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Interactive design of intelligent machine vision based on human–computer interaction mode

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ABSTRACT

The intelligent machine vision technology based on man-machine interaction mode has the advantages of weak intrusion, low adhesion and no device binding. With the development and progress of science and technology, the intelligent machine vision technology has become one of the most important directions in the field of human–computer interaction. Compared with the traditional interactive mode, the intelligent machine vision interaction technology is quite convenient, and the existence of these problems can also influence the vision of the intelligent machine to a certain extent. And the wide application of the sense interaction. At present, the operation precision is the main basis of the machine vision interaction design. Therefore, this paper studies the precision of the visual interaction of the intelligent machine. In this paper, three point-to-click experiments will be carried out on the basis of the Fitts' Law. The accuracy of the machine vision algorithm is experimentally studied from the operating direction, the mapping scale equation and the machine vision algorithm, and a reasonable suggestion is made for the intelligent machine vision interactive design of the human interaction mode.

1. Introduction

Human–computer interaction is based on the research and implementation of computer interaction. Human–computer interaction is based on the interdisciplinary fields of computer technology and human–machine science [1]. It is also widely used in many fields, including modeling, design, evaluation and other theories and methods. Good human–computer interaction methods will fully understand human characteristics and pay more attention to user demand, so as to better realize human–computer interaction technology. In the process of human–computer interaction development, gesture interaction is increasingly used, thereby achieving higher popularity [2]. The use of gesture interaction will inevitably make people more convenient for human–computer interaction. Therefore, in the process of using gestures to interact, it is necessary to create a more natural and intuitive human–computer communication mode [3].

2. Evaluation method and accuracy analysis of interactive performance

2.1. Evaluation method

With the development of science and technology and the advancement of the times, non-keyboard input task types have become more and more, which must include fixed-point and indefinite-point interactive tasks. As for the conceptual model of pointing tasks, Fitts 'Law has extracted the most basic interactive tasks. This model concept is widely used in many areas of human–computer interaction, and it is also a commonly used evaluation method by related personnel [4,5].

L Scott MacKenzie and others studied eye tracking systems. In this research, they studied eye tracking performance based on the international standards of ISO 9241-9 [6]. They choose three advanced tracking technologies and compare them with traditional methods. The performance index obtained through the conclusion is used as the standard for user performance measurement, and the conclusion is drawn based on these standards. The requirement for a long-term follow-up survey requires the respondent to stare at the screen for a long time, and then stay for 750 ms to select a relevant action; the follow-up survey for a period of time requires the respondent to stay for 500 ms. The final conclusion shows that the performance index of the long-term eye tracking

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survey is smaller than the short-term tracking index. At the same time, in the study, eye tracking was compared with a mouse click to determine the time to determine the target, and then the three technologies were compared to get the best performance index [7]. The eye tracking performance index was 4.36 bits / s. The performance of the mouse The index is 4.56 bits / s, and there is little difference between them.

The international standards of ISO9241-9 are defined as:

$$Throughput = \frac{IDe}{T}$$
$$IDe = \log 2\left(1 + \frac{D}{We}\right)$$
$$We = 4.133 \times SD \tag{1}$$

(1) Fitz's Law [8]

Fitz's law has a very important position in the field of human–computer interaction, and it is widely used in evaluation. Fitz's Law refers to a basic model of human–machine interaction and human activity that is a real or virtual touch between human and machine. It predicts the time required to reach the target area from the beginning of the movement and What is the relationship between the distance of the distance and the size of the target area. At the same time, Fitz's Law also shows that a basic problem is that when the target area is relatively far and small, it is more difficult to hit. Therefore, in order to improve the speed and accuracy of focusing on this problem, it is necessary to shorten the target distance and increase the size of the target area.

Fitz's law has important applications in many fields and plays an important role in the field of human–computer interaction. The more common Fitz's law is the Shannon formula proposed by a professor at York University:

$$T = a + b\log 2\left(1 + \frac{D}{W}\right)$$
$$ID = \log 2\left(1 + \frac{D}{W}\right) \tag{2}$$

- **T** refers to the average time to complete the job
- **a** represents the start and end time of the device, and **b** represents the speed of the device. These data can be obtained through experiments.
- D refers to the distance from the starting position to the target area
- W refers to the width of the target area during interpersonal interaction

ID indicates the difficulty of task completion. The larger the value, the higher the difficulty of the task and the more difficult it is to complete.

According to this equation of Fitz's law, the following conclusions can be drawn. For small goals or distant goals, it often takes more time and effort, and the difficulty factor is greater. Therefore, for near targets and large targets, the difficulty factor is relatively small, and it is relatively easy to complete.

