A Design of Wide-angle Open and Close Multifunctional Smart Windows

Zilong Liu [1], Luqi Shen [1], Jiarun Xu [1], Longyu Gao [1], Fengzhi Dai [1, 2 *]

[1] *Tianjin University of Science and Technology, China;*

[2] *Tianjin Tianke Intelligent and Manufacture Technology CO., LTD, China*

*E-mail: * daifz@tust.edu.cn*

www.tust.edu.cn

Abstract

Current smart windows always have low intelligence and a few functions. And almost all kinds of traditional windows have the problem of inconvenient cleaning outside. The paper proposed a new mechanical structure design of the window, so that the window can be turned by nearly 180 degrees, which is convenient for cleaning the inside and outside of the window. In terms of intelligent systems, a variety of sensors combined with Internet modules are used to realize the remote intelligent control (turning with the wind, and automatically closing windows when there is no one at home when bad weather). The added child mode uses visual inspection to identify children. When a child is detected, the window will be automatically closed to prevent the child from climbing the window and falling from the building.

Keywords: Smart window, new structure, machine vision

1. Introduction

With the development of science and technology and the improvement of people's living standards, the global smart windows are developing rapidly. Thanks to the development of construction industry, the current smart window market in my country is growing steadily year by year, becoming the future development trend of the door and window industry and occupying an important market position.

In the process of research on smart windows, it is found that existing smart windows have obvious defects. The specific manifestation is: low degree of intelligence, some products can only realize remote control.

Although the technology has been upgraded, it is only electric, not smart. Secondly, all types of smart windows have a single function. For example, smart dimming glass windows are researched on the permeability of glass; smart security windows are developed in terms of automatic alarms.

The traditional intelligentization of windows is mainly to upgrade the indoor brightness, voice control, and anti-theft. It has few functions, low practicality, and low degree of universality, so it is limited in practical applications. The traditional smart window is shown in Fig 1.

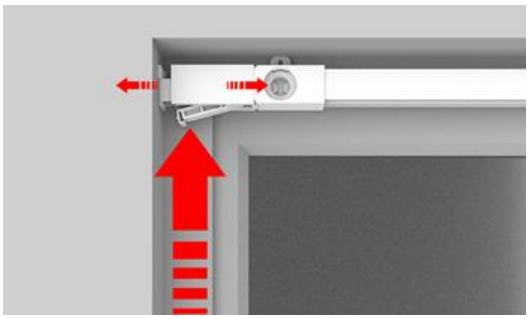

Fig.1. Traditional smart windows

At the same time, we have noticed that almost all smart windows are only functionally studied. The structure of the windows has not been upgraded [1]. Therefore, in

addition to the limitations of non-intelligence for various types of smart windows, the problem of the outside of the window that is not conducive to cleaning still exists, which has become a major pain point for users of smart windows. The structure of a traditional window is shown in Fig.2.

Fig.2. Traditional window structure

In response to the existing problems of smart windows, a new structure of smart windows was designed by our project team. It combines the advantages of traditional casement windows and smart windows to improve the shortcomings of the two types of windows to the greatest extent.

It not only solves the problem that the outside of the window is difficult to clean, but also realizes the diversity of windows in terms of functions, which can cope with various scenarios, and is more intelligent and humane.

2. Hardware Design

ESP8266 is used as the core controller of the control system. The sensor part includes compass module, temperature and humidity sensor, air dust sensor, rain sensor, harmful gas sensor, combustible gas sensor [2].

The 1.3-inch display screen is used to display various data of the window. Stepper motors and stepper motor drivers are used to control the mechanical structure of the window. The main elements of the window are shown in Fig.3.

2.1. Hardware connection

The single-chip microcomputer is connected to the sensor to receive various data and conduct a comprehensive analysis, and through the motor control the mechanical structure part, complete the control of the window state. And the necessary information is displayed on the display, so that the user can grasp the status of the window in real time. The connection mode of each sensor and the one-chip computer is shown as in Fig.4.

