
Human gesture interaction recognition algorithm based on augmented reality in smart wristband equipment

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Abstract: In order to overcome the poor recognition effect of traditional gesture recognition methods, this paper proposes a human gesture interactive recognition algorithm based on augmented reality for intelligent wristband device. The moving window method is used to detect the human gesture change image, and the mean filter is used to smooth the gesture image. The human gesture features of smart wristband device are extracted by augmented reality technology, and the interactive recognition model of human gesture of smart wristband device is constructed. The virtual real synthesis technology is used to synthesise the real-scene image and the virtual position according to the obtained spatial coordinates. Complete the human gesture interactive recognition of intelligent wristband device. Simulation results show that the recognition accuracy of the proposed method can reach 99.9%, and the recognition efficiency is significantly improved.

Keywords: augmented reality; smart wristband device; human gestures; interactive recognition.

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1 Introduction

Nowadays, due to the continuous development of high-tech means, smart wearable devices have become a technological medium integrating fashion, technology, intelligence and trends, including smart watches, smart wristbands, etc. In order to adapt to the current society, major companies have begun to fall into in the wave of research and development of smart wearable devices. The smart wristband device is the best embodiment of the characteristics of smart wearable devices, using smart operating systems, sensing technology, visualisation technology, wireless technology, etc. and through related industrial chains and internet means, developed according to user needs, the current. The development of the electronic product market has a certain impact (Dong and Zhao, 2020; Si et al., 2019; Zhang, 2019). Apple designed the Apple watch smart wristband device to increase people's awareness of smart wearable devices. Smart wristband equipment is a smart wearable device with detection function worn on the user's wrist, through sensors and other devices to monitor and record the wearer's physical activity data such as walking steps, heart rate changes and calorie consumption and obtain the wearer Active device. Therefore, it has been loved and welcomed by the public. Smart wristband devices occupy a place in smart wearable devices due to their small size, easy operation, novelty and practicality. Their functional characteristics are different from the human-computer interaction of smart devices of mobile phones, and they are superior in terms of user experience. At present, the human body gesture interactive recognition of smart wristband devices has become a current research hotspot (Tian et al., 2018).

Deng et al. (2019) proposed a smart wristband device human gesture interaction recognition algorithm based on a shallow three-dimensional dense network. First, the smart wristband device human gesture data is obtained, and then based on the gesture data, the smart wristband device human gesture feature extraction is performed to extract the result As a basis, the two-dimensional dense network is converted into a three-dimensional dense network to recognise human gestures of smart wristband devices, and the research on human gesture recognition of smart wristband devices is completed. Simulation experiments show that this method can effectively recognise human gestures of smart wristband devices. Jia and Li (2020) proposed a human-computer interaction-based smart wristband device human gesture interaction recognition algorithm. By collecting the smart wristband device human gesture data, the smart wristband device human gesture image is obtained, and the human body contour tracking system is used to obtain the smart wristband. The device human body gesture contour uses the depth threshold method to segment the acquired human body gesture contour to obtain an image without fingers. Based on this, the human body gesture of the smart wristband device is recognised based on the palm coordinates. Wang et al. (2018) proposed a MYO-based smart wristband device human gesture interaction recognition algorithm. First, collect the human body gesture signal of the smart wristband device, extract the human body gesture features of the smart wristband device and according to the extracted human gesture features of the smart wristband device, Recognise human gestures in smart wristband devices. However, the human body gesture interaction recognition accuracy of the smart wristband device of the above two methods is low, resulting in poor recognition effect. Wang and Ma (2020) proposed a smart wristband device human gesture interactive recognition algorithm based on CSI phase difference, collected smart wristband device human gesture data, combined with Hampel filter and Savitzky-Golay

filter to pre-process the gesture data and extract the smart wristband. The human body gesture features of the device, and the dynamic time warping algorithm is used to classify the human gestures of the smart wristband device according to the extracted gesture features. According to the classification results, the CSI phase difference is used to construct the human body gesture interaction recognition model of the smart wristband device to complete the smart wristband Device human body gesture interactive recognition. However, the human body gesture interaction recognition time of the smart wristband device of the above two methods is shorter, resulting in lower recognition efficiency.

