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(54) **DEVICE AND METHOD FOR A SECURITY SENSOR**

(57) A sensing device (300), comprising: an electromagnetic sensor (401) having a surface with at least one electromagnetic radiation interception area (303); and at least one analog signal processor (408) connected to the electromagnetic sensor. The at least one analog signal processor is adapted to: apply a transfer function (403) to an analog signal (409) received from the electromagnetic sensor to produce a resulting signal (406) having a first substantially constant amplitude when the electro-

magnetic sensor intercepts radiation from a person (301) and a second substantially constant amplitude when the electromagnetic sensor intercepts radiation from a pet animal (302); determine according to a comparison (404) between the resulting signal and a predetermined amplitude threshold (405) whether a movement of a person or a pet is detected; and deliver an output (407) indicative of the determination.

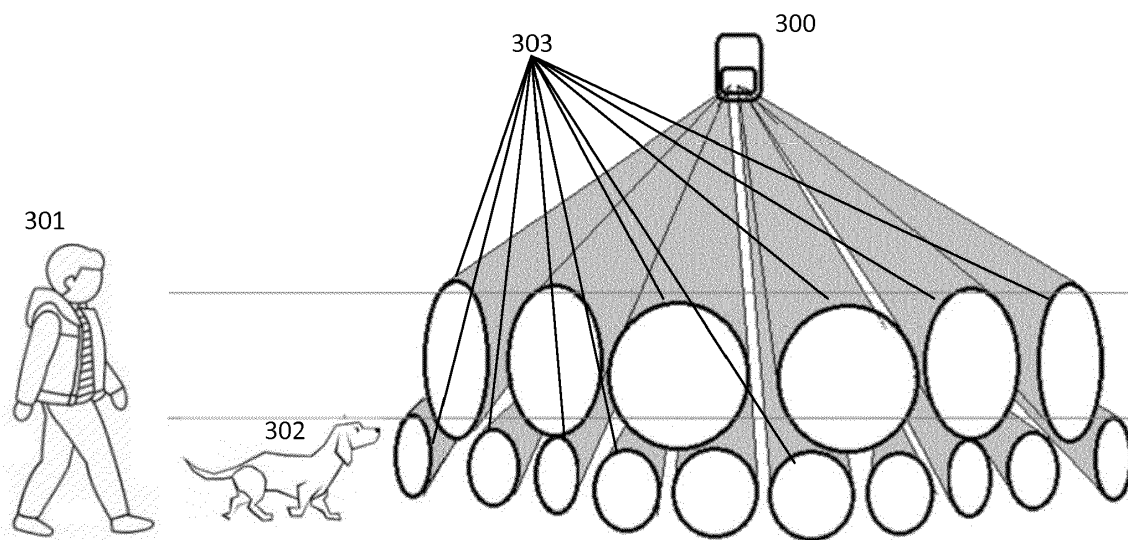


FIG. 1

Description

BACKGROUND

[0001] Some embodiments of the present invention relate to an electromagnetic sensor, and more specifically but not exclusively, to a motion sensor, for sensing motion in an outdoor environment.

[0002] In a typical monitoring and alarm system, one or more sensing devices, for example a passive infra-red (PIR) sensing device, are installed on premises for the purpose of detecting objects moving on the premises. In such systems, an electromagnetic sensor of an installed sensing device intercepts electromagnetic radiation from objects moving in a certain range of distances from the sensing device. When an electromagnetic sensor intercepts electromagnetic radiation from an object it is said that the electromagnetic sensor detects the object. Moving objects are typically persons or vehicles. On some premises, for example a dwelling such as a house, pet animals and other animals may move in the vicinity of the sensing device, causing the sensing device to detect the moving pet animals and other animals.

[0003] In a typical monitoring and alarm system, an installed sensing device triggers an action following detecting a moving object. Examples of actions are sounding an alarm, activating a camera, and sending a message to a predefined recipient. In a typical system, the same action is triggered regardless of the object detected by the installed sensing device. However, in some systems, there is a need to differentiate between different detected objects. For example, there may be a need to differentiate between detecting a person and detecting a pet.

SUMMARY

[0004] It is an object of the invention to provide a device and method for differentiating between a person detected by a motion sensor and a pet detected by a motion sensor.

[0005] The foregoing and other objects are achieved by the features of the independent claims. Further implementation forms are apparent from the dependent claims, the description and the figures.

[0006] Aspects and embodiments of the present invention are set out in the appended claims. These and other aspects and embodiments of the invention are also described herein.

[0007] According to a first aspect of the present invention, a sensing device comprises an electromagnetic sensor having a surface with at least one electromagnetic radiation interception area, and at least one analog signal processor connected to the electromagnetic sensor. The at least one analog signal processor is adapted to: apply a transfer function to an analog signal received from the electromagnetic sensor to produce a resulting signal having a first substantially constant amplitude when the elec-

tromagnetic sensor intercepts radiation from a person and a second substantially constant amplitude when the electromagnetic sensor intercepts radiation from a pet animal; perform a determination of whether a movement of a person or a pet is detected according to a comparison between the resulting signal and a predetermined amplitude threshold; and deliver an output indicative of the determination.

[0008] Signals produced by the electromagnetic sensor are analog electrical signals having variable amplitudes over time. Transforming an electromagnetic sensor's output signal to produce a signal having a substantially constant amplitude enables using simple amplitude comparison to distinguish between detection of a person by the electromagnetic sensor and detection of a pet by the electromagnetic sensor.

[0009] According to a second aspect of the present invention, a method for distinguishing between a person and a pet, comprises: receiving a signal from an electromagnetic sensor; applying a transfer function to an analog signal received from the electromagnetic sensor to produce a resulting signal having a first substantially constant amplitude when the electromagnetic sensor intercepts radiation from a person and a second substantially constant amplitude when the electromagnetic sensor intercepts radiation from a pet animal; performing a determination of whether a movement of a person or a pet is detected according to a comparison between the resulting signal and a predetermined amplitude threshold; and delivering an output indicative of the determination.

[0010] With reference to the first aspect, in a first possible implementation of the first aspect the predefined threshold is dependent on an air temperature in the vicinity of the sensing device. Using a fixed threshold might cause false results at some temperatures. Using a threshold suitable to air temperature in the vicinity of the sensing device increases the accuracy of the determination.

[0011] With reference to the first aspect, in a second possible implementation of the first aspect at least one analog signal processor applies the transfer function to the analog signal by using at least one operational amplifier. Operational amplifiers are common electrical components, making the present invention an economical solution to the problem of distinguishing between detection of a person and detection of a pet animal.

[0012] With reference to the first aspect, or the second possible implementation of the first aspect, in a third possible implementation of the first aspect at least one operational amplifier is connected to an input of at least one additional operational amplifier for applying the transfer function to the analog signal. Combining the functionality of multiple operational amplifiers enables improved constancy of the result signal's significantly constant amplitude.

[0013] With reference to the first and second aspects, in a first possible implementation of the first and second aspects, movement of a person is detected when the first

substantially constant amplitude exceeds the predetermined amplitude threshold. Typically persons weigh more than pets, therefore the resulting signal typically has a significantly higher substantially constant amplitude when detecting a person than when detecting a pet. An electrical circuit for amplitude comparison is typically cheap to manufacture, improving the economy of the solution offered by the present invention.

[0014] With reference to the first and second aspects, in a second possible implementation of the first and second aspects, movement of a pet is detected when the first substantially constant amplitude is less than the predetermined amplitude threshold.

[0015] With reference to the first and second aspects, in a third possible implementation of the first and second aspects the analog signal processor applies a transfer function to the analog signal by convoluting a transfer signal representing a predetermined transfer function with the analog signal. An electrical circuit for convoluting two signals is typically cheap to manufacture, improving the economy of the solution offered by the present invention.

[0016] With reference to the first and second aspects, in a fourth possible implementation of the first and second aspects delivering an output comprises sounding an alarm. Sounding an alarm facilitates alerting a plurality of persons about the determination.

[0017] With reference to the first and second aspects, in a fifth possible implementation of the first and second aspects delivering an output comprises sending a message to a predefined recipient. Sending a message to a predefined recipient allows alerting a specific person of the determination.

[0018] With reference to the first and second aspects, in a sixth possible implementation of the first and second aspects the sensing device further comprises a distance sensor adapted to intercept electromagnetic radiation received from objects in a predefined range of distances from the sensing device; and a controller. The controller is adapted to: identify a correlation between the movement and a detection of a moving object by the distance electromagnetic sensor; and deliver an output when the correlation is identified. Adding a second electromagnetic sensor to detect a moving object at a predefined range of distances from the electromagnetic sensor facilitates detection of a moving person at a predefined distance from the sensing device and ignoring pets moving at the predefined distance from the sensor.

[0019] With reference to the first and second aspects, or the sixth possible implementation of the first and second aspects, in a seventh possible implementation of the first and second aspects delivering an output comprises sounding an alarm.

[0020] With reference to the first and second aspects, or the sixth possible implementation of the first and second aspects, in an eighth possible implementation of the first and second aspects delivering an output comprises sending a message to a predefined recipient.

[0021] With reference to the second aspect, the method may further comprise receiving a second analog signal from a second electromagnetic sensor at the same time of said receiving said signal from said electromagnetic sensor; identifying a correlation between said movement and a detection of a moving object in said second analog signal; and delivering an output when said correlation is identified. The method may further comprise identifying a person at a predefined distance from said electromagnetic sensor; wherein said second analog signal is received only upon said identifying a person at said predefined distance from said electromagnetic sensor. Delivering an output may comprise sounding an alarm and/or sending a message to a predefined recipient.

[0022] Other systems, methods, features, and advantages of the present disclosure will be or become apparent to one with skill in the art upon examination of the following drawings and detailed description. It is intended that all such additional systems, methods, features, and advantages be included within this description, be within the scope of the present disclosure, and be protected by the accompanying claims.

[0023] Unless otherwise defined, all technical and/or scientific terms used herein have the same meaning as commonly understood by one of ordinary skill in the art to which the invention pertains. Although methods and materials similar or equivalent to those described herein can be used in the practice or testing of embodiments of the invention, exemplary methods and/or materials are described below. In case of conflict, the patent specification, including definitions, will control. In addition, the materials, methods, and examples are illustrative only and are not intended to be necessarily limiting.

