Wearable Based Fall Detection System for the Elderly

Erich Meissner
Clark School of Engineering, University of Maryland, College Park, MD 20740
me@erichmeissner.com

Overview—**According to the World Health Organization, falls are the second leading cause of accidental or unintentional injury deaths worldwide. Adults older than 65 suffer the greatest number of fatal falls. Therefore, the quality of life of older people can be improved by using automatic fall detection systems. The primary objective of this research project is to build a fall detection system that monitors in real-time an older adult. The system defines two major components: a wearable device and a smart phone. The wearable has the capability of communicating with a smart phone and can be located in a 200ft radius. Once, the wearable device detects a fall, it will send an alert to the smart phone; then the smart phone alerts to the emergency contacts defined by the user. The secondary objective is to avoid the need of carrying the smart phone every time. In addition, our system will have a panic button that can be used in order to alert the emergency contacts in the event that the user feels that a fall may happen.**

I. Overview

Falls are the second leading cause of death by accidental or unintentional injuries. Worldwide, 424,000 people die due to fall related injuries. Out of this number, the ones who suffer fatal falls more often are the elderly people over 65 years old. But how can we know if an elder has fallen? Nowadays, most elderly people have in their possession cellphones in case of emergency. However with the constant evolution of technology, some senior citizens face hurdles in adopting new innovations. Therefore, how can we design a solution involving technology when most elderly people have problems adapting to such novelties?

Following is some of the most relevant work on fall detection. Usually fall detection systems are based on one of the following approaches: wearable sensors, computer vision, and ambient-fusion. However, in this ENEE499L research proposal, we focus just on methods based on wearable sensors.

Most of the fall detection systems using mobile devices apply accelerometers as the primary sensor. Accelometry is a useful mechanism to measure the acceleration of different parts of the human body, and thus a useful tool for fall detection [1], and in general for human activity recognition [2]–[5].

Threshold-based methods are one of the most popular techniques for fall detection using wearable sensors. Here, a fall is reported when the acceleration goes beyond pre-defined thresholds. A typical problem with this approach is the difficulty of generalizing results for diverse populations (e.g., height and weight). (This topic of generalization corresponds to the teachings of the ENEE439M machine learning course I am currently enrolled in.) Thereby, these methods need a set of predefined parameters that should be adjusted according to the target population. Some research uses the smartphones' built-in sensors (accelerometer, gyroscope) to identify the location of the cellphone in the users body (chest, pocket, holster, etc) and to find known patterns associated with falls [6].

Following a similar approach, one certain study used specific locations in the user's body to compute different thresholds with data collected from a three-axes accelerometer and gyroscope [7]. Sensor locations with the greatest fall recognition accuracy included places such as the users waist and head.

Finally, a popular experiment presents a fall detection system based on accelerometry [8]. Here, the sensor is located in the user's pelvis. The solution is based on scenarios, namely stand still, sit to stand, stand to sit, walking, walking backwards, stoop, jump and lie on the bed.

A different category of wearable sensor approaches for fall detection includes the systems based on machine learning techniques.
The general architecture of these systems include a data collection module for gathering motion data, a feature extraction module that selects the most relevant characteristics from the motion that are useful for fall prediction, and an inference learning module that finds relationships from the extracted features to come up with a descriptive model for fall detection. A commended project proposes a method based on artificial neural networks [9]. The system uses an accelerometer on the user's waist and a microcontroller. The neural network is able learn falling events. In a similar work, but this time using decision trees, some researchers used a method that combines acceleration and air pressure [10]. The air pressure data was collected from a wearable sensor located in the user's waist. These two input signals, namely acceleration and air pressure, were used to build a decision tree for fall detection.

II. Methodology

This proposal anticipates a fall detection system for the elderly. The system defines two major components: a wearable device that detects, using an accelerometer and a gyroscope, if the user has suffered a fall, and a mobile application that automatically calls a predetermined number in case of emergency. The main advantage of the proposed system is that it does not require that the person carry the cell phone everywhere since the fall detection will be carried out in the wearable device. Therefore, the mobile phone can be located in any place in a house. The wearable device has the capability of detecting a fall sensing with an accelerometer and a gyroscope. Current advances in microelectromechanical systems allows for measuring a person's acceleration and orientation for an electronic device to detect a fall [5]. Therefore, this proposal will measure the acceleration in 3-axes as well as the angular position of a wrist, pendant, and waist wearable. If the acceleration achieves a defined threshold, the angular position is measured. Then, if a position threshold is achieved, a fall has been detected, and the emergency protocol is activated. The emergency protocol includes a phone call contact that will be selected by the user previously. This order of events will be experimented with throughout the semester.

During the semester, we hope that the experimental results will show a high accuracy of 90%, limiting false positives. A functional prototype will be implemented and tested for this project. This prototype will include the wearable device and an Android application to activate the emergency protocol, which will include an alerting call and a text message. In addition, our system will allow the user to activate the emergency protocol when required, pressing a panic button as well as to cancel a call using a button in order to avoid false alerts. Throughout the semester, we hope the experimental results will show that the wearable sensor will achieve high accuracy in fall detection (over 90%).

