

METHOD FOR ROBOT ELEVATOR-TAKING PATH PLANING AND CROWD SIZE PREDICTION, AND COMPUTER DEVICE

The present disclosure claims the priority of the Chinese patent application filed on February 21th, 2022 before the Chinese Patent Office with the application number of 202210158526.7; the priority of the Chinese patent application filed on November 29th, 2021 before the Chinese Patent Office with the application number of 202111433207.4; the priority of the Chinese patent application filed on August 6th, 2021 before the Chinese Patent Office with the application number of 202110901196.1; the entire contents of which are incorporated herein by reference.

TECHNICAL FIELD

The present disclosure relates to the technical field of intelligent equipment, and more particularly, to a method for robot elevator-taking path planning and crowd size prediction, an apparatus, an computer device and a storage medium.

BACKGROUND

Elevator, as a convenience tool, has almost become a necessity for modern buildings. From residential buildings to office buildings, shopping malls to subway stations, elevators are everywhere providing reliable and fast vertical movement for people and goods. Taking elevators has become a common thing in modern people's life. However, with the continuous improvement and refinement of the elevator, people's dependence on the elevator is also increasing, especially for super high-rise buildings, elevators are indispensable. As a result, we have also observed some new worries, such as, people waiting in line for elevators during rush hours and frequent stops of a single elevator on the move, which makes it difficult for people to estimate the time for going up or down the stairs, which could cause rush and anxiety; Moreover, the time difference between the actual and the expected waiting and taking of the elevator can easily cause disruption to a tight schedule (e.g., taking a

taxi).

On the other hand, considering the transportation efficiency, stability and energy consumption of goods, riding an elevator is the best choice for the robot to move across floors in a building, especially when there are many floors, riding an elevator is almost the only option. In order to ensure transmission efficiency, high-rise buildings are often equipped with multiple groups of elevators corresponding to different floors, so that the number of floors that can affect a single elevator group is not too many. Depending on the architectural design, the floors may be divided into high-rise area and basement area according to the physical height, transfer floor and sightseeing floor according to the attributes, and odd or even floors. At the same time, with the flow of people, the elevator elevator-waiting periods is also changing. For robots working in the building distribution scenario, it is also necessary to predict the time of matching elevator and taking elevator, so as to carry out advance planning and real-time correction of the path, so as to provide users with accurate future expectations.

Furthermore, since the operation data of the elevator contains information on the flow of people. We can deduce the population size of each floor based on the stopping and load changes of the elevator. Real-time control of the number of personnel in each floor of the building will undoubtedly contribute greatly to the intelligent management of the entire building. However, most elevator weighing systems do not have the function of information transmission. At the same time, because the weighing system is embedded in the elevator, the transformation and upgrading of it will produce a large cost. In comparison, relying on external IoT equipment to monitor elevator operation in real time is a cheaper and more versatile solution. This scheme can quickly and completely collect elevator movement information, but there is no good means in terms of load. First, the cost of camera control is high, which is not conducive to privacy protection. Second, due to the field of vision, shielding and other factors, it is difficult to avoid large deviations.

SUMMARY

Based on this, it is necessary to provide a method for robot elevator-taking path planning and crowd size prediction, apparatus, computer device and storage medium for the above technical problems. It can adapt to the division of various floors and provide several optimal paths of elevator and time expectation according to the starting floor and target floor. It provides the robot user with an accurate expected periods of elevator ride, and the robot can plan the path in advance and correct deviation in real time according to the expected periods of elevator ride, which improves the efficiency of robot task execution. It can also accurately estimate the population size of each floor of a building, providing corresponding data support for a more general building scenario.

According to various embodiments of the present disclosure, a method for robot elevator-taking path planning and crowd size prediction, apparatus, computer device and storage medium are provided.

In an embodiment, the embodiment of the present disclosure provides a method for robot elevator-taking path planning, including:

- step S1, obtaining the starting floor and the ending floor of the robot;
- step S2, determining all elevator groups that can reach the starting floor to form a cache path sequence; wherein, each cache path in the cache path sequence includes an elevator group sequence, an elevator sequence, a floor sequence and an expected time point sequence;
- step S3, traversing all the cache paths, if the elevator group corresponding to the traversed cache path can reach the ending floor directly, adding the cache path to the available path sequence; otherwise, taking the last floor in the floor sequence of the elevator group corresponding to the current cache path as the current floor;
- traversing all transfer elevator groups reachable from the current floor, and excluding the duplicate elevator groups in all transfer elevator groups and the current cache path; if the traversed transfer elevator group can reach the ending floor, adding the transfer elevator group and the ending floor to the current cache path, and adding the current cache path to the available path sequence as an elevator-taking path; and
- step S4, repeating the step S3 until all cache paths are traversed.

In some embodiments, further includes:

step S5, after traversing all cache paths, adding 1 to the pathfinding count value; wherein, the initial value of the pathfinding count is 0;

step S6, repeating the steps S3 to S5 until the pathfinding count value is greater than n ; wherein, n is less than or equal to the number of elevator groups; and arranging the elevator-taking paths in the available path sequence in up order of the number of elevator-taking nodes; wherein, the elevator-taking node represents the process of taking a single elevator, and the elevator-taking node includes an elevator group, an elevator, a starting floor, an ending floor, expected start time and expected end time.

10 In some embodiments, wherein the elevator-taking path, the elevator group, elevator, and starting floor of the elevator-taking node i correspond to the i^{th} element of the elevator group sequence, elevator sequence, and floor sequence in the elevator-taking path, respectively; the ending floor of the elevator-taking node corresponds to the $(i+1)^{th}$ element of the floor sequence in the elevator-taking path.

15 In some embodiments, wherein the step S3, if the transfer elevator group cannot reach the terminal floor, the current cache path is used as a blueprint to increase the elevator-taking nodes from the current floor to all floors reachable by the transfer elevator group to form a new path, add the new path to the cache path sequence.

In some embodiments, wherein the method further comprises:

20 step S7, if the available path sequence is empty, determining the start time of the robot movement and the end time of reaching the elevator; and determining a number of supplementary paths according to the start time and the end time, as well as the elevator-waiting periods of each elevator in the cached route and the elevator-taking time to the ending floor.

25 In some embodiments, wherein the determining a number of supplementary paths according to the start time and the end time, as well as the elevator-waiting periods of each elevator in the cached route and the elevator-taking time to the ending floor comprises:

converting the elevator group sequence and floor sequence of the cache path into nodes in sequence, wherein the i^{th} node corresponds to the i^{th} elevator group from

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the i^{th} floor to the $(i+1)^{th}$ floor;

determining the elevator-waiting periods for each elevator in node i to reach the i^{th} floor in the desired direction, as well as the elevator-taking periods to the $(i+1)^{th}$ floor.

Calculating the new start time and new end time based on the elevator-waiting periods and elevator-taking periods of each elevator in the cached path, arranging the m supplementary paths with the earliest end time according to the new end time, and determining a new elevator-taking path according to the supplementary path.

In some embodiments, wherein the method involves a server and a client, the client includes a robot; and the method comprises:

- 10 obtaining the historical data of the elevator group in each preset time period;
- calculating the expected data of each floor of the individual elevators in the elevator group according to the historical data; and
- receiving the elevator-taking request sent by the robot, and return the building information and the expected data according to the elevator-taking request; the robot
- 15 configured for calculating the final expected periods according to the building information and the expected data.

In some embodiments, wherein calculating the expected data of each floor of the individual elevators in the elevator group according to the historical data comprises:

- obtaining the expected stopping times and average stopping periods of the elevator
- 20 group in each of the preset time periods according to the historical data;
- converting the expected stopping times and average stopping periods into the expected stopping probability of individual elevators in the elevator group;
- calculating the expected moving periods according to the elevator information of the elevator group;
- 25 calculating the expected elevator-waiting periods according to the expected moving periods, the average stopping periods and the expected stopping probability;
- calculating the expected stopping periods according to the average stopping periods and the expected stopping probability; and
- storing the expected moving periods, the expected elevator-waiting periods and the
- 30 expected stopping periods.

In some embodiments, wherein the expected data includes expected moving periods, expected elevator-waiting periods and expected stopping periods of each floor of individual elevators within a preset time period.

5 In some embodiments, wherein the robot configured for calculating the final expected periods according to the building information and the expected data comprises:

the robot obtains all non-repetitive elevator group paths from the starting floor to the target floor according to the building information; calculates the final expected periods of all elevator group paths; selects the elevator group path with the shortest
10 final expected periods or several shorter elevator group paths.

In some embodiments, wherein the elevator-taking request includes a user identification code, user authentication information, and elevator-taking information, and the elevator-taking information includes a start time, starting floor and target floor.

15 In an embodiment, the embodiment of the present disclosure provides a method for floor crowd size prediction based on elevator operation data, including:

obtaining event messages, position information and elevator running state during the running process of the elevator, wherein the running state of the elevator includes up and down, the position information includes the current position and the passing
20 floors during the running process;

determining an elevator passenger carrying state based on the event message, wherein the elevator carrying state includes carrying passengers and not carrying passengers;

if the current position is a stopping floor, updating the crowd index of each floor
25 based on the elevator passenger carrying state and the elevator running state to obtain the updated crowd index of each floor; and

determining the crowd size of each floor based on the preset judgment condition and the target index; wherein the target index is the updated crowd index obtained after the elevator runs for a preset cycle.

