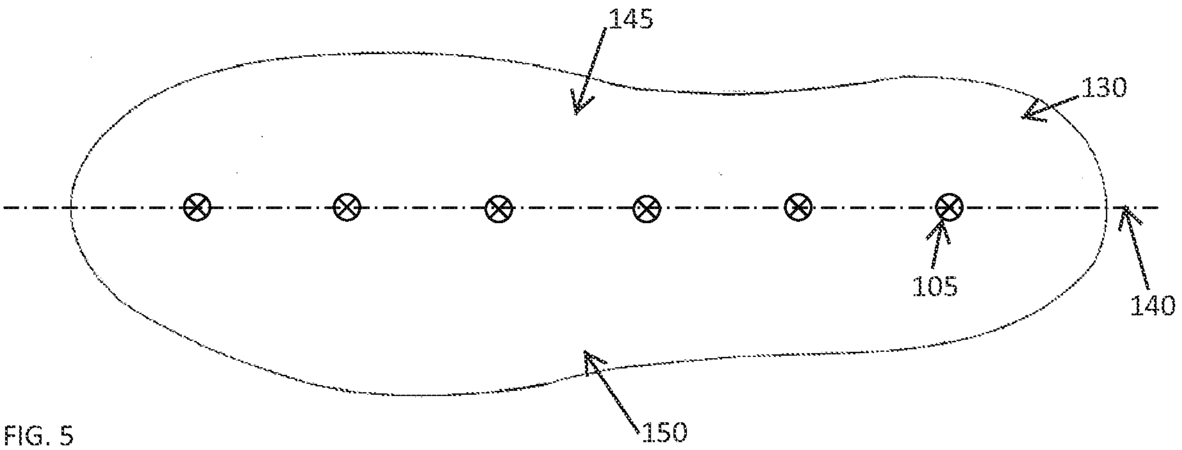


FIG. 5

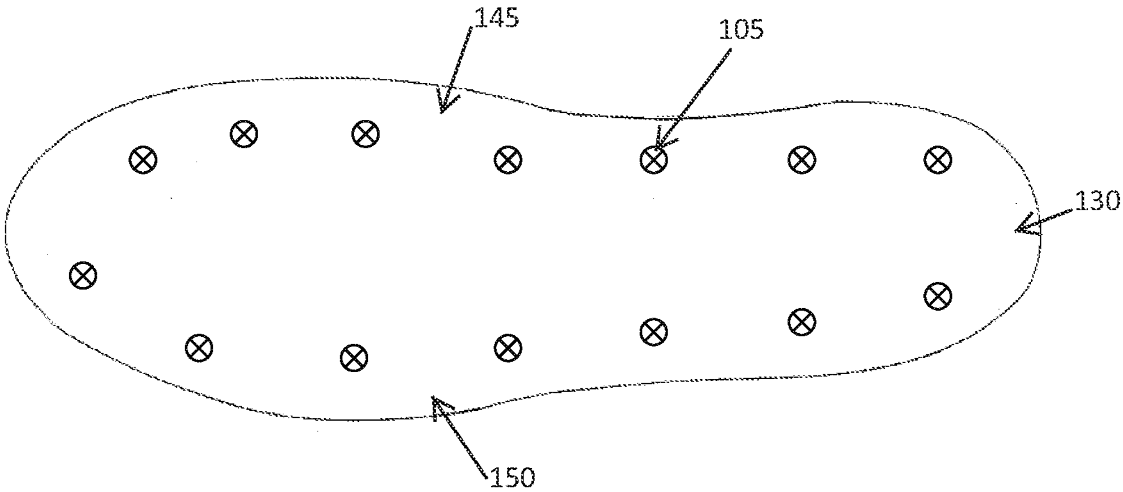


FIG. 6

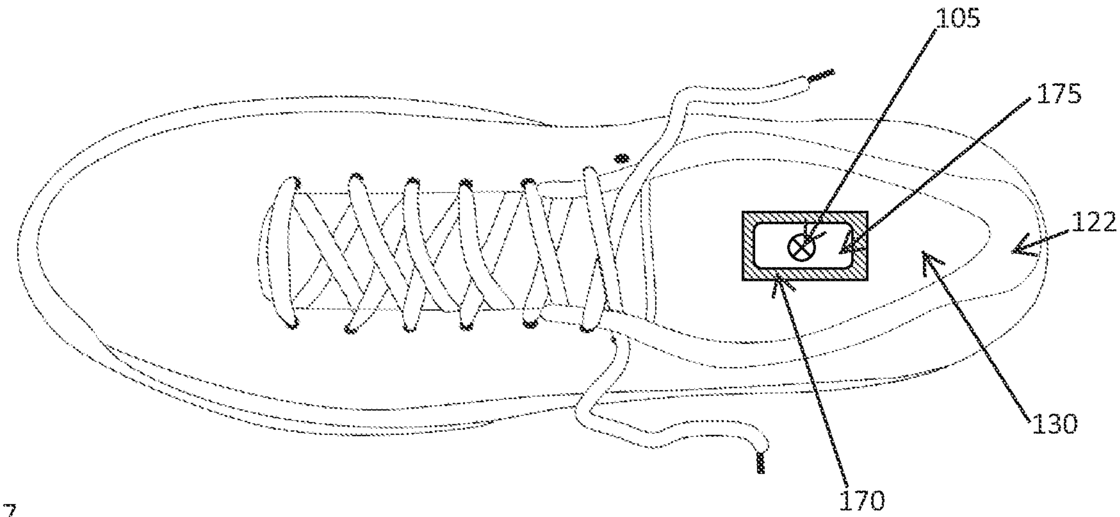
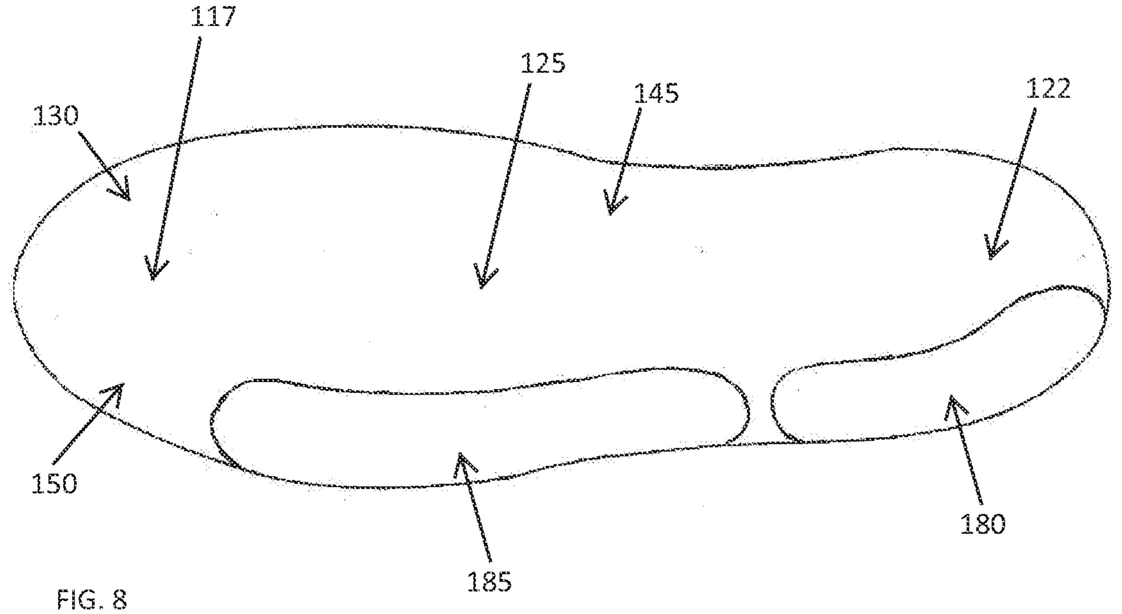