[0024] Any feature in one aspect of the invention may be applied to other aspects of the invention, in any appropriate combination. In particular, method aspects may be applied to apparatus aspects, and vice versa. As used herein, means plus function features may be expressed alternatively in terms of their corresponding structure, such as a suitably programmed processor and associated memory.

[0025] Furthermore, any, some and/or all features in one aspect can be applied to any, some and/or all features in any other aspect, in any appropriate combination.

[0026] It should also be appreciated that particular combinations of the various features described and defined in any aspects of the invention can be implemented and/or supplied and/or used independently.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

[0027] Some embodiments of the invention are herein described, by way of example only, with reference to the accompanying drawings. With specific reference now to the drawings in detail, it is stressed that the particulars shown are by way of example and for purposes of illus-

trative discussion of embodiments of the invention. In this regard, the description taken with the drawings makes apparent to those skilled in the art how embodiments of the invention may be practiced.

[0028] In the drawings:

FIG. 1 is a schematic illustration of the range where a sensor intercepts radiation from a person and pet; FIG. 2A is a schematic graph representing an amplitude output by a sensor in response to a frequency of the energy intercepted from a detected object, according to some embodiments of the present invention;

FIG. 2B is a schematic graph representing a target amplitude output by a sensor in response to a frequency of the energy intercepted from a detected object, according to some embodiments of the present invention;

FIG. 3 is a schematic block diagram of an exemplary sensing device, according to some embodiments of the present invention;

FIG. 4 is a sequence diagram of an optional flow of operations, according to some embodiments of the present invention;

FIG. 5 is a schematic illustration of an exemplary sensing device comprising two sensors, according to some embodiments of the present invention.

FIG. 6 is a schematic block diagram of an exemplary sensing device having two sensors, according to some embodiments of the present invention;

FIG. 7 is a sequence diagram of another optional flow of operations, according to some embodiments of the present invention having a sensing device with two sensors;

FIG. 8A is a schematic illustration of an exemplary lens array, according to some embodiments of the present invention;

FIG. 8B is a schematic illustration of the top view of a single lens from an exemplary lens array; where the lens is a Fresnel lens, according to some embodiments of the present invention;

FIG. 8C is a schematic illustration of the cross section of the lens shown in FIG. 8B, according to some embodiments of the present invention;

FIG. 9 is a schematic illustration of detection areas of a sensor, according to some embodiments of the present invention;

FIGs. 10A and 10B are graphs representing captured amplitude output by a sensor when detecting objects moving in front of the sensor, in tests executed according to some embodiments of the present invention; and

FIG. 11 is three schematic graphs representing possible signal gain in response to a frequency, according to some embodiments of the present invention.

DETAILED DESCRIPTION

[0029] For brevity, the term "sensor" refers to an electromagnetic sensor, the terms "energy" and "radiation" refer to electromagnetic radiation, the term "sector" refers to an interception sector, and the term "pet" refers to a pet animal or another animal.

[0030] Some embodiments of the present invention relate to an electromagnetic sensor, and more specifically but not exclusively, to a motion sensor, for sensing motion in an outdoor environment.

[0031] A typical electromagnetic sensor comprises at least one sensing surface, for intercepting electromagnetic radiation energy such as visible light, thermal infrared energy or naturally emitted microwave energy. In some embodiments the sensing surface is a sensing panel having a plurality of different electromagnetic radiation interception areas. Such a sensor typically outputs an electrical signal having a varying amplitude and frequency. A sensor is said to detect an object when the sensor intercepts radiation from the object. When the sensor intercepts radiation and detects an object, the sensor outputs a signal having an amplitude and a frequency reflective of the amount of radiation intercepted by the sensor and the frequency at which the sensor intercepts the radiation.

[0032] Typically, a sensor intercepts more radiation from an object at a certain distance from the sensor than from the same object at a distance greater than the certain distance from the sensor. In some embodiments, the sensor comprises a plurality of interception sectors arranged in a plurality of parallel rows. In addition, the field of view is typically an angle, i.e. the sector's field of view at a certain distance from the sensor is greater than the field of view closer to the sensor than the certain distance. Thus an object moving at a certain distance from the sensor has certain angular velocity greater than the angular velocity of the object moving at the certain velocity at a distance from the sensor which is greater than the certain distance.

[0033] An object moving in front of the sensor is detected by one or more of the plurality of sectors. A sector detects more energy when the object is in front of the center of the sector than when the object is in front of an edge of the sector. Thus, an object moving across the field of view of the sensor causes the sensor to generate an output signal having variable amplitude and a frequency reflective of the angular velocity of the object. As a result the sensor intercepts radiation from an object moving at a certain distance from the sensor at a lower frequency than when the sensor intercepts radiation from an object moving closer to the sensor than the certain distance. Thus, as an object, for example a person, approaches the sensor, the closer the object is to the sensor the higher is the amplitude and the higher is the frequency of the signal output by the sensor. For example, an infrared sensor, sensitive to the temperature changes caused by movement of objects, outputs a signal with an ampli-

tude and frequency dependent on the object's distance from the sensor, both amplitude and frequency increasing as the object moves closer to the sensor and decreasing as the object moves farther from the sensor.

[0034] In addition, the sensor intercepts more radiation from a given object at a certain distance from the sensor than from another object weighing less than the given object, at the same certain distance from the sensor.

[0035] One problem dealt with by the present invention is the need to differentiate between persons and pet animals, for example dogs and cats, or other animals, for example raccoons, approaching an area, for example an entrance to a home. For example, there may be a need to take an action, such as sound an alarm or activate a camera, when a person is detected approaching an entrance to a home, but there may be no need to take any action when a cat is detected approaching the entrance.

[0036] A typical motion sensor, adapted to detect any motion in a certain vicinity of the entrance, does not differentiate between persons and pets. In a typical sensor, the amplitude and frequency of the output signal when intercepting radiation from a person at a certain distance from the sensor is similar to another amplitude and another frequency of the output signal when intercepting radiation from a pet at a different distance closer to the sensor than the certain distance. Thus, a typical sensor does not distinguish between a pet and a person. To solve this problem, in some embodiments of the present invention, an analog signal processor applies a transfer function to the signal output by the sensor to produce a resulting signal having, in a certain range of frequencies, a first substantially constant amplitude when the sensor intercepts energy from a person and a second substantially constant amplitude when the sensor intercepts energy from a pet. For example, in a predefined range such as between 0.2 Hertz and 6 Hertz, the difference between a highest amplitude and a lowest amplitude of the resulting signal may be no more than 30% of the resulting signal's highest amplitude in the predefined range. In such embodiments, the resulting signal has a ratio between the resulting signal's lowest amplitude and the resulting signal's amplitude that is maintained when detecting persons and pets.

[0037] In such embodiments, amplitudes of the resulting signal produced when the sensor intercepts radiation from pets are significantly different, and lower, than other amplitudes of the resulting signal produced when the sensor intercepts radiation from persons, regardless of distances and speeds of the persons and pets. For example, the resulting signal's amplitude when detecting a pet weighing 30 kilograms is about one third the resulting signal's amplitude when detecting a person weighing about 85 kilograms. In some embodiments the resulting signal is compared to predefined amplitude threshold. The result of the comparison is used in these embodiments to differentiate between detection of a person and detection of a pet. For example, in some embodiments the resulting signal has amplitudes between 0.8 volts and

1.04 volts when detecting a dog, and amplitudes between 1.68 volts and 2.4 volts when detecting a person. An amplitude threshold may be set at 1.3 volts.

[0038] In these embodiments, it is possible to differentiate between detection of a person and detection of a pet using analog signal processing only, without the need to use a camera and image processing technologies. Using analog signal processing is significantly cheaper and easier to install than using image processing technologies.

[0039] Before explaining at least one embodiment of the invention in detail, it is to be understood that the invention is not necessarily limited in its application to the details of construction and the arrangement of the components and/or methods set forth in the following description and/or illustrated in the drawings and/or the Examples. The invention is capable of other embodiments or of being practiced or carried out in various ways.

[0040] The present invention may be a system, a method, and/or a computer program product. The computer program product may include a computer readable storage medium (or media) having computer readable program instructions thereon for causing a processor to carry out aspects of the present invention.

[0041] The computer readable storage medium can be a tangible device that can retain and store instructions for use by an instruction execution device. The computer readable storage medium may be, for example, but is not limited to, an electronic storage device, a magnetic storage device, an optical storage device, an electromagnetic storage device, a semiconductor storage device, or any suitable combination of the foregoing.

[0042] Computer readable program instructions described herein can be downloaded to respective computing/processing devices from a computer readable storage medium or to an external computer or external storage device via a network, for example, the Internet, a local area network, a wide area network and/or a wireless network.

[0043] The computer readable program instructions may execute entirely on the user's computer, partly on the user's computer, as a stand-alone software package, partly on the user's computer and partly on a remote computer or entirely on the remote computer or server. In the latter scenario, the remote computer may be connected to the user's computer through any type of network, including a local area network (LAN) or a wide area network (WAN), or the connection may be made to an external computer (for example, through the Internet using an Internet Service Provider). In some embodiments, electronic circuitry including, for example, programmable logic circuitry, field-programmable gate arrays (FPGA), or programmable logic arrays (PLA) may execute the computer readable program instructions by utilizing state information of the computer readable program instructions to personalize the electronic circuitry, in order to perform aspects of the present invention.

[0044] Aspects of the present invention are described

herein with reference to flowchart illustrations and/or block diagrams of methods, apparatus (systems), and computer program products according to embodiments of the invention. It will be understood that each block of the flowchart illustrations and/or block diagrams, and combinations of blocks in the flowchart illustrations and/or block diagrams, can be implemented by computer readable program instructions.

[0045] The flowchart and block diagrams in the Figures illustrate the architecture, functionality, and operation of possible implementations of systems, methods, and computer program products according to various embodiments of the present invention. In this regard, each block in the flowchart or block diagrams may represent a module, segment, or portion of instructions, which comprises one or more executable instructions for implementing the specified logical function(s). In some alternative implementations, the functions noted in the block may occur out of the order noted in the figures. For example, two blocks shown in succession may, in fact, be executed substantially concurrently, or the blocks may sometimes be executed in the reverse order, depending upon the functionality involved. It will also be noted that each block of the block diagrams and/or flowchart illustration, and combinations of blocks in the block diagrams and/or flowchart illustration, can be implemented by special purpose hardware-based systems that perform the specified functions or acts or carry out combinations of special purpose hardware and computer instructions.

