

SENSOR DEVICE AND SENSORY NETWORK

TECHNICAL FIELD

[0001] The present disclosure relates to sensor devices and sensory networks, the latter being a network of sensory devices.

5 BACKGROUND

[0002] Sensor devices are becoming increasingly prevalent in domestic and commercial buildings. Such sensor devices comprise a sensor usually designed to monitor a single measurand such as heat or temperature, dust, smoke, noise, movement, light, gas and any other quantity capable of being sensed by a sensor.

10 [0003] In order to measure different measurands, different sensor devices are required. Moreover, if those different measurands are to be sensed concurrently, then multiple power outlets are required in order to power each sensor device.

SUMMARY OF INVENTION

[0004] In accordance with the present invention, there is provided a sensor device
15 comprising:
a housing;
one or more sensor attachment ports accessible from outside the housing;
and
a sensor detector for automatically determining a type of each of one or
20 more sensors, when the one or more sensors are attached to respective ones of the sensor attachment ports.

[0005] In accordance with the present invention, there is further provided a sensory network comprising:
a hub; and
25 a plurality of sensor devices in communication with the hub, each sensor device comprising one or more sensors and being capable of transmitting a respective output signal to the hub based on an output of the respective one or more sensors,

wherein at least one sensor device of the plurality of sensor devices is configured to receive a signal from each other sensor device of the plurality of sensor devices, and determine if the respective other sensor device is functional

[0006] In accordance with the present invention there is also provided a sensor device comprising:

a housing;

one or more sensors fixed in relation to the housing, for sensing a respective one or more measurands; and

a power connector for connecting to a power source from which power is drawn to power the one or more sensors,

wherein the power connector and housing are movably connected

[0007] In this sense, a sensor is “functional” if the output of that sensor is uncorrupted or otherwise not erroneous. In other words, the sensor is operating as it is designed to do and as reflected by its output. Similarly, a sensor is not functional if the output is erroneous – for example, the output is corrupted –, absent or otherwise does not conform to the expected output for such a sensor if it were operating as it was designed to do.

[0008] Some sensor devices in accordance with present teachings may enable multiple measurands to be concurrently sensed using a single sensor device. This permits a single power source, mains power connector or socket to be used to power multiple sensors.

[0009] Some sensor devices in accordance with present teachings may be capable of being updated remotely.

[0010] Some sensor devices in accordance with present teachings may be capable of being monitored remotely.

[0011] Some sensory networks in accordance with present teachings enable a sensor device in the sensory network to monitor the proper functioning of the other sensor device or sensor devices in the sensory network.

[0012] Some sensor devices in accordance with present teachings can be selectively oriented, relative to a power source, so as to position the sensor device in a desired position or orientation.

BRIEF DESCRIPTION OF DRAWINGS

[0013] Some embodiments of the present invention will now be described by way of non-limiting example only, with reference to the accompanying drawings in which:

FIG. 1 provides a perspective view of a sensor device in accordance with present teachings;

FIG. 2 provides a simplified schematic overview of an internal structure of the sensor device of FIG. 1;

FIG. 3 provides a schematic overview of the interconnection of sensors with the sensor device;

FIG. 4 is a simplified block diagram of an exemplary network-based system or sensory network;

FIG. 5 illustrates an exemplary configuration of a computing device for use in present methods and systems;

FIG. 6 is an exemplary sensory network; and

FIG. 7 is a further embodiment of a sensor device in accordance with present teachings.

DETAILED DESCRIPTION

[0014] Some portions of the description which follows are explicitly or implicitly presented in terms of algorithms and functional or symbolic representations of operations on data within a computer memory. These algorithmic descriptions and functional or symbolic representations are the means used by those skilled in the data processing arts to convey most effectively the substance of their work to others skilled in the art. An algorithm is here, and generally, conceived to be a self-consistent sequence of steps leading to a desired result. The steps are those requiring physical manipulations of physical quantities, such as electrical, magnetic or optical signals capable of being stored, transferred, combined, compared, and otherwise manipulated.

[0015] Unless specifically stated otherwise, and as apparent from the following, it will be appreciated that throughout the present specification, discussions utilizing terms such as “scanning”, “calculating”, “determining”, “replacing”, “generating”,

“initializing”, “outputting”, or the like, refer to the action and processes of a computer system, or similar electronic device, that manipulates and transforms data represented as physical quantities within the computer system into other data similarly represented as physical quantities within the computer system or other information storage, transmission or display devices.

[0016] The present specification also discloses apparatus for performing the operations of the methods. Such apparatus may be specially constructed for the required purposes, or may comprise a computer or other device selectively activated or reconfigured by a computer program stored in the computer. The algorithms and displays presented herein are not inherently related to any particular computer or other apparatus. Various machines may be used with programs in accordance with the teachings herein. Alternatively, the construction of more specialized apparatus to perform the required method steps may be appropriate. The structure of a computer will appear from the description below.

[0017] In addition, the present specification also implicitly discloses a computer program, in that it would be apparent to the person skilled in the art that the individual steps of the method described herein may be put into effect by computer code. The computer program is not intended to be limited to any particular programming language and implementation thereof. It will be appreciated that a variety of programming languages and coding thereof may be used to implement the teachings of the disclosure contained herein. Moreover, the computer program is not intended to be limited to any particular control flow. There are many other variants of the computer program, which can use different control flows without departing from the spirit or scope of the invention.

