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(54) **METHOD AND APPARATUS FOR CONTROLLING AIR CONDITIONER, AND ELECTRONIC DEVICE**

(57) A method and an apparatus for controlling an air conditioner, and an electronic device are provided in the present application. The method is applied to a controller of the air conditioner and includes: obtaining temperature data and humidity data of the air conditioner; inputting a mode, a prediction type, temperature data and humidity data of the air conditioner into a pre-trained prediction model of the air conditioner, and outputting a predicted time of the air conditioner; and controlling a startup or a shutdown of the air conditioner based on the predicted time. In this method, the mode, the prediction type, the temperature data and the humidity data of the air conditioner are input into the pre-trained prediction model of the air conditioner, the predicted time of the air conditioner is output, and the startup or the shutdown of the air conditioner is controlled based on the predicted time. According to this method, the predicted startup time and the predicted shutdown time of the air conditioner are predicted through the prediction model, an energy consumption of the air conditioner may be saved, an occurrence of waste of energy would not be caused, the air conditioner has an excellent thermal adaptability.

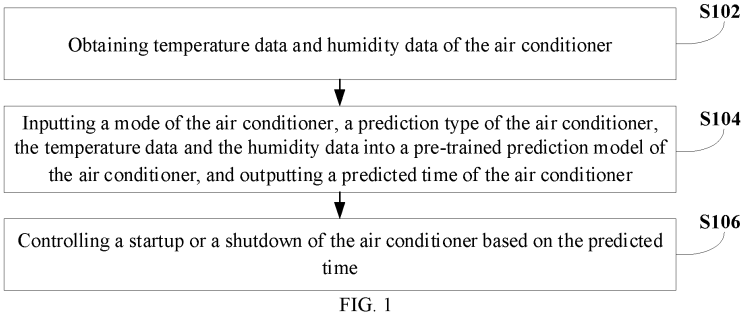

FIG. 1

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Description

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority to Chinese patent application No. 202111163463.6, filed on September 30, 2021, and entitled "method and apparatus for controlling air conditioner, and electronic device", the entire contents of which is incorporated herein by reference.

TECHNICAL FIELD

[0002] The present application relates to the field of air conditioner technologies, and more particularly, to a method for controlling an air conditioner, an apparatus for controlling an air conditioner, and an electronic device.

BACKGROUND

[0003] In a commercial scenario, startup and shutdown of an air conditioner is generally completed through manual operation of a property personnel, that is, an employee of property personnel in a building manually turns on the air conditioner before he/she is on-duty, and manually turn off the air conditioner after he/she is off-duty, an employee sometimes complains or makes a complaint on this control method which completely depends on manual control, because that the air conditioner cannot be started up in time or because of a waste of energy consumption caused because that a person forgets to shut down the air conditioner.

[0004] With the promotion and application of a building management system (Building Management System, BMS, which is also referred to as a building automatic control system), the control method of starting up and shutting down the air conditioner manually by the property staff has been partially replaced by a time schedule control of the BMS, that is, startup and shutdown time of the air conditioner are preset in the BMS and the air conditioner is automatically started up or shut down according to the preset startup and shutdown time. However, the time schedule control method still has a certain defect, the startup and shutdown time of the air conditioner in the time schedule is set manually according to experience. If the air conditioner is started up too early, an indoor temperature is too low, and a waste of energy consumption is caused. If an air conditioner system is started up too late, the indoor temperature during the on-duty time is too high.

[0005] Therefore, the two control methods of the air conditioner cannot adjust the startup and shutdown time according to the change of the actual load of the building, and thus there exists problems of large energy consumption, waste of energy and poor thermal comfort of the air conditioner.

SUMMARY

[0006] In view of this, the present application provides a method and an apparatus for controlling an air conditioner, and an electronic device, which aims at conserving energy consumption of the air conditioner, an occurrence of waste of energy would not be caused, and an excellent thermal comfort is realized.

[0007] Some embodiments of the present application provide a method for controlling an air conditioner, wherein the method being for a controller of the air conditioner, the method for controlling the air conditioner comprises: obtaining temperature data and humidity data of the air conditioner, wherein the temperature data comprises an indoor temperature and an outdoor temperature, the humidity data comprises indoor humidity and outdoor humidity; inputting a mode of the air conditioner, a prediction type of the air conditioner, the temperature data and the humidity data into a pre-trained prediction model of the air conditioner, and outputting a predicted time of the air conditioner; where the mode of the air conditioner comprises a cooling mode and/or a heating mode; the prediction type of the air conditioner comprises a prediction of startup time and/or a prediction of shutdown time; parameters of the prediction model comprises a preset indoor temperature, a preset indoor temperature threshold value, preset indoor humidity and a preset indoor humidity threshold value; the predicted time comprises a predicted startup time and/or a predicted shutdown time; and controlling a startup or a shutdown of the air conditioner based on the predicted time.

[0008] In some optional embodiments of the present application, the step of obtaining the temperature data and the humidity data of the air conditioner may comprise: obtaining a first current time; and obtaining the temperature data and the humidity data of the air conditioner, in response to the first current time reaches a preset determination time.

[0009] In some optional embodiments of the present application, if the prediction type of the air conditioner is the prediction of startup time, the predicted startup time of the air conditioner may be determined by a computational formula which is expressed as:

$$\Delta t_{open} = c_1 \cdot (T_{in} - T_{set} - T_{comp}) + c_2 \cdot (T_{out} - T_{set} - T_{comp}) + c_3 \cdot (RH_{in} - RH_{set} - RH_{comp}) + c_4 (RH_{out} - RH_{set} - RH_{comp});$$

where, $\triangle t_{open}$ represents the predicted startup time, c_1-c_4 represents preset coefficients for the prediction of startup time, T_{in} represents the indoor temperature, RH_{in} represents the indoor humidity, T_{out} represents the outdoor temperature, RH_{out} represents the outdoor humidity, T_{set} represents the preset indoor temperature, RH_{set} represents the preset indoor humidity, T_{comp} represents the preset indoor temperature threshold value, and RH_{comp} represents the preset indoor humidity threshold value; in response to the prediction type of the air conditioner is the prediction of shutdown time, the predicted shutdown time of the air conditioner may be determined by a computational formula which is expressed as:

$$\Delta t_{close} = d_1 \cdot (T_{in} - T_{set} - T_{comp}) + d_2 \cdot (T_{out} - T_{set} - T_{comp}) + d_3 \cdot (RH_{in} - RH_{set} - RH_{comp}) + d_4 \cdot (RH_{out} - RH_{set} - RH_{comp});$$

where, $\triangle t_{close}$ represents the predicted shutdown time, d_1-d_4 represents predetermined coefficients for the prediction of shutdown time.

[0010] In some optional embodiments of the present application, after the step of outputting the predicted time of the air conditioner, the method for controlling the air conditioner may further comprise: using, in response to the predicted time is greater than a preset upper limit value of the startup time or the shutdown time, the upper limit value as the predicted time; or using, in response to the predicted time is less than a lower limit value of the startup time or the shutdown time, the lower limit value as the predicted time.

[0011] In some optional embodiments of the present application, the step of controlling the startup or the shutdown of the air conditioner based on the predicted time may comprise: obtaining a second current time; and calculating a time difference between the second current time and a preset on-duty time or a preset off-duty time, and controlling the air conditioner to be powered on or powered-off, in response to the time difference is smaller than or equal to the predicted startup time or the predicted shutdown time.

[0012] In some optional embodiments of the present application, after obtaining the predicted startup time $\triangle t_{open}$ is obtained, a time difference Δt between the second current time and the on-duty time is calculated in real time and the time difference Δt is compared with the predicted startup time $\triangle t_{open}$, continue to wait if a condition of $\triangle t > \triangle t_{open}$ is met; or a startup instruction is sent to the air conditioner such that the air conditioner starts operation if a condition of $\triangle t \leq \triangle t_{open}$ is met.

[0013] In some optional embodiments of the present application, after the predicted shutdown time $\triangle t_{close}$ is obtained, a time difference Δt between the second current time and the off-duty time is calculated in real time and the time difference Δt is compared with the predicted shutdown time $\triangle t_{close}$, continue to wait if a condition of $\triangle t > \triangle t_{close}$ is met; or, a shutdown instruction is sent to the air conditioner such that the air conditioner stops operations if a condition of $\triangle t \leq \triangle t_{close}$ is met.

[0014] In some optional embodiments of the present application, after the step of controlling the startup or the shutdown of the air conditioner based on the predicted time, the method for controlling the air conditioner further comprises: determining a temperature reaching time of the air conditioner; and adjusting the parameters of the prediction model based on the temperature reaching time.

[0015] In some optional embodiments of the present application, the step of determining the temperature reaching time of the air conditioner comprises: determining a startup time of the air conditioner in response to the predicted type of the air conditioner is the prediction of startup time; obtaining a third current time if the indoor temperature is greater than or equal to a summation of the preset indoor temperature and the preset indoor temperature threshold value; and taking a difference value between the third current time and the startup time as the temperature reaching time; or, determining the shutdown time of the air conditioner in response to the prediction type of the air conditioner is the prediction of shutdown time; obtaining a fourth current time in response to the indoor temperature is less than or equal to a summation of the preset indoor temperature and the preset indoor temperature threshold value; and taking a difference value between the fourth current time and the shutdown time as the temperature reaching time.

[0016] In some optional embodiments of the present application, the step of adjusting the parameters of the prediction model based on the temperature reaching time comprises: determining a first absolute value of a difference value between the temperature reaching time and the predicted startup time if the prediction type of the air conditioner is the prediction of startup time, and adjusting the parameters of the prediction model if the first absolute value is greater than a preset first error threshold value; or, determining a second absolute value of a difference between the temperature reaching time and the predicted shutdown time in response to the prediction type of the air conditioner is the prediction of shutdown time; and adjusting the parameters of the prediction model in response to the second absolute value is greater than a preset second error threshold value.