FIG. 7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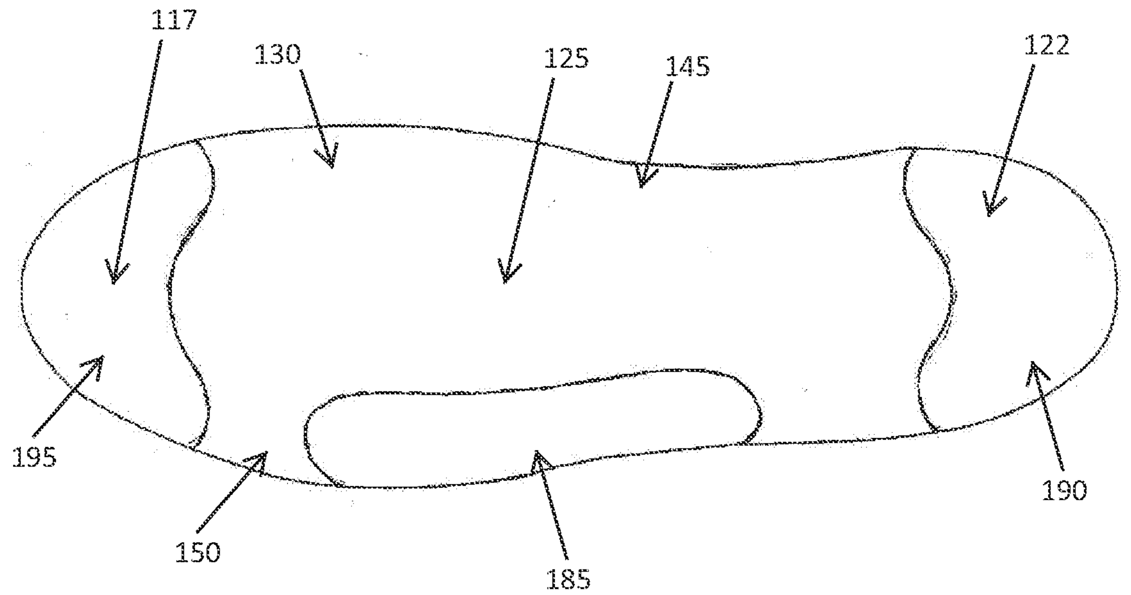
125
145
122
130
150
185
180

FIG. 8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130
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145
122
195
150
185
190

