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(54) AUTOMATIC CONTROL METHOD AND APPARATUS FOR WATER HEATER, AND WATER HEATER AND ELECTRONIC DEVICE

(57) Provided in the embodiments of the present application are an automatic control method and apparatus for a water heater, and a water heater and an electronic device. In the embodiments of the present application, corresponding water heater set temperatures for different time periods during a future water usage process are predicted according to water usage volumes corresponding to different time periods during a historical water usage process and to water usage volumes that a water heater can supply at different set temperatures, and thus, the water heater is controlled according to the corresponding water heater set temperatures, obtained through prediction, for the different time periods during the future water usage process. It can be seen that the embodiments of the present application realizes an automatic control method for a water heater that can be adaptive to a water usage behavior of a user, and the user does not need to manually reserve the temperature of the water heater, thereby realizing the intelligent control of the water heater.

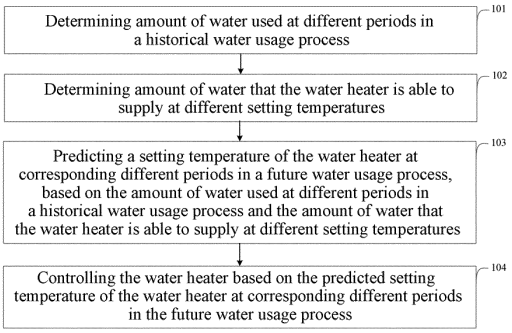

FIG. 1

EP 3 978 824 A1

Description

CROSS-REFERENCE TO RELATED APPLICATION

[0001] The present application claims priority to Chinese patent application No. 2019108757046 filed on September 17, 2019, entitled "Automatic Control Method and Device for Water Heater, Water Heater and Electronic Device".

FIELD OF TECHNOLOGY

[0002] The present application relates to the technical field of intelligent control, and in particular to a method and a device for automatically controlling a water heater, water heater and an electronic device.

BACKGROUND

[0003] During the use of an electric water heater, most users will set a temperature of the water heater at a higher level permanently and run it 24 hours a day, but the electric water heater is only used a little time during each day, and is in idle state during most time of the day, and thus it will cause wasting energy.

[0004] The above-mentioned problem has always been pain points in the use of the water heater. The user expects to lower the temperature or even turn off the water heater during not being used so as to save energy. The current solution solves this problem mainly through manual operation by the user.

[0005] However, the manual operation has problems such as difficult operations, easiness in forgetting, and poor user experience.

BRIEF SUMMARY

[0006] In view of the problems in the prior art, according to embodiments of the present application, a method and a device for automatically controlling a water heater, a water heater, and an electronic device are provided.

[0007] In order to solve the technical problems above, the following technical solutions are provided according to embodiments of the present application.

[0008] According to a first aspect of the present application, a method for automatically controlling a water heater is provided, including:

determining amount of water used at different periods in a historical water usage process;

determining amount of water that the water heater is able to supply at corresponding different setting temperatures;

predicting a setting temperature of the water heater at corresponding different periods in a future water usage process, based on the amount of water used at different periods in the historical water usage process and the amount of water that the water heater is able to supply at different setting temperatures; and

controlling the water heater based on the predicted setting temperature of the water heater at corresponding different periods in the future water usage process.

[0009] Further, the determining the amount of water used at different periods in a historical water usage process specifically includes:

determining the amount of standard-temperature water used at different periods in the historical water usage process; wherein the amount of used standard-temperature water is obtained by converting the amount of water used at different temperature conditions into the amount of water used at the standard-temperature.

[0010] Further, the determining the amount of standard-temperature water used at different periods in the historical water usage process specifically includes:

determining the amount of actually used water, an intra-tank temperature and an inlet water temperature at different periods in the historical water usage process; and

determining, based on the amount of actually used water, the intra-tank temperature and the inlet water temperature at different periods in the historical water usage process, amount of standard-temperature water used at different periods in the historical water usage process by a model of a first preset amount of used standard-temperature water;

the model of the first preset amount of used standard-temperature water is a model that represents a corresponding relationship between the amount of actually used water and the amount of used standard-temperature water at different intra-tank temperatures and inlet water temperatures.

[0011] Further, the model of the first preset amount of used standard-temperature water is as follows:

$$Q_1 = Q_0 * \left(1 + \frac{T_1 - T_0}{T_0 - T_2}\right)$$

where Q_1 represents a first amount of used standard-temperature water, Q_0 represents the amount of actually used water, T_0 represents the standard-temperature, T_1 represents the intra-tank temperature, and T_2 represents the inlet water temperature.

[0012] Further, the determining the amount of water that the water heater is able to supply at different setting

temperatures specifically includes:
determining the amount of standard-temperature water that the water heater is able to supply at different setting temperatures;

[0013] Further, the determining the amount of standard-temperature water that the water heater is able to supply at different setting temperatures specifically includes:

determining, based on different setting temperatures, inlet water temperatures and a rated capacity of the water heater, the amount of standard-temperature water that the water heater is able to supply at different setting temperatures by a model of second preset amount of used standard-temperature water; the model of the second preset amount of used standard-temperature water is a model that represents a corresponding relationship between the rated capacity of the water heater and the amount of used standard-temperature water at different setting temperatures and inlet water temperatures.

[0014] Further, the model of the second preset amount of used standard-temperature water is as follows:

$$Q_2 = Q * \left(1 + \frac{T_3 - T_0}{T_0 - T_2}\right)$$

where Q_2 represents a second amount of used standard-temperature water, Q represents the rated capacity of the water heater, T_2 represents the setting temperature, T_0 represents the standard-temperature, and T_2 represents the inlet water temperature.

[0015] Further, the predicting the setting temperature of the water heater at corresponding different periods in the future water usage process, based on the amount of water used at different periods in the historical water usage process and the amount of water that the water heater is able to supply at different setting temperatures specifically includes:
predicting the setting temperature of the water heater at different periods in the future water usage process, based on the amount of standard-temperature water used at different periods in a historical water usage process and the amount of standard-temperature water that the water heater is able to supply at different setting temperatures.

[0016] Further, the predicting the setting temperature of the water heater at different periods in the future water usage process, based on the amount of standard-temperature water used at different periods in the historical water usage process and the amount of standard-temperature water that the water heater is able to supply at different setting temperatures specifically includes:

determining the setting temperature of the water heater at different periods of a day in historical water usage days, based on the amount of standard-temperature water used at different periods of the day in the historical water usage days and the amount of standard-temperature water that the water heater is able to supply at different setting temperatures; and

predicting the setting temperature of the water heater at corresponding different periods of a day in the future water usage process, based on the setting temperature of the water heater at different periods of the day in historical water usage days.

[0017] Further, the predicting a setting temperature of the water heater at corresponding different periods of the day in the future water usage process, based on the setting temperature of the water heater at different periods of the day in historical water usage days specifically includes:

transmitting the setting temperature of the water heater at different periods of the day in historical water usage days to a client device;

receiving a voting value for the setting temperature of the water heater at different periods of the day in historical water usage days transmitted by the client device; and

predicting the setting temperature of the water heater at corresponding different periods of the day in the future water usage process, based on the voting value for the setting temperature of the water heater at different periods of the day.

[0018] Further, the predicting the setting temperature of the water heater at corresponding different periods of the day in the future water usage process, based on the setting temperature of the water heater at different periods of the day in historical water usage days specifically includes:

determining a highest setting temperature of the water heater at different periods of the day, based on the setting temperature of the water heater at different periods of the day in historical water usage days and

determining the highest setting temperature of the water heater at different periods of the day as the setting temperature of the water heater at corresponding different periods of the day in the future water usage process.

[0019] Further, the method for automatically controlling a water heater further includes:

determining atmospheric temperature data at differ-

ent periods in the future water usage process;

correcting the predicted setting temperature of the water heater at corresponding different periods of a day in corresponding future water usage process, based on the atmospheric temperature data at different periods in a future water usage process and

controlling the water heater based on the corrected setting temperature.

[0020] Further, the method for automatically controlling a water heater further includes:

determining saved power after the water heater is automatically controlled based on the predicted setting temperature of the water heater at different periods in the future water usage process;

determining consumed power after the water heater is automatically controlled based on the predicted setting temperature of the water heater at corresponding different periods in the future water usage process; and

determining saved power cost based on the saved power, the consumed power and a ladder-type pricing model.

[0021] According to a second aspect of the present application, a device for automatically controlling a water heater is further provided, including:

a first determiner configured to determine the amount of water used at different periods in a historical water usage process;

a second determiner configured to determine the amount of water that the water heater is able to supply at different setting temperatures;

a predictor configured to predict a setting temperature of the water heater at corresponding different periods in a future water usage process, based on the amount of water used at different periods in a historical water usage process and the amount of water that the water heater is able to supply at different setting temperatures; and

a controller configured to control the water heater based on the predicted setting temperature of the water heater at corresponding different periods in a future water usage process.

