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(54) Title: THERMOSTAT GESTURE CONTROL

(57) Abstract: A method and apparatus to enable the control of a building HVAC thermostat using hand gestures is provided so that there is no need to physically touch the thermostat to change its state. A thermostat controller for building HVAC systems that is responsive to hand gestures may include: at least one sensor responsive to hand gestures; a recognition circuit coupled to receive signals from the at least one sensor and adapted to determine gesture parameters therefrom; a processor coupled to the recognition circuit and adapted to determine HVAC control parameters from the gesture parameters; and HVAC control circuitry for controlling HVAC systems in accordance with HVAC control parameters communicated from the processor circuit. The at least one sensor may be supported by a housing, wherein the at least one sensor is responsive to hand gestures only in proximity to the housing. The thermostat controller can include a thermostat display screen mounted in the housing, with a plurality of sensor electrodes arranged in a two-dimensional pattern in front of and/or around the periphery of the display screen.
Thermostat Gesture Control

Related Applications

[0001] This application claims priority to Australian Provisional Patent Application No. 2013903632 in the name of Planet Intellectual Property Enterprises Pty Ltd, which was filed on 20 September 2013, entitled "Thermostat Gesture Control" and the specification thereof is incorporated herein by reference in its entirety and for all purposes.

Field of Invention

[0002] This invention relates to a method and apparatus to enable the control of a building HVAC thermostat using hand gestures so that there is no need to physically touch the thermostat to change its state.

Background to Invention

[0003] Throughout this specification the use of the word "inventor" in singular form may be taken as reference to one (singular) inventor or more than one (plural) inventor of the present invention.

[0004] It is to be appreciated that any discussion of documents, devices, acts or knowledge in this specification is included to explain the context of the present invention. Further, the discussion throughout this specification comes about due to the realisation of the inventor and/or the identification of certain related art problems by the inventor. Moreover, any discussion of material such as documents, devices, acts or knowledge in this specification is included to explain the context of the invention in terms of the inventor's knowledge and experience and, accordingly, any such discussion should not be taken as an admission that any of the material forms part of the prior art base or the common general knowledge in the relevant art in Australia, or elsewhere, on or before the priority date of the disclosure and claims herein.
Smart home automation systems have been available for a number of years, although they have struggled somewhat to gain market penetration due to the costs of the systems and the complexity required for installation. In the past few years, new sales channels have emerged which have seen the typical customer transform from "early adopter" of these systems into the "early majority". The inventor has come to the realisation that this transition has also affected user expectations, with the result that consumers of these systems now also expect more from the point of view of user experience, influenced by slick interfaces such as those provided in products like smartphones.

**Summary of Invention**

[0006] It is an object of the embodiments described herein to overcome or alleviate at least one of the above noted drawbacks of related art systems or to at least provide a useful alternative to related art systems.

[0007] In accordance with one aspect of the present invention, there is provided a thermostat controller for building HVAC systems responsive to hand gestures, including:

- at least one sensor responsive to hand gestures;
- a recognition circuit coupled to receive signals from the at least one sensor and adapted to determine gesture parameters therefrom;
- a processor coupled to the recognition circuit and adapted to determine HVAC control parameters from the gesture parameters; and
- HVAC control circuitry for controlling HVAC systems in accordance with HVAC control parameters communicated from the processor circuit.

[0008] The at least one sensor may be supported by a housing, wherein the at least one sensor is responsive to hand gestures only in proximity to the housing.

[0009] The at least one sensor may be one or a combination of a capacitive sensor, an inductive sensor, or an infrared optical sensor.

[0010] The thermostat controller may include a plurality of sensor electrodes arranged in a two-dimensional pattern, wherein the recognition circuit is operative, in
use, to determine gesture parameters in response to two-dimensional hand gestures substantially parallel to and in proximity of the sensor electrode pattern.

[0011] A thermostat display screen may be mounted in the housing, wherein the pattern of sensor electrodes is arranged in front of and/or around the periphery of the display screen.

[0012] In accordance with another aspect of the present invention, there is provided a method for controlling a building HVAC system, including:

- providing a thermostat unit within the building, the thermostat unit being capable of communication with the building HVAC system and having at least one sensor capable of detecting hand movements in the vicinity thereof;
- monitoring the at least one sensor to detect hand movements in the vicinity of the thermostat unit;
- decoding the detected hand movements to determine gesture parameters therefrom;
- determining HVAC control parameters corresponding to said gesture parameters; and
- communicating control signals to control the building HVAC system in accordance with the determined HVAC control parameters.

