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(54) **LIGHTING SYSTEM FOR A HOUSEHOLD APPLIANCE**

(57) A method of controlling illumination in a household appliance (40) including receiving ranging measurement data from each of a plurality of distance sensors (101, 102, 103) arranged at fixed positions relative to the appliance. The ranging measurement data indicates a distance reading taken by the respective distance sensor. The position of an object relative to the appliance can be determined from the received ranging measurement data, and at least one area (401-1, 401-2, 401-3) of the appliance can be identified based on the determined position of the object. A control signal to adjust the illumination of the identified area is then transmitted to at least one of a plurality of lighting devices (20-1, 20-2, 20-3) of the appliance.

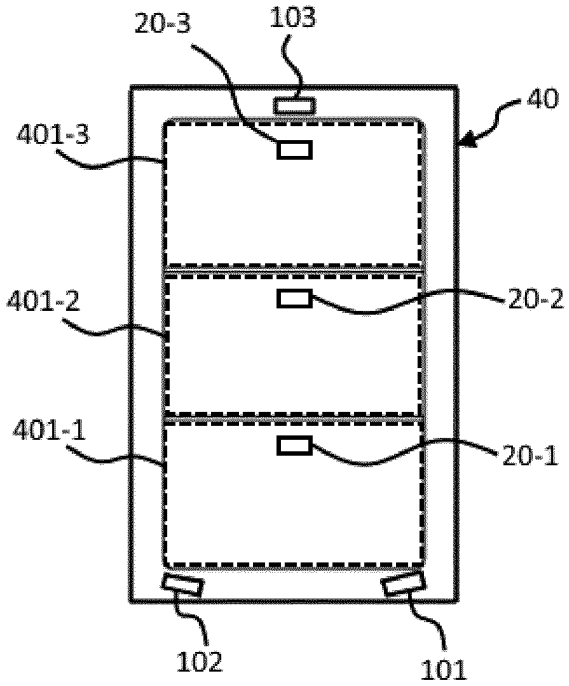

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FIG 3

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Description

Field of disclosure

[0001] The present invention relates to lighting systems for household appliances, and more particularly to a lighting system to dynamically adjust illumination of the household appliance depending on the position of a detected object at an opening of the household appliance.

Background

[0002] Many modern homes include a number of appliances, such as refrigerators, freezers, ovens, dishwashers, sanitizers, clothes-dryers etc., that comprise an interior space where an object may be placed for storage and/or processing. In some such appliances, such as refrigerators and microwave ovens, a light turns on when a door is opened to allow a user to see inside the appliance. Manipulation of an object in the appliance by the user is thereby simplified.

[0003] Typically, a light for the interior of a appliance turns on when the door of the appliance opens. However, it is more energy efficient to illuminate only a relevant part of the interior of an apparatus. For example, the interior of many refrigerators contains a number of shelves that divide the interior of the refrigerator into compartments, such that a first compartment may be defined by the bottom of the interior of the refrigerator and the lowest shelf, a second compartment may be defined by the lowest shelf and the next lowest shelf and so forth. When a user removes an item from the refrigerator, they will require light to only the compartment of the interior of the refrigerator that the item is located. Accordingly, there is no need to illuminate the remaining compartments of the interior of the refrigerator.

[0004] JP2008-151359A relates to a refrigerator defining an interior storage room that illuminates a compartment of that storage room. As with conventional refrigerators, a switch is provided to detect when the door is opened. In addition, each shelf in the cold storage room includes a proximity sensor to detect a hand that enters the storage room. When the door is opened, therefore, the lights in the storage room of the refrigerator turn on. When a hand is subsequently detected in a particular compartment of the storage room, lighting to the other compartments of the storage room is turn off.

[0005] The arrangement of JP2008-151359A therefore requires a door switch in addition to at least one proximity sensor for each shelf of the refrigerator in order to provide complete coverage for the storage room.

[0006] There remains a need for a lighting system that is readily adaptable to any household appliance and, more particularly, for such a lighting system with improved power efficiency.

Means for solving the problem

[0007] In accordance with the present invention, there is provided a method as set out in claim 1, a lighting system as set out in claim 8, a household appliance as set out in claim 11 and a computer readable medium as set out in claim 15. Other aspects of the invention can be found in the dependent claims.

[0008] A method of controlling illumination in a household appliance, the method comprising:
receiving ranging measurement data from each of a plurality of distance sensors arranged at fixed positions relative to the appliance, wherein ranging measurement data indicates a distance reading taken by the respective distance sensor; determining, from the received ranging measurement data, the position of an object relative to the appliance; identifying at least one area of the appliance based on the determined position of the object; and transmitting a control signal to adjust the illumination the identified area.

[0009] Some arrangements comprise transmitting data acquisition control signals to a plurality of distance sensors, wherein the data acquisition control signal controls the distance sensors to acquire distance.

[0010] Some arrangements comprise setting a lighting configuration in a system status in response to identifying at least one area of the appliance based on the determined position of the object, the lighting configuration indicating an illumination intensity for a plurality of lighting devices. Control signals are transmitted to the plurality of lighting devices in accordance with the lighting configuration.

[0011] In some arrangements, each of the plurality of distance sensors has a respective first threshold. A control signal is transmitted to adjust the lighting devices to turn off when the ranging measurement data associated with at least one of the plurality of distance sensors indicates a distance reading below the respective first threshold.

[0012] In some arrangements, each of the plurality of distance sensors has a respective second threshold. A control signal is transmitted to adjust all the lighting devices to turn on when the ranging measurement data associated with each of the plurality of distance sensors indicates a distance reading above the respective second threshold

[0013] Some arrangements comprise transmitting a further data acquisition control signal to the plurality of distance sensors after transmitting the lighting control signal, the further data acquisition control signal for controlling the plurality of distance sensors to acquire further distance readings.

[0014] In some arrangements, the position of an object is determined by, for the ranging measurement data from each of the plurality of distance sensors, determining which of a number of pre-defined criteria are met, the pre-defined criteria indicating distance ranges in relation to each of plurality of distance sensors; and determining

which one of a plurality of pre-defined conditions are satisfied based on the met criteria. The satisfied pre-defined condition indicates the identified area.

[0015] A lighting system for a household appliance, the lighting system comprising: a plurality of distance sensors attachable at fixed positions relative to the household appliance, wherein a distance sensor has a field of view in which it is able to obtain distance readings; a plurality of lighting devices; and a control device operable to receive ranging measurement data indicating distance readings from each of the plurality of distance sensors and to send a lighting control signal to the lighting devices based on the received ranging measurement data.

[0016] In some arrangements, the plurality of distance sensors consists of three distance sensors.

[0017] In some arrangements, the distance sensors are time of flight detectors.

[0018] A household appliance comprising a lighting system as disclosed herein, and having an interior volume and an opening to access the interior volume. The identified area is a target area of the interior volume.

[0019] In some arrangements, the household appliance comprises a door operable to cover the opening and wherein the door is at least partially within the field of view of each of the plurality of distance sensors when covering the opening.

[0020] In some arrangements, the interior volume is comprises a plurality of target areas, wherein at least one of the plurality of lighting devices is associated with two or more of the target areas.

[0021] In some arrangements, the interior volume is comprises a plurality of target areas, wherein at least one of the target areas is associated with two or more lighting devices.

[0022] A computer readable medium having stored thereon instructions which, when executed by a suitable processor, cause a lighting system to perform a method as set out herein.

[0023] Various embodiments and aspects of the present invention are described without limitation below, with reference to the accompanying figures.

Brief description of the drawings

[0024]

Figure 1 shows a system block diagram of a lighting system.

Figures 2A-B front and side views of a household appliance with a lighting system attached.

Figures 3A-B show a front view of a container with the interior split into target areas in various configurations.

Figure 4 shows block diagram of a method for using a lighting system.

Figure 5 shows a block diagram of a method of determining the position of an object.

Figure 6 shows a state diagram for a lighting system.

Figure 7 shows block diagram of a method of initiating a sensor array.

Figure 8 shows a block diagram of a method of acquiring ranging measurement data.

Figures 9A-C show combinations of distance sensors detecting an object in various locations.

Figures 10A-B show views from the front of a container with distance sensors attached to the frame of a portal of the container.

Figures 11A-E show side views of a container with sensors attached in various arrangements.

Detailed description of a preferred embodiment

[0025] The present invention relates to a lighting system for selectively illuminating the interior of a household appliance, a household appliance incorporating a lighting system and a method of dynamically illuminating the interior of a household appliance. A household appliances comprise refrigerators, freezers, ovens, dishwashers, sanitizers, and clothes-dryers, for example.

[0026] The sensors of the lighting system can be arranged around an opening of the household appliance, such that an object breaking the plane of the opening can be detected by the sensors. A processor of the lighting system can then determine the position of the object and control lighting devices accordingly.

[0027] As shown in Fig. 1, a lighting system 1 comprises a plurality of depth sensors 10 (also termed 'distance sensors' herein) and a plurality of lighting devices 20 in communication with a control device 30. The control device 30 includes one or more input/output interface 301, a processor 302, a memory 303, an object detection module 304 and a lighting control module 305. The object detection module 304 may be implemented as code in the memory 303 to cause the lighting system 1 to obtain distance measurements and determine the location of an object. The lighting control module 305 may be implemented as code in the memory 303 to cause the lighting system 1 to adjust the illumination of a household appliance according to the determined location of the object.

[0028] Distance measurements from the distance sensors 10 can be transmitted to the control device 30, which controls the lighting devices 20 accordingly. For example, if the interior of the household appliance 40, such as a refrigerator, is separated into three areas (or compartments) by two shelves, a user may wish to pick up an item from the middle area (i.e. an item on the lower shelf).

As the user moves their hand toward the item, sensors 10 detect a distance to the hand or arm as the user moves to pick up the item. The control device 30 determines that the user's hand is in a position associated with the middle area and transmits a lighting control signal to increase the illumination of lighting devices 20 associated with the middle area and to decrease illumination of lighting devices 20 not associated with the middle area.

[0029] The distance sensors 10 can be any sensor capable of determining a distance to an object. In a preferred embodiment, the sensors 10 are time-of-flight (ToF) detectors. In some embodiments, the sensors 10 are infrared sensors, and may be ToF sensors. An example of a suitable infrared, ToF sensor is a VL53L1 sensor by STMicroelectronics, although it will be apparent to a skilled reader that other distance sensors can be used within the scope of the present invention.

[0030] Time of flight detection uses a known propagation speed and a measured time to determine a distance. More particularly, particles or waves, with a known propagation speed in a given medium, are emitted from the emitter over a field of view, FoV. When a particle or wave encounters an object, it is reflected back toward the receiver. The time difference between emission of the particle or wave and reception of the particle or wave is then used, along with the speed of that particle or wave in the propagation medium, to determine the distance travelled by the particle or wave.