[0022] According to a third aspect of the present application, a water heater, including the device for automatically controlling a water heater as described in the second aspect is further provided.

[0023] According to a fourth aspect of the present application, an electronic device, including a processor, and a memory configured to store computer programs that, when executed by the processor, causes the processor to perform a method for automatically controlling the water heater in the first aspect is further provided.

[0024] According to a fifth aspect of the present application, a non-transitory computer-readable storage medium having stored thereon computer programs that are executed by a processor to perform a method for automatically controlling a water heater in the first aspect is further provided.

[0025] From the above technical solutions that according to the method and device for automatically controlling the water heater, the water heater and the electronic device of the present application, a setting temperature of the water heater at different periods in a future water usage process is predicted based on the amount of water used at different periods in a historical water usage process and the amount of water that the water heater can supply at different setting temperatures and the water heater is controlled based on the predicted setting temperature of the water heater at different periods in a future water usage process. It can also be seen from the above embodiments, by combining the amount of water used at different periods in a historical water usage process and the amount of water that the water heater can supply at different setting temperatures, the setting temperature of the water heater at different periods in a future water usage process is predicted and thus a method for automatically controlling the water heater capable of being adaptive to a water usage behavior of a user, which not only solves the problem that a user manually reserves the temperature of the water heater, but also may allow the water heater to operate in a manner of low energy consumption under the premise of ensuring the water demand, thereby intelligently controlling the water heater.

BRIEF DESCRIPTION OF THE DRAWINGS

[0026] In order to more clearly illustrate technical solutions disclosed in the embodiments of the present application or the prior art, the drawings used in the descriptions of the embodiments or the prior art will be briefly described below. The drawings in the following description are only certain embodiments of the present application, and other drawings can be obtained according to the drawings without any creative work for those skilled in the art.

Fig. 1 is a flowchart of a method for automatically controlling a water heater according to an embodiment of the present application;

Fig. 2 is a schematic structural diagram of a device for automatically controlling a water heater according to an embodiment of the present application; and

Fig. 3 is a schematic structural diagram of an elec-

tronic device according to an embodiment of the present application.

DETAILED DESCRIPTION

[0027] In order to make the object, technical solutions and advantages of the embodiments of the present application more clear, the technical solutions in the embodiments of the present application are clearly and completely described in the following with reference to the accompanying drawings in the embodiments of the present application. These embodiments are a part of the embodiments of the present application, and not all of the embodiments. All other embodiments obtained by a person of ordinary skill in the art based on the embodiments of the present application without any creative work belong to the scope of the present application.

[0028] According to the present application, it is intended to predict a setting temperature of the water heater at different periods in a future water usage process, based on the amount of water used at different periods in a historical water usage process and the amount of water that the water heater can supply at different setting temperatures. According to the present application, a problem of waste of energy consumption caused by the user constantly setting the temperature of the water heater to a higher gear for operation during the use of the electric water heater may be solved. The working principle and working process of a method for automatically controlling a water heater according to the present application will be explained in detail below through specific embodiments.

[0029] FIG 1 shows a flowchart of a method for automatically controlling a water heater according to an embodiment of the present application. Referring to FIG. 1, the method for automatically controlling a water heater according to an embodiment of the present application includes:

step 101: determining the amount of water used at different periods in a historical water usage process;
step 102: determining the amount of water that the water heater can supply at different setting temperatures;
step 103: predicting a setting temperature of the water heater at different periods in a future water usage process, based on the amount of water used at different periods in a historical water usage process and the amount of water that the water heater can supply at different setting temperatures; and
step 104: controlling the water heater based on the predicted setting temperature of the water heater at different periods in a future water usage process.

[0030] In the present embodiment, the different periods may refer to different periods within a day, such as 12:00-14:00, 14:00-16:00, and 16:00-18:00. It may also refer to different periods within a week, such as Monday, Tuesday, Wednesday, etc. It may also refer to the combination of both, such as 12:00-14:00, 14:00-16:00, 16:00-18:00 on Mondays, and 12:00-14:00, 14:00-16 on Tuesdays :00, 16:00-18:00, Wednesday 12:00-14:00, 14:00-16:00, 16:00-18:00, etc. In the present embodiment, the historical water usage process may refer to a historical water usage process of a day, or may refer to a historical water usage process of multiple days. For example, it is possible to predict a setting temperature of the water heater at different periods in a next day, based on the amount of water at different periods of each day in a historical water usage process for seven days. For another example, it is possible to predict a setting temperature of the water heater at different periods from Monday to Sunday in the next week based on the amount of water at different periods from Monday to Sunday during the historical water usage process for seven says.

[0031] In the present embodiment, when the setting temperature of the water heater at different periods in a future water usage process is predicted based on the amount of water at different periods in a historical water usage process, the prediction may further be made by determining a typical day in the historical water usage days, for example, the first day, on Monday having a relatively large reference value, determining a setting temperature at different periods on Monday based on the amount of water used at different periods on this day and the amount of water that the water heater can supply at different setting temperatures and finally predicting the setting temperature of the water heater at different periods of the day in the future water usage process.

[0032] In the present embodiment, the setting temperature of the water heater herein may be a discrete physical temperature adjustment gear (such as 40°C, 45°C, 50°C) in the water heater, or continuous setting temperature, such as 41°C, 41.5°C, 42°C, 43°C, 44°C, 45°C, etc. which can be controlled in real time through an electronic control algorithm.

[0033] In the present embodiment, it should be noted that before performing the above step 101, it is necessary to perform the step of obtaining historical water usage data. The historical water usage data refers to data generated by the user during the historical use of the water heater, such as the amount of water (determined according to the water flow rate and the duration of water usage), a intra-tank temperature and an inlet water temperature, and so on. Specifically, when the historical water usage data are obtained, a water usage event may be constructed based on the status data reported by sensors (including temperature sensors, flow sensors, timers, etc.) disposed inside the water heater, and then the (average) water flow rate, (average) intra-tank temperature, (average) water inlet temperature, water usage duration and other indicators of the water usage event may be obtained. The average water flow rate and water usage duration of the water use event at different periods may be used to calculate the amount of water of the water usage event at different periods. For example, when the

water heater has historical status reporting data for 14 consecutive days, every two adjacent statuses (a piece of status data representing the status of the water heater at the time of reporting, including a current water flow rate, a current intra-tank temperature, and the current point in time and other information) constitute a water usage event, in which the intra-tank temperature is data obtained by the central temperature sensor.

[0034] In the present embodiment, after the historical water usage data are obtained, the setting temperature of the water heater at different periods in a future water usage process may be predicted based on the amount of water at different periods in a historical water usage process. It is necessary to predict the setting temperature of the water heater at different periods in a future water usage process based on the amount of water used at different periods in a historical water usage process and the amount of water that the water heater can supply at different setting temperatures when the setting temperature of the water heater at different periods in a future water usage process may be predicted based on the amount of water at different periods in a historical water usage process. For example, the setting temperature corresponding to the different periods of each day in the historical water usage days may be determined based on the amount of water at different periods of the day in the historical water usage days and the amount of water that the water heater can supply at the different setting temperatures and the setting temperature of the water heater at different periods of each day in the future water usage process may be predicted based on the setting temperature corresponding to the different periods of each day in the historical water usage days.

[0035] By the way of example, it is assumed that the historical water usage data includes 6 days of historical water usage. The amount of water used at different periods in each day of the 6 days based on the historical water usage data are as follows:

in a first day:

00:00-02:00: 0 liter;
02:00-04:00: 0 liter;
04:00-06:00: 0 liter;
06:00-08:00: 10 liters;
08:00-10:00: 10 liters;
10:00-12:00: 5 liters;
12:00-14:00: 5 liters;
14:00-16:00: 0 liter;
16:00-18:00: 0 liter;
18:00-20:00: 25 liters;
20:00-22:00: 50 liters;
22:00-24:00: 5 liters;

in a second day:

12:00-02:00: 0 liter;
02:00-04:00: 0 liter;
04:00-06:00: 0 liter;
06:00-08:00: 10 liters;
08:00-10:00: 5 liters;
10:00-12:00: 0 liter;
12:00-14:00: 5 liters;
14:00-16:00: 0 liter;
16:00-18:00: 0 liter;
18:00-20:00: 25 liters;
20:00-22:00: 50 liters;
22:00-24:00: 10 liters;

in a third day:

12:00-02:00: 0 liter;
02:00-04:00: 0 liter;
04:00-06:00: 0 liter;
06:00-08:00: 5 liters;
08:00-10:00: 10 liters;
10:00-12:00: 0 liter;
12:00-14:00: 10 liters;
14:00-16:00: 0 liter;
16:00-18:00: 0 liter;
18:00-20:00: 25 liters;
20:00-22:00: 50 liters;
22:00-24:00: 10 liters;

in a fourth day:

