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(54) **MOTION SENSOR**

(57) There is provided a motion sensing apparatus (200) comprising: a housing storing: a motion sensor (250) that senses at least one object (254) moving relative to the motion sensor, a camera (252) that captures at least one image of the at least one object, and a rotation mechanism configured for rotating the motion sensor within the housing to set the motion sensor in a position for detecting the at least one moving object within a monitored region (256). Optionally, an optical assembly (202) filters and/or directs electromagnetic energy arriving from the monitored region within the field of view (258) of the motion sensor, to match or be less than the field of view (260) of the camera such that the at least one object located within the monitored region is captured by the at least one image of the camera when the at least one object is sensed by the motion sensor.

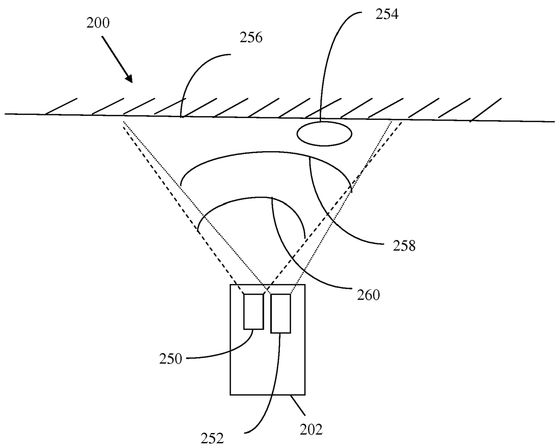

FIG. 2

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Description

RELATED APPLICATION

[0001] This application claims the benefit of priority under 35 USC §119(e) of U.S. Provisional Patent Application No. 62/292,370 filed February 8, 2016, the contents of which are incorporated herein by reference in their entirety.

FIELD AND BACKGROUND OF THE PRESENT INVENTION

[0002] The present invention, in some embodiments thereof, relates to sensors and, more particularly, but not exclusively, to motion sensors.

[0003] Motion sensors are designed to monitor a defined area, which may be outdoors (e.g., entrance to a building, a yard, and the like), and/or indoors (e.g., within a room, in proximity of a door or window, and the like). Motion sensors may be used for security purposes, to detect intruders based on motion in areas in which no motion is expected, for example, an entrance to a home at night.

SUMMARY OF THE PRESENT INVENTION

[0004] 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.

[0005] According to a first aspect, a motion sensing apparatus comprises: a housing storing: a motion sensor that senses at least one object moving relative to the motion sensor, a camera that captures at least one image of the at least one object, and a rotation mechanism configured for rotating the motion sensor within the housing to set the motion sensor in a position for detecting the at least one moving object within a monitored region.

[0006] The rotation mechanism enables changing the field of view orientation of the motion sensor inside the housing without visual identification from outside. The motion sensing may be performed without rotating the external part of the whole apparatus, but rather only its internal part. This does not only make installation easier without special measurements, but also disables a person, such as an intruder from noticing which areas are monitored and which are not.

[0007] The rotation mechanism may be adjusted such that a selected monitored region is being monitored for motion of the object(s) by the motion sensor and image(s) of the moving object(s) is captured using the camera.

[0008] According to a second aspect, a motion sensing apparatus comprises: a motion sensor that senses at least one object moving relative to the motion sensor, a camera that captures at least one image of the at least one object, wherein the field of view of the motion sensor is at least one of larger than and misaligned relative to the field of view of the camera, such that when the at least one object is located at least at one position within a monitored region, the at least one object is sensed by the motion sensor and is not captured by the at least one image of the camera, and an optical assembly that at least one of filters and directs electromagnetic energy arriving from the monitored region within the field of view of the motion sensor, to match or be less than the field of view of the camera such that the at least one object located within the monitored region is captured by the at least one image of the camera when the at least one object is sensed by the motion sensor.

[0009] The motion sensing apparatus may be designed with a common, or set of common, adjustable rotation mechanisms and/or adjustable optical assemblies that are adjusted and customized for the relative distance and/or field of view angles between the installation location of the motion sensing apparatus and the monitored region. The adjustment is designed for customization over a range of distances and/or field of view angles. The motion sensing apparatus may be installed at a certain location and adjusted according to the distance and/or field of view angle to the monitored region, rather than designing sensors and/or the motion sensing apparatus for a specific distance and/or field of view angle.

[0010] The filtering and/or directing of electromagnetic energy arriving from the field of view of the motion sensor to match with or be contained in and/or be less than the field of view of the camera, by the optical assembly of the sensing device, ensures that moving object(s) located within a monitored region that are sensed by the motion sensor are captured in image(s) by the camera.

[0011] The field of view of the motion sensor may be set to be less than the field of view of the camera, such that the images captured by the camera include regions external to the monitored area. For example, an intruder entering the monitored region being monitored by the motion sensor is detected. The camera (which has a larger field of view than the motion sensor) captures image(s) of the intruder even when the intruder moves out of the monitored regions, which increase the probability of capturing the intruder.

[0012] In a first possible implementation form of the apparatus according to the first or second aspects (the second aspect further comprises a housing stores the motion sensor, the camera, and the optical assembly), the housing is configured to at least partially hide the motion sensor, such that an external human observer human is unable to determine which region is the monitored region that is being monitored by the motion sensing apparatus.

[0013] In a second possible implementation form of the apparatus according to the first or second aspects as such or according to any of the preceding implementation forms of the first or second aspects, the housing comprises a one way reflective surface in the shape of a semisphere that covers the motion sensor and the camera.

[0014] In a third possible implementation form of the apparatus according to the first or second aspects as such (where the first aspect further comprises the optical assembly) or according to any of the preceding implementation forms of the first or second aspects, the at least one of filters and directs is performed for the monitored region to detect movement of the at least one object along a plurality of directions and a range of distances relative to the motion sensor.

[0015] In a fourth possible implementation form of the apparatus according to the first or second aspects as such (where the first aspect further comprises the optical assembly) or according to any of the preceding implementation forms of the first or second aspects, the optical assembly comprises a range limiting mechanism that performs the filtering by reducing the field of view of the motion sensor to match with or be less than the field of view of the camera.

[0016] In a fifth possible implementation form of the apparatus according to the preceding fourth implementation form of the first or second aspects, the range limiting mechanism comprises at least two flaps that form an angle that limits the field of view of the motion sensor to match with or be less than the field of view of the camera.

[0017] In a sixth possible implementation form of the apparatus according to the first or second aspects as such (where the first aspect further comprises the optical assembly) or according to any of the preceding implementation forms of the first or second aspects, the optical assembly comprises at least one lens optically arranged relative to the motion sensor to direct electromagnetic energy arriving from the monitored region, wherein the camera is set to capture at least one image of the monitored region.

[0018] In a seventh possible implementation form of the apparatus according to the preceding sixth implementation form of the first or second aspects, the optical assembly is divided into regions, wherein each respective region includes a lens configured to concentrate electromagnetic energy arriving from a respective subregion of the monitored region located at a respective distance from the motion sensor.

[0019] In an eighth possible implementation form of the apparatus according to the preceding sixth or seventh implementation forms of the first or second aspects, each region of the optical assembly includes a Fresnel lens.