30 In some embodiments, wherein determining an elevator passenger carrying state

based on the event message comprises:

if the event message includes a door opening event, recording the time corresponding to the door opening event as the first-time node, and continue to monitor the event message of the elevator running process;

- 5 recording a time node corresponding to the elevator startup event as a second-time node when receiving an event message including an elevator startup event;

calculating the difference between the first-time node and the second-time node as the startup operation interval; and

- comparing the startup operation interval with the preset startup threshold, if the
10 startup operation interval exceeds the preset startup threshold, confirming that the elevator passenger carrying state is not carrying passengers, otherwise, confirming that the elevator passenger carrying state is carrying passengers.

In some embodiments, wherein the elevator passenger carrying state is carrying passengers, and if the current position is a stopping floor, updating the crowd index

- 15 of each floor based on the elevator passenger carrying state and the elevator running state to obtain the updated crowd index of each floor comprises:

adding 1 to the crowd index of the floor corresponding to the current position when the elevator running state is up, and determining whether the floor corresponding to the current position is an access floor;

- 20 if the floor corresponding to the current position is the access floor, subtracting 1 from the crowd index of the access floor to obtain the updated crowd index of each floor; and

if the floor corresponding to the current position is a non-access floor and the floor corresponding to the current position is the floor that stops for the first time in this

- 25 up, subtracting 1 from the crowd index of the last passing floor of the floor corresponding to the current position to obtain the updated crowd on each floor index.

In some embodiments, wherein the elevator passenger carrying state is carrying passengers, and if the current position is a stopping floor, updating the crowd index of each floor based on the elevator passenger carrying state and the elevator running

- 30 state to obtain the updated crowd index of each floor further comprises:

determine whether the current position is an access floor when the elevator running state is down;

if the current location is the access floor; subtracting 1 from the crowd index of the floor passing by the elevator during this running process and clear the record of the floor passing by; and

if the current location is the non-access floor; subtracting 1 from the crowd index of the floor passing by the elevator during this running process, adding 1 to the crowd index of the floor corresponding to the current position of the elevator and clear the passing floor record.

10 In some embodiments, wherein the elevator passenger carrying state is not carrying passengers, and if the current position is a stopping floor, updating the crowd index of each floor based on the elevator passenger carrying state and the elevator running state to obtain the updated crowd index of each floor further comprises:

15 determining whether the current location is an access floor based on the location information;

if the current location is the access floor; subtracting 1 from the crowd index of the floor passing by the elevator during this running process and clear the record of the floor passing by; and

20 if the current location is the non-access floor; subtracting 1 from the crowd index of the floor passing by the elevator during this running process, adding 1 to the crowd index of the floor corresponding to the current position of the elevator and clear the passing floor record.

In an embodiment, the embodiment of the present disclosure provides a apparatus for robot elevator-taking path planning, including:

25 an initialize module configured for obtaining the starting floor and the ending floor of the robot;

a cache path module configured for determining all elevator groups that can reach the starting floor to form a cache path sequence; wherein, each cache path in the cache path sequence includes an elevator group sequence, an elevator sequence, a

30 floor sequence and an expected time point sequence;

an available path determination module configured for traversing all the cache paths, if the elevator group corresponding to the traversed cache path can reach the ending floor directly, adding the cache path to the available path sequence; otherwise, taking the last floor in the floor sequence of the elevator group corresponding to the current
5 cache path as the current floor;

traversing all transfer elevator groups reachable from the current floor, and excluding the duplicate elevator groups in all transfer elevator groups and the current cache path; if the traversed transfer elevator group can reach the ending floor, adding the transfer elevator group and the ending floor to the current cache path, and adding
10 the current cache path to the available path sequence as an elevator-taking path; and repeating the above steps until all cache paths are traversed.

In an embodiment, the embodiment of the present disclosure provides a prediction apparatus of floor crowd size based on elevator operation data, including:

an information acquisition module configured for obtaining event messages,
15 position information and elevator running state during the running process of the elevator, wherein the running status of the elevator includes up and down, the position information includes the current position and the passing floors during the running process;

a state determination module configured for determining an elevator passenger
20 carrying state based on the event message, wherein the elevator carrying state includes carrying passengers and not carrying passengers;

an index update module configured for, if the current position is a stopping floor, updating the crowd index of each floor based on the elevator passenger carrying state and the elevator running state to obtain the updated crowd index of each floor; and

25 a size determination module configured for determine the crowd size of each floor based on the preset judgment condition and the target index; wherein the target index is the updated crowd index obtained after the elevator runs for a preset period.

In an embodiment, the embodiment of the present disclosure provides A computer device, comprising a memory and one or more processors, computer-readable
30 instructions are stored in the memory, and the computer-readable instructions, when

being executed by the one or more processors, enables the one or more processors to execute the steps of the method provided in any embodiments of the present disclosure.

5 In an embodiment, the embodiment of the present disclosure provides a computer-readable storage medium storing a computer program, wherein the computer program, when executed by a processor, implements the steps of the method provided in any embodiments of the present disclosure.

Other features and advantages of this disclosure are set forth in subsequent specifications and, in part, become apparent from the specifications or are known
10 through the implementation of this disclosure. The purposes and other advantages of this disclosure are realized and obtained in such structures as are specifically indicated in the specification, claims and appended drawings, and details of one or more embodiments of this disclosure are set out in the appended drawings and descriptions below.

15 In order to make the above purposes, features and advantages of this disclosure more obvious and understandable, alternative embodiments are given below, and detailed in conjunction with the attached drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

In order to more clearly explains openly practiced cases of existing technology or
20 the technical scheme, the following described for example or existing technology in the appended drawings of the need to use introduce simply, clearly, for the purpose of this field common technical personnel, under the premise of not pay a creative labor, can also according to the appended drawings for other appended drawings.

FIG. 1A is a scenario diagram of the method for robot elevator-taking path planning
25 and crowd size predictions provided by one or more embodiments of the present disclosure;

FIG. 1B is another scenario diagram of the method for robot elevator-taking path planning and crowd size predictions provided by one or more embodiments of the present disclosure;

FIG. 2 is a flowchart of the method for robot elevator-taking path planning and crowd size predictions provided by one or more embodiments of the present disclosure;

5 FIG. 3 is an elevator-taking path diagram of the method for robot elevator-taking path planning and crowd size predictions provided by one or more embodiments of the present disclosure;

FIG. 4 is a schematic diagram of elevator group path complementation process in the method for robot elevator-taking path planning and crowd size predictions provided by one or more embodiments of the present disclosure;

10 Figure 5 is another flowchart of the method for robot elevator-taking path planning and crowd size predictions provided by one or more embodiments of the present disclosure;

15 FIG. 6 is a schematic diagram of the expected data stored in the robot elevator-taking path planning and crowd size methods provided by one or more embodiments of present disclosure;

Figure 7 is another flowchart of the method for robot elevator-taking path planning and crowd size prediction provided by one or more embodiments of present disclosure;

20 Figure 8 is another flowchart of the method for robot elevator-taking path planning and crowd size prediction provided by one or more embodiments of present disclosure;

FIG. 9 is a specific schematic diagram of the crowd size of each floor in the method for robot elevator-taking path planning and crowd size prediction provided by one or more embodiments of present disclosure;

25 FIG. 10 is another specific schematic diagram of the crowd size of each floor in the method for robot elevator-taking path planning and crowd size prediction provided by one or more embodiments of present disclosure;

FIG. 11 is a structure diagram of the robot elevator-taking path planning and crowd scale prediction device provided by one or more embodiments of present disclosure;

30 FIG. 12 is another structure diagram of the robot elevator-taking path planning and

crowd scale prediction device provided by one or more embodiments of present disclosure;

FIG. 13 is another structure diagram of the robot elevator-taking path planning and crowd scale prediction device provided by one or more embodiments of present disclosure;

FIG. 14 is a schematic structural diagram of a computer device provided by the embodiments of the present disclosure.

DETAILED DESCRIPTION OF THE EMBODIMENTS

In order to gain a clearer understanding of the purposes, features, and advantages of the disclosure, further description of the disclosure scheme is provided below. It should be noted that, under the condition of no conflict, the disclosed embodiments and the features in them can be combined with each other.

Many details are explained in the following description to fully understand this disclosure, but this disclosure can be implemented in ways other than those described here; obviously, the embodiments in the specification are only part of this disclosure and not all embodiments.

The terms “first” and “second” in this disclosure specification and claims are used to distinguish between different objects and are not used to describe a particular order of objects. For example, the first camera and the second camera are used to distinguish between different cameras, not to describe a particular order of cameras.

In this disclosure embodiment, the words “exemplary” or “for example” are used to indicate an example, illustration, or illustration. No embodiments or designs described as “exemplary” or “for example” in this disclosed embodiment shall be construed to be superior or superior to other embodiments or designs. Specifically, the use of words such as “exemplary” or “for example” is intended to present the relevant concepts in a concrete manner, and in the description of this disclosed embodiment, “more than one” means two or more, unless otherwise specified.

In order to ensure transmission efficiency, high-rise buildings are often equipped with multiple groups of elevators corresponding to different floors, so that the

number of floors that can affect a single elevator group is not too many. Depending on the architectural design, the floors may be divided into high-rise area and basement area according to the physical height, transfer floor and sightseeing floor according to the attributes, and odd or even floors. At the same time, with the flow of people, the elevator-waiting periods is also changing.