12:00-02:00: 0 liter;
02:00-04:00: 0 liter;
04:00-06:00: 0 liter;
06:00-08:00: 10 liters;
08:00-10:00: 10 liters;
10:00-12:00: 0 liter;
12:00-14:00: 10 liters;
14:00-16:00: 0 liter;
16:00-18:00: 0 liter;
18:00-20:00: 25 liters;
20:00-22:00: 50 liters;
22:00-24:00: 5 liters;

in a fifth day:

12:00-02:00: 0 liter;
02:00-04:00: 0 liter;
04:00-06:00: 0 liter;
06:00-08:00: 10 liters;
08:00-10:00: 20 liters;
10:00-12:00: 0 liter;
12:00-14:00: 10 liters;
14:00-16:00: 0 liter;
16:00-18:00: 0 liter;
18:00-20:00: 25 liters;
20:00-22:00: 50 liters;
22:00-24:00: 0 liter;

in a sixth day:

12:00-02:00: 0 liter;
02:00-04:00: 0 liter;
04:00-06:00: 0 liter;
06:00-08:00: 10 liters;
08:00-10:00: 5 liters;
10:00-12:00: 0 liter;
12:00-14:00: 5 liters;
14:00-16:00: 0 liter;
16:00-18:00: 0 liter;
18:00-20:00: 50 liters;
20:00-22:00: 50 liters;
22:00-24:00: 5 liters.

[0036] In the present embodiment, the amount of water in the different periods shown above may be the amount of water under different temperature conditions. For example, the amount of water in the time period of 12:00-14:00 and the time period of 20:00-22:00 may correspond to different inlet water temperatures and intra-tank temperatures. In the present embodiment, no attention is paid to the difference between the inlet water temperature and the intra-tank temperature, and the corresponding setting temperature is predicted at different periods based on the amount of water. However, in other embodiments of the present application, the amount of water under different temperature conditions is unified to the amount of water under the standard-temperature, referred to as the amount of used standard-temperature water, which is explained in other subsequent embodiments.

[0037] After obtaining the above historical water usage data, the method proceeds to the next step, that is, to determine the amount of water that the water heater can supply at the different setting temperatures. For example, it is assumed that the water heater has 8 setting temperatures (not limited to this, here is only used for illustration), the amount of water that the water heater can supply at the different setting temperatures include:

5 liters of water that may be supplied at the 40°C setting temperature;
8 liters of water that may be supplied at the 45°C setting temperature;
10 liters of water that may be supplied at the 50°C setting temperature;
20 liters of water that may be supplied at the 55°C setting temperature;
25 liters of water that may be supplied at the 60°C setting temperature;
40 liters of water that may be supplied at the 65°C setting temperature;
50 liters of water that may be supplied at the 70°C setting temperature; and
60 liters of water that may be supplied at the 75°C setting temperature;

[0038] In the present embodiment, the amount of water that may be supplied at different setting temperatures here refers to the amount of water that may be supplied within a preset temperature range in a unit time (for example, within one hour) when the water heater is at different setting temperatures. The preset temperature range here refers to the appropriate temperature when the user uses water and may be 38°C-50°C. For example, 5 liters of water that may be supplied at the 40°C setting temperature means that the water heater may supply 5 liters of water with a temperature of 38°C-50°C per hour at the 40°C setting temperature. For another example, 25 liters of water that may be supplied at the 60°C setting temperature means that the water heater may supply 25 liters of water with a temperature of 38°C-50°C per hour at the 60°C setting temperature.

[0039] In the present embodiment, it should be noted that the amount of water that may be supplied at different setting temperatures here does not consider the feature of water temperature, but only considers the water heater may be supplied at different setting temperatures of the water heater when the water temperature is within a certain preset temperature range. However, in other embodiments of the present application, the amount of water that may be supplied under different setting temperature conditions is unified to the amount of water that may be supplied under the standard-temperature, referred to as the amount of used standard-temperature water, which is explained in other subsequent embodiments.

[0040] After obtaining the amount of water that the above water heater can supply at different setting temperatures, the method proceeds to the next step, that is, to determine a setting temperature of the water heater at different periods of a day in historical water usage days based on the amount of water at different periods of each day in the historical water usage days and the amount of water that the water heater can supply at the setting temperature. When performing this step, the setting temperature of the water heater at different periods of a day in historical water usage days may be determined based on a matching relationship between above the amount of water,

in a first day:

00:00-02:00: 40°C setting temperature (because the amount of water at 40°C setting temperature is 5 liters, which can meet the water usage demand of 0 liters during this time period, the following description has similar principle to it, and will not be explained one by one);
002:00-04:00: 40°C setting temperature;
04:00-06:00: 40°C setting temperature;
06:00-08:00: 50°C setting temperature (because the amount of water at 50°C setting temperature is 10 liters, which can meet the water usage demand of 10 liters during this time period, the following description has similar principle to it, and will not be explained one by one);
08:00-10:00: 50°C setting temperature;

10:00-12:00: 40°C setting temperature;
12:00-14:00: 40°C setting temperature;
14:00-16:00: 40°C setting temperature;
16:00-18:00: 40°C setting temperature;
18:00-20:00: 60°C setting temperature;
20:00-22:00: 70°C setting temperature;
22:00-24:00: 40°C setting temperature;

in a second day:

12:00-02:00: 40°C setting temperature;
02:00-04:00: 40°C setting temperature;
04:00-06:00: 40°C setting temperature;
06:00-08:00: 50°C setting temperature;
08:00-10:00: 40°C setting temperature;
10:00-12:00: 40°C setting temperature;
12:00-14:00: 40°C setting temperature;
14:00-16:00: 40°C setting temperature;
16:00-18:00: 40°C setting temperature;
18:00-20:00: 60°C setting temperature;
20:00-22:00: 70°C setting temperature;
22:00-24:00: 50°C setting temperature;

in a third day:

12:00-02:00: 40°C setting temperature;
02:00-04:00: 40°C setting temperature;
04:00-06:00: 40°C setting temperature;
06:00-08:00: 40°C setting temperature;
08:00-10:00: 50°C setting temperature;
10:00-12:00: 40°C setting temperature;
12:00-14:00: 50°C setting temperature;
14:00-16:00: 40°C setting temperature;
16:00-18:00: 40°C setting temperature;
18:00-20:00: 60°C setting temperature;
20:00-22:00: 70°C setting temperature;
22:00-24:00: 50°C setting temperature;

in a fourth day:

12:00-02:00: 40°C setting temperature;
02:00-04:00: 40°C setting temperature;
04:00-06:00: 40°C setting temperature;
06:00-08:00: 50°C setting temperature;
08:00-10:00: 50°C setting temperature;
10:00-12:00: 40°C setting temperature;
12:00-14:00: 50°C setting temperature;
14:00-16:00: 40°C setting temperature;
16:00-18:00: 40°C setting temperature;
18:00-20:00: 60°C setting temperature;
20:00-22:00: 70°C setting temperature;
22:00-24:00: 40°C setting temperature;

in a fifth day:

12:00-02:00: 40°C setting temperature;
02:00-04:00: 40°C setting temperature;
04:00-06:00: 40°C setting temperature;
06:00-08:00: 50°C setting temperature;
08:00-10:00: 55°C setting temperature;
10:00-12:00: 40°C setting temperature;
12:00-14:00: 50°C setting temperature;
14:00-16:00: 40°C setting temperature;
16:00-18:00: 40°C setting temperature;
18:00-20:00: 60°C setting temperature;
20:00-22:00: 70°C setting temperature;
22:00-24:00: 40°C setting temperature;

in a sixth day:

12:00-02:00: 40°C setting temperature;
02:00-04:00: 40°C setting temperature;
04:00-06:00: 40°C setting temperature;
06:00-08:00: 50°C setting temperature;
08:00-10:00: 40°C setting temperature;
10:00-12:00: 40°C setting temperature;
12:00-14:00: 40°C setting temperature;
14:00-16:00: 40°C setting temperature;
16:00-18:00: 40°C setting temperature;
18:00-20:00: 70°C setting temperature;
20:00-22:00: 70°C setting temperature;
22:00-24:00: 40°C setting temperature;

[0041] It should be noted that in order to deal with a user's minor-probability water usage event, the setting temperature may be set to 40°C during the time period when the water usage is 0, so as to meet user's demand for water usage when a temporary minor-probability water usage event occurs. However, from the perspective of energy saving, the heating function of the water heater during the time period when the amount of water is zero may be turned off so as to save energy. It may be determined to set a lower 40°C setting temperature or turn off the heating function of the water heater during the time period when the water usage is 0 based on specific needs.

[0042] After determining the setting temperature of the water heater at different periods of a day in historical water usage days, it is necessary to predict a setting temperature of the water heater at different periods of a day in a future water usage process based on the setting temperature of the water heater at different periods of a day in historical water usage days.