(2) Mathematical analysis methods

The analysis of data needs to be based on the conclusions of relevant experiments and data records, and use scientific and effective methods for analysis, so that scientific and accurate conclusions can be obtained [9,10]. At the same time, these conclusions can be obtained at an objective level verification. At the same time, it should be noted that in the process of mathematical analysis of interpersonal interaction, it is necessary to make a survey of the subjective impression of the user through a questionnaire to obtain a scientific result in many aspects [11].

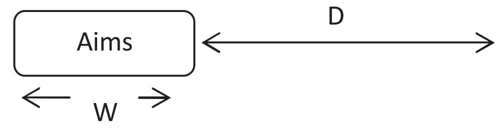

Fig. 1. Application of Fitz's law in human–computer interaction.

2.2. Usability analysis of gesture interaction accuracy

Usability design goes to the design of interaction interfaces, objects, and environments. The user's fault tolerance rate is an important content of gesture interaction accuracy. A user's fault tolerance rate can reflect a general aspect of interaction accuracy [12].

In the research of this paper, the main focus is on interaction accuracy. According to the operation, the operation accuracy is divided into low, medium and high. Among these three levels, the pixels selected are 8, 40, and 80. According to these three levels, the experimental levels are divided [13].

$$\text{Low accuracy}: ID = \log 2\left(1 + \frac{D}{W}\right) = \log 2\left(1 + \frac{960}{80}\right) = 3.7bit \tag{3}$$

$$\text{Medium accuracy}: ID = \log 2\left(1 + \frac{D}{W}\right) = \log 2\left(1 + \frac{800}{40}\right) = 4.39bit \tag{4}$$

$$\text{High accuracy}: ID = \log 2\left(1 + \frac{D}{W}\right) = \log 2\left(1 + \frac{640}{8}\right) = 6.34bit \tag{5}$$

2.3. Factors affecting the accuracy of gesture interaction

(1) Operating direction

The operation direction is one of the important factors affecting the accuracy of gesture interaction. Because most of the gesture interaction process is done in the air, the driving force of the human body in different operating directions, the habits of people, and the difficulty in moving in the air are different. of. Therefore, when people use gesture interaction, it will affect accuracy [14,15].

(2) Mapping scale equation

The mapping ratio equation refers to the law of the relative proportion of the movement of the input device in the air equivalent to the movement in the virtual space in reality [16].

In order to increase the accuracy of gesture interaction in the process of gesture interaction, it is necessary to appropriately enlarge or reduce the mapping distance equation in the operating space, reduce or increase the scale of the mapping scale equation, and adjust the operation time And so on, thereby improving the accuracy in the interaction process. Fig. 1.

(3) Equipment accuracy [17]

The accuracy of the device will affect the accuracy of gesture interaction. For devices with higher accuracy, it is more desirable for users to see. When the accuracy of the device is higher than the ideal accuracy of the user, the user will be more willing to use this accuracy, which will also increase the user's satisfaction [18,19].

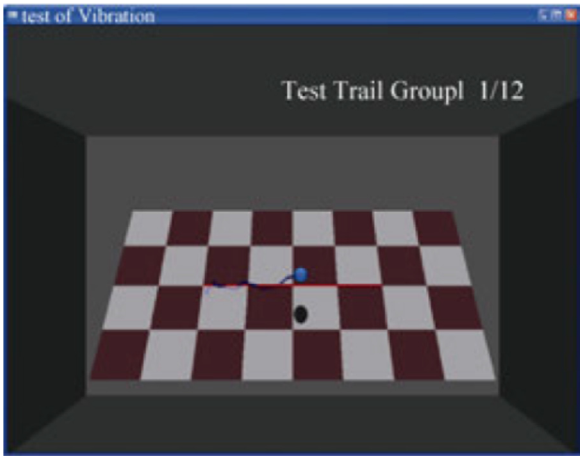

Fig. 2. Program interface.

3. Influence of operating direction on accuracy

3.1. Experimental process

When studying the influence of the operation direction on accuracy, it is mainly based on the influence of the accuracy on the gesture interaction when the user operates in different operation directions. Fig. 2.

In order to study the influence on accuracy in different operating directions, this paper selects horizontal, vertical and experimental research in the direction of the object. The experiment is first performed in the horizontal direction. The specific experimental process is as follows:

Before doing experiments, you need to modulate the resolution of relevant equipment, prepare the environment, and adjust the mapping equation to:

$$Vcursor - 800 \begin{cases} 20V_{hand} & V_{hand} \leq 1.50 \\ 68_{hand} - 72 & 1.50 < V_{hand} < 4.00 \\ 150V_{hand} - 400 & 4.00 < V_{hand} < 8.00 \\ 200V_{hand} - 800 & V_{hand} \geq 8.00 \end{cases} \quad (6)$$

(1) Program interface

Set the direction to horizontal, vertical, and diagonal directions, so its degree is set to 0, 90, 135;

N is the number of times when the target is hit, the number of experimental hits in this article is 4 times, **W** is the width of the operation target, and **D** is the horizontal moving distance.