[0031] Each depth sensor (distance sensor) 10 has an associated field of view, FoV, and is able to detect a distance to an object within the FoV. A FoV for a sensor is the space observable by that sensor (i.e. the space in which an object may be detected by the sensor). The combination of the FoV of the plurality of sensors 10 in a sensor arrangement is termed a detection space herein.

[0032] An example of the respective FoVs when a lighting system 1 is attached to a refrigerator 40 with two shelves can be seen in Figs. 2A and 2B, with Fig. 2A showing a view from the front and Fig. 2B showing an associated view from the side. FoVs are represented by dotted lines. In some embodiments, the maximum detection distance for each sensor extends beyond the dimensions of the refrigerator 40. For simplicity, the control device is not shown in Fig. 2A. Although Figs. 2A and 2B relate to an example of a refrigerator 40, the lighting system 1 can be attached to other household appliances 40 to provide dynamic lighting to those appliances.

[0033] In Fig. 2A, each sensor 10 has two representative cones indicated by the dotted lines, one cone represents a cone of emission and the other represents a cone of detection. The FoV of a sensor 101 on the bottom right of the refrigerator 40 is projected upward (directly upward or generally upward), the FoV of a sensor 102 on the bottom left of the refrigerator 40 is projected upward (directly upward or generally upward) and the FoV of a sensor at the top of the refrigerator 40 is projected downward (directly downward or generally downward).

[0034] In the arrangement shown in Fig. 2A, the axes (or lines of symmetry) of the FoV associated with the first 101 and second 102 sensors (i.e. the sensors on the bottom of the refrigerator 40) extend away from the sidewalls of the refrigerator 40 in the horizontal (side-to-side) direction, and toward the top of the frame, as the axes move further from the respective sensor. The axes of the fields of view associated with the first 101 and second 102 sensors are therefore inclined to a vertical axis. The axis (or line of symmetry) of a FoV associated with the third sensor 103 points toward the centre of the bottom of the refrigerator opening (i.e. the midpoint between the first sensor 101 and the second sensor 102 in Fig. 2A) when viewed from the front as in Fig. 2A. The detection space created by the combination of the FoV associated with the first to third sensors therefore covers the entire opening of the refrigerator 40 such that an object entering or exiting the refrigerator 40 must pass through the detection space.

[0035] As can be seen in Fig. 2B, the axis of a field of view preferably extends away (in the front-to-back direction) from the refrigerator 40 as it extends away from the sensor 10. The fields of view are therefore inclined away from the interior of the refrigerator 40 and, accordingly, fewer features of the interior of the refrigerator 40 are within the detection space. A number of criteria to be taken into account when determining the position of an object is therefore reduced. In some embodiments, the detection space does not cover any features, such as shelves, of the interior of the refrigerator 40.

[0036] Other orientations of sensors and positions of sensors are possible to cover the opening of a household appliance 40. It is to be noted that the detection space covers the opening to the household appliance 40 such that an object entering or exiting the household appliance 40 will necessarily pass through the detection space. As the detection space covers the opening, the control device 30 is able to determine the location of any object, such as a user's hand or arm, entering or exiting the household appliance 40. The household appliance 40 does not, therefore, require a dedicated sensor for each target area (e.g. a compartment or sector of its interior), but the lighting system 1 can instead illuminate the relevant target area 401 of the household appliance 40 based only on distance readings from the sensors 10 whose fields of view cover the opening. Moreover, when the sensor arrangement has three sensors 101, 102, 103 and is attached to a household appliance 40, the detection space can cover the opening of the household appliance 40 such that the position of an object passing through any part of the opening can be detected irrespective of the number of target areas 401 (e.g. the number of compartments into which the interior is divided). An arrangement with three sensors 10 can accurately detect the position of an object while minimising power use.

[0037] A household appliance 40 can be separated into a plurality of target areas 401 (e.g. the interior can be separated into a plurality of interior compartments s 401).

The target areas 401 may be defined by physical elements of the household appliance 40. Figs. 3A and 3B show examples of the interior of a refrigerator 40 being separated into a plurality of target areas 401, as indicated by the dotted lines. As with Figs. 2A and 2B, Figs. 3A and 3B relate to an example of a refrigerator 40, although the lighting system 1 can be attached to other household appliances 40.

[0038] Fig. 3A shows the arrangement of Fig. 2A split into three target areas 401, with the interior walls of the refrigerator 40 and the shelves distinguishing between those areas 401. The areas 401 of the refrigerator 40 can be defined in many ways and are not limited to being defined by the shelves. For example, two shelves could be contained in a single target area 401. Fig. 3B shows other examples in which the upper shelf forms the upper bound of three target areas 401-2a, 401-2b, 401-2c, which are also all bounded by the lower shelf. The upper shelf is the lower bound of two target areas 401-3a, 401-3b, which are also both bounded by the upper wall of the interior volume of the household appliance 40.

[0039] Each of the target areas 401 shown in Figs. 3A has an associated lighting device 20-1, 20-2, 20-3, although different numbers and/or positions of lighting devices 20 is within the scope of the present invention. In the arrangement of Fig. 3B, the lower target area 401-1 is defined in the same way as for Fig. 3A, although it has an associated strip of four lighting devices 20-1a, 20-1b, 20-1c, 20-1d. More or fewer lighting devices 20 can be associated with a target area 401 as needed. For example, the upper section, between the upper shelf and the top of the refrigerator 40, is split into two target areas 401-3a, 401-3b in Fig. 3B. Each target area 401-3a, 401-3b has two associated lighting devices; the first upper target area 401-3a is associated with a first and second upper lighting device 20-3a, 20-3b, and the second upper target area 401-3b is associated with a third and fourth upper lighting device 20-3c, 20-3d. Both target areas in the upper section of the arrangement of Fig. 3B are illuminated from more than one angle without increasing the number of sensors 10.

[0040] In some arrangements, a lighting device 20 may be associated with more than one target area 401 of a household appliance 40. For example, in Fig.3B, the middle section between the upper and lower shelves is divided into three target area 401-2a, 401-2b, 401-2c. The first and second middle lighting devices 20-2a, 20-2b are associated with the first middle target area 401-2a. The second and third middle lighting devices 20-2b, 20-2c are associated with the second middle target area 401-2b. The third and fourth middle lighting devices 20-2c, 20-2d are associated with the third middle target area 401-2c. The target areas in the middle section of the arrangement of Fig. 3B are illuminated from more than one angle without increasing the number of sensors or the number of lighting devices.

[0041] The arrangements shown in the lower, middle and upper section of Fig. 3B are illustrative examples of different arrangements of target areas 401 and lighting devices 20 and can be applied in other combinations. For example, all sections may include two target areas 401. Other arrangements of target areas 401 and lighting devices 20, such as more or fewer target areas or more or fewer lighting devices 20, can be implemented.

[0042] A method of dynamically controlling lights in a household appliance 40 is described with regard to Fig. 4. The method of Fig. 4 is described with reference to the sensor arrangement shown in Fig. 2, although it will be appreciated that other sensor arrangements are within the scope of the present invention.

[0043] At step S10, hardware, such as the control device 30, is initiated. The object detection module 304 and lighting control module 305 can be initialised at this stage. As well, at step S20, the sensors 10 are initiated. Initiation of a sensor 101 of the sensors is described in more detail below in relation to Fig. 7. Although shown as separate, sequential steps in Fig. 4, steps S10 and S20 can occur concurrently.

[0044] At step S30, the apparatus 1 sets an initial system status (system state). The initial system state will be set such that the lighting system 1 is able to obtain distance readings and determine a relative position of an object (i.e. a 'range' state). For example, when in the initial system state, the control device 30 may function in accordance with instructions of the object detection module 304.

[0045] At step S40, it is determined whether the lighting system 1 is in a state in which distance measurements can be obtained and the position of any objects/targets in the detection space can be calculated (i.e. in a 'range' state). This determination is carried out by the control device 30 and, more particularly, the processor 302 of the control device 30. If the determination is 'yes' at step S40, the lighting system 1 will function in accordance with instructions of the object detection module 304. If the determination is 'no' at step S40, the lighting system 1 (i.e. the lighting system 1 is not in the 'range' state), the process moves to step S100.

[0046] To acquire ranging data, the lighting system 1 enters an acquisition iterative loop comprising steps S50-S70. Particularly, the processor 302 of the controller 30 determines if an acquisition indexing value, i, is greater than the number of distance sensors (depth sensors) 10 in lighting system 1 at step S50. This may include interrogating the database 303 to retrieve the number of sensors 10 and the current acquisition indexing value, i. The number of sensors 10 may be stored in a fast access memory such as RAM. In the example shown in Fig. 4, an acquisition index value i of 0 relates to the first run of the acquisition iterative loop S50, S60, S70, an acquisition index value i of 1 relates to the second run of the acquisition iterative loop S50, S60, S70 and so forth.

[0047] When it is determined that the acquisition index number is less than the number of sensors 10 (three, in the example shown in Fig. 2A), the processor 302 causes the input/output interface 301 to transmit, to a sensor 10

associated with the acquisition index number i (e.g. first sensor 101), an acquisition control signal in accordance with instructions of the object detection module 304. On receipt of the acquisition control signal, the sensor 10 associated with the index number i (e.g. the first sensor 101) obtains a distance measurement reading. Once the distance measurement reading has been obtained, the sensor 10 transmits ranging measurement data associated with the measurement reading, to the input/output interface 30. The received ranging measurement data is transmitted to the processor 302, via the system bus, for processing.

[0048] On receipt of the ranging measurement data, the processor 302 stores the ranging measurement data to the memory 303 in association with the sensor 10 associated with the acquisition index number i. For example, an indication of sensor 10 and the index number may be stored in a table in the memory 303, and the ranging measurement data or an indication of a distance range can be stored in the table in association with the sensor 10. Once the ranging measurement data has been stored, the processor 302 increases the acquisition index number by 1 (S70), and begins the acquisition iterative loop again by determining (S50) if the acquisition index number is greater than the number of sensors 10 in the lighting system 1. For example, when the acquisition index number has increased by 1, the second sensor 102 may be caused to provide ranging measurement data. The process of acquiring ranging measurement data from sensors 10 is repeated until it is determined, at step S50, that the acquisition index number i is greater than or equal to the number of sensors in the lighting system 1.

[0049] When it is determined at step S50 that the acquisition index number is greater than or equal to the total number of distance sensors 10, the iterative process of acquiring data is complete and the method moves to step S80, where the acquisition index number is reset (i.e. the processor 302 sets the acquisition index number to 0).

