TELKOMNIKA, Vol. 11, No. 4, April 2013, pp. 1769~ 1775
ISSN: 2302-4046

Sitting Posture Recognition Based on Data Fusion on Pressure Cushion

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Abstract

Sitting postures affect their safety in wheelchair for persons with the disability or the elder people. In this paper, we built the body pressure collection system, it is explored the relationship between the pressure distributions and sitting posture. Based on daily sitting posture of disabled and older people, the eight states is summarized that people sit on the wheelchair, and using density-based clustering methods establish the evaluation model of difference sitting postures. The instances verify that the model can accurately predict the relations between pressure distribution and sitting postures.

Keywords*: sitting postures, density-based clustering algorithm, pressure sensor, body pressure distribution, body sensor networks*

1.Introduction

With the acceleration of the process of global aging, the disabled and elderly people in independent living will be more and more [1],Good care for them will be a serious problem faced by the family and society, simultaneously an increasing number of them will take into account to sit on the wheelchair. Wheelchair that monitoring and analysis system for the elderly and disabilities was established; fast, accurate and effective state behavior of abnormal state analysis in wheelchair can improve the quality of life of them [2], the family members of disabled and elderly people can sense and grasp their the real-time state, while their family members of them can foresee the future actions and measures need to be taken to improve service quality.

The sitting postures of the real-time recognition have great significance, human postures recognition can use a variety of methods, literature [3, 4] provide posture recognition method with acceleration sensor. Intelligent cushion have been applied in various domains, such as, to apply to the driving seat of the car, for the dynamic monitoring of the driver's emotional state, and propose timely warning [5, 6], the United Kingdom QinetiQ company developed a kind of wisdom aircraft seats, it can be automatically detected include the terrorists and patients with a fear of flying, including the nervous passengers, and promptly notify the crew. The seat is equipped with a pressure sensor, can feel the action of the passenger's behavior, and related data to only the crew can have access to the computer, and crew members to judge from these data [7]. The literature [8] think the sensors that detect the pressures at the user-cushion methods for Spinal cord injuries. The literature [9] argues to gain insight about the influence of body posture on the pressure at the seat surface and to establish to what extent different seat cushions designed for incontinent patients reduce maximum pressures with the research of pressure distribution in the cushion .

The cushion of wheelchair plays an important role through indirect means to sense the sitting postures. Wheelchair cushion collect the pressure value of sitting gesture of the elderly and disabled person, At the same time, sitting posture and the degree of danger based on real-time data analysis results released to medical personnel, community service, and their family members through the means of communication remind them to take a more scientific and security sitting gesture, and to coping abnormal statement in real time.

Clustering techniques have broadly been researched [10, 11],clustering is the problem of finding a set of groups of similar objects within a data set while keeping dissimilar objects separated in different groups. And Density-based clustering methods is to organize a set of

Received January 4, 2013; Revised February 6, 2013; Accepted February 18, 2013

objects into groups which are similar to each other and different from those in other groups, A fundamental difference between the density-based methods and other methods: it is not based on the distance of the Euclidean or Manhattan distance metric, but based on the density, this algorithm can overcome the distance-based algorithm can only be found “round-like "clustering disadvantages. Guiding ideology of this method is that as long as the density of dots in a region greater than a certain threshold, it is added thereto in similar clusters. The representative algorithm: DBSCAN [12], OPTICS [13], DENCLUE [14]; OPTICS is a generalization of DBSCAN that removes the need to choose an appropriate value for the range parameters of Eps and MinPts , and produces a hierarchical result related to that of linkage clustering [15].

With the accuracy sitting posture for the disability or the elderly, the cushion can sense the actions of its occupant and therefore can better interpret the user’s intentions. And can provide much useful information to its occupant and relative person. Further, intelligent cushion can been find applications in many areas including intelligent environment, and safety of automobile operations, and so on.

The remainder of this paper is structured as follows: Section 2 gives the description of acquisition system for cushion pressure distribution information; Section 3 illustrates the frame of discernment of the body sitting postures; Section 4 introduces sitting postures recognizing; Section 5 is experimental verification; finally, we present the conclusions.