[0018] Furthermore, one or more of the steps of the computer program may be performed in parallel rather than sequentially. Such a computer program may be stored on any computer readable medium. The computer readable medium may include storage devices such as magnetic or optical disks, memory chips, or other storage devices suitable for interfacing with a computer. The computer readable medium may also include a hard-wired medium such as exemplified in the Internet system, or wireless medium such as exemplified in the GSM mobile telephone system. The computer program when loaded and executed on such a computer

effectively results in an apparatus that implements the steps of the preferred method.

[0019] FIG. 1 shows a sensor device 100. The sensor device 100 includes a housing 102, a plurality of sensor attachment ports 104 accessible from outside the housing 102, and a mains power connector 106.

[0020] The housing 102 houses the electronics of the sensor device 100 to ensure they are free from contaminants and are electrically isolated or otherwise safe for people near the sensor device 100 when it is operational.

[0021] Each sensor attachment port 104 enables attachment of a respective sensor, such as light sensor 108, to the sensor device 100. Each port 104 serves to connect such a sensor with the internal electronics of the device 100, and to connect the sensor to power source. In the present embodiment, power for sensors connected to the sensor device 100 is drawn from mains power through connector 106.

[0022] To this end, each port 104 is configured to receive any one of a plurality of different types of sensor. The sensors are then removably attached to the sensor device 100 via the sensor attachment ports 104. Thus the sensor device 100 can be selectively configured to sense one or more measurands, and can be updated to change the one or more measurands that are sensed. Thus the sensor device 100 can provide the same functionality as a large number of other sensor devices configured only to sense a fixed measurand or measurands.

[0023] While the sensor device 100 comprises multiple sensor attachment ports 104, it will be appreciated that some embodiments of the sensor device 100 may include only one sensor attachment port 104, two such ports 104, or any other number of sensor attachment ports as desired. In some embodiments, it may be useful to have only fixed sensors (i.e. sensors that cannot be removed and exchanged). To that end, such a sensor device may have no sensor attachment ports 104.

[0024] The sensor device 100 further includes a plurality of sensors 108, 110 fixed in relation to the housing. Each sensor 108, 110 is configured to sense a respective one or more measurands. Typically, each sensor will sense a single measurand. In the present case, the sensors 108, 110 each sense a respective one of motion, temperature, humidity and light intensity. Accelerometers may also be provided and

may be useful where, for example, movement or improper closure of a door or window is to be monitored. A sensor may also be capable of sensing weight – in this case the power connector 106 may be moved to a top of the housing 102 so that the device 100 can lie flat, and the device may then send a signal when the weight of that which is being measured exceeds or drops below a threshold weight. Noise sensors may also be provided.

[0025] There may be three such fixed sensors as shown. However, any other number of fixed sensors may also be used – for example, a single fixed sensor, two fixed sensors or upwards of three fixed sensors may be provided. Similarly, the device may include no fixed sensors and instead rely on the removable attachment of sensors.

[0026] In some embodiments, the sensor device 100 is low power and the power connector 106 is shaped and configured to be received in one of the slots or ports 104. As such, a first sensor device 100 with a mains power connector may be attached to a wall socket, and one or more further sensor devices may be attached to the first sensor device, or to each other, and be powered from the ports 104 of the first sensor device 100. Thus sensor devices of the present teachings can be spread from a single location, throughout a room or building, or externally of a room or building, in a net or daisy-chaining manner.

[0027] The sensor device 100 may further include a display 112. The display 112 is located on top of the housing 102. The display 112 may be used to control functions of the device 100. For example, the display 112 may be a touchscreen, enabling a user to selectively send data to a remote server (not shown). In this case, the device 100 will require memory (see, e.g. memory 210 in FIG. 2) to store measurements until the user sends those measurements. The display may also enable a user to selectively receive and install updates for driving various sensors and smoothing (e.g. removing noise from) signals and measurements. The screen may also enable the user to set a timer for setting switch ON/OFF times of various sensors – for example, a light sensor may be switch ON at 7pm and OFF at 7am, so as to detect lights switching ON/OFF during the night.

[0028] The sensor device 100 may further include a battery pack 114 (shown in broken lines). The battery pack 114 may be internal to the housing 102. The battery pack may alternatively be external to, or detachably connected to the housing 102.

The battery pack 112 may be chargeable from power supplied through connector 106, or may be chargeable externally of the device 100. The battery pack 114 provides uninterrupted power to the sensor device 100 to facilitate operation if power through the connector 106 cuts out. In some cases, the device 100 may enter a low-power mode in the event of cessation of power through the connector 106. Thus transmission of signals from the sensor device 100 may cease, with data instead being stored temporarily in memory – see FIG. 2 – until power resumes. Power from the battery pack 114 may also be able to be switched off when the device is being moved 100, so that sensing does not continue when no sensible or useable data is capable of being gathered.

[0029] As shown in FIG. 2, a sensor device 200 includes a number (from 0 to any integer number) of fixed sensors 202 and a number of removable or swappable sensors 204. The removable or swappable sensors 204 are connected to the sensor device 200 via attachment ports, presently referred to as end detection ports 206. The sensor device 200 is capable of determining a type of each of one or more sensors 202, 204 when the one or more sensors 202, 204 are attached to respective ones of the sensor attachment ports or end detection ports 206.

[0030] End detection ports 206 are smart ports. Each port 206 is configured to receive a sensor 204 and to detect the presence of that sensor 204. This ensures the sensor device 200 does not continually attempt to receive information through vacant ports 206. Thus noise from vacant ports 206 is not erroneously deemed to be a sensor reading.