Augmented reality technology, also known as AR technology, was first proposed in 1990 and is a current computer image processing technology. This technology integrates the virtual world and reality through the screen, and has been well developed in many fields. Therefore, in response to the problems of the above methods, this paper proposes an augmented reality-based smart wristband device human gesture interaction recognition algorithm. The specific research ideas are as follows:

Firstly, the moving window method is used to detect the change of human gesture image, and the smart wristband device is used to collect the change of human gesture image to judge whether the gesture operation is correct or not; Adaptive filter is used to denoise the effective gesture image; Combined with augmented reality and 3D registration technology, the virtual position of human gesture in real space is calculated, and the interactive recognition model of human gesture of intelligent wristband device is constructed;

Secondly, the virtual world human gesture on the smart wristband device screen is interacted with the real-world human gesture through augmented reality;

Then, the real-scene image and virtual position are synthesised by augmented reality method, and the human gesture recognition of intelligent wrist belt device is completed;

Finally, shallow 3D dense network recognition algorithm, human-computer interaction recognition algorithm and augmented reality recognition algorithm are used to verify the gesture recognition accuracy of intelligent wristband device and the efficiency of human gesture recognition, and effective conclusions are drawn.

2 Human gesture feature processing of intelligent wristband device

2.1 Human body gesture image acquisition of smart wristband device

The moving window method is used to detect the active segment of the human body electromyographic image of the smart wristband device, obtain the human body gesture image of the smart wristband device and judge the complete validity of the image according to the execution time of the gesture and obtain the effective gesture image (Miao et al., 2020; Chakraborty et al., 2018; Latorre-Carmona et al., 2018).

First, the EMG image is used to detect the human body gestures of the smart wristband device to store three gesture images, and the storage of the three gesture images is terminated when the execution of the human body gesture of the smart wristband device is detected (Javidi et al., 2020).

Use the moving window method to set the window size w_s and the window movement amount w_t . Each time the window is moved, an EMG image segment with a

window size of w_s will be obtained, and the EMG image segment energy E_{energy} will be calculated. If E_{energy} is equal to the threshold T , It means that the human muscles are in an active state, otherwise, it is considered that the human muscles are in a resting state. However, since the human body also produces an EMG image when it moves unconsciously, the complete validity of the image is judged based on the execution time of the gesture, the misoperation of the gesture image is eliminated, and the effective gesture image is obtained. If Time is less than the execution time of the gesture, that is to say $E_{\text{energy}} \geq T$, the gesture image is judged to be a valid gesture image. If, $E_{\text{energy}} < T$, the gesture image is judged to be a misoperation gesture image (Viunytyskiy et al., 2020). The specific process is:

(1) The energy E_{energy} of the EMG image segment is expressed as:

$$E_{\text{energy}} = \frac{1}{M \times w_s} \sum_{i=0}^{w_s-1} \text{emg}[i]^2 \quad (1)$$

In the above formula, emg is the energy consumption of human gesture action, and M is the number of EMG image segments.

- (2) Set the window energy threshold as T . If the window energy is $E_{\text{energy}} \geq T$ and the number of active windows is $i = 0$, the smart wristband device human body gesture is considered to start, $i + 1$, the window moves backward w_t , turn (1); if the window energy $E_{\text{energy}} \geq T$ and $i > 0$, then the gesture In the process of execution, $i + 1$, the window moves backward by w_t and turn (1); if $E_{\text{energy}} < T$ and $i = 0$, the human body gesture is not executed, and the window moves backward by w_t and turn (1); if $E_{\text{energy}} < T$ and $i > 0$, it is considered smart When the human body gesture of the wristband device ends, go to (3).
- (3) Obtain valid gesture images (Ahmed et al., 2020; Bhateja et al., 2018; Qi et al., 2019). When $i \geq M$, the gesture is considered to be a valid gesture, otherwise the gesture is considered to be a misoperation.

2.2 Image pre-processing

Since there will be noise and jumping points in the process of acquiring effective gesture images, the acquired effective gesture images are pre-processed to obtain smooth images, so that the subsequent extracted smart wristband device human gesture features are more accurate and clear, thereby improving. The accuracy of the algorithm (Song et al., 2021; Ding et al., 2020).

