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Contactless Switching System Based on Gesture Recognition

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Abstract: With the downgrading of COVID-19, the public affairs we contact in our daily life still cause potential indirect transmission risks, so we should pay more Gesture recognition is used to safely and quickly control these objects, so as to avoid them becoming the "hotbed" of virus transmission, reduce the chance of virus infection, and ensure the safety of public health. Gesture recognition is used to safely and quickly control these objects, so as to avoid them becoming the "hotbed " of virus transmission, reduce the chance of virus infection, and ensure the safety of users. Based on this, we propose to develop a contactless switching system using low cost and high reliability infrared gesture recognition.

Keywords: Gesture recognition, NO contact, Infrared sensor.

1. Preface

Due to the development of artificial intelligence technology in recent years, gesture recognition technology has been greatly improved and therefore gesture recognition-based contactless operating systems are gradually being used in various scenarios such as smart homes.

The contactless operating system uses cameras, sensors and software to recognise the user's gestures in real time and to perform the corresponding operations according to the user's gesture commands.

The main functions of the system are:

(1) Real-time recognition of the user's gestures, supporting many types of gestures such as waving, thumbs, fingertip twitching fingers, etc.;

(2) Performing corresponding operations based on user gesture commands, such as controlling appliances, adjusting lighting, etc.;

(3) Support for voice interaction, allowing home appliances to be adjusted by voice commands, etc;

(4) Intelligent, with the ability to open curtains, adjust the temperature, etc. according to the user's habits.

A contactless operating system based on gesture recognition can greatly improve the user's operating experience, increase the completion rate of home automation and popularise the application of smart homes. However, there are currently some difficulties that need to be addressed urgently: data collection difficulties: due to the complex and changing forms of gesture representation, collecting complex gesture data requires a large amount of data collection and experimentation, thus consuming time and effort; technical difficulties: from collecting to processing data and then to final recognition, it involves various technologies such as pattern recognition, image processing, machine learning, etc. The technical threshold is high and difficult; Accuracy issues: due to the complexity of gestures, the user has a large degree of freedom, and some subtle differences in gestures may have a large impact on the recognition results, so the accuracy rate is not high; user feedback: as users may not be used to using gesture operations, so there may be situations where users are not used to it, thus affecting the user experience. Improving the user experience remains a daunting task.

2. Current Status of Domestic and International Research

2.1. "Research status and trends in "gesture recognition technology

Gesture recognition technology is a recognition technology that consists of hand movements supplemented by expressions and postures as symbols for sign language recognition. Gesture recognition is generally regarded as a natural and efficient way of human-computer interaction and can be divided into contact and non-contact according to the distance of human-computer interaction during recognition. From the perspective of domestic and international research development, significant achievements have been made in gesture recognition research in China. Domestic scholars are actively exploring gesture recognition technology based on deep learning and have developed various applications based on it, such as smart home, smart security, indoor positioning etc. In addition, there are also domestic scholars working on video-based gesture recognition technology to provide technical support for fields such as virtual reality. Looking into the future development of gesture recognition research, the performance of deep neural networks will be explored in depth and the accuracy and reliability of the models will be continuously improved. New applications such as virtual reality, robotics and computer vision will also continue to be explored and developed to better serve humans. Gesture recognition will also continue to be of interest in the near future and will continue to make significant breakthroughs in the future

2.2. Contact 3D gesture recognition technology

2.2.1. Data glove based gesture recognition technology

3D gesture recognition technology is a new type of interaction technology that uses 3D sensors to track hand gestures and convert the tracked data into machine commands to control devices, which will replace the original computer keyboard, mouse and other input devices and expand the user's interaction methods. The earliest gesture recognition was based on data glove research, which generally used data gloves and position trackers to capture the trajectory and

timing information of hand posture and hand movement in space or by detecting the bending status of finger joints, thus realising the recognition of various gestures. 1983 Grimes was the first to receive the "data glove" patent at AT&T. "In 1995 Christopher Lee and Xu at Carnegie Mellon University used the CyberGlove data glove to recognise gestures, completing a gesture-controlled robotics system. In addition, 3D gesture recognition can also be applied to virtual reality (VR) and augmented reality (AR) technologies to achieve more accurate control

The system based on data gloves is a complex device that affects the dexterity and normal movement of the hands, which tend to get sweaty after a long time.