[0031] The end detection ports 206 may detect the presence of a sensor 204 through depression of a pin, similar to a lock and key arrangement. Alternatively, a sensor may send a power up signal informing the sensor device of their attachment to a slot 206. Other appropriate mechanisms may also be used, will be apparent to the skilled person in light of the present disclosure, and are intended to fall within the scope of the present disclosure.

[0032] The end detection ports 206 communicate with a sensor detector 208. The sensor detector 208 automatically detects the type of sensors 204. Automatic detection can be performed in a variety of ways. In the present embodiment, since the sensor detector 208 is electrically connected to the sensors 204 (via the end

detection ports 206) the sensor detector 208 automatically determines the type of each of the one or more sensors 204 by identifying at least one of:

- one or more electrical characteristics of each sensor 204; and
- one or more output characteristics of a respective output of each sensor 204.

5 [0033] It will be appreciated that the sensor detector may be configured, in some embodiments, to be connected to the fixed sensors 202 as an alternative to, or in addition to, connection with the removable sensors 204. However, the type of each fixed sensor 202 is known in advance and thus detecting the type of each fixed sensor 202 will usually not need to be performed.

10 [0034] To detect electrical characteristics, the sensor detector 208 must be capable of measuring the particular electrical characteristic sought to be used to differentiate one type of sensor (e.g. heat sensor, humidity sensor) from another. Sensors 204 of different types must similarly be different in the relevant electrical characteristic or characteristics. For example, the electrical characteristic or characteristics in respect
15 of which the sensors 204 differ may comprise:

- an internal impedance of the respective sensor;
- a power usage of the respective sensor
- a current draw of the respective sensor, and
- a voltage drop over the respective sensor.

20 [0035] Using these quantities, the sensor detector 208 may measure or detect the internal impedance, power usage, current draw or voltage drop over each sensor 204. Such measurement is performed using the same functionality as, for example, a voltmeter, ammeter, or multimeter.

[0036] Having measured the relevant electrical characteristic or characteristics, to
25 distinguish the type of one sensor 204 from another the sensor detector 208 may store a list of relevant electrical characteristics, along with tolerances in the measurements, and determine the type of each sensor 204 by matching the measured electrical characteristic or characteristics with the stored list. The list may instead be stored in memory 210, or stored remotely (for example in cloud storage
30 as discussed with reference to router 212) and consulted on an as needs basis.

[0037] The sensor detector 208 may similarly detect differences between sensors 204 based on one or more output characteristics of each sensor 204. The output may comprise one of:

- a voltage range of the output,
- a structure of data comprising the output, and
- a baud rate of the output.

[0038] The sensor detector 208 is therefore configured to detect or measure the particular quantity or quantities used to distinguish the type of one sensor 204 from another 204.

[0039] In each case, the electrical or output characteristic or characteristics used to distinguish one sensor 204 from another must be unique to each type of sensor 204. The sensor detector 208 can therefore be used to automatically determine the type of each sensor by identifying the relevant unique characteristic, or combination of two or more characteristics, of each sensor 204.

[0040] Alternatively, the sensor detector 208 may be configured to receive a power-on signal – a signal emitted by a sensor 204 upon current starts flowing through it – from each respective sensor 204 and determine, from the power-on signal, a type of the respective sensor 204. This signal may also be received by the end detection ports 206 to positively identify the presence of a sensor in the respective port 206. This illustrates that there is a variety of different mechanisms that can be used to distinguish between types of sensors 204.

[0041] The output of each sensor 204 may be formatted in a manner interpretable by user-facing software (i.e. software for viewing the output of the sensor or sensors 204). However, in some cases different features are necessary to evidence or identify in an output. For example, it may be desirable to adjust the sensitivity of the sensor so as to reduce data storage or noise on the output, or to calibrate a sensor 204 particularly where the operation of the sensor 204 deteriorates or changes over time. It can therefore be useful to format the output according to the desired usage and desired features of that output. For this reason, the output passes to an output formatter 214 that formats the output from each sensor 204 or adapts it for further processing.

[0042] Since the output from the fixed sensors 202 is known, in the present embodiment that output does not pass through the output formatter 214. In other embodiments, the output from sensors 202 may also pass through the output formatter 214 or, alternatively, there may be no output formatter 214 and the outputs are instead delivered by the sensors 202, 204 in an appropriate, useable format.

[0043] Once formatted by the output formatter 214, the formatted output is passed to the configurable program module 216. The configurable program module 216 executes various response routines that sensor device 200 uses to respond to particular conditions sensed by the sensors 202, 204. Some response routines may be alarm routines. For example, one function of the sensor device 200 may be to determine when the temperature exceeds or drops below a predetermined threshold. To this end, the sensors 202, 204 may include a temperature sensor for measuring the temperature in the environment around the sensor device 200. The temperature measurement from the temperature sensor is passed to the configurable program module 216. If that measured temperature exceeds the predetermined temperature threshold – e.g. when there is a fire – the configurable program module 216 initiates an alarm. Conversely, an alarm may be raised if the temperature drops below a predetermined threshold temperature, for example in an infant's bedroom. Some other applications for temperature detection would be using a temperature or humidity detector in the form of a probe (e.g. stainless steel probe) to detect the temperature of items in the oven, or to check the temperature of a temperature controlled space such as a humidifier, or to check the humidity of soil.