[0017] In some optional embodiments of the present application, the step of adjusting the parameters of the prediction model based on the temperature reaching time comprises: obtaining historical temperature data and historical humidity data of the air conditioner within a preset time range; and adjusting the parameters of the prediction model based on

the historical temperature data and the historical humidity data.

[0018] In some optional embodiments of the present application, the controller of the air conditioner is arranged in the air conditioner; or, the controller of the air conditioner is arranged in a server being in communication connection with the air conditioner.

[0019] An apparatus for controlling an air conditioner is further provided in some other embodiments of the present application. The apparatus is applied to a controller of the air conditioner, and may comprise: a data acquisition module configured to obtain temperature data and humidity data of the air conditioner, where the temperature data comprises an indoor temperature and an outdoor temperature, the humidity data comprises indoor humidity and outdoor humidity; a time prediction module configured to input a mode of the air conditioner, a prediction type of the air conditioner, the temperature data and the humidity data into a pre-trained prediction model of the air conditioner, and output a predicted time of the air conditioner, where the mode of the air conditioner comprises a cooling mode and/or a heating mode; the prediction type of the air conditioner comprises a prediction of startup time and/or a prediction of shutdown time, parameters of the prediction model comprise a preset indoor temperature, a preset indoor temperature threshold value, preset indoor humidity and a preset indoor humidity threshold value, the predicted time comprises a predicted startup time and/or a predicted shutdown time; an air conditioner control module configured to control a startup or a shutdown of the air conditioner based on the predicted time.

[0020] An electronic device is further provided in some other embodiments of the present application, this electronic device may comprise a processor and a memory, the memory may store a computer-executable instruction executable by the processor, the processor is configured to execute the computer-executable instruction so as to implement the aforesaid method for controlling the air conditioner.

[0021] A computer-readable storage medium is further provided in some other embodiments of the present application. The computer-readable storage medium may store a computer-executable instruction, that, when being invoked and executed by a processor, causes the processor to implement the aforesaid method for controlling the air conditioner.

[0022] The embodiments of the present application may at least have the following beneficial effects:

According to the method and the apparatus for controlling the air conditioner and the electronic device provided by the embodiment of the present application, the mode, the prediction type, the temperature data and the humidity data of the air conditioner are input into the pre-trained prediction model of the air conditioner, the predicted time of the air conditioner is output, and the startup or the shutdown of the air conditioner is controlled based on the predicted time. In this way, the predicted startup time and the predicted shutdown time of the air conditioner are predicted through the prediction model, energy consumption of the air conditioner may be saved, an occurrence of waste of energy would not be caused, and the air conditioner has an excellent thermal adaptability.

[0023] Other features and benefits of the present application will be illustrated in the following description. Alternatively, some of the features and benefits may be deduced or unambiguously determined from the description or be obtained by implementing the above-mentioned technical solutions of the present application.

[0024] In order to make the above objective, the features and the benefits of the present application to be more obvious and more comprehensible, preferable embodiments are provided as examples below with reference to the accompanying drawings, and are described in detail below.

DESCRIPTION OF THE DRAWINGS

[0025] In order to explain the technical solution in the embodiments of the present application or in the related art, a brief introduction regarding the accompanying drawings that need to be used for describing the embodiments or the related art is given below. It is obvious that the accompanying drawings described below are only some embodiments of the present application, for the person of ordinary skill in the art, other drawings may also be obtained according to the current drawings without paying creative labor.

FIG. 1 illustrates a schematic flow diagram of one method for controlling an air conditioner according to one embodiment of the present application;

FIG. 2 illustrates a schematic flow diagram of another method for controlling an air conditioner according to one embodiment of the present application;

FIG. 3 illustrates a schematic diagram of a method for controlling an air conditioner based on a prediction of startup time according to one embodiment of the present application;

FIG. 4 illustrates a schematic diagram of a method for controlling an air conditioner based on a prediction of shutdown time according to one embodiment of the present application;

FIG. 5 illustrates a schematic diagram of a curve of startup time according to one embodiment of the present application;

FIG. 6 illustrates a schematic structural diagram of one apparatus for controlling an air conditioner according to one embodiment of the present application;

FIG. 7 illustrates a schematic structural diagram of another apparatus for controlling an air conditioner according to one embodiment of the present application;

FIG. 8 illustrates a schematic structural diagram of an electronic device according to one embodiment of the present application.

DETAILED DESCRIPTIOIN OF EMBODIMENTS

[0026] In order to make the objective, the technical solutions and the benefits of the present application be clearer, the technical solutions in the embodiments of the present application will be described clearly and comprehensively. It is apparent that, the embodiments described below are only some embodiments of the present application, instead of all of the embodiments. Based on the embodiments in the present application, other embodiments which are obtained by a person of ordinary skill in the art without paying creative labors, should all be included in the protection scope of the present application.

[0027] Currently, a method for controlling an air conditioner in a public building comprises two approaches for controlling startup and shutdown of the air conditioner, that is, manually operating by a property staff and setting a time schedule, both of the two approaches cannot adjust startup time and shutdown time according to the change of the actual load of the building, and problems of large energy consumption, problems of waste of energy and poor thermal comfort of the air conditioner are existed. In view of this, a method and an apparatus for controlling an air conditioner, and an electronic device provided in the embodiments of the present application may be applied to a startup and shutdown controller of an air conditioner having a self-learning function, and may calculate a cooling or heating temperature change rate of the air conditioner according to parameters such as indoor and outdoor temperature and humidity of the latest several days, and predict an early startup time or an early shutdown time for the air conditioner according to the temperature change rate, thereby achieving an effect of automatic optimization of the startup and shutdown of the air conditioner without human intervention.

[0028] In order to facilitate understanding of the embodiments of the present application, firstly, a method for controlling an air conditioner disclosed in the embodiments of the present application is described in detail.

[0029] A method for controlling an air conditioner is provided in one embodiment of the present application, this method is applied to a controller of the air conditioner. With reference to the flow diagram of the method for controlling the air conditioner shown in FIG. 1, the method for controlling the air conditioner may comprise the following steps:

In a step of S102, temperature data and humidity data of the air conditioner is obtained.

[0030] The temperature data in this embodiment may comprise an indoor temperature and an outdoor temperature, and the humidity data may comprise indoor humidity and outdoor humidity. The air conditioner in this embodiment may be a central air-conditioning. As an alternative, the air conditioner may also be other types of air conditioners other than the central air-conditioning. The air conditioner is taken as the central air conditioner as an example in this embodiment, and details are not repeatedly described herein. The controller of the air conditioner may be disposed in the air conditioner, and may also be disposed in a server being in communication connection with the air conditioner. Where, the server may be a cloud server, and may also be a physical server, the server is not limited in this embodiment.

[0031] The main function of the air conditioner is to ensure the temperature of the indoor environment by processing indoor cold load or heat load, and the main parameters that affect the cooling or heating rate of the air conditioner is the indoor temperature, the indoor humidity, the outdoor temperature, the outdoor humidity, flow density and heating quantities of devices. Since the flow density and the heating quantities of devices are the parameters being difficult to be obtained. Regarding a commercial office building, it can be considered that the flow density and the heating parameters of devices are fixed parameters before being on-duty or before being off-duty every day. Therefore, the indoor temperature, the indoor humidity, the outdoor temperature, and the outdoor humidity are the parameters that actually affect the cooling or heating rate of the air conditioner. The outdoor temperature and the outdoor humidity may be directly obtained from a database of the server, and the indoor temperature and the indoor humidity may be collected by a temperature sensor and a humidity sensor arranged in the air conditioner.

[0032] In a step of S104, a mode of the air conditioner, a prediction type, the temperature data and the humidity data of the air conditioner are input into a pre-trained prediction model of the air conditioner, and a predicted time of the air conditioner is output.

[0033] Where, the mode of the air conditioner in this embodiment may comprise a cooling mode and/or a heating mode, the prediction type of the air conditioner may comprise a prediction of startup time and/or a prediction of shutdown time. The parameters of the prediction model of the air conditioner may comprise: a preset indoor temperature, a preset indoor temperature threshold value, preset indoor humidity, and a preset indoor humidity threshold value. The predicted time may comprise a predicted startup time and/or a predicted shutdown time.

[0034] In this embodiment, the startup time and the shutdown time of the air conditioner may be predicted, which are respectively referred to as the predicted startup time and the predicted shutdown time. If the air conditioner is in the prediction of startup time, the predicted startup time may be output, if the air conditioner is in the prediction of shutdown

time, the predicted shutdown time may be output. In addition, when the air conditioner is in different modes, the numerical values of the parameters of the prediction model of the air conditioner may be the same or be different, the parameters of the prediction model of the air conditioner are not limited herein.

[0035] In a step of S106, the air conditioner is controlled to be started up or shut down based on the predicted time.

[0036] Thus, after the predicted time is determined, the controller may control the startup or shutdown of the air conditioner according to the predicted time. The output predicted time in this embodiment may be a specific time point, or may be a time duration.

[0037] For example, if the controller determines that the predicted startup time is a specific time point 8, the air conditioner may be controlled to be started up at the time point 8 o'clock. If the controller determines that the predicted shutdown time is 18 o'clock, the air conditioner may be controlled to be shut down at 18 o'clock.

[0038] For another example, if the controller determines that the predicted startup time is 1 hour, the air conditioner may be controlled to be started up at 8 o'clock according to the time when the employees should be on-duty and the predicted startup time, after previously determining that the time when the employees should be on-duty is 9 o'clock.