[0046] In order to understand the present invention, let us first understand the source of a problem the present invention solves in some embodiments thereof.

[0047] Reference is now made to FIG. 1, showing a schematic illustration of the range where a sensor intercepts radiation from a person and a pet, according to some embodiments of the present invention. In some embodiments, a sensing device 300 comprises at least one sensor having a plurality of sectors adapted to intercept radiation from objects in a plurality of detection areas 303 in front of the at least one sensor. Some of the sectors are arranged in multiple rows, one row above the other, resulting in the detection areas being arranged in multiple areas, one area above the other. When an object moves in front of the sensing device, the object may cover, fully or partially, one or more of the detection areas. When the height of a person 301 moving in front of the sensing device is greater than a height threshold, for example 1 meter, the person is present in one or more of the detection areas simultaneously, for example detection areas associated with sectors from two different rows. Thus, some of the plurality of sectors intercept radiation from the person from one or more of the detection areas simultaneously, such that the some of the plurality of sectors intercept a certain amount of energy and the at least one sensor's output signal has a certain amplitude. A pet 302, for example a dog, may be present in only one detection area at a time; however, when moving close to the sensing device, the pet may cover a large part of the

detection area from which the at least one sensor intercepts radiation from the pet. In some embodiments of the present invention, when the pet covers a large part of the detection area, the at least one sensor's output signal has substantially the same certain amplitude when the pet is detected as when the person is detected. In such embodiments the amplitude of the at least one sensor's output signal is substantially the same when detecting a remote person and a nearby pet, thus an amplitude of the at least one sensor's output signal cannot be used to distinguish between a person and a pet. However, amplitude comparison is simple to implement. The present invention, in some embodiments thereof, applies a transfer function to the sensor's output signal to create a signal having significantly constant amplitude that can be used to differentiate between detection of a person and detection of a pet.

[0048] To understand how the present invention works, let us look at a typical output signal from a sensor.

[0049] When a sensor detects an object at a certain distance from the sensor, for example 6 meters, the sensor's output signal has a certain frequency, for example 1 Hertz. When the sensor detects the same object at another certain distance greater than the certain distance, for example 10 meters, the sensor's output signal has another frequency lower than the certain frequency, for example 0.1-0.3 Hertz.

[0050] Reference is now made to FIG. 2A, showing a schematic graph representing an amplitude output by a sensor in response to a frequency of the energy intercepted from a detected object, according to some embodiments of the present invention. X-axis 108 represents the frequency of the signal output by the sensor, starting at zero (no signal output) and increasing. Y-axis 107 represents the amplitude of the signal output by the sensor. Graph 109 represents a typical relationship between the amplitude of the signal output by the sensor, in response to the output signal's frequency. In such embodiments, frequencies below a point 114 and above a point 115 are considered noise and the amplitude in these frequencies is not considered when differentiating between movement of persons and movement of pets. For example, point 114 may represent 0.2 Hertz, which in turn may correspond with energy intercepted from an object at a distance of 12 meters from the sensor. Point 115 may represent 6 Hertz, which in turn may correspond with energy intercepted from an object at a distance of 4 meters from the sensor. The graph indicates that between 114 and 115, the output signal's amplitude increases as the frequency increases, reflecting that the output signal's amplitude increases as the object is nearer the sensor. An output signal generated by the sensor in response to detecting a human and an output signal generated by the sensor in response to detecting a pet typically both have the same shape as graph 103. Typically, a sensor electrically amplifies the sensor's raw output signal to produce the sensor's output signal. However, the maximal amplitude of the sensor's output signal

generated by the sensor in response to detecting a human is typically greater, for example 2.4 volts after gain, than the maximal amplitude of the sensor's output signal generated by the sensor in response to detecting a pet, for example 0.8 volts after gain. Also, at a given frequency (representing a distance from the sensor), the amplitude of the sensor's output signal generated by the sensor in response to detecting a human is typically greater than the amplitude of the sensor's output signal generated by the sensor in response to detecting a pet at the same given frequency. Typically, an amplitude when detecting a person is 3 times another amplitude when detecting a pet. The present invention uses this similarity in output signal shape but difference in amplitudes related to the same frequency to create an amplitude comparison for differentiating between detection of a human and detection of a pet by applying a transfer function to the output signal to produce a resulting signal that can be used in the amplitude comparison.

[0051] A target output signal has a first amplitude when detecting a person at any distance, and a second amplitude, lower than the first amplitude, when detecting a pet at any distance. In embodiments having a sensor producing such a target signal, comparing the amplitude of the output signal to an amplitude threshold may be used to differentiate between detection of a person, when the output signal's amplitude exceeds the amplitude threshold, and detection of a pet, when the output signal's amplitude is less than the amplitude threshold.

[0052] Reference is now made to FIG. 2B, showing a schematic graph representing a target amplitude output by a sensor in response to a frequency of the energy intercepted from a detected object, according to some embodiments of the present invention. X-axis 105 represents the frequency of the signal output by the sensor, starting at zero (no signal output) and increasing. Y-axis 104 represents the amplitude of the signal output by the sensor. Graph 106 represents the target amplitude of the sensor's output signal, in response to the distance. Between a certain frequency 112 and another certain frequency 113 the output signal has a substantially constant certain target amplitude, regardless of the object's distance from the sensor. Above the other frequency 113 the output signal's amplitude descends to zero because these frequencies are considered noise and do not represent a detected object. In such ideal embodiments, values of a first plurality of target amplitudes of the sensor's output signal when detecting a plurality of persons are significantly similar. In addition, values of a second plurality of target amplitudes of the sensor's output signal when detecting a plurality of pets are significantly similar. The values of the first plurality of target amplitudes and the values of the second plurality of target amplitudes are significantly different, with the values of the first plurality of target amplitudes being significantly greater than the values of the second plurality of target amplitudes. Such a significant difference allows, in ideal embodiments where the sensor's output signal has a shape sim-

ilar to graph 106, for identifying an object as a person or as a pet according to the amplitude of the target signal the sensor outputs when intercepting radiation from the object.

[0053] One possible way to achieve a transformed signal having a shape similar to the shape of the target output signal 106 is by convoluting an output signal from the sensor with a transfer signal. In some embodiments of the present invention, an analog signal processor convolutes the sensor's output signal with a transfer signal, representing a transfer function, to produce a resulting signal having a substantially constant amplitude. For example, in embodiments where the amplitude of the output signal increases when detecting objects at a distance of 4 to 5 meters from the sensor and decreases when detecting objects at a distance above 7 or 8 meters from the sensor, a possible transfer function increases gain at frequencies between 0.2 Hertz and 0.6 Hertz by about 20 decibels, increases gain at frequencies between 6 Hertz and 10 Hertz by about 8 decibels, and decreases gain at frequencies above 10 Hertz. The transfer function reflects the amplitudes in relation to frequency of the output signal in the substantially constant amplitude of the resulting signal. An output signal having amplitudes in relation to frequency relatively higher than other amplitudes in relation to frequency of another output signal, results in a resulting signal having substantially constant amplitude higher than another substantially constant amplitude of another result signal from the other output signal.

[0054] Reference is now made to FIG. 3, showing a schematic block diagram of an exemplary sensing device 400 according to some embodiments of the present invention. In such embodiments, a sensor 401 is electrically connected to an analog signal processor 408. The sensor outputs an analog output signal 409 having an amplitude and frequency reflective of an amount of radiation intercepted by the sensor from the sensor's environment and from objects moving in front of the sensor and the frequency at which the radiation is intercepted. The analog signal processor may comprise an electrical component 403, such as electrical circuits, for generating a transfer function. The analog signal processor may comprise an electrical component 402, such as electrical circuits, for applying the transfer function to a signal received from the sensor. In such embodiments, applying the transfer function to the signal received from the sensor produces a resulting signal 406 having a substantially constant amplitude in the predefined range of frequencies. In such embodiments, the analog signal processor comprises an electrical component 404, such as electrical circuits, for comparing the resulting signal to an amplitude threshold 405. In some embodiments, when the resulting signal's amplitude is greater than the amplitude threshold, the analog signal processor determines that a person is detected. Optionally, when the resulting signal's amplitude is less than the amplitude threshold, the analog signal processor determines that a pet is detect-

ed. In some embodiments the analog signal processor outputs an indication 407 of the determination.

[0055] In some embodiments of the present invention, the amplitude threshold depends on a temperature of the environment of the sensor. In such embodiments, the analog signal processor has one amplitude threshold used when the environment temperature has a value approximately equal to the temperature of a human body, and another amplitude threshold used when the environment temperature has a value lower or higher than the temperature of a human body. For example, when the environment temperature has a value between 30 degrees centigrade and 38 degrees centigrade, the amplitude threshold may be 1.3 volt and when the temperature has a value of 25 degrees centigrade or 40 degrees centigrade the amplitude threshold may be 1.4 volt. In some embodiments the sensing device comprises a hardware processor. In embodiments comprising a hardware processor, thermal compensation may be implemented in software executed by the hardware processor.

[0056] In some embodiments the analog signal processor comprises at least one operational amplifier for applying at least part of the transfer function to the sensor's output signal. In some embodiments comprising more than one operational amplifier, an output of one of the more than one operational amplifier is connected to an input of another of the more than one operation amplifier to apply the transfer function to the sensor's output signal.

[0057] In some embodiments, the indication of the determination comprises delivering an electrical current on an output of the analog signal processor. Optionally, the electrical current is delivered on the output of the analog signal processor only when a person is detected. In some embodiments, the indication of the determination comprises sounding an alarm. Optionally, the alarm is sounded only when a person is detected. In other embodiments the indication of the determination comprises sending a message to a predefined recipient. The sensing device may be electrically connected to a hardware processor adapted to send a message using a data network, for example a Wireless Fidelity (WiFi) network or a Global System for Mobile communication (GSM). Optionally, the message is sent only when a person is detected.