[0050] The lighting system 1 can now determine a target position (S90) based on the ranging measurement data acquired from the sensors 10 during the acquisition iterative loop, and set a lighting configuration in the system status accordingly. The lighting configuration indicates how the household appliance 40 is to be illuminated. In some embodiments, the lighting configuration indicates an illumination intensity for the lighting devices 20.

[0051] A process of determining the position of a target in step S90 is now discussed in in relation to Fig. 5.

[0052] At step S902, a control device 30 determines if ranging measurement data has been received and stored in relation to at least one distance sensor 10 of the lighting system 1. The processor 302 may determine if the table includes a flag indicating that ranging measurement data or an indication of a distance range, associated with any sensor 10, is stored in the memory 303. If so, the method moves onto step S904. If not, the method ends.

[0053] At step S904, the control device 30 determines if the door of the household appliance 40 is closed. In the preferred embodiment, the processor 302 retrieves ranging measurement data stored in relation to a distance sensor 10 in the step of acquiring data (S60), and the respective first (lower) threshold of that distance sensor 10 from memory 303. The processor 302 then determines if the reading from the distance sensor 10 is below the respective first threshold. The processor 302 can repeat this process for other distance sensors 10 if needed. Preferably, the first threshold is set at 5cm. In some embodiments, each distance sensor 10 of the lighting system 1 has an associated first threshold which may or may not be the same as the first threshold of one or more of the other distance sensors 10 in the lighting system 1.

[0054] If the received ranging measurement data indicated a distance reading below the first threshold of the at least one distance sensor 10, the control device 30 determines, at step S914, that a door is closed and the system status is changed to indicate that all lights are to be turned off (S916).

[0055] In some embodiments, the control device 30 always starts with a particular one of the sensors 10 when determining if any of the sensors has taken a reading below the respective first threshold. For example, the processor 302 may always determine whether the door is closed starting with a determination based on ranging measurement data from the first sensor 101.

[0056] In some embodiments, only a single distance sensor 10 is required to determine whether the door is closed. Once it has been determined that the door is closed, power need only be supplied to the single distance sensor 10 to determine when the door subsequently opens. In such embodiments, ranging measurement data is only checked for the single distance sensor 10 in step S904.

[0057] In some embodiments, step S904 can be omitted. For example, the household appliance 40 may have other means for determining if the door is closed, such as a switch (no shown) provided in the door and/or the frame to allow power to be supplied to the sensors 10 when the door is opened.

[0058] If it is not determined that the door is closed, the control device 30 determines, at step 906, whether the ranging measurement data of any of the distance sensors 10 indicates a distance reading below a respective second threshold. The processor 302 retrieves ranging measurement data stored in relation to a distance sensor 10 in the step of acquiring data (S60), and the respective second (upper) threshold of that distance sensor 10 from memory 303. The determination at step S906 is based on a comparison of the retrieved ranging measurement data and the respective second threshold. The process is carried for each sensor 10 in the lighting system 1, either in parallel or sequentially. In an arrangement with three sensors, for example, the processor 302 determines whether: the distance reading associated with the first sensor 101 indicates a distance below a second threshold of the first sensor 101; the distance reading

associated with the second sensor 102 indicates a distance below a second threshold of the second sensor 102; and the distance reading associated with the third sensor 103 indicates a distance below a second threshold of the third sensor 103.

[0059] The respective second threshold for each sensor 10 may be the maximum set in step S214 or may be the based on the physical dimensions of the opening. If based on the physical dimensions of the opening, the second threshold can be slightly above the maximum dimension of the opening to account for an error margin. In some embodiments, each distance sensor 10 has an associated second threshold which may or may not be the same as the second threshold of one or more of the other distance sensors 10 in the lighting system 1.

[0060] If it is determined, at step S906, that none of the distance sensors 10 of the lighting system 1 provided ranging measurement data indicating a distance below their respective second threshold, the control device 30 determines that the household appliance 40 door is open and that no object is present in the detection space (S918). In response, the control device 30 sets the system status to indicate that all lights are to be turned on (S920), such that all compartments of the interior of the container 40 are illuminated for ease of viewing.

[0061] When a distance below the respective second threshold is returned in relation to at least one sensor 10 at step S906, the control device 30 determines there to be an object (such as a user's hand or arm) in the detection space and begins determining a target area 401 (such as a compartment of the interior) associated with the location of the object (S908-S912). To determine a target area 401 of the household appliance 40 associated with the location of the detected object, the control device 30 determines which of a plurality of predetermined criteria are met by the ranging measurement data received from each distance sensor 10, and stores the determined criteria in memory 303 in relation to the respective sensor 10. In some arrangements, a plurality of predetermined criteria is stored in the memory 303 in relation to each of the sensors 10 (e.g. a first plurality of predetermined criteria are stored in relation to the first sensor 102, a second plurality of predetermined criteria are stored in relation to the second sensor 102 and a third plurality of predetermined criteria is stored in relation to the third sensor 103 in the arrangement shown in Figs. 2 and 3).

[0062] In the preferred embodiment, the control device 30 determines a met criterion in relation to each of the sensors 10 of the lighting system 1, and then determines the met condition (also termed a system condition herein) based on those met criteria. The conditions may be met by one met criterion relating to one sensor or by the combination of one met criteria relating to two or more sensors. For example, a plurality of possible criteria may be stored in the memory 303 in relation to each of the sensors 10. The processor 302 may compare the ranging measurement data received in relation to each sensor 10 with the respective stored criteria to determine which of the respective criteria are met by the ranging measurement data in relation to each distance sensor 10. Once a met criterion has been determined in relation to each distance sensor 10, the met criteria can be compared to a number of pre-determined conditions related to the lighting system 1 to determine the met condition.

[0063] The processor 302 can retrieve ranging measurement data associated with the first distance sensor 101 and one or more predetermined distance ranges (criteria) associated with that first distance sensor 101 from memory 303. The processor 302 can determine which of the distance ranges include the distance indicated by the ranging measurement data and store the determined criteria in memory 303. Once the processor 302 has determined criteria in relation to each sensor 10, it is determined which predetermined condition is met. A condition is met depending on the determined criteria, and may be met by one or more criteria being met. In an arrangement with three distance sensors 10, three criteria will have been determined - one determined criteria will be associated with each sensor 10. The processor 302 determines which predetermined condition matches the determined criteria. Each condition is associated with a target area such that if a condition is met, it is determined that an object is in the associated target area. The system status can then be set depending on determined condition (or determined target area). This includes setting a lighting configuration that indicates how each of the plurality of lighting devices are to be controlled.

[0064] The method shown in Fig. 5 can apply to a lighting system 1 attached to a refrigerator 40, that includes three target areas 401. An example of determining the conditions is set out below in relation to the arrangement of Fig. 2A, where the lighting system 1 has three distance sensors 10. The sensors 10 can have a maximum detection distance (the maximum distance at which they can detect an object) that exceeds the longest distance of the opening. For example, the sensors may have maximum detection distance of 220cm (i.e. MAX=220cm).

[0065] A first condition may be met by the following criteria, where first measurement relates to ranging measurement data from the first sensor 10, second measurement relates to ranging measurement data from the second sensor 102, and third measurement relates to ranging measurement data from the third sensor 103:

- [(51.5 cm < third measurement < 75 cm)]; OR
- [(5 cm < first measurement < 23.5 cm) AND (second measurement = MAX)]; OR
- [(5 cm < second measurement < 23.5cm) AND (first measurement = MAX)]

[0066] If the control device 30 determines that the first condition is met at step S908, the object is in a location related to a first compartment 401 of the interior of the household appliance 40 (first target area 401) (S922). In

the present example, the first compartment 401 of the interior is between the bottom of the interior of the household appliance 40 and the lowest shelf as shown in Fig. 2A. The control device 30 sets a system status based on which the lighting device 20 (bottom-most lighting device 20 in Fig. 2A) associated with the first target area 401 is to be turned on, or for its intensity to increase, and the other lighting devices 20 dimmed or turned off (S924).

[0067] If the control device 30 determines that the first condition is not met at step S40, it determines whether the second condition is met (S50).

[0068] A second condition may be met by the following criteria:

- [(first measurement= MAX) AND (23.5 cm < second measurement < 47 cm)]; OR
- [(second measurement = MAX) AND (23.5 cm < first measurement< 47 cm)] OR
- [(23.5 cm < first measurement< 47 cm) AND (23.5 cm < second measurement < 47 cm)]

[0069] If the control device 30 determines that the second condition is met at step S910, the object is in a location related to a second compartment of the interior of the household appliance 40 (second target area) (S926). In the present example, the second compartment 401 of the interior is between the lowest shelf and the highest shelf as shown in Fig. 2A. The control device 30 sets a system status based on which the lighting device 20 (the middle lighting device 20 in Fig. 2A) associated with the target area is to be turned on, or for its intensity to increase, and the other lighting devices 20 dimmed or turned off (S928).

[0070] If the control device 30 determines that the second condition is not met at step S50, it determines whether the third condition is met (S60).

[0071] A third condition may be met by the following criteria:

- [third measurement<= 23.5 cm] OR
- [(first measurement= MAX) AND (46.5 cm < second measurement < 70 cm)] OR
- [(second measurement = MAX) AND (46.5 cm < first measurement< 70 cm)] OR
- [(46.5 cm < second measurement < 70 cm) AND (46.5 cm < first measurement< 70 cm)]

[0072] If the control device 30 determines that the third condition is met at step S912, the object is in a location related to a third compartment of the interior of the household appliance 40 (third target area) (S930). In the present example, the third compartment of the interior is between the highest shelf and the top of the interior of the household appliance 40 as shown in Fig. 2A. The control device 30 sets a system status based on which the lighting device 20 (i.e. the top-most lighting device 20 in Fig. 2A) associated with the third target area is to be turned on, or for its intensity to increase, and the other lighting devices 20 dimmed or turned off (S932).

[0073] If the control device 30 determines that the third condition is not met at step S60, the process ends. Similarly, if a system status is set in any of steps S924, S928 and S932, the process ends.

[0074] The method shown in Fig. 5 relates to a household appliance 40, such as a refrigerator 40, when the interior of the household appliance 40 has been split into three compartments (i.e. there are three target areas). The number of conditions is not limited to three, and will depend on the number of target areas (interior compartments of the household appliance 40) of the interior of the household appliance 40. It is to be noted, however, that the number of distance sensors 10 in the lighting system 1 need not exceed three to provide accurate readings irrespective of the number of conditions.