[0044] Detector 108 may be replaced with a wireless receiver (not shown) to facilitate receipt of signals from devices such as video recording devices and the like. In effect, the device 100 may act as a relay or wireless hot spot through which wireless devices can send information to a remote repository or the Internet.

[0045] In another embodiment, the sensor device 200 may be used to illuminate part of a room or switch on lamps, lighting systems and other appliances when the intensity of other visible light, such as sunlight, is low. In this case, the sensors 202, 204 will include a light sensor used to measure light intensity in the environment

around the sensor device 200. The configurable program module 216 receives the output from the light sensor, which may be formatted by the output formatter 214, detects when light intensity is below a threshold light intensity and initiates switching on of one or more light sources, such as light-emitting diodes (LEDs) 220, to illuminate the sensor device 200. Similarly, when light intensity exceeds that threshold, or another threshold, the configurable program module 216 may initiate switching off the one or more LEDs 220.

[0046] The configurable program module 216 may also comprise a response routine for determining when operation of one or more sensors 202, 204 is deteriorating.

For example, the configurable program module 216 may initiate an alarm where the load across a sensor 202, 204 disappears, indicating absence or circuit failure of that sensor 202, 204, or where the load across a sensor 202, 204 increases by an amount that indicates the sensor 202, 204 is no longer properly functioning.

[0047] The programs executed by the configurable program module 216 may be stored within the module 216 itself, or may be stored in memory 210.

[0048] In some circumstances the sensor device 200 does not need to perform any response routines and, instead, simply delivers sensor measurements to another system for processing. In this case, the configurable program module 216 may not be required.

[0049] The output manager 218 then manages outputs from the configurable program module 216, or from the sensors 202, 204 directly when, for example, there is no configurable program module 216. Where a response routine indicates one or more light sources should be illuminated, the output manager 218 will power on LEDs 220. Where a response routine indicates that an alarm should be sounded, for example where the sensor device 200 includes a gas sensor and the concentration of a noxious gas in the environment exceeds a threshold concentration, then the output manager 218 will power on buzzer 222. The gas and concentrations relating to the thresholds may be specified as needed, and may be used to detect smoke (i.e. function as a smoke alarm) or detect the parts per million of haze particles etc.

[0050] In other circumstances, the output manager 218 passes the output to an external system for processing. In this case, the output manager 218 sends the outputs from sensors 202, 204, formatted or otherwise, to a transmitter 224 that

transmits the output to the router 212. The router 212 then directs the output, for example over the Internet, to the external system in which the output is processed – refer to client system 404 in FIG. 4.

[0051] Where there is no output manager 218, the output is routed directly from sensors 202, 204 to the external system using the transmitter 224. The transmitter is thus in communication, directly or indirectly, with one or more sensors, to transmit an outbound signal based on an output of each of the one or more sensors. The outbound signal, comprising the output from at least one, and generally each, sensor, is transmitted to a hub, the hub in the present case being a router 212. The hub may alternatively be a computing system that can process the signals from the transmitter 224 and interpret them in a visual form observable by a user, or react (e.g. trigger alarm events) in response to events occurring in the signals.

[0052] Transmission may use wireless communication or hardwired communication. The transmitter 224 may also comprise a power-line communication (PLC) module 226 permitting the transmitter 224 to communicate with a hardwired PLC-enabled router (i.e. a router capable of receiving signal sent over power-lines using a PLC protocol) over power-lines. In this case, the transmitter 224 may be coupled to the power connector 106 (refer to FIG. 1) through which a signal comprising the output is sent over the power-lines used to power the sensor device 200.

[0053] Sensor systems evolve over time and it may be found that a particular configuration of sensors is now desired over the existing configuration. To that end, each of sensors 204 can be swapped for another sensor. In some cases a sensor may be inserted into one of the attachment ports 104 that the sensor device 200 was not originally configured to detect. For example, the sensor may have a higher or lower power draw than an older sensor of the same type, may have higher accuracy than the older sensor, or may be configured to emphasise particular features in its output – for example, a temperature sensor may be configured to add a flag to its output at one minute intervals to facilitate ease of visually analysing the output over time, or may be configured to store, in internal memory, outputs over a predetermined time interval – for example three seconds, five seconds or ten seconds – and output an average for that time interval so as to reduce the amount of data outputted by the

sensor device 200. Such averaging may similarly occur in the output formatter 214 or output manager 218.

[0054] In order to operate new types of sensor, upgraded sensors of an existing type, to receive new response routines and other upgrades, the sensor device 200 may comprise upgradable firmware stored either in memory 210, or in one or more of modules 214, 216, 218. Upgrades and changes to the firmware are received from the router 212 via a receiver 228, that then manages the delivery of the new firmware to the memory 210 and/or modules 214, 216, 218. Firmware may similarly be delivered to sensors 202, 204 in this manner.

[0055] To manage installation of new firmware, to run the system clock and perform other operations, a central processing unit (CPU) 234 may be provided. The CPU 234 may comprise the other modules (e.g. modules 208, 214, 216, 218) or may be in communication with those modules. The CPU and output management module 218 may together form a system controller, comprising control over Wi-Fi transmission (e.g. where transmitter 224 comprises a Wi-Fi antenna) or other forms of communication.

[0056] The receiver 228 may also comprise a PLC module 230, enabling it to receive communications along power-lines attached to the power connector 106. In general, the transmitter 224, receiver 228 and PLC modules 226, 230 will be considered, or replaced with, a transceiver 232 through which outgoing signal communications are managed. Outputs are therefore transmitted as signals, whether over a wireless connection or hard-wired connection.