[0058] Reference is also made to FIG. 4, showing a sequence diagram of an optional flow of operations 600, according to some embodiments of the present invention. In such embodiments, an analog signal processor receives 601 an output signal from a sensor. In such embodiments the analog signal processor applies 602 a transfer function to the signal to produce a resulting signal having a substantially constant amplitude. The transfer function may be an inverse Gaussian function. In some embodiments the substantially constant amplitude of the resulting signal is greater when movement of a person is detected by the sensor than when movement of a pet is detected by the sensor. In such embodiments, the analog signal processor compares 603 the resulting signal to an amplitude threshold, and according to the compar-

ison determines 604 whether movement of a person was detected or movement of a pet. In some embodiments, movement of a person is detected when the amplitude of the resulting signal is higher than the amplitude threshold. Movement of a pet may be detected when the amplitude of the resulting signal is lower than the amplitude threshold. In some embodiments the analog signal processor outputs 605 an indication of the determination. The indication may be, but is not limited to, activating a camera, sounding an alarm, and sending a message to a predefined recipient. In some embodiments the analog signal processor is connected to another electrical component, for example a controller. In such embodiments a possible indication is driving an electrical current on an output of the analog signal processor connected to the other electrical component.

[0059] Reference is now made to FIG. 5, showing a schematic illustration of an exemplary sensing device 200 comprising two sensors, according to some embodiments of the present invention. In such embodiments, the sensing device comprises two sensors: a top sensor 204 and a bottom sensor 208. Reference is also made to FIG. 6, showing a schematic block diagram of an exemplary sensing device 500 having two sensors, according to some embodiments of the present invention. Optionally, sensor 401 is a top sensor on a vertical axis of the sensing device, electrically connected to the analog signal processor to differentiate between detecting a person and detecting a pet. The sensing device may comprise a bottom sensor 501 on the vertical axis of the sensing device, electrically connected to a controller 502, such that the bottom sensor's output signal 503 is delivered to the controller. In addition, in such embodiments the analog signal processor's indication 407 is delivered to the controller. Optionally, the bottom sensor is adapted to detect moving objects from a certain range of distances from the sensing device. In some embodiments, the controller is adapted to deliver current on an output 504 of the controller when the analog signal processor indicates that a person is detected at the same time as the bottom sensor detects an object in the certain range of distances from the sensing device. The bottom sensor may detect a person or a pet but not differentiate between a person and a pet. In such embodiments the controller delivers current on the output only when the bottom detects any object and the analog signal processor indicates the top sensor detects a person. Optionally, the controller is delivered with a current by the analog signal processor only when the top sensor detects a person.

[0060] In some embodiments the controller output is connected to a device capable of emitting a light or emitting a sound, for example an alarm. In other embodiments the controller is electrically connected to hardware processor adapted to send a message using a data network, for example a Wifi network or a GSM network. In some such embodiments, the hardware processor sends a message to a predefined recipient using the data network when the controller drives a current on the output.

[0061] Reference is also made to FIG. 7, showing a sequence diagram of another optional flow of operations 700, according to some embodiments of the present invention having a sensing device with two sensors. In such embodiments, a controller connected to the analog signal processor receives 701 the indication of the determination from the analog signal processor and in 702 the controller receives an output signal from a second sensor. In such embodiments the controller identifies 703 a correlation between the second sensor detecting movement of an object and the analog signal processor indicating the detection of a person. In some embodiments the controller outputs an indication of the correlation. The indication may be, but is not limited to, driving current on an output of the controller, activating a camera, sounding an alarm, or sending a message to a predefined recipient. In some embodiments the second sensor is adapted to detect objects moving at a certain range of distances from the sensor. In such embodiments, the controller outputs the indication of the correlation only when a person moves at the certain range of distances from the sensor.

[0062] In some embodiments, the sensing device further comprises a lens located in front of the sensor. Optionally, the lens is a lens array, for example a multiple-frame Fresnel lens sheet, having multiple frames with different optical characteristics and where the multiple frames are arranged in multiple parallel rows. The different optical characteristics may be for detecting objects at different distances from the sensor.

[0063] Reference is now made to FIG. 8A, showing a schematic illustration of an exemplary lens array, according to some embodiments of the present invention. In these embodiments the frames are arranged in multiple parallel rows, one row above the other.

[0064] In these embodiments each frame may be processed as a Fresnel lens, using cutting or processing techniques as known in the art.

[0065] Reference is now made to FIGs. 8B and 8C showing schematic illustrations of a single frame from an exemplary lens array, according to some embodiments of the present invention. FIG. 8B shows a schematic illustration of a flattened top view of a single frame from an exemplary lens array where the frame is a Fresnel lens, according to some embodiments of the present invention. FIG. 8C shows a schematic illustration of a vertical cross section of the same single frame, according to some embodiments of the present invention.

EXAMPLES

[0066] Reference is now made to the following examples which, together with the above descriptions, illustrate the invention in a non-limiting fashion.

[0067] The following examples demonstrate signal amplitude of a sensor's output signal when detecting an object moving horizontally in parallel to a vertical surface perpendicular to the sensor's horizontal axis.

[0068] Reference is now made to FIG. 9, showing a

schematic illustration of detection areas, or zones, of a sensor, according to some embodiments of the present invention. In such embodiments, a sensor is located at 901 on an imaginary axis 908. A right-to-left path 903 at a constant distance 902 from the sensor has an arc shape. Axis 908 represents a plane perpendicular to the sensor's horizontal axis. A first right-to-left path 906 parallel to the plane at a distance 904 from the plane has a varying distance from the sensor. 909 is an example of a distance of the first path from the sensor greater than distance 904. Also a second right-to-left path 906 parallel to the plane at a distance of 905, greater than distance 904, has a varying distance from the sensor. 910 is an example of a distance of the second path from the sensor greater than distance 905.

[0069] Reference is now made to FIGs. 10A and 10B, showing graphs representing captured amplitude output by a sensor when detecting objects moving in front of the sensor, in tests executed according to some embodiments of the present invention. In these tests, the objects move in horizontal paths parallel to a vertical surface perpendicular to the sensor's horizontal axis.

[0070] FIG. 10A shows a graph representing sample amplitude output by the sensor when detecting a person moving in a first horizontal path parallel to the surface at a distance of 8 meters from the surface. X-axis 801 is time in seconds. Y-axis 802 is the sensor's output signal's amplitude in volts. Graph 803 shows the amplitude of the sensor's output signal related to time. As the person moves along the first path, at first the person moves closer to the sensor, and thus the amplitude and the frequency of the graph increase. Next the person moves away from the sensor, and the amplitude and the frequency of the graph decrease.

[0071] FIG. 10B shows a graph representing sample amplitude output by the sensor when detecting a person moving in a second horizontal path parallel to the surface at a distance of 3 meters from the surface. X-axis 804 is time in seconds. Y-axis 805 is the sensor's output signal's amplitude in volts. Graph 806 shows the amplitude of the sensor's output signal related to time. As the person moves along the second path, at first the person moves closer to the sensor, and thus the amplitude and the frequency of the graph increase. Next the person moves away from the sensor, and the amplitude and the frequency of the graph decrease.

[0072] Graphs 803 and 806 are similar in shape, but differ in the values of amplitude and frequency. In graph 803, representing amplitudes captured from motion at a distance of 8 meters, the values of amplitude do not exceed 1.824 volts. In graph 806, representing amplitudes captured from motion at a nearer distance of 3 meters, peak amplitudes are as high as 2.069 volts. These graphs demonstrate how the amplitude of the sensor's output signal is affected by the object's distance from the sensor.

[0073] Reference now is made to FIG. 11, showing three schematic graphs representing possible signal gain in response to a frequency, according to some embodi-

ments of the present invention. A graph showing gain in response to frequency is a common equivalent representation for showing amplitude in response to time. X-axis 1001 is a logarithmic representation of frequency in Hertz. Y-axis 1002 is gain in decibels/decade. Graph 1005 shows a possible sensor's output signal, where between frequency 1007 (representing about 0.2 Hertz) and frequency 1008 (representing about 6 Hertz) the graph is shaped as half a Gaussian distribution function.

[0074] Graph 1004 shows a possible transfer function, where the transfer function increases the gain for frequencies above 0.0100 Hertz and below 10.000 Hertz. For frequencies significantly below 0.0100 Hertz and significantly above 10.000 Hertz the transfer function decreases the gain.

[0075] A Bode graph having zeros and poles, showing the transfer function's gain related to frequency, demonstrates a shape of the transfer function. In this example, a first zero indicates an increase in gain of 20decibels/decade starting at 0.01 Hertz, a first pole indicates no change in gain starting at 0.2 Hertz, a second pole decreases gain by 20 decibels/decade starting at 0.4 Hertz, a second zero indicates no change in gain starting at 6 Hertz and a third pole indicates a decrease in gain of 20 decibels/decade starting at 12 Hertz. This set of zeros and poles results in a graph shaped similar to graph 1004.

[0076] Graph 1003 shows a possible resulting function after convoluting the output signal represented by graph 1004 with the transfer function represented by graph 1005. In the resulting function, between points 1007 and 1008 the graph shows a substantially constant gain.

[0077] In further examples, there is provided a sensing device, comprising: an electromagnetic sensor having a surface with at least one electromagnetic radiation interception area; and at least one analog signal processor connected to the electromagnetic sensor. The at least one analog signal processor is adapted to: apply a transfer function to an analog signal received from the electromagnetic sensor to produce a resulting signal having a first substantially constant amplitude when the electromagnetic sensor intercepts radiation from a person and a second substantially constant amplitude when the electromagnetic sensor intercepts radiation from a pet animal; determine according to a comparison between the resulting signal and a predetermined amplitude threshold whether a movement of a person or a pet is detected; and deliver an output indicative of the determination.

[0078] The descriptions of the various embodiments of the present invention have been presented for purposes of illustration, but are not intended to be exhaustive or limited to the embodiments disclosed. Many modifications and variations will be apparent to those of ordinary skill in the art without departing from the scope and spirit of the described embodiments. The terminology used herein was chosen to best explain the principles of the embodiments, the practical application or technical improvement over technologies found in the marketplace,

or to enable others of ordinary skill in the art to understand the embodiments disclosed herein.

[0079] It is expected that during the life of a patent maturing from this application many relevant electromagnetic sensors will be developed and the scope of the term "sensor" is intended to include all such new technologies a priori.

[0080] As used herein the term "about" refers to $\pm 10\%$.

[0081] The terms "comprises", "comprising", "includes", "including", "having" and their conjugates mean "including but not limited to". This term encompasses the terms "consisting of" and "consisting essentially of".

[0082] The phrase "consisting essentially of" means that the composition or method may include additional ingredients and/or steps, but only if the additional ingredients and/or steps do not materially alter the basic and novel characteristics of the claimed composition or method.