[0075] Returning now to Fig. 4, once the lighting system 1 has completed step S90, it will have determined a target position and set a system status including a lighting configuration, which will indicate how each lighting device is to be controlled. Due to the change in system status, the lighting control system 1 can now be controlled in accordance with instructions from the lighting control module 305. The illumination of the interior of the appliance, therefore, can be controlled based on the determined object location.

[0076] At step S100, lighting control signals are transmitted to adjust the illumination of lighting devices 20 based on the result of step S90. Referring again to the arrangement of Fig. 2A as an example, and assuming it has been determined that an object is in a location associated with a target area between the bottom of the household appliance 40 and the lowest shelf, the lighting configuration will indicate that the bottom-most lighting device 20 is to increase in intensity (turned on) and that the middle lighting device 20 and the top-most lighting device 20 are to decrease in intensity (turn off). Control signals will therefore need to be transmitted to each lighting device 20.

[0077] The processor 302 determines how a first lighting device 20 is to be controlled, based on the lighting configuration set in the system status, and will cause a control signal to be transmitted to that first lighting device 20 accordingly. In some embodiments, the control signal is stored in the lighting control module 305. In some embodiments, the control signal is stored in the memory 303.

[0078] After a control signal has been transmitted to the first lighting device 20, the lighting configuration is updated, at step S110, to indicate that the first lighting device 20 has been controlled to have the illumination in accordance with the result of step S90.

[0079] The method reverts back to step S40, where it will be determined if the system state indicates that fur-

ther distance readings can be obtained and processed (i.e. if the system is in a 'range' state). If the lighting configuration indicates that control signals are still required in relation to lighting devices 20, for example, the determination at step S40 will be negative, and the method moves to step S100 and a control signal can be transmitted to the next lighting device 20 that requires an illumination adjustment.

[0080] Once lighting control signals have been sent to each lighting device that requires an illumination adjustment, the system status is changed, at step S110, to place the lighting system 1 in a state in which distance measurements can be obtained and the position of any objects/targets in the detection space can be calculated (i.e. in a 'range' state). The lighting system 1 can now function again in accordance with instructions from the objection detection module 305.

[0081] The method shown in Fig. 4, where distance information is acquired and processed to determine a target area associated with the position of an object, and the illumination of lighting devices is adjusted based on the target area, can be repeated as many times as necessary. If the object moves, the lighting system 1 will therefore detect an updated position of the object and determine an associated target area accordingly. The lighting system 1 can therefore adjust illumination of a household appliance in real-time. In some arrangements, when a sensor detects that an object at a distance lower that its respective first threshold, it may determine that the door if the appliance has been closed and power supply to one or more of the sensors may be restricted (limited or prevented).

[0082] Fig. 6 illustrates various states of the lighting system 1. The lighting system 1 of a preferred embodiment can change from a 'range' state, in which the control device 30 is able to receive data indicating distance readings from the distance sensors 10 and determine how to control the lighting devices 20, to one of a plurality of 'fade' states (or 'control states'), in which lighting control signals are sent to lighting devices 20.

[0083] Determination of how to control the lighting devices 20 includes determining a location of an object in the detection space and/or whether a door of a household appliance 40 is open, as discussed elsewhere in this document. Once the controller 30 has determined how lighting devices 20 are to be controlled, the lighting system 1 can change to a 'fade' state accordingly. For example, referring to the state diagram of Fig. 6, if the controller 30 determines that the entire interior of the household appliance 40 needs to be illuminated, the controller 30 changes to a 'fade on' state; if the controller 30 determines that a compartment of the interior needs to be illuminated, the controller 30 changes to a 'sector fade on' (or 'compartment fade on') state; if the controller 30 determines that a compartment of the interior no longer needs to be illuminated, the controller 30 changes to a 'sector fade off (or 'compartment fade off') state; and if the controller 30 determines that the entire interior no longer needs to be illuminated, the controller 30 changes to a 'fade off' state. Once the controller 30 has sent a lighting control signal to lighting devices 20, the fade state (i.e. 'fade on', 'fade off', 'sector fade on', 'sector fade off') has been completed and the controller 30 can change to the 'range' state. As the lighting system 1 has reverted to the 'range' state, it is able to receive and process further data from the distance sensors 10. In this way, the lighting system 1 is able to react to objects moving within the detection space, and adjust the lighting system 20 in real-time accordingly. In some embodiments, the lighting system 1 will remain in a 'fade' state for a time period for one second (approximately one second or exactly one second) before reverting to the 'range' state.

[0084] An example of sensor initiation in step S20 is described with reference to Fig. 7. Once the sensor initiation has begun, the apparatus 1 sets a sensor initiation index number to 0 at step S202 and begins initiating a sensor 10 (e.g. first sensor 101) associated with the sensor initiation index number.

[0085] At step S204, the apparatus 1 determines if the sensor initiation index number, i, is greater than or equal to the total number of sensors 10 in the lighting system 1. If the sensor initiation index number is less than the total number of sensors 10, a device address is set at step S206. For example, a table in the memory 303 is populated with the address of a sensor 10 associated with the sensor initiation index number i. Preferably, the processor 302 populates the table in the memory 303.

[0086] With the address of the sensor 10 associated with the sensor initiation index number i set, controller 30 waits until that sensor 10 has booted (S208). Steps S204 and S206 can occur concurrently in some aspects. When the address is set before the sensor 10 associated with the sensor initiation index number i is booted, the controller 30 still waits after setting the address.

[0087] When the sensor 10 associated with the sensor initiation index number i has booted, various parameters and data indications are set. In the process shown in Fig. 7, steps S208-S218 relate to setting such parameters and data indications. The processor 302 may store those parameters and data indications in the memory 303 in relation to the sensor associated with sensor initiation index number i. For example, those parameters and data indications may be saved in the relevant fields in the table.

[0088] Data initiation at step S210 involves defining criteria for distance measurements taken by the sensor 10 associated with sensor initiation index number i. For example, if the household appliance 40 is a refrigerator, the spaces between the shelves can be defined as individual compartments 401 of the interior of the household appliance 40. Each compartment 401 will have an associated range defined by a minimum distance and a maximum distance from the sensor 10. Those ranges can be stored in the memory 303 in association with the sensor 10.

[0089] Static initialization at step S212 involves estab-

lishing readings for known, or static, elements in the field of view of the sensor 10 associated with sensor initiation index number i. For example, in some arrangements where the apparatus 1 is attached to a household appliance 40, a shelf or the bottom of the interior may be partially in the field of view of the sensor 10. Static initialization allows the control device 30 to discount distance measurements associated with such elements when determining a target position.

[0090] Setting the distance mode at step S214 relates to sensors 10 capable of detecting objects at distances in excess of the dimensions of the household appliance 40. A longer detection distance will require more power. Accordingly, it is more efficient to use the appropriate distance mode for required detection space. The distance mode defines the upper distance limit that can be measured by a sensor 10. The upper limit of the sensor 10 can be adjusted by controlling the power applied to that sensor 101. For example, a VL53L1X sensor by STMicroelectronics is capable of measuring distances up to 400cm (https://www.st.com/en/imaging-and-photonics-solutions/v15311x.html) but distance measurements beyond a certain limit may be irrelevant. When the lighting system 1 is attached to a refrigerator, for instance, there may be no need for a sensor 10 attached to the top of the frame of the refrigerator and facing down to be able to take measurements at a distance of 400cm. Instead, the maximum distance at which the sensor 10 can detect an object may be limited to conserve power. This can be done by adjusting a distance mode of the sensor 10. Having a distance mode set to a 'high' setting may set the sensor 10 to full power (e.g. with a maximum measurement distance of 400cm); a distance mode set to a 'medium' setting may limit the power of the sensor 10 (e.g. with a maximum measurement distance of 220cm); a distance mode set to a 'low' setting may further limit the power to the sensor 10 (e.g. with a maximum measurement distance of 100cm). A sensor 10 may have more or fewer distance modes.

[0091] In the process shown in Fig. 7, the distance mode is set to 'medium'. This may set the maximum detection distance at 220cm even though the sensor 101 is capable of detecting objects at a greater distance. Other settings for a distance mode are possible. It is to be noted that the sensors will work without setting a distance mode.

[0092] Setting the measurement timing budget in step S216 involves defining a time limit for a sensor 10 to acquire data. If a sensor 10 takes longer than the defined timing budget (maximum data acquisition time period), it can be assumed that there is no valid reading. In some embodiments, an indication of no valid reading during data acquisition will result in ranging measurement data associate with a sensor 101 indicating a maximum value.

[0093] Setting the inter measurement period in step S218 involves defining the time period between data acquisition. In some circumstances, a sensor 10 that has transmitted first ranging data to a control device 30 may be able to acquire second ranging data and transmit that second ranging data to the control device 30 before the control device 30 has completed processing of the first ranging data. For example, a first sensor 101 of the lighting system 1 can acquire (first) ranging measurement data and transmit that data to the control device 30 before a second sensor 102 begins taking measurements. Defining the time period between data acquisition can prevent the first sensor 101 taking (second) ranging measurement data while the second sensor 101 is still acquiring data. Power efficiency of the apparatus 1 may therefore be improved.

[0094] Once parameters and data indications are set for the sensor 10 associated with the sensor initiation index number i, that sensor 10 is capable of data acquisition. A flag indicating that the sensor 10 is capable of data acquisition may be set in the table in the memory 303. As shown in Fig. 7, the sensor 10 can take a measurement once the parameters and data indications are set at step S220 and can used as the first data measurement for that sensor 10. In such arrangements, the acquisition indexing number can be updated to indicate that data has been acquired for that sensor 10. This could lead to by-passing the acquisition iterative loop S50, S60, S70 when the sensors 10 have just been initialised. Step S220 can be omitted in some arrangements, in which the first data measurement will occur in step S60.

[0095] Once the sensor 10 associated with sensor initiation index number i is initiated, the control device 30 increments the sensor initiation index number i by 1 (S222) and the process reverts to step S204. When it is determined that the sensor initiation index number is less than the number of sensors 10 in the lighting system 1, another sensor is selected (e.g. if the first sensor 101 in Fig. 2A or 3A was initiated when sensor initiation index number=0, the second sensor 102 can be initiated when the sensor initiation index number =1). When it is determined that the sensor initiation index number is greater than or equal to the number of sensors 10 in the lighting system 1, the sensor initiation process (S20) ends.

[0096] A method of data acquisition (S60) is discussed in relation to Fig. 8. The controller 30 can transmit a data acquisition control signal to a sensor 10 to begin measurement (step S602).

[0097] Once the control signal to begin the measurement has been sent, the controller 30 waits to allow the measurements to be taken (step S604). Once measurements have been taken, ranging measurement data taken by the sensor 10 and received by the controller 30 (step S606).

