Signal Processing of Geospatial and Biometric Data from Wearable Devices for Fall Detection

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Abstract. In this paper, we present a detection algorithm that accurately differentiates the event of a person falling from normal activities of daily living (ADL). Our algorithm processes signals recorded from accelerometers built into wearable activity monitoring devices such as a Fitbit or Apple Watch that is worn on an individual's wrist. Given the potential danger of injury resulting from a fall, especially for the elderly population whom are more susceptible, an accurate fall detection algorithm could be the precursor to an autonomous emergency alert system that pages paramedics. Immediate medical intervention is critical for survival in urgent situations such as a stroke, cardiac event, or TBI; unfortunately, in many of these cases the individual may be unconscious and unable to intervene on their own behalf. With the advancement of geospatial technology, an algorithm that can distinctly detect the event of a fatal fall can automatically trigger a call for emergency medical services to the exact GPS coordinates of a mobile device or the wearable wrist device itself. We will explore the use of a combination of threshold-based and machine learning-based approaches to develop a refined fall-detection algorithm that builds upon previous research.

Keywords: fall detection · activities of daily living (ADL) · signal processing

1 Introduction

In 2016, approximately 30,000 adults aged 65 years and older died as the result of fatal falls, the leading cause of injury-related fatalities within this age range. The adjusted-age death rates for this senior population in the United States have steadily increased 31% from 2007 to 2016, with an estimated 43,000 deaths due to fatal falls in 2030 if these current rates remain stable. These higher death rates are consistent with risk factors of advanced age as well as other associated predispositions such as: 1) reduced activity; 2) chronic conditions, including arthritis, neurologic disease, and incontinence; 3) increased use of prescription medications, which might act synergistically on the central nervous system; and 4) age-related changes in gait and balance. [1]

[1] https://www.cdc.gov/mmwr/volumes/67/wr/mm6718a1.htm?s_cid=mm6718a1_w

Globally, the World Health Organization (WHO) reports an estimated 37.3 million falls annually that require medical attention and potentially hospitalization, which is the second leading cause of accidental or unintentional injury deaths worldwide. From these falls, the WHO reports an estimated 646,000 fatalities globally with over 80% occurring in low and middle income regions. Their findings are consistent with the fact that adults older than 65 experience the greatest incidents of fatalities from a fall, but report a wider range of risk factors that include: 1) occupations with hazardous working conditions, 2) substance abuse, 3) socioeconomic factors, 4) underlying medical conditions, 5) side effects of medication, and 6) physical depreciation. [2]

The danger of a fall is not life-threatening itself, but is associated with potential complications of the event such as a stroke or a traumatic brain injury (TBI). In such cases, an accurate fall-detection algorithm developed from the sensor data built into wearable activity monitors on an individual's wrist could be invaluable. With the detection of a fall, the wrist device could be programmed to alert paramedics and dispatch them to the exact GPS location of the device for immediate medical intervention.

We will analyze how competing algorithms perform when combining a threshold-based model with different machine learning-based models. We are specifically interested in seeing how linear discriminant analysis (LDA), support vector machines (SVM), naïve Bayesian (NB), decision trees (DT), and random forests (RF) compare on a binary-classification task that differentiates between a fall and an ADL. We will compare competing models based on the classification accuracy, specificity, sensitivity, and precision using ROC-AUC curve to visualize the results.

[2] https://www.who.int/news-room/fact-sheets/detail/falls