Development of a Measurement System for the Acquisition of Training Data in Fall Detection

MCI DIE UNTERNEHMERISCHE HOCHSCHULE

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INTRODUCTION

Falls are a major cause of injury-related deaths, particularly among adults over 60 years, with the problem intensifying as the global population ages [1]. Apart from causing physical harm, falls often lead to reduced independence and quality of life [2]. Fall Detection Systems (FDS) address this by triggering emergency alerts and logging incidents. For these systems to be effective, they must be both accessible and seamlessly integrated into daily live. Hearing aids and implants represent a promising platform due to their widespread use among older adults and the established link between hearing loss and fall risk [3].

METHODS

To support ear-based FDS development, this thesis introduces a training and validation dataset recorded using a custom-developed system equipped with Inertial Measurement Unit sensors placed at two positions behind the ear. A fall study was conducted using real-world fall triggers and safety gear to capture simulated falls, near falls, and ADLs (Figure 1 & 2). Post-processing included segmentation, dataset structuring, a comparison of accidental and simulated falls using correlation and Dynamic Time Warping (DTW), as well as a data analysis on a representative fall sample.

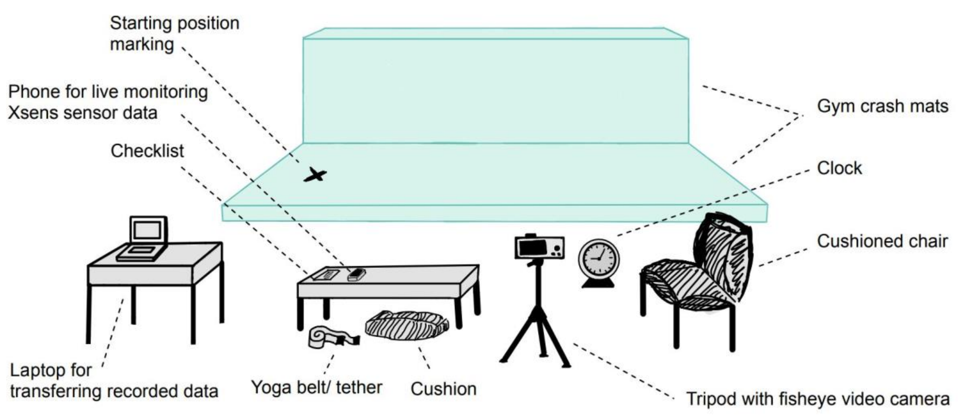

Fig. 1: Study Setup

Fig. 2: Safety Gear

RESULTS

Twelve participants (5 men, 7 women) each completed three video-recorded trials. For every participant metadata (age, height, weight, gender) was collected. Each trial consisted of 10 near falls, 10 falls, and 10 ADLs, resulting in 90 activity files per person. With two sensor systems and one reference device, the final dataset contains 2,092 activity files and 986 reference files.

Beyond the structured trials, eight accidental falls occurred during near fall attempts when participants failed to recover. As the intention was to avoid falling and movements were natural, these were classified as real-world falls. An example is shown in Figure 3.

Fig. 3: Example of an accidental fall to the back

Seven accidental falls were compared to simulated counterparts using DTW and correlation analysis. The results (average correlation 0.41; DTW 13.81) fall within the expected range for similar movements, though slightly higher than average. An example is shown in Figure 4.

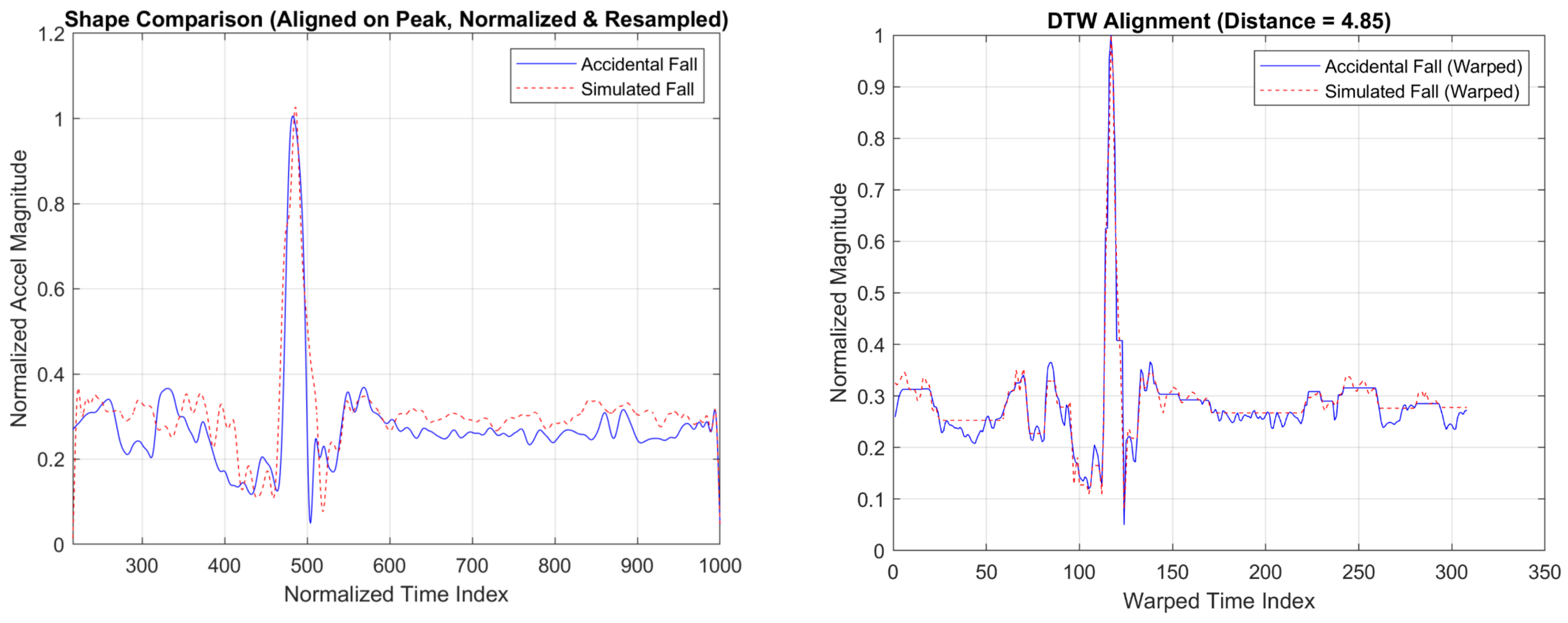

Fig. 4: Example of shape comparison an DTW alignment used in the analysis

CONCLUSION

This thesis presents a fall dataset recorded with a custom IMU system at two ear positions, consisting of simulated falls, near falls and activities of daily living. Notably, eight accidental real-world falls enabled the first matched dataset with simulated counterparts under identical conditions, allowing for a structured comparison. Therefore, this thesis addresses a key research gap. These results establish a foundation for future research into sensor placement, near fall analysis, and real-world algorithm training and validation.

COOPERATION PARTNER

MED-EL

References:
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[3] F. R. Lin and L. Ferrucci, "Hearing loss and falls among older adults in the United States," Archives of Internal Medicine, vol. 172, no. 4, pp. 369–371, Feb. 2012.