III. Student Involvement

Erich Meissner is the founder of Symbiont Health LLC. Symbiont Health is a 2017 startup that has received over $17,000 in funding from the University of Maryland. It placed as a finalist in the Do Good Challenge in April 2017 and won the Computer Science Department's Fishbowl Competition. Furthermore, it was accepted to the Dingman Center for Entrepreneurship's TerpStartup program and was most recently awarded an Impact Seed Fund from the Maryland Technology Enterprise Institute (MTech). Erich Meissner is an Electrical Engineering student who places almost 40 hrs/week into the development of his company. He has raised many funds from and established several strategic connections at the University of Maryland. He hopes to work on the experimentation of the wearable (hardware) and the fall detection algorithm (software) as part of an ENEE499L or ENEE488 upper-level class.

IV. Project Schedule

The embedded electronics will be sourced immediately in the Spring 2018 semester. The hardware design will be centered around the Intel Curie chip, a microprocessor with an Accelerometer, Gyroscope, and Blue-tooth dongle included. The first milestone will be February 20th, and it will be to complete a working prototype. The second milestone will be met on March 15th, and it will involve a beta-product that will be feasible and aesthetically-pleasing enough for geriatric patients to test with. This goal will be hit by utilizing the resources of Terrapin Works through silicon injection molding. To reach a fall detection accuracy of 50%, there must be additional Arduino code written on top of the free-fall algorithm already provided by Intel. This third milestone will be hit by March 31st, around the time of the Mid-Semester report. By April 12th, the fourth milestone will be to reach an accuracy of 80% by using a support vector machine (SVM) learning algorithm. Through a simple regression and classification technique, the training sets of data can improve the accuracy more to 90%, elimination a majority of false positives. This fifth milestone should be hit by April 30th. Finally, the final report and sixth milestone will be an analysis of the product from the standpoint of actual seniors. Consumer-centric design is incredibly important to the business, and I will highlight the feedback by the end of the semester.

IV. Student Learning Outcomes

Given the topics and methodology highlighted above, this research projects applies several fundamentals and advanced curriculum of the ECE department . Microcontroller selection and design, embedded systems programming, and machine learning are the greatest initiatives of this ENEE499L proposal. Furthermore, there is a technology entrepreneurship learning aspect to this research project.

REFERENCES

[1] *Y. S. Delahoz and M. A. Labrador, "Survey on fall detection and fall prevention using wearable and external sensors," Sensors, vol. 14, no. 10, pp. 19806–19842, 2014.*

[2] *O. D. Lara and M. A. Labrador, "A survey on human activity recognition using wearable sensors," IEEE Communications Surveys & Tutorials, vol. 15, no. 3, pp. 1192–1209, 2013*

[3] *L. G. Jaimes, Y. De La Hoz, C. Eggert, and I. J. Vergara-Laurens, "Pat: A power-aware decision tree algorithm for mobile activity recognition," in 2016 13th IEEE Annual Consumer Communications & Networking Conference (CCNC), pp. 54–59, IEEE, 2016.*

[4] *L. G. Jaimes and I. J. Vergara-Laurens, "Corredor, a mobile human-centric sensing system for activity recognition," 2015.*

[5] *L. G. Jaimes, T. Murray, and A. Raij, "Increasing trust in personal infor-matics tools," in International Conference of Design, User Experience, and Usability, pp. 520–529, Springer, 2013.*

[6] *L. Valcourt, Y. De La Hoz, and M. Labrador, "Smartphone-based human fall detection system," IEEE Latin America Transactions, vol. 14, no. 2, pp. 1011–1017, 2016.*

[7] *M. Kangas, A. Konttila, P. Lindgren, I. Winblad, and T. J¨ams¨a, "Com-parison of low-complexity fall detection algorithms for body attached accelerometers," Gait & posture, vol. 28, no. 2, pp. 285–291, 2008.*

[8] *G.-C. Chen, C.-N. Huang, C.-Y. Chiang, C.-J. Hsieh, and C.-T. Chan, "A reliable fall detection system based on wearable sensor and signal magnitude area for elderly residents," in International Conference on Smart Homes and Health Telematics, pp. 267–270, Springer, 2010.*

[9] *M. Vallejo, C. V. Isaza, and J. D. L´opez, "Artificial neural networks as an alternative to traditional fall detection methods," in 2013 35th Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC), pp. 1648–1651, IEEE, 2013.*

[10] *F. Bianchi, S. J. Redmond, M. R. Narayanan, S. Cerutti, and N. H. Lovell, "Barometric pressure and triaxial accelerometry-based falls event detection," IEEE Transactions on Neural Systems and Rehabilitation Engineering, vol. 18, no. 6, pp. 619–627, 2010.*


Symbiont