[0043] For example, for each period, the highest setting temperature at the corresponding period in six days may be selected as a predicted value of the setting temperature at the corresponding period. For example, for the period from 08:00 to 10:00 of a day, the corresponding highest setting temperature in 6 days is 55°C. Therefore, the 55°C of setting temperature may be regarded as the predicted value of the setting temperature at the corresponding period. In addition, the setting temperature with the most occurrence numbers at the corresponding period in 6 days may also be selected as the predicted value of the setting temperature at the corresponding period. For example, for the period from 08:00 to 10:00 of a day,

the corresponding highest setting temperature in 6 days is 55°C. The 55°C setting temperature appears once, the 40°C setting temperature appears twice, and the 50°C setting temperature appears 3 times, and the 50°C setting temperature with the most occurrence numbers may be used as the predicted setting temperature at corresponding period. In addition, the predicted value of the setting temperature at the corresponding period may also be determined according to the user's voting result on the setting temperature that appears at the corresponding period of 6 days. For example, the user's voting results on the setting temperature at the corresponding period of these 6 days include 0 vote for 40°C, 0 vote for 55°C, and 3 votes for 50°C, so that the 50°C setting temperature votes with the most votes may be determined as the predicted value of the setting temperature at the corresponding period.

[0044] In the present embodiment, it should be noted that the two implementation methods of selecting the highest setting temperature or the setting temperature with the most occurrence numbers as the predicted value of the setting temperature at the corresponding period are respectively given above. It is understandable that selecting the highest setting temperature as the predicted setting temperature at the corresponding period may meet the needs of hot water usage, that is, selecting the highest setting temperature as the predicted setting temperature at the corresponding period considers a satisfaction level for hot water. Selecting the setting temperature with the most occurrence numbers as the predicted value of the setting temperature at the corresponding period can meet the accuracy of hot water usage, that is, selecting the setting temperature with the most occurrence numbers as the predicted value of the setting temperature at the corresponding period considers the accuracy rate. In actual processing, these two factors of hot water satisfaction level and accuracy rate may be considered comprehensively, which can be achieved by setting a probability threshold. For example, when the frequency at which a certain setting temperature appears exceeds the probability threshold, this setting temperature can be used as the predicted value of the setting temperature at the corresponding period, otherwise, the highest setting temperature is used as the predicted value of the setting temperature at the corresponding period.

[0045] In addition, in the present embodiment, it should be noted that when predicting based on water usage data in historical water usage days, it is not that the more historical water usage days, the better. Since older behaviors have less influence on the current behavior, it is necessary to appropriately "forget" preceding behavioral data. Experiments have shown that too many or too few days will affect the accuracy rate and relatively good prediction results will be obtained using 14 historical water usage days.

[0046] It can be seen from the above technical solutions that according to the method for automatically controlling the water heater, the water heater of the present application, a setting temperature of the water heater at different periods in a future water usage process can be predicted based on the amount of water used at different periods in a historical water usage process and the amount of water that the water heater can supply at different setting temperatures and the water heater is controlled based on the predicted setting temperature of the water heater at different periods in a future water usage process. It can also be seen from the above embodiments, by combining the amount of water at different periods in a historical water usage process and the amount of water that the water heater can supply at different setting temperatures, the setting temperature of the water heater at different periods in a future water usage process is predicted and thus a method for automatically controlling the water heater capable of being adaptive to a water usage behavior of a user, which not only solves the problem that a user manually reserves the temperature of the water heater, but also may allow the water heater to operate in a manner of low energy consumption under the premise of ensuring the water demand, thereby intelligently controlling the water heater.

[0047] Based on the content of the foregoing embodiment, in the present embodiment, the step 101 of determining the amount of water used at different periods in a historical water usage process includes the following steps:

step 101': determining the amount of standard-temperature water used at different periods in the historical water usage process; wherein the amount of used standard-temperature water is obtained by converting the amount of water under different temperature conditions into the amount of used water at the standard-temperature.

[0048] In the present embodiment, in order to solve the problem that the amount of water cannot be compared at different temperatures, a method of standardizing the amount of water at different temperatures through a unified standard-temperature to obtain the amount of used standard-temperature water is adopted in the present embodiment. Adopting the processing method of the present embodiment has such advantage that there is no need to consider whether the amount of water corresponding to each period is comparable when the temperature in the water heater is different at different periods.

[0049] Based on the content of the foregoing embodiment, in the present embodiment, the step 101' of determining the amount of standard-temperature water used at different periods in a historical water usage process includes the following steps:

step A1: determining the amount of actually used water, an intra-tank temperature and an inlet water temperature at different periods in the historical water usage process; and

step A2: determining the amount of standard-temperature water used at different periods in the historical water usage process by the model of the first

preset amount of used standard-temperature water based on the amount of actually used water, the intra-tank temperature and the inlet water temperature at different periods in the historical water usage process; where the model of the first preset amount of used standard-temperature water is a model that characterizes a corresponding relationship between the amount of actually used water and the amount of used standard-temperature water at different intra-tank temperatures and inlet water temperatures;

[0050] In the present embodiment, when the amount of standard-temperature water used at different periods in the historical water usage process is determined, the processing methods of steps A1-A2 are adopted. The amount of actually used water at different periods in the historical water usage process may be converted to the amount of used standard-temperature water by using the model of the first preset amount of used standard-temperature water. Since the amount of actually used water at different periods in the historical water usage process may be converted to the amount of used standard-temperature water, accurate prediction results may be obtained when subsequent calculations and predictions are performed based on the amount of standard-temperature water at different periods in the historical water usage process which eliminates the influence of the fluctuation factor of different temperatures on the amount of water.

[0051] In the present embodiment, it can be understood that the model of the first preset amount of used standard-temperature water is a model that characterizes a corresponding relationship between the amount of actually used water under different temperature conditions and the amount of used standard-temperature water unified to the standard-temperature conditions. In addition, in the present embodiment, the model of the first preset amount of used standard-temperature water has the following equation:

$$Q_1 = Q_0 * \left(1 + \frac{T_1 - T_0}{T_0 - T_2}\right)$$

where Q_1 represents a first amount of used standard-temperature water, Q_0 represents the amount of actually used water, T_0 represents the standard-temperature, T_1 represents the intra-tank temperature, and T_2 represents the inlet water temperature.

[0052] It should be noted that the model of the first preset amount of used standard-temperature water mentioned in the present embodiment is not limited to the above-mentioned form, and can also have other forms as required, for example:

$$Q_1 = Q_0 * \left(1 + k_1 \frac{T_1 - T_0}{T_0 - T_2}\right)$$

where k_1 represents a first adjustment factor and has values can be set according to actual needs, k_1 represents an adjustment factor representing the influence of differences between the water inlet temperature and the standard-temperature and the intra-tank temperature and the standard-temperature on the relationship between the amount of actually used water and the amount of used standard-temperature water and has value of 0.8-0.95.

[0053] Based on the content of the foregoing embodiment, in the present embodiment, the step 102 of determining the amount of water that the water heater can supply at different setting temperatures includes the following steps:

determining the amount of standard-temperature water that the water heater can supply at different setting temperatures.

[0054] In the present embodiment, in order to solve the problem that the amount of water that the water heater can supply at different setting temperatures are not well unified, a method of standardizing the amount of water that the water heater can supply at different setting temperatures through a unified standard-temperature to obtain the amount of standard-temperature water that the water heater can supply at different setting temperatures is adopted in the present embodiment. Adopting the processing method of the present embodiment has such advantage that there is no need to consider whether the amount of water that the water heater can supply at different setting temperatures is comparable.

[0055] Based on the content of the foregoing embodiment, in the present embodiment, the step 102' of determining the amount of standard-temperature water that the water heater can supply at different setting temperatures includes the following steps:

step B1: determining a rated capacity of the water heater;

step B2: determining the amount of standard-temperature water that the water heater can supply at different setting temperatures by a model of the second preset amount of used standard-temperature water based on different setting temperatures, inlet water temperatures and a rated capacity of the water heater;

where the model of the second preset amount of used standard-temperature water is a model that characterizes a corresponding relationship between the rated capacity of the water heater and the amount of used standard-temperature water at different setting temperatures and inlet water temperatures.

[0056] In the present embodiment, when the amount

of standard-temperature water that the water heater can supply at different setting temperatures is determined, the processing methods of steps B1-B2 are adopted. The amount of water supplied at different setting temperatures may be converted to the amount of used standard-temperature water by using the model of the second preset amount of used standard-temperature water and thus the amount of standard-temperature water supplied at the different setting temperatures are obtained. Therefore, more accurate matching result may be obtained when the amount of standard-temperature water supplied at different setting temperatures is matched with the amount of standard-temperature water used at different periods in a historical water usage processes.

[0057] In addition, in the present embodiment, the model of the second preset amount of used standard-temperature water has the following equation:

$$Q_2 = Q * \left(1 + \frac{T_3 - T_0}{T_0 - T_2}\right)$$

where Q_2 represents a second amount of used standard-temperature water, Q represents the rated capacity of the water heater, T_2 represents the set temperature, T_0 represents the standard-temperature, and T_2 represents the inlet water temperature.