FIG. 9

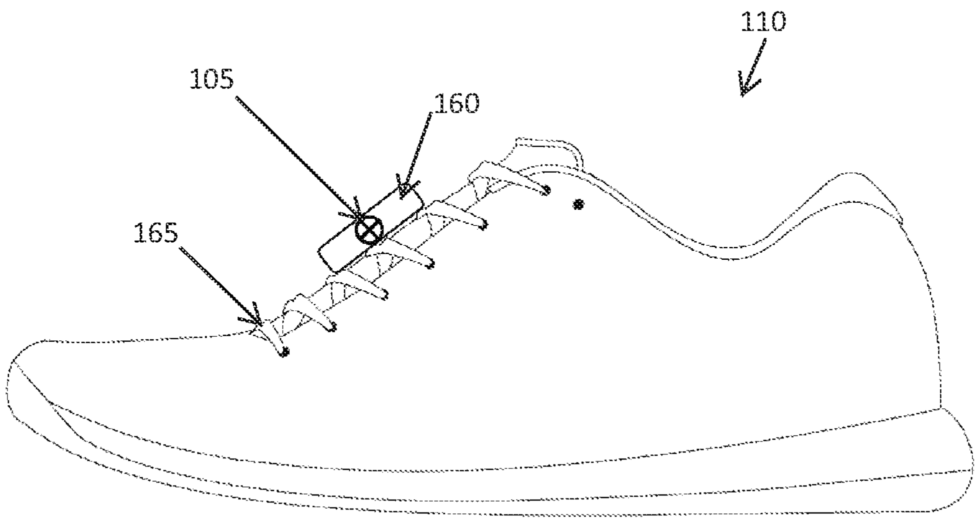

FIG. 10

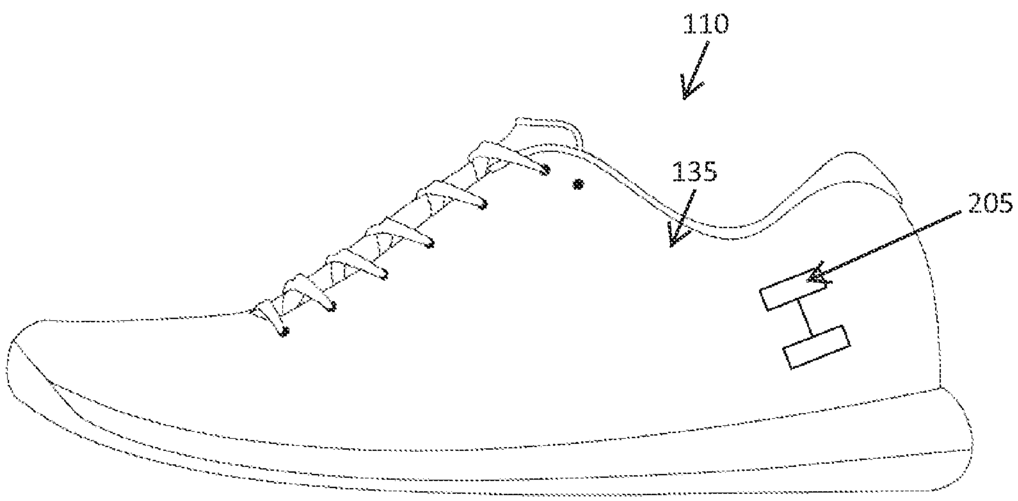

FIG. 11

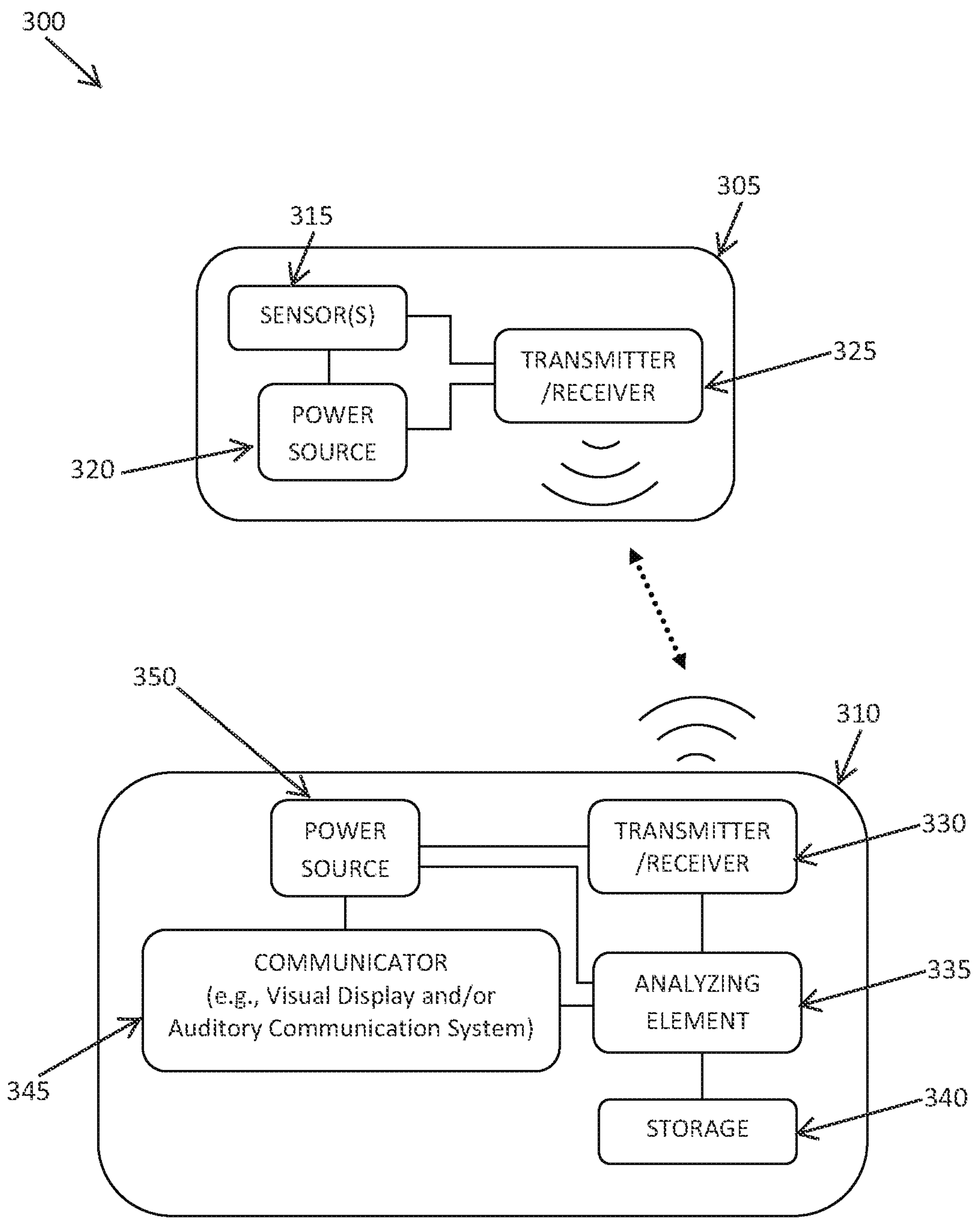
300
305
315
SENSOR(S)
TRANSMITTER /RECEIVER
325
POWER SOURCE
320
350
310
POWER SOURCE
TRANSMITTER /RECEIVER
330
COMMUNICATOR (e.g., Visual Display and/or Auditory Communication System)
ANALYZING ELEMENT
335
345
STORAGE
340

FIG. 12

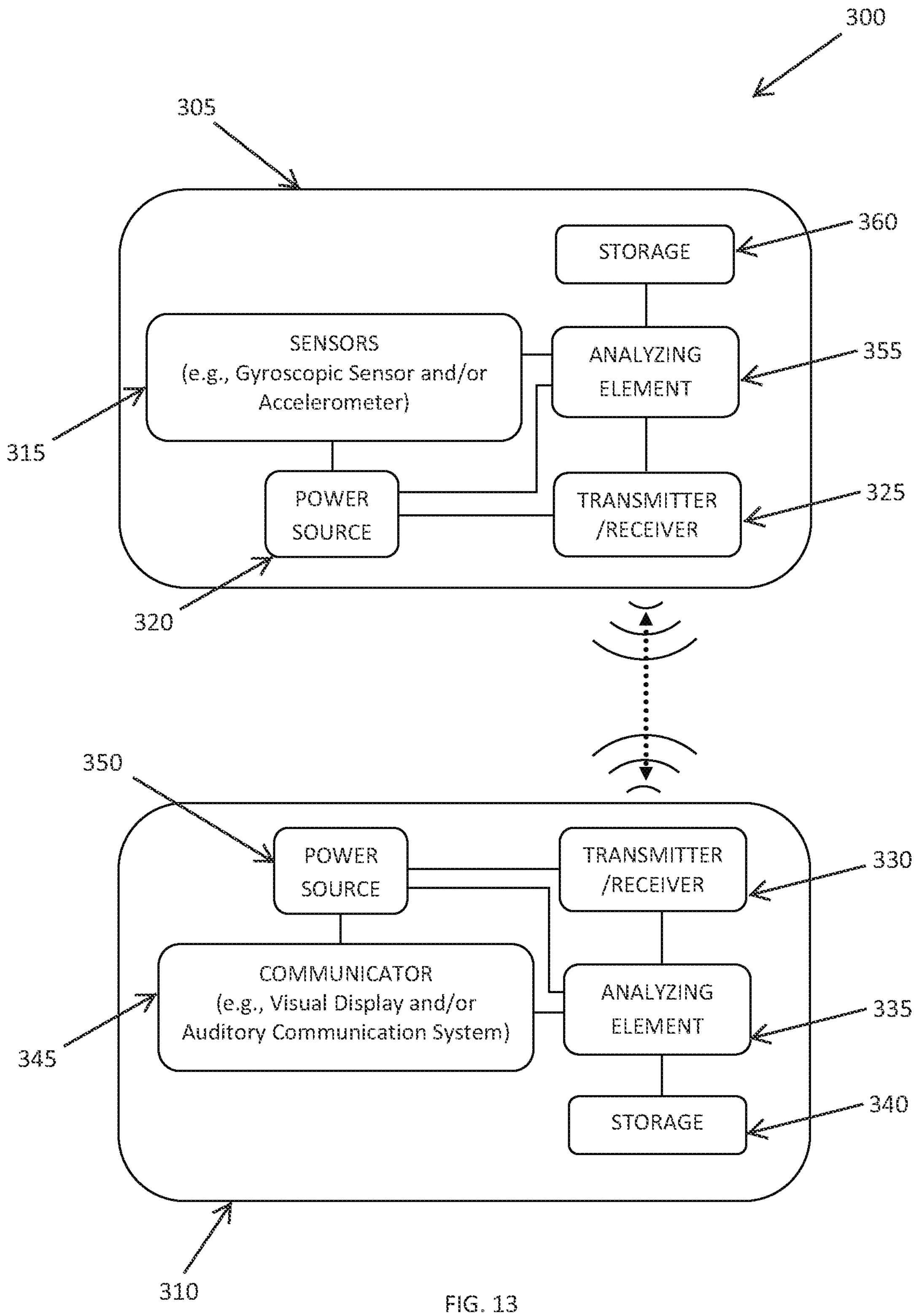
300
305
STORAGE
360
SENSORS
(e.g., Gyroscopic Sensor and/or
Accelerometer)
ANALYZING
ELEMENT
355
315
POWER
SOURCE
TRANSMITTER
/RECEIVER
325
320
350
POWER
SOURCE
TRANSMITTER
/RECEIVER
330
COMMUNICATOR
(e.g., Visual Display and/or
Auditory Communication System)
ANALYZING
ELEMENT
345
335
STORAGE
340
310