[0057] FIG. 3 shows a sensor device 300, comprising a core 302, two built-in sensors 304, 306 and two swappable or removable sensors 308, 310. Using, for example, the transceiver 232, the sensor 304 transmits a signal comprising its output using an MQTT (machine-to-machine/"Internet-of-things" transfer protocol) to a remote device such as router 212. In the case the communication is made with router 212, the router 212 would then forward that signal to a computing system for analysis.

[0058] Sensors 306 and 308 similarly communicate with remote devices by each sending a signal comprising their respective output (i.e. measurements of the measurand being sensed) using conditional statements such as those employed

using IFTTT (i.e. If This Then That) over the Internet, via router 212, to a remote computing system.

[0059] If sensor 310 is removed, a further sensor device may be plugged in to the empty port so that sensor devices can be daisy-chained.

5 [0060] FIG. 3 therefore illustrates that a wide variety of communication protocols may be employed to transmit sensor information. Moreover, different sensors may use different communication protocols. While transmission of signals may be managed by individual sensors, FIG. 2 provides an example where transmission is governed by the output manager 218. The arrangement of FIG. 2 can be useful to
10 ensure versatility in the event that one communication method breaks down (e.g. a Wi-Fi connection disappears), since the output manager 218 can reroute signals using another communication method (e.g. PLC).

[0061] FIG. 6 provides an example of a sensory network 600. The sensory network 600 includes a hub 602 for delivering a signal from a plurality of sensor devices 604,
15 606, 608, 610 to an external computing system. The external computing system may be accessible over the Internet 612, making the hub 602 an Internet router. Each sensor device 604, 606, 608, 610 is in communication with the hub 602 and comprises one or more sensors, such as fixed or removable sensors 202, 204, and is capable of transmitting a respective output signal to the hub 602 based on an output
20 of the respective one or more sensors. In some embodiments there may be a single hub for each sensor device, or more than one hub each of which is connected to more than one sensor device. Using these various embodiments, the sensor devices may operate independently of each other (i.e. be decentralised) to independently measure the same or different measurands in various locations. Conversely, the
25 sensor devices may operate in unison (i.e. be centralised) so that the same measurand or measurands are monitored at different locations. In other words, where there are multiple hubs the output signals from the one or more sensor devices connected to one of those hubs may or may not depend on the output signals from one or more sensor devices connected to another one of the hubs.
30 Similarly, for sensors devices connected to a common hub, the output signals from those sensor devices may be related or unrelated. In addition, sensor 604 comprises

an end-detection port 622, similar or the same as port 104 of FIG. 1, for detecting a removable sensor 624.

[0062] At least one sensor device 604, 606, 608, 610 is configured to receive a signal from each other sensor device 604, 606, 608, 610. From this signal, the at least one sensor device can determine if the respective other sensor device is functional. In other words, one or more of the sensor devices 604, 606, 608, 610 is configured to monitor the health of the other sensor devices to determine whether they are functioning properly, or whether they are malfunctioning. While each sensor device may be capable of monitoring the other sensor devices, for illustrative purposes sensor device 604 will be described as the sensor device that monitors the other sensor devices 606, 608, 610.

[0063] Sensor device 604 determines if a particular other sensor device 606, 608, 610 is not functional, using various methods. In one example, sensor device 604 is connected to the output of router 602 in a similar manner to the connection with the Internet 612. Sensor device 604 then receives a signal from each sensor device 606, 608, 610, via the router. When a sensor 606, 608, 610 fails to provide a signal, sensor device 604 determines the respective sensor to be faulty. Sensor device 604 may then trigger an alarm or update its output signal to identify the particular sensor 606, 608, 610 that has dropped out of communication. To this end, sensor device 604 may produce an output comprising measurements of a measurand sensed by the one or more sensors mounted to, or comprising part of device 604, along with sensor operation data indicating the operational status of each other sensor in the sensory network 600.

[0064] The operational status portion of the output of sensor device 604 may comprise a binary "Working/Not working" flag for each other sensor device 606, 608, 610 or may comprise various other conditions such as "Working/Not working/Malfunctioning/Recalibrate" and so forth. The sensor device 604 may identify a "Malfunctioning" status when, for example, a sensor device 606, 608, 610 produces an out-of-range output, such as a temperature reading outside an expected temperature range, or where the output rapidly oscillates where it should otherwise change slowly, for example with daily environmental temperature change. In other words, the sensor device 604 may identify an erroneous signal and update

to “Malfunctioning” the status of the sensor device from which the erroneous signal was received. “Recalibrate” may be used where, for example, the other sensor devices 606, 608, 610 each measure temperature or light intensity and would usually provide a similar reading, but one of the sensor devices 606, 608, 610 consistently provides a slightly higher or slightly lower reading than the other sensor devices – a “reading” will be taken to mean the same as an “output”, “measurement” and other terms used to describe the output of a sensor and sensor device.

[0065] The devices 604, 606, 608, 610 may each sense the same or different measurands in disparate locations. Alternatively, devices 604, 606, 608, 610 may sense measurands from a similar location – for example, there may be multiple sensor devices placed around a large room or near critical infrastructure in a room, such as a server room.

[0066] Where the multiple devices incorporate motion sensors, the devices may be positioned throughout a building or premises to monitor the movements of occupants and animals within the premises. This can be advantageous where, for example, head counts are required such as when a building needs to be evacuated.