[0058] It should be noted that the model of the second preset amount of used standard-temperature water mentioned in the present embodiment is not limited to the above-mentioned one form, and can also have other forms as required, for example:

where k_2 represents a second adjustment factor and has values can be set according to actual needs, k_2 represents an adjustment factor representing the influence of differences between the water inlet temperature and the standard-temperature and the setting temperature and the standard-temperature on the relationship between the rated capacity of the water heater and the amount of standard-temperature water that the water heater can supply at different setting temperatures and has value of 0.7-0.95.

[0059] Based on the content of the foregoing embodiment, in the present embodiment, the step 103 of predicting a setting temperature of the water heater at different periods in a future water usage process, based on the amount of water used at different periods in a historical water usage process and the amount of water that the water heater can supply at different setting temperatures specifically includes:

step 103': predicting a setting temperature of the water heater at different periods in a future water usage process, based on the amount of standard-temperature water used at different periods in a historical water usage process and the amount of standard-temperature water that the water heater can supply at different setting temperatures.

[0060] In the present embodiment, it should be noted that by processing in the above embodiments, the amount of standard-temperature water used at different periods in a historical water usage process and the amount of standard-temperature water that the water heater can supply at different setting temperatures are obtained and thus the setting temperature of the water heater at different periods in a future water usage process is predicted by mapping the amount of used standard-temperature water with each other based on the amount of standard-temperature water used at different periods in a historical water usage process and the amount of standard-temperature water that the water heater can supply at different setting temperatures. When the amount of used standard-temperature water are mapped with each other, a principle needs to be followed, that is, the amount of standard-temperature water that the water heater can supply is greater than or equal to the amount of standard-temperature water used at a corresponding period in the historical water usage process and needs to be closest to the amount of standard-temperature water used the corresponding period in historical water usage process.

[0061] In addition, when the amount of used standard-temperature water are mapped with each other, the amount of standard-temperature water used at the corresponding period in historical water usage process may be further discretized using the amount of water difference between the amount of water may be supplied at two setting temperatures and thus the influence of abnormal sensor data on results. For example, assuming that the amount of standard-temperature water that may be supplied at 40°C setting temperature is 10 liters and the amount of water that can be supplied at 45°C setting temperature is 15 liters, the amount of standard-temperature water used at the corresponding period in historical water usage process may be further discretized using the amount of water difference (15-10=5) between the amount of used standard-temperature water may be supplied at 40°C setting temperature and 45°C setting temperature, that is, the amount of standard-temperature water used at the corresponding period in historical water usage process is processed into discrete data points such as 5 liters, 10 liters, 15 liters, 20 liters, and 25 liters.

[0062] Based on the content of the foregoing embodiment, in the present embodiment, the step 103' of predicting a setting temperature of the water heater at different periods in a future water usage process, based on the amount of standard-temperature water used at different periods in a historical water usage process and the amount of standard-temperature water that the water heater can supply at different setting temperatures specifically includes:

step C1: determining a setting temperature of the water heater at different periods of a day in historical water usage days, based on the amount of standard-temperature water used at different periods of the

day in the historical water usage days and the amount of standard-temperature water that the water heater can supply at different setting temperatures; and

step C2: predicting a setting temperature of the water heater at different periods of a day in a future water usage process, based on the setting temperature of the water heater at different periods of a day in historical water usage days.

[0063] In the present embodiment, the setting temperature corresponding to the different periods of each day in the historical water usage days is first determined based on the amount of standard-temperature water used at different periods of the day in the historical water usage days and the amount of standard-temperature water that the water heater can supply at the different setting temperatures and the setting temperature of the water heater at different periods of each day in the future water usage process may be predicted based on the setting temperature of the water heater corresponding to the different periods of each day in the historical water usage days.

[0064] Based on the content of the foregoing embodiment, in the present embodiment, the step C2 of predicting a setting temperature of the water heater at different periods of a day in a future water usage process, based on the setting temperature of the water heater at different periods of a day in historical water usage days specifically includes:

step C21: transmitting the setting temperature of the water heater at different periods of a day in historical water usage days to a client device;

step C22: receiving a voting value for the setting temperature of the water heater at different periods of a day in historical water usage days transmitted by the client device; and

step C23: predicting the setting temperature of the water heater at different periods of a day in a future water usage process, based on the voting value for the setting temperature of the water heater at different periods of a day.

[0065] In the present embodiment, the temperature voting mechanism is used to determine the setting temperature of the water heater at different periods of a day in a future water usage process. In the present embodiment, a probability threshold can be set. The larger the probability threshold, the lower the tolerance for small-probability water usage events. For example, for setting temperatures (setting temperatures matched well in step 103)) in a certain period, i.e., past six days, a voting mechanism is used to vote against a setting temperature that should be set for this time period in the next day. The voting mechanism here refers to transmitting the setting temperature of the water heater at different periods in the past 6 days to a use device, and then allowing the user to vote against the setting temperature of the water heater at different periods in past 6 days separately. For example, assuming that after matching in step 103, it is determined that the setting temperature corresponding to the period of 00:00-02:00 in past 6 days is 40°C, 40°C, 45°C, 45°C, 40°C, 40° C, these setting temperatures are then transmitted to the user and the user votes against these setting temperatures, and the final statistical voting result includes: 5 votes for 40°C setting temperature and 1 vote for 45°C setting temperature. It can be seen that the proportion of votes for 40°C setting temperature 40 is 5/6=0.83, and the proportion of votes for 45°C setting temperature of is 1/6=0.16. It should be noted that when the percentage of votes for a certain setting temperature (referring to the ratio of the number of votes for a certain setting temperature to that of historical water usage days) exceeds the set probability threshold (which can be 0.8), the setting temperature is regarded as the predicted setting temperature of the time period (also called the predicted value of the setting temperature the corresponding period) next day. According to the above example, for the period 00:00-02:00 in six days in the above example, the proportion of votes for 40°C setting temperature exceeds the set probability threshold of 0.8, so that 40°C setting temperature can be used as the predicted setting temperature at the present period of the next day. After the user votes, it is found that there is no setting temperature that the proportion of votes exceeds the set probability threshold, the highest gear of all the historical corresponding setting temperatures is selected as the predicted setting temperature at the period of next day. For example, for the period of 00:00-02:00 in six days of the above example, the 45°C setting temperature is selected as the predicted setting temperature at the period of next day.

[0066] It can be seen from the above scheme that in the present embodiment, using the temperature voting mechanism, and the setting temperature whose number of votes exceeds the set probability threshold is used as the predicted setting temperature, such that the predicted setting temperature can meet the user's water usage behavior with the greatest probability. In addition, in the present embodiment, the probability of occasional water usage events is estimated, and tolerance of minor-probability water usage events is controlled by controlling the probability threshold parameter.

[0067] Based on the content of the foregoing embodiment, in the present embodiment, the step C2 of predicting a setting temperature of the water heater at different periods of a day in a future water usage process, based on the setting temperature of the water heater at different periods of a day in historical water usage days specifically includes:

determining a highest setting temperature of the water heater at different periods of a day, based on the setting temperature of the water heater at different periods of a day in historical water usage days and

determining the highest setting temperature of the water heater at different periods of a day as the setting temperature of the water heater at different periods of a day in a future water usage process.

[0068] In the present embodiment, unlike the above-mentioned embodiments, the present embodiment does not need to use a voting mechanism, but directly uses the highest setting temperature among all setting temperatures under different historical water usage days corresponding to each time period as the predicted value of the setting temperature at different periods of the day in future water usage process, so as to ensure that the predicted setting temperature can meet the user's water demand with the greatest probability.

[0069] In addition, it should be noted that the historical water usage days in the present embodiment refers to the continuous historical water usage days by default. However, if the water heater has no continuous historical water usage days, the date of missing water usage data can be ignored. However, in practical applications, the allowable number of days of missing water usage data may be set. When the number of days of missing water usage data exceeds the allowable number of days of missing water usage data, and no prediction is made for the water heater. For example, the number of days of missing water usage data may be set to three days. When the number of days of missing water usage data exceeds three days and no prediction is made for the water heater. For example, when the water heater does not have 14 consecutive days of data, the most recent 14 days of data may be selected and the missing dates are ignored. In the present embodiment, the allowable number of missing days is 3 days, and no prediction is made for the water heater when the number of days of missing water usage data exceeds 3 days.

[0070] Based on the content of the foregoing embodiment, in the present embodiment, the method for automatically controlling the water heater further includes:

determining atmospheric temperature data at different periods in a future water usage process;
correcting the predicted setting temperature of the water heater at different periods of a day in a future water usage process, based on the atmospheric temperature data at different periods in a future water usage process; and
controlling the water heater based on the corrected setting temperature.