Set the order of the filter to Q , and use the mean filter to perform preliminary linear filtering on the noisy human body gesture image $g(s, t)$ of the smart wristband device. Using the inverse harmonic mean filter to restore the human gesture image of the smart wristband device, the operating principle formula is as follows:

$$f(s, t) = \frac{\sum_{S_{xy}} g(s, t)^{Q+1}}{\sum_{S_{xy}} g(s, t)^Q} \quad (2)$$

Set S_{xy} to represent the local area, $mn-d$ to indicate the number of jump points, and $g_r(s, t)$ to indicate the number of jump points. According to the average value of $g_r(s, t)$, construct an alpha mean filter:

$$S(s, t) = \frac{f(s, t)}{mn-d} \sum g_r(s, t) \quad (3)$$

When the filters mentioned above are applied to human gesture images of smart wristband devices, they cannot accurately and quickly extract the human gesture features of smart wristband devices. Therefore, an adaptive filter with better filtering performance is used to obtain effective gesture images. Denoising processing (Tsai et al., 2020; Selvarathi, 2020). The filter acts on the local area S_{xy} , and the response at any point (x, y) is based on the following four quantities:

Set $g(x, y)$ to represent the value of the noise image at point (x, y) ; σ_ϕ^2 to interfere with $f(x, y)$ to form the noise variance of $g(x, y)$; m_L to represent the local mean value of the jumping point on S_{xy} ; σ_L^2 to represent the local variance of the jumping point on S_{xy} .

If σ_ϕ^2 is zero, the filter should simply return the value of $g(x, y)$ ($g(x, y)$ equals $f(x, y)$ in the case of zero noise). If the local variance and σ_ϕ^2 are highly correlated, then the filter should return an approximate value of $g(x, y)$. If the two variances are equal, the filter returns the arithmetic mean of the region S_{xy} . In order to obtain a smooth human gesture image $f(x, y)$ of the smart wristband device, the adaptive expression based on these assumptions is as follows:

$$f(x, y) = g(x, y) - \frac{\sigma_\phi^2}{\sigma_L^2} (g(x, y) - m_L) \quad (4)$$

Through formula (4), the pre-processing result of human gesture image of smart wristband device is obtained, so as to extract accurate human gesture features.

2.3 Human gesture feature extraction of intelligent wristband device

According to the obtained smooth image of the human body gesture of the smart wristband device, the features of the human body gesture of the smart wristband device are extracted. First, wavelet transform is used to analyse the characteristics of grey and detail in the human gesture image of the grey smart wristband device after pre-processing, and then the image is extracted by the grey projection method to form the corresponding feature map. Finally, the problem of image frame feature extraction evolves into the classification of the foreground and background of the human gesture

image of the smart wristband device. The separation coefficient is determined by the ratio function of the variance of the human gesture image feature distribution of the smart wristband device in the foreground and the background area, and the human body of the smart wristband device. The extraction process of gesture features is as follows:

The Mallat algorithm is used to decompose the smooth image of the human body gesture of the effective smart wristband device by wavelet decomposition, obtain the grey image and use the grey image to construct the detail pyramid $O_k(s, d)$, the size is represented by s , the three details of the image are represented by d , and the original grey the establishment of the image is completed by the pyramid $L_k(s)$ and the detail pyramid $O_k(s, d)$ calculated in the above process, and multiple feature displays of the two detail features can be obtained at the same time.

In the human gesture image of intelligent wrist belt equipment, the local contrast of an image at different positions in a certain range is determined by the difference $DOG(x, y, \sigma_c, \sigma_s)$ of scales, and the effect of contrast of grey image is improved. The formula is as follows:

$$DOG(x, y, \sigma_c, \sigma_s) = \frac{1}{2\pi\sigma_c^2} \exp\left(-\frac{r}{2\sigma_s^2}\right) \quad (5)$$

