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A Mutlimodal Approach to Measure the Distraction Levels of Pedestrians using Mobile Sensing

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Abstract

The emergence of smart phones has had a positive impact on society as the range of features and automation has allowed people to become more productive while they are on the move. On the contrary, the use of these devices has also become a distraction and hindrance, especially for pedestrians who use their phones whilst walking on the streets. This is reinforced by the fact that pedestrian injuries due to the use of mobile phones has now exceeded mobile phone related driver injuries. This paper describes an approach that measures the different levels of distraction encountered by pedestrians whilst they are walking. To distinguish between the distractions within the brain the proposed work analyses data collected from mobile sensors (accelerometers for movement, mobile EEG for electroencephalogram signals from the brain). The long-term motivation of the proposed work is to provide pedestrians with notifications as they approach potential hazards while they walk on the street conducting multiple tasks such as using a smart phone.

Keywords: Electroencephalogram (EEG) Signals; Pedestrian Safety; Safety Awareness; Mobile Sensing; Walking Behavior; Working Memory

1. Introduction

Over the last decade, the usage of smart mobile phones has increased exponentially, which has led to these devices becoming an integral part of people's daily lives, such as shopping, banking, social media interaction, playing games, listening to music or even watching movies. The ubiquitous nature of the

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services provided by a smart phone allows the end user to engage with them on the go. Recent statistics show that over 68 percent of the world's population own a mobile phone, this is expected to increase to 72 percent by 2019 [1]. Even though these devices offer convenience, they also pose a threat to the safety and well-being of the end users. Studies have shown that pedestrians have slower reaction times and decreased situation awareness whilst using a mobile phone, thus they are also more prone to be involved in motor vehicle collisions [2,3]. This is a concern, as the increase in the availability of mobile phones naturally leads to an increase in the time spent using them, and the number of injuries related to mobile phones usage is also likely to increase [4]. Being able to understand and recognise the impact of distractions can be complex, as many researchers have attempted this by collecting and interpreting data from multiple sensors. The work in this paper looks to build on existing work, with the emphasis on the relationship between the data captured from body movements (accelerometers) and the signals from the brain (mobile EEG) and muscles (mobile EMG). This paper proposes a multi-modal based approach that measures the different levels (with and without a mobile phone) of distraction encountered by pedestrians whilst they are walking. A series of experiments have been conducted to measure the levels of distraction while walking on the street. The novelty aspect of this work is the adoption of a *multimodal approach* where data has been analysed from mobile sensors such accelerometers, surface EMG (i.e. muscular) and and scalp EEG (i.e. brain) signals captured from a mobile EEG unit. The remainder of the paper is organised as follows. Section 2 provides an overview of the related literature, while Section 3 describes the key characteristics of the proposed approach. Section 4 describes the user study and experimental set up followed by the results in Section 5 that validate the findings of the proposed work.

2. Related Work

A study by Nasar and Troyer [4] compared the number of injuries between drivers and pedestrians who were using a mobile phone while walking and driving. This study revealed that the number of injuries among pedestrians in the USA was around 1506. The nature of these injuries ranged from contusions to fractures around different parts of the body (e.g. head, limbs, back, chest). The number of mobile phone related injuries to pedestrians is likely to increase due to the surge in mobile phones, as in 2017 the population of people with mobile phones reached 4.77 billion worldwide and 53.7 million in the United Kingdom [1].

Gallahan et al. [5] developed a system to reduce distractions encountered by drivers by inferring potential distractions based on the head and neck movement of the driver. This system was based on the deployment of a series of sensors that detected movement in the head and upper skelton. An example of the detected movement would be reaching an object, talking on the phone or looking away from the road. If any of these movements was constant for more than 2 seconds then the system would alert the drivers by using sounds at different frequencies. A limitation of this system is the potential false positives that could be generated given the neck movement, and the inclusion of motion capture and eye tracking would improve distraction recognition results.

EEG signals have been used in another study [6] to measure attention during controlled movements. This study recorded these signals in three different conditions: sitting, cycling and walking. Beside EEG, EOG and EMG signals have been also acquired as references for the event related potentials measureing cognitive activity reflecting the attention. It was claimed that the available approaches of measuring attention during movement were not adequate, as kinematic research study have mainly concentrated on the employment of the motion sensing systems. These systems are accurate and can provide a quantitative approach, however they do not provide an effective brain activity acquisition to measure the attention. Hence the work by Killane et al [6] measured the cortical activity through the amplitude and latency of potentials related to externally cued auditory events: same levels of attentions were observed in all the performed experimental conditions, suggesting this as a valid method to investigate attention during gait. However, this work did not show the relationship between gait and attention and how it could benefit the monitoring of mobile activities.