[0071] In the present embodiment, in order to precisely predict the water heater in various periods next day, the external atmospheric temperature data is further considered which is particularly important for areas where the outdoor temperature changes significantly. In the present embodiment, temperature data of the local weather forecast in next day needs to be obtained first as correction parameters. The difference between the specific implementation method and the above-mentioned embodiment is that after obtaining the setting temperature at different periods of the day in the future water usage process, the predicted setting temperature of the water heater at different periods of a day in a future water usage process is corrected using the atmospheric temperature data at different periods one day in a future water usage process and the water heater is controlled automatically based on the corrected setting temperature. when making specific corrections, the following corresponding relationship can be used, for example, the setting temperature of the corresponding time period increases by 5 degrees (maximum 75 degrees) when the atmospheric temperature decreases every 10 degrees.

[0072] Based on the content of the foregoing embodiment, in the present embodiment, the method for automatically controlling the water heater further includes:

determining saved power after the water heater is automatically controlled based on the predicted setting temperature of the water heater at different periods in a future water usage process;
determining a consumed power after the water heater is automatically controlled based on the predicted setting temperature of the water heater at different periods in a future water usage process; and
determining saved power cost based on the saved power, the consumed power and a ladder-type pricing model.

[0073] In the present embodiment, the power costs that can be saved after implementing the method for automatically controlling the water heater control according to the present embodiment are further given, so that the user can intuitively see the saved power, thereby improving user experience.

[0074] In the present embodiment, when the water heater is turned on first, the original setting temperature data before the water heater is turned on is recorded (if it is not turned on, the water heater will be heated and kept at the original setting temperature). After the water heater is turned on, it is automatically adjusted based on the predicted setting temperature output in the present embodiment. The original setting temperature, the predicted setting temperature output in the present embodiment, the ambient temperature and the water usage data are used to estimate saved power after the water heater is turned on by a fitting equation. After the saved power is estimated, a heating time of the water heater, a rated power of the water heater and the data of the ladder-type pricing data in the local area are obtained, and the consumed power during the operation of the water heater is calculated. Saved power costs (=consumed power+saved power)*pricing 1-consumed power*pricing 2 is then calculated. Pricing 1 and pricing 2 are ladder-type pricing.

[0075] According to the above description and analysis, it can be seen that the method for automatically con-

trolling the water heater according to the present embodiment can adapt to the user's water usage behavior, so that the water heater can operate in a low energy consumption mode under the premise of ensuring the water demand. In addition, in the present embodiment, using the temperature voting mechanism, and the setting temperature whose number of votes exceeds the set probability threshold is used as the predicted setting temperature, such that the predicted setting temperature can meet the user's water usage behavior with the greatest probability. In addition, in another embodiment, the maximum setting temperature is used as the predicted setting temperature, which ensures that the setting temperature meets the user's water demand with the greatest probability.

[0076] In addition, in the present embodiment, a certain degree of data loss can also be tolerated because the user's water usage habits in a certain period have no change in a short period, so even if the data of a certain period of a day is missing, it will not have significant influence on the final prediction result.

[0077] In addition, in the present embodiment, a certain degree of abnormal value can also be tolerated because the amount of actually used standard-temperature water is discretized by using the amount of standard-temperature water corresponding to a temperature section, which can effectively avoid influence of very large or very small abnormal value on the results.

[0078] In the present embodiment, it should be noted that the method for automatically controlling a water heater according to the present embodiment can be used in a storage-type electric water heater that uses water for bathing or catering. The present application does not limit this. According to actual needs, the method for automatically controlling a water heater according to the present embodiment can also be used in storage-type electric water heaters for other purposes.

[0079] In another embodiment of the present application, a device for automatically controlling a water heater is provided. Referring to FIG. 2, the device for automatically controlling a water heater includes: a first determiner11, a second determiner 12, a predictor 13 and controller 14, where

a first determiner 11 configured to determine the amount of water used at different periods in a historical water usage process;

a second determiner 12 configured to determine the amount of water that the water heater can supply at different setting temperatures;

a predictor 13 configured to predict a setting temperature of the water heater at different periods in a future water usage process, based on the amount of water used at different periods in a historical water usage process and the amount of water that the water heater can supply at different setting temperatures; and

a controller 14 configured to control the water heater based on the predicted setting temperature of the water heater at different periods in a future water usage process.

[0080] Since the device for automatically controlling a water heater according to the present embodiment can be used to implement the method for automatically controlling a water heater described in the foregoing embodiment, it has similar working principles and beneficial effects to the method, so that they will not be described in detail here, and the specific content can be referred to the introduction of the foregoing embodiment.

[0081] In still another embodiment of the present application, a water heater is provided including the device for automatically controlling a water heater according to the above embodiment.

[0082] Since the water heater according to the present embodiment includes the device for automatically controlling a water heater according to the above embodiment, it has similar working principles and beneficial effects to the method, so that they will not be described in detail here, and the specific content can be referred to the introduction of the foregoing embodiment.

[0083] In yet another embodiment of the present application, an electronic device is provided. Referring to Fig. 3, the electronic device specifically includes: a processor 301, a memory 302, a communication interface 303, and a bus 304;

wherein the processor 301, the memory 302 and the communication interface 303 communicate with each other through the bus 304; the communication interface 303 is configured to implement information transmission between various modeling software and intelligent manufacturing equipment module libraries and other related equipment transmission; and

the processor 301 is configured to call computer programs in the memory 302, when executed by the processor, the computer programs cause the processor to implement steps of the method for automatically controlling the water heater mentioned above, for example, determining the amount of water used at different periods in a historical water usage process; determining the amount of water that the water heater can supply at different setting temperatures; predicting a setting temperature of the water heater at different periods in a future water usage process, based on the amount of water used at different periods in a historical water usage process and the amount of water that the water heater can supply at different setting temperatures; and controlling the water heater based on the predicted setting temperature of the water heater at different periods in a future water usage process.

[0084] It should be noted that the electronic device mentioned in the present embodiment may be a mobile

terminal or a cloud server.

[0085] According to yet still another embodiment of the present application, a non-transitory computer-readable storage medium having stored thereon computer programs, when executed by a processor, the computer programs cause the processor to implement steps of the method for automatically controlling the water heater mentioned above, for example, determining the amount of water used at different periods in a historical water usage process; determining the amount of water that the water heater can supply at different setting temperatures; predicting a setting temperature of the water heater at different periods in a future water usage process, based on the amount of water used at different periods in a historical water usage process and the amount of water that the water heater can supply at different setting temperatures; and controlling the water heater based on the predicted setting temperature of the water heater at different periods in a future water usage process.

[0086] In addition, the logic instructions in the memory described above may be implemented in the form of a software functional unit and may be stored in a computer readable storage medium while being sold or used as a separate product. Based on such understanding, the technical solution of the present application or a part of the technical solution, which is essential or contributes to the prior art, may be embodied in the form of a software product, which is stored in a storage medium, including several instructions to cause a computer device (which may be a personal computer, server, or network device, etc.) to perform all or part of the steps of the methods described in various embodiments of the present application. The storage medium described above includes: a U disk, a mobile hard disk, a read-only memory (ROM), a random access memory (RAM), a magnetic disk, or an optical disk, and the like.

[0087] The device embodiments described above are merely illustrative, wherein the units described as separate components may or may not be physically separate, and the components displayed as units may or may not be physical units, that is, may be located at the same place, or it can be distributed to multiple network units. Some or all of the modules may be selected according to actual needs to achieve the purpose of the solution of the embodiment. Those of ordinary skill in the art can understand and implement the embodiments described above without paying creative labors.

[0088] Through the description of the embodiments above, those skilled in the art can clearly understand that the various embodiments can be implemented by means of software and a necessary general hardware platform, and of course, by hardware. Based on such understanding, the technical solution of the present application or a part of the technical solution, which is essential or contributes to the prior art, may be embodied in the form of a software product, which is stored in a storage medium such as ROM/RAM, magnetic Discs, optical discs, etc., including several instructions to cause a computer device (which may be a personal computer, server, or network device, etc.) to perform various embodiments or a part of the methods described in various embodiments.

[0089] In the description of the present application, it is to be noted that the orientation or positional relationships indicated by terms such as "upper", "lower", etc. are based on the orientation or positional relationship shown in the drawings, and are merely for the convenience of describing the present application and simplifying the description, rather than indicating or implying that the device or component stated must have a particular orientation, is constructed and operated in a particular orientation, and thus is not to be construed as limiting the disclosure. Unless explicitly stated and defined otherwise, the terms "installed," "connected with," and "connected" shall be understood broadly, for example, it may be either fixedly connected or detachably connected, or can be integrated; it may be mechanically connected, or electrically connected; it may be directly connected, or indirectly connected through an intermediate medium and the communication between the interior of two elements. The specific meanings of the terms above in the present application can be understood by a person skilled in the art in accordance with specific conditions.