[0013] In the context of the present discussion it is to be noted that the term "gesture" or "hand gesture" is used herein to describe a movement or sequence of movements of a limb, hand, digit or the like.

[0014] Furthermore, in the context of this discussion it is also to be noted that the term "HVAC" is used herein to describe heating, ventilation and/or air-conditioning apparatus and like systems for effecting control of interior environmental conditions although a given HVAC system may not necessarily include each of or separate heating, ventilation and air-conditioning equipment.

[0015] In embodiments of the invention, gestures that may be used to control the thermostat are primarily based on the motion of a hand in 2-dimensions. By way of example, this may include:
- a swipe of the hand from left to right, up to down or diagonally;
- motion of the hand in a clockwise or anti-clockwise circle;
- a sequence of swipes made in succession, where the end position of one swipe is the start position of the next swipe (e.g. up-down-up);
- movement of the hand to a location and staying stationary at that location for a period of time (e.g. a pointing gesture).

[0016] Further scope of applicability of embodiments of the present invention will become apparent from the detailed description given hereinafter. However, it should be understood that the detailed description and specific examples, while indicating preferred embodiments of the invention, are given by way of illustration only, since various changes and modifications within the spirit and scope of the disclosure herein will become apparent to those skilled in the art from this detailed description.

**Brief Description of the Drawings**

[0017] Further disclosure, objects, advantages and aspects of preferred and other embodiments of the present invention may be better understood by those skilled in the relevant art by reference to the following description of embodiments taken in conjunction with the accompanying drawings, which are given by way of illustration only, and thus are not limitative of the disclosure herein, and in which:

[0018] Figure 1 is a functional block diagram of a building HVAC system incorporating a gesture control thermostat in accordance with an embodiment of the present invention;

[0019] Figure 2 is a diagrammatic front view illustration of a gesture control thermostat in accordance with an embodiment of the present invention;

[0020] Figure 3 is a diagrammatic side view illustration of a gesture control thermostat in accordance with an embodiment of the present invention;
Figure 4 is a schematic block diagram of primary functional components of a gesture control thermostat in accordance with an embodiment of the present invention;

Figure 5 is a flow-chart diagram of a thermostat gesture control procedure in accordance with an embodiment of the present invention;

Figures 6, 7 and 8 are diagrammatic front view illustrations indicating examples of hand gestures.

Detailed Description

Traditionally, control of an HVAC thermostat has been achieved by pushing buttons directly on the front panel. Use of gestures can enable three key advantages:

1) Without the need to physically touch the front panel, the thermostat remains clean and smudge-free. This is something that is increasing valued by consumers who treat consumer electronics as "trophy pieces" (e.g. the proliferation of smartphone covers and protection sleeves).

2) Because the use of gestures does not require any physical contact with the thermostat front panel, standard wear and tear or dirt build-up on buttons or touch sensors, that might otherwise cause reliability problems, is avoided.

3) In comparison to buttons or sensors which have a binary input (on/off), the use of gestures allows for a greater combination of commands to be sent to the thermostat (e.g. vertical, horizontal or diagonal swipes) whilst still remaining easy to memorise for the user.

The invention may be embodied in a gesture control thermostat that uses sensors, which may include capacitive sensors, inductive or infra-red optical sensors, oriented to face the user, the raw output of which is connected to a signal processing chip, with algorithms specifically designed to recognise gestures made by the hand, to detect the movement of a hand at a distance from the thermostat front panel. The signal processing chip mentioned above may be a dedicated circuit chip adapted for use with a gesture control thermostat or, alternatively it may be
embodied in the form of the signal processing circuitry that is part of a processor chip with multiple features, for example, a microcontroller. The gesture recognition chip then outputs a signal to the central electronic controller of the thermostat, which defines the type, direction, speed and other parameters of the gesture. Based on these outputs, the thermostat controller will change its state (e.g. increase set-point temperature, change operation from heating to cooling mode).

[0026] A functional block diagram of a building HVAC system 10 employing a gesture control thermostat 100 according to an embodiment of the invention is illustrated in Figure 1. The HVAC system may be used to control the interior environment of commercial or domestic premises, such as a home or office, by heating, cooling and ventilation. In this case the thermostat is of a specific type that has a wireless connection to a home automation system 60.

[0027] The home automation system allows for changing the state of the thermostat using a personal computer 70 or smartphone 80, and in particular enables a very wide and complex range of commands to be sent to the thermostat. Consequently, the set of commands that the user is required to execute by direct interaction with the thermostat front panel is drastically reduced. Given the much smaller and simpler command set, use of gestures becomes a practical control method as the user only has to remember a few movements (e.g. up, down, left right) to control the wall panel, and all other more complex control may be done remotely through the smartphone/home automation system.