2.2.2. Surface electromyographic signal (SEMG) sensor-based gesture recognition technology

SEMG-based motion recognition began in the 1970s, and in 1971, D. Taylor et al. used a multi-electrode array to acquire SEMG signals for effective recognition of shoulder, elbow and forearm movements of the upper limb. In 1999, Nishwa et al. used two conductor dry electrodes placed at the elbow to acquire motion signals and achieved a real-time recognition rate of 10 gestures for three users of 91.5%. In China, Yang Dapeng et al. used six surface EMG electrodes placed on the forearm to identify 19 hand gestures with an offline verification success rate of 90% compared to data gloves, based on the SEMG sensor design is simple to produce and less costly, and the SEMG electrodes are generally strapped to the arm without touching the fingers, making the fingers more flexible and natural when doing the movements, but each time the user uses it, the electrodes and The position of the electrodes and the skin more or less has displacement changes that affect the experimental results, and the difference in the force of different people doing the same gesture will also affect the classification results, and the small difference in the collected SEMG signals makes classification difficult.

2.2.3. Gesture recognition technology based on acceleration sensors

The acceleration sensor data acquisition module captures information about the movement of the human hand and this information is transmitted through the device to the information resolution module for the purpose of gesture recognition. In 2004, Jang I J W and Park W B proposed the concept of static acceleration and dynamic acceleration, and gave the recognition methods respectively. 2009, Kong Jun used acceleration sensors to recognise ten Arabic numerals and simple hand gestures, but the system was complex and computationally intensive. computationally intensive. These acceleration sensors are not limited by the background, light and shadow, angle and space and other objective conditions when acquiring gesture data, easy to carry and move, and also can obtain the acceleration value of these handheld devices with certainty, but this has the same disadvantage as data gloves, which need to be handheld or worn on the body, making the user's experience greatly reduced, so non-contact gesture recognition methods are rapidly evolving.

2.2.4. Contactless 3D gesture recognition technology

(1) Computer vision-based gesture recognition technology

In 1996, Xu and Lee at Carnegie Mellon University developed a gesture control system for simple control of robots. In 2003, Sony released the Eye Toy Play, which allows users to control simple interactions through the camera. Following the launch of the Wii console by Nintendo in 2006, Microsoft released the Kinect body camera in 2010, which captured the user's gestures in real time and recognised them, and later applied them to game consoles. In May 2012, Leap Motion developed a body gesture that allows the computer to recognise gestures as valid actions, requiring only a small sensor to be connected to the computer to receive gesture signals, which can track movements down to 0.01mm without the user noticing the delay.

The vision-based contactless gesture recognition method has greatly improved the "naturalness" and "comfort" of human-computer interaction, and the equipment is inexpensive and easy to use. However, the uncertainty of vision makes it subject to environmental changes such as background, illumination and camera viewing angles, limiting its application.

(2) Acoustic wave-based gesture recognition technology

In 2012, Microsoft Research developed Soundwave, a gesture recognition technology based on sound waves. In 2013, Chirp Microsystems developed a microchip using ultrasound, which is not limited by the intensity of light and is smaller than a button battery and can be implanted in smart devices.

(3) Gesture recognition technology based on electric field sensing

In 2011, Ident Technology AG developed a chip called GestIC, which uses "e-field" electric field sensing technology to sense the user's hand movements via wireless signals and translate them into operating commands for gesture control.

(4) Infrared-based gesture recognition technology

Infrared-based gesture recognition is a novel way of gesture recognition, infrared sensing technology can be applied in remote control, communication, navigation and distance measurement, etc. In addition to its own characteristics such as high sensitivity and low interference by external light can also be used in the field of gesture recognition in the new generation of human-computer interaction by sending infrared beams to this or through the target object, the object or mirror reflects the infrared beam, the infrared sensor receives the reflected back beam and determines the presence of the object based on the intensity of the beam. In 2012, Ge Gengyu and Wang Yujun from Southwest University used an AT89S51 microcontroller to control a TCRT5000 photoelectric sensor module as an example to design a simple gesture recognition system that can discern four types of gestures. 2015, Huang Yan et al. researched a simple gesture recognition system based on an infrared photoelectric sensor that can also meet simple system functional requirements.

3. System Design

3.1. Working principle

Using the PAJ7620U2 module for gesture recognition, the PAJ7620U2 is an optical array sensor from Original Phase Technology (PixArt) with a built-in light source and ambient light suppression filter integrated LED, lens and gesture sensor in a small cube module that can operate in dark or low light environments. The sensor also has built-in gesture recognition, supporting 9 gesture types and outputting gesture interrupt results. And there is a built-in proximity detection

function for sensing the approach or departure of objects.

The block diagram of the PAJ7620U2's module functions is shown in the figure: Figure 1.