FIG. 13

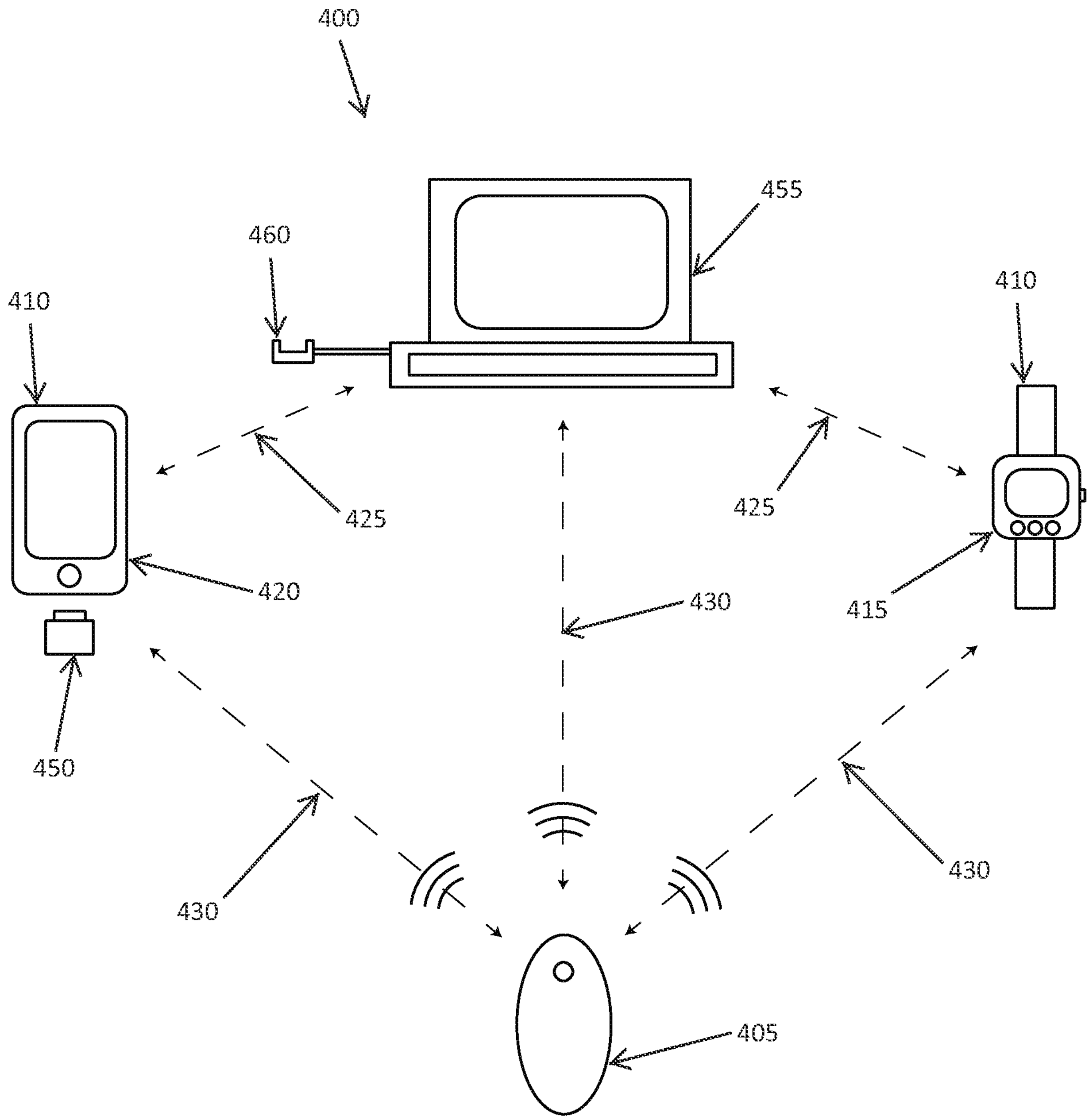

FIG. 14

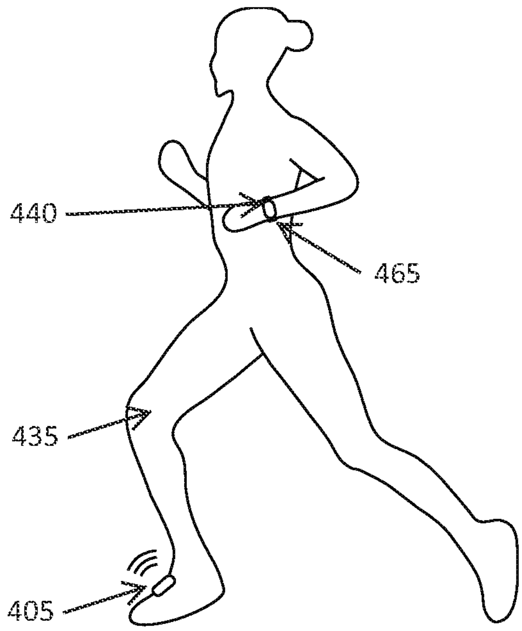

FIG. 15

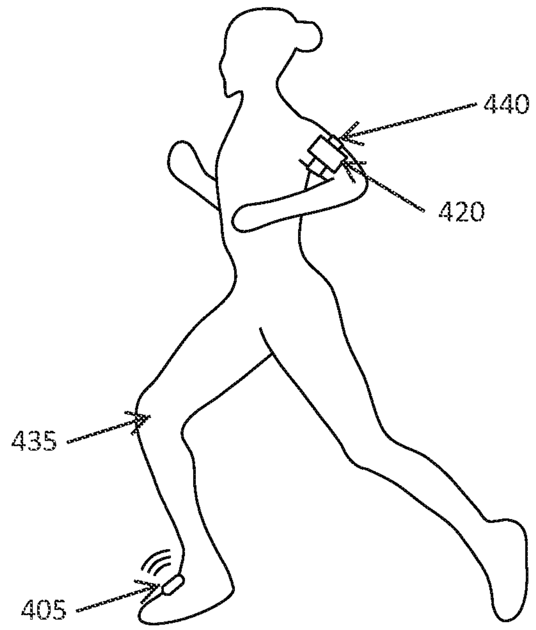

FIG. 16

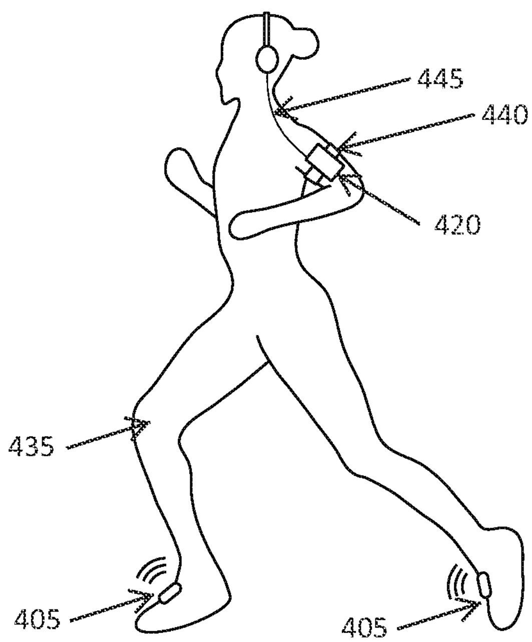

FIG. 17

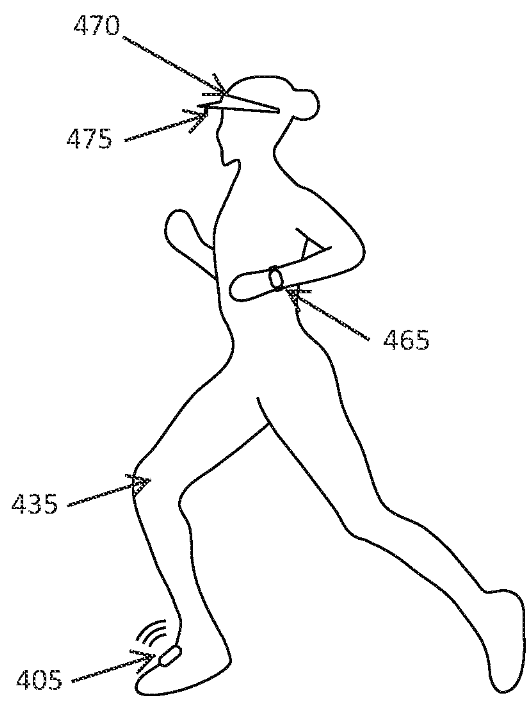

FIG. 18

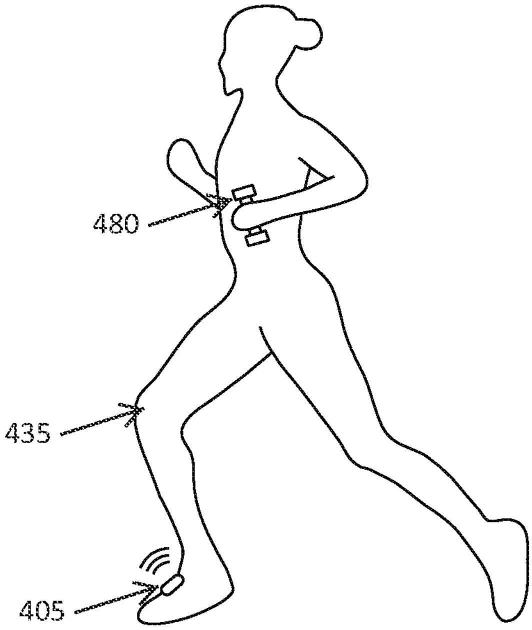

