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Research and application of gesture recognition technology in human-computer interaction technology with taking Leap Motion device as an example

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Abstract

Leap Motion is a device that realizes a new type of human-computer interaction. It expands the selection range of human-computer interaction, allowing people to control the computer through gestures, so that the operating space of human-computer interaction can be expanded to a larger scope, and it makes the more reasonable use of space, the convenience and scalability show the practical research significance. This paper aims to expound its research and application in human-computer interaction technology from the principle of this device, to the technology and application prospects used, and finally to the problems that still need to be faced in the development process.

Keywords

Gesture recognition, human-computer interaction, space, Leap Motion device.

1. Introduction

Since the advent of computers, people have been pursuing a more convenient way of human-computer interaction, which is why the interaction methods have been diversified, from DOS interface to mouse and keyboard interaction, voice interaction, touch interaction, etc. Gesture interaction for more convenience has gradually become one of the very important ways in human-computer interaction. The purpose of gesture recognition is to use the posture and movement position of the human hand as the input content and turn it into instructions to manipulate the computer. The infrared sensor of gesture recognition can accurately and effectively capture hand information, transmit the information to the computer, and realize non-contact interaction and control. Non-contact dynamic gesture interaction has been applied to somatosensory games, assisted driving, sign language recognition and other fields, bringing people a simple and convenient user experience.

2. Leap Motion overview

2.1. Definitions

Leap Motion is a somatosensory manufacturing company Leap for PC and MAC Vision-based somatosensory sensor released in 2013. The size is very small, and users do not need complicated operations. They only need to wave their fingers in front of the sensor to achieve various operations, such as browsing websites, zooming in and out of pictures, flipping through articles, or playing music. They can even use their fingertips to write and draw designs and so on.

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2.2. Working principle

Leap Motion uses infrared camera technology, which is the key to capturing the user's hand movements. It has a wide sensor field of view, about 105 degrees, and the effective detection range is about 0.03 meters to 0.6 meters above the device. . It can track the three-dimensional coordinate information of the hand and 10 fingers within a diameter of about 1 meter through the infrared light of the LED, record the gesture and coordinate information, and combine the gesture recognition operation to complete the control of the computer.

2.3. Basic information

Leap Motion device can capture data at 215 frames per second and has a positional accuracy of 0.01mm. Its API supports multi-language platforms, allowing access to raw data such as querying 5 -finger 3D coordinates, hand grip value, hand rotation angle, etc., helping to build a dataset to implement and analyze gesture recognition algorithms.

Leap Motion device system uses a right Cartesian coordinate system. The origin is above the top of the device. The plane formed by the X axis and the Z axis is parallel to the top of the device, wherein the X axis is parallel to the long side of the device, and the Z axis is parallel to the short side of the device. The Y-axis is perpendicular to the device and upwards is the positive direction. The Z axis has positive values that increase towards the user, as shown in Figure 1.

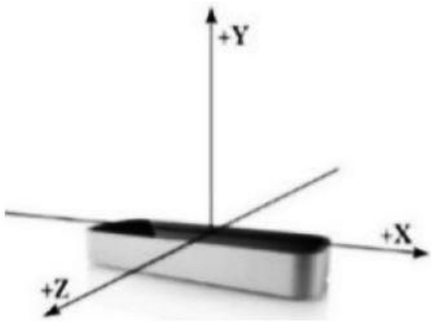

Figure 1 The Leap Motion coordinate system

3. 3. Gesture Recognition Overview

Gesture recognition can be divided into two categories according to gesture input devices: gesture recognition systems using data gloves as input devices and gesture recognition systems using cameras as input devices. Leap Motion equipment adopts the latter, the price is relatively low, but the calculation process is complex, the recognition rate and real-time performance are poor, but the learning and use are simple and flexible, do not interfere with users, and are more natural and direct human-computer interaction Way. The key issues are gesture segmentation, gesture modeling, gesture analysis and gesture recognition, as shown in Figure 2.