Therefore, an elevator-taking path planning method is needed, so that the robot can calculate and modify the riding elevator scheme in real-time and estimate the elevator-taking time, so that the user can have a better prediction of the robot's moving process.

Therefore, the embodiment of the invention provides a method, system and related products for robot elevator-taking path planning and crowd size prediction, which can adaptively plan the elevator-taking path according to the division mode of elevator group and floor. It can adapt to the division of various floors and provide several optimal paths of elevator and expected periods according to the starting floor and target floor. Several embodiments will be described and introduced as follows.

The present disclosure will be further described in detail below with reference to the drawings and embodiments. It should be understood that the specific embodiments described herein are merely illustrative of the present disclosure and are not intended to limit the present disclosure. In addition, it should be noted that, for ease of description, the drawings show only a portion of the contents related to the present disclosure, but not all the contents. Moreover, in case of no conflict, the embodiments in the present disclosure and the features in the embodiments may be combined with each other.

The method for robot elevator-taking path planning and crowd size prediction provided by the present disclosure can be applied to the application environment as shown in FIG. 1A. This method is applied to robot elevator-taking path planning and crowd size prediction system. The robot elevator-taking path planning and crowd size prediction system includes the server 100 and the client 200. The server 100 and the client 200 communicate through the network so that the data can be transmitted between the server 100 and the client 200 to realize information interaction. Among

them, the server 100 can be realized by an independent server or a server cluster composed of multiple servers. It can also be a cloud server, such as the commercial cloud servers of Ali Cloud and Tencent Cloud. Client for the intelligent terminal or robots, intelligent terminal for but not limited and all kinds of personal computers, laptops, smart phones, tablets and portable wearable devices, the robot can be, but not limited to, a distribution, patrol and protect the function such as mobile device, regardless of what kind of equipment, the client is both can satisfy the ladder expected demand. Networks can include various types of connections, such as wired, wireless communication links, or fiber optic cables.

As shown in FIG. 1B, the system can include both server 100 and client 200 Network. The network 104 is configured for a medium for providing a communication link between the server 105 and the client 101, 102, 103. Network 104 can include various types of connections, such as wired, wireless communication links, or fiber optic cables. Users can use clients 101, 102, and 103 to interact with server 105 over network 104 to receive or send messages. The client 101, 102, 103 can be a variety of computer devices with display screens that support web browsing, including but not limited to smart phones, tablets, laptop and desktop computers, etc. The server 105 can be a server that provides various services, such as a background server that supports the pages displayed on client 101, 102, and 103. The server can be an independent server. It can also be a cloud server that provides cloud services, cloud databases, cloud computing, cloud functions, cloud storage, Network services, cloud communications, middleware services, domain name services, security services, Content Delivery Network (CDN), big data and artificial intelligence platforms and other basic cloud computing services. It should be noted that the method for floor crowd size prediction based on elevator operation data provided in this present embodiment is implemented by the server, and accordingly, the prediction apparatus of floor crowd size based on elevator operation data is set in the server. The robot can act as a client or as a user.

It should be understood that the number of clients, networks, and servers in Figure 1A and Figure 1B is only illustrative. According to the implementation needs, there

can be any number of clients, networks and servers. The clients in this present embodiment can correspond to the application system in actual production.

FIG. 2 provides a method for robot elevator-taking path planning and crowd size prediction for an embodiment of the present disclosure. The application of the method to the server in FIG. 1 and 2 is taken as an example to illustrate the method, which includes:

Step S1. The server obtains starting floor and the ending floor of the robot. In this embodiment, the ending floor is unchanged, and the starting floor is variable. Among them, the starting floor of the robot changes once for each transfer. The starting floor refers to the starting floor of a certain elevator that the robot rides. If there is transfer, then the starting floor becomes the departing floor (non-ending floor) of the next transfer elevator.

In this embodiment, the server obtains elevator information, elevator group, and elevator group information in advance. Among them, the elevator information is used to describe the state of the elevator, including operating parameters, load, speed, height, direction (up, down, idle), door state, target floor and reachable floor, etc. Operation parameter refers to the default value of the elevator when it is running, such as: maximum speed, acceleration, unimpeded door opening time, etc. The load includes not only the current bearing capacity and maximum bearing capacity of the elevator, but also the number of robots on the elevator, which is used to limit the number of robots in a single elevator. An elevator group is a collection of elevators; the elevator group information describes the information about the same elevators in the group, for example, the reachable floors and the corresponding heights of the floors. Elevators in a group may have different reachable floors due to design or other reasons. In this case, the reachable floors of an elevator group are the union of all reachable floors in the group. The reachable floors are determined by the reachable floors of the elevators during route finding.

Step S2. The server determines all elevator groups that can reach the starting floor to form a cache path sequence. Wherein, each cache path in the cache path sequence includes elevator group sequence, elevator sequence, floor sequence and expected

time point sequence.

In this embodiment, the reachable floors to the elevators in the same elevator group are roughly the same, and a normal elevator riding process includes any elevator group at most once. In this embodiment, the server first divides the elevator groups with different reachable floors into elevator groups with similar reachable floors, and then constructs the elevator group path in the following way according to the principle of “the same elevator group can be experienced at most once”. The elevator group path adopts the same structure as the elevator-taking path, but the elevator sequence and time point sequence are temporarily empty. Since the number of elevator groups is much smaller than the number of elevators, this can greatly improve the efficiency of route finding.

The server further initializes the available path sequence, the potential path sequence and sets the pathfinding count value to 0. The available path sequence is configured for store the pathfinding results, and the elevator group path can be reached from the starting floor to the ending floor. The initial value is an empty. Potential path sequence is configured for store the intermediate paths that may form available paths. Generate an elevator group path for all elevator groups that can reach the starting floor and add the potential path sequence.

Step S3, the server replaces the cache path sequence with the potential path sequence and clears the potential path sequence. The server traverses all the cache paths, if the elevator group corresponding to the traversed cache path can reach the ending floor directly, adding the cache path to the available path sequence and exits after traversing. Otherwise, taking the last floor in the floor sequence of the elevator group corresponding to the current cache path as the current floor; and perform the subsequent steps of the above embodiment to find the available path.

For example, the traversed cache paths include: elevator group sequence = [3, 3], elevator sequence = [2, 3], floor sequence = [3, 5, 8]; It means to take elevator no. 2 in elevator group 3 from the 3rd floor to the 5th floor, and then take elevator No. 3 in elevator group 3 from the 5th floor to the 8th floor.

In step S3, the server traverses all the cache paths, If the elevator group

corresponding to the traversed cache path cannot reach the ending floor, the last floor in the elevator group sequence corresponding to the current cache path as the current floor; traversing all transfer elevator groups reachable from the current floor, and excluding the duplicate elevator groups in all transfer elevator groups and the current
5 cache path; if the traversed transfer elevator group can reach the ending floor, adding the transfer elevator group and the ending floor to the current cache path, and adding the current cache path to the available path sequence as an elevator-taking path.

In this embodiment, as shown in FIG. 3, the elevator-taking path is configured for describe the entire elevator riding process. An elevator-taking path contains at least
10 elevator group sequence, floor sequence, elevator sequence and expected time point sequence, which corresponds to a riding node sequence. The riding node is configured for describe the process of riding a single elevator. A node consists of elevator group, elevator, starting floor, ending floor, expected start time, and expected end time.

15 In the elevator-taking path, the elevator group, elevator, and starting floor of the elevator-taking node i correspond to the i^{th} element of the elevator group sequence, elevator sequence, and floor sequence in the elevator-taking path, respectively; the ending floor of the elevator-taking node corresponds to the $(i+1)^{\text{th}}$ element of the floor sequence in the elevator-taking path. Since when the elevator transfers, the
20 finishing floor of the last node is equal to the beginning floor of the next node, there is no need to repeat the record. The expected time point sequence can be recorded as a long $2N$ sequence according to the start and end, as well as the start and end time series respectively.

For example, the elevator-taking path includes: elevator group sequence = [3, 5],
25 elevator sequence = [2, 3], floor sequence = [10, 3, 21]; It means to take elevator No. 2 in elevator group 3 from the 10th floor to the 3rd floor, and transfer to elevator No. 3 in elevator group 5 from the 3rd floor to the 21st floor.

The server traverses all transfer elevator groups accessible to the current floor, excluding transfer elevator groups that have passed through the current path. When
30 the traversed transfer elevator group can reach the ending floor, the transfer elevator

group and the ending floor are added to the current path (i.e., the cache path), and the current path is added to the available path sequence. If the transfer elevator group cannot reach the ending floor, the current cache path is used as a blueprint to increase the elevator-taking nodes from the current floor to all floors reachable by the transfer
5 elevator group to form a new path, and add the new path to the cache path sequence. Step S4, repeating the step S3 until all cache paths are traversed.

Step S5, after traversing all cache paths, adding 1 to the pathfinding count value; wherein, the initial value of the pathfinding count is 0.

Step S6. Repeat steps S3 to S4 on the server until the pathfinding count value is
10 greater than n ; wherein, n is less than or equal to the number of elevator groups. And arranging the elevator-taking paths in the available path sequence in up order of the number of elevator-taking nodes; wherein, the elevator-taking node represents the process of taking a single elevator, and the elevator-taking node includes an elevator group, an elevator, a starting floor, an ending floor, expected start time and expected
15 end time.