[0039] According to the method for controlling the air conditioner provided in this embodiment of the present application, the mode, the prediction type, the temperature data and the humidity data of the air conditioner are input into the pre-trained prediction model of the air conditioner to output the predicted time of the air conditioner, and the startup or the shutdown of the air conditioner is controlled based on the predicted time. In this way, the predicted startup time and the predicted shutdown time of the air conditioner are predicted through the prediction model, thus, energy consumption of the air conditioner may be saved, an occurrence of waste of energy would not be caused, and the air conditioner has an excellent thermal adaptability.

[0040] Another method for controlling an air conditioner is provided in another embodiment of the present application, this method is implemented on the basis of the aforesaid embodiment. With reference to the flow diagram of the method for controlling the air conditioner shown in FIG. 2, the method for controlling the air conditioner in this embodiment may comprise the following steps:

In a step of S202, the temperature data and the humidity data of the air conditioner is obtained.

[0041] Regarding the method for the controlling air conditioner based on the prediction of startup time and the method for the controlling air conditioner based on the prediction of shutdown time, reference can be made to schematic diagram of the method for controlling the air conditioner based on the prediction of the startup time as shown in FIG. 3 and the schematic diagram of the method for controlling the air conditioner based on the prediction of shutdown time shown in FIG. 4. In this embodiment, this embodiment is explained first by taking FIG. 3 as an example, and then is explained by taking FIG. 4 as an example, details of this embodiment will not be repeatedly described again.

[0042] As shown in FIG. 3 and FIG. 4, the temperature data and the humidity data of the air conditioner may be obtained after a time axis reaches a preset determination time. For example, a first current time is obtained, the temperature data and the humidity data of the air conditioner are obtained if the first current time reaches the preset determination time.

[0043] As shown in FIG. 3, a time module in the controller may obtain a first current time t, compare the first current time t with a preset determination time T0 in real time, and continue to wait if the first current time t is less than the preset determination time T0, or trigger an early startup control if the first current time is equal to the preset determination time T0 (i.e., the first current time reaches the preset determination time).

[0044] As shown in FIG. 4, a time module in the controller may obtain a first current time t, compare the first current time t with a preset determination time T0 in real time, and continue to wait if the first current time t is less than the preset determination time T0, or trigger an early shutdown control if the first current time is equal to the preset determination time T0 (i.e., the first current time reaches the preset determination time).

[0045] In a step of S204, the mode of the air conditioner, the prediction type, the temperature data and the humidity data of the air conditioner are input into a pre-trained prediction model of the air conditioner, and a predicted time of the air conditioner is output.

[0046] As mentioned above, for the commercial office building, it can be considered that before being on-duty or before being off-duty every day, the flow density and the heating quantities of devices are fixed parameters, and the indoor temperature, the indoor humidity, the outdoor temperature and the outdoor humidity are the remaining parameters that actually influence the cooling rate or the heating rate of the air conditioner. For a cooling scenario, it is obvious that, the higher the indoor temperature and the outdoor temperature, the greater the sensible heat load to be processed by the air conditioner, and the longer the required cooling time. The higher the indoor humidity and the outdoor humidity, the greater the latent heat load to be processed by the air conditioner, and the longer the required cooling time. The cooling scenario is in contrast to the heating scenario.

[0047] Thus, the predicted startup time of the air conditioner may be represented by the following computational formula:

$$\Delta t_{open} = f_1(T_{in}, RH_{in}, T_{out}, RH_{out}, T_{set}, RH_{set}, T_{comp}, RH_{comp}) .$$

[0048] Where, $\triangle t_{open}$ represents a predicted startup time, and $\triangle t_{open}$ is a time duration rather than a moment of time. T_{in} represents the indoor temperature, RH_{in} represents the indoor humidity, T_{out} represents the outdoor temperature, RH_{out} represents the outdoor humidity, T_{set} represents the preset indoor temperature, RH_{set} represents the preset indoor humidity, T_{comp} represents the preset indoor temperature threshold value, and RH_{comp} represents the preset indoor humidity threshold value.

[0049] Herein, it should be noted that, for the preset indoor temperature T_{set}, the cooling mode may be set to 1°C, the heating mode may be set to -1°C. The preset indoor temperature T_{set} reflects a tolerance of a person on the deviation of the indoor temperature. For the preset indoor humidity threshold value RH_{comp}, the cooling mode may be set to 10%, the heating mode may be set to -10%, and the preset indoor humidity threshold value RH_{comp} reflects the tolerance of the person on the deviation of the indoor humidity.

[0050] The aforesaid function may be expressed as the form of a variety of equations. Considering that the computing power of a controller chip is limited, a form of multivariate linear equation: that is, if the prediction type of the air conditioner is the prediction of startup time, the predicted startup time of the air conditioner is determined by the following computational formula.

$$\Delta t_{open} = c_1 \cdot (T_{in} - T_{set} - T_{comp}) + c_2 \cdot (T_{out} - T_{set} - T_{comp}) + c_3 \cdot (RH_{in} - RH_{set} - RH_{comp}) + c_4 (RH_{out} - RH_{set} - RH_{comp})$$

;

[0051] C_1-C_4 in the above computational formula is a preset coefficient for the prediction of startup time, and may be preset in the controller:

Early shutdown of the air conditioner is a reverse process of early startup of the air conditioner. The air conditioner is shut down in advance by utilizing the indoor tolerable temperature deviation and humidity deviation, the indoor temperature is maintained to off-duty time by utilizing cold storage or heat storage of the building. Thus, the energy consumption of the air conditioner is conserved, the early shutdown time of the air conditioner may be represented by the following computational formula expressed below:

$$\Delta t_{close} = f_2(T_{in}, RH_{in}, T_{out}, RH_{out}, T_{set}, RH_{set}, T_{comp}, RH_{comp}) .$$

[0052] In the above formula, $\triangle t_{close}$ represents a predicted early shutdown time of the air conditioner, and $\triangle t_{close}$ is a time duration rather than a moment of time. Other parameters are the same as the parameters described above:

The aforesaid function is also expanded into the form of multivariate linear equation: that is, in response to the prediction type of the air conditioner is the prediction of shutdown time, the predicted shutdown time of the air conditioner is determined through the following computational formula which is expressed as:

$$\Delta t_{close} = d_1 \cdot (T_{in} - T_{set} - T_{comp}) + d_2 \cdot (T_{out} - T_{set} - T_{comp}) + d_3 \cdot (RH_{in} - RH_{set} - RH_{comp}) + d_4 \cdot (RH_{out} - RH_{set} - RH_{comp})$$

;

[0053] Where, $\triangle t_{close}$ represents the predicted shutdown time, d_1-d_4 represents the preset coefficients of prediction of shutdown time that can be preset in the controller.

[0054] As shown in FIG. 3, the early startup time is calculated, and the controller may collect and record the indoor temperature and humidity and the outdoor temperature and humidity at the current time, and calculate the early startup time $\triangle t_{open}$ according to early startup time prediction equation. However, there exists an upper limit value and a lower limit value for the early startup time, that is, the air conditioner cannot be started up too early or too late. Therefore, if the predicted time is greater than an upper limit value of the preset startup time or the preset shutdown time, the upper limit value is used as the predicted time. If the predicted time is less than the lower limit value of the startup time or the shutdown time, the lower limit value is taken as the predicted time.

[0055] Taking the predicted time as time duration as an example, taking the startup as an example, if the predicted startup time is 1 hour, however, the lower limit value of the startup time is 30 minutes, the predicted time is less than the lower limit value of the startup time, so that the lower limit value can be used as the predicted time.

[0056] The condition of shutdown is similar to the condition of startup, as shown in FIG. 4, the early shutdown time is calculated, the controller collects and records indoor temperature and humidity and outdoor temperature and humidity at the current time, and calculates the early startup time $\triangle t_{close}$ according to the early startup time prediction equation. If $\triangle t_{close}$ exceeds an upper limit value $\triangle t_{max}$ of the shutdown time, $\triangle t_{close} = \triangle t_{max}$; if $\triangle t_{close}$ is less than the lower limit value $\triangle t_{min}$ of the shutdown time, $\triangle t_{close} = \triangle t_{min}$.

[0057] In a step of S206, the air conditioner is controlled to be started up or shut down based on the predicted time.

[0058] Taking the predicted time as the time duration as an example. As shown in FIG. 3 and FIG. 4, when the controller controls the startup or shutdown of the air conditioner, the controller may first perform a step of determining whether the air conditioner is started up, such as obtaining a second current time; and calculating a time difference between the second current time and a preset on-duty time or a preset off-duty time, controlling the air conditioner to be started up or shut down if the time difference is less than or equal to the predicted startup time or the predicted shutdown time.

[0059] As shown in FIG. 3, whether the air conditioner is started up is determined. The controller calculates a time difference $\triangle t$ between the second current time t and the on-duty time t_{on} in real time after the predicted startup time is obtained, and compares the time difference Δt with the predicted startup time $\triangle t_{open}$. If a condition of $\Delta t > \triangle t_{open}$ is met, it indicates that the startup time is not reached currently, and the controller continues to wait; if a condition of $\Delta t \leq \triangle t_{open}$ is met, it indicates that the startup time is reached, the controller sends a startup instruction to the air conditioner, so that the air conditioner starts to be operated.

[0060] As shown in FIG. 4, whether the air conditioner is started up is determined. When the predicted shutdown time Δt_{close} is obtained, the controller calculates a time difference Δt between the second current time t and an off-duty time t_{off} in real time, and compares the time difference Δt with the $\triangle t_{close}$. If a condition of $\Delta t > \triangle t_{close}$ is met, it indicates that the startup time is not reached currently, and the controller continues to wait; If a condition of $\Delta t \leq \triangle t_{close}$ is met, it indicates that the shutdown time is reached, the controller sends a shutdown instruction to the air conditioner, and the air conditioner stops operation.

[0061] In a step of S208, a temperature reaching time of the air conditioner is determined.