Among them, r represents the characteristic contrast measurement value; the value of σ_c represents the range of the characteristic area; the value of σ_s represents the range of the image suppression area. Set $F(c)$ to represent the coarse-scale image, which can suppress features other than the target area and $F(s)$ represents the fine-scale image, which can describe the detailed features of the target area. Then, the expression for the difference $F(c, s)$ between the scales of $F(c)$ and $F(s)$ is shown in equation (6):

$$F(c, s) = TF(c)F(s)DOG(x, y, \sigma_c, \sigma_s) \quad (6)$$

$F(s)$ adjusts the difference to the area of the same scale as $F(c)$, denoted by $L_k(c)$ and $L_k(s)$, and subtracts each point, and takes the corresponding absolute value $O_k(c, d)$ and $O_k(s, d)$, thereby obtaining the grey-scale characteristics of the human body gesture image of the smart wristband device $L_k(c, s)$ and the detailed feature $O_k(c, s, d)$, its formula is as follows:

$$\begin{cases} L_k(c, s) = L_k(c)L_k(s)F(c, s) \\ O_k(c, s, d) = O_k(c, d)O_k(s, d)F(c, s) \end{cases} \quad (7)$$

Setting $G_k(i, j)$ represents the grey-value of the (I, j) -th pixel in the human gesture image of the smart wristband device; $G_{k-m}(\cdot)$ represents the difference in translation amount; dx and dy , respectively represent the evaluation estimates between the images.

Calculate the image feature display image $M_k(i, j)$ according to the translation estimate, and its expression is shown in equation (8):

$$M_k(i, j) = |G_k(i, j) - G_{k-m}(i - dy, j - dx)| \quad (8)$$

Set the grey-scale image as $N(L_k)$ and the detailed image as $N(O_k)$, determine a set of weighting factors α, β, γ , perform weighted fusion on the image through the above method, and extract the features of the human gesture image of the smart wristband device. The expression is shown in equation (9):

$$S_k = \frac{\alpha N(L_k) + \beta N(O_k) + \gamma N(M_k)}{M_k(i, j)} \quad (9)$$

Among them, S_k represents the last extracted feature value of the human body gesture image of the smart wristband device.

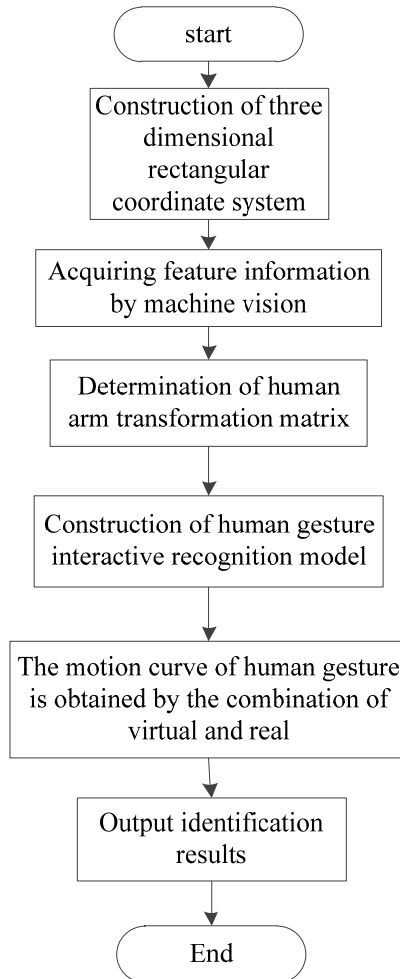
3 Interactive recognition of human gesture of intelligent wrist belt equipment based on augmented reality

Augmented reality technology has the function of human-computer interaction, which is the integration and interaction of the real environment and the virtual environment. Through the user's manipulation of the actual product, the generated virtual model will also change accordingly. The most important aspect of augmented reality technology is the display device, which uses smart wristband devices to obtain interactive images of human gestures and output images. Therefore, display technology is particularly important. Another method of augmented reality technology is human-computer interaction technology. The user issues instructions to virtual objects by manipulating the computer. The virtual objects perform tasks according to the instructions, and then the computer outputs feedback results, which realises the interaction of virtual information between humans and computers. The most important aspect of augmented reality technology is the effective integration of virtual and reality. Its most important core technology is 3D registration technology. The 3D registration technology can be used to determine the space coordinates of the virtual scene and obtain the 3D space coordinates of specific objects in the 3D space. Therefore, based on the extracted human gesture features of the smart wristband device, the augmented reality technology is used to interactively recognise the human body gesture of the smart wristband device. The specific identification process is shown in Figure 1.