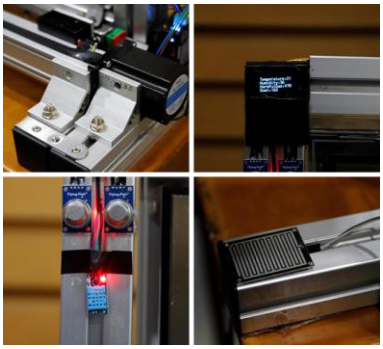

Fig.3. The main elements of the window

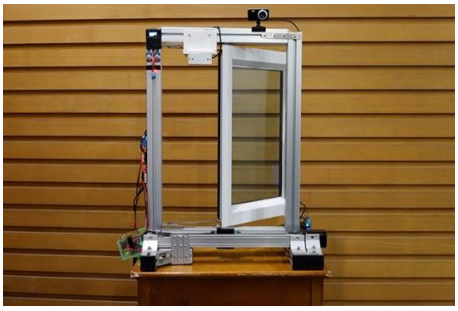

Fig.4. Nearly 180° flipped windows

A stepping motor is connected between the controller and the mechanical structure of the window, and the stepping motor is controlled by sending a pulse signal to the motor driver to open or close the window.

The Bluetooth module mounted on the window is connected to the controller through the USART bus to realize short-distance wireless transceiver function. The circuit connection diagram of the control system is shown in Figure 5.

2.2. Structural design

The clever design of the mechanical structure is the key to the large-angle opening and closing of the smart window. By adding the connecting rod design (the motor drives the lead screw, the slide moves horizontally through the movement of the lead screw, and the window is rotated by the connecting rod during the movement of the slide), only one motor is needed to realize the nearly 180° flip of the window.

The connecting rod structure and the window mechanical structure are shown in Figures 6 and 7 respectively.

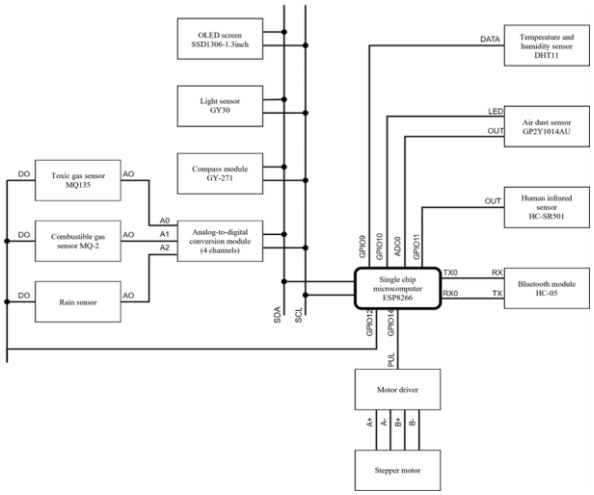

Fig.5. Control system connection diagram

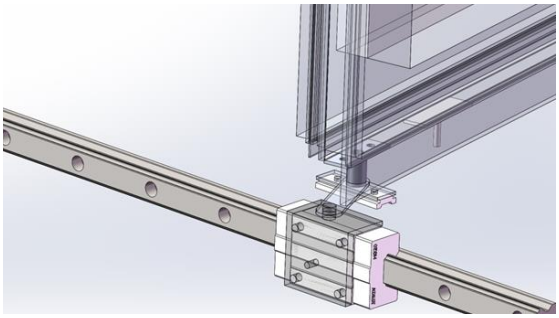

Fig.6. Connection rod structure

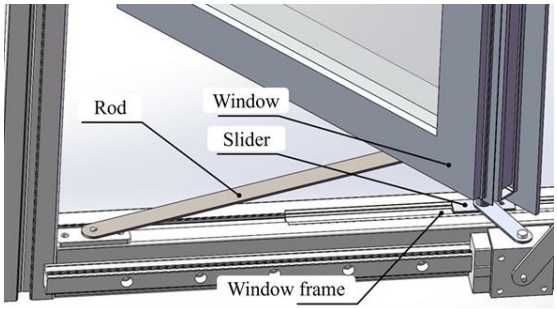

Fig.7. Mechanical structure drawing

Fig.8 shows the three typical open states of windows, namely 30°, 90° and 160°. Compared with existing windows, it effectively solves the problem that the outside of the window is difficult to clean, thereby greatly reducing the risk of falling. Clean the outside of the window is shown in Fig.9.

