**HUMAN ACTIVITY RECOGNITION USING WEARABLE SENSORS**

**ABSTRACT**

This project aims to deal with the human activity recognition using wearable sensors. It is the experiment results of seven different activities: normal walk, jogging, walking on toe, walking on heel, upstairs, downstairs and sit-ups. In this the data is collected for different activities using tri-axial inertial measurement unit (IMU) sensor enabled with three-axis accelerometer to capture the spatial data, three-axis gyroscopes to capture the orientation around axis and 3° magnetometer.

It was wirelessly connected to the receiver. The IMU sensor is placed at the centre of mass position of each subject. The captured data is pre-processed using different filters and cubic spline techniques. After processing, the data are labelled into seven activities. For data acquisition, a Python-based GUI has been designed to analyse and display the processed data. The data is further classified using four different deep learning model: deep neural network, bidirectional-long short-term memory (BLSTM), convolution neural network (CNN) and CNN-LSTM.

All data is collected using an IMU sensor enabled with gyroscope, accelerometer and magnetometer in both offline and real-time activity recognition using gait. The inverse kinematics algorithm is solved to calculate the joint angle from spatial data for all six joints hip, knee, ankle of left and right leg. Practical implications – This work helps to recognize the walking activity using gait pattern analysis. Further, it helps to understand the different joint angle patterns during different activities. A system is designed for real-time analysis of human walking activity using gait. A standalone realtime system has been designed and realized for analysis of these seven different activities. Originality/value – The data is collected through IMU sensors for seven activities with equal timestamp without noise and data loss using wirelessly. The setup is useful for the data collection in an open environment outside the laboratory environment for activity recognition.

INTRODUCTION

Human activity recognition (HAR) became the active research area over the past few years because of its wide human-centric applications (Chen, 2017). One of the main application areas is to monitor the daily lifestyle because the modern lifestyle is going to increase the common health problems such as obesity, insomnia, diabetes, blood pressure and cardiovascular diseases. Such patients follow some routine exercises such as walking, cycling, jogging, running, push-ups, sit-ups and so on (Arzani, 2020).

Accurate information about the duration of such activities plays a vital role for the subject to evaluate their daily performance. Thus, activity recognition also identifies whether the subject has any difficulty for following their daily routines. Activity recognition may also be used for an eldercare support system, as this system also provides family members to track the activities of the elderly people in their family or inhabitants when they are outside their home (Muramatsu, 2016; Semwal and Nandi, 2015; Semwal, 2017). Activity recognition is the core component of security, surveillance, home automation, offices, Internet of Things and smart cities, electrical energy saving systems, object tracking, bipedal robot walking (Semwal and Nandi, 2016; Nandi et al., 2016) and pedestrian navigation. This may be also applicable to the emergency of an accident to detect activities such as fall detection (Semwal, 2013). For the above reason, the development of a sophisticated solution that tracks the different walking activities of human through various computational technologies is getting much needed thrust (Modares, 2016).

The HAR problem is a typical pattern recognition problem. Specifically, it is a classification problem in which activity being performed by an individual is identified (Wang, 2019; Gupta, 2014). Mostly, HAR solutions are developed using artificial neural network (ANN), extreme learning machine (Semwal, 2019), support vector machine (Anguita, 2012), Naive Bayes, decision tree, K-nearest neighbour (Semwal and Nandi, 2015; Raj, 2018) and deep learning methods (Semwal, 2017; Semwal, 2017). The use of deep learning methods for HAR has significantly increased recognition accuracy (Chai, 2019; Murad and Pyun, 2017). The strength of deep learning is that it can automatically extract features as per the task requirement.

There are two main techniques for capturing human activities data using vision-based and sensor-based data. Computer vision-based data may be captured using Kinect sensor v2 (Hu, 2015) and other RGB-D cameras (Zou, 2018), whereas sensor-based data acquisition techniques can be further divided into three categories based on deployment of the sensor (Hussain, 2019), which are as follows: 1 wearable (Dernbach, 2012; Brezmes, 2009); 2 object tagged (device bound); and 3 dense sensing (device free).

Various researchers have designed many models to recognize activities through smart phones and wearable sensors (Bulling, 2014; He and Jin, 2009). But some problems that still need to be overcome are as follows: intraclass variability; interclass similarity; and the null class problem. Also, some direct challenges associated specifically with the implementation of HAR are as follows: definition and diversity of physical activities; class imbalance; ground truth annotation; and data collection and experiment design. Some application challenges which are still there (Sousa Lima et al., 2019) are as follows: variability in sensor characteristics (Connie, 2017); and trade-off’s in HAR system design.

LITERATURE REVIEW

The researchers are dealing with the human gait analysis for different clinical and pathological trails of patients suffering from stroke, Parkinson’s disease, elderly stage walking problem and various neurological disorder problems (Patil, 2019). The technology experts are considering the human gait analysis (Peng, 2020) as biometric identification of a person (Raj, 2019; Raj, 2018), multi-mode gesture generation, humanoid robot walking pattern generation (Semwal and Nandi, 2016; Wang, 2019) and performance analysis of athletes (Deng, 2020). HAR refers to the tracking of different human walking motion (Zhang, 2019; Liu, 2015). HAR is one of the advance areas of research related to human walking analysis to track the different subjects (Li, 2019; Cook, 2013). It also enables a way for telemedicine health-care mobile applications for tracking a user’s activities (Semwal and Nandi, 2015). Bulling et al. (2014) proposed the activity recognition chain system as a dedicated step for HAR activities.

Typical activity recognition chain system

