

A Gait Recognition System based on SVM and Accelerations

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Abstract. In order to get a higher recognition accuracy of gaits, a gait recognition system based on SVM and acceleration is proposed in this paper. The acceleration data are obtained from acceleration acquisition system based on AT90CAN128 and four accelerometers that attached on human's thigh and shank. Acceleration data includes four gaits which consist of sitting, standing, walking and going upstairs. After normalization and median filtering are used for data, GA based on SVM is applied for gait recognition. The overall recognition accuracy of four gaits is more than 90%. Proved by the results of experiments, gait recognition based on acceleration and SVM whose parameter C and g selected by GA is an effective approach.

1 INTRODUCTION

Biological recognition is a technology which collects and analyzes the inherent characteristics of the human body (physiological characteristics and behavior characteristics) for identification by computer technology. Common characteristics include: finger-prints, face, iris, handwriting, and walking gait, key pressure and so on. Over the years gait recognition has become more and more popular because it can be measured from any angle without the learner's awareness.

Mathie has proposed a multilevel categorized algorithm which used decision-binary tree and temporal information of acceleration, such as the size of Signal Magnitude Area (SMA), the arccosine of vertical acceleration. The research can realize the recognition of various motions, include dynamic activities and static posture[1]. Amit kale used the binarized images of the human body's side profiles as features and chose a specimen collection using c-means algorithm for every individual in a gait cycle. Then the distance between each frame of a gait sequence and the sample called feature example distance (FED) vector was calculated in the gait recognition which used Hidden Markov Model (HMM)[2]. Chiraz Benadbelkader provided a non-parametric method based on self-similar graphs (SSP) of gait sequence and a parametric method based on gait cycle and span[3]. Zernike velocity moments are extracted as gait features for gait recognition in Shutler's paper[4].

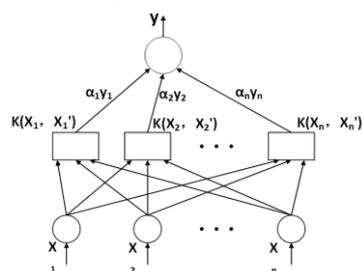
A gait recognition system based on SVM and acceleration is proposed in this paper. Four kinds of gaits are collected while people are in four common gaits: sitting, standing, walking and going upstairs. The acceleration data

of gaits is obtained from the accelerometers that attached on the middle of thigh and shank. Then Support Vector Machines (SVM) is adopted for recognition.

2 SUPPORT VECTOR MACHINES

2.1 The Basic Principle of Support Vector Machines.

Support Vector Machines (SVM) originates from Vapnik's statistical learning theory[5] and it is a super-vised learning model in the field of machine learning. It can be used for pattern recognition, classification, and regression. The basic principle of SVM can be summarized as: The sample space is mapped into a high-dimensional and even the infinite dimensional feature space through a nonlinear transformation. It makes a nonlinear separable problem in sample space become a linear separable in feature space. Then calculate the optimal linear classification surface by de-fining the appropriate inner product function in feature space. The schematic diagram of SVM is shown in Fig. 1. $K(X, X')$ represents inner product in optimal hyperplane. The letter α represents weight which we can set as needed[6].



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Figure 1. The schematic diagram of Support Vector Machines.

2.2 Parameter Optimization.

In support vector classification for two-class and multi-class, we should select kernel function and set up parameters properly for better recognition rate[7]. Radial Basis Function (RBF) is the common kernel function is used in SVM because it could implement nonlinear mapping. When RBF is selected in the re-search, penalty parameter C and gamma (γ) should be set by algorithms. Genetic Algorithm (GA) is a method for searching optimal solution method by simulating natural evolution. It learnt from Darwin's biological evolution theory.

3 DATA ACQUISITION AND PREPROCESSING

In the field of gait recognition, acceleration acquisition system has been one of the most important application on account of its flexibility and portability[8].

