Energy Saving E Butler - an Integrated Device for Predictive Regulation Based on Smart Buildings

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Abstract. As of today, "carbon emission exceeds the standard" has seriously affected people's life, and it has become the responsibility and obligation of every citizen to monitor and reduce the carbon emission beam. At present, China is the world's largest construction market, and most of the new buildings are still high-energy buildings, and the proportion of building energy consumption is increasing. Nowadays, China's economy and society are developing in the direction of low-carbon economy and green environment protection. Therefore, this paper develops an "integrated system of predictive control based on smart building", which first classifies the people in the building by statistical methods, and then constructs the demand curves of different people for each control parameter in the building through the people behavior model. Based on the demand curve, the optimal control scheme for energy saving in the building is made on the premise of meeting the demand of most people for environmental comfort, and then the optimized control parameters are applied to the actual regulation through a series of sensors and control elements to realize fully automatic control of the building facilities.

Keywords: Carbon emissions overload, smart buildings, predictive regulation integration devices.

1. Introduction

During the "Two Sessions" in 2021, the government work report proposed the goals of "carbon peaking" and "carbon neutrality"[1]. Data shows that the total carbon emissions from the operation phase of buildings account for 21.9% of the national carbon emissions, while lighting and air conditioning account for 61% of the total carbon emissions from the operation phase of buildings [2]. Therefore, it is very important to reduce the energy consumption in the operation phase of buildings, especially the energy consumption of lighting systems and air conditioning equipment, to achieve "carbon peak" and "carbon neutral".

The two most widely used technologies for lighting and air conditioning regulation - manual and mechanical regulation - are both flawed [3]. Manual regulation is accurate, but human energy is limited, which does not guarantee the effectiveness of regulation, and aggravates the problem of waste of resources and environmental pollution. Mechanized regulation is limited in scope, for example, the lights are turned off at night in student dormitories, which can only be adjusted for the whole floor, and the regulation of lighting is too absolute to meet the individual needs of the population.

Therefore, in order to achieve the goal of "carbon peak" and "carbon neutral" as soon as possible, this design is based on the consideration of human comfort and energy saving and emission reduction goals, through the advance distribution of questionnaires to understand the different people's preference for the ambient light and temperature[4], the data will be recorded into the This design uses intelligent algorithms to personalize the control of blinds, air conditioners, lighting systems and other equipment in indoor installations under the premise of ensuring human comfort, thus realizing the integration of predictive control without manual The purpose of predictive regulation and control integration without manual drive. Therefore, if this device is applied to private houses, libraries, shopping malls and office buildings, it will drive the economic development of related industries and increase a large number of jobsz.

2. Design theory and related principles

2.1. Time (in winter, for example)

The time-based strategy is the lowest level of regulation. During off-hours, the whole building will not need to consider the comfort of the personnel and will directly apply the maximum energy saving measures: the overall lights will be turned off, the shading will be turned on during the day to heat the building with sunlight, and the shading will be turned off at night to preserve the residual heat [5].

During working hours, when the time is in working hours and there are staff in the building, the system will call the personnel behavior model to adjust air conditioning and lighting, and Markov model to adjust sun shading. decision curve, and for each room, the decision curve will be different according to the different people in the room, so as to achieve personalized control [6].

2.1.1. Acquisition of people preference information

The personnel information acquisition section is divided into face recognition and personnel information database: Face recognition section.

This part is responsible for acquiring the information of people entering and facilitating the retrieval of personnel data from the database. It interacts with cloud computing resources, runs the trained convolutional neural network model on the Tencent cloud platform, performs face recognition, and compares it with the information in the database. For unregistered personnel in the database, a questionnaire is issued to register them in the database for the next regulation, and for existing personnel, preference information is directly extracted and entered into the system to start personalized regulation.

Personnel database section.

The process of personnel preference classification adopts the method of clustering, which abstracts the personnel's answers to the questions in the questionnaire into high-dimensional vectors, and then adopts the K-means algorithm in the high-dimensional space to accurately classify the personnel into two categories and six sub-categories, which are then matched with the personnel IDs and stored in the database for the subsequent regulation.