[0098] The ranging measurement data indicates a distance from the sensor 10 to the detected object. In some embodiments, the controller 30 waits a predetermined period before moving to step S608, and receives ranging measurement data from each sensor during that predetermined period. In other embodiments, the process moves to step S608 on receipt of ranging measurement data from the sensor 10.

[0099] At step S608, the controller 30 stores the received ranging measurement data in the memory 303. The received ranging measurement data is stored in association with the sensor 10. For example, the received ranging measurement data may be stored in a field, associated with the sensor 10 that is associated with the sensor initiation index number i, in the table. When different ranges for the measurements from a sensor 10 have been defined in step S210, the control device 30 may determine which of the different ranges the received ranging measurement data falls into. Instead of storing the received ranging measurement data, the control device 30 may set a new range associated with the sensor 10 (i.e. the control device 30 can store an indication of the determined range in relation to sensor that acquired the ranging measurement data).

[0100] At step S610, the controller 30 indicates that the data from the sensor 10 associated with the sensor initiation index number i has been read. For example, the controller 30 can set a flag associated with the ranging measurement data of the sensor 101.

[0101] It is not require for each sensor 10 of a lighting system 1 to detect the object in order to determine the position of the object. For example, Figs. 9(a)-(c) show an object in different positions where it can be detected by one or more of the distance sensors 10. In Fig. 9(a), the object is outside of the FoV of the third sensor 103, but can be detected by the first sensor 101 and second sensor 102 as indicated by the arrows. As the ranging measurement data for the third sensor 103 would indicate the maximum value for the third sensor 103, the processor 302 can determine that the object is not within the FoV of the third sensor 103. As the distance from the first sensor 101 is greater than the distance from the second sensor 102, the processor 302 can determine that the object is toward the same side of the household appliance 40 as the second sensor 102.

[0102] In Fig. 9(b), the object is outside of the FoV of both of the first sensor 101 and second sensor 102, but can be detected by the third sensor 103. As both the first sensor 101 and second sensor 102 would return ranging measurement data indicating their respective maximum value, but the third sensor 103 would return a value less than the maximum value, the processor 302 can still determine that the object is within the space between the FoV of the first sensor 101 and second sensor 102 and at the determined distance from the third sensor 103. This is sufficient to ascertain the location of the object and control lighting devices 20 accordingly.

[0103] In Fig. 9(c), the object is within the FoV of each of the three sensors 10. The position of the object can be calculated from the distance readings from all three sensors 10.

Other aspects, embodiments and modifications

[0104] In Figs. 2A, 3A-B and 9A-C, the lighting system 1 includes three sensors 101 with two detectors in the corner of a first side of the frame and an opposed detector in the centre of a second side of the frame opposed to the first side. In other embodiments, the opposed sensor is position to closer to a corner of the second side of the frame. For example, in Fig. 10A, the opposed distance sensor (sensor 103) is positioned at a first (left) corner on second side of the frame of the opening and in Fig. 10B, the opposed detector (sensor 103) is positioned at a second (right) corner on second side of the frame of the opening. In still other embodiments, the detectors are not all on opposed sides of the frame of the opening. For example, the opposed detector in Figs. 10A and 10B can be positioned on the left or the right side of the frame of the opening, with the associated FoV covering the plane of the opening. The criteria and conditions will be adjusted to account for the different position of the distance sensors 10.

[0105] In Fig. 2B, the distance sensors 10 are shown as being angled away from the interior of the household appliance 40 and mounted within the frame of the household appliance 40. The distance sensors can be attached to the household appliance in different ways.

[0106] In Figs. 11A and E, the distance sensors 10 are on the outside of the household appliance 40. With this arrangement, it is simple to retro-fit the distance sensors 10 to the household appliance 40 and there is no hindrance to placing items in the household appliance 40. A door of the household appliance 40 can be adjusted to accommodate the sensors 10 on a surface of the frame that faces the door. Alternatively, the sensors 10 can be attached to the outside of the frame such that the door closes between the sensors 10.

[0107] In Figs. 11B and E, the distance sensors 10 are attached to interior walls of the household appliance 40. With this arrangement, it is simple to retro-fit the sensors 10 to the household appliance 40, and operation of a door of the household appliance 40 will not be affected by the sensors 10.

[0108] Figs. 11A-C show the distance sensors 10 attached to the household appliance 40 with a vertical alignment, such that a line through the centroid and through the apex at the distance sensor (line of symmetry or axis) of the FoV is parallel to a side wall of the household appliance 40. When the FoV of the distance sensors 10 is conical, therefore, part of the interior of the household appliance 40 is within the FoV. The controller 30 can be calibrated to discount features of the interior of the household appliance 40 detected by the distance sensors 10.

[0109] In the preferred embodiments described above, the lighting system 1 comprised a plurality of distance sensors 10 for determining a position of a target object. In other arrangements, the lighting system 1 can contain a single distance sensor 10. For example, a single ToF sensor projecting a matrix of detection can monitor a target's position and movement relative to the matrix position. When attached to a household appliance 40, the single sensor 10 can be positioned in a corner of the frame to maximise the coverage of the portal.

[0110] In relation to Figs. 4 and 7, a separate data acquisition control signal is transmitted separately for each distance sensor 10. In an alternative embodiment, a single control signal can be transmitted, to a sensor controller (not shown), for all sensors 10 to acquire a distance measurement. Each sensor 10 may be controlled to provide ranging measurement data only at a certain time to avoid a bottleneck in obtaining and processing the ranging measurement data.

[0111] A person skilled in the art would understand that other various types of sensor and light could be as used, in addition to those described above.

[0112] Many other variants and embodiments will be apparent to the skilled reader, all of which are intended to fall within the scope of the invention whether or not covered by the claims as filed. Protection is sought for any and all novel subject matter and combinations thereof disclosed herein.

Claims

1. A method of controlling illumination in a household appliance, the method comprising:

receiving ranging measurement data from each of a plurality of distance sensors arranged at fixed positions relative to the appliance, wherein ranging measurement data indicates a distance reading taken by the respective distance sensor;
determining, from the received ranging measurement data, the position of an object relative to the appliance;
identifying at least one area of the appliance based on the determined position of the object; and
transmitting a control signal to adjust the illumination the identified area.

2. A method according to claim 1, further comprising: transmitting data acquisition control signals to a plurality of distance sensors, wherein the data acquisition control signal controls the distance sensors to acquire distance readings.

3. A method of any preceding claim, further comprising:

setting a lighting configuration in a system status in response to identifying at least one area of the appliance based on the determined position of the object, the lighting configuration indicating an illumination intensity for a plurality of lighting devices; and
wherein transmitting a control signal to illuminate the identified area comprises transmitting control signals to the plurality of lighting devices in accordance with the lighting configuration.

4. A method of any preceding claim, wherein each of the plurality of distance sensors has a respective first threshold, and wherein the control signal is transmitted to adjust the lighting devices to turn off when the ranging measurement data associated with at least one of the plurality of distance sensors indicates a distance reading below the respective first threshold.

5. A method according to any preceding claim, wherein each of the plurality of distance sensors has a respective second threshold, and wherein the control signal is transmitted to adjust all the lighting devices to turn on when the ranging measurement data associated with each of the plurality of distance sensors indicates a distance reading above the respective second threshold.

6. A method according to any preceding claim, further comprising transmitting a further data acquisition control signal to the plurality of distance sensors after transmitting the lighting control signal, the further data acquisition control signal for controlling the plurality of distance sensors to acquire further distance readings.

7. A method according to any preceding claim, wherein the position of an object is determined by:

for the ranging measurement data from each of the plurality of distance sensors, determining which of a number of pre-defined criteria are met, the pre-defined criteria indicating distance ranges in relation to each of plurality of distance sensors;
determining which one of a plurality of pre-defined conditions are satisfied based on the met criteria, wherein the satisfied pre-defined condition indicates the identified area.

8. A lighting system for a household appliance, the lighting system comprising:

a plurality of distance sensors attachable at fixed positions relative to the household appliance, wherein a distance sensor has a field of view in which it is able to obtain distance readings;
a plurality of lighting devices; and
a control device operable to receive ranging measurement data indicating distance readings from each of the plurality of distance sensors and to send a lighting control signal to the lighting devices based on the received ranging measurement data.

9. A lighting system as set out in claim 8, wherein the plurality of distance sensors consists of three distance sensors.

10. A lighting system as set out in any of claims 8 -9, wherein the distance sensors are time of flight detectors.

11. A household appliance comprising the lighting system of any of claims 8-10 and having an interior volume and an opening to access the interior volume, wherein the identified area is a target area of the interior volume.

12. A household appliance as set out in claim 11, further comprising a door operable to cover the opening and wherein the door is at least partially within the field of view of each of the plurality of distance sensors when covering the opening.

13. A household appliance as set out in any of claims 11 to 12, wherein the interior volume is comprises a plurality of target areas, wherein at least one of the plurality of lighting devices is associated with two or more of the target areas.

14. A household appliance as set out in any of claims 11 to 13, wherein the interior volume is comprises a plurality of target areas, wherein at least one of the target areas is associated with two or more lighting devices.

15. A computer readable medium having stored thereon instructions which, when executed by a suitable processor, cause a lighting system to perform the method of any of claims 1 to 7.