[0020] In a ninth possible implementation form of the apparatus according to the preceding sixth, seventh, or eighth implementation forms of the first or second aspects, the size of each lens of each region per row of the optical assembly increases from a top row of lenses of the optical assembly to the bottom row of lenses of the optical assembly.

[0021] The varying sizes of the regions which accommodate lenses designed to focus energy from different distances enable a relatively small optical element to focus energy from a predefined monitored region, which may be relatively large, onto the motion sensor.

[0022] In a tenth possible implementation form of the apparatus according to the preceding sixth, seventh, eighth, or ninth implementation forms of the first or second aspects, the optical assembly including at least one lens is flexible, and wherein the curve and radius of the at least one lens is adjustable to direct light from the field of view of the motion sensor to match with or be less than the field of view of the camera.

[0023] In an eleventh possible implementation form of the apparatus according to the preceding eighth, ninth, or tenth implementation forms of the first or second aspects, Fresnel lenses are arranged along the regions of the optical assembly to receive the electromagnetic energy arriving from varying distances at a substantially constant frequency.

[0024] The Fresnel lenses at higher rows (i.e., closer to the top) of the optical assembly are relatively smaller than the Fresnel lenses at relatively lower rows (i.e., closer to the bottom), which compensates for the lower frequency at which the electromagnetic energy is received from relatively larger distances (i.e., in a farther distance from the motion sensor, an object has to pass a larger linear distance in order to cover the same angle than in a closer distance from the motion sensor).

[0025] In a twelfth possible implementation form of the apparatus according to the preceding seventh, eighth, ninth, or tenth, eleventh implementation forms of the first or second aspects, one or more flaps are adjustable to an angle that corresponds to one or more regions of the optical assembly that include whole Fresnel lenses.

[0026] The angles may be predefined such that only angles in which flap(s) 304 correspond to edges of the Fresnel lenses, and in particular the smallest Fresnel lenses, are allowed, this concentrating the incoming electromagnetic energy to motion sensor 350 using one or more full Fresnel lenses, rather than partial Fresnel lenses which may erratically disperse the incoming electromagnetic radiation instead of concentrating the electromagnetic radiation.

[0027] In a thirteenth possible implementation form of the apparatus according to the preceding twelfth implementation form of the first or second aspects, the one or more regions of the optical assembly that include whole Fresnel lenses are selected according to one or more Fresnel lenses of corresponding regions of the optical assembly designed to concentrate electromagnetic energy received from a predefined distance between the motion sensor and the monitored region being monitored for motion of the at least one object.

[0028] When each region includes a Fresnel lens, partial Fresnel lenses within the field of view of the motion sensor are avoided.

[0029] 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 present 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 present 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.

[0030] 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.

[0031] 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.

[0032] 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 DRAWING(S)

[0033] Some embodiments of the present 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 illustrative discussion of embodiments of the present invention. In this regard, the description taken with the drawings makes apparent to those skilled in the art how embodiments of the present invention may be practiced.

[0034] In the drawings:

FIG. 1 is a schematic that illustrates a technical problem arising from a conventional motion sensor and an associated camera imaging a monitored region to detect a moving object, in accordance with some embodiments of the present invention;

FIG. 2 is a block diagram of components of a sensing device that includes an optical assembly that filters and/or directs energy arriving from the monitored region within a field of view of a motion sensor to match with or be less than a field of view of a camera, in accordance with some embodiments of the present invention;

FIG. 3 is a schematic top view of an exemplary implementation of a motion sensing apparatus, in accordance with some embodiments of the present invention;

FIGs. 4A-4C are schematics of an exemplary design of the lens implementation and/or component of the optical assembly, in accordance with some embodiments of the present invention; and

FIG. 5 is a flowchart of a process of adjusting a motion sensing apparatus by filtering and/or directing energy arriving from the monitored region within the field of view of a motion sensor to match with or be less than the field of view of a camera, in accordance with some embodiments of the present invention.

DESCRIPTION OF SPECIFIC EMBODIMENTS OF THE PRESENT INVENTION

[0035] The present invention, in some embodiments thereof, relates to sensors, and more particularly, but not exclusively, to motion sensors.

[0036] An aspect of some embodiments of the present invention relates to a motion sensing apparatus that senses motion of a moving object(s) within a monitored region using a motion sensor, and captures an image(s) of the moving object(s) using a camera. An optical assembly filters and/or directs electromagnetic energy arriving from the monitored region within the field of view of the motion sensor to match with or be less than the field of view of the camera, so that the camera captures the image(s) of the moving object regardless of the location of the moving object when the moving object is sensed by the motion sensor. The matching is performed so that the field of view of the motion sensor is included in the field of view of the camera.

[0037] Optionally, a rotation mechanism (e.g., a hinge) rotates the motion sensor housed within a housing. The rotation mechanism may rotate the optical assembly in association with the motion sensor. The rotation mechanism may rotate the camera in association with the motion sensor and/or optical assembly. The rotation mechanism may be adjusted such that a selected monitored region is being monitored for motion of the object(s) by the motion sensor and image(s) of the moving object(s) is captured using the camera. The rotation mechanism may perform an internal swivel of the optical assembly and the motion sensor within the housing. The motion sensor may be implemented using dual detecting technology, optionally using two PIR (Passive Infrared) sensors. The rotation mechanism enables changing the field of view orientation of the motion sensor inside the housing without visual identification from outside. The rotation mechanism may be set to rotate at predefined steps having predefined angles, and/or rotate smoothly. Rotation may be along one present axis, two preset axis, or provide full range of motion in three dimensions. In an exemplary implementation, the technical effect achieved by using repetitive PIR lenses and constant tracking angle of the swivel with mechanical stoppers provides a constant angle of 11.25 for each rotation step, or other values, for example, steps of about 5 degrees, 15 degrees, or other angles.

[0038] The motion sensing apparatus is oriented to the defined monitored area for detection of moving object(s). The optical assembly sets the field of view of the motion sensor (optionally the PIR sensor) to be less than or equal to the field of view of the camera, when measured in terms of angles. The field of view of the motion sensor may be set according to the defined monitored area for monitoring moving objects. The field of view of the motion sensor may be set to be less than the field of view of the camera, such that the images captured by the camera include regions external to the monitored area. For example, an intruder entering the monitored region being monitored by the motion sensor is detected. The camera (which has a larger field of view than the motion sensor) captures image(s) of the intruder even when the intruder moves out of the monitored regions, which increases the probability of capturing the intruder. The field of view of the motion sensor may be set relative to the field of view of the camera, for example, about the same, less than about 10-30 degree, less than about 15-45 degrees, or other values.

[0039] In the absence of the optical assembly, the field of view of the motion sensor may be larger than the field of view of the camera, and/or the field of view of the motion sensor may be misaligned with the field of view of the camera. When the moving object is located within a portion of the field of view of the motion sensor that is outside the field of view of the camera, the camera does not capture the image(s) of the moving object. The moving object is able to evade recognition, and evade capture. For example, the motion sensor may detect the presence of a burglar trying to enter a home, but the camera is unable to capture image(s) of the burglar that are used to identify the burglar. The optical assembly ensures that image(s) of the moving object are captured by the camera when the moving object is sensed by the motion sensor.

[0040] Optionally, the optical assembly may comprise a range limiting mechanism, optionally including one or more flaps that limit the field of view of the motion sensor for matching with the field of view of the camera, for example being smaller than or equal to the field of view of the camera.