[0067] A user interacts with the sensors 604, 606, 608, 610 through interface device 620. The interface device may be, for example, a smartphone, tablet, personal computer or laptop. The interface device 620 communicates with the router or hub 602, either directly (e.g. local connection) or via the Internet 612 (remote connection). Communication between the interface device 620, hub 602 and Internet 612 may be a two-way connection. That two-way connection may be achieved using hardwired or wireless connection such as WiFi.

[0068] The interface device 620 further connects with the sensors 604, 606, 608, 610 either directly (e.g. direct connection via WiFi or through the hub 602 – local connection) or indirectly over Internet 612 (remote connection). The interface device 620 can be used to update sensors (e.g. where new firmware has been developed), change alarm thresholds and other functions. Communication between the sensors 604, 606, 608, 610 and the interface device 620 or hub 602 may be a two-way connection. That two-way connection may be achieved using hardwired or wireless connection such as WiFi.

[0069] A further embodiment of a sensor device 700 is shown in FIG. 7. The sensor device 700 includes a housing 702, one or more sensors 704 fixed in relation to the housing 702, for sensing a respective one or more measurands, and a power connector 706 for connecting to a power source (not shown – for example, a wall socket) from which power is drawn to power the one or more sensors 704. The power connector 706 and housing 702 are movably connected.

[0070] While the movable connection between the power connector 706 and housing 702 may permit relative sliding movement, or translation movement (e.g. if the case of a flexible cord connecting between the power source and housing 702) in the present embodiment power connector 706 and housing 702 are movably connected to permit rotational movement of the housing 702 relative to the power connector 706.

[0071] This relative movement between the power connector 706 and housing 702 facilitates positioning of the one or more sensors 704 with respect to an environment in which the one or more measurands can be sensed. For example, where sensor 704 is a light sensor, it may be detrimental to have the light sensor directed towards the carpet or flooring in a room. Instead, the light sensor should typically face upwardly. To this end, the housing 702 can be rotated relative to power connector 706 until the light sensor 704 faces upwardly or, in any case, in the desired direction.

[0072] To facilitate movement of the housing 702 relative to the power connector 706, the housing 702 comprises one part of a two-part movement guide, and the power connector 706 comprises the other part of the two-part movement guide. In this instance, the part of the housing 702 is a plurality of lugs or projections 708, or may alternatively be a circumferential ridge, projecting outwardly from an inner side of an aperture 710 in which the power connector 706 is disposed. The cooperating part on the power connector 706 is a circumferential groove 710. With rotation of the housing 702, the lugs 708 slide within groove 710 to guide rotation of the housing 702.

[0073] The housing 702 further comprises one or more limiters 712, 714, and the power connector 706 comprises one or more limit lug 716. The limiters 712, 714 are used to limit the range of movement of the housing 702. The housing 702 can thus

be rotated in a first direction (indicated by arrow X) until limit lug 716 comes into contact with limiter 714, preventing further rotation in that direction. The housing 702 can similarly be rotated in the opposite direction until limiter 712 comes into contact with limit lug 716. Thus limiters 712, 714 and limit lug 716 define the range of rotation of the housing 702.

[0074] Limiting rotation prevents excessive twisting of power cable 718. The power cable 718 itself resides in a cavity 720. The cavity 720 ensure that more cable 718 is contained within the device 700 than is necessary to form a direct link between the power connector 706 and internal circuitry of the device 700 (e.g. modules, CPU, transmitter and receiver as discussed with reference to FIG. 2). This provides flexibility and enables a twist to form in the cable 718 without disrupting the functionality or integrity of the cable 718.

[0075] In an alternative embodiment, the lugs or projections 708 may extend in parallel into and out of the page so the connector 706 can be slid out of contact with the housing 702. This will enable exchange of the connector 708 in order to accommodate local power outlet configurations. Of course, the wiring scheme will need to be exchanged for a contact arrangement whereby contacts on the power connector 708 enable power conductivity when in contact with contacts on the housing 702.

[0076] On the front of the housing 702 is a power outlet 722. This enables another device to be attached to the front of the housing 702. Thus a wall power outlet need not be dedicated to the device 700. Instead, normal usage may be made of the wall outlet. Similarly, the device 700 may comprise a power switch associated with the power outlet on the front of the housing. Switching ON/OFF of power to the outlet 722 may be governed through touchscreen functions (see touchscreen 112 in FIG. 1).

[0077] Figure 4 is a simplified block diagram of an exemplary network-based system or sensory network 400 – i.e. network of sensor devices such as sensor device 100 – for sensing one or more measurands from a plurality of locations. System 400 may be a client/server system utilized for storage and delivery of data, such as signals from sensor devices or data, upgrades and the like, for transmission to sensor devices. More specifically, in the example embodiment, system 400 includes a server system 402. Server system 402 may also comprise a plurality of server systems

including, for example, at least one server system of a first location or premises in which particular measurands are being sensed, and at least one other location in which other measurands are being sensed. Thus a central repository can be used to store data from multiple sensor devices and sensory networks. The system 400 also includes at least one client computer system 404 which, in a first instance, may comprise a sensor device where the server system 402 includes a router (not shown), in a second instance, may comprise a sensory network where the system 400 is a network of sensory networks or, in a third instance, may comprise a computing system including a display device for displaying sensor data.