2.2. Human behavior model to regulate temperature, humidity and light

The occupant behavior model processes temperature, humidity and illumination data to determine the opening and closing of lighting and air conditioning facilities [7].

The control curves of the occupant behavior model will vary depending on the type of occupant. Ultimately, the system will combine the preferences of all people in the room and use a weighted average to derive a comprehensive control curve that matches the preferences of the majority of people, so that rooms with people who prefer cold environments will be cooled more aggressively, while rooms with people who do not prefer cold environments will tend to be warmer. The same is true for light intensity. In this way, each room will be personalized to the maximum extent possible, ensuring the comfort of the personnel.

Through the face recognition system, the system can obtain the number of people in different rooms and their preference information from the database, and the system dynamically adjusts the control strategy of each room according to the preference of different people. In order to achieve personalized control, to meet the needs of comfort as much as possible while protecting the environment. Schematic diagram of K-means clustering method is shown in Fig. 1[8].

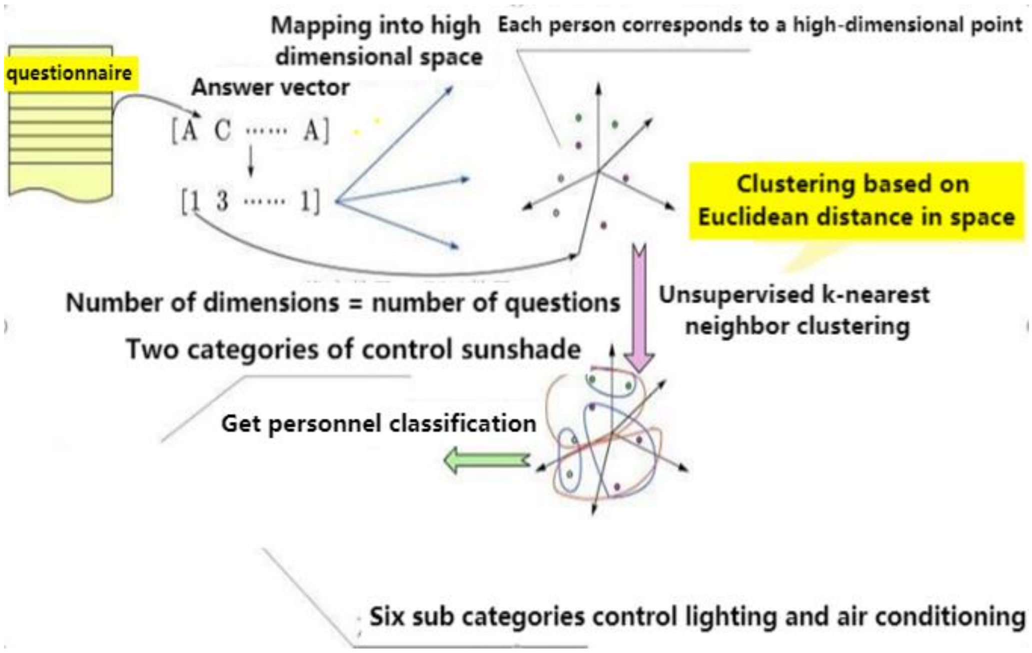

Figure 1. Schematic diagram of K-means clustering method

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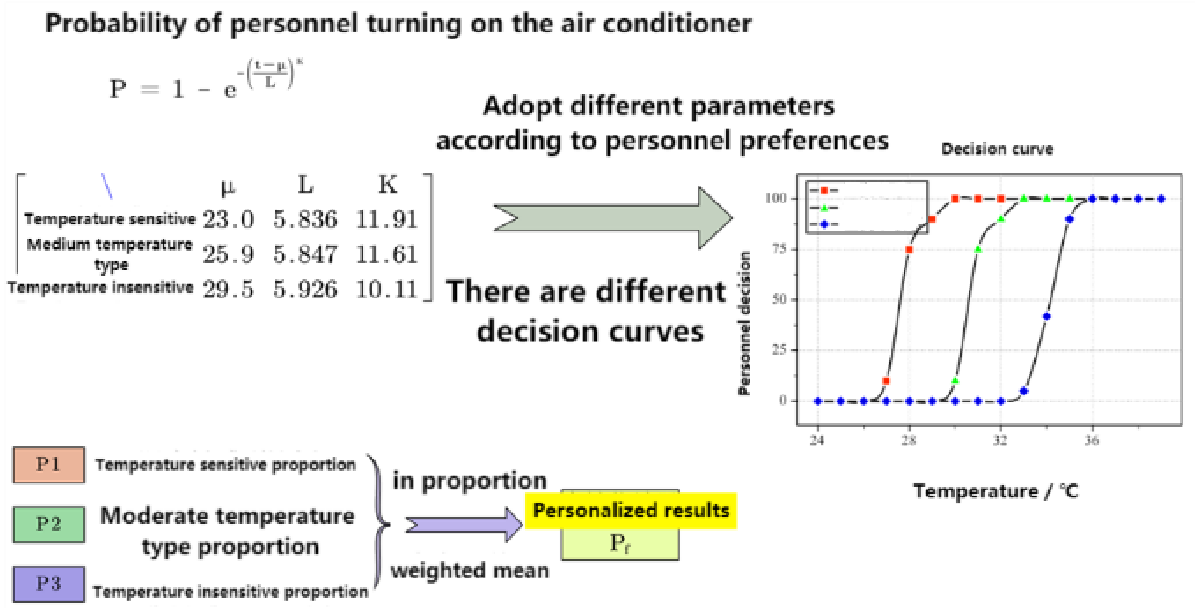

Figure 2. Air conditioning regulation curve

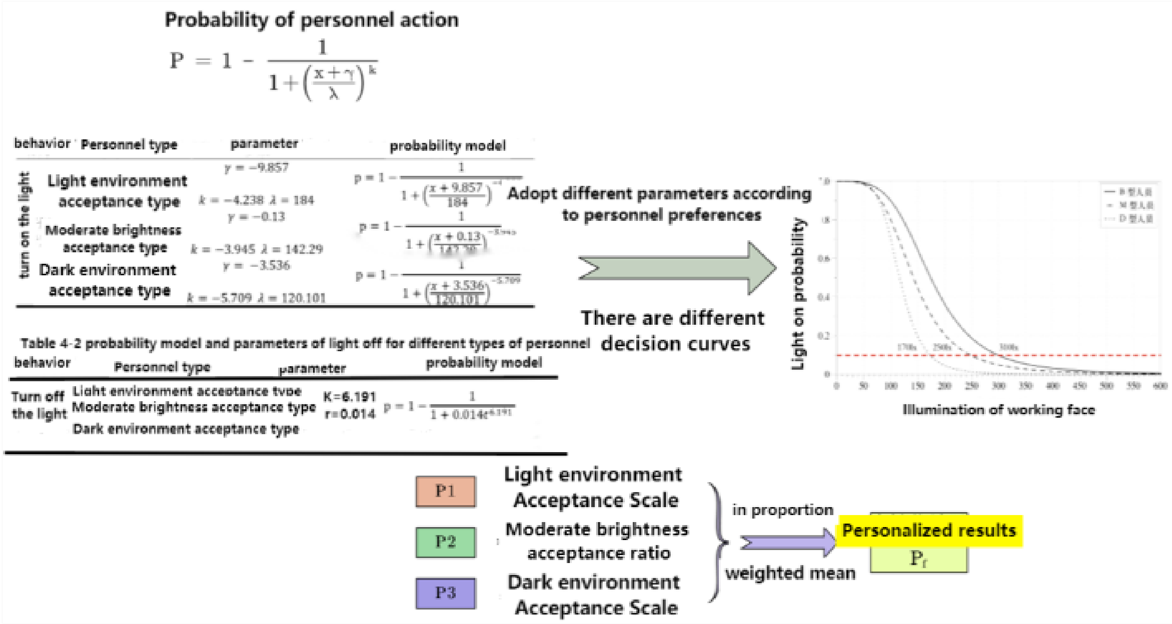

Figure 3. Illumination control curve

3. Markov model regulates internal and external illumination

A Markov model is used to control the sharing of the building.

