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Development of a Machine Learning Based Fall Detection System for the Elderly and Disabled

by Farhan Ahnaf Rashid

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the degree of

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CERTIFICATE OF ORIGINAL AUTHORSHIP

I, Farhan Ahnaf Rashid declare that this thesis, is submitted in fulfilment of the requirements for the award of Master of Engineering (Research), in the Faculty of Engineering and Information Technology at the University of Technology Sydney.

This thesis is wholly my own work unless otherwise referenced or acknowledged. In addition, I certify that all information sources and literature used are indicated in the thesis.

This document has not been submitted for qualifications at any other academic institution.

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Related Publication/ Research Papers Presented at Conferences

Farhan Ahnaf Rashid, Kumbesan Sandrasegaran and Xiaoying Kong, “Simulation of SisFall Dataset for Fall Detection Using MATLAB Classifier Algorithms”. In 12th International Symposium on Parallel Architectures, Algorithms and Programming (PAAP’2021), December 10-12, 2021, Xian, China. (Paper published in the conference proceeding).

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LIST OF ACRONYMS

ADL	Activities of Daily Living/Life
ANN	Artificial Neural Network
DBN	Dynamic Bayesian Network
DOF	Degrees of freedom
DSP	Digital Signal Processing
DT	Decision Tree
FPGA	Feld programmable gate array
EMG	Surface electromyography
GPS	Global Positioning System
HMM	Hidden Markov Model
I2C	Inter-integrated circuit
KNN	k-Nearest Neighbors
ML	Machine learning
MLP	Multilayer perceptron
NB	Naïve Bayes
NN	Neural Network
RFID	Radio Frequency Identification Devices
RPROP	Resilient Backpropagation
STPRtool	Statistical Pattern Recognition Toolbox
SVM	Support Vector Machine

ABSTRACT

Fall accidents from accidental injury are considered one of the significant global public health concerns, and the largest proportion of fatal accidents are experienced by elderly people. Currently, there is a demand for creating an effective machine learning-based fall detection system that is portable at a low cost.

Hence, this project is aimed at undertaking a research study on the various fall detection and navigation systems designed for the elderly and disabled and developing an effective machine learning-based low-cost fall detection system. The methodology included a study on the various fall detection systems as well as general features used in machine learning for fall and ADL (Activities of Daily Living) classifications. The most suitable potential combination of machine learning algorithms that will provide the best accuracy, precision, sensitivity, specificity and lowest training time were developed via simulation models using MATLAB. The SisFall and MobiFall datasets were used for both classification and testing for input data in simulations. SisFall dataset used ADXL345 and MMA8451Q accelerometer model, while the MobiFall dataset used LSM330DLC inertial module from a Samsung Galaxy S3 smartphone.

Up to 24 algorithms were simulated, including Decision Trees, Naïve Bayes Classifiers, Support Vector Machines, KNN and available Ensemble Classifiers. Four experiments were done, with Experiment 1 using the ADXL345 accelerometer with 5-fold cross-validation, Experiment 2 using 10-fold cross-validation, Experiment 3 using the MMA8451Q accelerometer with 10-fold cross-validation and Experiment 4 using the MobiFall Dataset with 5-fold cross-validation. The classifier models were run ten times, and each iteration was saved for further processing. Classifiers showing the most accuracy (up to 99%) in both training and testing phases included Quadratic SVM, Cubic SVM, Medium Gaussian SVM and Fine KNN.

A stacked ensemble method was simulated as well utilizing classifiers such as Medium Gaussian SVM, Cubic SVM and Fine KNN. SisFall and MobiFall Datasets were further used to train and test the classifier system. Initial testing and training had shown an improvement in accuracy (up to 99% in binary classifications) when compared to the system using individual classifiers. Results had shown a remarkable increase in precision, sensitivity and accuracy when classifying data in a binary classification system compared to classifying the data based on the specific categories (the various types of falls and

ADLs). Hence an effective system model was developed and trained to identify the data between both Fall Events and ADLs as well as separately identifying the actual type of Fall/ADLs.