Fall detection and prevention among elderly persons using wearable technologies

Reinhardt Rading [1]

[1]Affiliation not available

October 30, 2023

Abstract

Falling down is prevalent among elderly persons resulting to to injuries, disability and even death. United Nations predicts a double increase in population of persons aged 65 and above by 2050 hence a need to research on methods for detecting and preventing falls from occurring.

This paper presents a theoretical proposal on detecting and preventing a fall using RFID and wearable technologies.

Fall detection and prevention in elderly persons using wearable technologies

Reinhardt Rading
Department of Engineering and Architecture
University of Parma
Parma, Italy
reinhardt.rading@studenti.unipr.it

***Abstract*—This paper proposes fall detection among elderly persons based on hands movement when a fall occurs. RFID tags strapped on the users' belt and RFID reader embedded on the smart phone are used to detect the occurrence of a fall. Fall prevention is achieved by analyzing the brain signals prior, during and after a fall. The model is based on recognition model that looks for similarity between the existing fall data and the incoming and the current fall victim data. The paper is categorized into two section. The first section discusses fall prevention and the related work while second section discusses fall detection and the related work.**

***Index Terms*—Fall prevention, Fall detection, RFID, Wearable devices**

I. Introduction

The United Nations predicts that by the year 2050, the number of persons with an age of 65 years and above will outnumber the population of children under the age of 5 years. To prepare for the aging population, we have to provide solutions to the daily to daily problems experienced by elderly persons.

Falling is the most common occurrence among elderly persons resulting to devastating consequences from disability to physiological issues and even death. This calls for solutions to detecting and preventing falls since it is prevalent in the aging population and their population is estimated to double [1] in a few decades and.

Various solutions have been proposed to prevent fall [2] including solutions for elderly persons living independently [3] but how do we detect a fall? This paper proposes fall detection and prevention system using a smart watch that is embedded with sensors that detects abnormal hand movements and collects heart variable signal, a wearable headband that collects electroencephalogram (EEG) signals, and a mechanism to predict the possibility of re-occurrence of fall based on machine learning algorithm.

This paper is divided into two section. The first describes the implementation of the fall prevention using the already existing technologies while the second section describes the implementation of fall detection using a new proposed system.

Identify applicable funding agency here. If none, delete this.

For each section, this paper provides related work done and explains theoretical implementation of the proposed system.

II. Fall Prevention

Different techniques have been proposed by researchers in preventing the occurrence of a fall, for example, Yannis Dionyssiotis in [2] explains that exercising at an old age, taking food rich in vitamin D and calcium, environmental intervention, and use of mobility aids are some examples that can prevent an elderly person from falling. The solutions provided by [2] assumes that we already know the causes of the falls but in real sense some falls are difficult to determine.

When we have body movements for in this case falling down, a brain signal is released in reaction to muscle movements. In [5] researchers were able to identify and analyze nervous system variations from electroencephalogram (EEG) signal and thus this paper proposes a solution of preventing the re-occurrence a fall by analyzing the brain activity signal and heart rate variability before, during and after a fall to detect and prevent it.

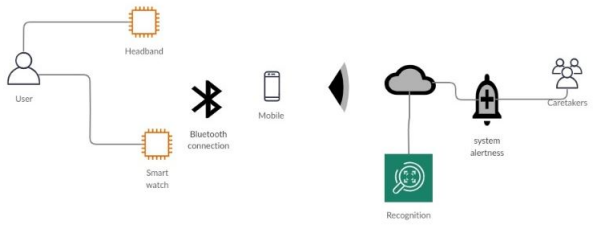

Fig. 1. Proposed Fall prevention model.

I propose a system where the behavior of an elderly person is monitored non-intrusively; EEG signals and heart variability rate are recorded at different intervals both at day and night as done in [3]. The heart rate variability is acquired from the smart watch while the EEG signal is acquired by wearing a headband incorporated with an electrode, filters and amplifiers.

The acquired EEG data is sent to the smart watch via wireless communication. A smart watch has limited computing

and storage capability and thus the received data is be pushed to the mobile phone via Bluetooth and from the phone pushed to the cloud where a signal processing module is applied. We assume at this point that the fall victim likely to experience a re-fall and thus there exists fall data collected from the previous fall.

At the cloud, a recognition model is applied on the current acquired data and the incoming data retrieved after applying the signal processing module comparing to the previous fall data. In research [6], a fatigue recognition model based on dynamic Bayesian network was done to detect drivers' alertness considering several features including the quality of sleep, conditions at working place, among others and it shown that EEG and ECG could significantly detect fatigue. If a similarity is detected with a certain threshold of probability, then a red flag is raised to the caregiver or to the victim's physician.