[0041] Alternatively or additionally, the optical assembly is implemented as one or more lenses that are optically arranged relative to the motion sensor. The lenses direct electromagnetic energy arriving from the monitored region (being monitored for movement of object(s)) within the field of view of the camera to match with the field of view of the motion sensor.

[0042] Optionally, the motion sensor is adjustable according to the installation location of the sensing apparatus relative to the monitored region being monitored for motion of object(s). The adjustment is based on the relative distance and/or relative angle between the location of the installed sensing apparatus relative to the monitored region.

[0043] The optical assembly, optionally when implemented with flap(s) may be connected and adjustable by rotation, using the rotation mechanism thus setting the angle between the flap(s) which defines the size of the field of view of the motion sensor. The optical assembly, optionally when implemented as one or more lenses is adjustable by selection of one or more of the lenses and/or adjustment of parameters of the lenses (e.g., curvature) according to the installation location. The optical assembly may include multiple lenses (optionally Fresnel lenses), where each lens is designed to concentrate electromagnetic energy from a certain distance. Certain lens(es) may be selected according to the relative distance between the installation location of the motion sensing apparatus and the monitored region. The lenses may be adjusted and set at a certain curvature and/or radius, optionally using a frame, according to the relative distance between the installation location of the motion sensing apparatus and the monitored region. The optical assembly may be fixed in the adjusted position.

[0044] The motion sensing apparatus may be designed with a common, or set of common, adjustable optical assemblies that are adjusted and customized for the relative distance between the installation location of the motion sensing apparatus and the monitored region. The adjustment is designed for customization over a range of distances. The motion sensing apparatus may be installed at a certain location and adjusted according to the distance to the monitored region, rather than designing sensors and/or the motion sensing apparatus for a specific distance.

[0045] An aspect of some embodiments of the present invention relates to motion sensing apparatus that includes a housing storing the motion sensor, the camera, and the rotation mechanism that rotates the motion sensor within the housing to set the motion sensor in a position for detecting the at least one moving object within a monitored region. The housing is designed (optionally by including a cover, optionally a one way reflective surface) to at least partially (optionally fully) hide the motion sensor. An external human observer is unable to determine which region is being monitored by the motion sensing apparatus. The housing may include a one way reflective surface in the shape of a semi-sphere that covers the motion sensor and the camera. The one way reflective surface may be sized larger than the angle of the field of view of the motion sensor and the angle of the field of view camera. The oversizing of the cover (optionally the one way reflective surface) hides where the motion sensor and camera are facing from an external observer.

[0046] Before explaining at least one embodiment of the present invention in detail, it is to be understood that the present 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 present invention is capable of other embodiments or of being practiced or carried out in various ways.

[0047] As used herein, the term *motion sensor* refers to one or more sensors, for example, two or more sensors.

[0048] As used herein, the term *camera* refers to one or more cameras and/or other imaging sensors.

[0049] Referring now to the drawings, FIG. 1 is a schematic that illustrates the technical problem arising from a conventional motion sensor 150 and an associated camera 152 imaging a monitored region 156 (which may include a surface and/or volume of space above a surface) to detect a moving object(s) 154, in accordance with some embodiments of the present invention. FIG. 1 depicts a top view of an environment that includes motion sensor 150 and camera 152 monitoring monitored region 156 for moving object(s) 154. Object 154 may be, for example, a person, an animal, a car, and the like. Object 154 may be moving on a surface, for example, land, a road, an entrance to a building, and the like. A field of view 160 of camera 152 is smaller (i.e., has a smaller angle) than a field of view 158 of motion sensor 150, and/or field of view 160 of camera 152 is misaligned relative to field of view 158 of motion sensor 150. When object 154 is located within field of view 158 of motion sensor 150 and located outside of field of view 160 of camera 152, object 154 is sensed by motion sensor 152 but cannot be captured in image(s) by camera 152. A situation arises in which the motion sensor detects the presence of a moving object within the field of view of the motion sensor, but the camera is unable to acquire a picture of the moving object. The moving object may evade recognition and/or capture.

[0050] Reference is now made to FIG. 2, which is a block diagram of components of a motion sensing device 200 that includes an optical assembly 202 that filters and/or directs energy arriving from a monitored region within a field of view 258 of a motion sensor 250 to match or be less than a field of view 260 of a camera 252, in accordance with some embodiments of the present invention. FIG. 2 depicts a top view of an environment that includes motion sensor 250 and camera 252 monitoring monitored region 256 for moving object(s) 254. Field of view 258 of motion sensor 250 may be adjusted and/or set to match (within a tolerance requirement) or be contained in, and/or less than field of view 260 of camera 252. The angle of field of view 258 of motion sensor 250 may be reduced (using range limiting mechanism, optionally flaps, as described herein) to match or be less than the angle of field of view 260 of camera 252. The match in the angle is about 100%, or about 90%, or about 80%, or about 70%, or about 50% (or other values), optionally within a tolerance requirement. When field of view 258 of motion sensor 250 is less than field of view 260 of camera 252, camera 252 may capture image(s) of moving object(s) 254 after the object has left the monitored region, for example, to track the direction in which the moving object is headed. Sensing device 200 addresses the technical problem described herein and with reference to FIG. 1. The filtering and/or directing of electromagnetic energy arriving from field of view 258 of motion sensor 250 to match with or be contained in and/or be less than field of view 260 of camera 252 by optical assembly 202 of sensing device 200 ensures that moving object(s) 254 located within a monitored region 256 that are sensed by the motion sensor are captured in image(s) by the camera.

[0051] Optical assembly 202 is set to maintain the filtering and/or directing of the electromagnetic energy arriving from field of view 258 of motion sensor 250 to match with or be less than field of view 260 of camera 252. The filtering and/or directing of the electromagnetic energy is maintained over a predefined monitored surface area and/or volume.

[0052] The filtering and/or directing of the electromagnetic energy may be performed according to the monitored region 256, which includes a surface area and/or volume of space above the surface being monitored for moving objects 254. Alternatively or additionally, the filtering and/or directing of the electromagnetic energy may be performed according to the space and/or volume above the surface area of the monitored region 256, for example, about 1 meter above the surface, or about 2 meters, or about 1-3 meters, or other values above the surface of monitored region 256. For example, the filtering and/or directing of the electromagnetic energy may be performed to cover a volume that includes an entrance way to a building, including the space above the entrance way that is approximately based on an average height of a human.

[0053] Motion sensor 250 senses motion of object(s) within a range of distance and/or a range of directions. As used herein, the phrase *field of view of the motion sensors* means the designated region (area and/or volume) that is monitored for motion of object(s) within the range of distances and/or range of directions.

[0054] Motion sensor 250 is implemented as, for example, an infrared (e.g., PIR) sensor that detects temperature changes relative to a background, signal processing methods that detect motion based on digital images acquired by a camera (e.g., subtraction of time spaced images to identify changes), a radar, a microwave sensor that transmits microwave pulses and measures the reflections from the moving object, and an ultrasound sensor that transmits ultrasound waves and measures reflections from the moving object.

