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Cost-Effective Human Movement Tracking for Elderly Care and Learning Using the nRF52840 Microcontroller

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Abstract

This paper explores the development of a cost-effective solution for tracking human movement using the nRF52840 microcontroller. The system can detect movements such as sitting, standing, walking, and falling, with applications in elderly care, education, and industry. This paper describes the design, implementation, and results of using sensors and machine learning to classify human activities. The project is particularly beneficial for elderly monitoring and providing students with hands-on learning opportunities.

Key words: nRF52840, Human Movement Tracking, Elderly Care, Machine Learning, Embedded Systems

Introduction

As the global population ages, technology becomes crucial in assisting elderly care, especially in areas where care resources are limited, and constant monitoring isn't possible Wang et al. (2019). Traditional systems like cameras are effective but costly for smaller facilities. This paper presents a more affordable solution using the nRF52840 microcontroller and machine learning to detect actions like sitting, standing, and falling, which could reduce the risk of accidents for elderly individuals Espinilla et al. (2017).

The proposed system leverages sensors, such as accelerometers and gyroscopes, to capture movement data. These sensors, combined with a machine learning model, classify various activities and relay data to mobile devices. This design has applications in education, where students can modify and retrain the machine learning model for hands-on experience Semiconductor (2024).

Design

The system's primary component is the nRF52840 microcontroller, which features Bluetooth Low Energy (BLE) capability and is integrated with sensors like accelerometers and gyroscopes Semiconductor (2024). This setup enables real-time classification of movements. The nRF52840's low power consumption makes it ideal for continuous monitoring without frequent recharging. The device is designed to be worn discreetly and transmit data to a mobile app, which can issue alerts during emergencies Studio (2024).

The real-time data is processed using a pre-trained machine learning model that classifies actions like sitting, standing, walking, running, and falling. In educational settings, students can retrain the model and implement their own algorithms Wang et al. (2019).

Results

Initial testing suggests that the system can accurately classify basic human movements such as sitting, standing, walking, and falling Espinilla et al. (2017). This classification is essential, particularly in scenarios involving elderly users where detecting falls is critical for timely intervention. The following movements were categorized successfully based on the collected sensor data:

- Sitting
- Standing
- Walking
- Running
- Falling

The goal is to ensure high accuracy in detecting falls, given the system's intended use in elderly care Wang et al. (2019).

Sample Data and Results

The system was tested with various samples to evaluate its accuracy and loss performance. Table 1 summarizes the results for different sample sizes.

Table 1. Accuracy and Loss for Different Sample Sizes

Samples	Accuracy	Loss
10	75%	0.53
23	100%	0.35
39	100%	0.20

The results show that with a sample size of 23 and 39, the system achieved 100% accuracy, while the loss decreased significantly as the number of samples increased. These results indicate that the machine learning model improves in classification performance with more data.

Sample Images

The following images display movement data visualized during testing. Each image represents a different dataset with varying sample sizes.

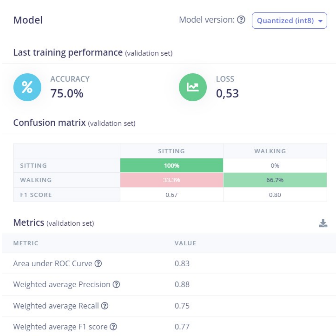

Fig. 1: Movement data for 10 samples

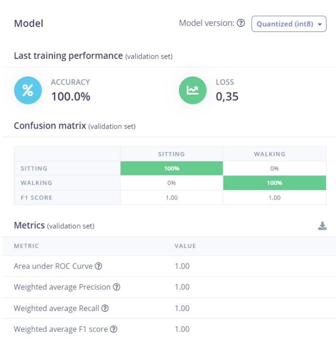

Fig. 2: Movement data for 23 samples

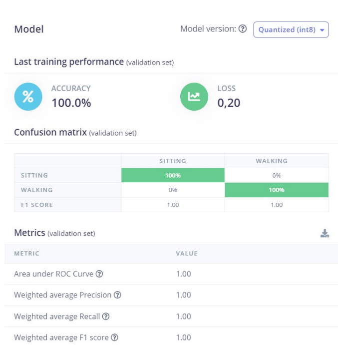

Fig. 3: Movement data for 39 samples

As seen from Figures 1, 2, and 3, the visualizations indicate smoother classification with larger sample sizes, which aligns with the improved accuracy and reduced loss values as shown in Table 1.

Analytical Approach: Probability of True Detection

The sensor's reliability can be modeled using a binomial probability model. Let the probability of true detection be represented by the system's accuracy, $P(\text{True Detection}) = \text{Accuracy}$. Given the results from the data, the sensor's performance can be modeled for each sample size.

The probability of detecting a true movement (e.g., fall detection) can be calculated based on the observed accuracy:

$$P(\text{True Detection}) = \frac{\text{True Positives}}{\text{True Positives} + \text{False Positives}}$$

As observed, the system's performance improves as the sample size increases, leading to higher detection accuracy and reduced false positives.

Reliability Graph

The following graph shows the sensor's accuracy over different sample sizes:

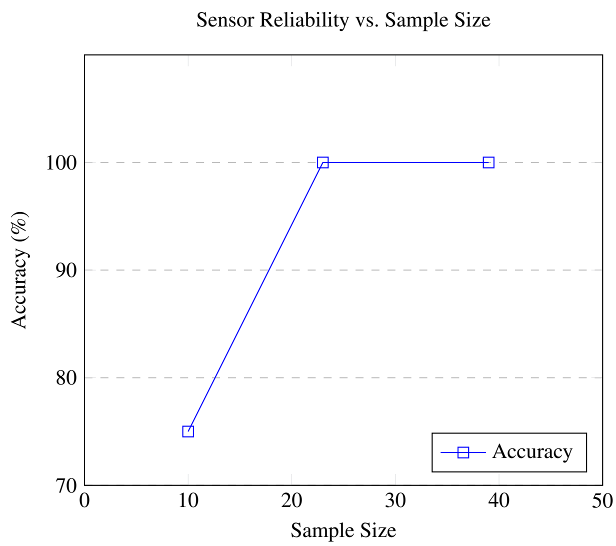

Fig. 4: Sensor reliability based on sample size

The graph in Figure 4 demonstrates the sensor's increasing accuracy with larger sample sizes, showing 100% accuracy for sample sizes above 23.

Conclusion

This project demonstrates that the nRF52840 microcontroller can be utilized effectively for human movement tracking. Its cost-effectiveness and low power consumption make it suitable for elderly care, education, and industrial applications. The system allows for real-time monitoring, with high potential for integration into larger safety systems.

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