Because the number of elevator groups is limited, and a path can only pass through the same elevator group at most once, when greater than or equal to the number of elevator groups, no new potential path will be generated. On the other hand, the pathfinding count value corresponds to the number of nodes that currently generate
20 available paths, and the increase in the number of nodes not only improves the path complexity but also greatly increases the elevator-taking periods. The number of nodes in available paths can be limited by adjusting N . In addition, according to the generation process, the r elevator-taking paths in the available path sequence are arranged according to the number of nodes in order to obtain all available path
25 sequences (the number of nodes is less than or equal to N).

If the available path sequence obtained through the above steps is empty, it indicates that no elevator group path can be found from the starting floor to the ending floor. Available paths can be obtained by complementing any available elevator group paths. The elevator group path complementation process is described below, so as
30 shown in FIG. 4, it also includes:

Step S7. If the server determines that the available path sequence is empty, determining the start time of the robot movement and the end time of reaching the elevator.

Use the current time as the first start time. According to the current position of the robot, the time to move to the elevator was estimated and the first end time was calculated.

The server converts the elevator group sequence and floor sequence of the cache path into nodes in sequence, wherein the i^{th} node corresponds to the i^{th} elevator group from the i^{th} floor to the $(i+1)^{\text{th}}$ floor. And determine the elevator-waiting periods for each elevator in node i to reach the i^{th} floor in the desired direction, as well as the elevator-taking periods to the $(i+1)^{\text{th}}$ floor. For node i^{th} , according to the historical data and the current state of the elevators in the elevator group, estimate the elevator-waiting periods for each elevator to reach the i^{th} floor in the desired direction and the subsequent moving periods to the $(i+1)^{\text{th}}$ floor.

The server calculates the new start time and new end time based on the elevator-waiting periods and elevator-taking periods of each elevator in the cached path, arranging the m supplementary paths with the earliest end time according to the new end time, and determining a new elevator-taking path according to the supplementary path. Where, start time of the new (current node) = end time of the previous node + elevator-waiting periods; end time of the new (current node) = start time of the new (current node) + elevator-taking periods.

See FIG. 5. The method for robot elevator-taking path planning and crowd size prediction provided by the present disclosure can be applied to the application environment as shown in FIG. 1A and FIG. 1B. This embodiment is mainly illustrated by the application of this method to the server in Figure 1A and FIG. 1B. In this embodiment, the method involves a server and a client, wherein the client includes a robot; The method includes the following steps:

At S501: the server obtains historical data of the elevator group in each preset time period.

At S502: The server calculates expected data of each floor of the individual elevators

in the elevator group according to the historical data.

At S503: the server receives the elevator-taking request sent by the robot, and return the building information and the expected data according to the elevator-taking request; the robot configured for calculating the final expected periods according to the building information and the expected data.

Understandably, the historical data for the elevator group within the individual elevator all do not need to be calculated to obtain the original data, such as opening time, closing time, event messages, location information and elevator running state and so on. The server can obtain the historical data of the elevator group in each preset time period, and calculate the expected data of each floor of the individual

elevator in the elevator group according to the historical data. Then receive the elevator-taking request sent by the robot, and return the building information and the expected data according to the elevator-taking request. Finally, the robot can calculate the final expected periods according to the building information and the

expected data. In other words, the server performs general calculation based on historical data at a certain frequency (for example, every second). When the robot sends an elevator-taking request to the server, the robot obtains the latest general calculation result and presents it to the user after the robot completes the final expected calculation locally. The expected elevator-waiting periods is divided into

general calculation and specific calculation is carried out after obtaining general results according to specified conditions. Based on the characteristics of complete server information, strong computing power and large number of servers, the expected elevator riding technology can realize real-time calculation and sharing in large-scale scenarios through the way that the server can complete the general calculation and the robot can complete the specific calculation. It provides accurate expected elevator-waiting periods of elevator ride for robot users.

In this embodiment, the expected elevator-waiting periods is divided into general calculation and specific calculation is carried out after obtaining general results according to specified conditions, provides accurate expected elevator-waiting periods of elevator ride for robot users. And the robot can according to the expected

elevator-waiting periods for path planning and real-time correction in advance. It improves the efficiency of the robot to perform a task.

In one embodiment, the expected data includes expected moving periods, expected elevator-waiting periods and expected stopping periods of each floor of individual elevators within a preset time period.

In one embodiment, S502 includes the following steps:

Obtaining the expected stopping times and average stopping periods of the elevator group in each of the preset time periods according to the historical data.

Specifically, the day is divided into different periods according to fixed time intervals (such as 10 minutes). According to the historical data, the expected stopping times of each elevator group at each floor in each time period are obtained, and the average stopping periods is obtained. The expected method can be to add the number of stops of each elevator in the elevator group, that is, the number of stops of each individual elevator in each period, and then obtain the weighted average of each period by the way of half-life weighting.

Converting the expected stopping times and the average stopping periods into the expected stopping probability of individual elevators in the elevator group. Specifically, assuming that the probability of each elevator stopping at a certain floor in a certain direction during $[t, t+T)$ can be expressed by the function $f(x)$, the expected stopping times at the floor in the direction of the elevator group in the period of time can be obtained by the following formula:

$$\text{expected stopping times} = \sum_{\text{elevator in elevator group}} \int_t^{t+T} f(x) dx$$

Since it is difficult to accurately predict the stopping periods of elevators in a distant period. We assume that $f(x)$ conforms to the rectangular distribution and is the same for each elevator in the elevator group. For example, in elevator group 1, the expected stopping probability of each individual elevator in elevator group 1 can be obtained by the following formula for each floor in each direction at each time period:

$$\text{expected stopping probability} = \frac{\text{expected stopping times} \times \text{average stopping periods}}{T \times W}$$

Wherein, W is the number of elevators in elevator group 1; the expected stopping

times and the average stopping periods is the data corresponding to elevator group 1.

Understandably, we usually assign the expected stopping probability of the elevator group to the individuals in the group by deductive method, which is more effective
5 for the near elevator expectation. However, the elevator is optimized and responded in the way of group when facing the demand of taking the elevator. The behavior of the elevator in the group affects each other. Even in the face of the same number of elevator-taking requests, the whole elevator group may have great differences due to the time order of the keys. Therefore, the conventional deduction method is not
10 suitable for the distant expectation of elevator riding. The invention interprets the expected stopping times of elevator groups by means of probability. Although the accuracy will be reduced in the near future, the overall expectation deviation in large-scale scenarios is not large.

Calculating the expected moving periods according to the elevator information of
15 the elevator group. Specifically, the elevator information is configured for describe the elevator state information, including operating parameters, load, speed, height, direction (up, down, idle), door state and target floor. Operation parameter refers to the default value of the elevator when it is running, such as: maximum speed, acceleration, unimpeded door opening time, etc. The load includes not only the
20 current and maximum load bearing capacity of the elevator, but also the number of robots on the elevator, which is used to limit the number of robots in a single elevator. Understandably, according to the average moving speed of the elevator and the height difference between floors, the movement time needed for each floor of the elevator-taking path is calculated from the bottom, namely the expected movement
25 periods. This part of the calculation result is fixed when the elevator speed is constant, so we can cache it for a long time.

Calculating the expected elevator-waiting periods according to the expected moving periods, the average stopping periods and the expected stopping probability.

Specifically, when the elevator is in the moving state, take a path floor as the starting

point. Otherwise, take the current floor as the starting point. When the elevator is at the end of the direction of travel (i.e., up corresponds to the highest level, down corresponds to the lowest level), the next path floor is the current floor, travel direction is reversed. When the elevator reaches the end, the elevator-waiting periods in the opposite direction will be recorded in reverse until the elevator-waiting periods of all floors in the two directions is calculated. When the elevator has a moving direction (not idle), the expected elevator-waiting periods for each floor in each path shall be calculated according to the following formula: expected elevator-waiting periods = (expected moving periods + average stopping periods) * expected stopping probability, and the expected elevator-waiting periods of the elevator at each floor is obtained. Understandably, when the elevator is idle, the expected elevator-waiting periods of each floor in the two directions of the elevator is obtained respectively under the two assumptions of up and down first, and then the minimum value under the two assumptions is taken as the final expectation.

Calculating the expected stopping periods according to the average stopping periods and the expected stopping probability. Specifically, according to the probability of the elevator stopping at each floor in the current direction and time period, the expected stopping periods of the elevator at each floor can be obtained according to: expected stopping periods = average stopping periods * expected stopping probability.

Storing the expected moving periods, the expected elevator-waiting periods and the expected stopping periods.

For details, please refer to FIG. 6. In FIG. 6, the expected data is stored in multiple copies of the calculation results. In addition, in order to further improve the query efficiency, the expected data can be fragmented according to the time period.

Further, the expected data includes the expected moving periods, the expected elevator-waiting periods and the expected stopping periods of each floor of the individual elevator in the present time period. Understandably, the server has the characteristics of complete information, strong computing power and large number.

Through the server, the general calculation of the expected moving periods, the

expected elevator-waiting periods and the expected stopping periods is completed, so that when the robot sends an elevator-taking request to the server, the latest general calculation data is obtained, and then complete the final expected calculation locally and present it to the user, providing the user with accurate future expectation.