[0055] Field of view 258 of motion sensor 250 is, for example, 90 degrees, 100 degree, 120 degrees, 150 degrees, 180 degrees, or other values. Field of view 258 of motion sensor 250 may be defined in all directions, or limited in one or more directions (e.g., as described herein). The range of field of view 258 may be based, for example, on the hardware structure of motion sensor 250, the location of installation, objects obstructing the field of view, and the like.

[0056] Camera 252 captures image(s) of field of view 260. As used herein, the phrase *field of view of the camera* means the designated area and/or volume that appears in the image(s) captured by the camera. Camera 252 may be set to capture image(s) independently of motion sensor 250 (i.e., independently of whether motion sensor senses motion or not), continuously (e.g., video camera), or periodically (e.g., still camera capturing one image every predefined number of seconds). Camera 252 may be set to capture image(s) when triggered by motion sensor 250 sensing motion. Camera 252 may capture a predefined number of images and/or video for a predefined time, and/or may capture image(s) until sensing of motion by motion sensor 250 is terminated.

[0057] Camera 252 is implemented as, for example, a digital camera, an optical camera, a still camera, a video camera, and a camera capturing two dimensional (2D) images. Camera 252 may be implemented as an optical sensor, for example, a charged coupled device (CCD), a complementary metal oxide semiconductor (CMOS), and the like.

[0058] Field of view 260 of camera 252 is, for example, about 60 degrees, about 90 degrees, about 120 degrees, about 150 degrees, or other values.

[0059] Optical assembly 202 is designed to include one or both of the following components: a range limiter mechanism and one or more lenses.

[0060] The range limiting mechanism filters the field of view 258 of motion sensor 250 according to a predefined monitored area that is monitored for moving objects. The range limiting mechanism reduces the field of view 258 of motion sensor 250 to coincide with field of view 260 of camera 252. The range limiting mechanism reduces the range of field of view 258 of motion sensor 250, for example, from about 100 degrees to about 90 degrees, or from 120 degrees to 90 degrees, or other values.

[0061] The optical assembly is optically arranged relative to motion sensor 250 to direct energy arriving from the monitored region, which matches or is less than the field of view 260 of camera 252, to motion sensor 250. Optical assembly directs light arriving from field of view 258 of motion sensor 252 by defining the region from which electromagnetic energy is received according to field of view 260 of camera 252.

[0062] The optical assembly may include one or more lenses (as an implementation and/or as components) designed to focus electromagnetic energy (e.g., visible light, infrared wavelengths) towards motion sensor 250. The curvature of the lens is selected to admit and focus electromagnetic energy from a region that matches or is less than the field of view 260 of camera 252.

[0063] Optical assembly 202 (and/or components thereof) is adjustable according to the installation location of sensing apparatus 200 relative to the monitored region that is being covered by field of view 258 of motion sensor 250 and field of view 260 of camera 252. The adjustment is performed to filter and/or direct electromagnetic energy arriving from the monitored region within field of view 258 of motion sensor 250 to match with or be less than field of view 260 of camera 252 and with the required monitoring range.

[0064] When installed, the motion sensing apparatus may be adjusted and customized for the installation location of the motion sensing apparatus. For example, if the monitoring range of the apparatus is about 90-100 degrees, then when the motion sensing apparatus is mounted on a wall of a building, the motion sensor may be adjusted to sense motion on a path leading to the building from a certain direction, and to exclude sensing of motion from other directions. However, the motion sensing may be performed without rotating the external part of the whole apparatus, but rather only its internal part. This does not only make installation easier without special measurements, but also disables a person, such as an intruder from noticing which areas are monitored and which are not.

[0065] The range setting mechanism may comprise or be coupled to (e.g., glued, integrated with, welded to, injection molded with) a rotation member, for example, a second hinge. The second hinge may be adjustable and set in place during installation of the motion sensing apparatus to sense motion in the defined range of directions. The motion sensing apparatus may be installed at a certain location by adjusting the range setting mechanism according to the desired sensing region, rather than, for example, designing different motion sensing devices with fixed ranges for each location.

[0066] Reference is now made to FIG. 3, which is a schematic of an exemplary implementation of a top view of a motion sensing apparatus 300, in accordance with some embodiments of the present invention. Motion sensing apparatus 300 is adjustable to monitor motion of objects in different direction ranges, for example, three exemplary directions (and/or in between positions), as depicted by positions 302A-C of motion sensing apparatus 300.

[0067] A motion sensor 350 of motion sensing apparatus 300 is designed to sense motion in a field of view of about 90 degrees.

[0068] The optical assembly (optionally a component of the optical assembly, as described herein) optionally comprises flap(s) 304, optionally two flaps, which are set at a predefined angle 316 relative to each other. Motion sensor 350 is limited to sensing motion through the gap between flaps 304. Angle 316 is selected to synchronize the field of view of motion sensor 350 with the field of view of camera 352 by limiting the field of view of motion sensor 350. Angle 316 may be selected to allow capturing at a range approximately equal to the size of the range of the field of view of camera 352, for example, angle 316 is set to 90 degrees when the field of view of camera 352 is about 90 degrees.

[0069] Angle 316 between flaps 304 may be adjustable using a vertical axis rotation member. Angle 316 may be increased or decreased between flaps 304 by rotating flaps 304 around a common hinge. In one implementation, one flap 304 is fixed, and another flap 304 is rotatable. Angle 316 between flaps 304 may be set during the manufacturing of motion sensing apparatus 300, and fixed in place, for example, by friction, a locking mechanism (e.g., screen), or other methods.

[0070] Flaps 304, motion sensor 350, and camera 352 may be rotated within a housing of the apparatus using a rotation mechanism, optionally hinge 308 and/or using another rotation member to select the direction for sensing motion from positions 302A-C or in between positions 302A-C. The direction of sensing motion may be selected, for example, during installation of the motion sensor.

[0071] The rotation mechanism may enable rotation of the optical assembly and motions sensor along a single axis, along two axes, or along three axes providing full range of motion.

[0072] Other exemplary rotation mechanisms include: a screw joint, a helical joint, a planar mechanism, a spherical mechanism, a spatial mechanism, and a gear.

[0073] Alternatively or additionally to flaps 304, the optical assembly may comprise lens(es) 320, which is positioned within the field of view of motion sensor 350 and camera 352. Lens(es) 320 may be arranged as a sheet, optionally flexible, that is formed into a curved sheet, a spherical cap, or other forms that may be included or comprise the casing of motion sensor apparatus 300. Lens(es) 320 may be transparent, include a one way mirror, or be partially opaque. Lens(es) 320 may be arranged as a curve around a longitudinal axis of motion sensor apparatus 300 to concentrate incoming energy onto motion sensor 350 and/or camera 352.

[0074] Lens(es) 320 is adjustable. The curve, location, and/or radius of the flexible lens implementation of lens(es) 320 may be selected to synchronize the region from which energy arrives with the field of view 260 of camera 252 (as described with reference to FIG. 2). Flexible lens 320 may be set (i.e., fixed during manufacturing or installation) in place based on a frame and/or external panel that secures the flexible lens within motion sensing apparatus 300. The frame may be adjustable to control the shape of lens(es) 320, and/or preset frames with different shapes may be selected and installed within motion sensing apparatus 300. The frame and/or panel may support the flexible lens(es) 320 at the edge portions, such that no unnecessary additional elements are located between lens 320 and motion sensor 350 and camera 352.