[0062] How the controller controls the startup and shutdown of the air conditioner has been described in the above steps. However, the prediction model in the air conditioner may be self-learned, and the parameters thereof may be adjusted. That is, the coefficients in the startup time prediction equation and the shutdown time prediction equation of the air conditioner is not fixed. As shown in FIG. 3 and FIG. 4, whether the parameter needs to be adjusted needs to be determined first, then, the parameters are adjusted. The temperature reaching time may be determined through the following steps: the step of determining the temperature reaching time of the air conditioner comprises:

the startup time of the air conditioner is determined, if the prediction type of the air conditioner is the prediction of startup time; a third current time is obtained, if the indoor temperature is greater than or equal to the summation of the preset indoor temperature and the preset indoor temperature threshold value; the difference value between the third current time and the startup time is used as the temperature reaching time.

[0063] As shown in FIG. 3, the temperature reaching time is calculated. The controller may collect the indoor temperature in real time, determine whether the indoor temperature is greater than or equal to the summation of the preset indoor temperature and the preset indoor temperature threshold value, the indoor temperature Tin=preset indoor temperature T_{set}+the preset indoor temperature threshold value T_{comp}. If the indoor temperature is greater than or equal to the summation of the preset indoor temperature and the preset indoor temperature threshold value, a third current time t_2 is recorded, the temperature reaching time $\triangle_{tr}$=the third current time t_2-the startup time t_1. Otherwise, the controller continues to wait.

[0064] The shutdown time of the air conditioner is determined in response to the prediction type of the air conditioner is the prediction of shutdown time. If the indoor temperature is less than or equal to the summation of the preset indoor temperature and the preset indoor temperature threshold value, a fourth current time is obtained; and a difference value between the fourth current time and the shutdown time is used as the temperature reaching time.

[0065] According to the temperature reaching time as shown in FIG. 4, the controller may collect the indoor temperature in real time, determine whether the indoor temperature is less than or equal to the summation of the preset indoor temperature and the preset indoor temperature threshold value. The indoor temperature T_{in}=preset indoor temperature T_{set}+the preset indoor temperature threshold value T_{comp}. If the indoor temperature is less than or equal to the summation of the preset indoor temperature and the preset indoor temperature threshold value, the third current time t_2 is recorded, the temperature reaching time $\triangle_{tr}$=the third current time t_2-off-duty time t_1. Otherwise, the controller continues to wait.

[0066] In a step of S210, the parameters of the prediction model are adjusted based on the temperature reaching time.

[0067] If a time deviation between the temperature reaching time and the predicted startup time or the predicted shutdown time is great, the parameters of the prediction model may be adjusted. For example, a first absolute value of a difference value between the temperature reaching time and the predicted startup time is determined if the prediction type of the air conditioner is the prediction of startup time; the parameters of the prediction model are adjusted if the first absolute value is greater than a preset first error threshold value. As an alternative, a second absolute value of a difference between the temperature reaching time and the predicted shutdown time is determined in response to the prediction type of the air conditioner is the prediction of shutdown time; the parameters of the prediction model is adjusted in response to the second absolute value is greater than a preset second error threshold value.

[0068] The first error threshold value and the second error threshold value may be the same or be different. The first error threshold value and the second error threshold value are not limited in this embodiment.

[0069] The coefficient of the prediction equation is self-learned and updated as shown in FIG. 3. An error between the temperature reaching time $\triangle t_r$ and the predicted startup time $\triangle t_{open}$ is compared. If $|\triangle t_r - \triangle t_{open}| \leq$the first error threshold

value, the coefficient of the prediction equation is not updated. If $|\triangle t_r - \triangle t_{open}|$ >the first error threshold value, the coefficient of the prediction equation is updated according to the historical indoor temperature and humidity, in combination with the outdoor temperature and humidity and the actual temperature reaching time.

[0070] The coefficient of the prediction equation is self-learned and updated as shown in FIG. 4. An error between the temperature reaching time $\triangle t_r$ and the predicted shutdown time $\triangle t_{close}$ is compared. If $|\triangle t_r - \triangle t_{close}| \leq$the second error threshold value, the coefficient of the prediction equation is not updated. If $|\triangle t_r - \triangle t_{close}|$ >the second error threshold value, the coefficient of the prediction equation is updated according to the historical indoor temperature and humidity, in combination with the outdoor temperature and humidity and the actual temperature reaching time.

[0071] When performing the step of adjusting the parameters of the prediction model, parameter adjustment may be performed according to the historical temperature data and the historical humidity data of the air conditioner. For example, the historical temperature data and the historical humidity data of the air conditioner within a preset time range are obtained; and the parameters of the prediction model are obtained based on the historical temperature data and the historical humidity data.

[0072] The parameters of the prediction model in the controller are not fixed because that the building load changes with the change of the outdoor meteorological parameter. Thus, the parameters of the prediction model should also be self-learned and adjusted over time, thereby adapting to the change of the load and ensuring the accuracy of the predicted time. Taking the early startup of the air conditioner as an example, the parameters of the prediction model need to be updated, and four simultaneous equations can be established for solution. Thus, the controller needs to record at least the indoor temperature and humidity values and the outdoor temperature and humidity values in four consecutive days, and perform adaptive updating on the four coefficients every day, updating of the coefficient of the equation of the prediction of startup time is expressed as follows:

$$\begin{cases} \Delta t_{r,k} = d_1 \cdot (T_{in,k} - T_{set} - T_{comp}) + d_2 \cdot (T_{out,k} - T_{set} - T_{comp}) + d_3 \cdot (RH_{in,k} - RH_{set} - RH_{comp}) + d_4 \cdot (RH_{out,k} - RH_{set} - RH_{comp}) \\ \Delta t_{r,k-1} = d_1 \cdot (T_{in,k-1} - T_{set} - T_{comp}) + d_2 \cdot (T_{out,k-1} - T_{set} - T_{comp}) + d_3 \cdot (RH_{in,k-1} - RH_{set} - RH_{comp}) + d_4 \cdot (RH_{out,k-1} - RH_{set} - RH_{comp}) \\ \Delta t_{r,k-2} = d_1 \cdot (T_{in,k-2} - T_{set} - T_{comp}) + d_2 \cdot (T_{out,k-2} - T_{set} - T_{comp}) + d_3 \cdot (RH_{in,k-2} - RH_{set} - RH_{comp}) + d_4 \cdot (RH_{out,k-2} - RH_{set} - RH_{comp}) \\ \Delta t_{r,k-3} = d_1 \cdot (T_{in,k-3} - T_{set} - T_{comp}) + d_2 \cdot (T_{out,k-3} - T_{set} - T_{comp}) + d_3 \cdot (RH_{in,k-3} - RH_{set} - RH_{comp}) + d_4 \cdot (RH_{out,k-3} - RH_{set} - RH_{comp}) \end{cases}$$

.

[0073] In the above equation, $\triangle_{tr}$ represents the actual temperature reaching time of the air conditioner (i.e., the time when the indoor temperature reaches $T_{set}+T_{comp}$), the subscript k represents today, k-1 represents yesterday, k-2 represents a day before yesterday, and k-3 represents three days ago. The controller implements the self-learning and updating of the coefficient of the prediction equation by collecting the indoor temperature and humidity values, the outdoor temperature and humidity values, and the temperature reaching time of the air conditioner in four consecutive days.

[0074] In addition, it should be noted that the controller of the air conditioner may be disposed in the air conditioner. As an alternative, the controller of the air conditioner may be disposed in a server being in communication connection with the air conditioner. The controller of the air conditioner may be composed of a time module, a signal collection module, a memory module, and a prediction module. Where, the time module may be configured to collect the current time. In order to ensure the accuracy of time, time may be automatically synchronized each time when the time module performs network connection with a principle computer. The signal collection module may be configured to collect indoor temperature and humidity and indoor temperature and humidity parameters. The memory module may be configured to record indoor temperature and humidity, indoor temperature and humidity parameters in consecutive few days at a preset determination moment, and some preset parameters of the controller, such as a cooling target temperature, a heating target temperature, a preset temperature threshold value, an on-duty time, an off-duty time, a preset determination time, an earliest startup time, a latest startup time, a time error threshold value, etc. The prediction module may be configured to calculate a predicted startup time or a predicted shutdown time according to a pre-programmed startup and shutdown time prediction equation based on temperature and humidity parameters transmitted from the collection module.

[0075] In addition, regarding the result of the method for controlling the air conditioner provided in this embodiment, reference can be made to the schematic diagram of the curve of the startup time shown in FIG. 5. FIG. 5 illustrates a startup time of the method for controlling the air conditioner provided in this embodiment used by a combined air conditioner in one building, a curve 1 is the actual pre-cooling time, and a curve 2 is a predicted pre-cooling time. It can be seen from FIG. 5 that the coefficient of the prediction equation is optimized by self-learning, and there is little error between the predicted cooling time and the actual pre-cooling time, which indicates that the energy consumption of the combined air conditioner can be reduced in maximum while the indoor temperature is effectively ensured.

[0076] In conclusion, a method for predicting an optimized startup and shutdown time of the air conditioner in different modes according to indoor and outdoor temperatures, humidity, and preset temperature in the room in the consecutive

few days are provided in the embodiments of the present application. Thus, the indoor temperature at the on-duty time or the off-duty time does not exceed a preset threshold range, and energy consumption of the air conditioner may be furthest saved. In this method, the prediction model of the air conditioner can self-learn adjustment parameters with the change of the building load, thereby ensuring the accuracy of the predicted time. One embodiment of the present application further provides a controller having an air conditioner startup and shutdown time prediction function. The controller is composed of the time module, the signal acquisition module, the memory module and the prediction module, not only a personnel operation is unnecessary, it does not need to access a BMS group control system, either. Thus, a local optimization startup and shutdown control of the air conditioner can be realized. Certainly, it is also possible that the controller is not disposed in the air conditioner, this function may be implemented by writing an optimization control algorithm into the principle computer or a cloud platform.