As can be seen from Figure 1, the PAJ7620U2 comes with its own internal LED driver, sensor sensing array, target information extraction array and gesture recognition array.

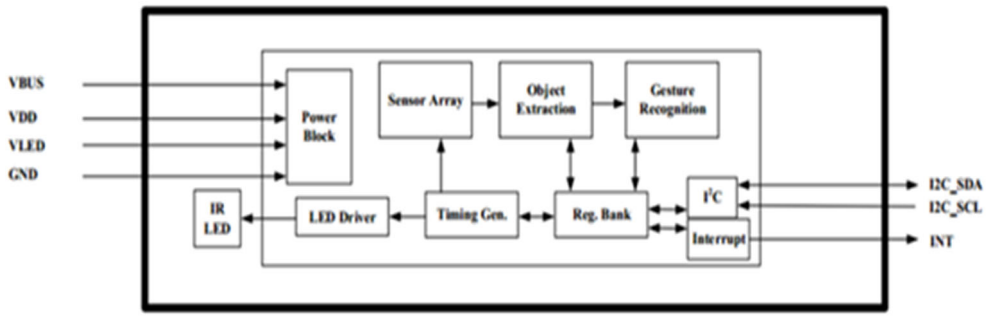

Figure 1.

When the PAJ7620U2 works, through the internal LED driver, it drives the infrared LED to emit infrared signals outwards. When the sensor array detects an object in the effective distance, the target information extraction array will acquire the characteristic raw data of the detected target, and the acquired data will be stored in the register, meanwhile the gesture recognition array will process the raw data for recognition, and finally the gesture result will be stored in the The user can read the raw data and the gesture recognition result according to the I2C interface.

3.2. Touchless gesture operation

Gesture recognition is a human-computer interaction technology that has been developed in recent years. It is a method of using computer technology to enable machines to recognise human gestures. Through gesture recognition, users can try to free themselves from the constraints of the environment and input devices and interact with the environment in a natural and effective gesture way, with a wider interaction space, higher flexibility and better interaction experience. Gesture is an important body language that has long existed in human society. It is simple, direct, efficient, clear and rich in content. Gesture recognition refers to the whole process of tracking human gestures and recognising their meaning. Gestures, due to their multiplicity, diversity and uncertainty, have no fixed definition and are generally understood as various gestures, shapes and actions formed by the hand or hand and arm together to express a certain meaning. Gestures can generally be customised to suit your own application scenario and environment. Gesture information includes three aspects: hand shape, position and direction.

This project addresses the need for user interaction with commonly used devices, customised gestures and has these features.

(1) The gestures are simple, easy to be remembered and operated by the user, and can be freely operated even by elderly people or children.

(2) Gestures are easily and reliably recognised by the device. There must be significant feature differences in the motion space for each type of gesture to ensure that the algorithm can accurately identify the gesture type. Based on the two basic gesture definition principles on W, this project defines a total of 10 commonly used gestures and divides them into three main categories according to the semantics of the action and the similarity of the amount of features. The horizontal plane operation gesture has the palm of the hand parallel to the top of the infrared sensor from top to bottom or from bottom to top, and can also be swung from left to right or from right to left as in Figure 2; the Z-axis operation gesture has two fingers parallel to the top of the infrared sensor drawing circles clockwise or counterclockwise from above. The rotation gesture moves the palm of the hand parallel to the top of the infrared sensor clockwise or counterclockwise as in Figure 3; the rotation gesture moves the palm of the hand parallel to the top of the infrared sensor close to the sensor or the palm of the hand parallel to the top of the sensor away from the sensor, with a relative change in distance from the sensor in the vertical direction as in Figure 4, resulting in "front", "back" recognition results as in Figure 4, "back" recognition results.

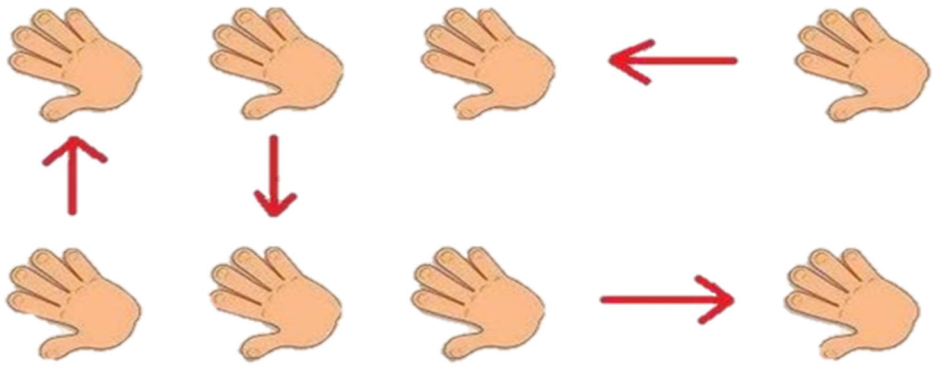

Figure 2.

