A Wearable Sensor for Fall Detection and Emergency Alert

ELECTRICAL & COMPUTER ENGINEERING
UNIVERSITY OF MICHIGAN

EECS 452: Digital Signal Processing Design Lab (Winter 2023)
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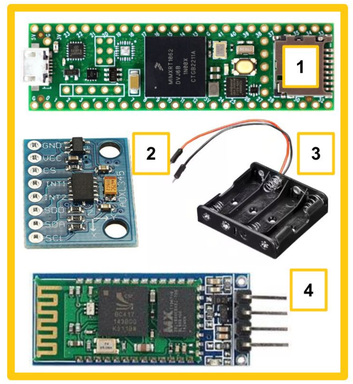
Introduction / Motivation

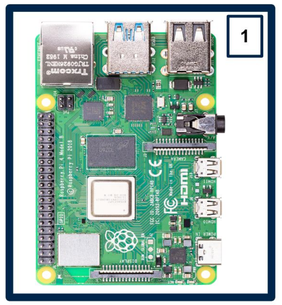
Introduction: We developed a fall detection system that can identify falls automatically and alert caregivers or emergency services. The system uses wearable sensors to detect sudden movements, changes in posture, and impacts associated with falls. The wearable device processes the sensor data in real time, analyzing the signals to detect fall events. If the algorithm determines that the user is falling, it initiates a 10 second countdown; If the user does not double tap the device within that time, an emergency alert is sent to a nearby device.

Motivation: Fall detection is a critical issue that affects elderly people, especially those who live alone. Falls are the leading cause of accidental deaths and injuries worldwide and can result in serious injuries, and even death. Therefore, developing an automatic fall detection system is an essential area of research. A fall detection system can help identify and respond quickly to a fall, reducing the risk of complications.

System Architecture / Specification

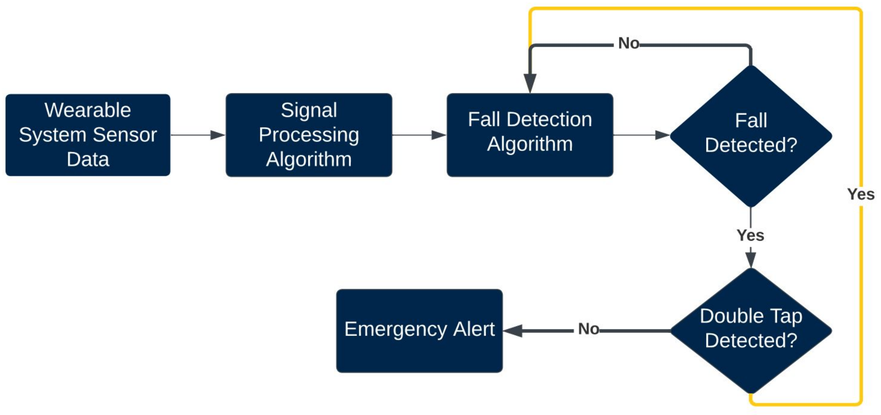


Wearable Device
1. Teensy
2. IMU
3. Battery Pack
4. HC-05 Bluetooth Module



Signal Processing
1. Raspberry Pi

Algorithm / Techniques



- Threading: solves synchronization issue by only allowing one thread to access data at a time
- Moving Average Filter
- Thresholding Parameters:
  - Sum vector magnitude
  - Angle between z-axis and vertical

Challenges / Innovation

Challenges:

- Bluetooth communication
- Synchronization (threading)
- Power (battery pack and 5V common rail)
- Sensitivity of orientation value (radians to degrees)
- Reliability of hardware

Innovation: The system being wearable on one's waist instead of wrist, reducing false positives

Acknowledgements

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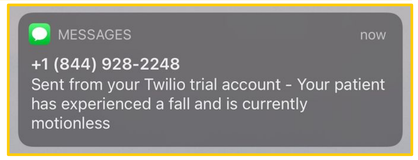
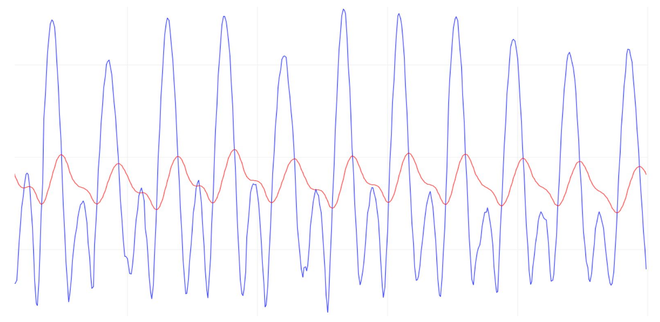
Results / Evaluation

TEST CASE	STATUS
Fall detected, 10 seconds, help alert	PASS
Fall detected, double tap, no help alert	PASS
Fall detected, 10 seconds, fall can be detected again	PASS
Fall detected, double tap, fall can be detected again	PASS
Testing Potential False Positives	
Jogging / Jumping up and down, no fall detected	PASS
Bend over, no fall detected	PASS
Sitting, no fall detected	PASS
Testing True Positives	
Fall from knees, fall detected	PASS
Fall from feet, fall detected	PASS
Fall from sitting position, fall detected	PASS
Fall left, fall detected	PASS
Fall right, fall detected	PASS

```
pi@raspberrypi:~/Desktop/fall_detection $ python fall_orig.py imu
Receiving data...
Hit enter or Ctrl-c to terminate:
FALL DETECTED!
We are glad you are okay! The alarm has been canceled.
FALL DETECTED!
Help is on the way!
```





Evaluation: The red curve shows IMU data passed through the Moving Average Filter. This system passes all tests of simulated falls to the best of our ability. For safety reasons, we were unable to make a hard impact. However we can reason that if soft falls are detectable, hard falls would be as well.