[0083] As used herein, the singular form "a", "an" and "the" include plural references unless the context clearly dictates otherwise. For example, the term "a compound" or "at least one compound" may include a plurality of compounds, including mixtures thereof.

[0084] The word "exemplary" is used herein to mean "serving as an example, instance or illustration". Any embodiment described as "exemplary" is not necessarily to be construed as preferred or advantageous over other embodiments and/or to exclude the incorporation of features from other embodiments.

[0085] The word "optionally" is used herein to mean "is provided in some embodiments and not provided in other embodiments". Any particular embodiment of the invention may include a plurality of "optional" features unless such features conflict.

[0086] Throughout this application, various embodiments of this invention may be presented in a range format. It should be understood that the description in range format is merely for convenience and brevity and should not be construed as an inflexible limitation on the scope of the invention. Accordingly, the description of a range should be considered to have specifically disclosed all the possible subranges as well as individual numerical values within that range. For example, description of a range such as from 1 to 6 should be considered to have specifically disclosed subranges such as from 1 to 3, from 1 to 4, from 1 to 5, from 2 to 4, from 2 to 6, from 3 to 6 etc., as well as individual numbers within that range, for example, 1, 2, 3, 4, 5, and 6. This applies regardless of the breadth of the range.

[0087] Whenever a numerical range is indicated herein, it is meant to include any cited numeral (fractional or integral) within the indicated range. The phrases "ranging/ranges between" a first indicate number and a second indicate number and "ranging/ranges from" a first indicate number "to" a second indicate number are used herein interchangeably and are meant to include the first and second indicated numbers and all the fractional and

integral numerals therebetween.

[0088] It is appreciated that certain features of the invention, which are, for clarity, described in the context of separate embodiments, may also be provided in combination in a single embodiment. Conversely, various features of the invention, which are, for brevity, described in the context of a single embodiment, may also be provided separately or in any suitable subcombination or as suitable in any other described embodiment of the invention. Certain features described in the context of various embodiments are not to be considered essential features of those embodiments, unless the embodiment is inoperative without those elements.

[0089] All publications, patents and patent applications mentioned in this specification are herein incorporated in their entirety by reference into the specification, to the same extent as if each individual publication, patent or patent application was specifically and individually indicated to be incorporated herein by reference. In addition, citation or identification of any reference in this application shall not be construed as an admission that such reference is available as prior art to the present invention. To the extent that section headings are used, they should not be construed as necessarily limiting.

[0090] It will be understood that the invention has been described above purely by way of example, and modifications of detail can be made within the scope of the invention.

[0091] Each feature disclosed in the description, and (where appropriate) the claims and drawings may be provided independently or in any appropriate combination.

[0092] Reference numerals appearing in the claims are by way of illustration only and shall have no limiting effect on the scope of the claims.

Claims

1. A sensing device (300), comprising:

an electromagnetic sensor (401) having a surface with at least one electromagnetic radiation interception area (303);
at least one analog signal processor (408) connected to said electromagnetic sensor and adapted to:

apply a transfer function (403) to an analog signal (409) received from said electromagnetic sensor to produce a resulting signal (406) having a first substantially constant amplitude when said electromagnetic sensor intercepts radiation from a person (301) and a second substantially constant amplitude when said electromagnetic sensor intercepts radiation from a pet animal (302); perform a determination of whether a movement of a person or a pet is detected ac-

ording to a comparison (404) between said resulting signal and a predetermined amplitude threshold (405); and deliver an output (407) indicative of said determination.

2. The sensing device of claim 1, wherein said movement of a person (301) is detected when said first substantially constant amplitude exceeds said predetermined amplitude threshold (405).

3. The sensing device of claim 1 or 2, wherein said movement of a pet (302) is detected when said second substantially constant amplitude is below said predetermined amplitude threshold (405).

4. The sensing device of any preceding claim, wherein said analog signal processor (408) applies said transfer function (403) to said analog signal by convoluting a transfer signal representing a predetermined transfer function with said analog signal.

5. The sensing device of any preceding claim, further comprising:

a distance sensor (501) adapted to intercept electromagnetic radiation received from objects in a predefined range of distances from said sensing device; and

a controller (502) adapted to:

identify a correlation between said movement and a detection of a moving object by said distance electromagnetic sensor; and deliver an output (504) when said correlation is identified.

6. The sensing device of any preceding claim, wherein said predefined threshold (405) is dependent on an air temperature in the vicinity of said sensing device (300).

7. The sensing device of any preceding claim, wherein said at least one analog signal processor (408) applies said transfer function (403) to said analog signal by using at least one operational amplifier.

8. The sensing device of claim 7, wherein said at least one operational amplifier is connected to an input of at least one additional operational amplifier for applying said transfer function to said analog signal.

9. A method for distinguishing between a person and a pet, comprising:

receiving (601) a signal from an electromagnetic sensor;
applying (602) a transfer function to an analog

signal received from said electromagnetic sensor to produce a resulting signal having a first substantially constant amplitude when said electromagnetic sensor intercepts radiation from a person and a second substantially constant amplitude when said electromagnetic sensor intercepts radiation from a pet animal; performing (604) a determination of whether a movement of a person or a pet is detected according to a comparison (603) between said resulting signal and a predetermined amplitude threshold; and delivering (605) an output indicative of said determination.

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10. The method of claim 9, wherein said delivering (605) an output comprises sounding an alarm.

11. The method of claim 9 or 10, wherein said delivering (605) an output comprises sending a message to a predefined recipient.

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12. The method of any of claims 9 to 11, further comprising:

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receiving (702) a second analog signal from a second electromagnetic sensor at the same time of said receiving said signal from said electromagnetic sensor; identifying (703) a correlation between said movement and a detection of a moving object in said second analog signal; and delivering (704) an output when said correlation is identified.

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13. The method of claim 12, further comprising identifying a person at a predefined distance from said electromagnetic sensor; wherein said second analog signal is received only upon said identifying a person at said predefined distance from said electromagnetic sensor.

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14. The method of claim 12 or 13, wherein said delivering (704) an output comprises sounding an alarm.

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15. The method of any of claims 12 to 14, wherein said delivering (704) an output comprises sending a message to a predefined recipient.

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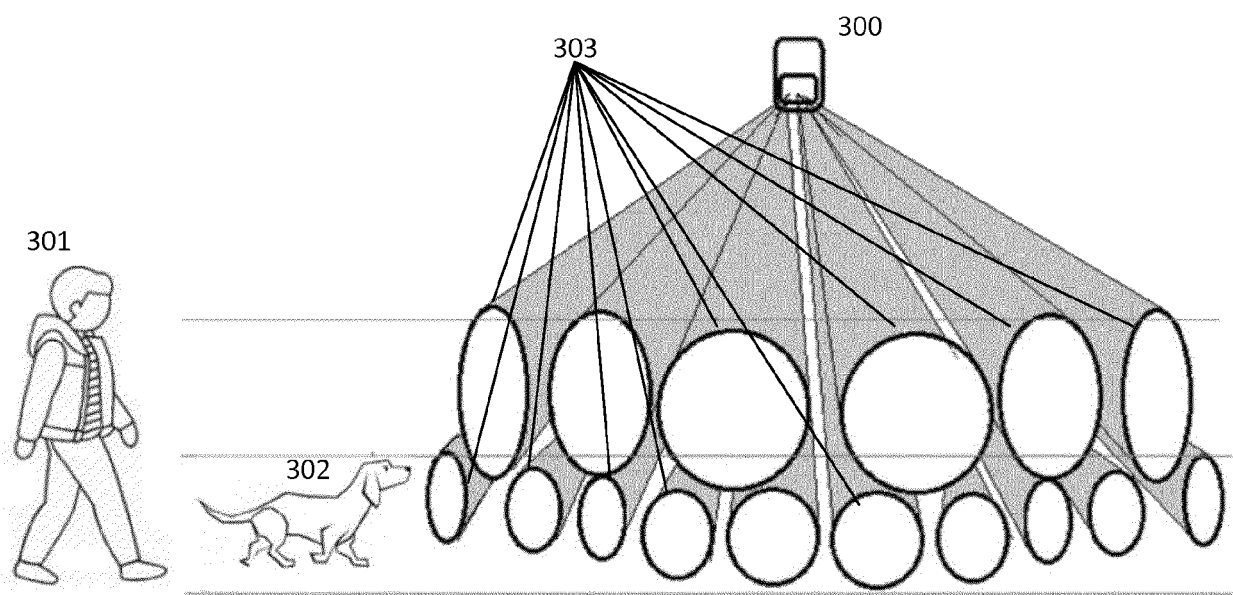


FIG. 1

FIG. 2A

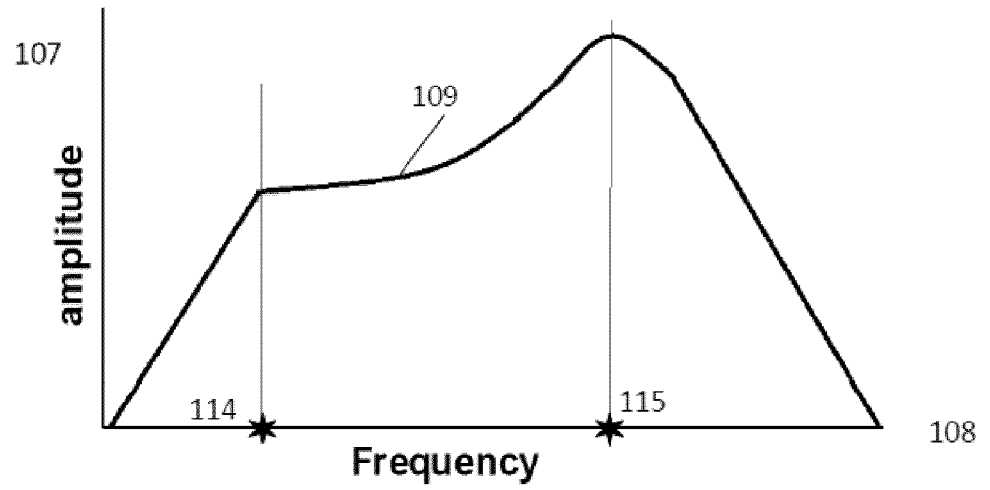
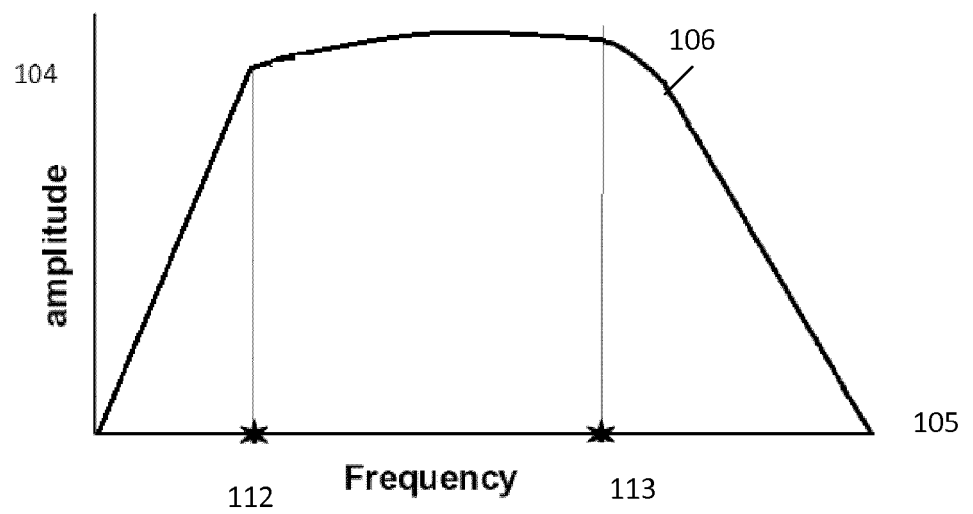