The space directly in front of the person wearing the smart wristband device is regarded as a three-dimensional space, and the arm of the human body wearing the smart wristband device is maintained at a right angle to the position of the body, with the shoulder of the human body wearing the smart wristband device as the origin and the hand as the zero point, Which is the starting position, establish a rectangular coordinate system in this three-dimensional space. When the human body moves up or down, the Y-axis coordinates are positive or negative, so that the most basic way to distinguish the approximate area the gesture moves to. The gesture sliding area is area $X_m Y_m$, the vertical axis of the gesture's starting position is Z_m ; the optical centre (x_0, y_0) of the

sensor is the origin of the sensor coordinate system $(X_c, Y_c, Z_c)^T$, the $X_c Y_c$ plane is located in the focal plane, and the Z_c -axis coincides with the optical axis; the ideal screen coordinate system is $(x_c, y_c)^T$; The actual screen coordinate system is $(x_d, y_d)^T$, and the sensor parameter is s . First, input the characteristic information of the human body gesture of the smart wristband device into the sensor coordinate system, then output the information obtained by the sensor into the ideal screen coordinate system and finally convert the information in the ideal screen coordinate system into the actual screen coordinate system.

Figure 1 Flow chart of human gesture recognition



To determine the spatial coordinates of human gestures in smart wristband devices, first obtain the relationship between the human arm coordinate system, the sensor coordinate system and the ideal screen coordinate system and then calculate the position of the human gesture in the actual screen coordinate system. Use machine vision to obtain the

relationship between the human arm coordinate system and the sensor coordinate system, and calculate the position of the human gesture in the sensor coordinate system. The expression is:

$$\begin{bmatrix} X_c \\ Y_c \\ Z_c \\ 1 \end{bmatrix} = \begin{bmatrix} R_{11} & R_{12} & R_{13} & T_1 \\ R_{21} & R_{22} & R_{23} & T_2 \\ R_{31} & R_{32} & R_{33} & T_3 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} X_m \\ Y_m \\ Z_m \\ 1 \end{bmatrix} = \begin{bmatrix} RT \\ 0 & 1 \end{bmatrix} \begin{bmatrix} X_m \\ Y_m \\ Z_m \\ 1 \end{bmatrix} = T_{cm} \begin{bmatrix} X_m \\ Y_m \\ Z_m \\ 1 \end{bmatrix} \quad (10)$$

In the formula, R is the orthogonal matrix, T is the movement amount of the human arm $(T_1, T_2, T_3)^T$, and T_{cm} is the transformation matrix between the human arm coordinate system and the sensor coordinate system.

According to the relationship between the sensor coordinate system and the ideal screen coordinate system, the position of the human gesture in the ideal screen coordinate system is obtained and the expression is:

$$\begin{bmatrix} hx_c \\ hy_c \\ h \end{bmatrix} = \begin{bmatrix} f & s & u_0 & 0 \\ 0 & af & v_0 & 0 \\ 0 & 0 & 1 & 0 \end{bmatrix} \begin{bmatrix} X_c \\ Y_c \\ Z_c \\ 1 \end{bmatrix} = S \begin{bmatrix} X_c \\ Y_c \\ Z_c \\ 1 \end{bmatrix} \quad (11)$$

In the formula, h is the time, S is the sensor parameter, f is the tilt coefficient, a is the pixel ratio, and (u_0, v_0) is the centre point of the image pixel.

According to the position of the human body gesture in the ideal screen coordinate system, the relationship between the human arm coordinate system and the ideal screen coordinate system is:

$$\begin{bmatrix} hx_c \\ hy_c \\ h \end{bmatrix} = ST_{cm} \begin{bmatrix} X_m \\ Y_m \\ Z_m \\ 1 \end{bmatrix} \quad (12)$$

According to the above three relationships, the position of human gestures in the actual screen coordinate system is calculated and a smart wristband device human gesture interaction recognition model is constructed to determine the spatial coordinates of human gestures in the virtual scene. The virtual-real synthesis technology is used according to the acquired space. Coordinates, the real-scene image and the virtual position are combined with virtual reality, and the expression is:

$$\begin{cases} x = s(x_c - x_0), y = s(y_c - y_0) \\ d^2 = x^2 + y^2 \\ p = (1 - fd^2) \\ x_d = px + x_0, y_d = py + y_0 \end{cases} \quad (13)$$

In formula (13), the screen coordinate of human gesture motion after virtual reality synthesis is (x_d, y_d) , the ideal screen coordinate of human gesture motion after virtual reality synthesis is (x_c, y_c) , p is the projection curve of human gesture and d is the motion curve of human gesture after virtual reality synthesis. According to the above human gesture interactive recognition model, the human gesture interactive recognition of intelligent wristband device is realised.