5 In some embodiments, please continue to refer to FIG. 7 continuously. FIG. 7 provides a method for robot elevator-taking path planning and crowd size prediction for an embodiment of the present disclosure. The application of the method to the server in FIG. 1A and 1B is taken as an example to illustrate the method, wherein the client includes a robot.

10 In this embodiment, the method includes the following steps:

At S701: An elevator-taking request sent by the robot to the server. The server is configured to obtain the historical data of the elevator group in each preset time period, and calculate the expected data of each floor of the individual elevator in the elevator group according to the historical data, and also configured to return the
15 building information and expected data to the robot according to the elevator-taking request.

At S702: The robot calculates the final expected periods according to the building information and the expected data.

In some embodiments, the elevator-taking request includes a user identification code,
20 user authentication information, and elevator-taking information, and the elevator-taking information includes a start time, starting floor and target floor. Building information is used to describe the structure of the building and the facilities in the building, including floor number, floor height and elevator group information. Understandably, the elevator group is a collection of elevators with similar properties
25 that can reach the same floor in the building. But even elevators corresponding to the same floor range can be divided into different elevator groups because of functional differences. For example, passenger elevators and freight elevators in the same group may have some floors within the range only reachable to some elevators.

30 In this embodiment, the robot initiates a elevator-taking request and sends the

elevator-taking request to the server; the server returns the building information and expected data to the robot according to the elevator-taking request. The robot can obtain the latest general calculation result of the server, and then complete the final expected calculation locally and present it to the user, providing the user with accurate future expectation. Understandably, the robot can rely on its built-in APP to send elevator-taking requests and obtain general calculations. Specifically, the server will return building information and expected data according to the robot user's elevator-taking request, and the expected data includes all elevator group information in the corresponding time period and moving direction. Among them, all the elevator group information is returned here, on the one hand, because there may be cross-elevator group situation; On the other hand, even if a single elevator group is reachable, it may be possible to get there faster by using other elevator groups, thus providing more choices for robot users.

The method provided in this disclosure enables the server to obtain the historical data of the elevator group in each preset time period; and calculate the expected data of each floor of the individual elevators in the elevator group according to the historical data. Then, the server receives the elevator-taking request sent by the robot, and returns the building information and expected data to the robot according to the elevator-taking request. Finally, the robot calculates the final expected periods according to the building information and expected data. It realizes that the expected elevator-waiting periods is divided into a broad and comprehensive general calculation and a specific calculation that extracts the general result according to the specified conditions, and provides accurate expected elevator-waiting periods of elevator riding for robot users. And the robot can according to the expected elevator-waiting periods for path planning and real-time correction in advance. It improves the efficiency of the robot to perform a task.

In some embodiments, S702 includes of the following steps:

The robot obtains all non-repetitive elevator group paths from the starting floor to the target floor according to the building information; calculates the final expected periods of all elevator group paths; selects the elevator group path with the shortest

final expected periods or several shorter elevator group paths.

In this embodiment, after receiving the building information and general calculation results returned by the server, the robot carries out path planning aiming at the shortest time. Specifically, according to the floors that the elevator group can reach (reachable floors), obtains all non-repetitive elevator group paths from the starting floor to the target floor. Since the number of elevator groups in the same building is limited, we must obtain a limited number of elevator group paths according to the non-repetitive condition. According to the general calculation results returned by the server, calculate the final expected periods of each elevator in the elevator group to complete the corresponding movement between two nodes according to the following formula:

$$\text{final expected periods} = \text{expected elevator} - \text{waiting periods} + |T1 - T2| + \sum_{\text{intermediate floor}} \text{expected stopping times}$$

Where, $T1$ is the expected movement periods of the target floor, $T2$ is the expected movement periods of the starting floor, the intermediate floor is the floor where the elevator passes from the starting floor to the ending floor. Finally, the first several short time-consuming elevator group paths are obtained and each path is presented to the robot in the form of nodes, thus providing accurate future expectations for robot users.

The first several short time-consuming paths are arranged in ascending order of time consuming, and the first several paths with shorter time consuming are selected. Finally, the selected short time-consuming elevator group paths are presented to robot users for selection.

In some embodiments, the robot may also choose the elevator group path with the shortest final expected periods.

In some embodiments, please continue to refer to FIG. 8 continuously. FIG. 8 provides a method for floor crowd size prediction based on elevator operation data provided by an embodiment of the present disclosure. The application of the method to the server in FIG. 1A and 1B is taken as an example to illustrate the method. The embodiments of the present disclosure can acquire and process related data based on artificial intelligence technology. Among them, artificial Intelligence (AI) is a theory,

method, technology and application system that uses digital computers or machines controlled by digital computers to simulate, extend and expand human Intelligence, perceive the environment, acquire knowledge and use knowledge to obtain the best results.

- 5 Basic ai technologies generally include sensors, dedicated AI chips, cloud computing, distributed storage, big data processing technology, operating systems, mechatronics and other technologies. Artificial intelligence software technology mainly includes computer vision technology, robotics technology, biometrics technology, speech processing technology, natural language processing technology
10 and machine learning and other major directions.

In this embodiment, the historical data includes event messages, location information and elevator running state. This embodiment includes the following steps:

- At S801: The server obtains the event message, position information and elevator
15 running state during the running of the elevator. The elevator running state includes up and down, and the position information includes the current position and the passing floors during the running process.

- Among them, the event message refers to the information of various events in the process of elevator running, such as opening event, closing event, elevator start event,
20 etc.

Among them, the position information refers to the data related to the position of the elevator in a running process. In this example, the running process of the elevator refers to the whole process of the elevator up or down.

- S802: The server determines the elevator carrying state based on the event message.
25 The elevator carrying state includes carrying passengers and not carrying passengers. Specifically, this embodiment determines the passenger carrying state based on the event message, which is conducive to quickly and accurately determining the passenger carrying state and improving the detection efficiency. Specific steps for confirming the state of carrying passengers can be referred to the description of
30 subsequent embodiments. In order to avoid repetition, it is not repeated here.

At S803: if the current position is a stopping floor, updating the crowd index of each floor based on the elevator passenger carrying state and the elevator running state to obtain the updated crowd index of each floor.

Among them, the crowd index is used to characterize the size of the crowd on the floor.

The crowd index of each floor is updated based on the elevator passenger carrying state and elevator running state, and the specific process of the updated crowd index of each floor can be obtained by referring to the description of subsequent embodiments. In order to avoid repetition, it is not described here.

At S804: The server determines the crowd size of each floor based on the preset judgment condition and the target index; wherein the target index is the updated crowd index obtained after the elevator runs for a preset cycle.

Among them, the preset judgment conditions can be limited according to the actual needs. For example, the target index can be calculated according to the formula to determine the crowd size.

The specific schematic diagram of crowd size on each floor is shown in FIG. 9 and FIG. 10.

In this embodiment, the server obtains the event message position information and elevator running state during the running process of the elevator; then determines an elevator passenger carrying state based on the event message; if the current position is a stopping floor, updating the crowd index of each floor based on the elevator passenger carrying state and the elevator running state to obtain the updated crowd index of each floor; Finally determines the crowd size of each floor based on the preset judgment condition and the target index, so as to improve the prediction efficiency of crowd size.

In some embodiments, at S802, the determining an elevator passenger carrying state based on the event message includes: if the event message includes a door opening event, recording the time corresponding to the door opening event as the first-time node, and continue to monitor the event message of the elevator running process; recording a time node corresponding to the elevator startup event as a second-time

node when receiving an event message including an elevator startup event; calculating the difference between the first-time node and the second-time node as the startup operation interval; and comparing the startup operation interval with the preset startup threshold, if the startup operation interval exceeds the preset startup threshold, confirming that the elevator passenger carrying state is not carrying passengers, otherwise, confirming that the elevator passenger carrying state is carrying passengers.

Specifically, the preset start threshold is the start-up running time of the elevator with passengers plus a certain delay time. For example, if the start-up running time of the elevator with passengers is 1.1 seconds and the delay time is 0.5 seconds, the preset start threshold is 1.6 seconds.

It should be noted that the delay time is to take into account the start-up of the elevator. Sometimes due to some environmental factors, the time will be slightly longer than the normal start-up running time of the elevator with passengers, so as to ensure the accuracy of the judgment of carrying passengers.

Among them, the opening event refers to the event message triggered when the elevator door is opened, and the elevator start event refers to the event message triggered when the elevator starts to go up or down.

When the elevator reaches a floor without a clear target, the time to the next movement is obviously longer than the normal start time.

In this embodiment, through the interval time between two events and preset start threshold, the elevator can determine whether to carry passengers without external camera or weighing equipment, which improves the efficiency of determining whether to carry passengers and reduces the application cost.

In some embodiments, at S803, the elevator passenger carrying state is carrying passengers, and if the current position is a stopping floor, updating the crowd index of each floor based on the elevator passenger carrying state and the elevator running state to obtain the updated crowd index of each floor includes: adding 1 to the crowd index of the floor corresponding to the current position when the elevator running state is up, and determining whether the floor corresponding to the current position

is an access floor; if the floor corresponding to the current position is the access floor, subtracting 1 from the crowd index of the access floor to obtain the updated crowd index of each floor; and if the floor corresponding to the current position is a non-access floor and the floor corresponding to the current position is the floor that stops
5 for the first time in this up, subtracting 1 from the crowd index of the last passing floor of the floor corresponding to the current position to obtain the updated crowd on each floor index.