FIG. 2B



400

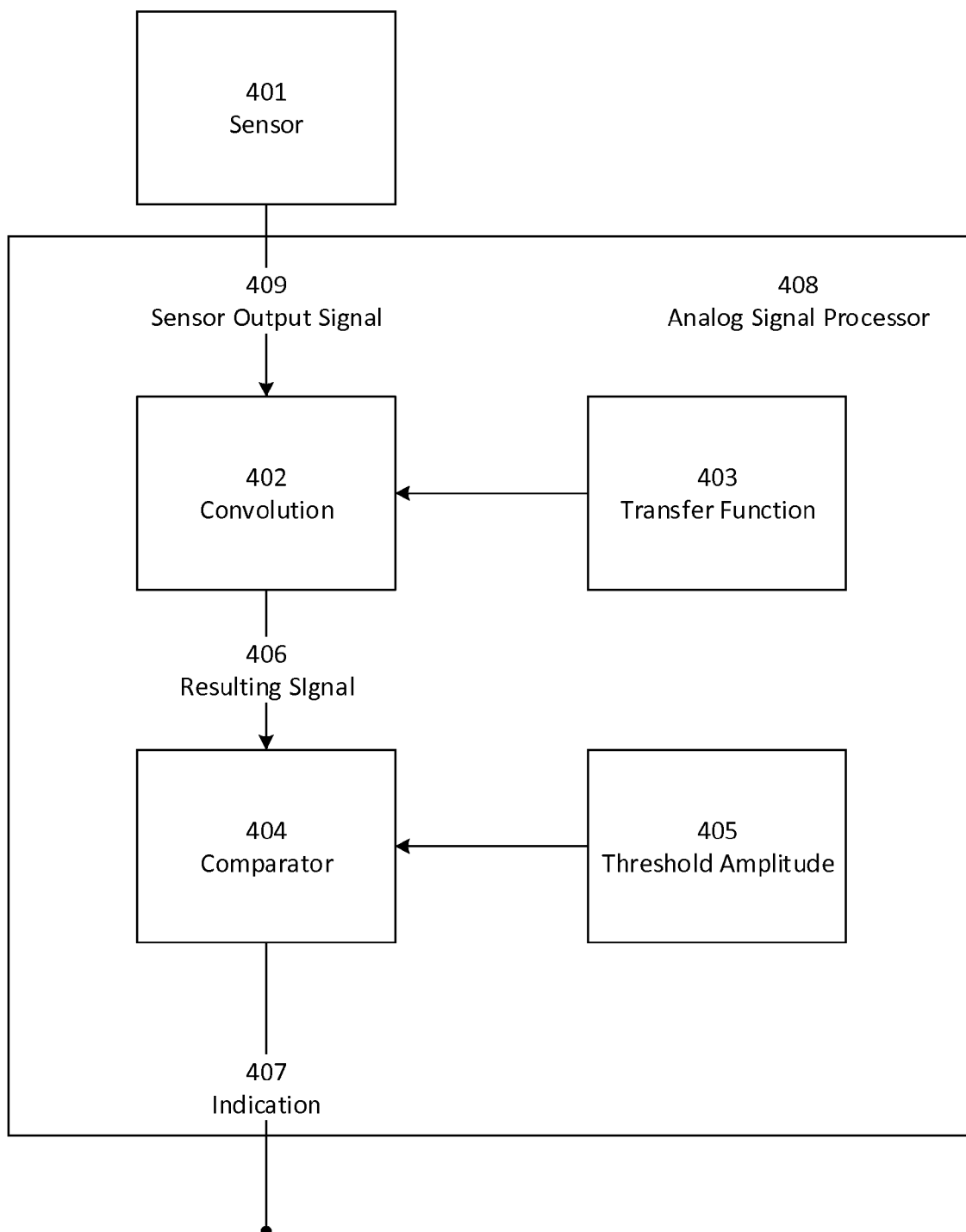


FIG. 3

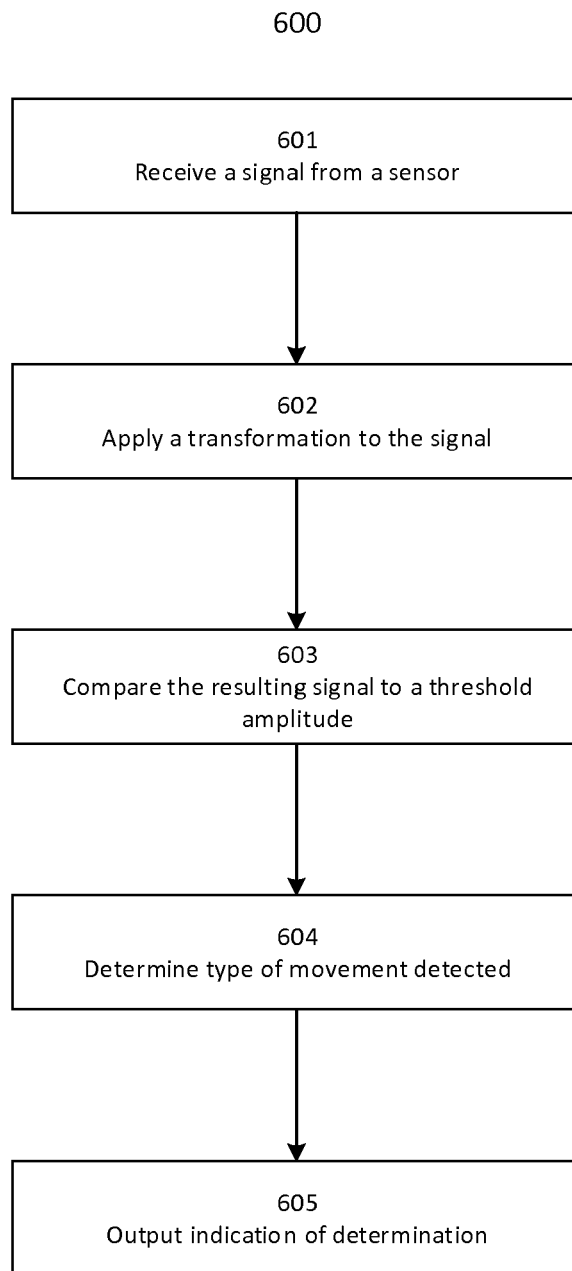


FIG. 4

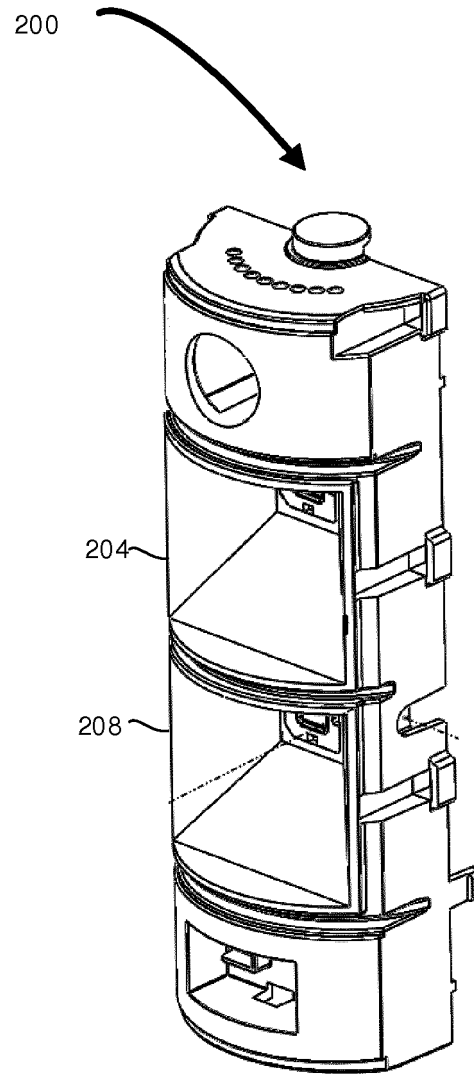


FIG. 5

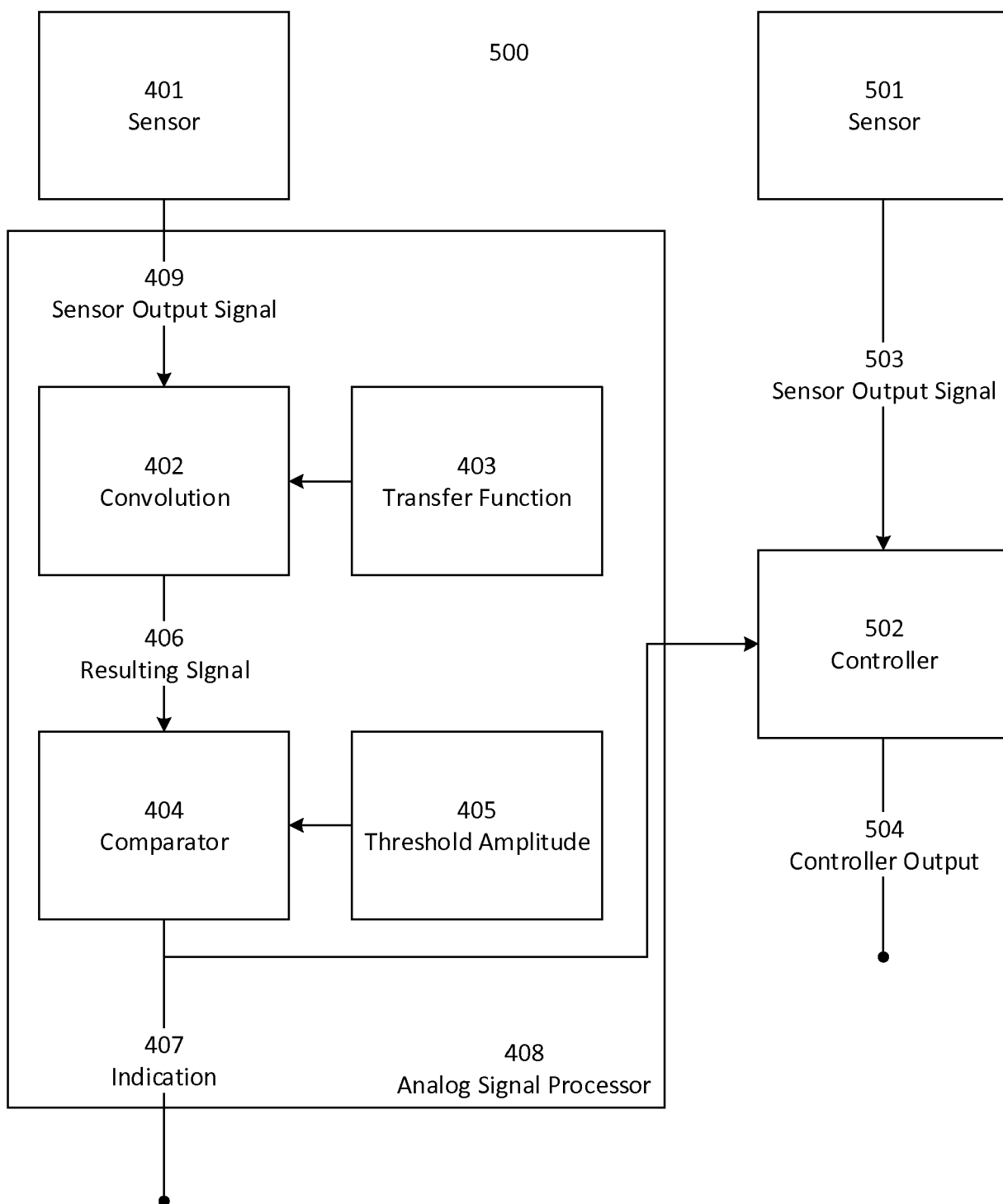


FIG. 6

700

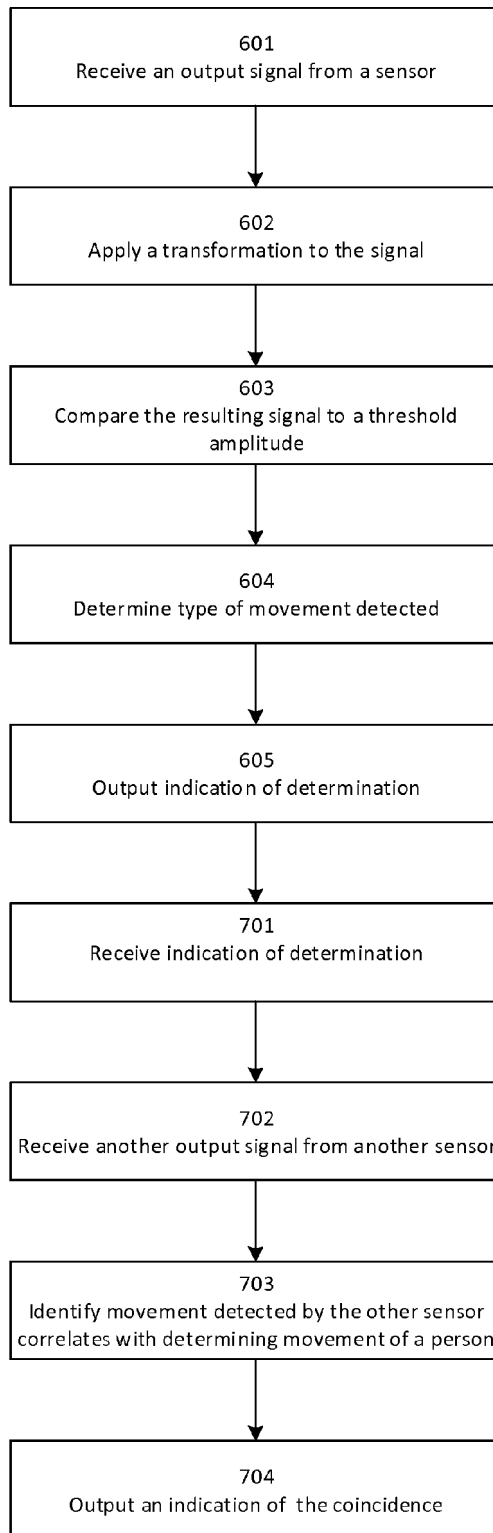