[0077] According to the method provided in the embodiments of the present application, the early startup or shutdown time of the air conditioner in the cooling/heating scenario may be predicted according to the indoor and outdoor air temperature and humidity parameters, such that the indoor temperature at on-duty time is just within the preset temperature range, and the air conditioner is shut down before the off-duty time, large fluctuation of the temperature is not caused, so that the energy consumption during the operation of the air conditioner is furthest reduced. Moreover, the prediction model may self-learn adjustment parameters with the change of the building load, thereby ensuring the accuracy of the predicted time. The calculation of prediction is absolutely completed by a local controller, without the assistance of the principle computer or the cloud platform. It is convenient to operate and use this method, and investment cost is saved.

[0078] Corresponding to the aforesaid method embodiments, another embodiment of the present application provides an apparatus for controlling air conditioner, which is applied to a controller of the air conditioner. Referring to a schematic structural diagram of the apparatus for controlling the air conditioner shown in FIG. 6, the apparatus for controlling the air conditioner may comprise:

a data acquisition module 61 configured to obtain temperature data and humidity data of the air conditioner, where the temperature data comprises an indoor temperature and an outdoor temperature, the humidity data comprises indoor humidity and outdoor humidity;

a time prediction module 62 configured to input a mode of the air conditioner, a prediction type of the air conditioner, the temperature data and the humidity data into a pre-trained prediction model of the air conditioner, and output a predicted time of the air conditioner; where the mode of the air conditioner comprises a cooling mode and/or a heating mode; the prediction type of the air conditioner comprises a prediction of startup time and/or a prediction of shutdown time; parameters of the prediction model comprise a preset indoor temperature, a preset indoor temperature threshold value, preset indoor humidity and a preset indoor humidity threshold value; the predicted time comprises a predicted startup time and/or a predicted shutdown time;

an air conditioner control module 63 configured to control a startup or a shutdown of the air conditioner based on the predicted time.

[0079] According to the apparatus for controlling the air conditioner provided by the embodiment of the present application, the mode, the prediction type, the temperature data and the humidity data of the air conditioner may be input into the pre-trained prediction model of the air conditioner, the predicted time of the air conditioner is output, and the startup or the shutdown of the air conditioner is controlled based on the predicted time. In this way, the predicted startup time and the predicted shutdown time of the air conditioner are predicted through the prediction model, so that the energy consumption of the air conditioner may be saved, occurrence of waste of energy would not be caused, and the air conditioner has an excellent thermal adaptability.

[0080] The data acquisition module may be configured to obtain a first current time, and obtain temperature data and humidity data of the air conditioner, in response to the first current time reaches a preset determination time.

[0081] The time prediction module may be configured to determine, if the prediction type of the air conditioner is the prediction of startup time, the predicted startup time of the air conditioner by a following computational formula which is expressed as:

$$\Delta t_{open} = c_1 \cdot (T_{in} - T_{set} - T_{comp}) + c_2 \cdot (T_{out} - T_{set} - T_{comp}) + c_3 \cdot (RH_{in} - RH_{set} - RH_{comp}) + c_4 (RH_{out} - RH_{set} - RH_{comp}) ;$$

where, $\triangle t_{open}$ represents the predicted startup time, c_1-c_4 represents a preset coefficient for the prediction of startup time, T_{in} represents the indoor temperature, RH_{in} represents the indoor humidity, Tout represents the outdoor temperature, RH_{out} represents the outdoor humidity, T_{set} represents the preset indoor temperature, RH_{set} represents the preset indoor humidity, T_{comp} represents the preset indoor temperature threshold value, RH_{comp} represents the preset indoor humidity threshold value.

[0082] The time prediction module is further configured to determine, in response to the prediction type of the air conditioner is the prediction of shutdown time, the predicted shutdown time of the air conditioner by the following computational formula which is expressed as:

$$\Delta t_{close} = d_1 \cdot (T_{in} - T_{set} - T_{comp}) + d_2 \cdot (T_{out} - T_{set} - T_{comp}) + d_3 \cdot (RH_{in} - RH_{set} - RH_{comp}) + d_4 \cdot (RH_{out} - RH_{set} - RH_{comp})$$

; where, $\triangle t_{close}$ represents the predicted shutdown time, and d_1-d_4 represents predetermined coefficients for the prediction of shutdown time.

[0083] The time prediction module may further be configured to use an upper limit value as the predicted time if the predicted time is greater than the preset upper limit value of the startup time or the shutdown time, and use a lower limit value as the predicted time if the predicted time is less than the lower limit value of the startup time or the shutdown time.

[0084] The air conditioner control module may be configured to obtain a second current time; and calculate a time difference between the second current time and a preset on-duty time or an off-duty time, and control the air conditioner to be started up or shut down if the time difference is less than or equal to the predicted startup time or the predicted shutdown time.

[0085] Referring to another structural schematic diagram of another apparatus for controlling an air conditioner shown in FIG. 7, the apparatus for controlling the air conditioner may further comprise: a model updating module 64 which may be connected to the air conditioner control module 63. The model updating module 64 may be configured to determine a temperature reaching time of the air conditioner, and adjust parameters of the prediction model based on the temperature reaching time.

[0086] The model updating module may be configured to: determine a startup time of the air conditioner in response to the predicted type of the air conditioner is the prediction of startup time; obtain a third current time if the indoor temperature is greater than or equal to a summation of the preset indoor temperature and the preset indoor temperature threshold value; and use a difference value between the third current time and the startup time as the temperature reaching time; or determine the shutdown time of the air conditioner in response to the prediction type of the air conditioner is the prediction of shutdown time, obtain a fourth current time in response to the indoor temperature is less than or equal to a summation of the preset indoor temperature and the preset indoor temperature threshold value, and use a difference value between the fourth current time and the shutdown time as the temperature reaching time.

[0087] The model updating module may be configured to: determine a first absolute value of a difference value between the temperature reaching time and the predicted startup time if the prediction type of the air conditioner is the prediction of startup time, and adjust the parameters of the prediction model if the first absolute value is greater than a preset first error threshold value; or determine a second absolute value of a difference between the temperature reaching time and the predicted shutdown time in response to the prediction type of the air conditioner is the prediction of shutdown time, and adjust the parameters of the prediction model in response to the second absolute value is greater than a preset second error threshold value.

[0088] The model updating module may be configured to obtain historical temperature data and historical humidity data of the air conditioner within a preset time range; and adjust the parameters of the prediction model based on the historical temperature data and the historical humidity data.

[0089] The controller of the air conditioner may be arranged in the air conditioner. As an alternative, the controller of the air conditioner may be arranged in a server being in communication connection with the air conditioner.

[0090] A person skilled in the art may clearly understand that, for the convenience and brevity of illustration, regarding the specific operating process of the apparatus for controlling the air conditioner described above, reference can be made to the corresponding process in the above-described embodiments of the method for controlling the air conditioner, details of the specific operating process are not repeatedly described herein.

[0091] An electronic device for operating the aforesaid method for controlling the air conditioner is provided in another embodiment of the present application. With reference to the schematic structural diagram of an electronic device shown in FIG. 8, the electronic device may comprise a memory 100 and a processor 101, where the memory 100 may be configured to store one or a plurality of computer instruction(s), and the one or plurality of computer instruction(s) is/are configured to be executed by the processor 101 so as to implement the method for controlling the air conditioner.

[0092] Optionally, the electronic device shown in FIG. 8 may further comprise a bus 102 and a communication interface 103. The processor 101, the communication interface 103, and the memory 100 may be connected through the bus 102.

[0093] The memory 100 may comprise a high-speed random access memory (RAM), or, the memory 100 may further comprise a non-volatile memory, for example, at least one disk memory. Communication connection between a system network element and at least one other network element may be implemented through the at least one communication interface 103 (which may be wired or wireless). Internet, a wide area network, a local area network, a metropolitan area network (MAN), etc. may be used. The bus 102 may be an ISA bus, a PCI bus, an EISA bus, or the like. The bus may be divided into an address bus, a data bus, a control bus, etc. For the convenience of representation, only one bidirectional

arrow is used to represent the bus in FIG. 8, however, this bidirectional arrow does not mean that there is only one bus or one type of bus.

[0094] The processor 101 may be an integrated circuit chip having signal processing capabilities. During an implementation process, the various steps of the aforesaid method may be completed through the integrated logic circuit in hardware form or the software instructions in software form in the processor 101. The aforesaid processor 101 may be a general-purpose processor which comprises a central processing unit (CPU), a network processor (NP), etc. The processor 101 may also be a digital signal processor (DSP), an application specific integrated circuit (ASIC), a field programmable gate array (FPGA), or other programmable logic devices, discrete gates or transistor logic devices, or discrete hardware components. The methods, steps, and logical block diagrams disclosed in the embodiments of the present application may be implemented or executed. The general-purpose processor may be a microprocessor or any conventional processor. The steps of the method disclosed in the embodiment of the present application may be directly executed and completed by a processor for hardware decoding, or by the combination of hardware and software modules in the processor for hardware decoding. Software modules may be located in a conventional storage medium in this field, such as random access memory (RAM), flash memory, read-only memory (ROM), programmable read-only memory (PROM), or electrically erasable programmable read-only memory (EEPROM), registers, etc. The storage medium may be located in the memory 100. The processor 101 may read information in the memory 100, and complete the steps of the method in the embodiments described above in combination with hardware thereof.

[0095] A computer-readable storage medium is further provided in the embodiments of the present application. The computer-readable storage medium may store a computer executable instruction. When the computer-executable instruction is invoked and executed by the processor, the computer executable instructions may cause the processor to implement the aforesaid method for controlling the air conditioner. Regarding the specific implementation of the method for controlling the air conditioner, reference can be made to the method embodiments, the implementation of the method for controlling the air conditioner is not be repeatedly described herein.

