Human Fall Detection Using Inertial Sensors

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Abstract

In this project we developed a wearable human fall-detection system intended for the elderly. On detecting a fall, the system sends an emergency SMS using the wearer's bluetooth enabled smartphone to a caregiver. The system uses a GY-87 inertial sensor integrated with an Arduino Nano micro-controller.

1 Problem Statement

Falls are a significant source of injury for the elderly. This wearable device aims to detect a fall by detecting the change in accelerometer output, before during and immediately after a fall. It also detects the direction of the fall by combining readings from the accelerometer with gyroscope output. The combination of readings from the two sensors using a complementary filter results in more usable readings compared to just the use of the accelerometer. The HC05 bluetooth module pairs the wearable with the user's bluetooth enabled smartphone. In the event of a fall the devices sends a message to the the smartphone which is loaded with an application to convert the message into a SMS to a designated caregiver.

2 Literature Review

[1] is a comprehensive survey of recent fall detection techniques which includes wearable based detection as well as detection using ambient and vision sensors. Wearable based detection increasingly gravitate towards accelerometer based techniques due to lower costs and power efficiency of mems-based accelerometers. Accelerometer-based techniques usually consist of detecting a sudden change in the acclerator output due to the fall-event.

[2] discusses appropriate filtering techniques to estimate the vertical acceleration vector from a tri-axial accelerometer. The readings from a tri-axial accelerometer cannot be used directly as they tend to be very noisy and are also combined with the acceleration due to the earth's gravity.

PCP's student's mtech thesis used a LPF to filter the accelerometer readings with a cut-off frequency of Hz.

[3] uses a threshold based technique combining readings from the accelerometer and gyroscope to detect the fall-event.

3 Approach

The how - broad level

4 Hardware Considerations

Our hardware setup consists of four major components:

GY-87 The GY-87 also known as the MPU-60X0 integrates a tri-axial accelerometer and gyroscope with on-chip ADCs to deliver digital outputs via an I2C interface to an off-chip controller. To a controller this device acts as a slave on the I2C. GY-87 also features an auxiliary I2C bus which it masters to integrage discrete sensors like magnetometers.

Arduino Nano The Arduino Nano is a board based on the ATmega328P microcontroller. The ATmega328 has 32 KB, (also with 2 KB used for the bootloader). We have chosen the Nano due to its small form factor as the device is meant to be a wearable.

HC05 The HC05 is a bluetooth to serial port module which communicates via UART. The bluetooth module communicates fall information to a bluetooth enabled smartphone

Power Supply A 9V battery is used as the power supply on the wearable.

4.1 Block Diagram

4.2 GY87 Calibration and Integration

4.3 Power Supply

How long do we expect a rechargable 9V cell to last? What is the current drawn under normal usage?

4.4 I2C Integration

5 Software

Algorithm. Flow diagram: sampling, lpf, hpf, complementary.

6 Investigations

6.1 GY87 Calibration

Cube readings. Pendulum experiment.

6.2 Combining Accelerometer and Gyroscope Readings

Complementary Filter.

7 Test Procedure

Need to ask PCP on an acceptable test setup.

8 Test Results

with plots and tables (appendices, if necessary).

9 Conclusion

suggestions for further improvement.

References

[1] M. Mubashir, L. Shao, and L. Seed, "A survey on fall detection: Principles and approaches," *Neurocomputing*, vol. 100, pp. 144–152, 2013.

[2] A. K. Bourke, K. O'Donovan, A. Clifford, G. Olaighin, and J. Nelson, "Optimum gravity vector and vertical acceleration estimation using a tri-axial accelerometer for falls and normal activities," *Proceedings of the Annual International Conference of the IEEE Engineering in Medicine and Biology Society, EMBS*, pp. 7896–7899, 2011.

[3] F. Wu, H. Zhao, Y. Zhao, and H. Zhong, "Development of a Wearable-Sensor-Based Fall Detection System," *International Journal of Telemedicine and Applications*, vol. 2015, pp. 1–11, 2015.