FIG. 19

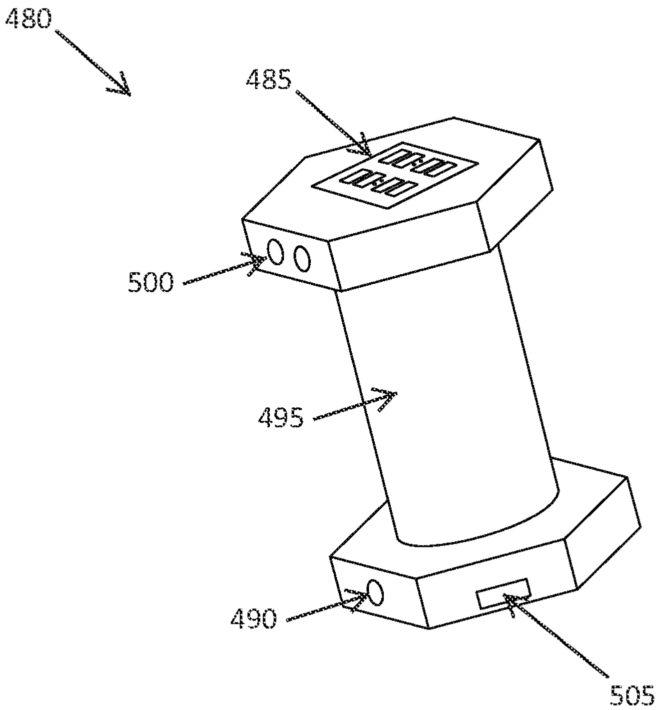

FIG. 20

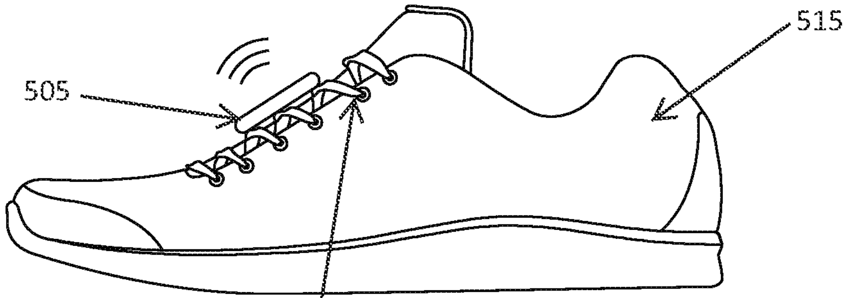

FIG. 21

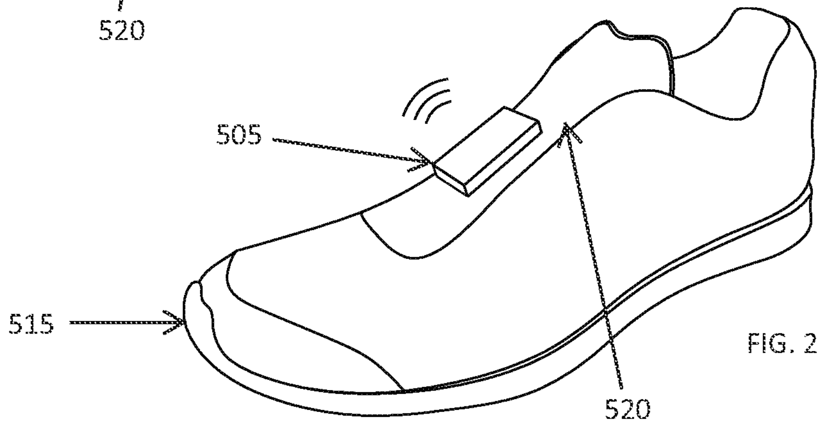

FIG. 22

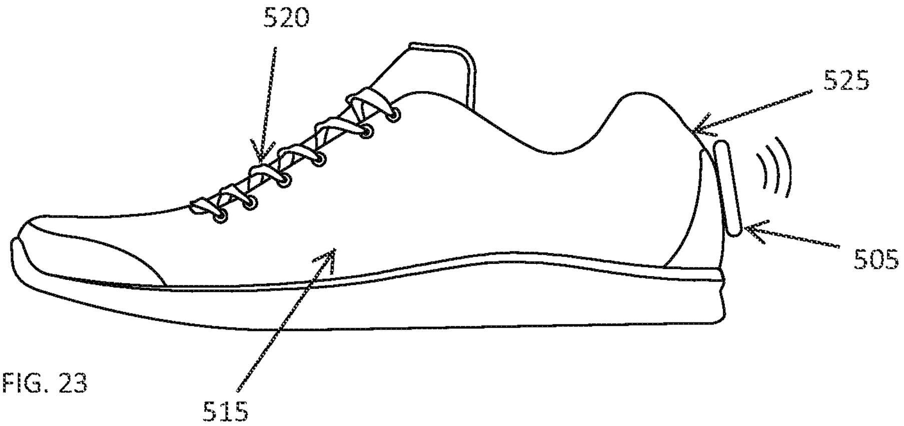

FIG. 23

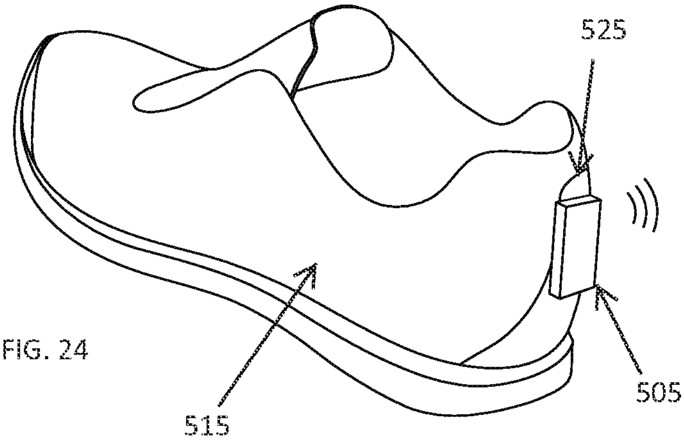

FIG. 24

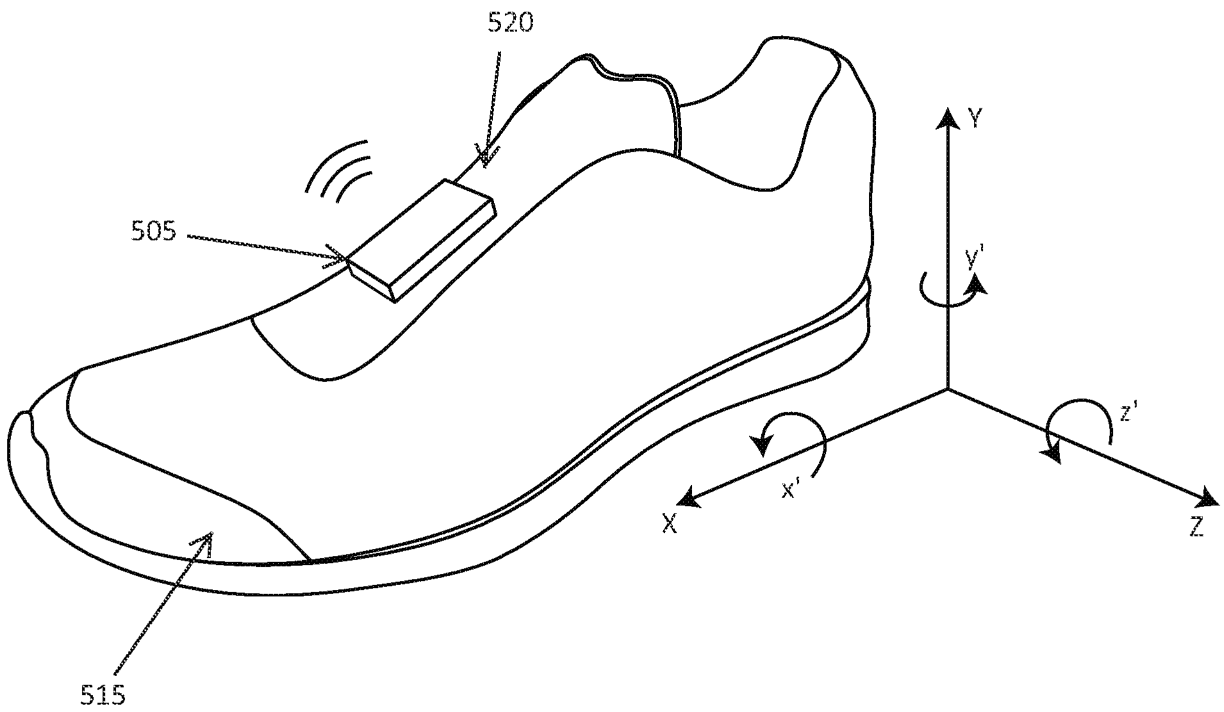

FIG. 25