[0096] A computer program product of the method and the apparatus for controlling the air conditioner, and the electronic device provided in the embodiments of the present application may comprise a computer-readable storage medium that stores program codes. The program codes comprise instructions that may be used for executing the method in the aforesaid method embodiment. Regarding the specific implementation of the method in the method embodiment, reference can be made to the method embodiment, the method is not repeatedly described herein.

[0097] The person of ordinary skill in the art may understand clearly that, for the convenience of illustration and conciseness, regarding the detailed operating process of the system and/or the apparatus, reference may be made to the corresponding process in the previously described method embodiment, the detailed operating process of the system and/or the apparatus is not repeatedly described herein.

[0098] In the present application, terms such as "mount", "connect with each other", "connect" should be generalizedly interpreted, unless there is additional explicit stipulation and limitation. For example, "connect" may be interpreted as being fixedly connected, detachably connected, or connected integrally; "connect" may also be interpreted as being mechanically connected or electrically connected; "connect" may be further interpreted as being directly connected or indirectly connected through intermediary, or being internal communication between two components or an interaction relationship between the two components. For the person of ordinary skill in the art, the specific meanings of the aforementioned terms in the present application may be interpreted according to specific conditions.

[0099] When the integrated unit is implemented in the form of a software functional unit and sold or used as an independent product, the integrated unit may be stored in a computer readable storage medium. Based on such understanding, the technical solutions of the present application essentially, or the part contributing to the prior art, or all or a part of the technical solutions may be implemented in the form of a software product. The software product is stored in a storage medium and comprises a plurality of instructions for instructing a computer device (which may be a personal computer, a server, a network device, etc.) to perform all or some of the steps of the methods described in the embodiments of the present application. The aforesaid storage medium comprises: any medium that can store program code, such as a USB flash drive, a removable hard disk, a read-only memory (ROM), a random access memory (RAM), a magnetic disk, or an optical disc.

[0100] In the description of the present application, it needs to be noted that, directions or location relationships indicated by terms comprising "center", "up", "down", "left", "right", "vertical", "horizontal", "inside", "outside" are the directions or location relationships shown in the accompanying figures, which are only intended to describe the present application conveniently and simplify the description, but not to indicate or imply that an indicated device or component must have specific locations or be constructed and manipulated according to specific locations. Thus, these terms shouldn't be considered as any limitation to the present application. In addition, terms of "the first", "the second" and "the third" are only used for description purposes, and thus should not be considered as indicating or implying any relative importance.

[0101] In conclusion, it should be noted that the aforesaid embodiments are only specific embodiments of the present application, and are used to illustrate the technical solutions of the present application, rather than limiting the technical

solutions of the present application. The protection scope of the present application is not limited thereto. Although the present application has been described in detail with reference to the aforesaid embodiments, the person of ordinary skill in the art should understand that any person familiar with this technical field can still modify the technical solutions recited in the aforesaid embodiments or is conceivable of changes within the technical scope disclosed in the present application, or equivalently replace some of the technical features. However, these modifications, changes or substitutions do not make the essence of the corresponding technical solution to be deviated from the spirits and the scopes of the technical solutions in the embodiments of the present application, and should all be comprised in the protection scope of the present application. Therefore, the protection scope of the present application shall be determined by the protection scope of the claims.

Industrial applicability

[0102] A method and an apparatus for controlling an air conditioner, and electronic device are provided in the present application. This method is applied to a controller of the air conditioner and comprises: obtaining temperature data and humidity data of the air conditioner; inputting a mode, a prediction type, temperature data and humidity data of the air conditioner into a pre-trained prediction model of the air conditioner, and outputting a predicted time of the air conditioner; and controlling a startup or a shutdown of the air conditioner based on the predicted time. In this method, the mode, the prediction type, the temperature data and the humidity data of the air conditioner are input into the pre-trained prediction model of the air conditioner, the predicted time of the air conditioner is output, and the startup or the shutdown of the air conditioner is controlled based on the predicted time. According to this method, the predicted startup time and the predicted shutdown time of the air conditioner are predicted through the prediction model, an energy consumption of the air conditioner may be saved, an occurrence of waste of energy would not be caused, and the air conditioner has an excellent thermal adaptability.

[0103] In addition, it should be understood that the method and the apparatus for controlling the air conditioner and electronic device in the present application may be reproducible, and may be applied in various industrial applications. For example, the method for controlling the air conditioner in the present application may be applied to the field of air conditioners.

Claims

1. A method for controlling an air conditioner, wherein the method being for a controller of the air conditioner, the method comprises:

   obtaining temperature data and humidity data of the air conditioner, wherein the temperature data comprises an indoor temperature and an outdoor temperature, the humidity data comprises indoor humidity and outdoor humidity;
   inputting a mode of the air conditioner, a prediction type of the air conditioner, the temperature data and the humidity data into a pre-trained prediction model of the air conditioner, and outputting a predicted time of the air conditioner; wherein the mode of the air conditioner comprises a cooling mode and/or a heating mode; the prediction type of the air conditioner comprises a prediction of startup time and/or a prediction of shutdown time; parameters of the prediction model comprise a preset indoor temperature, a preset indoor temperature threshold value, preset indoor humidity and a preset indoor humidity threshold value; the predicted time comprises a predicted startup time and/or a predicted shutdown time; and
   controlling a startup or a shutdown of the air conditioner based on the predicted time.

2. The method for controlling the air conditioner according to claim 1, wherein the step of obtaining the temperature data and the humidity data of the air conditioner comprises:

   obtaining a first current time; and
   obtaining the temperature data and the humidity data of the air conditioner, in response to the first current time reaches a preset determination time.

3. The method for controlling the air conditioner according to claim 1 or 2, further comprising: determining, in response to the prediction type of the air conditioner is the prediction of startup time, the predicted startup time of the air conditioner by a computational formula which is expressed as:

$$\Delta t_{open} = c_1 \cdot (T_{in} - T_{set} - T_{comp}) + c_2 \cdot (T_{out} - T_{set} - T_{comp}) + c_3 \cdot (RH_{in} - RH_{set} - RH_{comp}) + c_4 (RH_{out} - RH_{set} - RH_{comp})$$

;

wherein, $\triangle t_{open}$ represents the predicted startup time, c_1 to c_4 represents preset coefficients for the prediction of startup time, T_{in} represents the indoor temperature, RH_{in} represents the indoor humidity, T_{out} represents the outdoor temperature, RH_{out} represents the outdoor humidity, T_{set} represents the preset indoor temperature, RH_{set} represents the preset indoor humidity, T_{comp} represents the preset indoor temperature threshold value, and RH_{comp} represents the preset indoor humidity threshold value;

determining, in response to the prediction type of the air conditioner is the prediction of shutdown time, the predicted shutdown time of the air conditioner by a computational formula which is expressed as:

$$\Delta t_{close} = d_1 \cdot (T_{in} - T_{set} - T_{comp}) + d_2 \cdot (T_{out} - T_{set} - T_{comp}) + d_3 \cdot (RH_{in} - RH_{set} - RH_{comp}) + d_4 \cdot (RH_{out} - RH_{set} - RH_{comp})$$

;

wherein, Δt_{close} represents the predicted shutdown time, d_1 to d_4 represents predetermined coefficients for the prediction of shutdown time.

4. The method for controlling the air conditioner according to any one of claims 1 to 3, wherein after the step of outputting the predicted time of the air conditioner, the method for controlling the air conditioner further comprises:

using, in response to the predicted time is greater than a preset upper limit value of the startup time or the shutdown time, the upper limit value as the predicted time; or

using, in response to the predicted time is less than a lower limit value of a startup time or a shutdown time, the lower limit value as the predicted time.

5. The method for controlling the air conditioner according to any one of claims 1 to 4, wherein the step of controlling the startup or the shutdown of the air conditioner based on the predicted time comprises:

obtaining a second current time; and

calculating a time difference between the second current time and a preset on-duty time or a preset off-duty time, and controlling the air conditioner to be powered on or powered off, in response to the time difference is smaller than or equal to the predicted startup time or the predicted shutdown time.

6. The method for controlling the air conditioner according to claim 5, further comprising:
after obtaining the predicted startup time $\triangle t_{open}$, calculating the time difference Δt between the second current time and the on-duty time in real time and comparing the time difference Δt with the predicted startup time $\triangle t_{open}$; continuing to wait if a condition of $\triangle t > \triangle t_{open}$ is met; or, sending a startup instruction to the air conditioner such that the air conditioner starts operation if a condition of $\triangle t \leq \triangle t_{open}$ is met.

7. The method for controlling the air conditioner according to claim 5, further comprising:
after obtaining the predicted shutdown time $\triangle t_{close}$, calculating the time difference Δt between the second current time and the off-duty time in real time and comparing the time difference Δt with the predicted shutdown time $\triangle t_{close}$; continuing to wait if a condition of $\triangle t > \triangle t_{close}$ is met; or, sending a shutdown instruction to the air conditioner such that the air conditioner stops operation if a condition of $\triangle t \leq \triangle t_{close}$ is met.

8. The method for controlling the air conditioner according to any one of claims 1 to 7, wherein after the step of controlling the startup or the shutdown of the air conditioner based on the predicted time, the method for controlling the air conditioner further comprises:

determining a temperature reaching time of the air conditioner; and

adjusting the parameters of the prediction model based on the temperature reaching time.