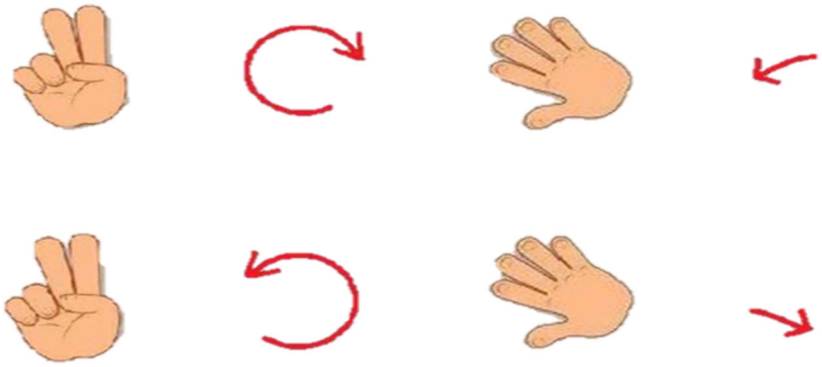

Figure 3. "Rotate clockwise", "Rotate counterclockwise", "Swing clockwise", "Swing

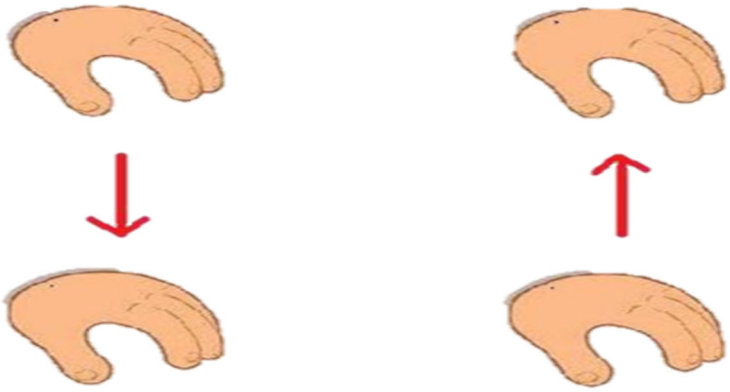

Figure 4. The "back and forth" gesture counterclockwise" gestures

3.3. Overall system flow

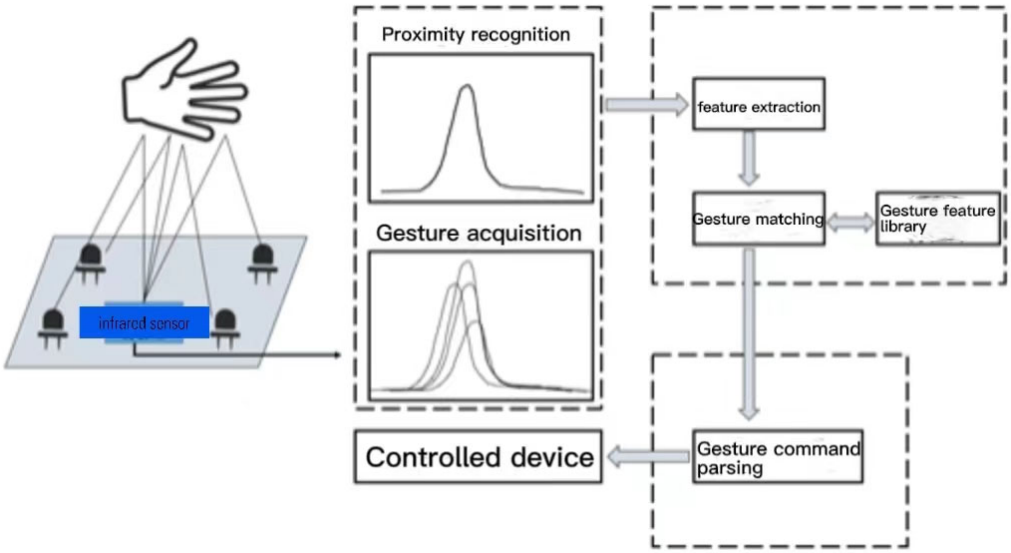

Figure 5.