[0078] The computing system may run an app that, when the sensor device is switched on and is detectable over Wi-Fi, will automatically discover the sensor device or devices and connect thereto for data collection. The usual security passwords and protocols may also be implemented to prevent third parties from viewing sensor information. This enables the user to govern the transmission of firmware upgrades and other updates to the sensor device or devices, and permit the user to view sensor device output on the computing system display. The user may similarly connect to sensor devices using the computing system, over the Internet. To do so, the sensor device or devices may be pre-programmed with a particular uniform resource locator (URL) so that the sensor device is visible through an Internet browser. Response routines can therefore give rise to alarms and events displayed in the Internet browser or on the app.

[0079] Thus after attachment of the sensor device to a wall socket and the sensor device is connected through Wi-Fi connection (or other connection), the sensor device will connect to a particular URL or to an app (e.g. on a smartphone) and will be ready to deliver sensor data.

[0080] Presently the system 400 includes a plurality of client sub-systems or client computers 404, connected to server system 402. In one embodiment, client systems 404 are Internet-enabled sensor devices or sensory networks such that server system 402 is accessible to client systems 404 using the Internet. This can enable the client systems 404 to access up-to-date versions of sensor or sensor device firmware, and to transmit sensory information (i.e. outputs from sensors) over the Internet – this facilitates remote monitoring of sensor information. Client systems 404 may be

interconnected to the Internet through a variety of interfaces including a router or a network, such as a local area network (LAN) or a wide area network (WAN), dial-in-connections, cable modems and special high-speed ISDN lines.

[0081] A database server 406 is connected to database 408, which stores the
 5 outputs from the sensors connected to, or forming part of, the system 400. This
 enables historical trending analysis to be performed to determine when particular
 events occur (e.g. releases of gas, where one or more sensors are gas sensors,
 switching on of lights or penetration of sunshine, where one or more sensors are
 light sensors, a temperature around the sensor device exceeds a predetermined
 10 threshold temperature, and so on) or when the sensitivity or accuracy of a sensor is
 degrading – this latter point is particularly relevant where multiple similar sensors
 are in the same network and are set to sense the same measurand from a similar
 location, but their outputs vary by an amount that suggests one or more of the
 sensors are not accurately sensing the measurand. In one embodiment, centralized
 15 database 408 is stored on server system 402 and can be accessed by potential users
 at one of client systems 404, or another Internet-enabled computing terminal (not
 shown), by logging onto server system 402 through one of client systems 404 or the
 Internet-enabled computing system. In an alternative embodiment, database 408 is
 stored remotely from server system 402 and may be non-centralized or
 20 decentralized. Database 408 may store electronic files. Electronic files may include
 accounts of users (e.g. businesses or people) having particular sensors in their
 sensory network that upload to the database 408, event occurrence data, stored in
 any format suitable for storage in database 408 and for delivery using system 400.

[0082] The system 400 may actually be involved in collection of that data. For
 25 example, the system 400 may be interconnected with particular sensory networks,
 and use data from those networks to calibrate or identify inaccuracies in a further
 sensory network. For example, where a plurality of sensory networks include a light
 sensor for detecting sunrise at particular, geographically near, locations, if one of the
 sensory networks registers sunrise considerably earlier or later than the others, then
 30 the system 400 may alert a user to a potential fault in that sensory network.

[0083] The database 408 may also be a non-transitory computer readable medium
 storing or embodying a computer program for operating a sensory network. The

program may include at least one code segment executable by a computer to instruct the computer to perform a method as described herein, for operating a sensory network.

[0084] Figure 5 illustrates an exemplary configuration of a computing device 500, similar to server system 400 (shown in Figure 4). Computing device 500 may include, but is not limited to, database server, application server, web server, fax server, directory server, and mail server.

[0085] Server computing device 500 also includes a processor 502 for executing instructions. Instructions may be stored, for example, in a memory area 504 or other computer-readable media. Processor 502 may include one or more processing units (e.g., in a multi-core configuration).

[0086] Processor 502 may be operatively coupled to a communication interface 506 such that server computing device 500 is capable of communicating with a remote device such as a sensory network or sensor device 404 (shown in Figure 4) or another server computing device 500. For example, communication interface 506 may receive information from devices 404, or deliver information (e.g. firmware upgrades) to those devices 404, via the Internet.

[0087] Processor 502 may also be operatively coupled to storage device 508. Storage device 508 is any computer-operated hardware suitable for storing and/or retrieving data. In some embodiments, storage device 508 is integrated in server computing device 500. For example, server computing device 508 may include one or more hard disk drives as storage device 508. In other embodiments, storage device 508 is external to server computing device 500 and may be accessed by a plurality of server computing devices 500. For example, storage device 508 may include multiple storage units such as hard disks or solid state disks in a redundant array of inexpensive disks (RAID) configuration. Storage device 508 may include a storage area network (SAN) and/or a network attached storage (NAS) system.

[0088] In some embodiments, processor 500 is operatively coupled to storage device 508 via a storage interface 510. Storage interface 510 is any component capable of providing processor 502 with access to storage device 508. Storage interface 510 may include, for example, an Advanced Technology Attachment (ATA) adapter, a Serial ATA (SATA) adapter, a Small Computer System Interface (SCSI)

adapter, a RAID controller, a SAN adapter, a network adapter, and/or any component providing processor 502 with access to storage device 508.

[0089] In some instances, storage device 508 may comprise cloud storage. The transmitter of the sensor device may then send sensor data, via a router, to cloud storage database 508.

