Identification method of the elderly based on foot pressure

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Abstract: The aging of our population has resulted in an increase in the number of lost persons in the elderly. Based on the foot pressure information, this paper presents a method which can be used to identify the elderly and prevent the loss of the elderly. Considering the two characteristics of foot contour shape and foot pressure distribution, using the improved closed foot contour to extract Fourier descriptor, the Laplace characteristic spectrum is extracted based on pressure, and the eigenvectors describing the foot contour are obtained. Using SVM (support vector machine) for machine learning and training classifier, it is proved that the recognition rate of this method to the elderly is more than 80%.

1. Introduction

Chinses population is entering the stage of aging, due to the shortage of nursing supply, there are more and more elderly people lost, resulting in a certain social burden. Based on the above social problems, this paper studies a method of identification of the elderly in order to deal with the current social problems.

In the long-term walking process, the human body has formed a foot pressure distribution with its own characteristics[1; 2]. Abroad, Mary[3] and others studied the distribution of foot pressure in people of different ages, and found that the stress distribution in bone and thumb areas was strongly correlated with age. Yamakawa[4] and other analysis of the dynamic foot distribution information of people with different foot types in the process of jogging, using cluster analysis, it is found that the relative impact size of 4 different regions of the forefoot can be used as the classification of eigenvectors, so as to identify the foot type. In China, Xia Yi[5] has proposed a gait recognition algorithm based on the space-time HOG of foot pressure distribution, which achieves the purpose of identification by fusing the temporal and spatial domain information of the foot pressure at the feature layer. Wang Xin[6] and other proposed to use the double-layer convolution neural network model to realize the gait recognition method based on the foot pressure image.

In this paper, the characteristics of the bottom pressure of the two dazu are extracted: The shape characteristics of the foot pressure contour and the characteristics of the foot pressure distribution, and the feature data collected by the one-to-one SVM (support vector machine) classifier are used to achieve the goal of identifying the elderly.

2. Composition of Foot Pressure Acquisition System

The composition of the foot pressure acquisition system is shown in Figure 1, and the distributed thin film piezo resistive sensor is installed on the foot pressure detection platform, and the resistance value corresponding to the increase of the pressure applied on the sensor surface becomes smaller, and through the array distribution structure of multiple rows and columns, the space minimum resolution is 4mm*4mm the size of the single point sensing area. The data collector carries on the AD conversion and the filtering to the collected array pressure value, through the USB and the host computer

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connection and the data transmission, the upper computer software analyzes the pressure value in the image mode according to the agreed communication protocol.

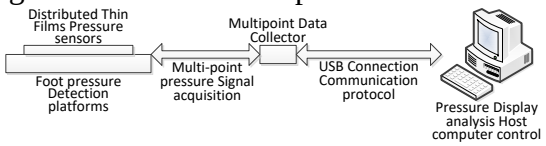


Fig. 1 Foot Pressure acquisition system

3. Data Preprocessing of Foot Pressure

The preprocessing of data is an important step before feature extraction, and the quality of preprocessing directly affects the effect of feature extraction. The preprocessing process of this paper is divided into two parts:

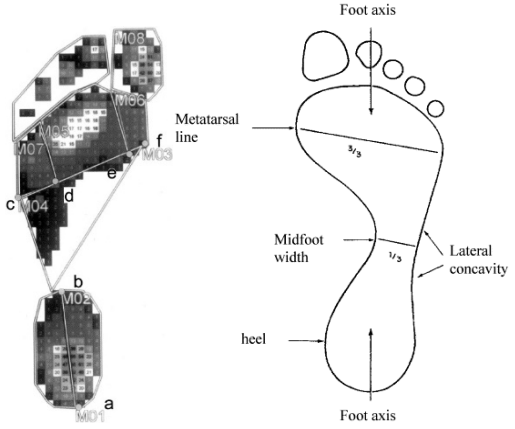
(1) Foot bottom zoning

(2) Data standardization

3.1 Foot pressure partition

At present, there are many methods of plantar partitioning, Fig.2 (a) in order to assess the foot dynamics abnormalities after foot tarsal resection, the plantar is divided into 8 anatomical areas, Fig.2 (b) is to compare the foot pressure of hemiplegia patients and healthy people[7], manually dividing the plantar into 3 areas.