The framework structure of an infrared-based gesture recognition switch control system is shown in Figure 5, in which a distance sensor is installed for proximity detection in order to reduce power consumption, and the system starts to work when an object is close, the gesture sensor starts to collect gestures, extracts gesture features and gesture feature library for gesture matching, and parses the gesture commands to output, thus controlling home appliances, such as switching on and off lights through gestures and the opening and closing of security doors.

4. Technical Solutions and Analysis

4.1. Contactless gesture recognition technology solutions

At present, infrared gesture recognition technology development is mainly used in mapping, communication, smart home, intelligent security, indoor positioning, etc., and few are used for public things. The contactless gesture recognition switch system mentioned in this paper uses the

PAJ7620U2 module to carry out gesture recognition, when an object is close, the system starts to work, the gesture sensor starts to collect gestures, extracts gesture features and gesture features library for gesture matching, and parses the gesture commands to output, thus achieving contactless control of object switching.

Contactless switch systems effectively isolate the cross transmission of germs, eliminating contact transmission routes from the source. For example, in our daily contact with the toilet door, or teachers' door, light switch, etc., install gesture recognition contactless switch system, the system does not have an impact on the original safety device, only need to add gesture recognition device to the door and window switch, can achieve effective control of the door and window switch, the device is lightweight, easy to install, can achieve not damage the original switch structure, isolate the virus contact transmission pathway, the door and window switch The device is lightweight and easy to install.

The gesture recognition device is of moderate size, highly compatible, suitable for a wide range of door and window opening and closing devices on the market, supports multiple size layouts, realises a variety of opening and closing needs without affecting the use of the original functions, and is powerful, with a strong endurance and low maintenance costs, and can be applied to a variety of scenarios.

4.2. Advantages of the technical solution and the proposed solution

4.2.1. Advantages of the technical solution

(1) Based on a study of the current state of research and development in China and abroad, infrared gesture recognition as a novel gesture recognition method has significant advantages in remote control, communication and navigation and ranging. In addition to this, it can also be used in the field of gesture recognition for new generation human-computer interaction with its own characteristics such as high sensitivity and low interference by external light. By emitting an infrared beam or passing through a target object, the object or mirror reflects the infrared beam, the infrared sensor receives the reflected beam and determines the presence of the object according to the intensity of the beam.

(2) The contactless switch system based on gesture recognition has low power, long life, long response time, the ability to implement a variety of gesture recognition algorithm design and support a variety of gesture recognition, this solution has the advantages of low maintenance costs and long application time, so it is a better choice for the development of small switch systems.

(3) Compared to direct contact control methods, gesture recognition is safer and more reliable, reducing the spread of viruses or bacteria caused by finger contact and contributing to public health safety.

(4) The use of infrared sensors for gesture recognition, in meeting the needs of daily life switch control, compared with machine vision, radar recognition and other gesture methods, hardware costs are lower, the technology is more mature and reliable, for gesture recognition control methods, access to the smart home system to provide a broader development of the future.

(5) The 10 characteristic gesture codes can be mapped to 0-9 Arabic numerals after parsing, providing a basis for digital input options, which can be used for lift control and also for device password management, such as for encryption management of security doors or data cabinets, increasing the application scenarios for this system.

4.2.2. Problems to be solved by infrared contactless gesture recognition systems

The infrared-based gesture recognition technology meets the system's need for accurate recognition of 10 characteristic gesture coding functions while preventing incorrect gesture commands from being output by mistaken touch resolution.

The proposed system of object recognition is triggered by adding feature gestures to the sensor and subsequently issuing feature extraction commands to parse the gesture commands and complete the operation.

5. Outlook and Conclusions

Taken together, contactless gesture recognition is used in a variety of diverse gesture recognition environments, when the user's hands are occupied and when multiple people come into contact with public objects in their daily lives. A contactless operating system based on gesture recognition can increase operational efficiency, improve the user experience and enable more natural and efficient operations. It can effectively curb computer waste due to excessive operations and can effectively reduce the burden on the user when using technology and improve the user experience. In addition, infrared-based gesture recognition systems are also powerful. Infrared gesture recognition systems can recognise a wide range of different gestures, allowing for a wider range of functions. For example, users can control facilities such as TVs, projectors and stage lighting through gestures, or they can control computers through gestures, enabling functions such as adding, deleting and checking documents, pictures and other content. Therefore contactless operating systems with infrared recognition will receive more attention. In the future, with the continuous development of artificial intelligence technology and infrared contactless gesture recognition technology, more attention being paid to public health in daily life and the growing demand for human-computer interaction, the infrared-based contactless gesture recognition switch system will certainly have a broad research and application prospect.

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