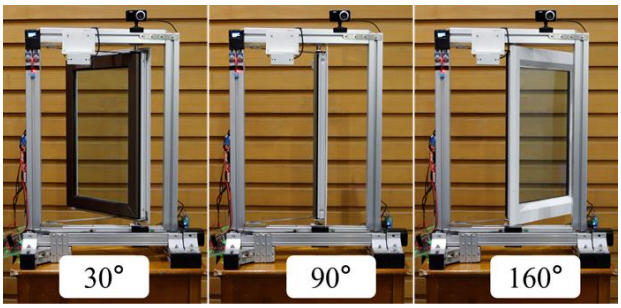

Fig.8. Mechanical structure drawing

Fig.9. Clean the outside of the window

3. Algorithm Design

3.1. Control algorithm design

In a general program cycle, the controller uses polling to obtain external information and display it on the display. However, due to sudden conditions such as rain outside the window, toxic gas, combustible gas and so on indoors, higher priority countermeasures are required. Therefore, various sensors can send interrupt signals to the controller through digital output pins, which ensures priority Deal with emergencies. The work flow chart is shown in Figure 10, which can realize the following functions:

- When the weather is bad and there is no one in the house, the windows will be closed automatically [3];
- Automatically open windows when the indoor air is bad or contains harmful gas;
- Adjust the opening and closing angle by itself according to the external wind direction.

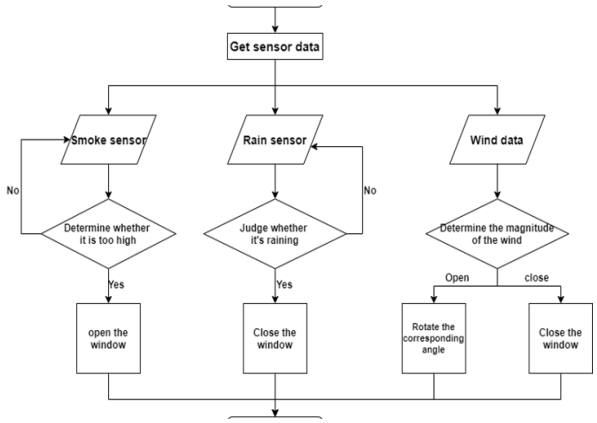

Fig.10. work flow chart

3.2. Child detection algorithm design

When the user is within the shooting range of the camera, the camera will automatically find and detect the user's face image.

A fixed-length feature vector is extracted from the convolution feature map, and then the feature vector is input into two fully connected layer networks. The age and gender classification training is performed on the extracted facial features through the random forest algorithm. When the camera detects that the child is close to the window, the window is automatically closed to prevent the child from climbing the window and falling from the building. The result of child face detection and recognition is shown in Fig.11.

Fig.11. Children's face recognition results

4. Conclusion

In view of the difficulty of cleaning the outside of traditional windows, a new type of multi-scene smart window is proposed. The structure is based on the original traditional casement window design, and a linkage mechanism is added, which enables the window to be turned over by nearly 180 degrees, effectively solving the problem of difficult cleaning of the outer side of the window.

At the same time, the window can adjust the opening and closing angle of the window according to the wind direction to ensure the maximum air intake. When the camera detects that there is a child's activity near the window, it will sound an alarm and automatically close the window to prevent accidents caused by children climbing the window. In summary, this wide-angle opening and closing multifunctional smart window will have broad market prospects.

References

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Authors Introduction

Mr. Zilong Liu

He majored in Machinery and electronics engineering in College of Mechanical Engineering, Tianjin University of Science and Technology. He studied mechanical control engineering and other related knowledge, and achieved certain results in related professional competitions.

Mr. Luqi Shen

He majored in industrial design at the School of Mechanical Engineering, Tianjin University of Science and Technology. He learned some computer programming and related knowledge .

Mr. Jiarun Xu

He majored in vehicle engineering at the School of Mechanical Engineering, Tianjin University of Science and Technology. He mainly learns about vehicle stability analysis, new energy and other related knowledge.

Mr. Longyu Gao

He majored in automation in College of Electronic Information and Automation, Tianjin University of Science and Technology. He learned SCM and data crawler and other related knowledge, and achieved certain results in relevant professional competitions.

Dr. Fengzhi Dai

He received an M.E. and Doctor of Engineering (PhD) from the Beijing Institute of Technology, China in 1998 and Oita University, Japan in 2004 respectively. His main research interests are artificial intelligence, pattern recognition and robotics.