4 Simulation experiment analysis

4.1 Experimental scheme design

- (1) *Experimental parameters*: The experimental comparison and analysis are carried out on the MATLAB simulation platform. The experimental data parameter settings are shown in Table 1.

Table 1 Experimental parameter setting

<i>Software</i>	<i>Edition</i>
Microsoft Visual Studio	2010
Open CV	2.3.1
Microsoft Windows Vista system	Longhorn

- (2) *Experimental data*: In order to verify the effectiveness of the proposed method, the human gesture recognition algorithm based on shallow three-dimensional dense network (algorithm in Deng et al., 2019), the human gesture recognition algorithm based on human-computer interaction (algorithm in Jia and Li, 2020) and the human gesture recognition algorithm based on Augmented Reality (algorithm in this paper) are used to test the above methods, The effectiveness of the proposed method has been verified.

The machine learning data set repository is selected as the experimental data set of gesture recognition (<http://archive.ics.uci.edu/ml/datasets.php>). Using MATLAB simulation software, the mean filter is used to realise the smooth processing of gesture image and the augmented reality is used to recognise human gesture interactively. The human gesture interactive recognition model is established to realise gesture interactive recognition. Iris, wine and balance scale are selected in the experiment. The specific content of the data set is shown in Table 2.

Table 2 Statistical table of data sets

<i>Data set name</i>	<i>Iris</i>	<i>Wine</i>	<i>Balance scale</i>
number of samples	168	208	762
Number of attributes	6	12	8
Number of categories	8	6	16

According to the data in Table 2, the interactive recognition of human gesture needs data pre-processing. The data in the data set is extracted with redundant value. The redundant operation is used to eliminate the human gesture noise, and the human gesture information without dirty data is obtained. The experimental verification is carried out.

(3) *Experimental index*: In order to verify the effectiveness of this method in human gesture interactive recognition, the following experimental indicators are designed:

- a) The accuracy of human gesture recognition is accurate. The accuracy of human gesture recognition is defined as the ratio of the number of gesture correctly recognised to the total number of candidate areas for human gesture recognition. The more candidate areas are generated, the lower the recognition precision of human gesture interaction. The formula for the accuracy of gesture recognition is as follows:

$$J = \frac{S_p}{S_p + E_p} = \frac{S_p}{S'} \quad (14)$$

Among them, S_p is defined as the total number of recognition candidate samples for correct detection of human gesture, E_p is the number of samples for wrong detection of human gesture and S' is the number of all human gesture samples. The higher the recognition accuracy of human gesture interaction of intelligent wristband device is, the better the gesture interaction recognition effect of this algorithm is. On the contrary, the effect of gesture recognition is worse.

- b) Human gesture recognition time. The shorter the interactive recognition time of human gesture in smart wristband device, the higher the interactive recognition efficiency of the proposed algorithm, on the contrary, the lower the interactive recognition effect of the proposed algorithm. The calculation formula of gesture recognition time T_s is as follows:

$$T_s = T_p + \Delta t \quad (15)$$

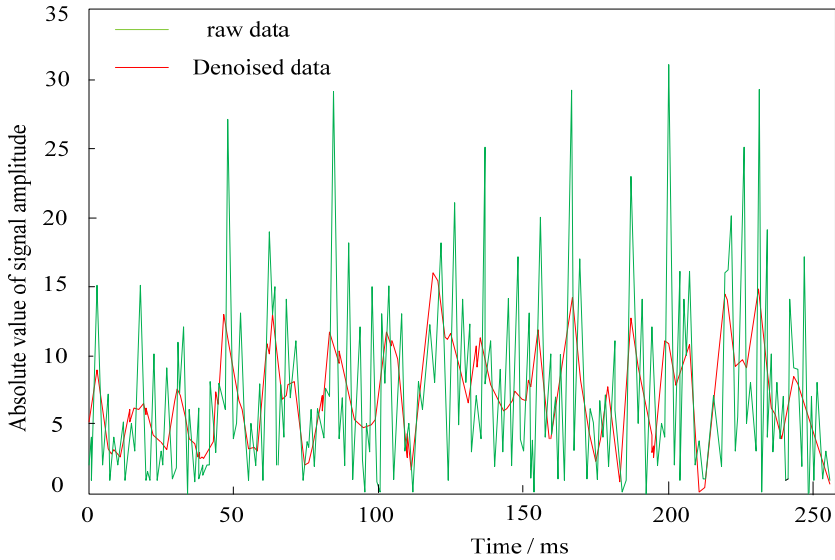
In formula (15), T_p is the time of human gesture interaction recognition, and Δt is the time delay of gesture interaction recognition error.

