International Journal of Advanced Culture Technology Vol.4 No.1 28-30 (2016)
http://dx.doi.org/10.17703/IJACT.2016.4.1.28

IJACT 16-1-4

Detecting user status from smartphone sensor data

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Abstract

Due to the high increment in usage and built-in advanced technology of smartphones, human activity recognition relying on smartphone sensor data has become a focused research area. In order to reduce noise of collected data, most of previous studies assume that smartphones are fixed at certain positions. This strategy is impractical for real life applications. To overcome this issue, we here investigate a framework that allows detecting the status of a traveller as idle or moving regardless the position and the direction of smartphones. The application of our work is to estimate the total energy consumption of a traveller during a trip. A number of experiments have been carried out to show the effectiveness of our framework when travellers are not only walking but also using primitive vehicles like motorbikes.

Keywords: *activity recognition, smartphone sensor, user status, motorbikes, smartphone reorientation, and tilt features.*

1. Introduction

Over past decades, human activity recognition has been intensively investigated for various application areas such as healthcare, context-aware communications, community sensing etc. In early time, most of researches focused on analyzing data collected from body-mounted sensors [1]. Recently, due to the emerging of smartphones coupled with various built-in sensors like Accelerometer, Gyroscope, Magnetometer, Proximity, Pressure sensors and so on, activity recognition based the smartphone sensor data has become an active research area. In this work, we concentrate on identifying *moving* and *idle* status of users while walking or using a vehicle, that allows estimating the total energy consumption of travellers.

In most of previous works, for detecting users' movement, the smartphone has to be fixed at a known orientation in the same plane and coordinates as the direction of travellers. This is quite impractical for real life application as users' smartphones can be put at any place as well as in any orientation during a trip. In this work, we follow the approach of Premerlani and Bizard [2] to reorient travellers 'smartphones such that our activity recognition framework is applicable in real life systems.

In addition, each window segment of accelerometer data is extracted into a set of tilt invariant features

Manuscript Received: Jan. 17, 2016 / Revised: Feb. 7, 2016 / Accepted: Feb. 27, 2016
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as done in Khan et al. [3] and Han et al. [4] in order to increase computational feasibility in real-time systems and the robust rotation of accelerometer in detecting user status.

To the best of our knowledge, none of the existing activity recognition methods have been tested for primitive vehicles, such as motorbikes – that are very popular in developing countries. Hence, we carried out a number of experiments to verify the effectiveness of our activity recognition framework while travellers are not only walking but also using motorbikes.

2. Related works

To overcome the limitation of most previous activity recognition methods that assume smartphones are fixed at a known orientation in the same plane and coordinates as the direction of travellers, several approaches were proposed for automatic reorientation of the accelerometer data on smartphones. Among those, Premerlani and Bizard [2] presented a method for calibrating Accelerometer signal with the help of Gyroscope and Magnetometer signal. This method does not use GPS signal, it thus minimizes smartphone power consumption.

A typical activity recognition procedure is carried out in the following steps: First, the recorded sensor signal is broken into a number of windows of predefined size. Then, a set of features representing the general characteristics of each window is extracted. Finally, a classification algorithm is used to predict the user activity. In fact, there are various approaches for extracting features from sensor data, such as time domain features, frequency domain features, or wavelet features [5]. More recently, Khan et al. [3] and Han et al. [4] show that using a group of tilt invariant features is not only computationally feasible in real-time systems but also robust to the rotation of accelerometer and reasonably accurate.

3. A flexible framework for detecting user status

Our activity recognition framework is presented in Figure 1. This flexible framework allows detecting user status as *idle* or *moving* while the smartphone of a user is put at any position and any direction through a number of steps as followings: First, the Reorienting module transforms the collected accelerometer signal from the phone coordinates to the traveller coordinates according to the reorienting method of Premerlani and Bizard [2]. The resulting Accelerometer signal, called transformed accelerometer signal, is then cut into a number of windows of a predefined size, for instance one second. For each window, a vector of six tilt features as proposed by Khan et al. [3] and Han et al. [4] is computed. Finally, a classification algorithm is used to predict the corresponding user status with the help of a training dataset containing labeled activity data.

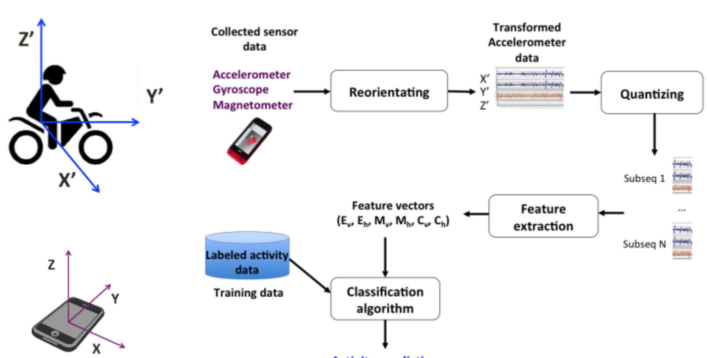

Figure 1. The proposed framework for flexible activity recognition regardless the position and the direction of smartphones. E, M, C, v, and h respectively stand for Energy, Mobility, Complexity, vertical, and horizontal

4. Experimental results

We used Samsung S4 and Samsung Note 3 to collect two datasets containing Accelerometer, Gyroscope, and Magnetometer signals recorded at the rate of 800 samples per second. Dataset 1 contains 347 examples collected from 2 walking subjects. Dataset 2 contains 2050 examples collected from 7 subjects using motorbikes. The transformed accelerometer data are split into a number of windows of one second with 66 % overlapping. For each window, six tilt features were extracted. Once two datasets were prepared, we used two classification algorithms employed in the WEKA tool [6] to predict the travellers ‘status: J48 Decision tree and Random Forest. In each case, the default setting was used. For evaluating the accuracy of the classification algorithm, we used 10-fold cross validation.

The summary results for predicting user status while they are walking (Dataset 1) and using motorbikes (Dataset 2) are presented in Table 1 (a) and (b) respectively.

	Random Forest	**J48**
Moving	**99.1 %**	**97.9 %**
Idle	85.5 %	74.0 %

(a) Dataset 1

	Random Forest	**J48**
Moving	**97.8 %**	**95.5 %**
Idle	89.5 %	79.6 %

(b) Dataset 2

Table 1. Accuracies for detecting user status.

5. Conclusion

In this work, we investigated an activity recognition framework that is able to detect the *idle* and *moving* status of travellers regardless the orientation of smartphones. Experimental results showed that our framework, relying on tilt features, achieved high accuracy in both cases that travellers were walking or using motorbikes. Moreover, this framework maintains its effectiveness when testing on a real-time system by deploying in an Android application. In the future, we are planning to extend this framework to identify the type of vehicle being used by travellers, for instance walking, a car, a motorbike, etc.

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