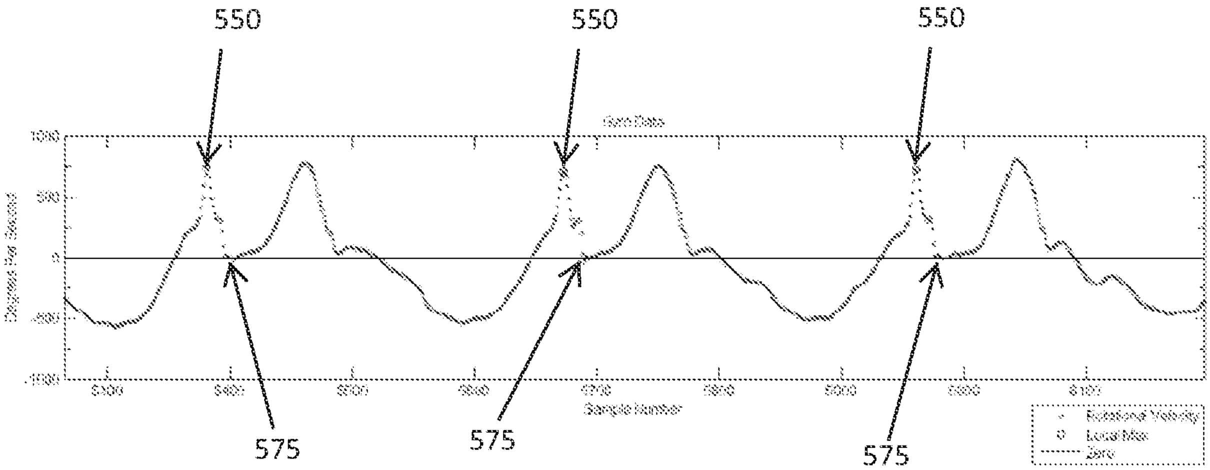

FIG. 26

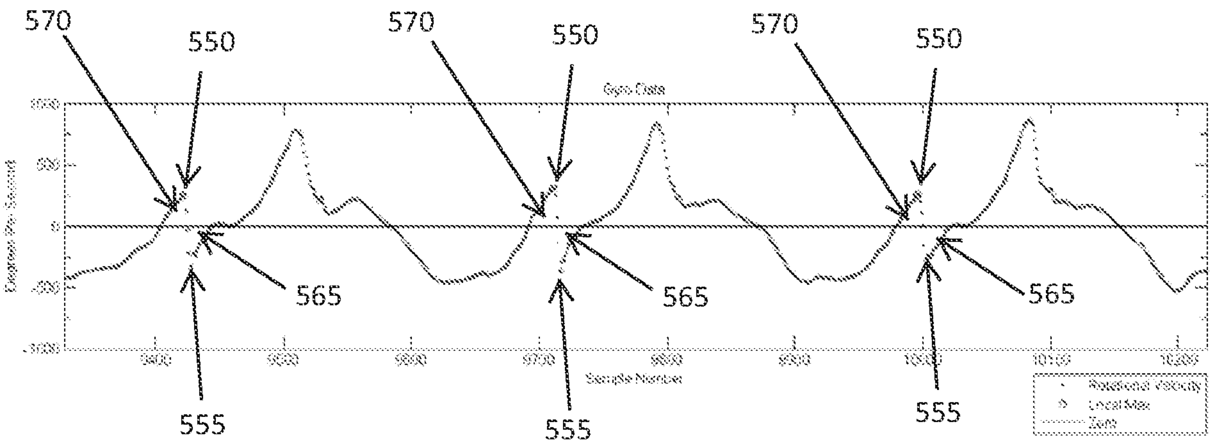

FIG. 27

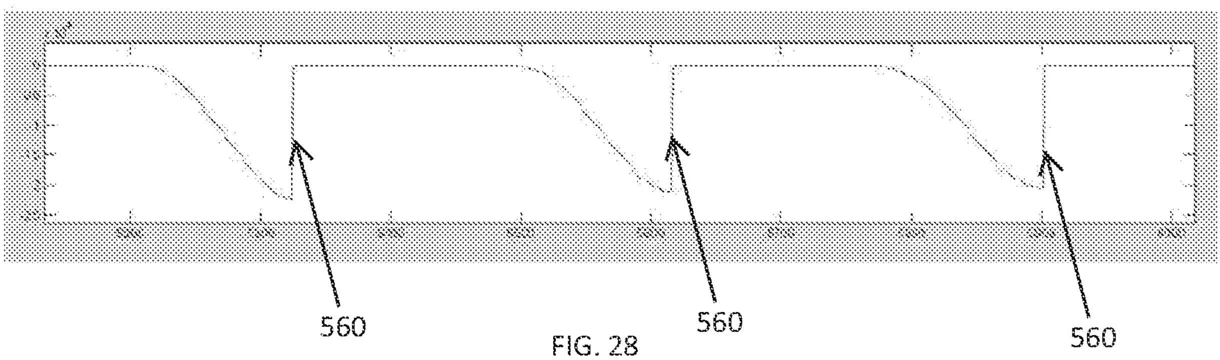

FIG. 28

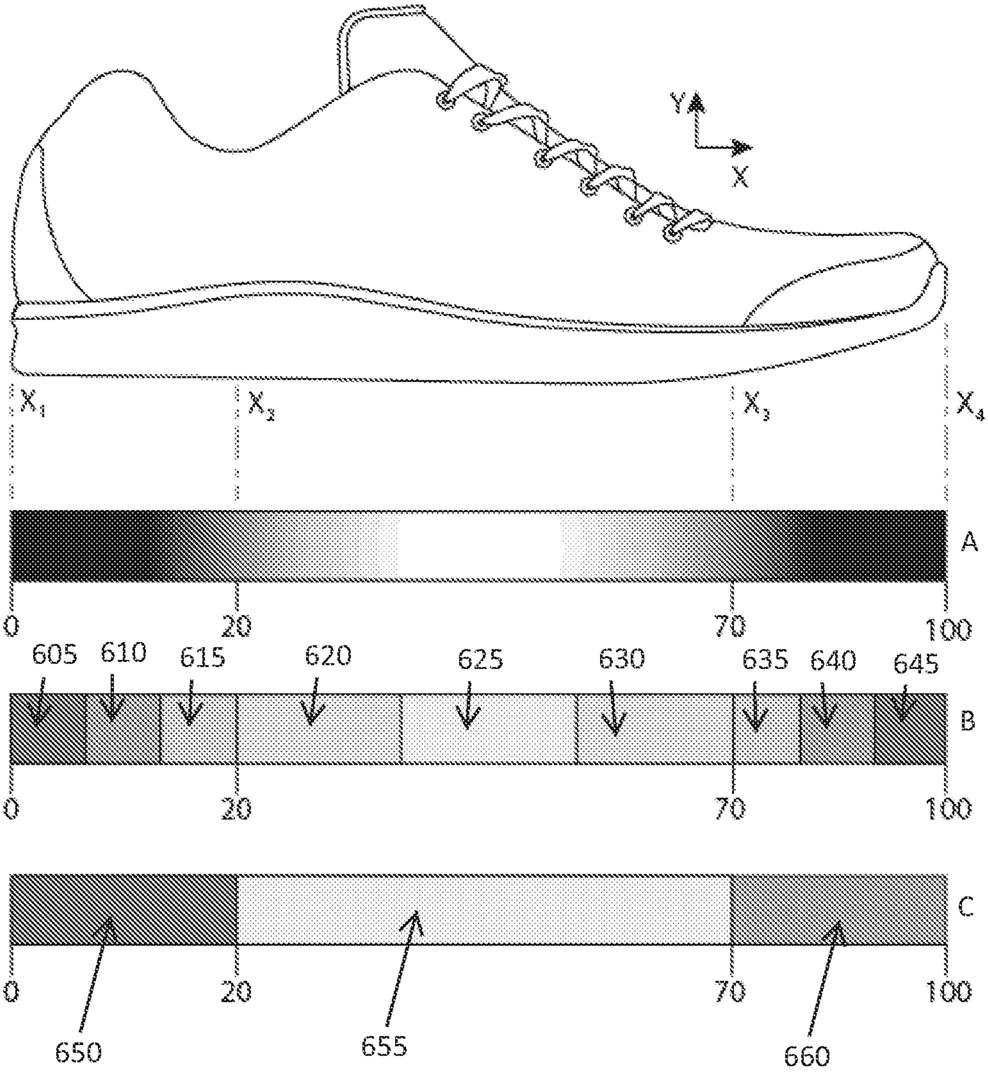
Y
X
X_1
X_2
X_3
X_4
A
0
20
70
100
605
610
615
620
625
630
635
640
645
B
0
20
70
100
C
0
20
70
100
650
655
660