2. Acquisition System for Cushion Pressure Distribution Information

The architecture of the proposed the disabled and elderly people sitting postures recognizing system, depicted in Figure 1, is basically composed of several pressure sensor nodes transmitting the collected raw pressure data to a central coordinator in charge of processing them. Sensor node is composed of three modules: sensing, processing and transmitting features.

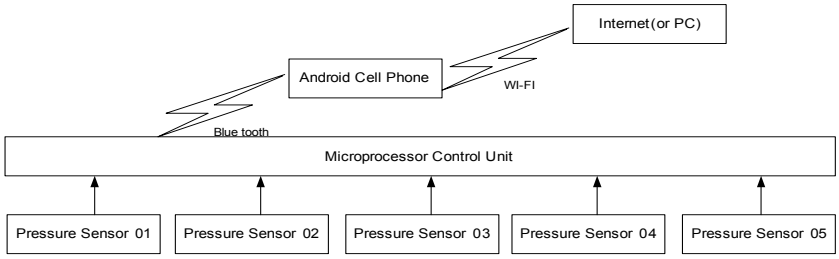


Figure 1. The Disabled and Elderly People Sitting Postures Recognizing System

FSR (Force Sensitive Resistor) will vary its resistance depending on how much pressure is being applied to the sensing area. The force is the greater, and the resistance is the lower. When no pressure is being applied to the FSR, its resistance will be larger than 1MΩ, with full pressure applied the resistance will be 200Ω. It is depicted In Figure 2. We assume the following value interval: the maximum resistance of the pressure sensor defines 5kΩ, the pressure value of 100g, and the minimum resistance of the pressure sensor defines 200Ω, the pressure value of 10000g.This system make use of single sensor elements as well as integrated arrays of sensors to obtain pressure maps of sitting postures.

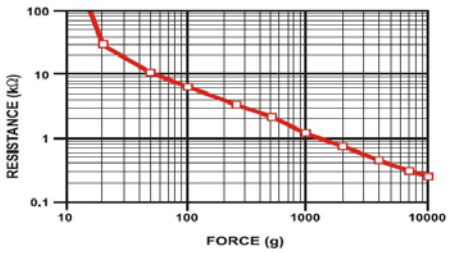


Figure 2. Nominal Force vs. Output Voltage Curve

We have established system that pressure data can be collected from a group of FSR. Record the output voltage at various pre-selected force points throughout the range of interest. A family of curves can be obtained, a nominal force vs. output voltage curve can be determined, then the force accuracy of the system can be obtained. Ultimately the pressure distribution of difference sitting postures of human body was obtained from the cushion.

Figure 3. Actual System Layout

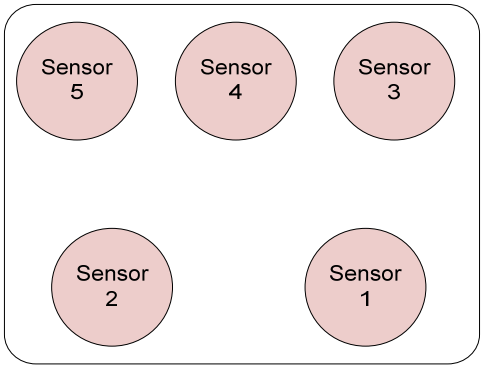


Figure 4. Pressure Sensors Layout

3. The frame of discernment of the body sitting postures

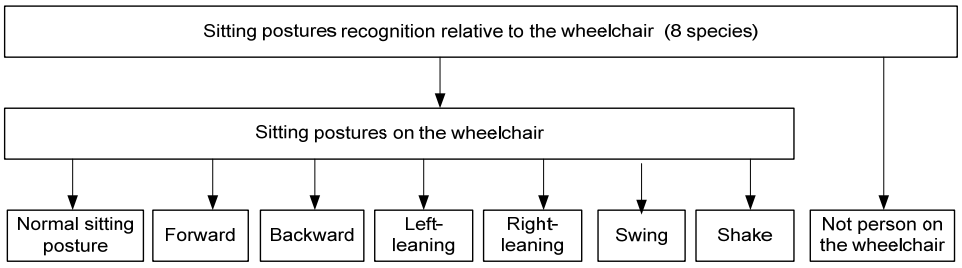


Figure 5. Sitting Postures on the Wheelchair

For accuracy recognizing human body sitting postures in this experiment, the frame of discernment is defined as follows:

