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ZHAO

RECOGNITION SYSTEM OF HUMAN PHYSICAL ACTIVITY BASED ON FREQUENCY FEATURES OF SENSOR DATA

Abstract
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INTRODUCTION

In recent years, the study of human behavior recognition has also gained attention from scholars.Human activity recognition (HAR) is a technique that somehow senses the human behavior, analyzes the relevant behavior information, and identifies the corresponding behavior mode.

Sensor-based human behavior recognition technology was launched in the 1990s, and some studies showed that it is feasible to collect behavioral data using inertial sensors such as three-axis accelerometers, and then use sensor technology and classification algorithms to identify human behavior.However, limited to the level of microelectronics technology and computer computing power, the research on behavior recognition is less successful and insufficient.Nowadays, with the rapid development of microelectronics technology, the rapid improvement of computer computing ability, and the development of machine learning, deep learning and other recognition algorithms, the field of human behavior recognition research has also made great development in recent years, and there are certain practical applications in the fields of physical sports and fitness.

In the study of human behavior recognition based on motion sensors, the categories of sensors generally used include accelerometers and gyroscopes, and some studies also use magnetometers.Among them, the 3 D acceleration signal obtained by the accelerometer detection can directly represent the human motion situation, so the accelerometer is the most commonly used sensor in the motion sensor-based human behavior recognition research.Some researchers only use accelerometers to identify human behavior, but also achieved a certain recognition ability.for instance, Gupta [et. al]. fixed a single three-axis accelerometer at any position in the waist to collect six behavioral data, including jumping, running, walking, sitting, sitting, and kneeling, And an overall identification accuracy of about 98% was achieved; Xiao Ziming [et. al]. also put a single 3-dimensional gravity accelerator on the waist for behavioral data collection, The average recognition accuracy of 94.5% was achieved for the six behaviors: falling, jumping, running, sitting, standing and walking; Khan [et. al]. placed the accelerometer in the chest pocket, the left and right pockets in front of the pants, the pants back pocket, and the inner jacket pocket, Seven behavioral activities, such as rest (lying down, sitting, standing), walking, walking upstairs, walking downstairs, running, cycling, and vacuuming, were identified, And achieved an average recognition accuracy of 94%; Wang Zhongmin and others used the smartphone's built-in accelerometer to collect users' behavior data, Identify human behavior methods, including stationary, walking, running, going up and down the stairs.

In addition, gyroscope is also commonly used in human behavior recognition. contrast analyzed the accelerometer, gyroscope and magnetometer sensor in behavior recognition, and the results show that for the final behavior recognition results, the acceleration data identification performance is the best, gyroscope data secondary, and comprehensive use of accelerometer and gyroscope data can further improve the accuracy of identification.

The aim of my thesis is to improve performance of the human activity recognition algorithm based on choice of frequency features and type of classifier.

To achieve this aim, the following tasks were solved in the dissertation:

1 The collection of ACC smartphone sensor data of the different classes of physical activities.

2 Filtering of the raw ACC data.

3 Extraction of frequency features from ACC sensor data.

4 Estimation of performance of the human activity recognition algorithm based on choice of frequency features and type of classifier.

GENERAL DESCRIPTION OF WORK

Relevance of the subject

The work corresponds to paragraph 1 «Digital information and communication and interdisciplinary technologies based on them production» of the priority areas of scientific,technical and innovative activities for 2021 - 2025. The work was carried out in the educational institution Belarusian State University of Informatics and Radioelectronics.

The aim and tasks of the work

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Personal contribution of the author

The data were extracted using matlab mobile, then extracted data were median-filtered and then filtered using a Butterworth low-pass filter, and the

frequency features were extracted from the filtered data, and then analyzed the performance of SVM algorithm,and comparing the performance of the different classification algorithms.

Task setting and discussion of the results were carried out together with the Supervisor, Associated Professor Ilya Baryskievic Anatolievich .

Testing and implementation of results

The main provisions and results of the dissertation work were reported and discussed at: recognition system of human physical activity based on frequency features of sensor (tri - axial accelerometer) data,the processed acceleration data was tested mainly using the SVM classification algorithm.

The results of the thesis are used in scientific and technical products of full name of the organization.

Author's publications

According to the results of the research presented in the dissertation, author's works was published, including: 3 articles in international conference and seminar proceedings.

Structure and size of the work

The dissertation work consists of introduction, general description of the work, three chapters with conclusions for each chapter, conclusion,bibliography.