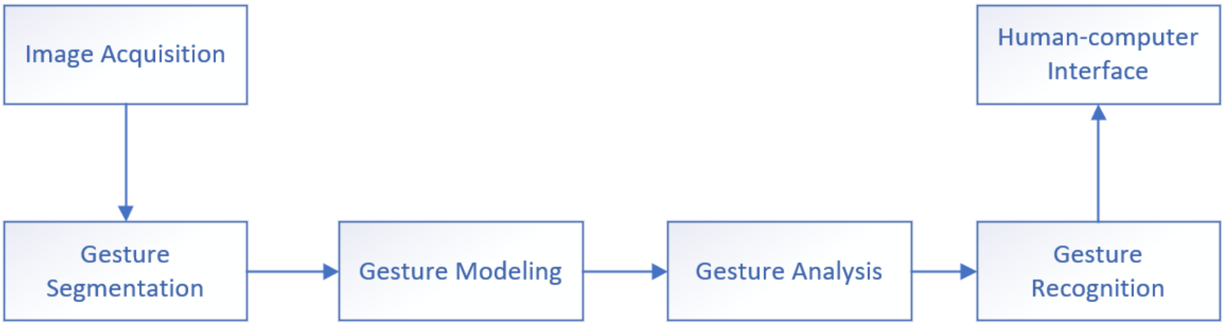

Figure 2 Architecture of Gesture Recognition System Based on Monocular Vision

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3.1. Gesture segmentation

Gesture segmentation is based on computer vision and refers to how to separate gestures from hand images. The main method is to let the hand emphasize the foreground through a specific glove or through a large-capacity gesture shape database, that is, a large amount of gesture data is stored as a template for recognition.

Gesture segmentation methods: ① Methods of increasing restrictions, such as using black and white walls, dark clothing, etc. to simplify the background, or requiring people to wear special gloves to emphasize the foreground, to simplify the division between the hand area and the background area; ② large Volumetric gesture shape database method, such as Michigan State University's computer department has established a database, in which there are hand images of various gesture classes at different positions and proportions at different times, as templates based on template matching recognition methods. ③The method of stereo vision, such as the computer department of Columbia University in New York, uses two reflection images that are not in the same plane mirror to calculate the distance between the object and the camera, and segment the human hand according to the distance information.

3.2. Gesture Modeling

Gesture modeling plays a key role in determining the recognition range. The selection of the model depends fundamentally on the specific application. If natural human-computer interaction is to be realized, a fine and effective gesture model must be established, so that the recognition system can respond correctly to most gestures made by the user.

At present, almost all gesture modeling methods can be classified into two categories: appearance-based gesture modeling and 3D model-based gesture modeling. A two-step modeling process is generally followed: first, the motion and pose of the hand and arm are modeled, and then the gesture model parameters are estimated from the motion and pose model parameters.

3.3. Gesture Analysis

The task of gesture analysis is to estimate the parameters of the selected gesture model. It generally consists of two parts: feature detection and parameter estimation. The basic positioning methods are as follows: ① Color-based positioning: use restrictive backgrounds or color gloves. ②Motion -based positioning: This positioning technique is usually used with certain assumptions. ③ Based on multi-modal positioning: For example, using the fusion of motion and color information to locate the human hand, the advantage is that it can overcome the limitation of single-cue positioning.

3.4. Gesture recognition

The gesture recognition mentioned here is based on computer vision gesture input, which is characterized by less restrictions on the user's movement, a large amount of data to be processed, and a complex processing method, which is not suitable for real-time recognition. Existing dynamic gesture recognition techniques can be classified into three categories: Hidden Markov Model (HMM) based recognition, Dynamic Time Warping (DTW) based recognition, and Compressed Timeline based recognition.

4. Application in human-computer interaction technology

Gestures are vivid, vivid and intuitive, have strong visual effects, and are a natural mode of human-computer communication. Through simple learning, users can learn a large number of operations in a short period of time, which is more in line with the reality of life and has a simple cognitive process.

In addition to basic sliding, zooming and other functions, Leap Motion also allows users to sculpt, cast, stretch, bend and build 3D images in 3D space, as well as take them apart and stitch them together again . Its unique space and its easy-to-learn and easy-to-use features make it a very broad space for use in all aspects .

4.1. Combining with smart home

At this stage, more and more smart homes are being designed, but these smart homes still need to touch devices or use mobile phones to control, so for some elderly people and children, smart homes are not smart. If gesture recognition technology It can be combined with smart home, so in the future, smart home can automatically sense the position of people within a fixed range, capture human movements, and allow humans to control more conveniently, which not only protects privacy, but also facilitates life.

4.2. Combine with 3D projection to make more rational use of 3D space

At this stage, many 3D demonstrations rely on computer software simulations. However, computers are two-dimensional after all. There are many inconveniences during demonstrations, and it is difficult for people to truly feel the three-dimensional model. If the model can be projected through 3D projection technology, and people can control it through the Leap Motion device, it can be easier to understand the model, improve work efficiency and accuracy, and realize remote manipulation in science fiction movies.