Θ= {θ1=Normal sitting posture, θ2=Forward, θ3=Backward, θ4=Left-leaning, θ5= Right-leaning, θ6= Swing, θ7= Shake, θ8= No person on the wheelchair}

The posture state space analysis:

A. Normal sitting posture: Read out and record the value of the five pressure sensors in the normal sitting condition which is naturally sat upright in cushion with the feet on the ground, it is the basic standard of recognizing the other sitting postures.

B. Forward: the state is the pressure value of the sensor 1 and sensor 2 become larger and the pressure value of the sensor 3, sensor4 and sensor 5 become smaller than the pressure value in the normal sitting posture.

C. Backward: the state is the pressure value of the sensor 1 and sensor 2 become smaller and the pressure value of the sensor 3, sensor4 and sensor 5 become larger than the pressure value in the normal sitting posture.

D. Left-leaning: the state is the pressure value of the sensor 1 and sensor 3 become larger and the pressure value of the sensor 2 and sensor 5 become smaller than the pressure value in the normal sitting posture.

E. Right-leaning: the state is the pressure value of the sensor 1 and sensor 3 become smaller and the pressure value of the sensor 2 and sensor 5 become larger than the pressure value in the normal sitting posture.

F. Swing: among two second, non-periodic short-term changes in five elements of the frame of discernment of the sitting postures, such as Normal sitting posture, Forward, Backward, Left-leaning, Right-leaning.

G. Shake: between two to ten second, periodic or non-periodic short-term changes in five elements of the frame of discernment of the sitting postures, such as Normal sitting posture, Forward, Backward, Left-leaning, Right-leaning .

H. No person on the wheelchair: the value of the five pressure sensors is about zero.

4. Sitting Postures Recognizing

The Figure 6 gives the description of the cushion pressure data acquisition system, data prepractice system and recognition system.

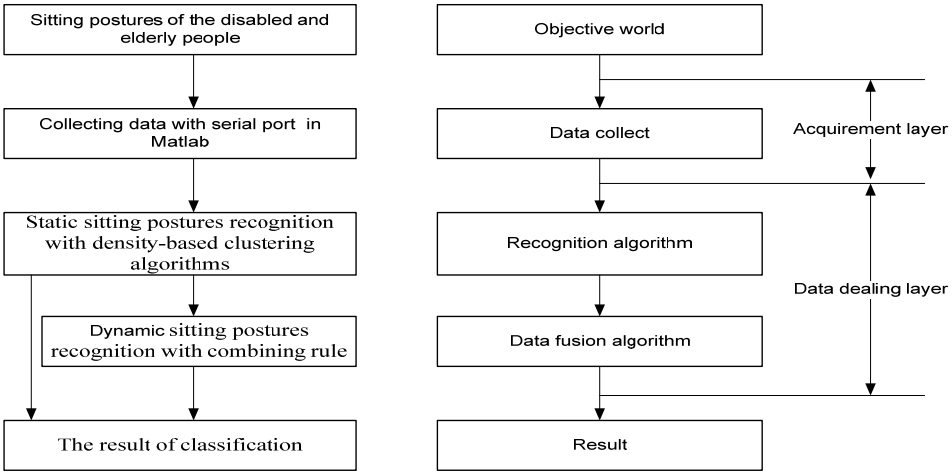
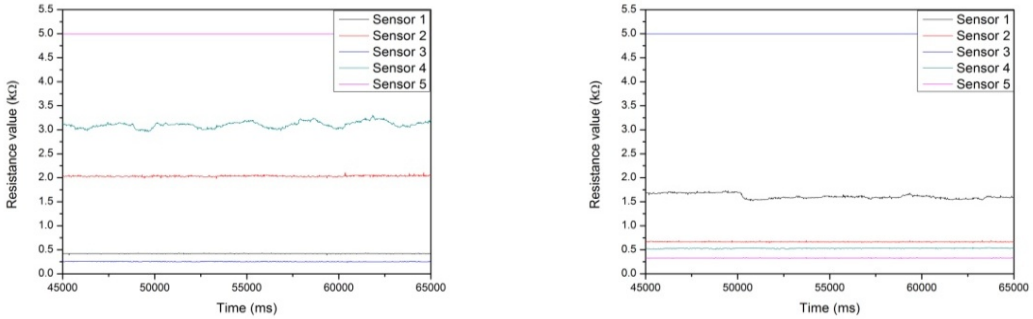


