A Data Processing Method for Human Motion Estimation to Reduce Network and Sensor NodeLoads

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ABSTRACT

Systems for estimating human motion using acceleration sensors present the following two problems: 1) advanced analysis and processing of sensor data are difficult because of resource limitations of sensor nodes; and 2) such analyses and processes burden the network because numerous sensor data are sent to the network. The authors’ proposed method described herein for sensor data analysis and processing uses a host computer located near sensor nodes (neighborhood host). This method is intended to achieve a good balance between reduction of the network load and advanced sensor data analysis and processing. Moreover, this method incorporates reduction of the load to sensor nodes. To evaluate their method, the authors implement two prototype systems that use different machine learning methods. The authors conduct some experiments using these prototype systems. The experimentally obtained results demonstrate that the proposed method can resolve two problems.

Keywords: Human Motion Estimation, K-Means Clustering, Sensor Data Processing, Support Vector Machine, Symbiotic Computing, Ubiquitous System

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INTRODUCTION

Recently, various context-aware systems using small sensor nodes have been proposed to monitor people and objects in real time. Watching service systems using sensor nodes are exemplary of such systems. These systems provide information to users such as an observed person’s actions, location, and health condition derived from acceleration data, location data, pulse data, and other information acquired at sensor nodes. For such services, the observed person’s motion is a necessary context. This research targets human motion estimation using acceleration sensors. In the context of CI-related studies, symbiotic computing has been proposed as a model of such a system (Suganuma, Sugawara, & Shiratori, 2007; Sugawara, Fujita, & Hara, 2007; Takahashi, Izumi, Kinoshita, & Shiratori, 2009). This model provided a framework to bridge gaps between Real Space (RS) and Digital Space (DS). A watching service system observes a person in RS and analyzes and processes data in DS (Suganuma, Takahashi, Izumi, Kinoshita, & Shiratori, 2009; Tokairin et al., 2007). Here, handling data efficiently in DS is important. For human motion estimation using acceleration sensors, two characteristics are applicable: (1) a system should analyze and process large amounts of sensor data; and (2) a system might have to conduct advanced analysis and processing such as pattern recognition.

To estimate human motion using acceleration sensors, the system must analyze and process acceleration data somewhere between sensor nodes and a host computer using various techniques. Two acceleration data analysis and processing locations exist. First, the acceleration data are analyzed and processed at sensor nodes. In such cases, the data size at sensor nodes can be reduced. For this reason, this case has advantages in terms of network loading and power consumption of sensor nodes. However, advanced data analysis and processing such as pattern recognition is difficult because sensor node resources are insufficient. Second, the acceleration data are analyzed and processed at the host computer. In this case, advanced data analysis and processing are possible. However, this case presents disadvantages in terms of the network load and power consumption of sensor nodes because sensor nodes must send acceleration data to the host computer.

To alleviate this shortcoming of such systems, we aim at achieving a good balance between reducing the network load and advanced sensor data analysis and processing. Therefore, a system realizes reduction of loads on the network and sensor nodes without reducing the motion estimation accuracy. Specifically, we propose a method for sensor data analysis and processing using a host computer located near the sensor nodes (neighborhood host). Moreover, this method incorporates reduction of the sensor node load. In this method, the system analyzes and processes sensor data before sending data to the network. Therefore, it is possible to reduce network loads. Moreover, advanced sensor data analysis and processing are possible because the neighborhood host has more resources than the sensor nodes have. In addition, the sensor node power consumption is reduced by controlling the time interval for data acquisition based on instructions from the neighborhood host.

The second section presents a description of the intended environment and reviews some earlier related studies. The following section describes the design of the proposed method. In the next section, we present the implementation of two prototype systems using different machine learning methods. In the section after, we explain the results of experimentation using a prototype system and its evaluation. Finally, we conclude this paper in the last section.
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