The Markov model generates two transfer matrices based on the internal and external illuminance at the present moment and the previous moment, respectively, and the current state of the blinds used for shading, where the transfer matrix based on the illuminance changes according to the preferences of the personnel to achieve the goal of personalization. and then the final decision is made [9].

For people who like natural light, illumination control will be based on natural light to meet the preferences of the personnel while also replacing part of the light through natural light, saving energy.

3.1. Hardware control section

The hardware body consists of a Raspberry Pi chip and a number of external sensors and a number of moving parts. The hardware control part realizes the overall regulation of the building light system and air conditioning system opening and closing.

3.2. Sensors

The illumination sensors are divided into internal and external sensors that detect indoor (installed at the work surface) and outdoor illumination (at the window area), and the illumination information is input into the prediction model.

The face recognition system uses cameras to identify the number of people and their categories in the building, and transmits the number of people and their preferences to the main body of the program. Shutter opening information can be returned directly to the system by the servo.

3.3. Control and Decision Making

The control part consists of a relay and a servo. The Raspberry Pi, as the main body of the program, only sends control signals to the external hardware, and the external hardware receives the signals to regulate the system [10]. The opening and closing of the lighting system and the air conditioner are realized by the relays, and the Raspberry Pi is responsible for controlling the relay on and off.

The servo part is responsible for controlling the opening degree of the blinds, which makes the light evenly distributed in the room, solving the drawback of uneven light in the room caused by ordinary windows. The blinds are set at five action levels, corresponding to 0%, 25%, 50%, 75% and 100% shading respectively.

The decision-making part is a python program.

4. Experimental test and result analysis

4.1. Experimental testing

A small sample (30 people) was selected to distribute questionnaires, and the results were analyzed to classify people and entered into a database. Face data was collected for matching with people. The face recognition system was successfully created and the initial run was basically successful, and the retrieved data basically matched with the entered data. Face recognition diagram is shown in Fig. 4.