[0075] As discussed herein, optical assembly 202 described with reference to FIG. 2 may be implemented as and/or may include lens(es) component (e.g., lens(es) 320 described with reference to FIG. 3).

[0076] The lens component and/or implementation of the optical assembly may be flexible. The flexible lens is adjustable. The curve, location, and/or radius of the flexible lens may be selected to direct the region from which energy arrives with the field of view 260 of camera 252.

[0077] Reference is now made to FIGs. 4A-4C which are schematics of an exemplary design of the lens(es) implementation and/or component of the optical assembly, in accordance with some embodiments of the present invention. FIG. 4A is a schematic of an optical assembly 420A divided into regions. FIG. 4B is a schematic of a top view of a Fresnel lens 426 implementation of optical assembly 420A, of one of the regions 422C or the whole optical assembly when the optical assembly is not divided into regions. Region 422C or the whole optical assembly is shown in the flattened (i.e., non-curved) state. FIG. 4C is a schematic of a cross sectional side view of Fresnel lens 426.

[0078] As used herein, the *Fresnel* lenses represent an exemplary and not necessarily limiting implementation of optical assembly. Other suitable lenses may be used.

[0079] With reference to FIG. 4A, optical assembly 420A may be formed as a rectangle and/or sheet, optically flexible, as described herein. Optical assembly 420A is divided into multiple regions. For clarity and illustration purposes, two regions 422A and 422B are marked. Each region is designed to concentrate electromagnetic energy (e.g., visible light, infrared radiation) arriving from the object(s) and/or monitored region to the motion sensor. The design of each region is based on an estimated location of a sub-portion of the monitored region being monitored for moving object(s) relative to the motion sensor. The electromagnetic energy arriving from each sub-portion of the monitored region in which the object(s) is moving arrives at the motion sensor through the respective region designed to concentrate the electromagnetic energy from the certain sub-portion.

[0080] Each region is designed as a square or rectangle. Other shapes may be used, for example, hexagons.

[0081] The size of each region per row of the optical assembly 420A increases from a top 424A of optical assembly 420A (i.e., when optical assembly 420A is installed relative to the surface being monitored) to a bottom 424B of the optical assembly 420A. Region 422A located near top 424A of optical assembly 420A is smaller than region 422B located near bottom 424B of optical assembly 420A. It is noted that the number of regions per row is a function of the size of the regions of that row. The row that includes region 422A located near top 424A includes a larger number of elements than the row that include region 422B located near bottom 424B.

[0082] With reference to FIG. 4B, each region 422C of optical assembly 420A (in the implementation of optical assembly which is divided into regions), or the optical assembly itself (in the implementation of optical assembly as a single lens which is not divided into regions), includes Fresnel lens 426. A cross-section of Fresnel lens 426 is shown in FIG. 4C.

[0083] Each Fresnel lens focuses energy from areas corresponding to a certain distance range (i.e., a certain portion of the monitored region being monitored for moving objects), in accordance with the location of the respective Fresnel lens on the vertical axis of optical assembly 420B and physical design characteristics of the respective Fresnel lens, for example, the number of steps of the Fresnel lens, the angle(s), the thickness, and the like. For example, each Fresnel lens in regions 422A of the top row near top 424A are designed to focus energy from areas at distance of about 10-12 meters from the motion sensor apparatus, into a top area of the motion sensor and/or camera. Fresnel lens in regions in the row below the top row may focus energy from areas at a distance of about 8-10 meters from the motion sensor apparatus, into a lower area of the motion sensor and/or camera. Each Fresnel lens in regions of rows towards bottom 424B may focus energy from closer portions of the monitored region.

[0084] The Fresnel lenses are arranged along optical assembly 420A to receive the electromagnetic energy at a substantially constant frequency when the electromagnetic energy is arriving from varying distances. The Fresnel lenses at higher rows (i.e., closer to top 424A) of optical assembly 420A are relatively smaller than the Fresnel lenses at relatively lower rows (i.e., closer to bottom 424B), which compensates for the lower frequency at which the electromagnetic energy is received from relatively larger distances (i.e., in a farther distance from the motion sensor, an object has to pass a larger linear distance in order to cover the same angle than in a closer distance from the motion sensor).

[0085] The varying sizes of the regions which accommodate Fresnel lenses designed to focus energy from different distances enable a relatively small lens to focus energy from a predefined monitored region, which may be relatively large, onto the motion sensor.

[0086] Referring now back to FIG. 3, in an implementation in which optical assembly 320 includes multiple regions with Fresnel lenses (e.g., as described with reference to FIGs. 4A-C), one or more flaps 304 are adjustable to angles that correspond to edges (e.g., vertical edges) of the Fresnel lenses and/or edges of the regions that include the Fresnel lenses. The angles may be predefined such that only angles in which flap(s) 304 correspond to edges of the Fresnel lenses, and in particular the smallest Fresnel lenses, are allowed, this concentrating the incoming electromagnetic energy to motion sensor 350 using one or more full Fresnel lenses, rather than partial Fresnel lenses which may erratically disperse the incoming electromagnetic radiation instead of concentrating the electromagnetic radiation.

[0087] Optical assembly 320 may include multiple regions with different Fresnel lenses, where each Fresnel lens is designed to concentrate incoming electromagnetic energy from different regions

[0088] The field of view of the motion sensor may be adjusted (using the flaps or another optical assembly) such that electromagnetic energy is received from the field of view through a whole number of regions of the lens covering the sensor and divided into areas shaped as Fresnel lenses. When each region includes a Fresnel lens, partial Fresnel lenses within the field of view of the motion sensor are avoided.

[0089] The Fresnel lenses may be selected to provide a compact motion sensing apparatus that is able to monitor a relatively large area for moving objects. It is noted that the Fresnel lens design is not necessarily limiting.

[0090] Thus, a motion sensing apparatus in accordance with embodiments of the disclosure may comprise one or two flaps defining the motion detection angle, possibly for adjusting it in accordance with optic components such as Fresnel lenses.

[0091] Additionally, the motion sensing components may be rotated within a housing during or after installation, without changing the location or installation of the housing, such that motion is sensed at a required direction.

[0092] The housing of the motion sensing apparatus may hide the presence of the motion sensing components. For example, a one way reflective surface in the shape of a semi-sphere may be installed over the motion sensing apparatus to give an impression to on-lookers that a full 180 degrees is being monitored in all directions, when in practice, the range limiting mechanism is set to focus on a certain region. An intruder is not able to tell which area is actually being monitored by the motion sensing apparatus, and may believe that the full range (e.g., large region) is being monitored, which may act as a deterrent.

[0093] Reference is now made to FIG. 5, which is a flowchart of a process of adjusting a motion sensing apparatus (e.g., as described with reference to FIGs. 2, 3, and 4A-4C) by filtering and/or directing energy arriving from the monitored region within the field of view of a motion sensor to match with or be less than the field of view of a camera, in accordance with some embodiments of the present invention.

[0094] At 502, a motion sensing apparatus is provided. The motion sensing apparatus includes a motion sensor that senses moving object(s) and a camera that captures image(s) of the moving object(s). The motion sensing apparatus is a common apparatus that is adjustable according to the installation environment.

[0095] The field of view of the motion sensor and the field of view of the camera are provided.

