# A Fall Detection System using Deep Learning on Smartwatch Devices


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## Introduction

The World Health Organization (WHO) reported that 28% to 35% of people aged 65 and over, fall each year. Falls threaten seniors' safety and independence. Therefore, developing an elderly-friendly fall detection system that implements Deep Learning models can be an alternate solution with the potential of saving lives. The elderly are also much more likely to wear smartwatches than other devices that they consider to be obtrusive and not aesthetic.

## Background Work

Past researchers have experimented with traditional algorithms and methods in fall detection. Such algorithms include the Support Vector Machine (SVM) and the Naïve Bayes (NB). They have showed some success, and will be used to compare the accuracy of our Deep Learning model. Past research did also not include a functional UI for the application.

## Overview of the System


Figure 1 - System architecture

Our method has a three layer architecture that is divided by:

- ➢ Smartwatch - collects sensor data
- ➢ Smartphone - analyzes and alerts
- ➢ Cloud Storage - saves the data for refinement of the fall detection model

## Fall Detection System UI

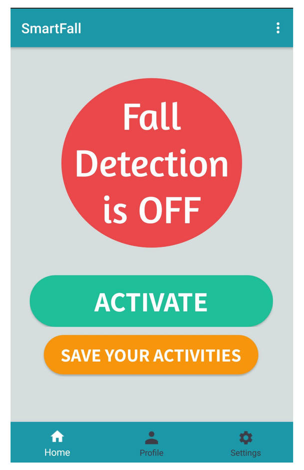


Figure 1 - Home page

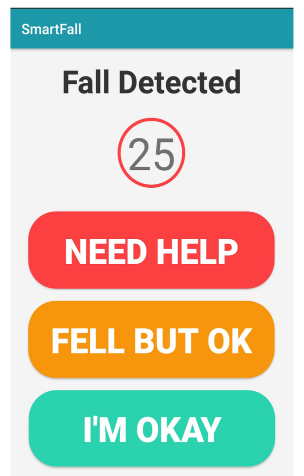


Figure 2 - Fall Alert


Figure 3 - User Guide

Designing for the elderly requires:

- ➢ Strict color scheme with high contrasts
- ➢ Legible and big fonts
- ➢ Descriptions of the system to make it easier for them to understand and use

## Deep Learning Architecture

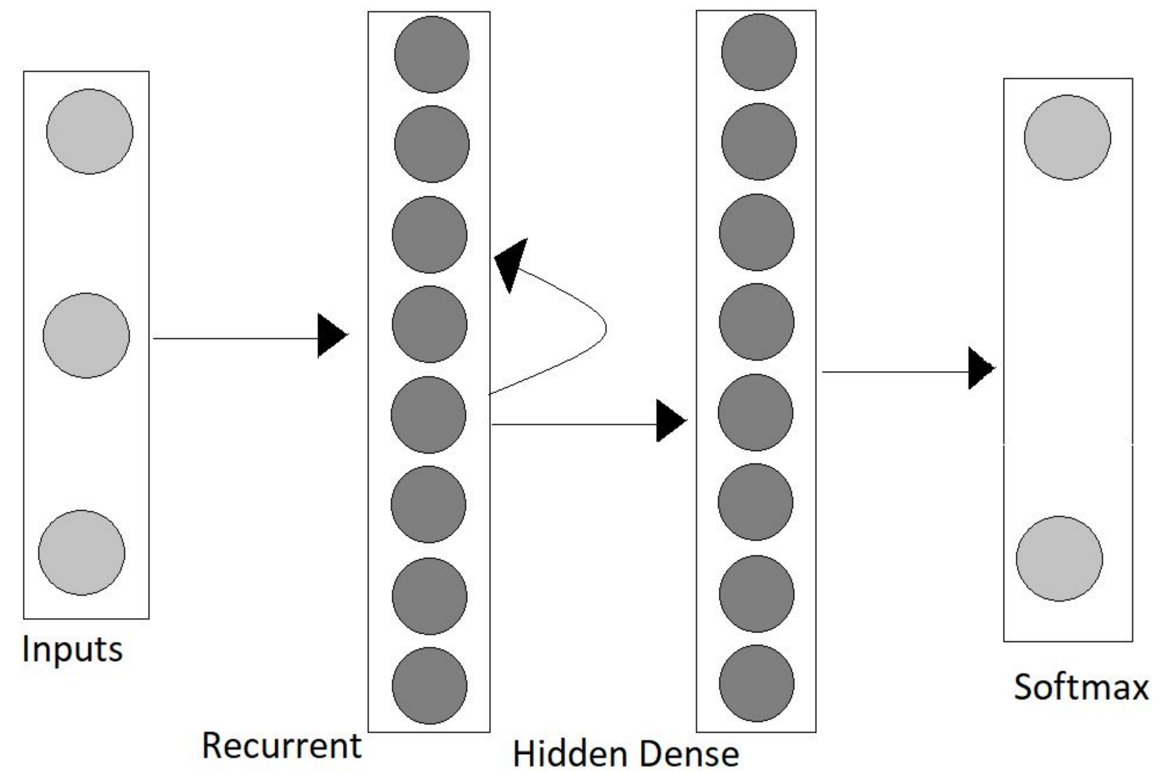


Figure 4 - Deep Learning Architecture

The input layer takes in the raw accelerometer x, y, and z vectors. Next, it feeds through a recurrent layer with GRU units (20), and then to a fully connected dense layer (20). Finally, the output layer produces a softmax that outputs the probability that a fall occurred.

## Evaluation

Each dataset contains the x, y, z vectors of accelerometer data over time. A label is added next to each row of accelerometer data that specifies if a person was falling at that point time.

| Acc X | Acc Y | Acc Z | Falling? |
|---|---|---|---|
| 0.342 | -0.935 | 1.345 | 0 (No) |
| 1.465 | -0.436 | 0.958 | 1 (YES) |

Table 1 - Accelerometer Data

- ➢ Smartwatch dataset uses a MS Band and collected data from ~7 young users.
- ➢ Notch dataset uses sensor modules and data collected from ~7 young users
- ➢ Farseeing dataset uses real falls from elderly people in a nursing home.

## Results

The tables below show the results from each dataset over actual falls, and activities of daily living (ADLs).

| **Smartwatch** | SVM | NB | Deep Learning |
|---|---|---|---|
| Falls (91 total) | 85.7% | 92.3% | 100.0% |
| ADLs (90 total) | 60.0% | 37.8% | 70.0% |

| **Notch** | SVM | NB | Deep Learning |
|---|---|---|---|
| Falls (107 total) | 80.4% | 88.8% | 87.9% |
| ADLs | 50.4% | 55.2% | 86.4% |

| **Real Nursing Home** | SVM | NB | Deep Learning |
|---|---|---|---|
| Falls (23 total) | 52.2% | 78.3% | 100.0% |
| ADLs | 97.0% | 8.2% | 91.8% |

| **Real-Time** | Deep Learning |
|---|---|
| Falls (20 total) | 85.0% |
| ADLs (20 total) | 90.0% |

The results from each dataset indicate that our deep learning architecture can provide accurate and robust detection of falls compared to that of traditional models used.


## Acknowledgements

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