4.3. Move closer to the field of convenience

Leap Motion device makes the user's operating space develop to a wider place, and at the same time gets rid of the constraints of physical hardware to a certain extent. Therefore, the user can control the items anytime and anywhere without having to touch the items and the remote control, which reduces the burden on the user and makes the human-computer interaction develop in a more convenient and efficient direction. For example, in the aspects of automobile intelligent center console, TV remote control, casual games, etc., simple gesture operations can easily complete various functions and provide convenience for life.

4.4. Combine with medical service

Today, there are still a large number of hearing-impaired people who need to communicate through sign language and other means. This number may be far beyond the imagination of ordinary people, and because of the particularity of this group, it is relatively difficult to be known in the public. Although our country's investment in the construction of information accessibility has gradually increased, the communication barriers of hearing-impaired people in many scenarios still need to be solved urgently. How to enable them to enjoy the convenience brought by modern technology is not only a technical issue, but also a people's livelihood issue. Although there are devices that convert speech into gestures to serve the hearing-impaired, the communication between people is by no means a one-way communication. How to convert gestures into speech to achieve two-way communication is still a technology problem. Gesture recognition technology promises to be a boon for people with hearing impairments.

5. Gesture recognition technology taking Leap Motion device as an example still needs to face problems in human-computer interaction technology

Although a large number of researchers have analyzed and developed vision-based gesture recognition technology, there are still some problems and difficulties to be solved in this field, mainly in the following aspects:

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5.1. Changes in ambient lighting

In real life, unstable lighting will cause changes in the colors of the recognition target and the background. Sometimes, the recognition effect of some regions may not be obvious, resulting in errors.

5.2. Background complexity

In practical applications, uncertain and disordered backgrounds bring huge difficulties to the accurate segmentation and tracking of gestures, especially gesture recognition based on monocular vision. It is difficult for the same algorithm to achieve satisfactory recognition results in all different complex backgrounds. The main factors that lead to the complexity of the background are: the motion of objects in the background, and the existence of objects similar to the target in the background (such as large-area skin-like objects such as faces) and so on.

5.3. High degree of freedom and complexity of the hand

The human hand is a non-rigid object with more than 20 degrees of freedom, which makes the state space of the hand shape very large. In addition, the hand undergoes translation, rotation and scale changes. Therefore, how to achieve accurate gesture recognition becomes extremely challenging.

5.4. Diversity of users

Different users' hands will have some differences in shape and color, and when different users make prescribed gestures, they will also vary from person to person. How the gesture recognition algorithm is independent of the user is also something that gesture recognition technology needs to overcome. question.

5.5. Insufficient accuracy

The focus of human-computer interaction is not only what form to use, but also what kind of precision can be achieved. The reason why the mouse and keyboard endure is that they are extremely accurate in completing tasks. There is almost no phenomenon that the user presses A to become B, or presses the left button to become the right button. However, in gesture recognition, due to recognition Problems such as limited accuracy and infrared occlusion lead to mismatches between user needs and machine responses, or false touches. Therefore, it is still necessary to strengthen the recognition accuracy.

5.6. Contradiction between accuracy and real-time performance

simple algorithms have faster running speed, but the recognition accuracy is difficult to guarantee. There are also more and more novel algorithms that can improve the accuracy of recognition. However, the complexity of these algorithms is relatively high, and the amount of computation increases, which makes the system lose its original real-time performance. How to find a balance between accuracy and real-time performance is also a problem that must be considered.

5.7. Gesture setting problem

Due to machine learning and input issues, device control gestures are determined by system settings, and it is still difficult for users to implement custom gestures. If the gestures can be customized, the user has more choices and control rights in the process of human-computer interaction, which can make the human-computer interaction more natural and closer to the user.

In practical applications, how to solve the impact of the above problems on gesture recognition and how to achieve a highly robust system are the key contents and technical difficulties of gesture recognition technology based on computer vision.

6. Conclusion

like Leap Motion have made people start using it and even popularized it with its ease and speed. This kind of device that can control the computer by sliding a finger in the void greatly liberates our hands, so that our hands are no longer limited to a series of peripherals such as keyboards and mice, so that we can more easily perceive and touch Touching the world makes human-computer interaction more natural and free—human-computer interaction can be achieved without touching. And this model also contains great potential, and it is likely to play its shining side in smart devices. Of course, it also inevitably has some shortcomings due to technical reasons, and it is still difficult to shake the status of peripherals such as mouse and keyboard. However, with the development of technology, with the development of pattern recognition, ejaculation network, artificial intelligence, digital image processing, computer vision and other disciplines, gesture recognition technology will inevitably make our daily life more intelligent and convenient.

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