FIG. 7

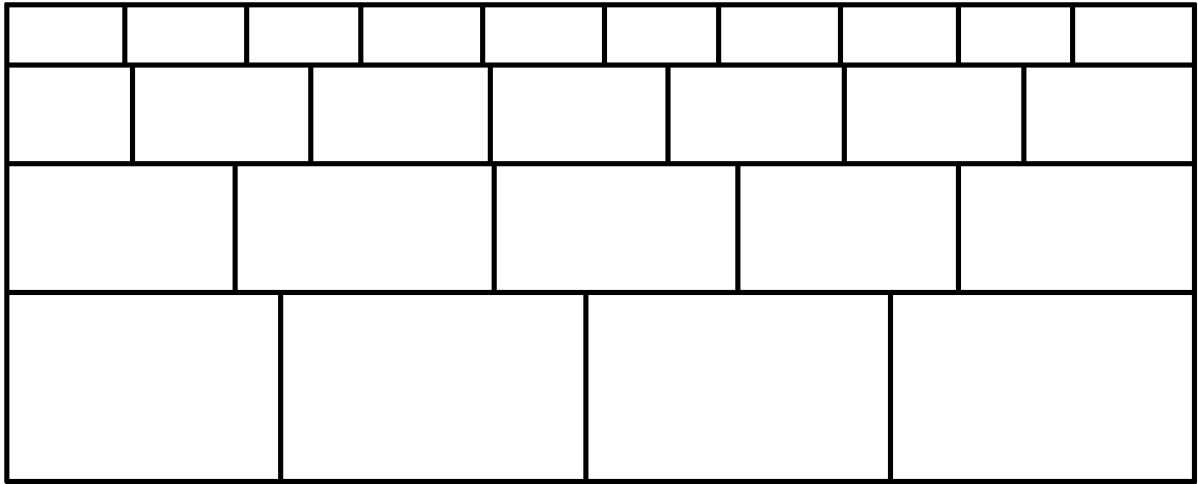


FIG. 8A

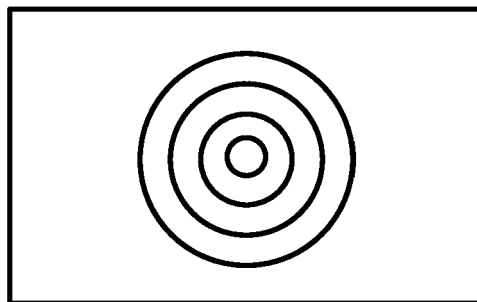


FIG. 8B

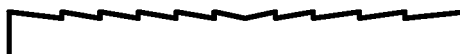


FIG. 8C

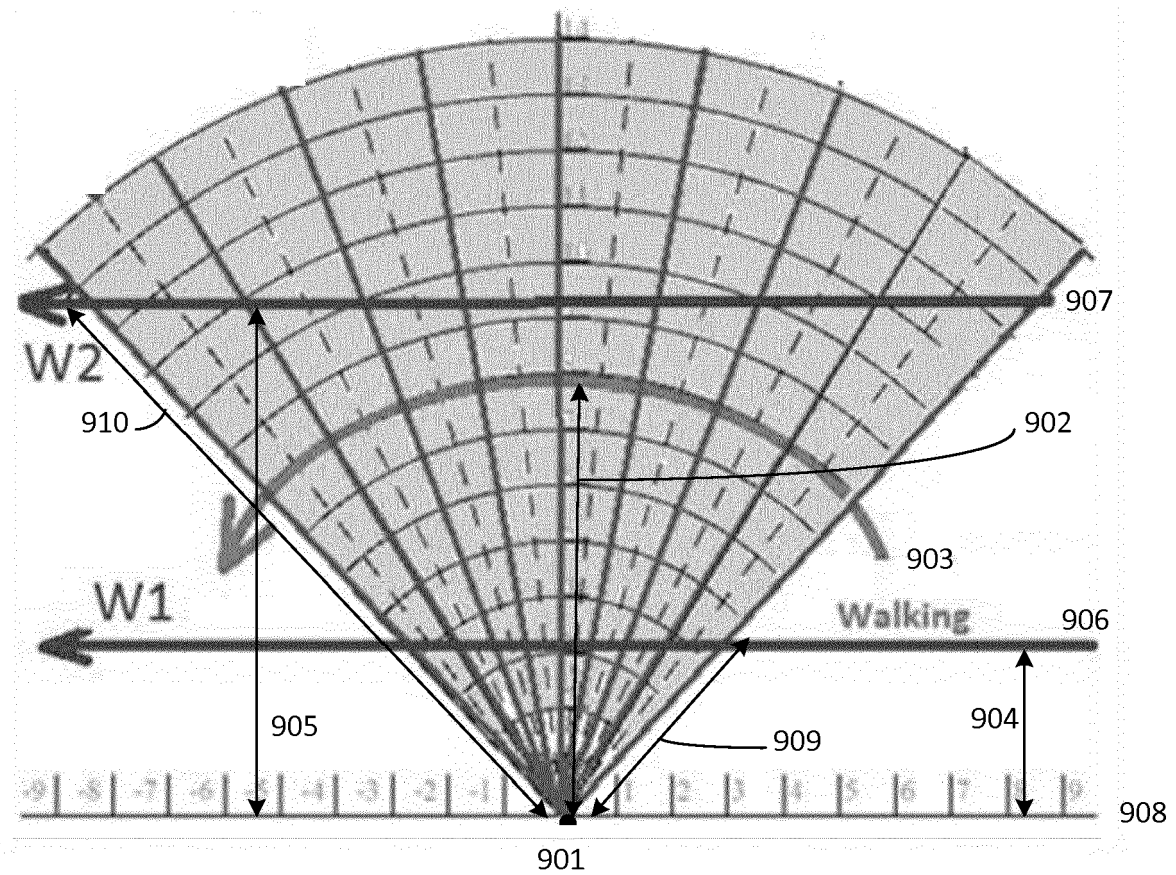


FIG. 9