9. The method for controlling the air conditioner according to claim 8, wherein the step of determining the temperature reaching time of the air conditioner comprises:

determining a startup time of the air conditioner in response to the predicted type of the air conditioner is the

prediction of startup time; obtaining a third current time in response to the indoor temperature is greater than or equal to a summation of the preset indoor temperature and the preset indoor temperature threshold value; and taking a difference value between the third current time and the startup time as the temperature reaching time; or, determining a shutdown time of the air conditioner in response to the prediction type of the air conditioner is the prediction of shutdown time; obtaining a fourth current time in response to the indoor temperature is less than or equal to the summation of the preset indoor temperature and the preset indoor temperature threshold value; and taking a difference value between the fourth current time and the shutdown time as the temperature reaching time.

10. The method for controlling the air conditioner according to claim 8 or 9, wherein the step of adjusting the parameters of the prediction model based on the temperature reaching time comprises:

determining a first absolute value of a difference value between the temperature reaching time and the predicted startup time if the prediction type of the air conditioner is the prediction of startup time, and adjusting the parameters of the prediction model if the first absolute value is greater than a preset first error threshold value; or, determining a second absolute value of a difference between the temperature reaching time and the predicted shutdown time in response to the prediction type of the air conditioner is the prediction of shutdown time; and adjusting the parameters of the prediction model in response to the second absolute value is greater than a preset second error threshold value.

11. The method for controlling the air conditioner according to claim 8 or 9, wherein the step of adjusting the parameters of the prediction model based on the temperature reaching time comprises:

obtaining historical temperature data and historical humidity data of the air conditioner within a preset time range; and
adjusting the parameters of the prediction model based on the historical temperature data and the historical humidity data.

12. The method for controlling the air conditioner according to any one of claims 1 to 11, wherein the controller of the air conditioner is arranged in the air conditioner; or, the controller of the air conditioner is arranged in a server being in communication connection with the air conditioner.

13. An apparatus for controlling an air conditioner, **characterized in that**, the apparatus for controlling the air conditioner is for a controller of the air conditioner, and comprises:

a data acquisition module configured to obtain temperature data and humidity data of the air conditioner, wherein the temperature data comprises an indoor temperature and an outdoor temperature, the humidity data comprises indoor humidity and outdoor humidity;
a time prediction module configured to input a mode of the air conditioner, a prediction type of the air conditioner, the temperature data and the humidity data into a pre-trained prediction model of the air conditioner, and output a predicted time of the air conditioner; wherein the mode of the air conditioner comprises a cooling mode and/or a heating mode; the prediction type of the air conditioner comprises a prediction of startup time and/or a prediction of shutdown time; parameters of the prediction model comprise a preset indoor temperature, a preset indoor temperature threshold value, preset indoor humidity and a preset indoor humidity threshold value; the predicted time comprises a predicted startup time and/or a predicted shutdown time;
an air conditioner control module configured to control a startup or a shutdown of the air conditioner based on the predicted time.

14. An electronic device, **characterized in that**, the electronic device comprises a processor and a memory, the memory stores a computer-executable instruction executable by the processor, the processor is configured to execute the computer-executable instruction so as to implement a method for controlling the air conditioner according to any one of claims 1 to 12.

15. A computer-readable storage medium, **characterized in that**, the computer-readable storage medium stores a computer-executable instruction, that, when being invoked and executed by a processor, causes the processor to implement a method for controlling the air conditioner according to any one of claims 1 to 12.

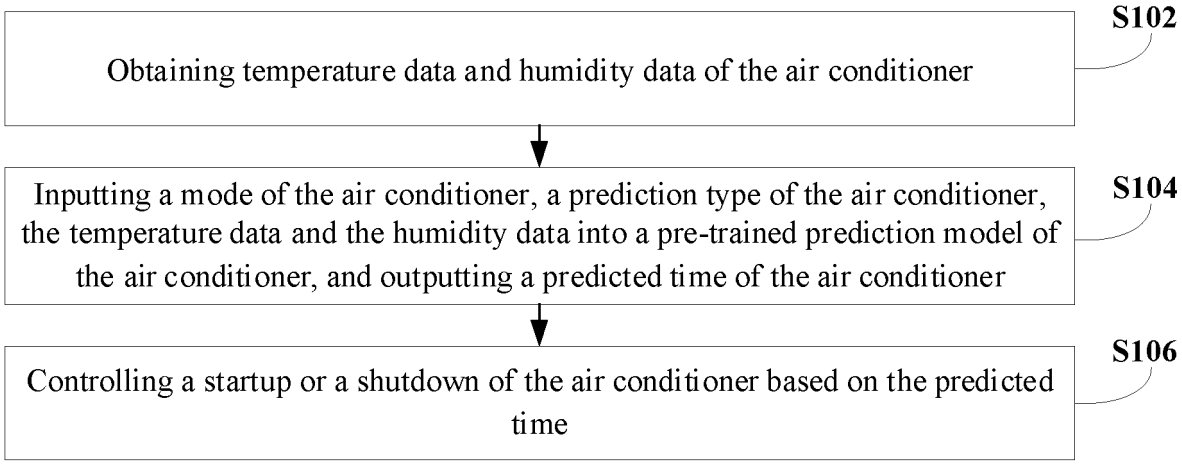
S102
Obtaining temperature data and humidity data of the air conditioner
S104
Inputting a mode of the air conditioner, a prediction type of the air conditioner, the temperature data and the humidity data into a pre-trained prediction model of the air conditioner, and outputting a predicted time of the air conditioner
S106
Controlling a startup or a shutdown of the air conditioner based on the predicted time

FIG. 1

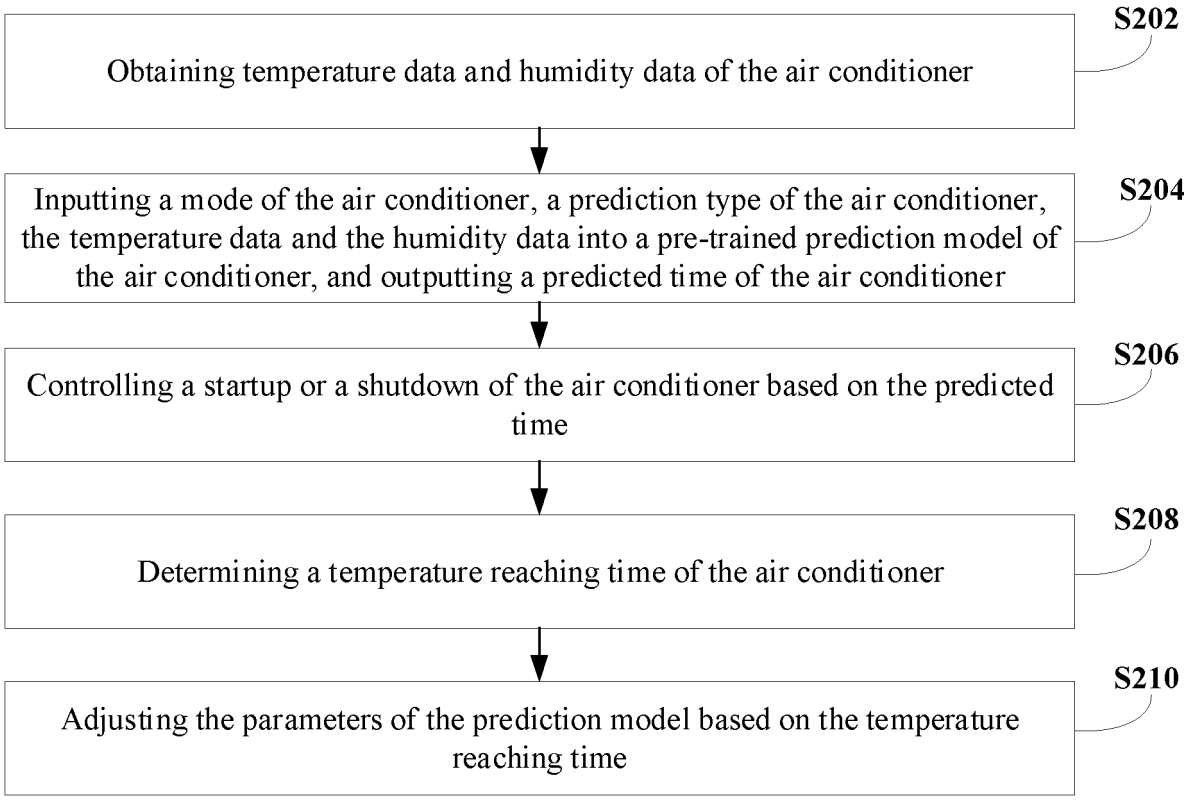
S202
Obtaining temperature data and humidity data of the air conditioner
S204
Inputting a mode of the air conditioner, a prediction type of the air conditioner, the temperature data and the humidity data into a pre-trained prediction model of the air conditioner, and outputting a predicted time of the air conditioner
S206
Controlling a startup or a shutdown of the air conditioner based on the predicted time
S208
Determining a temperature reaching time of the air conditioner
S210
Adjusting the parameters of the prediction model based on the temperature reaching time

FIG. 2

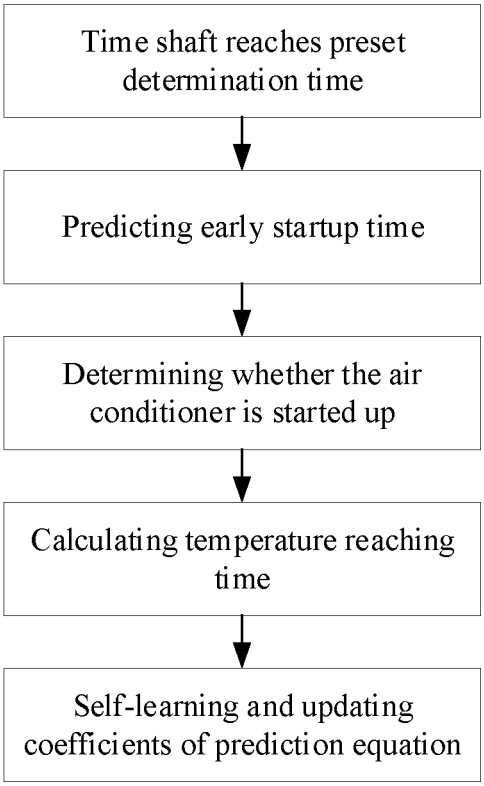
Time shaft reaches preset determination time
Predicting early startup time
Determining whether the air conditioner is started up
Calculating temperature reaching time
Self-learning and updating coefficients of prediction equation