In this article, in order to facilitate the recording of experiments, the experiments should be numbered to facilitate later recording.

(2) Test the experiment, enter a width and a horizontal distance for each group, and then output the results.
(3) After the data is collected, a questionnaire survey is required for the relevant testers.
(4) Change the research direction, and then conduct data collection and survey.

3.2. Experimental results

In the course of the experiment, three directions of horizontal, vertical and diagonal are selected as experiments. From these three directions, the influence of the interaction accuracy in the three directions is analyzed, and the results after the experiment are statistically summarized:

Table 1
Test results.

D (pixel)	W (pixel)	ID (pixel)	T (s)
960	80	3.70	
960	72	3.84	
945	64	3.98	
920	56	4.12	
870	48	4.26	
800	40	4.39	
910	32	4.88	
970	24	5.37	
895	16	5.83	
640	8	6.34	

The following data is calculated based on related formulas, as the relevant data in horizontal, vertical and diagonal directions.

Through the data analysis, we can get that the correlation coefficients of horizontal, vertical and diagonal are 0.95, 0.88 and 0.84, respectively, which are more than 0.7, which are highly correlated. Therefore, the effect of linear regression in these three directions is very significant, but relatively speaking, the data in the horizontal direction is the most significant and stable.

In terms of performance, the horizontal, vertical and diagonal directions are 1.57 bit/s, 1.49 bit/s and 1.46 bit/s respectively. Therefore, from the perspective of performance direction, the performance in the diagonal direction is the worst among the three, and the performance in the horizontal direction is the best.

Comfort and usability are the main factors for users to consider.From the perspective of usability, there is no obvious difference in the three directions, but it can be seen from the conclusion that it is the most comfortable in terms of level and is also the user's favorite. Therefore, in terms of comfort and usability, the horizontal direction is operational best choice.

3.3. Design recommendations

By analyzing and investigating the above problems and analyzing the experimental data, it can be known that in the experiments of clicking in these three directions, the target width is 24 pixels and the difficulty factor is about 5.38. The overall performance in the diagonal direction is the worst Yes, horizontal is best. Although the difficulty of operation is almost the same, the horizontal direction is the most comfortable for the user in terms of comfort, so it is designed to be the horizontal operation direction as much as possible Table 1.

It can be known from the experimental results that there is no obvious difference in the difficulty of operation in the three directions at medium and low accuracy. When it comes to high precision, the user thinks that the horizontal direction is the most comfortable operation direction, and the horizontal direction is the best in terms of overall performance. Therefore, it is suggested that when designing intelligent machine vision interaction based on the human–computer interaction mode, the interactive interface should try to make the width of the target not less than 24 pixels, and also control its difficulty factor to not exceed 5.37. When performing interactive tasks, try to control and perform the interactive tasks in the horizontal direction as much as possible.

4. The impact of mapping equations on accuracy

4.1. Experimental process

For the impact of the mapping equation on accuracy, there are mainly long-distance and short-distance mapping equations, so you can study from these two aspects, one is to reduce the distance of movement, and the other is the amplitude of short-range

Table 2
Summarizes the data in horizontal, vertical, and diagonal directions.

D	W	ID	Horizontal direction	Vertically	Diagonal direction
960	80	3.7	1873.95	1792.44	1886.45
960	72	3.84	1896.38	2175.50	1698.06
945	64	3.98	2230.57	2187.39	2046.11
920	56	4.12	2148.00	2252.33	2703.23
870	48	4.26	2320.67	2296.00	2086.54
800	40	4.39	2409.08	2324.72	2038.34
910	32	4.88	2684.33	2448.62	2548.03
970	24	5.37	3250.85	3277.89	2809.03
895	16	5.83	4778.53	4461.45	4707.71
640	8	6.34	6249.38	8175.39	9446.73

Table 3
Test results.

	Horizontal direction	Vertically	Diagonal direction
Mean	2984.17	3139.18	3196.25
Throughput	1.57	1.49	1.46
a	−4064.14	−5612.14	−7098.26
b	1508.95	1873.54	2203.94
r	0.95	0.88	0.84

movement. Research to improve the accuracy of the interaction. This experiment mainly adjusts from fast speed to slow speed.

At short distance, we select Vcursor 'of 20 pixel/s and 40 pixel/s respectively, the rest are unchanged, and the most comfortable horizontal direction is selected as the research object.