[0090] From the database 508, the sensor data can be extracted and plotted into graphs in a manner that will be appreciated by the skilled person in light of the present disclosure. Where the database 508 is part of a computing device, the user may access sensor data directly or, where database 508 is part of a cloud storage system, the user may access sensor data through an appropriate cloud application program interface (API).

[0091] In operation, the processor 502, coupled to a memory device (including memory device 504 and storage device 508), is configured to execute computer program steps to implement a method for operating a sensory network.

[0092] The computer system 500 may be instructed to perform a method for operating a sensory network by a computer program embodied on a non-transitory computer readable medium, such as memory device 408 or storage device 508. The program stored on the device 408, 508 would include at least one code segment, and most likely many thousands of code segments, executable by a computer to instruct the computer to perform the requested operations.

[0093] Similarly, the program may be stored remotely. To this end, the computer system may constitute a client computer system of a network-based system for operating a sensory network.

[0094] Many modifications and variations of the present teachings will be apparent to the skilled person in light of the present disclosure. All such modifications and variations are intended to fall within the scope of the present disclosure. Moreover, to the extent possible, features form one of the embodiments described herein may be used in one or more other embodiments to enhance or replace a feature of the one or more other embodiments. All such usage, substitution and replacement is intended to fall within the scope of the present disclosure.

CLAIMS

1. A sensor device comprising:

a housing;

one or more sensor attachment ports accessible from outside the housing; and

5 a sensor detector for automatically determining a type of each of one or more sensors, when the one or more sensors are attached to respective ones of the sensor attachment ports.

2. A sensor device according to claim 1, wherein the sensor detector automatically

10 determines the type of each of the one or more sensors by identifying at least one of:

one or more electrical characteristics of each sensor; and

one or more output characteristics of a respective output of each sensor.

3. A sensor device according to claim 2, wherein each of the one or more electrical

15 characteristics comprises at least one of:

an internal impedance of the respective sensor,

a power usage of the respective sensor,

a current draw of the respective sensor, and

a voltage drop over the respective sensor.

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4. A sensor device according to claim 2 or 3, wherein each of the one or more output characteristics comprises at least one or:

a voltage range of the output,

a structure of data comprising the output, and

25 a baud rate of the output.

5. A sensor device according to any one of claims 2 to 4, wherein the electrical characteristic or output format is unique to the respective sensor.

30 6. A sensor device according to any one of claims 2 to 5, wherein the sensor detector automatically determines the type of each sensor by identifying a unique combination of

two or characteristics of the respective sensor, each characteristic of the two or more characteristics comprising either an electrical characteristic or an output characteristic.

7. A sensor device according to claim 1, wherein the sensor detector is configured to
5 receive a power-on signal from each respective sensor and determine, from the power-on signal, a type of the respective sensor.

8. A sensor device according to any preceding claim, further comprising a mains power connector for connecting to a wall socket mains power source.

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9. A sensor device according to claim 1, further comprising a transmitter in communication with the one or more sensors, to transmit an outbound signal based on an output of each of the one or more sensors.

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10. A sensor device according to claim 9, wherein the transmitter is configured to transmit the outbound signal to a hub.

11. A sensory network comprising:

a hub; and

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a plurality of sensor devices in communication with the hub, each sensor device comprising one or more sensors and being capable of transmitting a respective output signal to the hub based on an output of the respective one or more sensors, wherein at least one sensor device of the plurality of sensor devices is configured to receive a signal from each other sensor device of the plurality of sensor devices, and determine if
25 the respective other sensor device is functional.

12. A sensory network according to claim 11, wherein the at least one sensor device determines if a particular said other sensor device is not functional if the at least one sensor device does not receive the respective signal from the particular other sensor device.

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13. A sensory network according to claim 11 or 12, wherein the at least one sensor device determines if a particular said other sensor device is not functional if the at least one sensor device receives an erroneous signal from the particular other sensor device.

5 14. A sensory network according to any one of claims 11 to 13, wherein at least one of the sensor devices is a sensor device according to any one of claims 1 to 10.

10 15. A sensory network according to any one of claims 11 to 14, wherein the hub is an Internet router capable of transmitting the output signals to a computing device over the Internet.

16. A sensory network according to any one of claims 11 to 15, comprising a plurality of hubs, each hub being connected to at least one of said sensory devices.

15 17. A sensory network according to claim 16, wherein the output signal from the or each sensory device connected to one said hub is independent of the output signal of the or each sensor device connected to at least one other hub.

20 18. A sensory network according to claim 16, wherein an output signal from the at least one sensory device connected to one of said hubs relates to an output signal from the at least one sensory device connected to at least one other hub.

25 19. A sensory network according to any one of claims 11 to 15, wherein the output signal from each sensor device to the hub is independent of the output signal from at least one other sensor device to the hub.

30 20. A sensory network according to any one of claims 11 to 15, wherein the output signal from each sensor device to the hub relates to the output signal from at least one other sensor device to the hub.

21. A sensor device comprising:
a housing;

one or more sensors fixed in relation to the housing, for sensing a respective one or more measurands; and

a power connector for connecting to a power source from which power is drawn to power the one or more sensors,

5 wherein the power connector and housing are movably connected.

22. A sensor device according to claim 21, wherein the power connector and housing are movably connected to permit rotational movement of the housing relative to the power connector.

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23. A sensor device according to claim 21 or 22, wherein the power connector and housing are movably connected to facilitate positioning of the one or more sensors with respect to an environment in which the one or more measurands can be sensed.