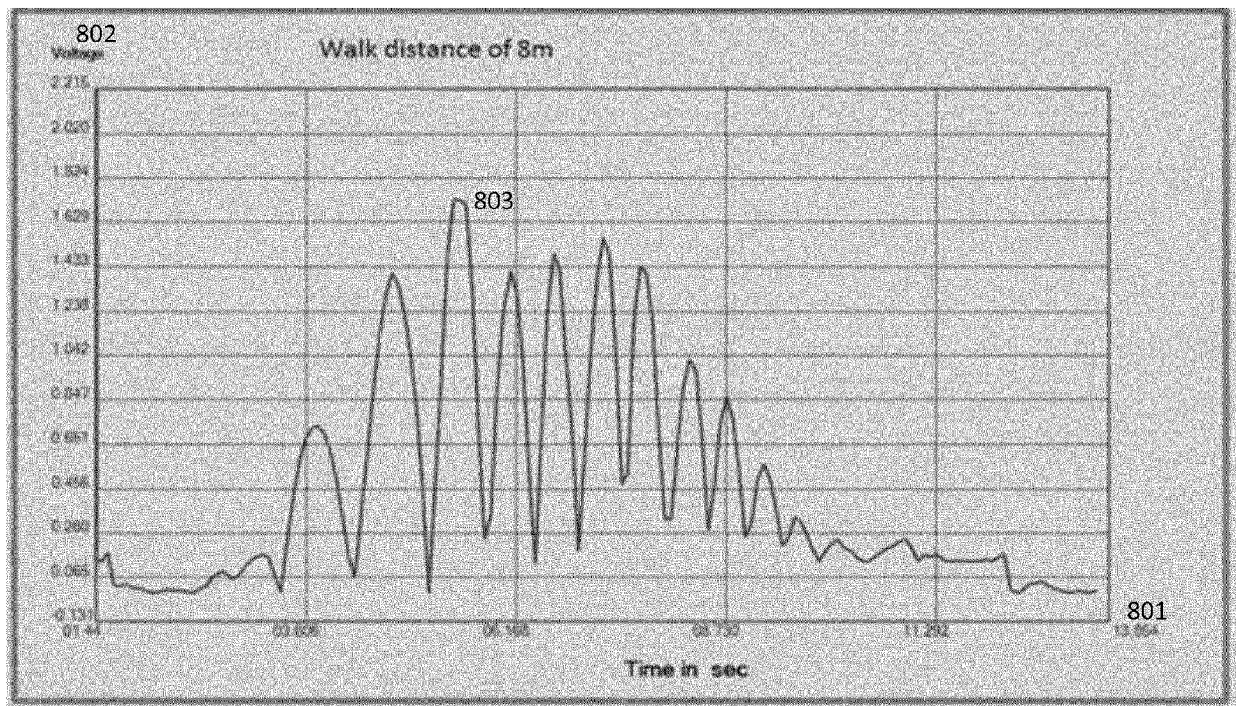


FIG. 10A

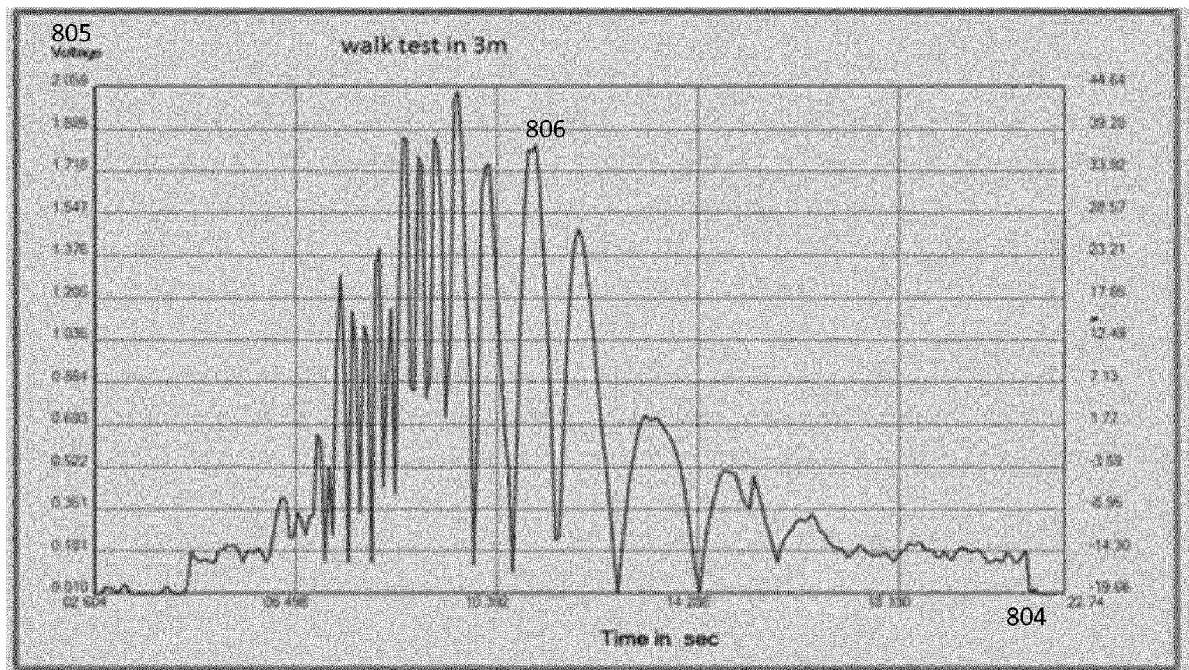
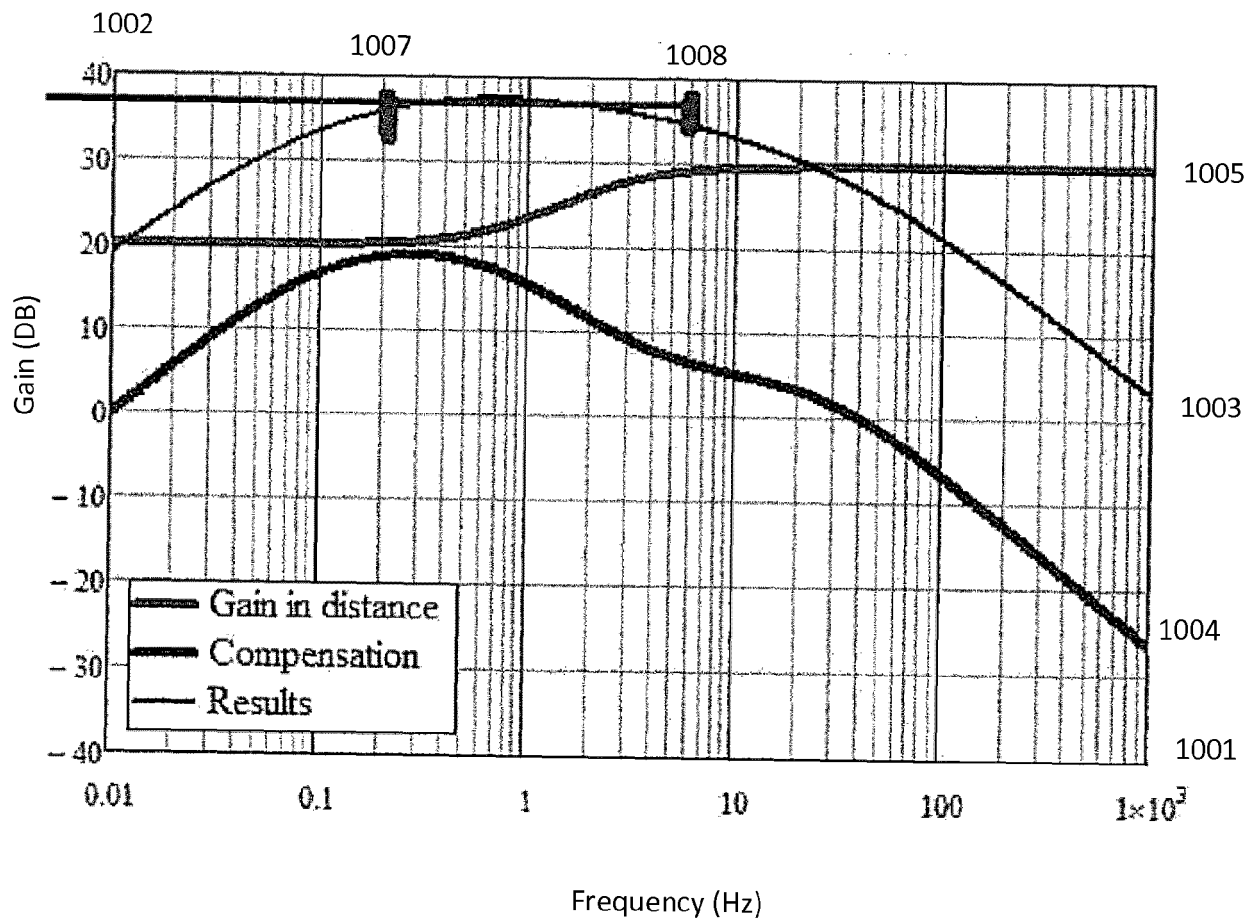


FIG. 10B

**FIG. 11**



EUROPEAN SEARCH REPORT

 Application Number
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