Among them, access floor refers to the floor into the building, such as: ground 1 floor, underground 1 floor, etc.

10 Among them, the crowd index refers to the index used to characterize the floor crowd size.

In this embodiment, the accuracy of the crowd index is improved by updating the floor crowd index through the running state of the elevator (i.e., the elevator running state) when carrying passengers.

15 In some embodiments, at S803, the elevator passenger carrying state is carrying passengers, and if the current position is a stopping floor, updating the crowd index of each floor based on the elevator passenger carrying state and the elevator running state to obtain the updated crowd index of each floor further includes: determine whether the current position is an access floor when the elevator running state is
20 down; if the current location is the access floor; subtracting 1 from the crowd index of the floor passing by the elevator during this running process and clear the record of the floor passing by; and if the current location is the non-access floor; subtracting 1 from the crowd index of the floor passing by the elevator during this running process, adding 1 to the crowd index of the floor corresponding to the current
25 position of the elevator and clear the passing floor record.

In some embodiments, at S803, the elevator passenger carrying state is not carrying passengers, and if the current position is a stopping floor, updating the crowd index of each floor based on the elevator passenger carrying state and the elevator running state to obtain the updated crowd index of each floor further includes: determining
30 whether the current location is an access floor based on the location information; if

the current location is the access floor; subtracting 1 from the crowd index of the floor passing by the elevator during this running process and clear the record of the floor passing by; and if the current location is the non-access floor; subtracting 1 from the crowd index of the floor passing by the elevator during this running process, adding 1 to the crowd index of the floor corresponding to the current position of the elevator and clear the passing floor record.

In this embodiment, the accuracy of the crowd index is improved by updating the floor crowd index based on the elevator running state when there are no passengers. It should be understood that the serial number of each step in the above embodiments does not mean the order of execution, and the order of execution of each process should be determined by its function and internal logic, and should not constitute any restriction on the implementation process of the invention embodiments.

It should be understood that although the steps in the flowchart shown in FIGs 2 to 8 follow the arrows, they are not necessarily executed in the order indicated by the arrows. Unless explicitly stated in this article, there is no strict order in which these steps can be performed, and they can be performed in any other order. In addition, at least part of the steps in FIGs 2 to 8 can include multiple sub-steps or stages. These sub-steps or stages are not necessarily executed at the same time, but can be executed at different times, and the execution sequence of these sub-steps or stages is not necessarily sequential. It may be performed alternately or in turn with other steps or at least part of a sub-step or phase of another step.

Based on the same idea, for the realization of the above methods, the present disclosure also provides an apparatus for robot elevator-taking path planning, the apparatus embodiments are corresponding to the aforementioned method embodiments. For ease of reading, the apparatus embodiments will not repeat the details of the aforementioned method embodiments one by one, but it should be clear that the apparatus in the apparatus embodiments can realize all contents of the aforementioned method embodiments.

In some embodiments, as shown in FIG. 9, the present disclosure also provides an apparatus for robot elevator-taking path planning, including initialization module,

cache path module and available path determination module, wherein:

An initialize module configured for obtaining the starting floor and the ending floor of the robot.

5 A cache path module configured for determining all elevator groups that can reach the starting floor to form a cache path sequence; wherein, each cache path in the cache path sequence includes an elevator group sequence, an elevator sequence, a floor sequence and an expected time point sequence;

10 An available path determination module configured for traversing all the cache paths, if the elevator group corresponding to the traversed cache path can reach the ending floor directly, adding the cache path to the available path sequence; otherwise, taking the last floor in the floor sequence of the elevator group corresponding to the current cache path as the current floor; traversing all transfer elevator groups reachable from the current floor, and excluding the duplicate elevator groups in all transfer elevator groups and the current cache path; if the traversed transfer elevator group can reach 15 the ending floor, adding the transfer elevator group and the ending floor to the current cache path, and adding the current cache path to the available path sequence as an elevator-taking path; and repeating the above steps until all cache paths are traversed.

20 In some embodiments, the available path determination module is also configured for adding 1 to the pathfinding count value after traversing all cache paths, repeating the steps S3 to S5 until the pathfinding count value is greater than n ; wherein, n is less than or equal to the number of elevator groups; repeating the steps S3 to S5 until the pathfinding count value is greater than n ; wherein, n is less than or equal to the number of elevator groups, wherein, the initial value of the pathfinding count is 0; 25 and arranging the elevator-taking paths in the available path sequence in up order of the number of elevator-taking nodes; wherein, the elevator-taking node represents the process of taking a single elevator, and the elevator-taking node includes an elevator group, an elevator, a starting floor, an ending floor, expected start time and expected end time.

30 In some embodiments, wherein the elevator-taking path, the elevator group, elevator,

and starting floor of the elevator-taking node i correspond to the i^{th} element of the elevator group sequence, elevator sequence, and floor sequence in the elevator-taking path, respectively; the ending floor of the elevator-taking node corresponds to the $(i+1)^{\text{th}}$ element of the floor sequence in the elevator-taking path.

5 In some embodiments, the available path determination module is also configured for that if the transfer elevator group cannot reach the ending floor, the current cache path is used as a blueprint to increase the elevator-taking nodes from the current floor to all floors reachable by the transfer elevator group to form a new path, and add the new path to the cache path sequence.

10 In some embodiments, the apparatus also includes a path supplementary module, configured for if the available path sequence is empty, determining the start time of the robot movement and the end time of reaching the elevator; and determining a number of supplementary paths according to the start time and the end time, as well as the elevator-waiting periods of each elevator in the cached route and the elevator-taking time to the ending floor.

In some embodiments, the path supplementary module is also configured for converting the elevator group sequence and floor sequence of the cache path into nodes in sequence, wherein the i^{th} node corresponds to the i^{th} elevator group from the i^{th} floor to the $(i+1)^{\text{th}}$ floor; determine the elevator-waiting periods for each
20 elevator in node i to reach the i^{th} floor in the desired direction, as well as the elevator-taking periods to the $(i+1)^{\text{th}}$ floor; and calculating the new start time and new end time based on the elevator-waiting periods and ride periods of each elevator in the cached path, arranging the m supplementary paths with the earliest end time according to the new end time, and determining a new elevator-taking path
25 according to the supplementary path.

In this embodiment, the first step is to select the cache path that can reach the starting floor, and then determine the cache path to reach the ending floor and determine the elevator group that can reach the ending floor, so as to obtain the transfer path; If the transfer path can reach the ending floor, the available path can be obtained by
30 combining cache path and transfer path directly. According to the elevator group,

floor division, adaptive planning of the elevator-taking path. It can adapt to the division of various floors and provide several optimal paths of elevator and expected data according to the starting floor and target floor.

In some embodiments, as shown in FIG. 11, the apparatus involves information interaction between a server and a client, including a robot. Wherein, the server 1100 comprises an acquiring module 1101, a first computing module 1102 and a receiving module 1103, wherein:

An acquiring module 1101, configured for obtaining the historical data of the elevator group in each preset time period.

A first calculation module 1102, configured for calculating the expected data of each floor of the individual elevators in the elevator group according to the historical data. A receiving module 1103, configured for receiving the elevator-taking request sent by the robot, and return the building information and the expected data according to the elevator-taking request; the robot configured for calculating the final expected periods according to the building information and the expected data.

In some embodiments, the first calculation module is also configured for obtaining the expected stopping times and average stopping periods of the elevator group in each of the preset time periods according to the historical data; converting the expected stopping times and the average stopping periods into the expected stopping probability of individual elevators in the elevator group; calculating the expected moving periods according to the elevator information of the elevator group; calculating the expected elevator-waiting periods according to the expected moving periods, the average stopping periods and the expected stopping probability; calculating the expected stopping periods according to the average stopping periods and the expected stopping probability; and storing the expected moving periods, the expected elevator-waiting periods and the expected stopping periods.

In some embodiments, the expected data includes expected moving periods, expected elevator-waiting periods and expected stopping periods of each floor of individual elevators within a preset time period.

For server-side apparatus embodiments, because they are basically similar to method

embodiments shown in FIG. 5, the description is relatively simple. For relevant points, please refer to the explanation of server-side method embodiments.

In some embodiments, as shown in FIG. 12, the apparatus involves information interaction between a server and a client, including a robot. The client comprises a
5 sending module 1201 and a second computing module 1202, wherein:

A sending module 1201 configured for the client send the elevator-taking request to the server; The service obtains the historical data of the elevator group in each preset time period according to the request of the elevator, calculates the expected data of each floor of the individual elevator in the elevator group according to the historical
10 data, and returns the building information and the expected data to the client.

A second calculation module 1202 configured for calculate the final expected periods according to the building information and the expected data.

As for the apparatus embodiments on the user side, they are basically similar to the method embodiments shown in FIG. 7, so the description is relatively simple. For
15 relevant points, please refer to the explanation of the method embodiments on the user side.

In this embodiment, the expected elevator-waiting periods is divided into general calculation and specific calculation is carried out after obtaining general results according to specified conditions, provides accurate expected elevator-waiting
20 periods of elevator ride for robot users. And the robot can according to the expected elevator-waiting periods for path planning and real-time correction in advance. It improves the efficiency of the robot to perform a task.