In this paper, a kind of partitioning method between complex partition and over-simple partition is adopted, combined with the specific requirements of this experiment, in order to make the selection of eigenvalues more effective[8], the foot bottom is divided as follows.



(a) (b)

Fig.2 Foot Pressure acquisition system

In the foot identification, the subjects are required to stand naturally and relax on the measuring plate. This results in different people due to the different posture habits, such as the inside and outside of the foot eight, so that the collected data cannot fully meet the distribution along the specified direction, will produce a tilt, as shown in Fig.3. In order to achieve the efficient work of automatically dividing the area, the above situation should be adjusted before automating the subregion, so that the data meets the requirements of the automation subregion.

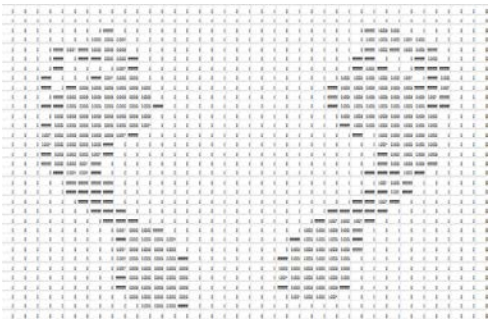


Fig.3 Outer eight feet

Using the axis of the foot to straighten the foot, Fig.4 (a) LL ', RR is the central axis of the foot, calculated the angle between the axis of the foot and the vertical direction, so that the feet according to the corresponding angle to adjust to the desired data direction.

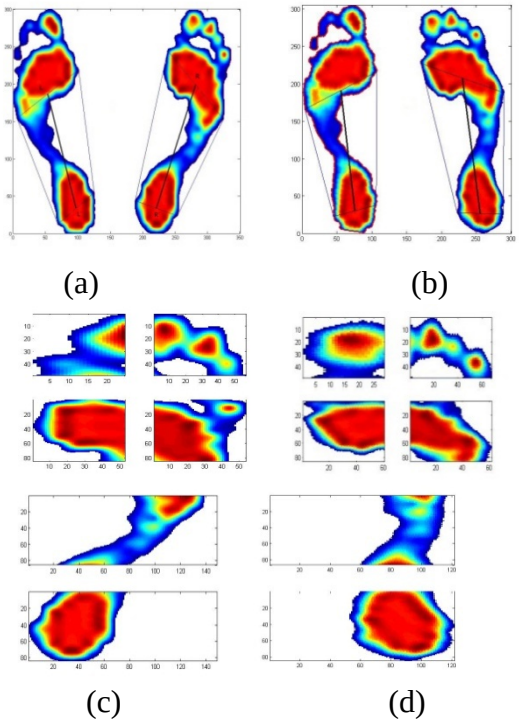


Fig.4 Contrast diagram before and after two-legged angle adjustment

The adjusted data are divided into areas as follows: The thumb of the toe is an important bearing part of the toe[9]. Therefore, the toe area is divided into thumb and two other four toe areas. In the soles area, it is divided into metatarsal area, middle foot area and heel area. As the main force area, the metatarsal region is further divided, and the metatarsal area is used as the two equal parts according to the axial direction of the foot. At this point, the foot is divided into 6 areas: heel, Middle foot, left half metatarsal area, right half metatarsal area, toe area, four-toe area.

3.2 Standardization of data

The size of the human foot varies, and the difference in the size of the foot in the calculation will have a scale effect on the extraction of the eigenvalue. Therefore, this paper adopts the method of relative position to avoid the influence of different size of foot on feature selection.

For the extracted position feature points, the relative position is used instead. The whole foot length is a and the width is b, and the feature point position is (x_i, y_i) The relative position is:

$$\begin{cases} X_i = x_i/a \\ Y_i = y_i/b \end{cases} \quad (1)$$

In formula (1), X_i, Y_i represent data on the position of the plantar pressure after standardized processing. All the plantar pressure data collected are standardized before feature extraction, and the pre-data standardization processing is omitted, omitting the process of reconstructing the scale invariance in the feature extraction algorithm, and improving the simplicity of the algorithm.