[0028] The thermostat has wired connections to the heating 30, cooling 50 or ventilation 40 appliances, a set of control relays and sensors and a microprocessor which controls the relays based on input from the sensors. The microprocessor may receive input from the user as to the desired environmental conditions (set-point, heating mode, fan speed, switch-on time, etc.), from two sources, either directly from the gesture recognition sensors and circuitry of the thermostat, or through a wireless link with a home automation system.

[0029] The gesture control thermostat unit 100 is illustrated diagrammatically in front and side views in Figures 2 and 3, respectively. The thermostat 100 may
typically be contained in a housing 110 that is mounted on or in an interior wall surface of a home or office with the front surface (112) exposed. The front of the thermostat has a display panel 120, such as a TFT display for indicating information such as temperature and HVAC equipment status, and a plurality of sensors 132, 134, 136, 138. In the embodiment as shown in Figure 3, the sensors may be arranged on a circuit board 130 and the display 120 and other control circuitry on a separate circuit board 140, although other configurations are possible. The thermostat 100 as shown also includes a power supply 150, which may be permanently wired or battery operated, and terminals 160 for connection to HVAC equipment (heaters, air-conditioner, fans, etc.) through cabling 165. Functional elements and operation of the gesture control thermostat are described in greater detail herein below.

[0030] A schematic block diagram of primary functional components of a gesture control thermostat according to a particular embodiment of the present invention is shown in Figure 4. The thermostat includes a microcontroller circuit 190 coupled to control HVAC equipment, and to receive ambient temperature information from a temperature sensor 195. The microcontroller circuit 190 is coupled to a display screen 120 for providing status information and the like, and is also coupled to receive input signals from a gesture recognition circuit 180. The gesture recognition circuit is in turn coupled to sensors 132, 134, 136, 138 arranged around the periphery of the display screen 120.

[0031] The gesture recognition circuit 180 may include, for example, a single-zone 3D tracking and gesture controller chip such as that designated MGC3130 and available from Microchip Technology Inc. In this case the sensors 132-138 are in the form of receiver electrodes arranged in a two dimensional pattern around or in front of the display screen 120. Four receiver electrodes can be utilised with optionally a centrally located fifth receiver electrode (not shown), in conjunction with a transmitter electrode (not shown). Other configurations of sensors are also possible. In use, the gesture recognition circuit generates an electric field through the transmitter electrode and can use the receiver electrodes to sense variations or distortions in the electric field brought about by the introduction and movement of a user's hand in the proximity of the receiver electrodes. By detecting the electric field variations at
different positions over time the gesture recognition circuit is able to measure the origin of the electric field distortion from the varying signals received. The information is used to calculate the position, track movements and to classify movement patterns (gestures).

[0032] The gesture recognition chip, the sensors and the thermostat microprocessor may be located on a single PCB, or on multiple PCB’s which are wired together. It is preferable to have the sensors as close as possible to the user (i.e. close to the front surface of the thermostat unit), so that the level of interference from other components is minimised. Accordingly, the electrodes may be formed from transparent conductors patterned on a transparent panel made from glass or plastics material that sits in front of the display screen in the thermostat unit.

[0033] The exact algorithm for recognition of gestures is defined by the specification of the gesture recognition chip purchased as an off the shelf component. The configuration and physical arrangement of the sensors is such that they are located at points close the expected endpoints of the gestures (i.e. the top, bottom, left and right sides).

[0034] Speaking more generally, Figure 5 shows a flow-chart diagram of a procedure 200 for thermostat control of an HVAC system according to embodiments of the invention. As described above, the thermostat uses sensors, which may include capacitive sensors, inductive or infra-red optical sensors, oriented to face the user, the raw output of which is connected to a commercially available signal processing chip, with algorithms specifically designed to recognise gestures made by the hand, to detect the movement of a hand at a distance from the thermostat front panel. The sensors are monitored (202) and signals therefrom are decoded according to recognised hand gestures (204). The gesture recognition chip then outputs a signal (206) to the microprocessor which defines the type, direction, speed and other parameters of the gesture. Based on these outputs, the thermostat controller determines whether a change of state (e.g. increase set-point temperature, change operation from heating to cooling mode) is required (208), and issues corresponding control signals to the HVAC equipment (210).
Figures 6, 7 and 8 are diagrammatic front views of a gesture control thermostat illustrating examples of hand gestures that may be used to control functions of an HVAC system. The gestures used by embodiments of the invention are primarily based on the motion of a hand in 2-dimensions. This includes, but is not limited to:

- a swipe of the hand from left to right, up to down or diagonally (e.g. left-to-right swipe indicated in Figure 6);
- a sequence of swipes made in quick succession, where the end position of one swipe is the start position of the next swipe (such as indicated in Figure 7);
- motion of the hand in a clockwise or anti-clockwise circle (such as indicated in Figure 8);
- movement of the hand to a location and staying stationary at that location for a period of time (i.e. a pointing gesture).