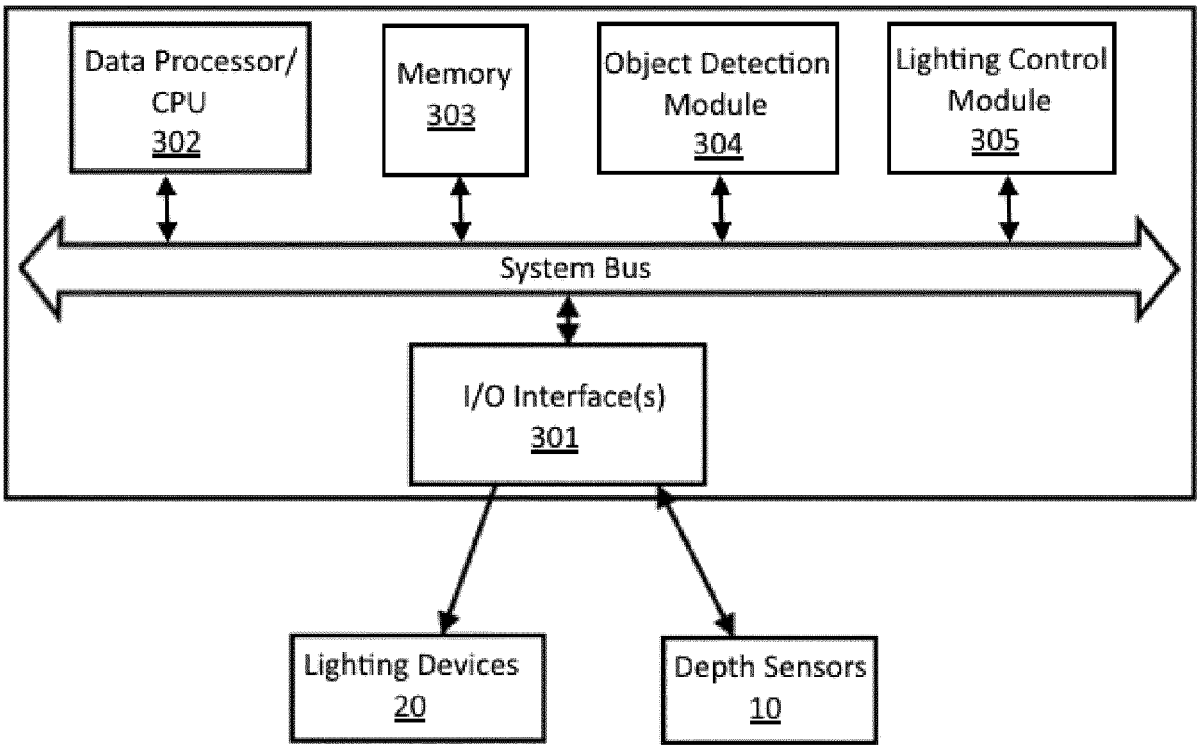
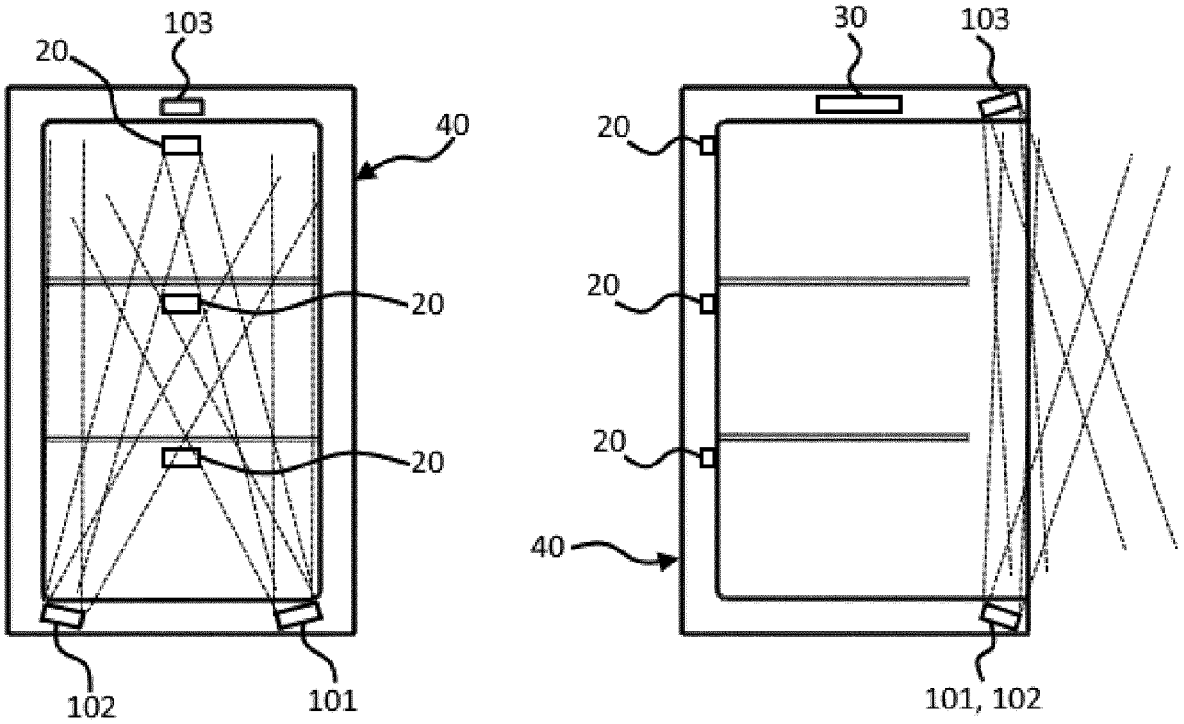

Data Processor/
CPU
302
Memory
303
Object Detection
Module
304
Lighting Control
Module
305
System Bus
I/O Interface(s)
301
Lighting Devices
20
Depth Sensors
10

FIG 1


103
20
40
20
20
102
101
30
103
20
20
20
40
101, 102

A B

FIG 2

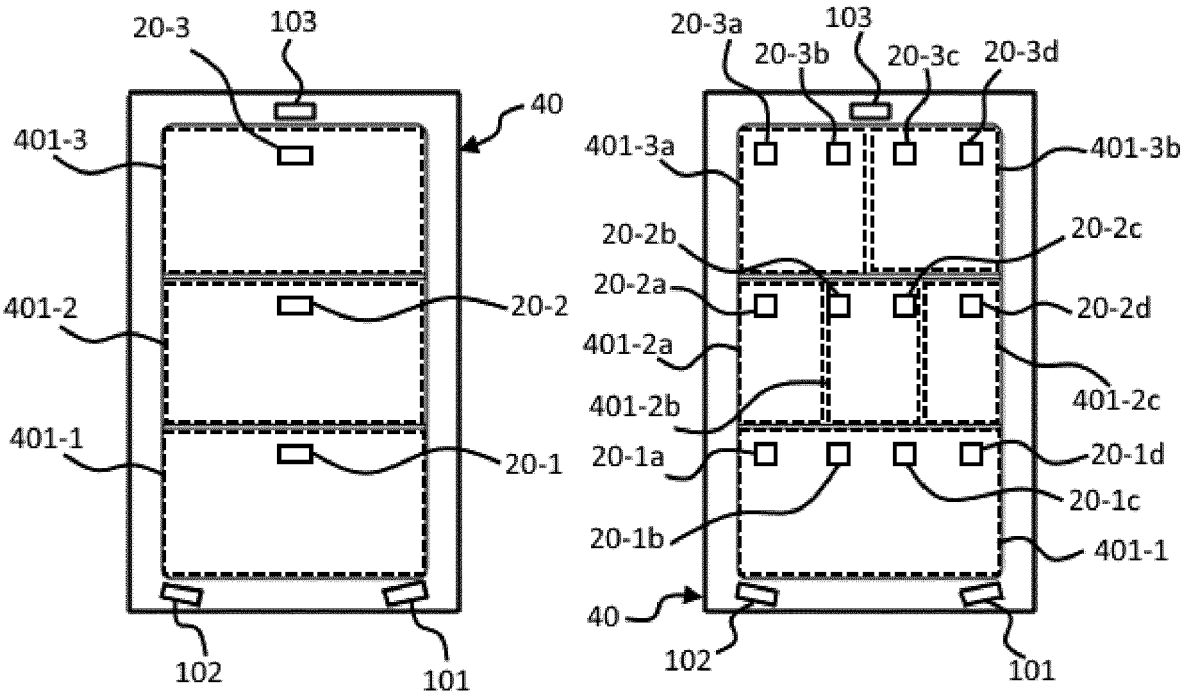

20-3
103
40
401-3
401-2
20-2
401-1
20-1
102
101
A
20-3a
103
20-3b
20-3c
20-3d
401-3a
401-3b
20-2b
20-2c
20-2a
20-2d
401-2a
401-2c
401-2b
20-1a
20-1d
20-1c
20-1b
401-1
40
102
101
B

FIG 3

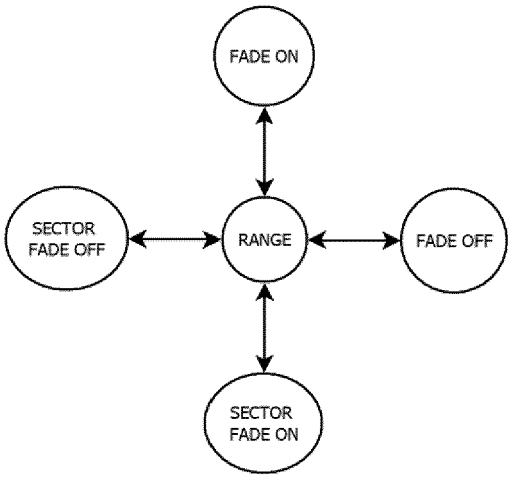
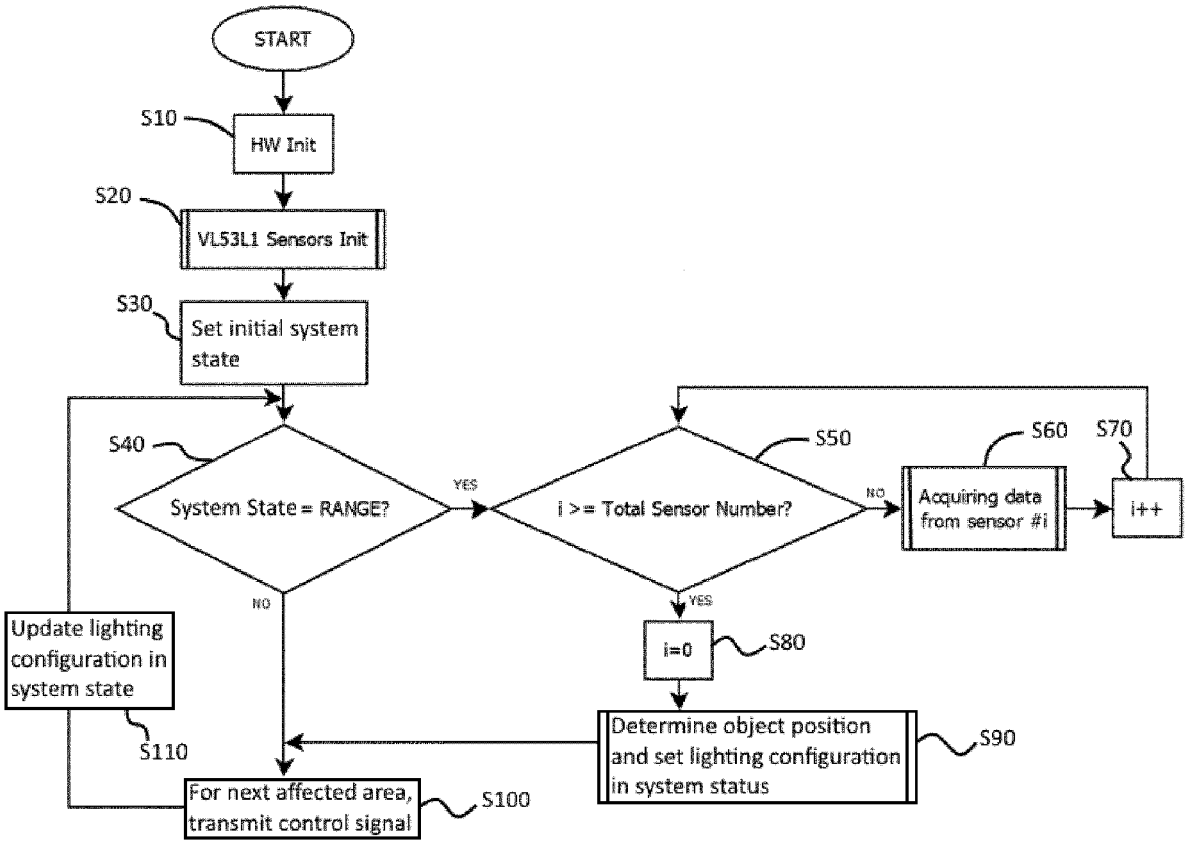