4. Feature Extraction Of Foot Pressure

The characteristics of plantar pressure proposed in this paper mainly include: the shape of foot contour and the distribution of foot pressure. The foot characteristics will be extracted mainly from the following two aspects:

(1) Foot contour characteristics based on Fourier descriptor;

(2) The characteristics of foot pressure distribution based on Laplace spectrum.

4.1 The characteristics of foot contour based on Fourier descriptor

The contour of the foot is an important feature of foot recognition, and the contour characteristics of the foot contain important information about identification.

Fourier descriptor[10] is a classic method of shape representation based on contour. The main idea is to use a set of data that represents the whole to describe the contour features. Fourier descriptor has the characteristics of clear definition, simple calculation, energy to low frequency concentration, and is one of the most widely used descriptors in shape representation[11]. A Viffourier descriptor has the advantages of translation and rotation invariance, and can make full use of boundary information. Therefore, a one-dimensional Fourier descriptor is used to extract the contour features of the foot.

The specific process is as follows:

(1) Construction of closed curves The premise of a Viffourier descriptor is that the target shape is a closed curve. However, the contour of the foot is not complete with the image footprint.

The paper proposes to extract only part of the edge contour of the heel part and the foot front palm, although this method effectively closes the foot pressure contour, but the removal of the toe and the foot will omit many important foot pressure characteristic information. In this paper, an extraction method of foot pressure contour is proposed. As shown in Fig.5, the main reason for the non-closure of the foot pressure contour is the high arch foot, mainly reflected in the disappearance of the middle foot area does not connect the heel region with the metatarsal region, the disappearance of the toenails pressure does not connect the toe with the metatarsal region. A complete method is adopted to find the nearest point and metatarsal area of the foot heel area to the nearest point of the heel part, which is two points connected. Locate each toe with the metatarsal area of the nearest two points, Wired. The contour of the foot after filling up is a closed curve. This method can not only effectively close the pressure contour curve of the foot bottom, but also show the characteristic information of the foot pressure completely.

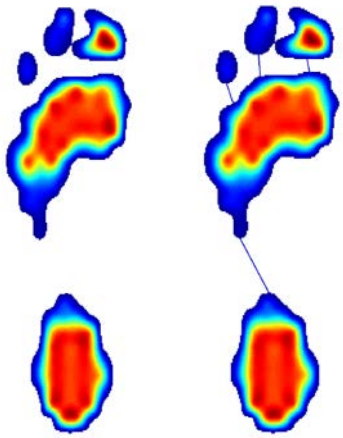


Fig.5 Construction of closed curve of foot contour

(2) Description of contour shape

Set the boundary coordinates of the target shape to {(x(t),y(t)),t=0,1,…,N-1}, and use the centroid distance function R (t) to describe the shape of the target.

$$r(t) = [(x(t) - x_c)^2 + (y(t) - y_c)^2]^{0.5} \quad (2)$$

$$t = 0,1,\dots,N-1$$

Which:

$$\begin{cases} x_c = \frac{1}{N}\sum_{i=0}^{N-1} x(t) \\ y_c = \frac{1}{N}\sum_{i=0}^{N-1} y(t) \end{cases} \quad (3)$$

The Fourier transform coefficient a(n) is obtained by Fourier transform of r(t),

$$a(n) = \frac{1}{N}\sum_{i=0}^{N-1} r(t)\exp\left(\frac{-j2\pi nt}{N}\right) \quad (4)$$

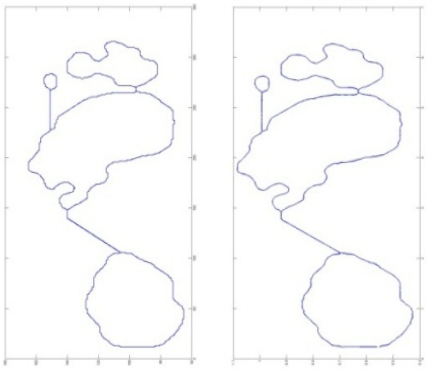
$$n = 0,1,\dots,N-1$$

The vector FD of the left and right feet is taken as the eigenvectors of the foot contour respectively:

$$FD = \left\{\frac{|a(2)|}{|a(1)|}, \frac{|a(3)|}{|a(1)|}, \dots, \frac{|a(n-1)|}{|a(1)|}\right\} = \{F_2, F_3, \dots, F_{n-1}\} \quad (5)$$

(3) Selection of eigenvalues

Assuming that the foot contour is composed of K dots, K Fourier descriptors can be obtained, and Figure 5 (a) (b) is, respectively, to take the outline of K descriptor and 0.5*K, and it can be seen from the graph that there is no obvious difference between the two boundaries. Therefore, it does not make much sense for too many depictions to be used as contour features.



