Activity Recognition from Accelerometer Data on a Mobile Phone

Tomas Brezmes[1], Juan-Luis Gorricho[2], and Josep Cotrina[2]

[1] France Telecom R+D, Spain
tomas.brezmes@orange-ftgroup.com
[2] Departamento de Telemática, UPC, Spain
{juanluis,jcotrina}@entel.upc.edu

Abstract. Real-time monitoring of human movements can be easily envisaged as a useful tool for many purposes and future applications. This paper presents the implementation of a real-time classification system for some basic human movements using a conventional mobile phone equipped with an accelerometer. The aim of this study was to check the present capacity of conventional mobile phones to execute in real-time all the necessary pattern recognition algorithms to classify the corresponding human movements. No server processing data is involved in this approach, so the human monitoring is completely decentralized and only an additional software will be required to remotely report the human monitoring. The feasibility of this approach opens a new range of opportunities to develop new applications at a reasonable low-cost.

Keywords: Pattern recognition, human movement's detection, accelerometer.

1 Introduction

An aging population is one of the main concerns of present administrations. Thinking about new health-care paradigms to diminish the expected ever increasing health-care budget is becoming a real necessity. Thankfully, recent progress in information communication technologies and sensor miniaturization have provided the foundation for the development of systems concerned with the remote supervision of home-based physiological monitoring. In particular, a real-time monitoring of human movements is expected to be a practical solution to monitor aged people or any human being who needs to be under medical control.

At present there is an extended bibliography on the field of human movement's detection with studies considering wearable sensor units [1]-[3] or employing multiple accelerometer units located on different body sites [4]-[7]. On the other hand, many studies are devoted to improve or compare the accuracy of pattern recognition to classify the human movements. The most commonly used techniques come from applying artificial intelligence principles: decision trees, k-nearest neighbors, neural networks, support vector machine, etc. [7]-[9].

This paper exposes the implementation of a real-time classification system for some representative human movements: walking, climbing-up stairs, climbing-down

S. Omatu et al. (Eds.): IWANN 2009, Part II, LNCS 5518, pp. 796–799, 2009.

stairs, standing-up, sitting-down and falling, using a conventional mobile phone equipped with a single triaxial accelerometer. Although most studies on human movement's recognition use several accelerometers located at particular body sites and with specific orientations [1]-[7], in our study the mobile device is hold by any user with no predefined orientation. This uncertainty on the device tilt increases notably the difficulty to recognize any movement pattern, depending on the orientation of the device the input data for the same movement differs notably.

2 Test Bed

The prototype has been developed using a Nokia N95 mobile phone. To obtain the accelerometer's data we have used a Python API: aXYZ [10], at present time no Java API was available to access the accelerometer. This way we have programmed an elementary Python script just to be able to use the mentioned aXYZ API, adding some coding to communicate, using local sockets, with a Java program running on the same mobile phone. All the graphical interfaces and also the required logic to recognize the movement patterns have been programmed within the Java module in the mobile phone.

Due to the necessary interconnection using local sockets between the Python script and the Java application, there is a limitation on the maximum sampling rate of the accelerometer data. Nevertheless, a sampling rate up to 30 samples per second has been achieved, and for the purpose of the present project it is proved to be enough.

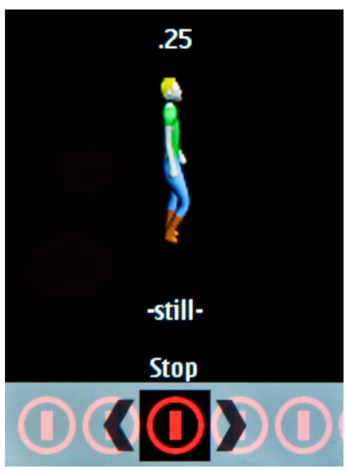

Fig. 1. Screenshot

As it is commonly the case on pattern recognition, there is a training phase to learn the system. Our proposal has been developed based on the K-nearest neighbors algorithm to recognize the intended movements. In such a way that, each user can train the application considering his usual way to hold the mobile phone: into a chest pocket, a front trousers pocket, a rear trousers pocket, an inner jacket pocket, etc.