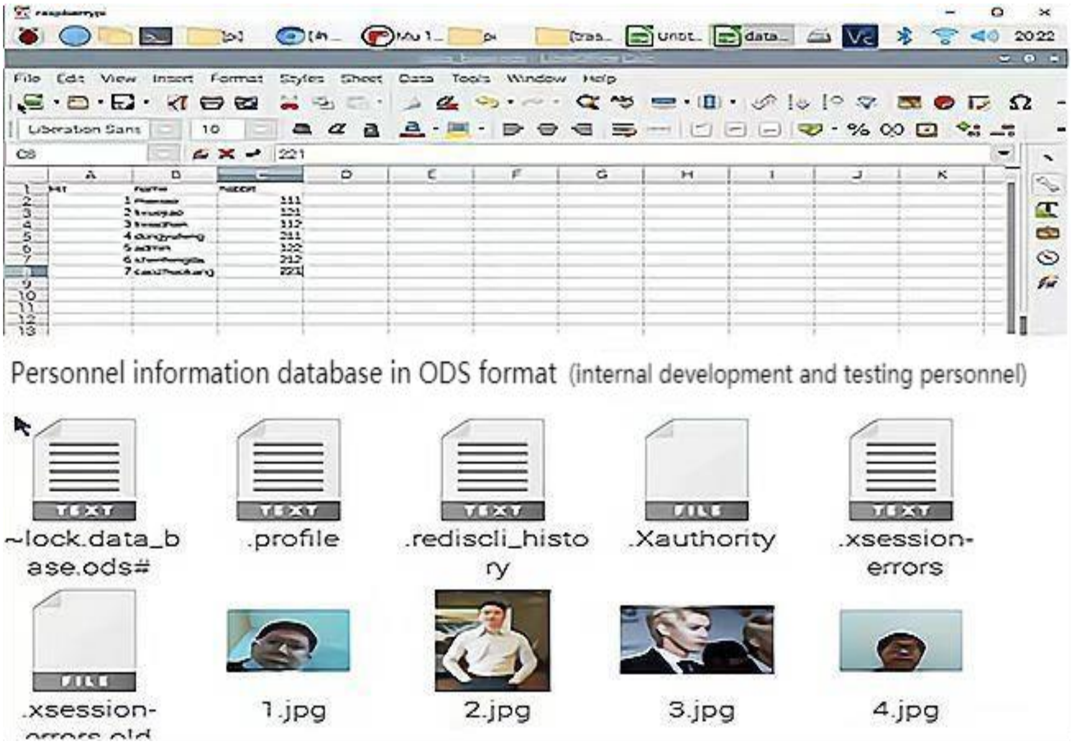

Figure 4. Face recognition diagram

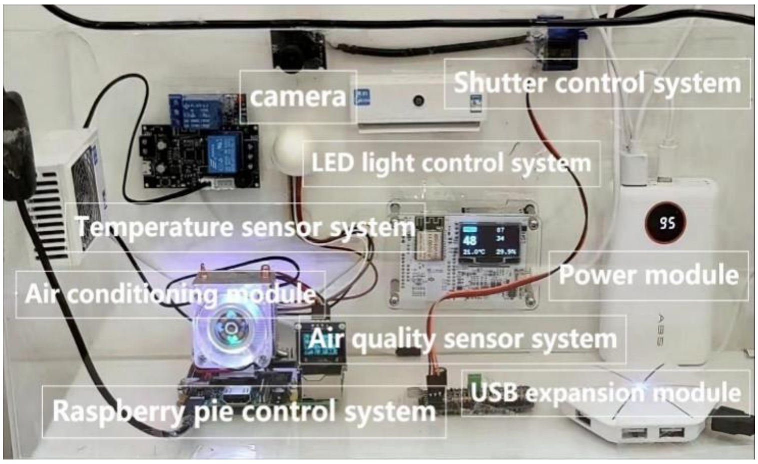

Figure 5. Physical model drawing

The scale-down model was created and the air conditioner, camera and blinds were successfully run, see Fig. 5 and Fig. 6.

Figure 6. Air quality monitoring map

4.2. Software Simulation

Energy Plus software was used to simulate the full energy consumption of the building for one week, compare it to the three existing regulation modes, and calculate the energy savings.

Conclusion: The control and regulation strategy saved 17.49% compared to manual regulation, 6.5% compared to lighting only (full shading), and 6.5% compared to lighting only (no shading). It is initially proved that this control strategy can effectively achieve the energy saving target.

5. Conclusion

The advantages of this device are.

Humanization: with the help of a database set up in advance, it makes a weighted average of the environmental preferences of indoor personnel to meet their needs to the greatest extent.

Intelligent integration: dynamically retrieve the information of personnel preferences in the database and make corresponding decisions by itself. This design predicts and regulates integrated operation to meet people's office needs on the basis of achieving the goal of energy saving.

Wide application: The degree of opening and closing of blinds is divided into multiple levels to accommodate regulation under different conditions and meet a variety of needs.

For office buildings, teaching buildings and other large public buildings using electricity unit intensive, energy consumption is great, and during non-working hours there may be untimely shutdown of light system and air conditioning equipment, resulting in a great waste of energy. The system conceived by our team can automatically analyze indoor and outdoor conditions and indoor personnel needs, and precisely make reasonable regulation to achieve energy saving.

Most of the smart energy-saving devices on the market today ignore the diversity of people's needs and only consider energy saving but ignore comfort, which is not conducive to people's daily study and work. At the same time, most studies use shading or lighting alone for regulation, which can be inadequate. Therefore, our product is more comprehensive and competitive.

In summary, our team's system has many advantages that traditional energy-saving devices do not have, and has great development prospects and application space. If it can be widely promoted in the future, it is bound to produce huge economic and social benefits and help the cause of energy saving and emission reduction.

Later we will install the whole house intelligent module to control all the programs and intelligent devices.

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