Figure 6. The Data Flow of Recognizing Information

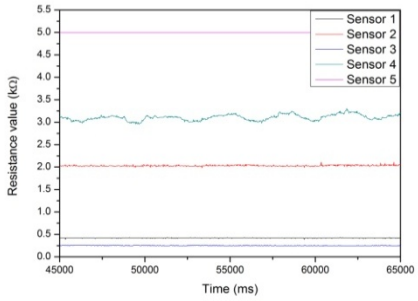
4.1. Recognizing of the Human Body Static Sitting Postures

The density-based clustering algorithms is majorly a set of data objects spread in the data space over a contiguous region of high density of objects, separated from other by contiguous regions of low density of objects. In

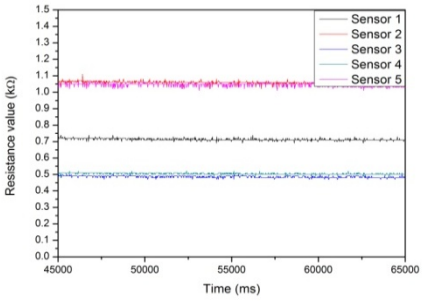
Figure 7, the figures of the data set is a set of 5-dimensional real-valued points,



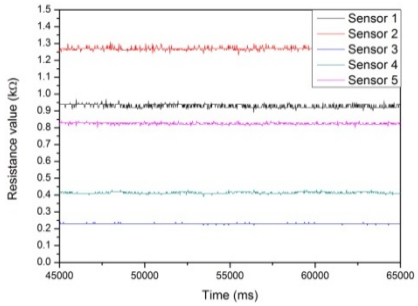
(a) Left-leaning (b) Right-leaning



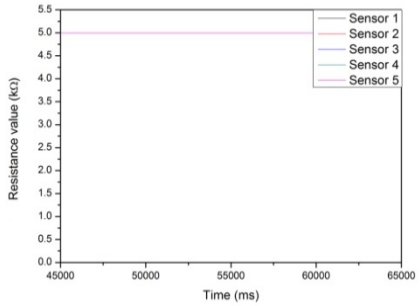
(c) Forward



(d) Backward

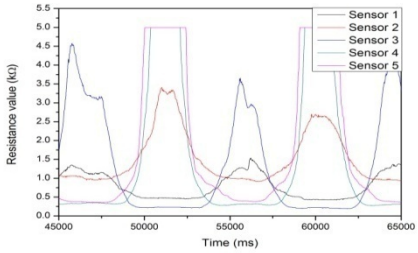


(e) Normal sitting posture

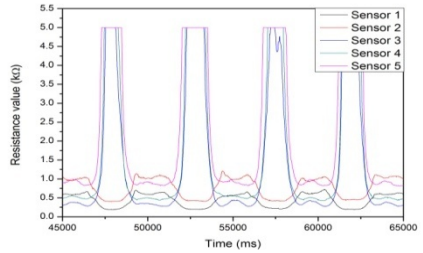


(f) No person on a chair

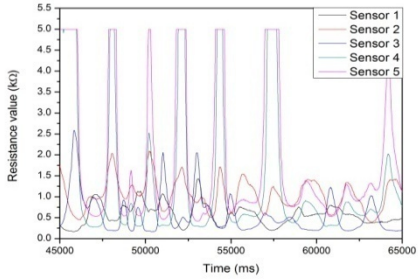
Figure 7. The Layout Body Static Stting Postures