4.2 Analysis of experimental results

4.2.1 Denoising of gesture signal data

In order to further verify the practical application value of this algorithm in human gesture recognition of intelligent wristband device, a simulation experiment is carried out through MATLAB simulation software. Firstly, this algorithm is used to denoise the collected human gesture signal data of the original intelligent wristband device. The denoising results of the gesture signal data are shown in Figure 2.

According to Figure 2, when the time is 50 ms, the absolute value of gesture signal amplitude is 28 before de-noising and 13 after de-noising; When the time is 100 ms, the absolute value of gesture signal amplitude is 16 before denoising and 6 after denoising; Analysis of the overall denoising curve shows that the algorithm in this paper has a good denoising effect on the collected human gesture signal data of the original intelligent wristband device.

Figure 2 Denoising processing results of gesture signal data

4.2.2 Recognition accuracy of human gesture interaction

After pre-processing the human gesture signal data of the original intelligent wristband device, the algorithm in this paper, the algorithm in Deng et al. (2019) and the algorithm in Jia and Li (2020) are used to compare and analyse the recognition accuracy of human gesture interaction of intelligent wristband device. The comparison results of recognition accuracy of human gesture interaction are shown in Table 3.

Table 3 Comparison results of human gesture interaction recognition accuracy of smart wristband devices/%

<i>Number of experiments</i>	<i>The algorithm in this paper</i>	<i>Deng et al. (2019) algorithm</i>	<i>Jia and Li (2020) algorithm</i>
10	92.4	73.2	51.3
20	92.2	74.2	52.6
30	93.4	76.1	53.2
40	94.7	77.3	53.8
50	95.3	78.5	54.2
60	95.4	79.2	55.4
70	96.7	80.1	56.5
80	97.6	82.4	57.6
90	98.4	83.1	58.4
100	99.9	85.6	59.4

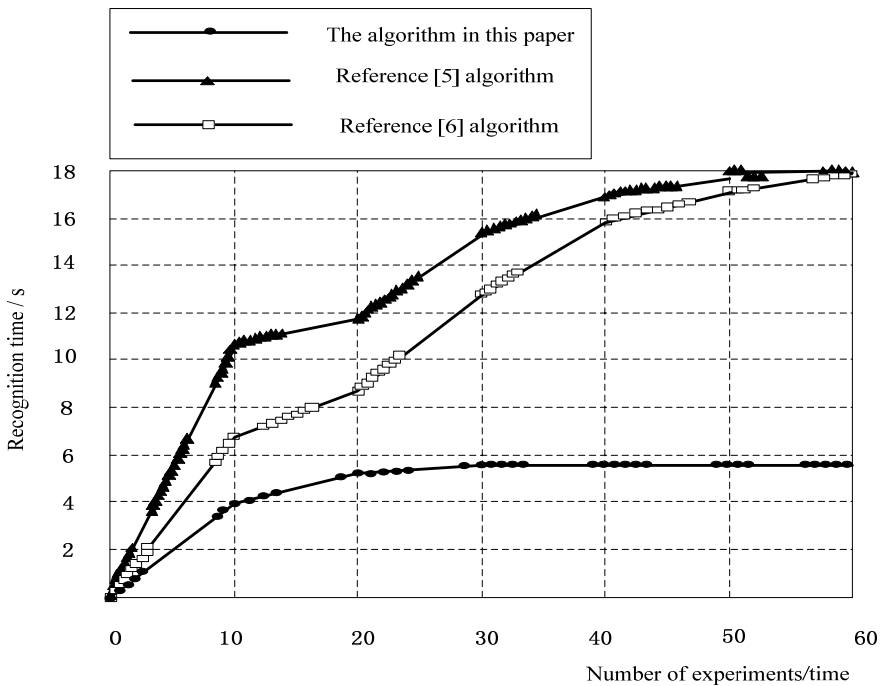
According to the data in Table 3, with the increase of the number of experiments, the recognition accuracy of human gesture interaction of intelligent wristband device based on the algorithm in this paper, the algorithm in Deng et al. (2019) and the algorithm in Jia