FIG. 3

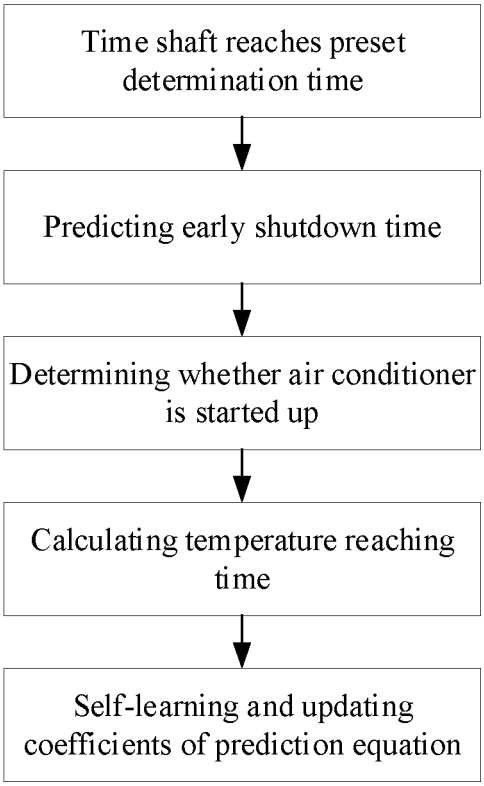
Time shaft reaches preset determination time
Predicting early shutdown time
Determining whether air conditioner is started up
Calculating temperature reaching time
Self-learning and updating coefficients of prediction equation

FIG. 4

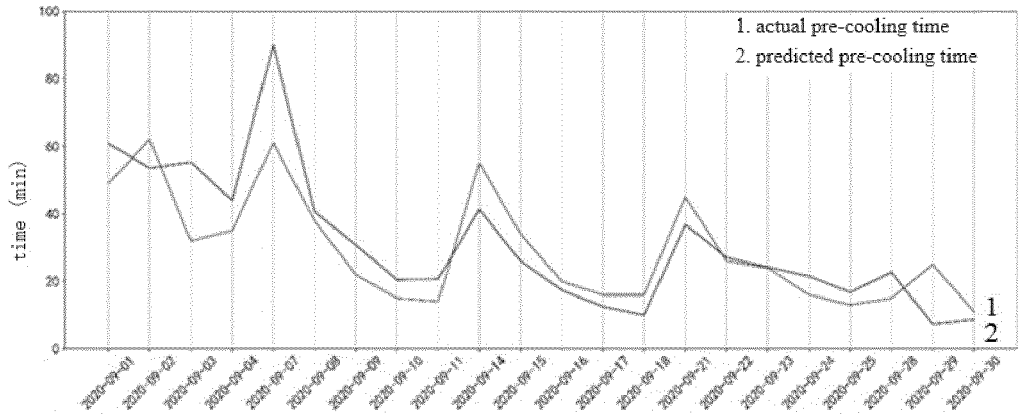
1. actual pre-cooling time
2. predicted pre-cooling time
time (min)
100
80
60
40
20
0
1
2

FIG. 5

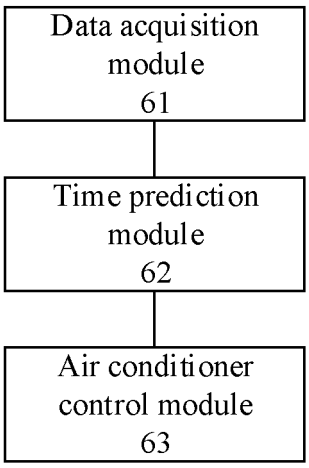
Data acquisition module
61
Time prediction module
62
Air conditioner control module
63

FIG. 6

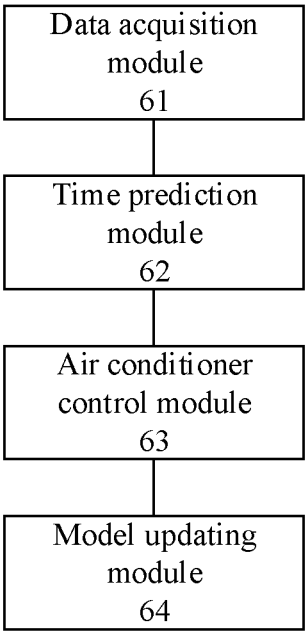
Data acquisition module 61
Time prediction module 62
Air conditioner control module 63
Model updating module 64

FIG. 7

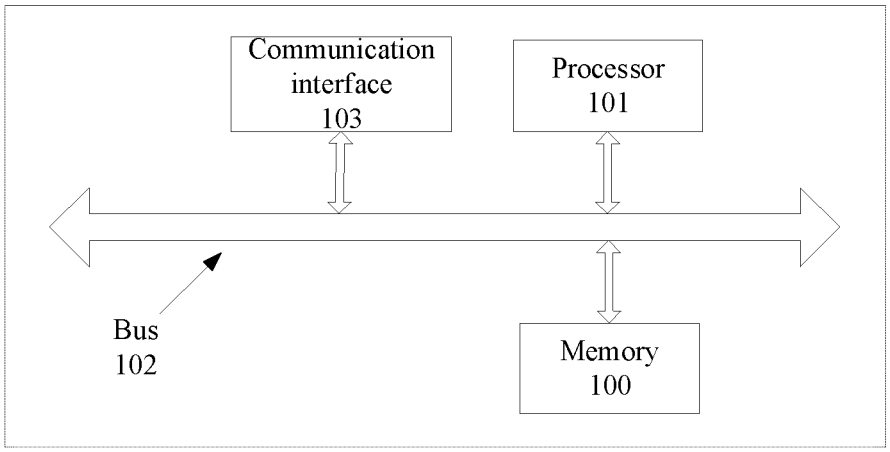
Communication interface 103
Processor 101
Bus 102
Memory 100

FIG. 8

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2022/091244

A. CLASSIFICATION OF SUBJECT MATTER

F24F 11/00(2018.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

F24F11/00; F24F; F25B49/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

CNABS, CNTXT, CNKI, VEN: 空调, 温度, 湿度, 预测, 训练, 模型, 时间, 启动, 关闭; AIR, CONDITIONER, CONTROL, TEMP, HUMIDITY, PREDICT, TRAIN, TIME, START, STOP, MODE

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
PX	CN 113739390 A (SHANGHAI MEIKONG WISDOM CONSTRUCTION CO., LTD. et al.) 03 December 2021 (2021-12-03) description, pages 4-10, and figures 1-8	1-15
X	CN 112283889 A (GUANGDONG MIDEA HEATING & VENTILATION EQUIPMENT CO., LTD. et al.) 29 January 2021 (2021-01-29) description, pages 4-11, and figures 1-6	1-15
X	CN 112762576 A (GUANGDONG MIDEA WHITE HOUSEHOLD APPLIANCE TECHNOLOGY INNOVATION CENTER CO., LTD. et al.) 07 May 2021 (2021-05-07) description, paragraphs 3-8, and figures 1-6	1-7, 12-15
Y	CN 112762576 A (GUANGDONG MIDEA WHITE HOUSEHOLD APPLIANCE TECHNOLOGY INNOVATION CENTER CO., LTD. et al.) 07 May 2021 (2021-05-07) description, paragraphs 3-8, and figures 1-6	8-11
Y	CN 109373539 A (ZHUHAI GREE ELECTRIC APPLIANCES INC.) 22 February 2019 (2019-02-22) description, pages 3-6, and figures 1-6	8-11

☑ Further documents are listed in the continuation of Box C. ☑ See patent family annex.

* Special categories of cited documents:
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"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
26 July 2022	**08 August 2022**
Name and mailing address of the ISA/CN **China National Intellectual Property Administration (ISA/CN)** **No. 6, Xitucheng Road, Jimenqiao, Haidian District, Beijing 100088, China** Facsimile No. **(86-10)62019451**	Authorized officer Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2022/091244

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	CN 110686382 A (GUANGDONG MIDEA HEATING & VENTILATION EQUIPMENT CO., LTD. et al.) 14 January 2020 (2020-01-14) entire document	1-15
A	CN 112050384 A (QINGDAO HAIER AIR CONDITIONER GENERAL CO., LTD. et al.) 08 December 2020 (2020-12-08) entire document	1-15
A	CN 107504656 A (ZHUHAI GREE ELECTRIC APPLIANCES INC.) 22 December 2017 (2017-12-22) entire document	1-15
A	US 2021018205 A1 (JOHNSON CONTROLS TECHNOLOGY COMPANY) 21 January 2021 (2021-01-21) entire document	1-15

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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2022/091244

Patent document cited in search report	Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
CN 113739390 A	03 December 2021	None	
CN 112283889 A	29 January 2021	None	
CN 112762576 A	07 May 2021	None	
CN 109373539 A	22 February 2019	CN 111006367 A	14 April 2020
CN 110686382 A	14 January 2020	WO 2021073025 A1	22 April 2021
		US 2022136725 A1	05 May 2022
		EP 3992538 A1	04 May 2022
CN 112050384 A	08 December 2020	None	
CN 107504656 A	22 December 2017	None	
US 2021018205 A1	21 January 2021	None	

Form PCT/ISA/210 (patent family annex) (January 2015)

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- CN 202111163463 **[0001]**