The accelerometer provides the forces (static and non-static) acting on the device. It returns a three component (x,y,z) vector that reports the three-axis forces acting on the Cartesian reference system of the mentioned accelerometer. Note that the accelerometer reference system is also constantly changing due to the user motion.

From this information, a first approach to estimate a movement pattern was to record the sequence of sampled forces during a given period of time (a movement record), and then identify the most relevant characteristics of the resultant time-domain samples to try and classify the different movements. A second approach was to translate the time-domain samples to the frequency domain, and then search for relevant parameters on the frequency-domain as in the former case. Nevertheless, these two similar approaches have proved to be useless, because different records on the time-domain and frequency-domain show a fairly irregular behavior, and it seems difficult to conclude some sort of characteristic pattern parameters for each type of movement, even examining records of the same movement produced by the same user. The alternative has been to store an increasing number of records for each movement during the training phase, this creates a minimum data base to be used later on to classify any new record during the monitoring phase, this classification is based on the k-nearest neighbors algorithm, obtaining the Euclidean distance of the present record with all the previously saved records already classified.

3 Results

Some representative results obtained from test executions are summarised on table 1.

Table 1. Percentage of success in pattern recognition

Movement	1 train session	2 train sessions	Full train
Walking	70%	70%	90%
Climbing-down stairs	20%	20%	80%
Climbing-up stairs	60%	60%	80%
Sitting down	30%	30%	70%
Standing up	50%	50%	70%
falling	70%	80%	90%

As we can appreciate the correct classification improves with training. It is worth mentioning that to obtain a full training set, the algorithm dynamically deletes previously saved records on the ongoing training, discarding those records with clear pattern recognition conflicts between different movements.

In spite of the simplicity of the pattern recognition algorithm applied, the obtained results are quite accurate.

Acknowledgments

This work was partially supported by CICYT Grants TSI2007-66637-C02 and TEC2006-04504.

References

1. Karantonis, D.M., Narayanan, M.R., Mathie, M., Lovell, N.H., Celler, B.G.: Implementation of a real-time human movement classifier using a triaxial accelerometer for ambulatory monitoring. IEEE Trans. on Information Tecnhology in Biomedicine 10(1) (2006)
2. Bouten, C.V., Koekkoek, K.T., Verduin, M., Kodde, R., Janssen, J.D.: A triaxial accelerometer and portable data processing unit for the assessment of daily physical activity. IEEE Trans. Biomed. Eng. 44(3), 136–147 (1997)
3. Mathie, M.J., Coster, A.C.F., Lovell, N.H., Celler, B.G.: A pilot study of long term monitoring of human movements in the home using accelerometry. J. Telemed. Telecare 10, 144–151 (2004)
4. Fahrenberg, J., Foerster, F., Smeja, M., Muller, W.: Assessment of posture and motion by multichannel piezoresistive accelerometer recordings. Psychophysiol. 34, 607–612 (1997)
5. Foerster, F., Fahrenberg, J.: Motion pattern and posture: Correctly assessed by calibrated accelerometers. Behav. Res. Meth. Instrum. Comput. 32, 450–457 (2000)
6. Veltink, P.H., Bussmann, H.B., de Vries, W., Martens, W.L., van Lummel, R.C.: Detection of static and dynamic activities using uniaxial accelerometers. IEEE Trans. Rehabil. Eng. 4(4), 375–385 (1996)
7. Song, Y., Shin, S., Kim, S., Lee, D., Lee, K.H.: Speed estimation from a tri-axial accelerometer using neural networks. In: 29th annual international conference of the IEEE EMBS (2007)
8. Yang, J.-Y., Wang, J.-S., Chen, Y.-P.: Using acceleration measurements for activity recognition: an effective learning algorithm for constructing neural classifiers. Pattern Recognition Letters (2008)
9. Ravi, N., Dandekar, N., Mysore, P., Littman, M.L.: Activity recognition from accelerometer data. American Association for Artificial Intelligence (2005)
10. http://wiki.forum.nokia.com/index.php/The_aXYZ_-_a_sensor_extension_for_Python