3.1 Acceleration Acquisition System.

There are four triaxial accelerometers which attached on the middle of shank and thigh, the installation site is shown in Fig. 2. In view of data processing and human motion frequency, the ADXL345 digital accelerometer meets the demand. It is a 3-axis accelerometer with high resolution (13-bit) measurement up to ± 16 g and provided by Analog Devices. ADXL345 measures the static acceleration of gravity in tilt-sensing applications, as well as the dynamic acceleration resulting from motion or shock.

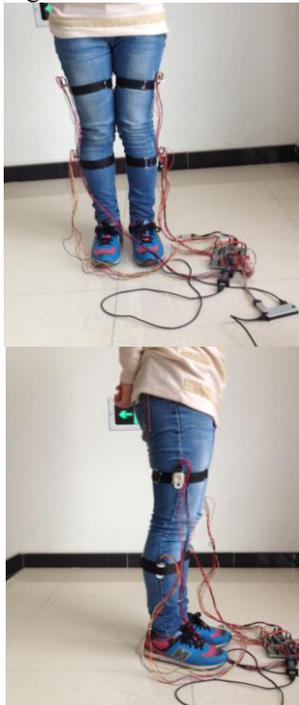


Figure 2. The acceleration acquisition system.

Two separated AT90CAN128 microcontrollers are used for collect sensors' information in consideration of four accelerometers distribution. AT90CAN128 is an 8-bit Microcontroller with 128K Bytes of ISP Flash and CAN (Controller Area Network) Controller. The acceleration will be transmitted to computer through CAN bus. These four accelerometers can measure the acceleration of human body. When people in daily activities, the acceleration of legs can basically reflect the motion of the human body.

3.2 Data Acquisition and Data Preprocessing.

In experiments, a lot of data are needed for analysis. Four volunteers (two males and two females.) are invited to participate in the experiment. The general information of four volunteers is as shown in Table1.

Table1. General information of volunteers

| Gender | Age | Height | Weight |
|--------|-----|--------|--------|
| Male | 23 | 170cm | 60kg |
| Male | 24 | 172cm | 65kg |
| Female | 23 | 167cm | 55kg |
| Female | 24 | 159cm | 50kg |

After wearing acceleration acquisition system, experiments are conducted by researchers. The forward direction of the human is the X axis of accelerometers. When a software programmed by VC++ 6.0 detected the start signal which is sent by AT90CAN128, the upper computer starts to receive data from CAN bus and save as a text file.

The frequency of daily activities of the body are below 20HZ[9] according related research. In paper, the sampling frequency is set at 25HZ can meet the demand. Acceleration data are collected when people in four gaits: sitting, standing, walking and going upstairs. Four sets of experiments are carried on in fixed time and the size of the total of data is 800×12 after every experiment.

Data are needed to be processed before simulating because some noises mixed with acceleration data. Common approaches includes: normalization, dimensionality reduction, and data filtering. In this paper, input and output is limited in the $[0, 1]$ or $[-1, 1]$ by normalization that can simplify calculation and avoid absolute error. Median filtering is a method that can effectively suppress noise and protect signals' edge. High dimensionality of the data against data processing speed and recognition accuracy, principal component analysis (PCA)[10] is applied and 12 dimensions data is reduced to 4 dimensions.

4 SIMULATION OF SVM FOR GAIT RECOGNITION

After data acquired and preprocessed completely, the acceleration data are divided into two parts, one part is used to make a 'traindata' dataset, and the other part is selected to make a 'testdata' dataset. A 'traindata' dataset consist of 480 sets of data which includes 120 sets of 'sitting', 120

sets of 'standing', 120 sets of 'walking', and 120 sets of 'going upstairs'. A 'testdata' dataset is constitutive of 320 sets of data including 80 sets of 'sitting', 80 sets of 'standing', 80 sets of 'walking', and 80 sets of 'going upstairs'.