The sensitivity of the gesture recognition chip can be adjusted to ensure that the recognition of gestures in the vicinity of the controller is robust, but that gestures made a distance away (which may not be intended as control gestures) are not recognised. The sensitivity can be set using a combination of adjustment of signal processing parameters and the placement of the sensors, and may be calibrated during production or by the user using a predefined set of gestures.

The microcontroller contains a look-up table of the possible gesture signals that can be received from the gesture recognition chip, including parameters such as gesture type (swipe, clockwise, point, multi-swipe), gesture orientation (up, down, clockwise) and velocity. The microcontroller may be configured to associate execution of any command relating the control of the HVAC system with any specific gesture parameter set. The thermostat may be supplied with a default configuration that can be changed by the user through the remote interface provided by the home automation system (e.g. default way to increase temperature is to swipe up, but user can change settings such that increasing temperature is done by swiping across).
Additionally, some gestures may be associated with functions of the thermostat that do not control external HVAC components, but modify the state of the thermostat microcontroller. For example, a gesture (or lack of a gesture for a period of time) may be used to indicate that the thermostat should change to an idle state where it uses less power and turns off the display.

Gestures may have multiple associations depending on the state of the thermostat. For example, if the thermostat is in idle state, then any gesture may be used to move it out of idle and into normal operating mode. Once in normal operating mode, the gestures may have associations as described above.

As mentioned above, in certain systems the user may also be able to provide input to the control panel of a home automation system to which the thermostat is connected. The home automation system may relay the control inputs to the thermostat using a wired or wireless (Zigbee, Wifi, Z-wave etc.) protocol. The interface to the home automation system may include a smartphone or PC which can be complex, and include multiple screen pages and have many different settings beyond what is available to be input directly onto the front panel of the thermostat via gesture control.

While this invention has been described in connection with specific embodiments thereof, it will be understood that it is capable of further modification(s). This application is intended to cover any variations uses or adaptations of the invention following in general, the principles of the invention and including such departures from the present disclosure as come within known or customary practice within the art to which the invention pertains and as may be applied to the essential features hereinbefore set forth.

As the present invention may be embodied in several forms without departing from the spirit of the essential characteristics of the invention, it should be understood that the above described embodiments are not to limit the present invention unless otherwise specified, but rather should be construed broadly within the spirit and scope of the invention as defined in the appended claims. The
described embodiments are to be considered in all respects as illustrative only and not restrictive.

[0043] It should also be noted that where a flowchart is used herein to demonstrate various aspects of the invention, it should not be construed to limit the present invention to any particular logic flow or logic implementation. The described logic may be partitioned into different logic blocks (e.g., programs, modules, functions, or subroutines) without changing the overall results or otherwise departing from the true scope of the invention. Often, logic elements may be added, modified, omitted, performed in a different order, or implemented using different logic constructs (e.g., logic gates, looping primitives, conditional logic, and other logic constructs) without changing the overall results or otherwise departing from the true scope of the invention.

[0044] Various embodiments of the invention may be embodied in many different forms, including computer program logic for use with a processor (e.g., a microprocessor, microcontroller, digital signal processor, or general purpose computer and for that matter, any commercial processor may be used to implement the embodiments of the invention either as a single processor, serial or parallel set of processors in the system.

[0045] Computer program logic implementing all or part of the functionality where described herein may be embodied in various forms, including a source code form, a computer executable form, and various intermediate forms (e.g., forms generated by an assembler, compiler, linker, or locator). Source code may include a series of computer program instructions implemented in any of various programming languages (e.g., an object code, an assembly language, or a high-level language). The source code may define and use various data structures and communication messages. The source code may be in a computer executable form (e.g., via an interpreter), or the source code may be converted (e.g., via a translator, assembler, or compiler) into a computer executable form.

[0046] The computer program may be fixed in any form (e.g., source code form, computer executable form, or an intermediate form) either permanently or transitorily
in a tangible storage medium, such as a semiconductor memory device (e.g., a RAM, ROM, PROM, EEPROM, or Flash-Programmable RAM), a magnetic memory device (e.g., a diskette or fixed disk), an optical memory device (e.g., a CD-ROM or DVD-ROM), or other memory device. The computer program may be fixed in any form in a signal that is transmittable to a computer using any of various communication technologies, including, but in no way limited to, analog technologies, digital technologies, optical technologies, wireless technologies (e.g., Bluetooth), networking technologies, and inter-networking technologies.