FADE ON
SECTOR FADE OFF
RANGE
FADE OFF
SECTOR FADE ON

FIG 6

FIG 4


START
S10
HW Init
S20
VL53L1 Sensors Init
S30
Set initial system state
S40
System State = RANGE?
YES
NO
S50
i >= Total Sensor Number?
NO
YES
S60
Acquiring data from sensor #i
S70
i++
i=0
S80
Determine object position and set lighting configuration in system status
S90
For next affected area, transmit control signal
S100
Update lighting configuration in system state
S110

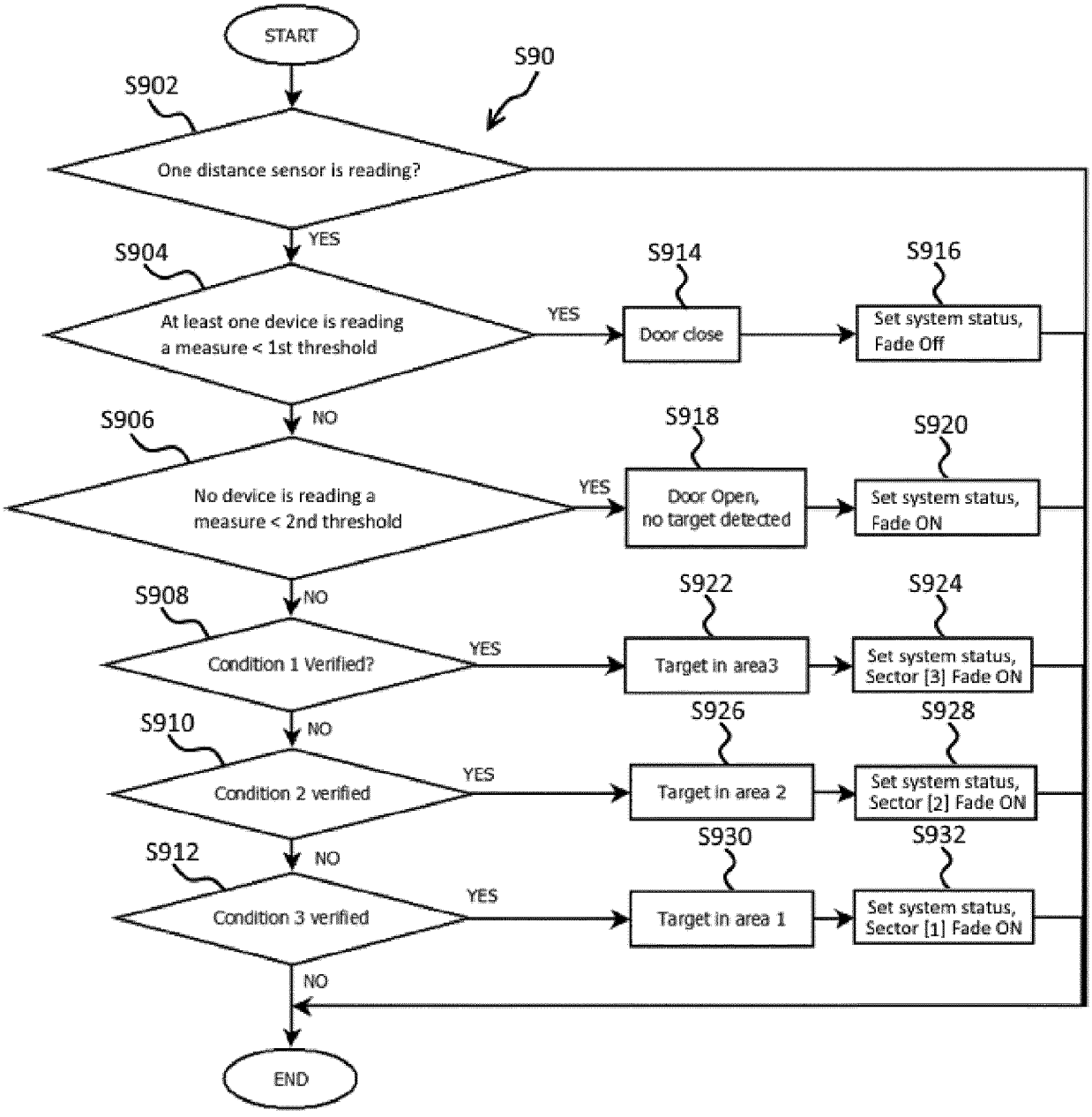

START
S90
S902
One distance sensor is reading?
YES
S904
At least one device is reading a measure < 1st threshold
YES
S914
Door close
S916
Set system status, Fade Off
NO
S906
No device is reading a measure < 2nd threshold
YES
S918
Door Open, no target detected
S920
Set system status, Fade ON
NO
S908
Condition 1 Verified?
YES
S922
Target in area3
S924
Set system status, Sector [3] Fade ON
NO
S910
Condition 2 verified
YES
S926
Target in area 2
S928
Set system status, Sector [2] Fade ON
NO
S912
Condition 3 verified
YES
S930
Target in area 1
S932
Set system status, Sector [1] Fade ON
NO
END

FIG 5

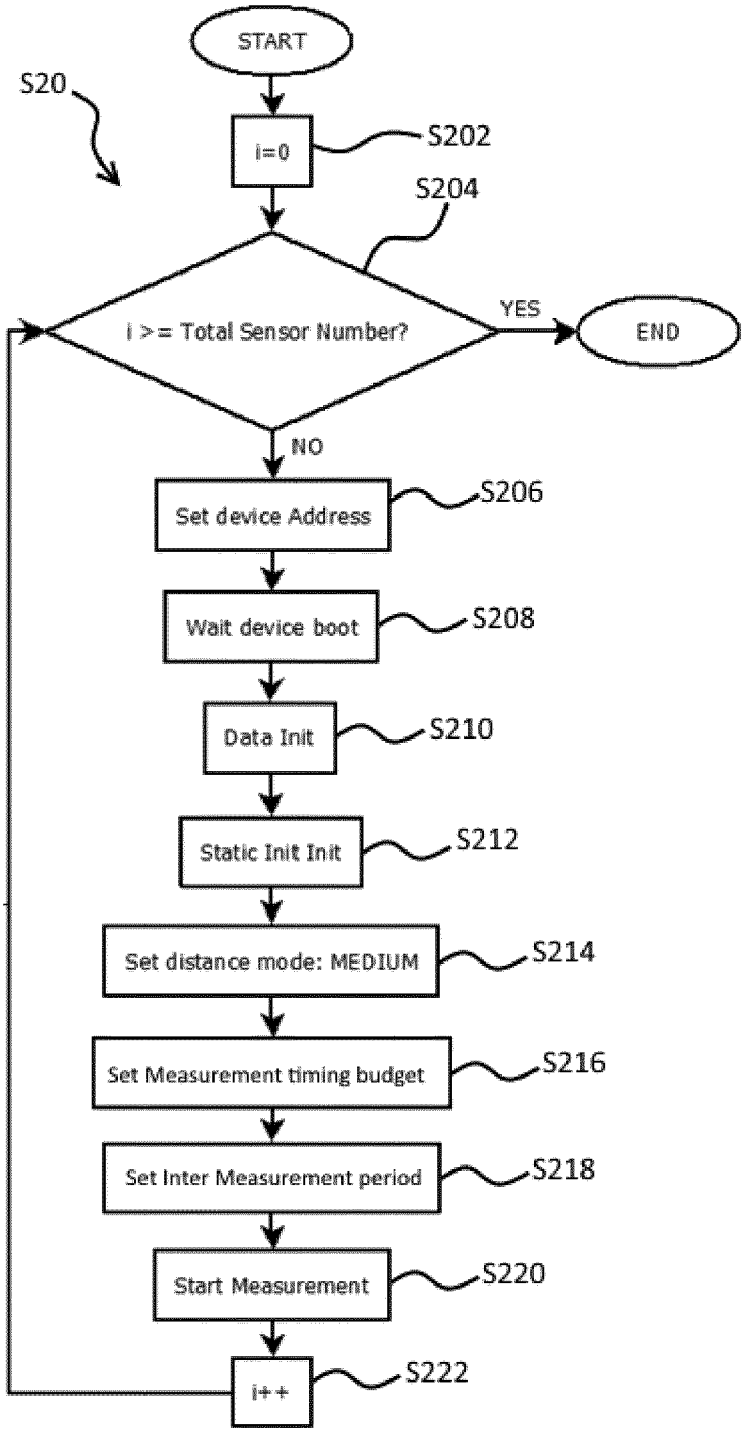

START
S20
i=0
S202
S204
i >= Total Sensor Number?
YES
END
NO
Set device Address
S206
Wait device boot
S208
Data Init
S210
Static Init Init
S212
Set distance mode: MEDIUM
S214
Set Measurement timing budget
S216
Set Inter Measurement period
S218
Start Measurement
S220
i++
S222

