Chapter 14
Motion and Location-Based Online Human Daily Activity Recognition

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ABSTRACT

In this chapter, the authors propose an approach to indoor human daily activity recognition that combines motion data and location information. One inertial sensor is worn on the thigh of a human subject to provide motion data while a motion capture system is used to record the human location information. Such a combination has the advantage of significantly reducing the obtrusiveness to the human subject at a moderate cost of vision processing, while maintaining a high accuracy of recognition. The approach has two phases. First, a two-step algorithm is proposed to recognize the activity based on motion data only. In the coarse-grained classification, two neural networks are used to classify the basic activities. In the fine-grained classification, the sequence of activities is modeled by a Hidden Markov Model (HMM) to consider the sequential constraints. The modified short-time Viterbi algorithm is used for real-time daily activity recognition. Second, to fuse the motion data with the location information, Bayes' theorem is used to refine the activities recognized from the motion data. The authors conduct experiments in a mock apartment, and the obtained results prove the effectiveness and accuracy of the algorithms.

1. INTRODUCTION

1.1. Motivation

The past decade has seen a steady growth of elderly population. As the baby boomers comprise nearly 26 percent of the U.S. population, they may bring an increased burden on the society in the near future. Compared to the rest of the population, more seniors live alone as the sole occupant of a private dwelling

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than any other population group. Therefore, helping seniors live a better life is very important and has great societal benefits. In many assisted living systems, there is a great need for automated recognition of human daily activities, which can be used in studying behavior-related diseases and detecting abnormal behaviors such as falling to the floor. Activity recognition is also indispensable for Human-Robot Interaction (HRI) (Yanco & Drury 2004) where a robot companion can understand human's intentions through his/her behaviors.

There are two main types of activity recognition: vision-based (Moeslunda, Hiltonb, & Kruger, 2006) and wearable sensor-based (Najafi, Aminian, Paraschiv-Ionescu, Loew, Bula, & Robert, 2003; Maurer, Smailagic, Siewiorek, & Deisher, 2006). Vision-based systems can observe full human body movement. However, it is very challenging to recognize human activities through images due to the inherited data association problem and the large volume of data. Compared to vision-based systems, wearable sensor-based systems have no data association problem and also have less data to process, but it is uncomfortable and obtrusive to the user if there are many wearable sensors on the human body.

In this paper, we proposed an approach that combines motion data from a single wearable inertial sensor and location information to recognize human daily activities. This approach has the following advantages: first, a single wireless inertial sensor worn by the user for motion data collection can reduce obtrusiveness to the minimum; second, less data is required for activity recognition so that the computational complexity is significantly reduced compared to a pure vision-based system; third, the recognition accuracy can be improved through the fusion of motion and location data.

This paper is organized as follows. The rest of Section 1 introduces the related work in this area. Section 2 describes the hardware platform for the proposed human daily activity recognition system. Section 3 first explains the activity recognition using motion data only, then explains the fusion of motion data and location information to improve the recognition accuracy. The experimental results are provided in Section 4. Conclusions and future work are given in Section 5.

1.2. Related Work

Researchers have made significant progress in the area of human daily activity recognition in recent years. Traditional human daily activity recognition is based on visual information. A typical approach for vision-based recognition has two steps: feature extraction and pattern recognition. In the feature extraction step, activities are analyzed in terms of the trajectories of moving body parts, and features are extracted from each image frame (Taylor, 2000; Parameswaran & Chellappa, 2004). In the pattern recognition step, activities are analyzed using context information of the body parts, which is represented by the extracted features (Park, & Trivedi, 2007; Nam, Wohn, & Kwang, 1999). For a detailed survey of vision-based recognition, please see (Moeslunda, Hiltonb, & Kruger, 2006). However, vision-based activity recognition incurs a significant amount of computational cost, and vision data are usually prone to the influence of environmental factors, such as poor lighting conditions and occlusions.

1.2.1. Wearable Sensor-Based Recognition

Due to the advancement in Microelectromechanical Systems (MEMS) and Very-Large-Scale Integration (VLSI) technologies (Spencer, Ruiz-s, & Kurata, 2004), wearable sensor-based activity recognition has been gaining attention. Inertial sensors are widely used to capture human motion data. For example, Bao *et al.* (Bao, & Intille, 2004) used five small biaxial accelerometers attached to different body parts.