In the datasheet, these data are labeled as follows: 1-'sitting', 2- 'standing', 3-'walking', 4- 'going upstairs'. The purpose of gait recognition system is to achieve the classification of four gaits, which means acceleration data should be labeled properly. Simulation of SVM and GA is established through the SVM toolbox in MATLAB. The main steps are as follows:

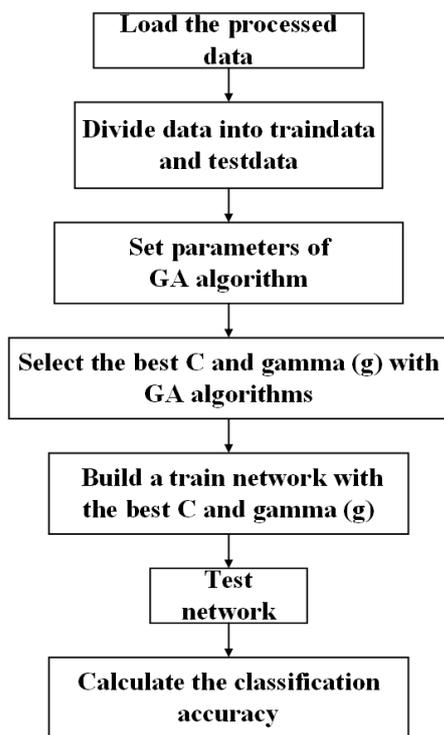


Figure 3. The execution flow chart of Support Vector Machines.

- 1) Load the processed data, and select data to form the 'traindata' and 'testdata' dataset.
- 2) Initialize parameters of GA algorithm. The maximum generation is set at 200, and the size of population is 20. The penalty parameter C and g is set in searching from 1 to 100 and 0.9 as the rate of individuals.
- 3) Use GA to find the optimal parameters C and g and save them.
- 4) Build a SVM train model with the best C and g, the remaining parameters is set to default values.
- 5) Test the model with 'testdata' dataset, and calculate accuracy.

The execution result of GA and SVM is shown in Fig. 5, the best C is 1.857, the best g is 0.000095368, and the best CVAccuracy is 93.25%.

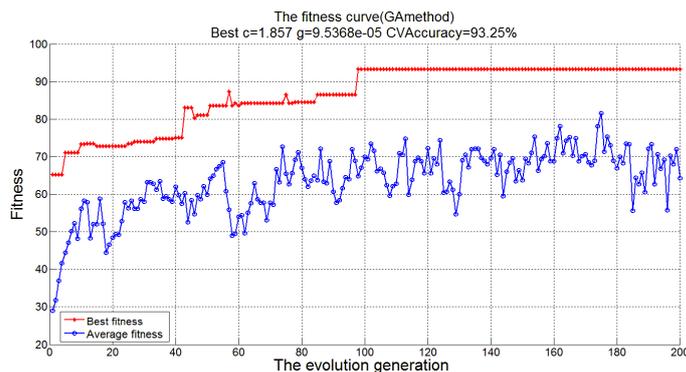


Figure 4. The execution result of parameters optimization by Genetic Algorithm.

The specific classification results is shown in the following Table2.

Table 2. The result of final gait recognition by GA and SVM

| Gaits | True number | Classified number | Accuracy |
|----------------|-------------|-------------------|----------|
| Sitting | 180 | 178 | 98.9% |
| Standing | 180 | 177 | 98.3% |
| Walking | 180 | 168 | 93.5% |
| Going upstairs | 180 | 161 | 89.4% |

5 DISCUSSION AND CONCLUSIONS

In this paper, the SVM based acceleration is put forward to realize an analysis system of human's common gaits in daily life. Acceleration data are got from acceleration acquisition system while people in four common gaits: sitting, standing, walking and going upstairs. From the above results of experiments, the overall classification accuracy rate of four gaits is more than 90% by GA based SVM. That proves that using a wearable acceleration acquisition system to collect acceleration and classifying the types of gait with GA and SVM is an effective method for gait recognition.

Although a high classification accuracy of gaits is get in this paper, there is so much we have to do in further study, such as finding another parameter selection method for SVM except for GA[11], and finding other algorithms.

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