[0090] In addition, in the present application, terms such as "first" and "second" are only used for descriptive purposes, and cannot be understood as indicating or implying relative importance or implicitly indicating the number of technical features indicated. Therefore, the features defined with "first" and "second" may explicitly or implicitly include at least one of the features. In the description of the present application, "a plurality of' means at least two, such as two, three, etc., unless specifically defined otherwise.

[0091] Further, in the present application, relational terms such as "first" and "second" are only used to distinguish one entity or operation from another entity or operation, and do not necessarily require or imply any such actual relation or order among these entities or operations. Also, the terms "include", "including" or any other variants thereof are intended to cover non-exclusive inclusion, so that a process, a method, an article, or a device that includes a series of elements includes not only those elements, but also includes other elements which are not explicitly listed or also include elements inherent to the process, the method, the article or the device. If there are no more limitations, the element defined by the sentence "including a..." does not exclude the existence of other same elements in the process, method, article, or equipment including the element.

[0092] In the description of this specification, descriptions with reference to the terms "one embodiment", "some embodiments", "examples", "specific examples", or "some examples" etc. mean that specific features, structure, materials or characteristics described in conjunction with the embodiment or example are included in at least one embodiment or example of the embodiments of the present application. In this specification, the sche-

matic expressions of the above terms do not necessarily refer to the same embodiment or example. Also, the described specific features, structures, materials or characteristics can be combined in any one or more embodiments or examples in a suitable manner. In addition, those skilled in the art may integrate and combine the different embodiments or examples and the features of the different embodiments or examples described in this specification without contradicting each other.

[0093] Finally, it should be noted that the above embodiments are only used to explain the technical solutions of the present application, and are not limited thereto; although the present application is described in detail with reference to the foregoing embodiments, it should be understood by those skilled in the art that they can still modify the technical solutions described in the foregoing embodiments and make equivalent replacements to a part of the technical features and these modifications and substitutions do not depart from the spirit and scope of the technical solutions of the embodiments of the present application.

Claims

1. A method for automatically controlling a water heater, comprising:

   determining amount of water used at different periods in a historical water usage process;
   determining amount of water that the water heater is able to supply at different setting temperatures;
   predicting a setting temperature of the water heater at corresponding different periods in a future water usage process, based on the amount of water used at different periods in the historical water usage process and the amount of water that the water heater is able to supply at different setting temperatures; and
   controlling the water heater based on the predicted setting temperature of the water heater at corresponding different periods in the future water usage process.

2. The method for automatically controlling the water heater of claim 1, wherein the determining the amount of water used at different periods in the historical water usage process comprising:

   determining amount of standard-temperature water used at different periods in the historical water usage process,
   wherein the amount of the used standard-temperature water is obtained by converting amount of water used at different temperature conditions into amount of water used at the standard-temperature.

3. The method for automatically controlling the water heater of claim 2, wherein the determining the amount of standard-temperature water used at different periods in the historical water usage process comprising:

   determining amount of actually used water, an intra-tank temperature and an inlet water temperature at different periods in the historical water usage process; and
   determining, based on the amount of actually used water, the intra-tank temperature and the inlet water temperature at different periods in the historical water usage process, the amount of standard-temperature water used at different periods in the historical water usage process by using a model of the first preset amount of used standard-temperature water;
   wherein the model of the first preset amount of used standard-temperature water is a model that represents a corresponding relationship between the amount of actually used water and the amount of used standard-temperature water at different intra-tank temperatures and inlet water temperatures.

4. The method for automatically controlling the water heater of claim 3, wherein the model of the first preset amount of used standard-temperature water is as follows:

$$Q_1 = Q_0 * \left(1 + \frac{T_1 - T_0}{T_0 - T_2}\right)$$

   where Q_1 represents a first amount of used standard-temperature water, Q_0 represents the amount of actually used water, T_0 represents the standard-temperature, T_1 represents the intra-tank temperature, and T_2 represents the inlet water temperature.

5. The method for automatically controlling the water heater of any one of claims 2 to 4, wherein the determining the amount of water that the water heater is able to supply at different setting temperatures comprises:
   determining the amount of standard-temperature water that the water heater is able to supply at different setting temperatures;

6. The method for automatically controlling the water heater of claim 5, wherein the determining the amount of standard-temperature water that the water heater is able to supply at different setting temperatures comprises:

   determining, based on different setting temper-

atures, inlet water temperatures and a rated capacity of the water heater, the amount of standard-temperature water that the water heater is able to supply at different setting temperatures by a model of second preset amount of used standard-temperature water;
wherein the model of the second preset amount of used standard-temperature water is a model that represents a corresponding relationship between the rated capacity of the water heater and the amount of used standard-temperature water at different setting temperatures and inlet water temperatures.

7. The method for automatically controlling the water heater of claim 6, wherein the model of the second preset amount of used standard-temperature water is as follows:

$$Q_2 = Q * \left(1 + \frac{T_3 - T_0}{T_0 - T_2} \right)$$

where Q_2 represents a second amount of used standard-temperature water, Q represents the rated capacity of the water heater, T_2 represents the setting temperature, T_0 represents the standard-temperature, and T_2 represents the inlet water temperature.

8. The method for automatically controlling the water heater of claim 5, wherein the predicting the setting temperature of the water heater at corresponding different periods in the future water usage process, based on the amount of water used at different periods in the historical water usage process and the amount of water that the water heater is able to supply at different setting temperatures comprises:
predicting the setting temperature of the water heater at different periods in the future water usage process, based on the amount of the standard-temperature water used at different periods in the historical water usage process and the amount of standard-temperature water that the water heater is able to supply at different setting temperatures.

9. The method for automatically controlling the water heater of claim 8, wherein the predicting the setting temperature of the water heater at different periods in the future water usage process, based on the amount of standard-temperature water used at different periods in the historical water usage process and the amount of standard-temperature water that the water heater is able to supply at different setting temperatures comprises:

determining the setting temperature of the water heater at different periods of a day in historical water usage days, based on the amount of standard-temperature water used at different periods of the day in the historical water usage days and the amount of standard-temperature water that the water heater is able to supply at different setting temperatures; and
predicting the setting temperature of the water heater at corresponding different periods of a day in the future water usage process, based on the setting temperature of the water heater at different periods of the day in historical water usage days.

10. The method for automatically controlling the water heater of claim 9, wherein the predicting the setting temperature of the water heater at corresponding different periods of the day in the future water usage process, based on the setting temperature of the water heater at different periods of the day in historical water usage days comprises:

transmitting the setting temperature of the water heater at different periods of the day in historical water usage days to a client device;
receiving a voting value for the setting temperature of the water heater at different periods of the day in historical water usage days transmitted by the client device; and
predicting the setting temperature of the water heater at corresponding different periods of the day in the future water usage process, based on the voting value for the setting temperature of the water heater at different periods of the day.

11. The method for automatically controlling the water heater of claim 9, wherein the predicting the setting temperature of the water heater at corresponding different periods of the day in the future water usage process, based on the setting temperature of the water heater at different periods of the day in historical water usage days comprises:

determining a highest setting temperature of the water heater at different periods of the day, based on the setting temperature of the water heater at different periods of the day in historical water usage days, and
determining the highest setting temperature of the water heater at different periods of the day as the setting temperature of the water heater at corresponding different periods of the day in the future water usage process.

12. The method for automatically controlling the water heater of claim 1, further comprising:

determining atmospheric temperature data at

different periods in the future water usage process;

correcting the predicted setting temperature of the water heater at corresponding different periods in the future water usage process, based on the atmospheric temperature data at different periods in the future water usage process; and

controlling the water heater based on the corrected setting temperature.

13. The method for automatically controlling the water heater of claim 1, further comprising:

determining saved power after the water heater is automatically controlled based on predicted setting temperature of the water heater at corresponding different periods in the future water usage process;

determining consumed power after the water heater is automatically controlled based on the predicted setting temperature of the water heater at corresponding different periods in the future water usage process; and

determining saved power cost based on the saved power, the consumed power and a ladder-type pricing model.

14. A device for automatically controlling a water heater, comprising:

a first determiner configured to determine amount of water used at different periods in a historical water usage process;

a second determiner configured to determine amount of water that the water heater is able to supply at different setting temperatures;

a predictor configured to predict a setting temperature of the water heater at corresponding different periods in the future water usage process, based on the amount of water used at different periods in the historical water usage process and

the amount of water that the water heater is able to supply at different setting temperatures; and

a controller configured to control the water heater based on the predicted setting temperature of the water heater at corresponding different periods in the future water usage process.

15. A water heater, comprising the device for automatically controlling the water heater of claim 14.

16. An electronic device comprising:

a processor; and

a memory configured to store computer programs that, when executed by the processor, causes the processor to perform a method for automatically controlling a water heater of any one of claims 1 to 13.

17. A non-transitory computer-readable storage medium storing computer programs which are executed by a processor to perform a method for automatically controlling a water heater of any one of claims 1 to 13.