The predictive mechanism can be further improved by correlating different victims' fall data with their causes and applying machine learning algorithm. The algorithm will be able to detect similarities from the prior fall data and warn a fall victim or his caretaker of possibility of fall occurrence.

III. Fall Detection

Instability caused by weak legs, aging, taking drugs like benzodiazepines [2] are the main reasons people fall. There exists a correlation between a victim falling and the victim seeking for stability using his or her hands and as such, a brain signal is sent to the hand nanoseconds before a fall when the body realizes a loss of stability. This paper proposes using the hand movements during a fall to detect the occurrence of a fall. The proposed method involves using passive high frequency radio frequency identity (RFID) tags and RFID reader that is assumed to be embedded on the smart watch.

Fig. 2. Smart Watch strap and an RFID tag.

Fig.3 shows the diagram of a smart watch strap with RFID tags measuring 3.2 millimeters in width and 0.7 millimeter embedded on it. Additional tags are strapped on the users' belt with the RFID reader knowing some of the tags and other tags are unknown.

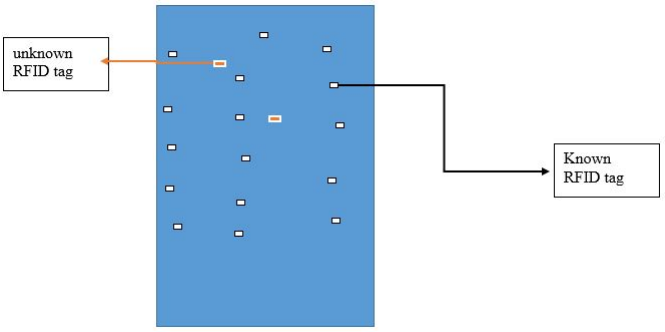

Fig. 3. Strap with both known and unknown RFID tags.

Radio frequency identity is based on the principle of detecting radio signals from a line of sight (LoS). The proposed tags are identifiable from utmost 20 centimeters from the RFID reader. Fall detection is based on the principle of received signal strength indicator (RSSI). When a fall occurs, some RFID tags strapped on the users' belt are obstructed from the LoS and thus cannot activate the RFID reader that is located on the users' hand. When the signal from the brain activates the need to move hands as a result of instability, the distance between the RFID tags and the RFID reader is increased and thus different delay signals. From the delays, we can easily calculate the delay profile of the signals and from it, we set a certain threshold such that if an average fraction of power is not met, an alert is created.

Total average power

$$P^2 = u^2 + 2d^2 \tag{1}$$

where

$$u^2 = Power\_from\_Los \tag{2}$$

$$2d^2 = Power\_from\_no\_Los \tag{3}$$

$$Pt^2 = \sum_{i=1}^{n} P^2 \tag{4}$$

Where Pt is total power received at the RFID reader.

Fraction of Power

$$Fraction\_of\_power = P^2/Pt^2 \tag{5}$$

An alert can be a notification message being displayed on the screen of the smart watch asking the user if he just fell and if he needs help. In cases where help is needed, unstructured supplementary service data is used to notify the caretakers of the fall. Further study can be made to improve the sensibility of

hands movement by incorporating sensors that monitor wrist movement as was done in [4].

IV. Conclusion

Elderly persons fall as a result of various reasons and fall can be prevented by monitoring and analyzing data of elderly persons who have fell or who are likely to fall. Analyzing the data is likely to identify a similar data or experience that all fall victims faces. The identified data can be used to predict the possibility of fall occurrence.

References

[1] United Nations Department of Economic and Social Affairs, World Population Prospects 2019, 2019 pp 16.

[2] Dionyssiotis.Y, Analyzing the problem of falls among elderly people International Journal of General Medicine, September 2012.

[3] Borelli.E, Giacomo.P, Antoniazzi.F, et al, HABITAT: An IoT Solution for Independent elderly, http://mdpi.com

[4] Morganti.E, Angelini.L, et al, A smart watch with embedded sensors to recognize objects, grasps and forearm gestures, International Symposium on Robotics and Intelligent Sensors 2012.

[5] Munoz.A, Domingo.M, et al Integration of Body Sensor Network and Vehicular Ad-hoc Network for Traffic Safety, http://mdpi.com.

[6] Yang, G.; Lin, Y.; Bhattacharya, P. A Driver Fatigue Recognition Model based on Information Fusion and Dynamic Bayesian Network. Inf. Sci. 2010, 10, 1942–1954.