FIG. 13 shows the schematic diagram of a prediction apparatus of floor crowd size based on elevator operation data 1300. As shown in FIG. 13, the apparatus includes
25 an information acquisition module 31, a state determination module 32, an index update module 33 and a size determination module 34, wherein:

An information acquisition module 31 configured for obtaining event messages, position information and elevator running state during the running process of the elevator, wherein the running state of the elevator includes up and down, and the
30 position information includes the current position and the passing floors during the

running process.

A state determination module configured for determining an elevator passenger carrying state based on the event message, wherein the elevator carrying state includes carrying passengers and not carrying passengers.

- 5 An index update module configured for, if the current position is a stopping floor, updating the crowd index of each floor based on the elevator passenger carrying state and the elevator running state to obtain the updated crowd index of each floor.

A size determination module configured for determine the crowd size of each floor based on the preset judgment condition and the target index; wherein the target index
10 is the updated crowd index obtained after the elevator runs for a preset period.

In some embodiments, the state determination module 32 includes: the first-time node determination unit configured for, if the event message includes a door opening event, recording the time corresponding to the door opening event as the first-time node, and continue to monitor the event message of the elevator running process;
15 recording a time node corresponding to the elevator startup event as a second-time node when receiving an event message including an elevator startup event; calculating the difference between the first-time node and the second-time node as the startup operation interval; and comparing the startup operation interval with the preset startup threshold, if the startup operation interval exceeds the preset startup
20 threshold, confirming that the elevator passenger carrying state is not carrying passengers, otherwise, confirming that the elevator passenger carrying state is carrying passengers.

In some embodiments, the elevator passenger carrying state is carrying passengers. The index update module 33 includes the first judgment unit, configured for adding
25 1 to the crowd index of the floor corresponding to the current position when the elevator running state is up, and determining whether the floor corresponding to the current position is an access floor; if the floor corresponding to the current position is the access floor, subtracting 1 from the crowd index of the access floor to obtain the updated crowd index of each floor; and if the floor corresponding to the current
30 position is a non-access floor and the floor corresponding to the current position is

the floor that stops for the first time in this up, subtracting 1 from the crowd index of the last passing floor of the floor corresponding to the current position to obtain the updated crowd on each floor index.

In some embodiments, the elevator passenger carrying state is carrying passengers.

5 The index update module 33 also includes the second judgment unit, configured for determine whether the current position is an access floor when the elevator running state is down; if the current location is the access floor; subtracting 1 from the crowd index of the floor passing by the elevator during this running process and clear the record of the floor passing by; and if the current location is the non-access floor;
10 subtracting 1 from the crowd index of the floor passing by the elevator during this running process, adding 1 to the crowd index of the floor corresponding to the current position of the elevator and clear the passing floor record.

In some embodiments, the state of the elevator carrying passengers is not carrying passengers. The index update module 33 also includes the third judgment unit,
15 configured for determining whether the current location is an access floor based on the location information; if the current location is the access floor; subtracting 1 from the crowd index of the floor passing by the elevator during this running process and clear the record of the floor passing by; and if the current location is the non-access floor; subtracting 1 from the crowd index of the floor passing by the elevator during
20 this running process, adding 1 to the crowd index of the floor corresponding to the current position of the elevator and clear the passing floor record.

In this embodiment, the server obtains the event message position information and elevator running state during the running process of the elevator; then determines an elevator passenger carrying state based on the event message; if the current position
25 is a stopping floor, updating the crowd index of each floor based on the elevator passenger carrying state and the elevator running state to obtain the updated crowd index of each floor; Finally determines the crowd size of each floor based on the preset judgment condition and the target index, so as to improve the prediction efficiency of crowd size.

30 For the specific limitations of the prediction apparatus of floor crowd size based on

elevator operation data, please refer to the above definition of the method for floor crowd size prediction based on elevator operation data,

And the specific limitations of the apparatus for robot elevator-taking path planning can refer to the above definition of the method for robot elevator-taking path planning. The above modules can be embedded in or independent of the processor in the computer device in the form of hardware, or stored in the memory in the computer device in the form of software, so that the processor can call to perform the operations corresponding to the above modules.

Based on the same idea, the present disclosure also provides a schematic diagram of the structure of a computer device, as shown in FIG. 14. The server can include: processor 1401, communications interface 1402, memory 1403, and communication bus 1404. The processor 1401, communication Interface 1402, and memory 1403 communicate with each other through communication bus 1404. Processor 1401 can call logical instructions in memory 1403.

In addition, the logic instructions in the memory 1403 can be implemented in the form of software functional units and stored in a computer-readable storage medium when sold or used as a stand-alone product. Based on the understanding of the essence of the technical scheme of the invention or on the existing technology contribute to the part or the part of the technical scheme can be manifested in the form of a software product, the computer software products stored in a storage medium, including several instructions to make a computer equipment (is a personal computer, server, or network equipment, etc.) performs all or part of the steps of the method described in each embodiment of the invention. The aforementioned storage media include: U disk, portable hard disk, ROM (Read-Only Memory), RAM (Random Access Memory), disk or CD-ROM and other media that can store program code.

In an embodiment, the embodiment of the present disclosure provides A computer device, comprising a memory and one or more processors, computer-readable instructions are stored in the memory, and the computer-readable instructions, when being executed by the one or more processors, enables the one or more processors

to execute the steps of the method provided in any embodiments of the present disclosure.

In an embodiment, the embodiment of the present disclosure provides a computer-readable storage medium storing a computer program, wherein the computer
5 program, when executed by a processor, implements the steps of the method provided in any embodiments of the present disclosure.

In an embodiment, the embodiment of the present disclosure provides a computer program, when executed by a master device, implements the steps in each embodiment of the method.

10 The computer program may be stored in whole or in part on a computer-readable storage medium packaged with the processor or in part or in whole on a memory not packaged with the processor.

In an embodiment, a processor is also provided that implements the steps in each of the above embodiments of the method. The processor can be a chip.

15 In an embodiment, a computer program product is also provided, including a computer program or instruction which, when executed by a processor, implements the steps in each of the embodiments of the method.

Ordinary technicians in the field can understand that all or part of the process in implementing the above embodiments can be accomplished by computer readable
20 instructions. Computer-readable instructions may be stored in a non-volatile computer readable storage medium and the computer-readable instructions may, when executed, include a flow of embodiments of each of the methods described above. Wherein, any reference to memory, database or other media used in each embodiment provided by this present disclosure may include at least one of both
25 non-volatile and volatile memory. Non-volatile Memory may include read-only Memory (ROM), magnetic tape, floppy disk, flash or optical Memory, etc. Volatile Memory can include Random Access Memory (RAM) or external cache Memory. As an illustration rather than a limitation, RAM is available in many forms, such as Static Random Access Memory (SRAM) and Dynamic Random Access
30 Memory (DRAM).

The technical features of the above embodiments can be combined arbitrarily. For the sake of conciseness of description, all possible combinations of the technical features in the above embodiments are not described. However, as long as the combination of these technical features is not contradictory, it should be considered
5 as the scope of this specification.

The above embodiments only express several embodiments of this disclosure, whose description is more specific and detailed, but cannot be understood as the limitation of the scope of invention patent. It should be pointed out that, for ordinary technical personnel in this field, under the premise of not deviating from the idea of this
10 disclosure, there are also a number of deformation and improvement, which belong to the scope of protection of this disclosure. Therefore, the scope of protection of this public patent shall be subject to the attached claims.

INDUSTRIAL APPLICABILITY

The method for robot elevator-taking path planning and crowd size prediction
15 provided by the present disclosure, can adapt to all kinds of floor division methods, according to the starting floor and target floor to provide several optimal paths of elevator and expected data. And the robot can according to the expected elevator-waiting periods for path planning and real-time correction in advance, improve the efficiency of the robot to perform tasks. It can also accurately estimate the population
20 size of each floor of a building, and provide corresponding data support for a more general building scene, with strong industrial practicability.

WHAT IS CLAIMED IS:

1. A method for robot elevator-taking path planning, comprising:

step S1, obtaining the starting floor and the ending floor of the robot;

step S2, determining all elevator groups that can reach the starting floor
5 to form a cache path sequence; wherein, each cache path in the cache path
sequence includes an elevator group sequence, an elevator sequence, a floor
sequence and an expected time point sequence;

step S3, traversing all the cache paths, if the elevator group
corresponding to the traversed cache path can reach the ending floor directly,
10 adding the cache path to the available path sequence; otherwise, taking the
last floor in the floor sequence of the elevator group corresponding to the
current cache path as the current floor;

traversing all transfer elevator groups reachable from the current floor,
and excluding the duplicate elevator groups in all transfer elevator groups
15 and the current cache path; if the traversed transfer elevator group can reach
the ending floor, adding the transfer elevator group and the ending floor to
the current cache path, and adding the current cache path to the available
path sequence as an elevator-taking path; and

step S4, repeating the step S3 until all cache paths are traversed.

20 2. The method according to claim 1, wherein the method further
comprises:

step S5, after traversing all cache paths, adding 1 to the pathfinding
count value; wherein, the initial value of the pathfinding count is 0;

step S6, repeating the steps S3 to S5 until the pathfinding count value
25 is greater than n; wherein, n is less than or equal to the number of elevator
groups; and

arranging the elevator-taking paths in the available path sequence in up
order of the number of elevator-taking nodes; wherein, the elevator-taking
node represents the process of taking a single elevator, and the elevator-

taking node includes an elevator group, an elevator, a starting floor, an ending floor, expected start time and expected end time.

