Computationally Efficient Human Activity Modeling and Its Application as a Service in Android Application Framework

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Human activity recognition has importance in many research areas including pervasive computing, human computer interaction, assistive living and technologies, and rehabilitation engineering [1] [2]. Provisioning uninterrupted services to the user is one of the main task of a ubiquitous computing system. This can be achieved through offering continuous services to the user based on his/her current location and/or physical activity [3]. The physical activity of a user unveils a lot about the context. An activity aware system helps to achieve context aware system [3] [4]. Therefore successful recognition of physical activities will help us to determine about the user context.

There has been extensive research on the human activity recognition (HAR) [1] [2]. The wearable and smartphone based HAR systems have advantages over computer vision approaches with respect to privacy, mobility, cost, and infrastructure [1]. The most common approach in this area is to use the inertial sensors (accelerometer, gyroscope) and model the activities using different machine learning techniques. There are two steps in this approach: 1) extract statistical and structural features from the raw sensor data, 2) use of classification algorithms such as decision tree, logistic regression, and support vector machine (SVM) [1]. Most of these approaches use 3 axes acceleration and/or 3 axes gyroscope. Some of the approaches use additional observation like pressure sensor data, and location data. In general, the existing approaches use at least 3 to 7 time series data from the sensors to train their models. Therefore they become computationally extensive for the portable devices and drain the power faster.

The goal of this study is the computationally efficient modeling of human activity. We use the dynamical system and chaos theory to model the human activity. The dynamical system captures the dynamics of the system which evolves over time. We use the time-delay embedding (TDE) to capture the underlying dynamics from the time series observations. In this case, the time series is the raw accelerometer sensor data taken from the built-in accelerometer sensor of the smartphone. Then we use probabilistic model to learn the underlying distribution of the dynamical system and use it distinguish them.

We have used eleven activities performed by forty participants to validate our approach. The performed activities are: walking, walking downstairs, walking upstairs, sitting, standing, running, driving, elevator up, elevator down, stationary, and lying down. We have analyzed the collected sensor data. We have seen from the analysis that the vertical acceleration shows the most significant changes in the pattern for each of the activities. We have modeled all the activities using the vertical acceleration. We have learned the underlying dynamics of the activities using TDE from this acceleration. We have used k-fold cross validation to validate our experiment. We have achieved 100% recognition accuracy for individualized activity model. We have also performed experiment with the existing machine learning techniques using statistical features (mean, standard deviation, etc.) extracted from the vertical acceleration data. The experimental results show that our approach outperforms the existing techniques by a large margin. In contrast to the existing approaches, our approach reduces the computational and memory complexity of the HAR system by reducing the amount of the sensor data that needs to be processed and also using the simple representational capability of the dynamical system.

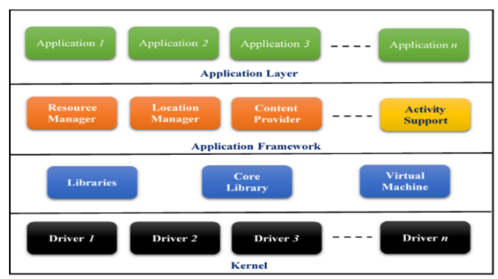

Figure 1: The "Activity Support" service in Android application framework.

There is an increasing demand of activity recognition service in mobile systems. There exists only a few such service (like Google Activity Recognition API) which can detect only a small number of activities. We implement our system in Android application framework to develop an open activity recognition API. It offers recognition of eleven different activities to all the applications from the application layer and other services from the application framework. We are working on gradually increasing the capability of this service by offering the recognition of more activities.

References

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