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A Comparison of Accelerometer-Based Multiclass Algorithms for Near-Fall Detection

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***Abstract*— Current activity detection systems commonly differentiate between falls and activities of daily living (ADLs), or between near-falls and ADLs. We developed and compared two multiclass classifiers to differentiate between falls, near-falls, and ADLs. Using a dataset collected from a single participant simulating 90 falls, 78 near-falls, and 840 segments of daily activities, we achieved an accuracy of 97.01%.**

***Clinical Relevance*— The developed algorithm allows for the detection of near-falls and falls for clinical fall risk assessment.**

I. INTRODUCTION

Near-falls are imbalance events that would result in a fall if sufficient recovery mechanisms were not activated. 25 - 35% of older adults experience a near-fall every month, and these near-falls have been shown to be an independent predictor of future fall risk [1]. However, current detection systems are unable to achieve a multiclass classification between near-falls, falls, and activities of daily living (ADLs). The objective of this study is to compare a multiclass thresholding algorithm with a novel algorithm for near-fall detection.

II. METHODS

We collected data from a participant (male, 32 years old) wearing an inertial measurement unit on the lower back collecting tri-axial linear accelerations at 1000Hz. The participant simulated various falls and near-falls (sit-to-stand, stand-to-sit, misstep, trip, hit/bump, loss of support, slip, and collapse), and various ADLs (walk, stand, sit-to-stand, stand-to-lie down, put down/pick up object, stair climbing, and jumping jacks). Falls and near-falls were identified from video and sectioned into 1s segments around the event for a total of 90 falls and 78 near-falls. 2-minute ADL signals were partitioned into 1s windows resulting in 840 ADL segments. Data were randomly split into a training (80%) and test (20%) dataset and low-pass filtered at 250 Hz.

Algorithm #1: We determined an upper fall threshold (UFT) based on previous work by Bourke et al. [2]. Upper peak values were extracted for each fall based on the magnitude of acceleration. The UFT was established based on the smallest peak. The same procedure was followed to identify an upper near-fall threshold (UNFT). Signals that crossed the UFT were labelled as falls. Signals that crossed the UNFT but not the UFT were labelled as near-falls. Signals that did not cross either were labelled as ADLs.

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Algorithm #2: We established a UNFT using the same procedure as Algorithm #1. Signals that did not pass the UNFT were labelled as an ADL. Signals that passed the UNFT were further analyzed. We extracted frequency-domain features (total power from 0-500Hz, power in 5Hz increments from 0-50Hz, power in 1Hz increments from 0-20Hz), and time-domain features (max, mean, variance) in the body-fixed anterior-posterior (AP), superior-inferior (SI), and left-right (LR) axes. We used forward feature selection to select the top features and trained a multiclass Support Vector Machine with a Radial Basis Function kernel using 10-fold cross-validation.

III. RESULTS

Algorithm #1: The UFT was set at 24.87 m/s^2 and the UNFT was set at 12.75 m/s^2. *Algorithm #2:* The UNFT was set at 12.75 m/s^2. The forward selected features were power in the 1-2Hz, 2-3Hz, 10-15Hz, 15-20Hz, and 12-13Hz frequency bands (AP); power in the 0-5Hz frequency band (LR); and power in the 4-5Hz frequency band (SI). *Overall:* Algorithm #2 performed better with an accuracy of 97.01% compared to Algorithm #1 with an accuracy of 65.67% (Fig. 1).

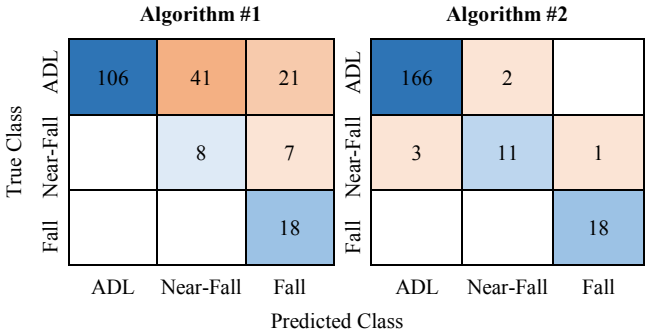

Figure 1. Confusion matrices for the 20% test dataset.

IV. DISCUSSION & CONCLUSION

Current fall risk assessments can be subjective and uncharacteristic of daily living. The development of a multiclass near-fall, fall, and ADL algorithm allows for a quantitative assessment of fall risk in daily environments.

REFERENCES

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