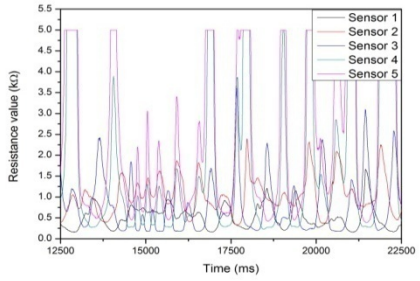
(a) Left-right shake



(b) Fore-back shake



(c) Irregular shaking



(d) Swing

Figure 8. The Layout of Dynamic Process of Swing or Shake in Cushion

In the experiment, the real-time data is sent by the board of data acquisition, the density based clustering algorithms in the Matlab 2012 is executed, in this algorithm, the major step as follow:

1) The values of parameters of Eps and MinPts are selected according to the experiences the many experts.
2) All the points in the dataset are marked as unclassified.
3) With parameters Eps and MinPts, an unclassified core-point p can be found. Then mark the point p to be classified. Finally start a new empty cluster Ct and assign p to this cluster.
4) Passing iteration, it can find all the unclassified points in the Eps-neighborhood of p and define other seed points.
5) Repeat steps 3 and 4 until the set of seed points is null set.
6) Output all the clusters found and mark all the points which do not belong to any cluster as noise points. Ultimately, the features of the classification are found.

4.2. Recognizing Dynamic Process of Swing or Shake of the Human Body Sitting Posture

Identification of key points can be drawn through the analysis of the body rocking jitter defined short-term changes in the cycle and non-cycle of several elements of the state space of a short period of time sitting, we define the state transitions in five seconds, and dynamic process more than 20 seconds duration identified as the body sway jitter state. Shown in the drawing is identified as a distribution of body pressure swing shake state.

5. Experimental Verification

In experiment, the disabilities or the elderly were asked to natural backward, lightly against the backrest, eyes flat as the front left and right thighs roughly parallel, knees bent roughly 90 degrees, the foot gently flat on the ground, basic non-load-bearing, the recording time of 5 minutes, sampling rate 50f/s.

In particular, ten person make 50, five static sitting postures respectively, total of 2500 sitting postures recognition experiments that have been carried out, that the recognition accuracy achieved by the system is shown in Table 1. (A_1,A_2,A_3,A_4,A_5,A_6,A_7,A_8), which correspond to Normal sitting posture, Forward, Backward, Left-leaning, Right-leaning, Swing, Shake, No person on the wheelchair, respectively.

Table 1. Posture Recognition Accuracy

		Predicted body sitting postures								Accuracy
		A_1	A_2	A_3	A_4	A_5	A_6	A_7	A_8	(%)
Actual body sitting postures	A_1	475	5	0	8	12	0	0	0	95
	A_2	11	484	0	12	3	0	0	0	97
	A_3	26	0	461	4	9	0	0	0	92
	A_4	22	9	0	469	0	0	0	0	94
	A_5	24	13	0	0	463	0	0	0	93
	A_6	0	0	0	0	0	95	5	0	95
	A_7	0	0	0	0	0	10	90	0	90
	A_8	0	0	0	0	0	0	0	100	100

The current static posture classification system operates in real time with an overall classification accuracy of 94.2% for familiar. The recognition rate of no person on the wheelchair is 100%, and recognition rate of the swing and shake is about 92.5% because the Similarity of their states

6. Conclusion

By characteristic parameters calculated and statistics, with density-based clustering methods recognize pressure cushion correspondence between the distribution model and sitting gesture; sitting postures recognition system broadly achieve different sitting posture of the elderly and disabilities. In order to better recognition effect, next the work will study ergonomic

principles and the body pressure distribution physical system, analysis the distribution of cushion sampling points.

However, Sitting is behavior art, it shows an individual's culture, interests, emotions, tendencies, and soberness of habit. Sitting gestures turn different in different situations, the frame of discernment of the body sitting postures is yet different.

Next work are research in emotion recognition and exploit the features information of emotional state to improve emotion recognition from the sitting postures on the cushion.

Acknowledgment

This research is partly sponsored by the Ministry of Science and Technology of China (Grant Number: 2012BAJ05B07), International cooperation projects of Hubei province (2011BFA012).

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