3. The method according to claim 2, wherein the elevator-taking path, the elevator group, elevator, and starting floor of the elevator-taking node i correspond to the i^{th} element of the elevator group sequence, elevator sequence, and floor sequence in the elevator-taking path, respectively; the ending floor of the elevator-taking node corresponds to the $(i+1)^{\text{th}}$ element of the floor sequence in the elevator-taking path.

4. The method according to claim 1, wherein the step S3, if the transfer elevator group cannot reach the ending floor, the current cache path is used as a blueprint to increase the elevator-taking nodes from the current floor to all floors reachable by the transfer elevator group to form a new path, and add the new path to the cache path sequence.

5. The method according to claim 1, wherein the method further comprises:

step S7, if the available path sequence is empty, determining the start time of the robot movement and the end time of reaching the elevator; and

determining a number of supplementary paths according to the start time and the end time, as well as the elevator-waiting periods of each elevator in the cached route and the elevator-taking time to the ending floor.

6. The method according to claim 1, wherein the determining a number of supplementary paths according to the start time and the end time, as well as the elevator-waiting periods of each elevator in the cached route and the elevator-taking time to the ending floor comprises:

converting the elevator group sequence and floor sequence of the cache path into nodes in sequence, wherein the i^{th} node corresponds to the i^{th} elevator group from the i^{th} floor to the $(i+1)^{\text{th}}$ floor;

determining the elevator-waiting periods for each elevator in node i to reach the i^{th} floor in the desired direction, as well as the elevator-taking periods to the $(i+1)^{\text{th}}$ floor; and

calculating the new start time and new end time based on the elevator-waiting periods and ride periods of each elevator in the cached path, arranging the m supplementary paths with the earliest end time according to the new end time, and determining a new elevator-taking path according to the supplementary path.

7. The method according to claim 1, wherein the method involves a server and a client, the client includes a robot; and the method comprises:

obtaining the historical data of the elevator group in each preset time period;

calculating the expected data of each floor of the individual elevators in the elevator group according to the historical data; and

receiving the elevator-taking request sent by the robot, according to the elevator-taking request building information and the expected data back to the robot; the robot configured for calculating the final expected periods according to the building information and the expected data.

8. The method according to claim 7, wherein calculating the expected data of each floor of the individual elevators in the elevator group according to the historical data comprises:

obtaining the expected stopping times and average stopping periods of the elevator group in each of the preset time periods according to the historical data;

converting the expected stopping times and the average stopping periods into the expected stopping probability of individual elevators in the elevator group;

calculating the expected moving periods according to the elevator information of the elevator group;

calculating the expected elevator-waiting periods according to the expected moving periods, the average stopping periods and the expected stopping probability;

calculating the expected stopping periods according to the average

stopping periods and the expected stopping probability; and

storing the expected moving periods, the expected elevator-waiting periods and the expected stopping periods.

9. The method according to claim 7, wherein the expected data includes
5 expected moving periods, expected elevator-waiting periods and expected
stopping periods of each floor of individual elevators within a preset time
period.

10. The method according to claim 7, wherein the robot configured for
calculating the final expected periods according to the building information
10 and the expected data comprises:

the robot obtains all non-repetitive elevator group paths from the
starting floor to the target floor according to the building information;
calculates the final expected periods of all elevator group paths; selects the
elevator group path with the shortest final expected periods or several shorter
15 elevator group paths.

11. The method according to any one of claims 7 to 10, wherein the
elevator-taking request includes a user identification code, user
authentication information, and elevator-taking information, and the
elevator-taking information includes a start time, starting floor and target
20 floor.

12. A method for floor crowd size prediction based on elevator
operation data, wherein the historical data in the method of any one of claims
7 to 11 includes event messages, location information and elevator running
state; comprising:

25 obtaining event messages, position information and elevator running
state during the running process of the elevator, wherein the running state of
the elevator includes up and down, the position information includes the
current position and the passing floors during the running process;

determining an elevator passenger carrying state based on the event
30 message, wherein the elevator carrying state includes carrying passengers

and not carrying passengers;

if the current position is a stopping floor, updating the crowd index of each floor based on the elevator passenger carrying state and the elevator running state to obtain the updated crowd index of each floor; and

5 determining the crowd size of each floor based on the preset judgment condition and the target index; wherein the target index is the updated crowd index obtained after the elevator runs for a preset cycle.

13. The method according to claim 12, wherein determining an elevator passenger carrying state based on the event message comprises:

10 if the event message includes a door opening event, recording the time corresponding to the door opening event as the first-time node, and continue to monitor the event message of the elevator running process;

recording a time node corresponding to the elevator startup event as a second time node when receiving an event message including an elevator
15 startup event;

calculating the difference between the first-time node and the second time node as the startup operation interval; and

comparing the startup operation interval with the preset startup threshold, if the startup operation interval exceeds the preset startup
20 threshold, confirming that the elevator passenger carrying state is not carrying passengers, otherwise, confirming that the elevator passenger carrying state is carrying passengers.

14. The method according to claim 12, wherein the elevator passenger carrying state is carrying passengers, and if the current position is a stopping
25 floor, updating the crowd index of each floor based on the elevator passenger carrying state and the elevator running state to obtain the updated crowd index of each floor comprises:

adding 1 to the crowd index of the floor corresponding to the current position when the elevator running state is up, and determining whether the
30 floor corresponding to the current position is an access floor;

if the floor corresponding to the current position is the access floor, subtracting 1 from the crowd index of the access floor to obtain the updated crowd index of each floor; and

if the floor corresponding to the current position is a non-access floor
5 and the floor corresponding to the current position is the floor that stops for the first time in this up, subtracting 1 from the crowd index of the last passing floor of the floor corresponding to the current position to obtain the updated crowd on each floor index.

15 15. The method according to claim 12, wherein the elevator passenger carrying state is carrying passengers, and if the current position is a stopping floor, updating the crowd index of each floor based on the elevator passenger carrying state and the elevator running state to obtain the updated crowd index of each floor further comprises:

15 determine whether the current position is an access floor when the elevator running state is down;

if the current location is the access floor; subtracting 1 from the crowd index of the floor passing by the elevator during this running process and clear the record of the floor passing by; and

20 if the current location is the non-access floor; subtracting 1 from the crowd index of the floor passing by the elevator during this running process, adding 1 to the crowd index of the floor corresponding to the current position of the elevator and clear the passing floor record.

25 16. The method according to claim 12, wherein the elevator passenger carrying state is no passenger, and if the current position is a stopping floor, updating the crowd index of each floor based on the elevator passenger carrying state and the elevator running state to obtain the updated crowd index of each floor further comprises:

determining whether the current location is an access floor based on the location information;

30 if the current location is the access floor; subtracting 1 from the crowd

index of the floor passing by the elevator during this running process and clear the record of the floor passing by; and

if the current location is the non-access floor; subtracting 1 from the crowd index of the floor passing by the elevator during this running process, adding 1 to the crowd index of the floor corresponding to the current position of the elevator and clear the passing floor record.

17. An apparatus for robot elevator-taking path planning, comprising:

an initialize module configured for obtaining the starting floor and the ending floor of the robot;

a cache path module configured for determining all elevator groups that can reach the starting floor to form a cache path sequence; wherein, each cache path in the cache path sequence includes an elevator group sequence, an elevator sequence, a floor sequence and an expected time point sequence;

an available path determination module configured for traversing all the cache paths, if the elevator group corresponding to the traversed cache path can reach the ending floor directly, adding the cache path to the available path sequence; otherwise, taking the last floor in the floor sequence of the elevator group corresponding to the current cache path as the current floor;

traversing all transfer elevator groups reachable from the current floor, and excluding the duplicate elevator groups in all transfer elevator groups and the current cache path; if the traversed transfer elevator group can reach the ending floor, adding the transfer elevator group and the ending floor to the current cache path, and adding the current cache path to the available path sequence as an elevator-taking path; and

repeating the above steps until all cache paths are traversed.

18. A prediction apparatus of floor crowd size based on elevator operation data, wherein the historical data in the method of any one of claims 7 to 11 includes event messages, location information and elevator running state; comprising:

an information acquisition module configured for obtaining event

messages, position information and elevator running state during the running process of the elevator, wherein the running status of the elevator includes up and down, and the position information includes the current position and the passing floors during the running process;

5 a state determination module configured for determining an elevator passenger carrying state based on the event message, wherein the elevator carrying state includes carrying passengers and not carrying passengers;

 an index update module configured for, if the current position is a stopping floor, updating the crowd index of each floor based on the elevator
10 passenger carrying state and the elevator running state to obtain the updated crowd index of each floor; and

 a size determination module configured for determine the crowd size of each floor based on the preset judgment condition and the target index; wherein the target index is the updated crowd index obtained after the
15 elevator runs for a preset period.

19. A computer device, comprising a memory and one or more processors, computer-readable instructions are stored in the memory, and the computer-readable instructions, when being executed by the one or more processors, enables the one or more processors to execute the steps of the
20 method according to any of claims 1 to 16.

20. A computer-readable storage medium storing a computer program, wherein the computer program, when executed by a processor, implements the steps of the method according to any one of claims 1 to 16.