UNIVERSITI TEKNOLOGI MARA

ELDERLY FALL CLASSIFICATION USING PASSIVE WI-FI RADAR AND MACHINE LEARNING

MUHAMMAD NAZRIN FARHAN BIN NASARUDIN

Thesis submitted in fulfilment
of the requirements for the degree of
Doctor of Philosophy
(Electrical Engineering)

College of Engineering

November 2024

ABSTRACT

In the context of Malaysia's changing demographic landscape, the increasing elderly population necessitates innovative solutions for their healthcare and safety. Fall incidents among the elderly significantly affect their health, prompting a focus on assistive living technologies aimed at fall detection. This study aims to enhance fall detection by developing a system using Passive Wi-Fi Radar, addressing limitations of previous approaches. This method alleviates issues related to the comfort of wearable devices, privacy concerns of vision-based devices, and detection limitations of other ambient sensors. Passive Wi-Fi Radar, initially intended for communication, presents challenges in detecting human falls and movements. To address this, an enveloping algorithm is introduced to mitigate the influence of beacon signals carrying trajectory information. Additionally, four signal transformations which are Fourier spectrum, power spectrum, scalogram, and spectrogram are employed to analyse and extract Amplitude modulation signatures related to falls and movements. Feature extraction and selection are then applied to identify points that distinguish various fall types and fall-like movements. For Fourier and power spectrum features, extraction and selection are performed using Principal Component Analysis, followed by classification tasks utilizing Support Vector Machine, Random Forest, and Feed Forward Neural Network. Spectrogram and scalogram features are fed into the AlexNet Convolutional Neural Network. This study also explores combining AlexNet feature layers with traditional machine learning techniques to create hybrid classifiers, improving the performance of traditional algorithms. Results show that the Hybrid Random Forest classifier, using spectrogram images, performs exceptionally in single person scenarios, achieving an accuracy of 97.5%, recall of 0.9684, precision of 0.9872, and an F1-score of 0.981. In multiple person scenarios, the classifier attains an accuracy of 98.51%, recall of 0.9786, precision of 0.9914, and an F1-score of 0.9888. These findings highlight the effectiveness of the proposed fall detection system in addressing the challenges posed by the elderly population, marking a significant advancement in assistive living technologies. In conclusion, this study demonstrates the feasibility of using Passive Wi-Fi radar to detect falls, even high-speed falls. The introduction of hybrid classifiers has notably enhanced the model's overall performance, representing a valuable improvement for utilizing Passive Wi-Fi radar in fall detection. This research provides important insights and advancements in fall detection technologies, paving the way for more effective and accurate solutions to address the healthcare and safety concerns of the growing elderly population.

ACKNOWLEDGEMENT

Completing this PhD thesis has been a long, challenging, and rewarding journey, and it would not have been possible without the support and encouragement of many individuals and institutions. I am deeply grateful to everyone who has contributed to this accomplishment.

First and foremost, I would like to express my sincere gratitude to my supervisors, Assoc. Prof. Dr. Megat Syahirul Amin Megat Ali, Prof. Ir. Dr. Emileen Abd Rashid, and Dr. Norayu Zalina Zakaria. Your expertise, guidance, and unwavering support have been invaluable throughout my research journey. Your insightful feedback, encouragement, and patience have significantly shaped my academic and professional growth. I am profoundly grateful for the countless hours you dedicated to reviewing my work and providing constructive criticism that enhanced the quality of this thesis.

I am also thankful to the funding bodies that supported my research financially. The Ministry of Science, Technology and Innovation Malaysia, through the Technology Development 1 (TeD1), provided the necessary resources that allowed me to focus on my studies and pursue my research goals without financial concerns. Your support has been crucial in making this work possible.

I would like to extend my heartfelt gratitude to all those who directly and indirectly contributed to the data collection process for this research. To the participants who generously shared their time and insights, your contributions are the foundation of this thesis. Special thanks to the stuntmen and volunteers for their exceptional commitment in organizing and facilitating data collection sessions, ensuring everything ran smoothly.

On a personal note, I would like to express my deepest appreciation to my family. Your unwavering love, encouragement, and belief in my abilities have been my foundation throughout this journey. Your sacrifices and support have made my academic pursuits possible.

Finally, I would like to acknowledge all the participants and contributors to my research. Without their willingness to engage and share their experiences, this thesis would not have been possible. Your contributions have been invaluable, and I hope this work does justice to your input. In conclusion, this thesis is a testament to the collective effort, support, and encouragement of a wonderful community of individuals. To all who have contributed in one way or another, I extend my heartfelt thanks. This achievement is as much yours as it is mine.

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CHAPTER 1
INTRODUCTION

1.1 Background Study

The global demographic landscape is undergoing a rapid transformation, characterized by a substantial increase in the elderly population. In light of this societal aging phenomenon, there arises a mounting apprehension for the well-being and safety of the elderly, particularly in the context of accidental falls. Falls occurring among the elderly constitute a significant and pressing public health challenge due to their potential for inflicting severe injuries, diminishing overall quality of life, and escalating healthcare expenditures [1]. According to a 2007 report from the World Health Organization (WHO), falls rank as the second leading cause of accidental or unintentional injury-related fatalities on a global scale, with the age group of adults aged 65 and older being disproportionately affected [2]. Although the aforementioned report may not reflect the most current data, it is noteworthy that numerous countries have diligently deliberated this issue and actively pursued preventive measures to date [1], [3], [4]. This issue assumes particular importance in the context of Malaysia, as evidenced by statistics provided by the Department of Statistics Malaysia (DOSM), which reveal a consistent upward trend in the elderly population, surging from 10.3% in 2020 to 11.1% in 2022. Projections further indicate an anticipated increase to 15% by the year 2030 [5].

In order to address this pressing concern, the WHO has advocated the implementation of various technologies, including artificial intelligence (AI), to mitigate the issue of falls among the elderly [3]. This call has been widely resonated within the global biomedical engineering research community, with a shared objective of developing Assistive Living Technologies (ALT) focused on fall detection. Several alternatives have been explored in this endeavour, such as wearable devices utilizing Inertial Measurement Units (IMUs), which combine gyroscopes and accelerometers to gauge the acceleration and orientation of the subject [6]. Additionally, vision-based, radar-based, ambient sensors, including pressure and acoustic sensors, have been considered [7], [8]. Among these sensor technologies, radar-based sensors have