The total amount of the thesis is 67 pages, of which 51 pages of text, 48 figures on 7 pages, 4 tables on 2 pages, a list of used bibliographic sources (26 titles on 2 pages), a list of the author's publications on the subject of the thesis (3 titles on 1 page), graphic material on 4 pages.

Plagiarism

An examination of the dissertation «Recognition system of human physical activity based on frequency features of sensor (tri -axial accelerometer) data» by Zhao Di was carried out for the correctness of the use of borrowed materials using the network resource «turnitin» (access address: https://www.turnitin.com) in the online mode 22.03.2022. As a result of the verification, the correctness of the use of borrowed materials was established (the originality of the thesis is 77%)

SUMMARY OF WORK

The **introduction** addresses the problems of improving performance of the human activity recognition algorithm based on choice of frequency features and

type of classifier.

The **general description of work** shows the connection between the work and the priority areas of scientific research, the aim and tasks of the research, the personal contribution of the applicant for a scientific degree, the approbation of the dissertation results.

In the first chapter introduces the acquisition process of ACC data, describes our steps to realize data acquisition using matlab mobile code .Then we describe the pre-processing process of the collection of ACC data, including window cutting of the data, filtering of the data, and decomposition of the data.

In the second chapter,we introduce the principle of using FFT to extract feature data from the tri-axis acceleration data. We respectively extract the central frequency, root mean square frequency, mean square frequency, mean frequency and frequency variance. Then we introduce the principle and implementation of PCA algorithm and OVO multi-class classification SVM algorithm and elaborated on their advantages and disadvantages.

In the third chapter show the user interface and experimental results of the human activity recognition system. Then we compared different classification algorithms by confusion matrix ,ROC curve and so on,and we have concluded that Fine Gaussian SVM has better human activity recognition effect.

CONCLUSION

The aim of the work is to improve performance of the human activity recognition algorithm based on choice of frequency features and type of classifier.We collected the human activity information from smartphone acceleration sensor,We used Matlab mobile code for collecting the smartphone sensor data.

We then performed the data preprocessing：using window segmentation with fixed window with overlapping (256 samples, 50% overlapping), filtering denoising by means of sliding median filtering (window length=7 samples) and third-order Butterworth low-pass filer (20Hz cutoff frequency) ,And we decomposed the acceleration signal into the linear acceleration signal and gravity signal by means of high-pass filter (0.3 Hz cutoff frequency).

We uses FFT extract features of six typical activities from tri-axial acceleration data.First,the frequency domain feature extraction algorithm adopted is a fast Fourier algorithm,we selected the center of gravity frequency, mean frequency, root mean square frequency , frequency standard deviation such characteristic parameters，and formed 15 features vectors.

Then we use PCA algorithm and OVO multi-class classification SVM algorithm.For PCA training, 339 of 1553481 observations were ignored because they contained Infs or NaNs,and PCA is keeping enough components to explain 95% variance,and the work specifies number of components is 10.

We build the model of Activity Energy Expenditure based on human physiology. The activity recognition algorithm is effective in recognizing six daily physical activities with an average accuracy more than 99%. It is able to distinguish walking, running,upstairing, downstairing,standing, sitting and jogging activities using only a single tri-axial accelerometer.

At last,we compared different classification algorithms by confusion matrix ,ROC curve and so on,and we have concluded that Fine Gaussian SVM has better human activity recognition effect.

LIST OF AUTHOR'S PUBLICATIONS

1 – A. Chuyue Yu. Design of smart code lock / Yu Chuyue, Xia Yiwei,Zhao Di,Hu Zhifeng // Telecommunications: Networks and Technologies, Algebraic Coding and Data Security : материалы междунар. науч.-техн. семинара (Республика Беларусь, Минск, ноябрь – декабрь 2021 г.) / редкол. : М. Н. Бобов [и др.]. – Минск : БГУИР, 2021. – С. 72-74.

2 – A.Di Zhao. Multi-class classfication SVM methods / Zhao Di //Coding and digital processing of signals in infocommunications: Materials of the International. scientific study. conf. (Republic of Belarus, Minsk, April 19, 2022) / Redaction. : V.C. Konopelko, V.Y. Tsykkov, L.A. Shicko. - Minsk: BSUIR, 2022 – P. 85-87.

3 – A.Di Zhao. Sensor data frequency feature extractionS / Zhao Di //Coding and digital processing of signals in infocommunications: Materials of the International. scientific study. conf. (Republic of Belarus, Minsk, April 19, 2022) / Redaction. : V.C. Konopelko, V.Y. Tsykkov, L.A. Shicko. - Minsk: BSUIR, 2022 – P. 66-68.