FIG. 29

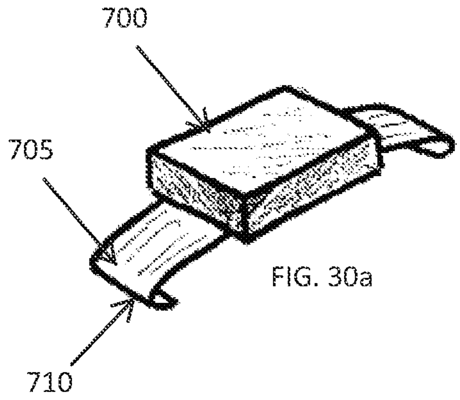

FIG. 30a

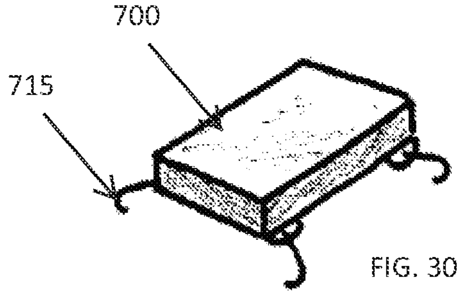

FIG. 30b

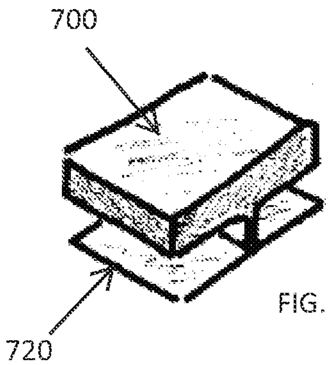

FIG. 30c

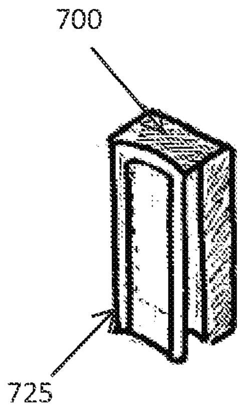

FIG. 30d

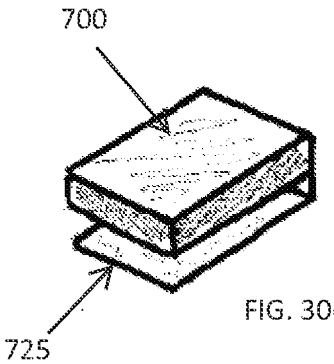

FIG. 30e

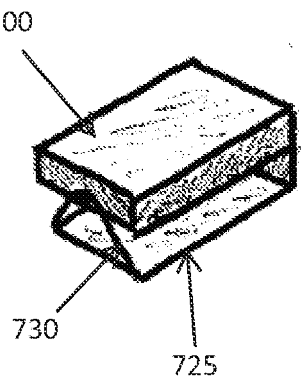

FIG. 30f

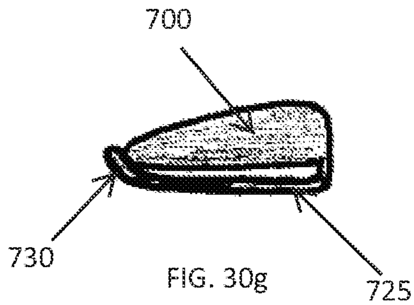

FIG. 30g

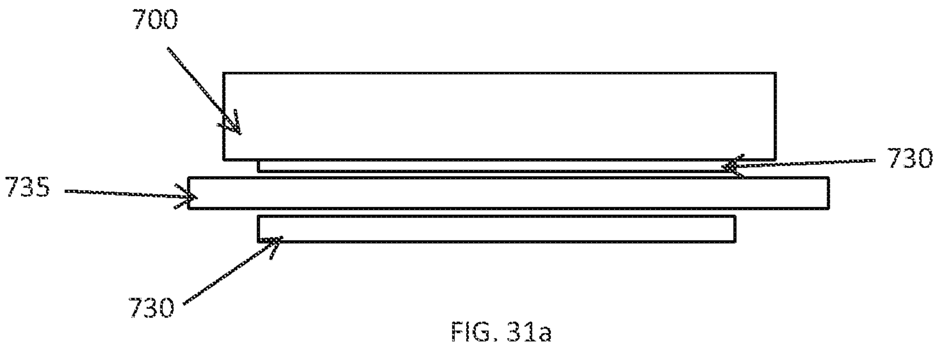

FIG. 31a

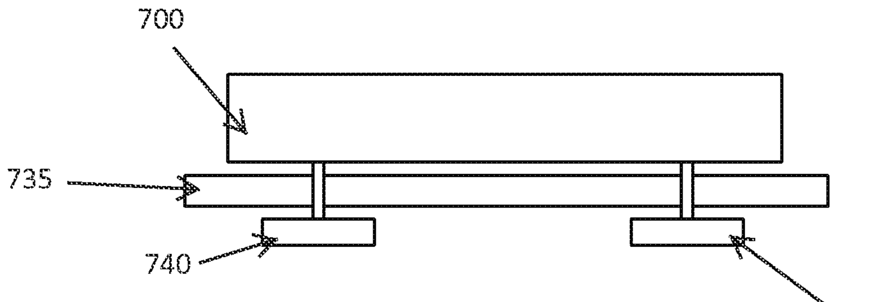

FIG. 31b

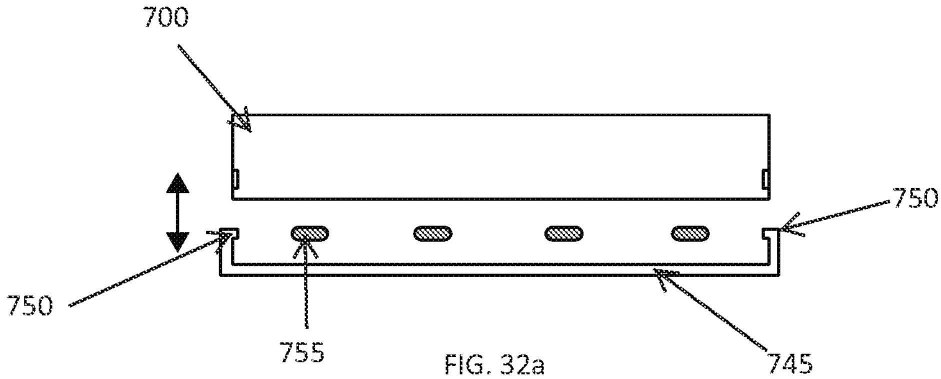

FIG. 32a

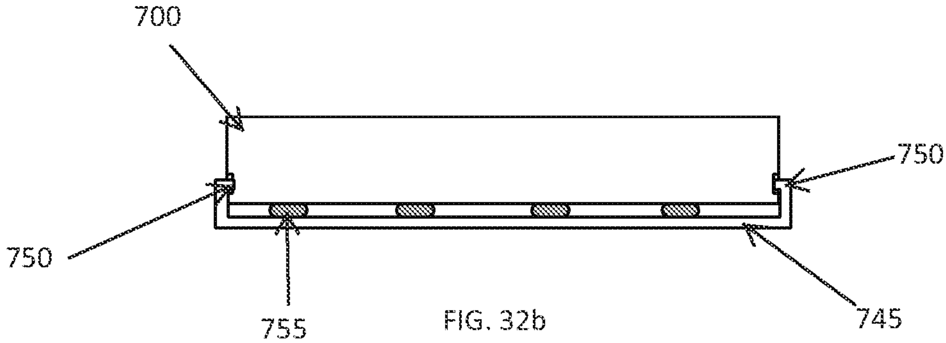

FIG. 32b

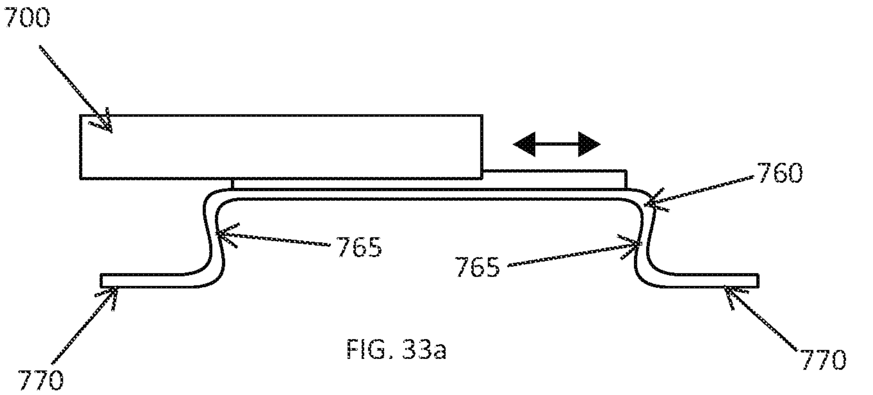

FIG. 33a

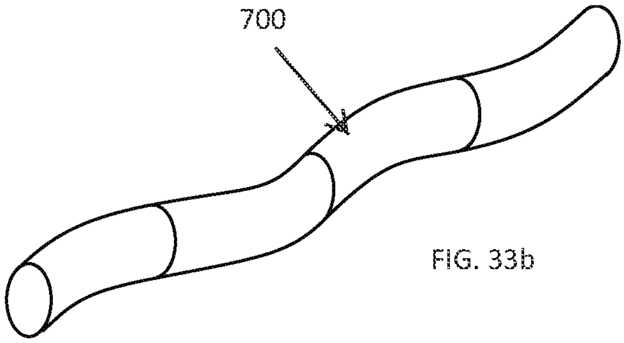

FIG. 33b

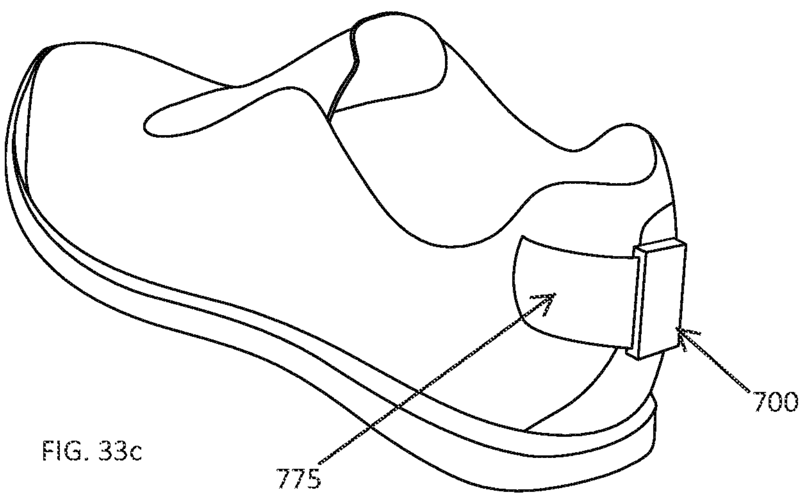

FIG. 33c

REFERENCES CITED IN THE DESCRIPTION

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- US 2007260421 A1 **[0005]**
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- US 2010063779 A1 **[0007]**