[0096] At 504, the location in which the motion sensing apparatus is installed relative to a region being monitored for moving objects is defined. The distance and/or angle between the motion sensing apparatus and the monitored region is defined. The range of distances between the motion sensing apparatus and sub-portions of the monitored region is defined.

[0097] At 506, energy arriving from the monitored region within the field of view of the motion sensor is filtered and/or directed to match with or be less than the field of view of the camera, such that object(s) moving within the monitored region are simultaneously sensed by the motion sensor and captured in image(s) by the camera.

[0098] The filtering and/or directing of the electromagnetic energy is performed by adjustment of the optical assembly of the motion sensing apparatus.

[0099] The adjustment may be performed by selecting an optical assembly having regions with Fresnel lenses designed to concentrated incoming electromagnetic radiation for the defined range of distances and/or angles between the installation location of the motion sensing apparatus and the monitored region.

[0100] The adjustment may be performed by rotating one or more flaps to limit the field of view of the motion sensor to match to or be less than the field of view of the camera.

[0101] The adjustment may be performed by rotating the flap(s) to correspond to the Fresnel lenses, such that one or more flaps correspond to a whole number of Fresnel lenses.

[0102] In further examples, there is provided a motion sensing apparatus comprising: a housing storing: a motion sensor that senses at least one object moving relative to the motion sensor, a camera that captures at least one image of the at least one object, and a rotation mechanism configured for rotating the motion sensor within the housing to set the motion sensor in a position for detecting the at least one moving object within a monitored region. Optionally, an optical assembly filters and/or directs electromagnetic energy arriving from the monitored region within the field of view of the motion sensor, to match or be less than the field of view of the camera such that the at least one object located within the monitored region is captured by the at least one image of the camera when the at least one object is sensed by the motion sensor.

[0103] It is expected that during the life of a patent maturing from this application many relevant sensors, camera, and lenses will be developed and the scope of the terms sensor, cameras, and lenses are intended to include all such new technologies *a priori.*

[0104] As used herein the term "about" refers to ± 10 %.

[0105] The terms "comprises", "comprising", "includes", "including", "having" and their conjugates mean "including but not limited to".

[0106] The term "consisting of" means "including and limited to".

[0107] The term "consisting essentially of" means that the composition, method or structure may include additional ingredients, steps and/or parts, but only if the additional ingredients, steps and/or parts do not materially alter the basic and novel characteristics of the claimed composition, method or structure.

[0108] 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.

[0109] Throughout this application, various embodiments of this present 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 present 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.

[0110] 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.

[0111] It is appreciated that certain features of the present 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 present 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 present 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.

[0112] Although the present invention has been described in conjunction with specific embodiments thereof, it is evident that many alternatives, modifications and variations will be apparent to those skilled in the art. Accordingly, it is intended to embrace all such alternatives, modifications and variations that fall within the spirit and broad scope of the appended claims.

[0113] 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.

[0114] 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.

[0115] Each feature disclosed in the description, and (where appropriate) the claims and drawings may be provided independently or in any appropriate combination.

[0116] 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 motion sensing apparatus (200), comprising:

a housing storing:

a motion sensor (250) that senses at least one object (254) moving relative to the motion sensor;
a camera (252) that captures at least one image of the at least one object; and
a rotation mechanism configured for rotating the motion sensor within the housing to set the motion sensor in a position for detecting the at least one moving object within a monitored region (256).

2. The motion sensing apparatus according to claim 1, wherein the housing is configured to at least partially hide the motion sensor (250), such that an external human observer is unable to determine a region that is being monitored by the motion sensing apparatus (200).

3. The motion sensing apparatus according to any of the previous claims wherein the housing comprises a one way reflective surface in the shape of a semisphere that covers the motion sensor (250) and the camera (252).

4. The motion sensing apparatus according to any of the previous claims, wherein the field of view (258) of the motion sensor (250) is at least one of larger than and misaligned relative to the field of view (260) of the camera (252), such that when the at least one object (254) is located at least at one position within the monitored region (256), the at least one object is sensed by the motion sensor and is not captured by the at least one image of the camera; and the motion sensing apparatus further comprises an optical assembly (202) that at least one of filters and directs electromagnetic energy arriving from the monitored region within the field of view of the motion sensor, to match or be less than the field of view of the camera such that the at least one object located within the monitored region is captured by the at least one image of the camera when the at least one object is sensed by the motion sensor.

5. A motion sensing apparatus, comprising:

a motion sensor (250) that senses at least one object (254) moving relative to the motion sensor;
a camera (252) that captures at least one image of the at least one object;
wherein the field of view (258) of the motion sensor is at least one of larger than and misaligned relative to the field of view (260) of the camera, such that when the at least one object is located at least at one position within a monitored region (256), the at least one object is sensed by the motion sensor and is not captured by the at least one image of the camera; and
an optical assembly (202) that at least one of filters and directs electromagnetic energy arriving from the monitored region within the field of view of the motion sensor, to match or be less than the field of view of the camera such that the at least one object located within the monitored region is captured by the at least one image of the camera when the at least one object is sensed by the motion sensor.

6. The motion sensing apparatus according to claim 4 or claim 5, wherein the optical assembly (202) comprises a range limiting mechanism that performs the filtering by reducing the field of view (258) of the motion sensor (250) to match with or be less than the field of view (260) of the camera (252).

7. The motion sensing apparatus according to claim 6, wherein the range limiting mechanism comprises at least two flaps (304) that form an angle (316) that limits the field of view of the motion sensor (250) to match with or be less than the field of view of the camera (252).

8. The motion sensing apparatus according to any of the claims 4 to 7, wherein the optical assembly (202) comprises at least one lens (320) optically arranged relative to the motion sensor (250) to direct electromagnetic energy arriving from the monitored region (256), wherein the camera (252) is set to capture at least one image of the monitored region.

9. The motion sensing apparatus according to claim 8, wherein the optical assembly (202) is divided into regions, wherein each respective region includes a lens (320) configured to concentrate electromagnetic energy arriving from a respective subregion of the monitored region (256) located at a respective distance from the motion sensor (250).

10. The motion sensing apparatus according to claim 8 or claim 9, wherein each region of the optical assembly (202) includes a Fresnel lens (426).

11. The motion sensing apparatus according to any one of claims 8-10, wherein the size of each lens (320) of each region per row of the optical assembly (202) increases from a top row of lenses of the optical assembly to the bottom row of lenses of the optical assembly.

12. The motion sensing apparatus according to any one of claims 8-11, wherein the optical assembly (202) including at least one lens (320) is flexible, and wherein the curve and radius of the at least one lens is adjustable to direct light from the field of view (258) of the motion sensor (250) to match with or be less than the field of view (260) of the camera (252).

13. The motion sensing apparatus according to any one of claims 10 to 12, wherein Fresnel lenses (426) are arranged along the regions of the optical assembly (202) to receive the electromagnetic energy arriving from varying distances at a substantially constant frequency.

14. The motion sensing apparatus according to any one of claims 9 to 13, wherein one or more flaps (304) are adjustable to an angle (316) that corresponds to one or more regions of the optical assembly (202) that include whole Fresnel lenses (426).

15. The motion sensing apparatus according to claim 14, wherein the one or more regions of the optical assembly (202) that include whole Fresnel lenses (426) are selected according to one or more Fresnel lenses of corresponding regions of the optical assembly designed to concentrate electromagnetic energy received from a predefined distance between the motion sensor (250) and the monitored region (256) being monitored for motion of the at least one object.