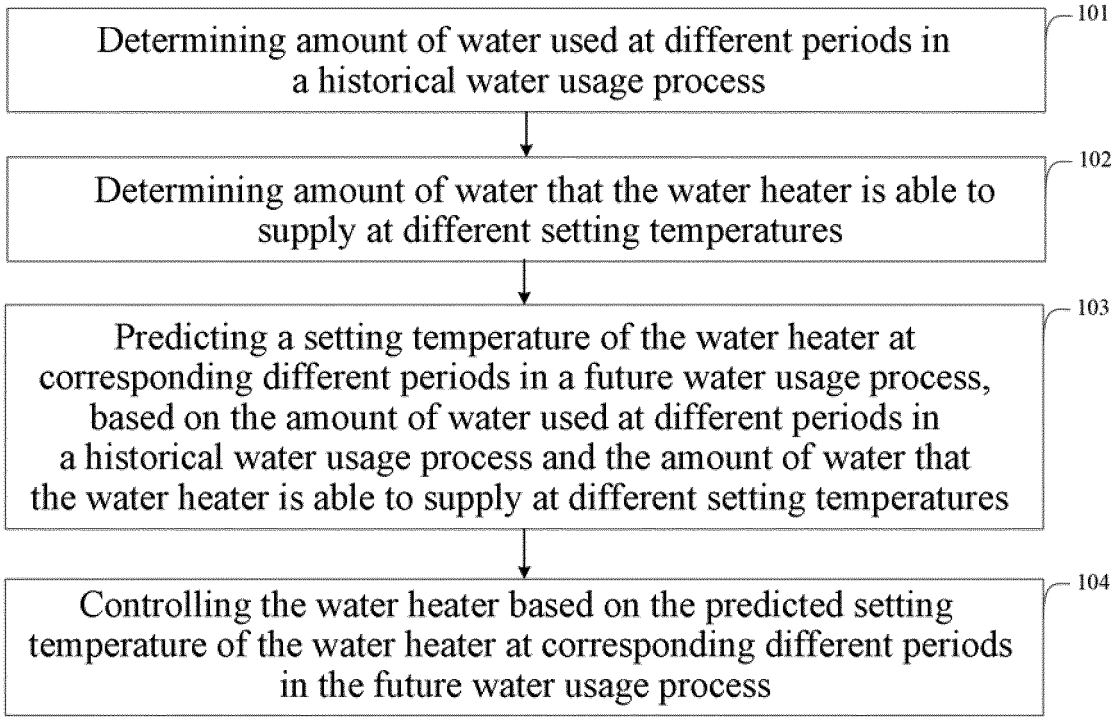
Determining amount of water used at different periods in a historical water usage process
101
Determining amount of water that the water heater is able to supply at different setting temperatures
102
Predicting a setting temperature of the water heater at corresponding different periods in a future water usage process, based on the amount of water used at different periods in a historical water usage process and the amount of water that the water heater is able to supply at different setting temperatures
103
Controlling the water heater based on the predicted setting temperature of the water heater at corresponding different periods in the future water usage process
104

FIG. 1

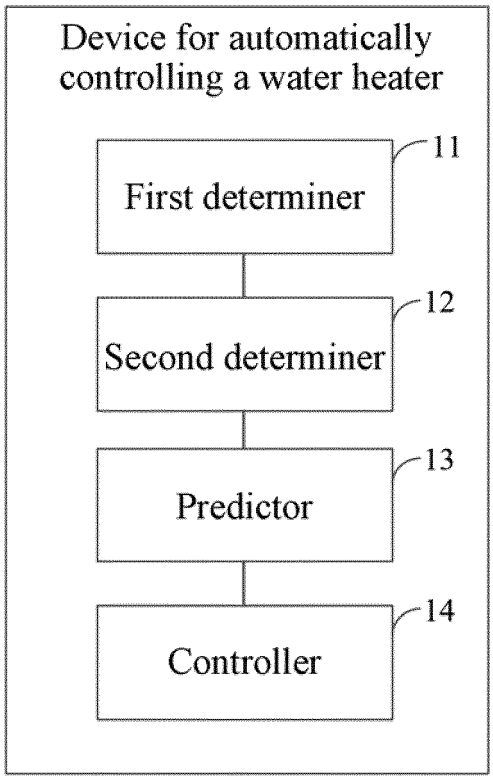
Device for automatically controlling a water heater
First determiner
11
Second determiner
12
Predictor
13
Controller
14

FIG. 2

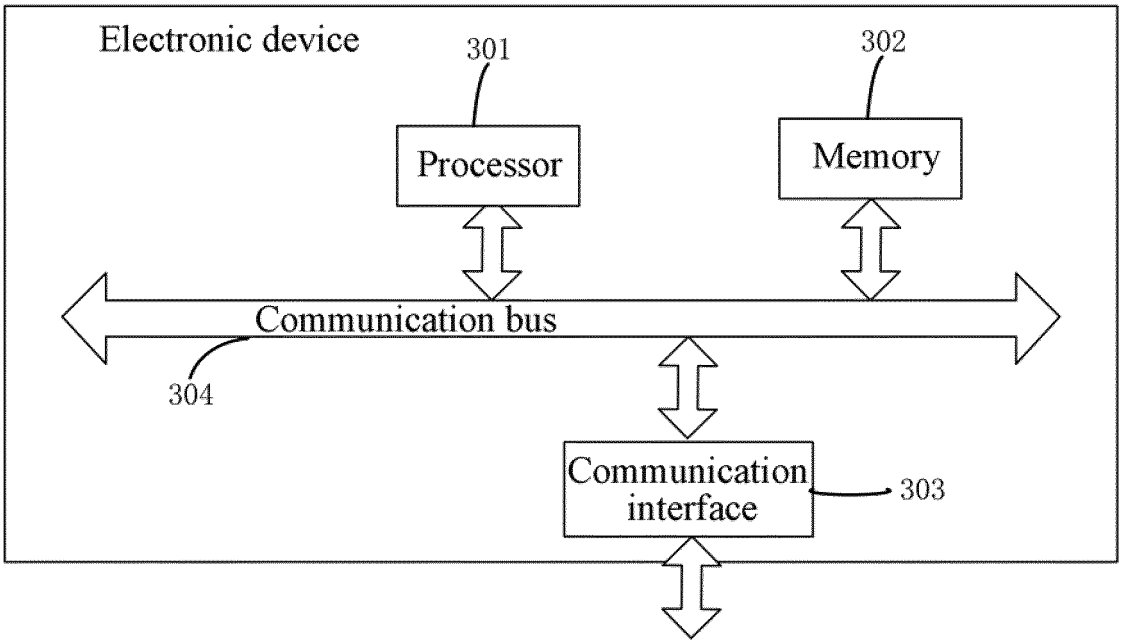
Electronic device
301
302
Processor
Memory
Communication bus
304
Communication interface
303

FIG. 3

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2019/130501

A. CLASSIFICATION OF SUBJECT MATTER

F24H 9/20(2006.01)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)

F24H

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, CNKI, DWPI, VEN: 热水器, 自动控制, 历史, 不同, 时间段, 用水量, 设置温度, 供应, 预测, heater, auto control, past, different, time, water consumption, set temperature, supply, forecast

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	CN 108931060 A (LI, Hailei) 04 December 2018 (2018-12-04) description paragraphs [0062]-[0134], figures 1-9	1-17
Y	CN 107918795 A (QINGDAO ECONOMIC DEVELOPMENT ZONE HAIER WATER HEATER CO., LTD.) 17 April 2018 (2018-04-17) description paragraphs [0069]-[0110], figures 1-7	1-17
PX	CN 110530035 A (MIDEA GROUP CO., LTD.) 03 December 2019 (2019-12-03) claims 1-17	1-17
A	CN 105972829 A (GREE ELECTRIC APPLIANCES, INC. OF ZHUHAI) 28 September 2016 (2016-09-28) entire document	1-17
A	CN 108826701 A (QINGDAO HAIER SCIENCE & TECHNOLOGY CO., LTD.) 16 November 2018 (2018-11-16) entire document	1-17
A	GB 2428782 A (CAMETRICS LTD) 07 February 2007 (2007-02-07) entire document	1-17

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

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
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"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
03 June 2020	**16 June 2020**
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**	Authorized officer
Facsimile No. **(86-10)62019451**	Telephone No.

Form PCT/ISA/210 (second sheet) (January 2015)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2019/130501

Patent document cited in search report	Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
CN 108931060 A	04 December 2018	None	
CN 107918795 A	17 April 2018	None	
CN 110530035 A	03 December 2019	None	
CN 105972829 A	28 September 2016	CN 105972829 B	12 October 2018
CN 108826701 A	16 November 2018	None	
GB 2428782 A	07 February 2007	GB 0515260 D0	31 August 2005

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 2019108757046 **[0001]**