- EP 1707065 A1 **[0008]**
- US 20090145005 A **[0027]**

专利名称(译)	用于监测运动表现的系统和方法
公开(公告)号	EP2672854A1
公开(公告)日	2013-12-18
申请号	EP2012704353
申请日	2012-02-07
申请(专利权)人(译)	NEW BALANCE运动鞋，INC.
当前申请(专利权)人(译)	NEW BALANCE运动鞋，INC.
[标]发明人	PEASE ETHAN RENNER KLAUS ROW GORDON BLAIR KIM B WAWROUSEK CHRIS MURPHY SEAN B FULLUM JEAN FRANCOIS PETRECCA KATHERINE TENBROEK TRAMPAS
发明人	PEASE, ETHAN RENNER, KLAUS ROW, GORDON BLAIR, KIM, B. WAWROUSEK, CHRIS MURPHY, SEAN, B. FULLUM, JEAN-FRANCOIS PETRECCA, KATHERINE TENBROEK, TRAMPAS
IPC分类号	A43B3/00 A63B69/00 G01C22/00 A61B5/00 A61B5/01 A61B5/0205 A61B5/024 A61B5/0402 A61B5/0476 A61B5/08 A61B5/103 A61B5/11 A63B71/06 G06K9/00 G09B19/00
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优先权	61/440243 2011-02-07 US
其他公开文献	EP2672854B1
外部链接	Espacenet

摘要(译)

本发明涉及用于监控用户的一个或多个运动表现特征的装置和方法。示例装置包括适于可附接到用户的鞋的感测单元，感测单元包括第一传感器，其适于在用户运动时监视用户的脚的运动，第一传感器包括陀螺仪传感器处理装置，用于根据第一传感器的输出确定用户的第一性能特征，第一性能特征包括用户脚在撞击地面时的脚击位置，以及用于传输数据包的传输装置代表远程接收器的性能特征。