and Li (2020) is gradually increasing. When the number of iterations is 50, the recognition accuracy of human gesture interaction in Deng et al. (2019) is 54.2%, the recognition accuracy of human gesture interaction in Jia and Li (2020) is 78.5%, and the recognition accuracy of human gesture interaction in this paper is 95.3%. When the number of iterations is 100, the recognition accuracy of human gesture interaction in Deng et al. (2019) is 85.6%, the recognition accuracy of human gesture interaction in Jia and Li (2020) is 59.4% and the recognition accuracy of human gesture interaction in this paper is 99.9%. The recognition accuracy of this algorithm can reach 99.9%, while the intelligent wrist device gesture recognition algorithm based on shallow three-dimensional dense network proposed in Deng et al. (2019) and the intelligent wrist device gesture interaction recognition algorithm based on human-computer interaction process proposed in Jia and Li (2020) are only 85.6% and 59.4%. The recognition accuracy of the intelligent wrist device gesture interaction recognition algorithm based on augmented reality is higher than that of the traditional one.

4.2.3 Human gesture interaction recognition time

In order to further verify the effectiveness of the algorithm in this paper, the human gesture interaction recognition algorithm for smart wristband devices proposed in this paper based on augmented reality, the human gesture interaction recognition algorithm for smart wristband devices based on shallow three-dimensional dense network proposed in Deng et al. (2019) and the Jia and Li (2020). The proposed smart wristband device human gesture interaction recognition time based on the smart wristband device human gesture interaction recognition algorithm in the human-computer interaction process is compared and analysed, and the comparison result is shown in Figure 3.

Figure 3 Human gesture interaction recognition time of smart wristband device



According to figure 3, with the increase of the number of experiments, the interactive recognition time of human gesture of different methods shows an increasing trend. When the number of experiments is 30, the human gesture recognition time of the algorithm in Deng et al. (2019) is 15.2 s, the human gesture recognition time of the algorithm in Jia and Li (2020) is 12.9 s, the human gesture recognition time of the intelligent wristband device in this paper is 5.5 s, and after 30 iterations, the human gesture recognition time curve tends to be stable. The overall analysis of the recognition time curve shows that the gesture recognition time of this method is within 6 s, while the gesture recognition time of the algorithm in Deng et al. (2019) and Jia and Li (2020) is always increasing, and it is far higher than the method in this paper, which shows that the time-consuming and high recognition efficiency of the intelligent wristband device human gesture interaction recognition of this method is low.

5 Conclusions

In this paper, a human gesture recognition algorithm based on augmented reality is proposed. The moving window method is used to detect the active segment of the EMG image to get the gesture image of the smart wristband device. However, there is noise in the image, so it needs to be denoised. Therefore, the inverse harmonic mean filter is used to denoise the gesture image of the smart wristband device. Wavelet transform is used to analyse the features of grey and detail in the pre-processed human gesture image of intelligent wristband device. Grey projection method is used to extract the features of the image, and augmented reality technology is used to recognise the human gesture of intelligent wristband device interactively. The results are as follows:

- 1) When the number of iterations is 50, the recognition accuracy of the proposed method is 95.3%, which shows that the proposed method has high recognition accuracy of human gesture interaction.
- 2) When the iteration times are 30, the time of the intelligent wrist device gesture recognition is 5.5 s. After several iterations, the time curve of human gesture interaction recognition tends to be stable, and within 6 s, it shows that the method of this method has low time and high-recognition efficiency.

Although the method in this paper obtains good results in human gesture interactive recognition, the denoising effect is not very ideal in the process of human gesture image of intelligent wristband device. Therefore, we need to further study how to improve the effect of human gesture image denoising.

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