At long distances, we select Vcursor 's of 600 pixel/s and 900 pixel/s respectively, the rest are unchanged, and the most comfortable horizontal direction is selected as the research object.

The purpose of this experiment is to explore the impact of different mapping equations on interaction accuracy. The specific process of the experiment is as follows: Table 2.

(1) Make preliminary preparations for the experimental equipment and experimental environment, adjust the screen resolution and the corresponding mapping equations.
(2) Familiarize the tester with the test equipment and operation steps. After being familiar with it, you can test it.
(3) Measure the tester, complete each task in Table 3 at the same time, and output the data after completion.
(4) Complete the collection of data and conduct a questionnaire survey on the test subjects.
(5) Change the mapped equation, and then complete the test again according to the previous steps to get the results.

4.2. Experimental results

In the experiment, different mapping equations are used to verify it experimentally, and based on the results of the experiment, improvements are made, and proposals for improvement and design are proposed.

In the short-range modification, 20 pixels/s and 40 pixels/s were selected respectively, and the other conditions are unchanged. Click on the horizontal task.

The mapping equations are:

$$V_{cursor}\begin{cases}13.3V_{hand,} & V_{hand}\le 1.50\\ 72V_{hand}-88, & 1.50<V_{hand}<4.00\\ 150V_{hand}-400, & 400<V_{hand}<8.00\\ 200V_{hand}-800, & V_{hand}\ge 8.00\end{cases}$$

Table 4
Take the data summary of 20, 30 and 40 pixels/s for $V_{cursor.}$

A (pixel)	W (pixel)	ID (bit)	20pixels/s T	20pixels/s T	20pixels/s T
960	80	3.7	2401.03	1873.95	1688.67
960	72	3.84	2046.67	1896.38	1751.08
945	64	3.98	1885.67	2230.57	1953.11
920	56	4.12	2678.45	2148.00	1842.83
870	48	4.26	2431.33	2320.67	2050.00
800	40	4.39	3424.50	2409.08	2339.38
910	32	4.88	3362.78	2684.33	3395.22
970	24	5.37	3330.28	3250.85	2923.38
895	16	5.83	4018.89	4778.53	2794.50
640	8	6.34	5492.67	6249.38	10452.67

Table 5
V_{cursor} takes the parameter values of 20, 30 and 40 pixels/s respectively.

	20 pixels/s	30 pixels/s	40 pixels/s
Mean	3107.41	2984.17	3318.98
Throughput	1.50	1.57	1.41
a	−2047.01	−4064.14	−8667.99
b	1103.49	1508.95	2566.25
r	0.92	0.95	0.86

$$V_{cursor}\begin{cases}26.7V_{hand,} & V_{hand}\le 1.50\\ 64V_{hand}-56, & 1.50<V_{hand}<4.00\\ 150V_{hand}-400, & 400<V_{hand}<8.00\\ 200V_{hand}-800, & V_{hand}\ge 8.00\end{cases} \quad (7)$$

Table 4 summarizes the data when Vcursor takes 20, 30, and 40 pixels/s:

The above data is calculated by the formula as the values of a, b, and r above the horizontal, vertical, and diagonal directions.

By analyzing the above data, it can be concluded that when Vcursor takes 20, 30, and 40 pixels/s, the correlation coefficients r are 0.91, 0.94, and 0.85, respectively. These three values are all greater than 0.7, which are highly linearly correlated. Three mapping equations The linear regression effect is very significant, and Vcursor is most significant when taking 30 pixels/s. The stability is the worst at 40 pixels/s. (Table 5).

4.3. Proposed amendments

According to the experimental verification and the questionnaire, in the mapping equation of short-distance movement, there is almost no impact on the accuracy of low or medium, but at high precision, the impact is relatively large. Therefore, it is suggested that when designing the mapping equations of intelligent machine vision interaction based on the human–computer interaction mode, the mapping equations used for movement over short distances should not be too fast, and the mapping equations should not be too fast when moving over long distances. It can't be too slow. So it is necessary to choose the proper mapping equation.

5. Conclusion

With the development of science and technology and the development of computer technology, intelligent machine vision interaction based on human–computer interaction mode has gradually become an important part of our daily lives. In terms of gesture interaction technology, due to various high-tech developments, there has been more understanding of its interpretation. Gestures, as the most common connection between people, are bound to be used more by people, and they are more intuitive to interact with. Therefore, it is important to effectively use gesture interaction between human and machine.

This paper mainly studies the interaction accuracy of gesture interaction in terms of usability. And according to the relevant data theory, its click experiment, and experiments on the accuracy of gesture interaction, and design the above improvements for the experimental results.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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