FIG 7

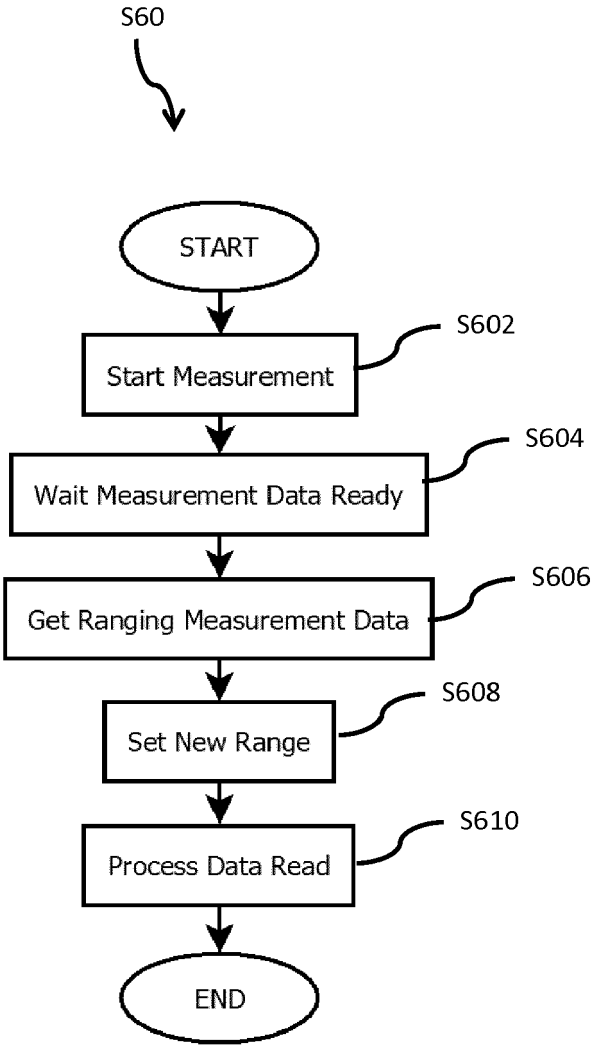

S60
START
S602
Start Measurement
S604
Wait Measurement Data Ready
S606
Get Ranging Measurement Data
S608
Set New Range
S610
Process Data Read
END

FIG 8

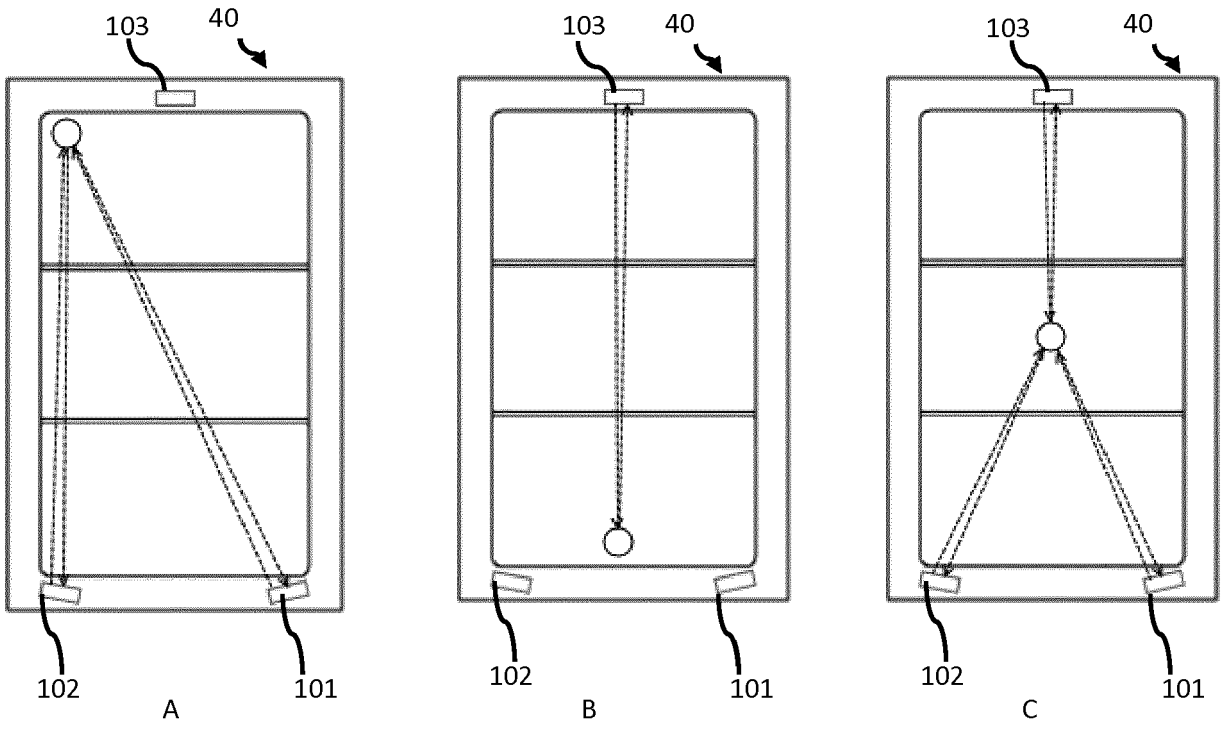


Fig. 9

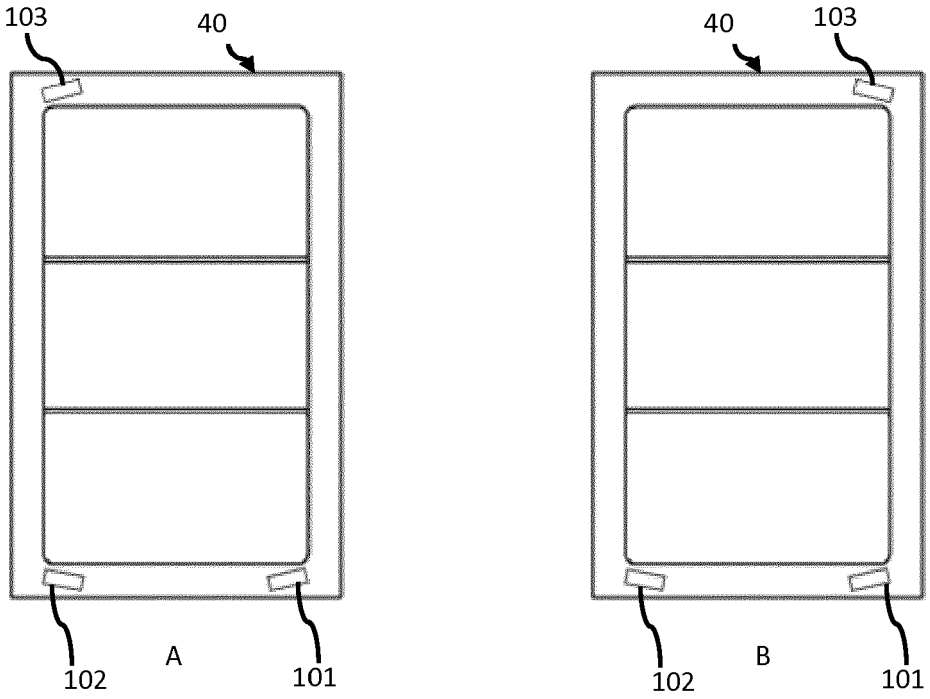


Fig. 10

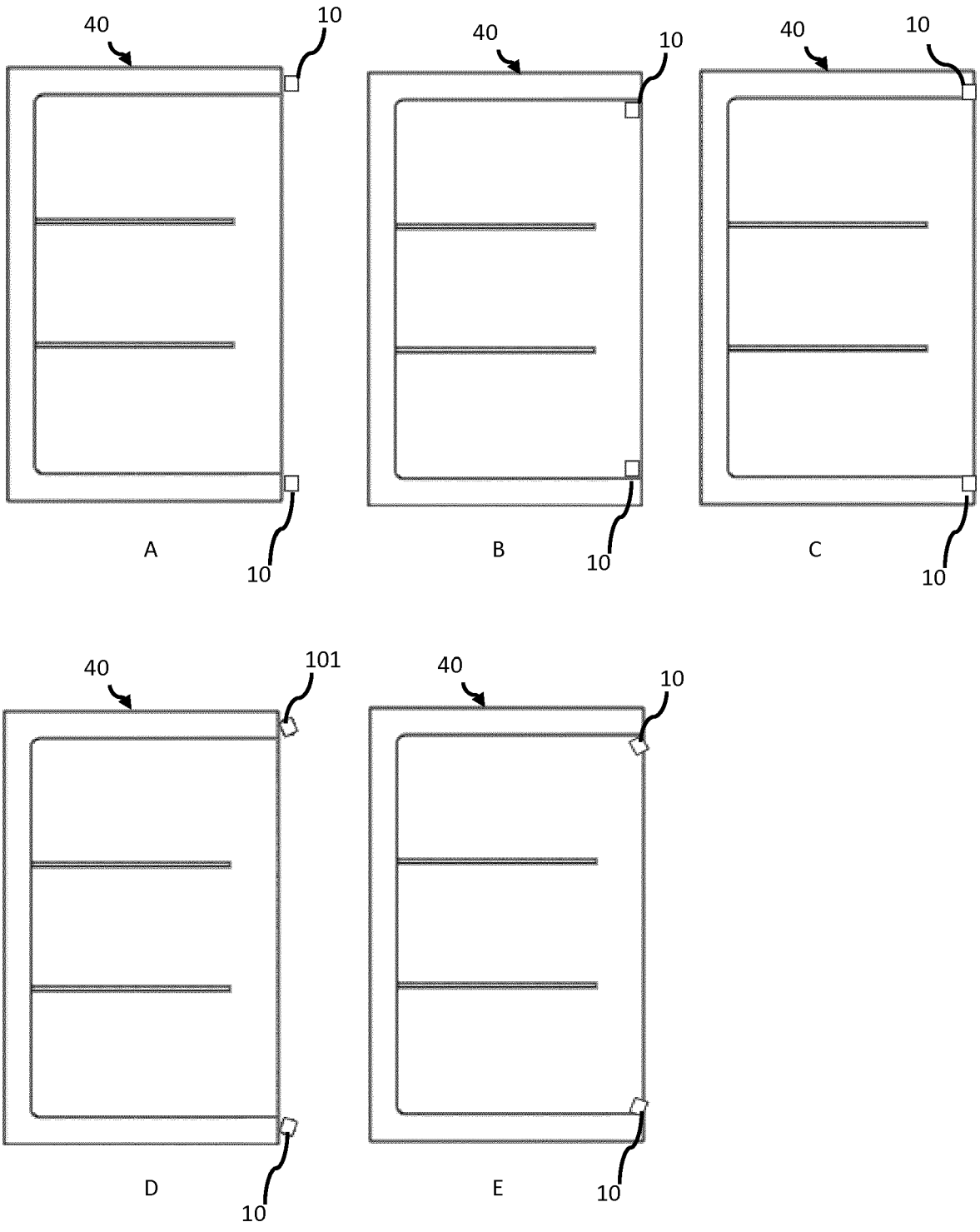


FIG 11

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EUROPEAN SEARCH REPORT

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