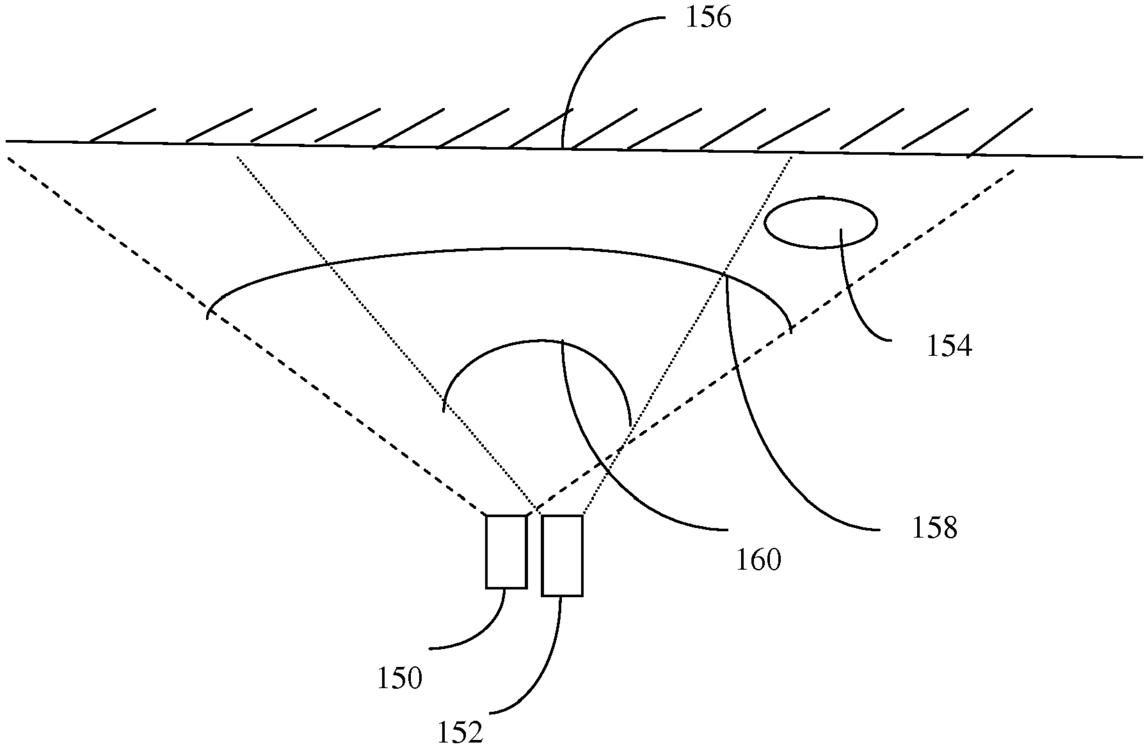

FIG. 1

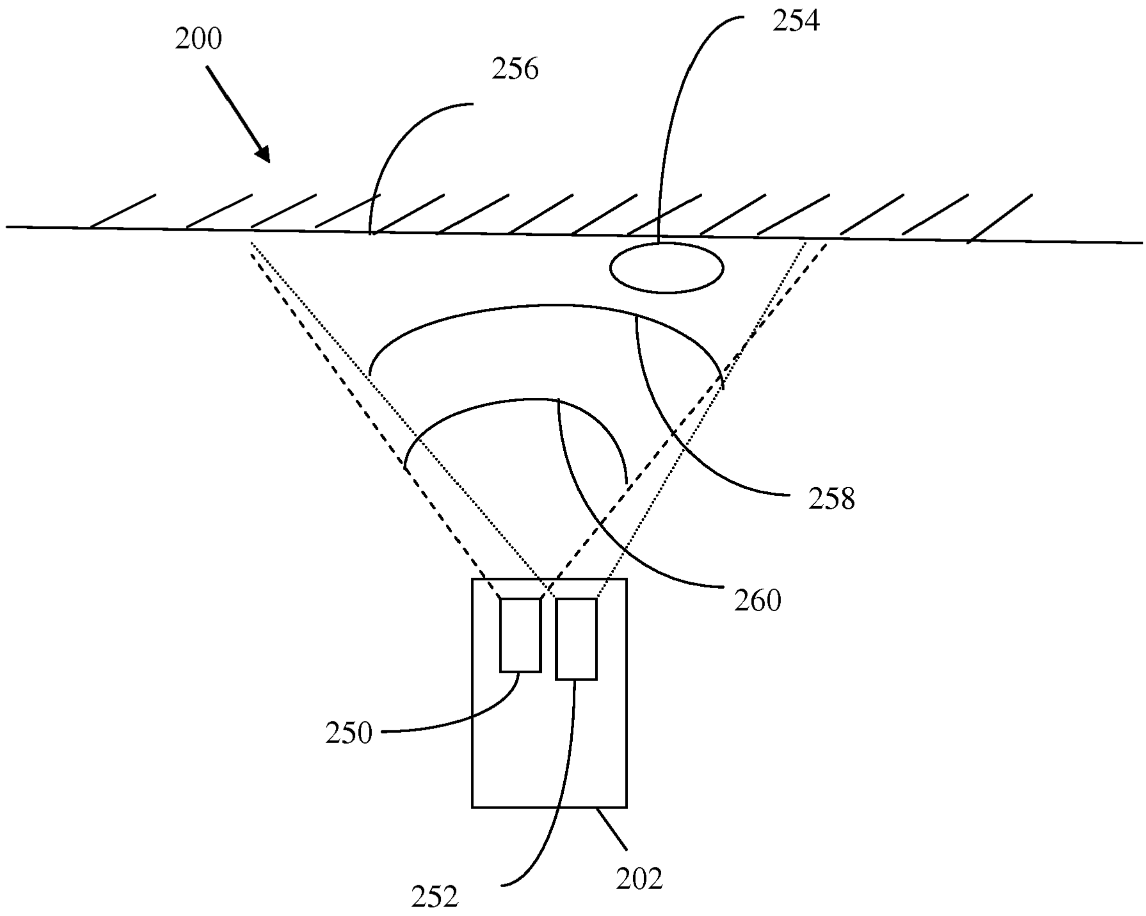

FIG. 2

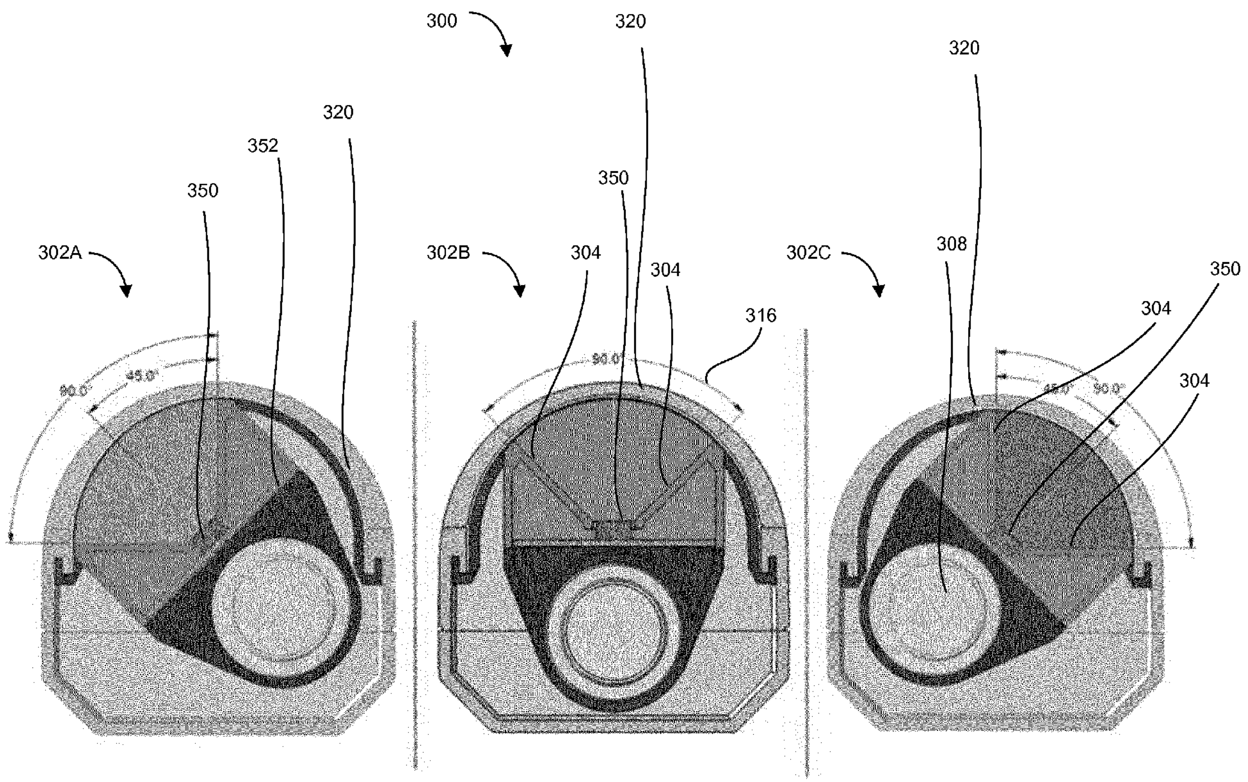
300
302A
350
352
320
90.0°
45.0°
302B
304
350
320
304
316
90.0°
302C
308
320
304
350
304
45.0°
90.0°

FIG. 3

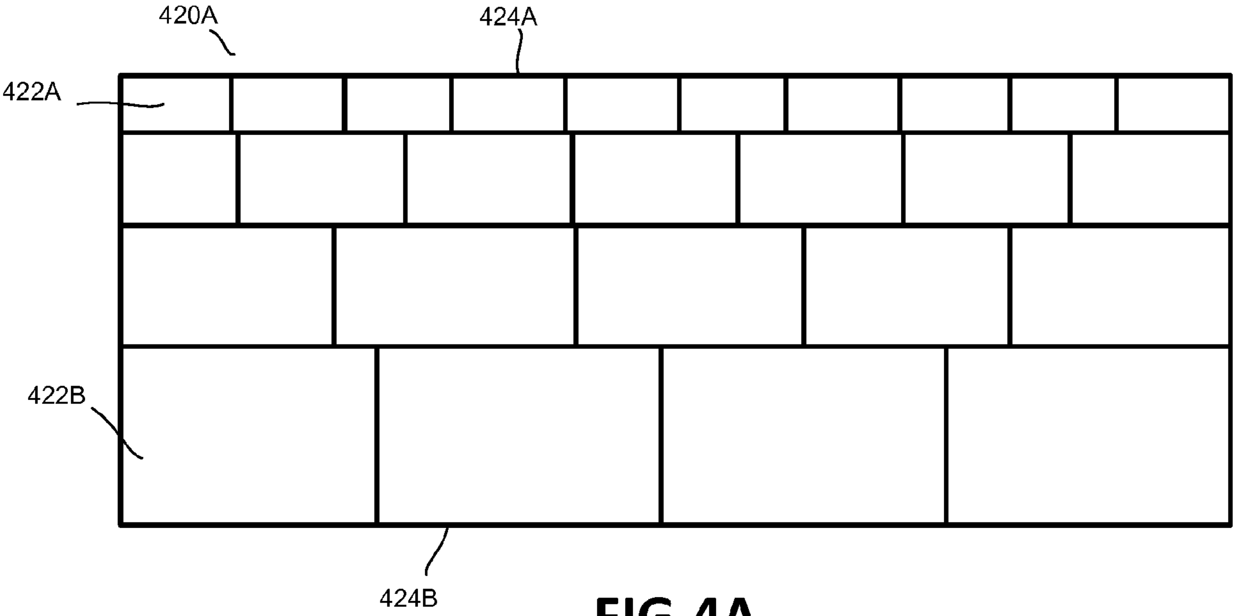

FIG.4A

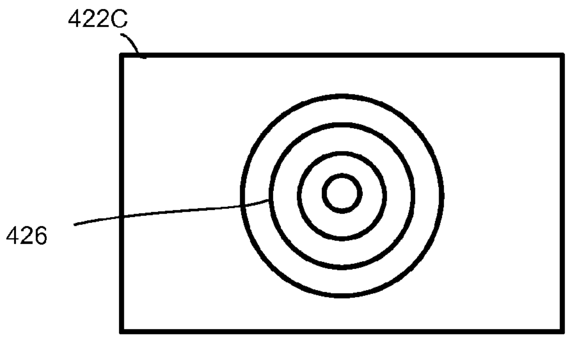

FIG. 4B

FIG. 4C

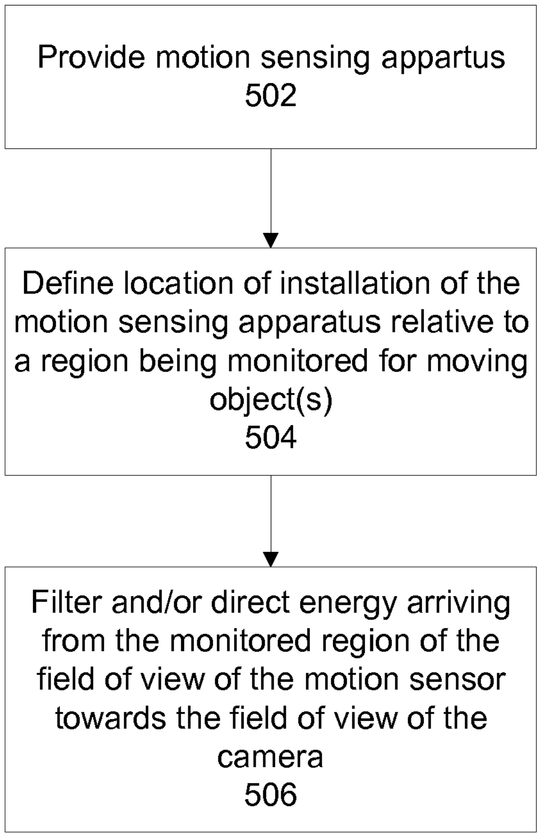
Provide motion sensing appartus
502
Define location of installation of the motion sensing apparatus relative to a region being monitored for moving object(s)
504
Filter and/or direct energy arriving from the monitored region of the field of view of the motion sensor towards the field of view of the camera
506

FIG. 5

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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