[0047] Hardware logic (including programmable logic for use with a programmable logic device) implementing all or part of the functionality where described herein may be designed using traditional manual methods, or may be designed, captured, simulated, or documented electronically using various tools, such as Computer Aided Design (CAD), a hardware description language (e.g., VHDL or AHDL), or a PLD programming language (e.g., PALASM, ABEL, or CUPL). Hardware logic may also be incorporated into display screens for implementing embodiments of the invention and which may be segmented display screens, analogue display screens, digital display screens, CRTs, LED screens, Plasma screens, liquid crystal diode screen, and the like.

[0048] "Comprises/comprising" and "includes/including" when used in this specification is taken to specify the presence of stated features, integers, steps or components but does not preclude the presence or addition of one or more other features, integers, steps, components or groups thereof. Thus, unless the context clearly requires otherwise, throughout the description and the claims, the words 'comprise', 'comprising', 'includes', 'including' and the like are to be construed in an inclusive sense as opposed to an exclusive or exhaustive sense; that is to say, in the sense of "including, but not limited to".
Claims

1. A thermostat controller for building HVAC systems responsive to hand gestures, including:
   at least one sensor responsive to hand gestures;
   a recognition circuit coupled to receive signals from the at least one sensor and adapted to determine gesture parameters therefrom;
   a processor circuit coupled to the recognition circuit and adapted to determine HVAC control parameters from the gesture parameters; and
   HVAC control circuitry for controlling HVAC systems in accordance with HVAC control parameters communicated from the processor circuit.

2. A thermostat controller responsive to hand gestures as claimed in claim 1, including a housing supporting the at least one sensor and wherein the at least one sensor is responsive to hand gestures only in proximity to the housing.

3. A thermostat controller responsive to hand gestures as claimed in claim 1 or claim 2, wherein the at least one sensor is one or a combination of a capacitive sensor, an inductive sensor, or an infrared optical sensor.

4. A thermostat controller responsive to hand gestures as claimed in claim 2, including a plurality of sensor electrodes arranged in a two-dimensional pattern, and wherein the recognition circuit is operative, in use, to determine gesture parameters in response to two-dimensional hand gestures substantially parallel to and in proximity of the sensor electrode pattern.

5. A thermostat controller responsive to hand gestures as claimed in claim 4, including a thermostat display screen mounted in the housing, and wherein the pattern of sensor electrodes is arranged in front of and/or around the periphery of the display screen.

6. A method for controlling a building HVAC system, including:
providing a thermostat unit within the building, the thermostat unit being capable of communication with the building HVAC system and having at least one sensor capable of detecting hand movements in the vicinity thereof;

monitoring the at least one sensor to detect hand movements in the vicinity of the thermostat unit;

decoding the detected hand movements to determine gesture parameters therefrom;

determining HVAC control parameters corresponding to said gesture parameters; and

communicating control signals to control the building HVAC system in accordance with the determined HVAC control parameters.
Figure 1
Figure 2

Heating Mode
15 °C
Power ON

Figure 3
Thermostat control procedure

Monitor gesture sensors

Decode hand gesture from sensor signals

Communicate gesture parameters to processor

Determine HVAC control parameters from gesture parameters

Issue control signals to HVAC system

Figure 5
## A. CLASSIFICATION OF SUBJECT MATTER

606F 17/00 [2006.01] G05D 23/00 [Z00e.Oi]

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## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

**Documentation searched:**

- Taska
- HVAC
- Automation
- Hand
- Gesture
- Electric field
- Similar keywords

**Keywords:** Thermostat, HVAC, automation, hand, gesture, electric field, and similar keywords.

**Google Patents, Google Scholar & Espacenet** were also searched with similar keywords as above.

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## C. DOCUMENTS CONSIDERED TO BE RELEVANT

**Category** | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No.
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Documents are listed in the continuation of Box C

![X] Further documents are listed in the continuation of Box C

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**Date of the actual completion of the international search:** 6 November 2014

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**Name and mailing address of the ISA/AU**

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**INTERNATIONAL SEARCH REPORT**

**International application No.**

**PCT/AU2014/000929**

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<td>X</td>
<td>US 2008/0238665 A1 (PENG) 02 October 2008 Paras 0021-0039 and figures 2-7f</td>
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End of Annex

Due to data integration issues this family listing may not include 10 digit Australian applications filed since May 2001.

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