(a) K depictions (b) 0.5*K a depiction of a child

Fig.6 Contour of Fourier descriptor reconstruction

It is necessary to find a reasonable number of Fourier depictions as a description of the contour characteristics of the foot. As shown in Fig.7, different numbers of Fourier depictions are used to reconstruct the foot contour. It is noted that when 34 depictions are taken to reconstruct the contour of the foot, the main shape characteristics of the contour can be maintained effectively: the rationality of the toe region and the rationality of the arch region. When reduced to 20, unaccepTable results were obtained as a result of the loss of the main features. Therefore, this paper selects 34 Fourier descriptors as eigenvalues to describe the contour of the foot .

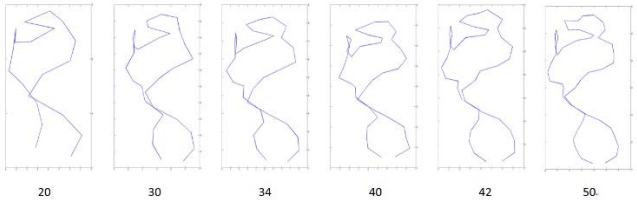


Fig.6 different numbers of depictions reconstruct the contour of the foot

4.2 Laplace spectrum characteristics of pressure Center

The core of the spectral graph theory is to study the relationship between the eigenvalue of the graph and the structure of the graph, and the eigenvalue of the Laplace matrix is that the invariant of the graph can react to the properties of the graph. The position of pressure center in each region is calculated as the characteristic parameter, and the Kepler feature is obtained by formula.

$$L = \begin{cases} \exp\left[-\dfrac{\left\|P_i - P_j\right\|^2}{2M^2}\right] & \left(i \neq j, i; j \in (1,2,\ldots,6)\right) \\ -\sum\limits_{k \neq i} l_{ik} \left(i = j; k \in (1,2,\ldots,6)\right) \end{cases} \tag{7}$$

Among them, P is the pressure center of each area after the foot partition and the pressure center of the whole foot, M takes the pressure value of the whole foot.

4.3 Construction of SVM classifier

SVM according to the category of training data can be divided into: linear can be divided into SVM, nonlinear can be divided into SVM, the need for kernel function mapping SVM. According to the

selected eigenvalue, the SVM which needs the kernel function mapping is selected to construct the classifier. This paper selects the classifier of one-to-one SVM method training. Select 50 frames in 80 frames of data per foot as training samples and 30 frames as test samples.

Select the radial base kernel function as the kernel function of the classifier:

$$K(x,y) = \exp(-\gamma\|x-y\|^2) \quad (8)$$

The objective function is:

$$L(\alpha) = \sum_{i=1}^{N} \alpha_i - \frac{1}{2}\sum_{i=1}^{N}\sum_{j=1}^{N} \alpha_i\alpha_j y_i y_j K(x_i, x_j) \quad (9)$$

The classification functions are:

$$h(x) = \mathrm{sgn}(\sum_{i\in SV} \alpha_i^* y_i K(x_i, x_j) + b^*) \quad (10)$$

The identification rate of the elderly with foot pressure obtained in this paper reached 80%.

5. Analysis of Experimental Results

In this paper, the method of identification of the elderly with foot pressure is proposed, mainly by extracting the eigenvalue of the foot contour based on the Fourier descriptor and the characteristic value of the pressure distribution based on the Laplace spectrum, and training the classifier according to the recognizable eigenvalue. The standardized processing of the data in advance reduces the complexity of the feature extraction process algorithm. In this paper, a new contour curve closure method which satisfies the biological structure of foot is proposed when Fourier descriptor is used to extract contour features, and the experimental results show that the method has high identification rate and reaches 80%.

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