Deep Human Activity Recognition Using Wearable Sensors

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ABSTRACT

This paper addresses the problem of classifying motion signals acquired via wearable sensors for the recognition of human activity. Automatic and accurate classification of motion signals is important in facilitating the development of an effective automated health monitoring system for the elderlies. Thus, we gathered hip motion signals from two different waist mounted sensors and for each individual sensor, we converted the motion signal into spectral image sequence. We use these images as inputs to independently train two Convolutional Neural Networks (CNN), one for each of the generated image sequences from the two sensors. The outputs of the trained CNNs are then fused together to predict the final class of the human activity. We evaluate the performance of the proposed method using the cross-subjects testing approach. Our method achieves recognition accuracy (F1 score) of 0.87 on a publicly available real-world human activity dataset. This performance is superior to that reported by another state-of-the-art method on the same dataset.

CCS CONCEPTS

• **Computing methodologies → Activity recognition and understanding**; **Neural networks**; **Ensemble methods**.

KEYWORDS

Human Activity Recognition, Convolutional neural network, Ensemble method

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1 INTRODUCTION

Human-centred monitoring systems are devices equipped with low-powered and low-cost sensors which are mounted on the human (e.g. wearable) or outside (e.g. cameras), for the collection of useful data for human activities and behaviour analysis [12]. Often these devices come with a wireless unit for data transmission to external storage and/or analysis unit. The common area of application of these systems includes home monitoring for elderly or patients in medicine [6], among others. In this paper, we focus on the analysis of the signals obtained via waist-mounted wearable sensors as this is commonly used to monitor the health status of older patients with movement assistive devices [1]. These sensors usually generate complex hips motion signals which are difficult to interpret without expert intervention. To automatically interpret the sensor readings in order to infer the kind of human activity that is been performed by a user, a computationally efficient modelling technique that will provide a meaningful characterisation of the sensor data is required.

Recently, machine learning methods including Support Vector Machines (SVM) [7] and Random Forest [11], have been proposed for the characterisation and automated interpretation of the sensor data. However, these methods usually require a hand-crafted features extraction by an expert which often affects the recognition accuracy [12]. Convolutional Neural Networks (CNN) [4] on the other hand, is a form of deep neural network learning paradigm that has the ability to learn complex patterns in data (including images) without the need for prior feature extraction by an expert [12]. Inspired by the success of CNN in related applications, we explore deep CNN as an alternative approach for recognising human activities including climbing jumping, lying, running, sitting, standing and walking using activity images generated from the signals obtained via waist-mounted sensor devices. For brevity, we will refer to our proposed approach as Deep Human Activity Recognition (DHAR) henceforth.

2 RELATED WORK

The presences of sensors such as accelerometer and gyroscope in many wearable devices have made it possible to collect body parts motion data and to recognise various activities performed by humans [11]. The accelerometer measures the physical acceleration of movable body parts, while the gyroscope is used to measure their orientations. The signals from both sensors are commonly used for Human Activity Recognition (HAR) to differentiate among very similar human activities [6]. Different classifiers have been proposed for the analysis of the motion signals and classification of the human activities. Ortiz Jorge [7] proposed the use of a waist-mounted smartphone for HAR. The method employed features obtained by computing the mean, correlation, and frequency skewness of the