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DESIGN AND IMPLENTATION OF A WIRELESS FALL DETECTION NETWORK PROTOTYPE USING MEMS SENSORS

by

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Disclamer

I hereby declare that this thesis is a product of my own work, unless otherwise referenced. I also declare that all opinions, results, conclusions and recommendations are my own and may not represent the policies or opinions of Vietnamese - German University and Frankfurt University of Applied Science.

Ho Ngoc Khang Minh

Abstract

Falling is becoming a serious problem to elderly people with the age of over 65, often causing unpredictable injuries such as hip fractures, head traumas, etc. More seriously, falls may lead to disability or even death on the victim if assistances from caregivers are not received in time. From this situation, there is a need for a wireless communication network which can automatically detect the fall and send an alarm to the caregivers if there is no safe signal from the victim within 10 minutes. There have been several algorithms such as detection of body orientation after a fall, image processing to detect the fall or applying machine learning techniques (Support Vector Machine (SVM), Markov model) in classifying between falling and other activities of daily living (ADL). However, these complex techniques require a huge amount of computations which can result in the system being overloaded or heavily delayed.

Addressing this problem calls for less computation-intensive techniques while retaining the accuracy and robustness of the system. One such approach is the combination of data from both accelerometer and gyroscope. The focus of this thesis is developing a wireless fall detection network which can combines the data from above sensors to detect falls and distinguish them from fall-like activities. A comparison on the performance of this network with other existing works is also included to evaluate the robustness of the system.

Keywords: *elderly people, fall detection, accelerometer, gyroscope, wireless communication network*

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Acronyms

WHO World Health Organization. 2

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1.1 Introduction to Fall

Nowadays, fall is becoming a dangerous issue which mostly cause the injuries and even leads to disability or fatal death on human, especially the elderly. According to Hwang *et.at.* [1], in the United State, one-third to one-half of elderly people over 65 years old fall at least one time each year and two-third of them will do so again within the next 6 months. Every 11 seconds, there is an elderly person is treated in the hospital's emergency area due to fall-related injuries and every 19 minutes, one faller die [2]. It is also reported that one out every 200 falls results in a hip fracture on people with age among 65 and 69 and increase to one out of 10 for those aged 85 and more [3]. The most profound effect of falling is the loss of functioning associated with the dependency of the elderly for the rest of their life. Besides, a great amount time and money have been spent on the medical treatments for the falls. Approximately $179 million were used as direct medical costs for treating fatal falls and $19 billion for non-fatal fall injuries within 2000 [4].

1.2 Definition of a Fall

Before starting a research about falls, it is necessary to understand about the meaning of the term *falls*. According to World Health Organization (WHO), a fall is defined as an event which results in a person coming to rest inadvertently on the ground or floor or other lower level with or without loss of consciousness or injury [5].

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A. C/C++ Code for Reading Data from Sensor

```
#include "Arduino.h"
#include "MPU6050.h"
#include "Wire.h"
#include "WiFiClient.h"
#include "ESP8266WiFiMulti.h"

ESP8266WiFiMulti WiFiMulti ;
#if I2CDEV_IMPLEMENTATION == I2CDEV_ARDUINO_WIRE
#include "Wire.h"
#endif

MPU6050 accelgyro;
//MPU6050 accelgyro(0x69); // <-- use for AD0 high

int16_t ax, ay, az;
int16_t gx, gy, gz;
float rotX, rotY, rotZ,normAcc;
float gyroX, gyroY, gyroZ, normGyro;
#define OUTPUT_READABLE_ACCELGYRO

#define LED_PIN 2
bool blinkState = false;

void Print_IMU()
{
#ifdef SERIAL_DEBUG
Serial.println("Accelerometer:");
Serial.print(rotX);
```

```
Serial.print("\t");
Serial.print(rotY);
Serial.print("\t");
Serial.println(rotZ);
Serial.println("Gyroscope: ");
Serial.print(gyroX);
Serial.print("\t");
Serial.print(gyroY);
Serial.print("\t");
Serial.println(gyroZ);
#endif
Serial.print(normAcc);
Serial.print(" ");
Serial.println(normGyro);
}

void init_IMU() {
// join I2C bus (I2Cdev library doesn't do this automatically)
Wire.begin();
Serial.begin(115200);

// initialize device
Serial.println("Initializing I2C devices...");
accelgyro.initialize();

// verify connection
Serial.println("Testing device connections...");
Serial.println(accelgyro.testConnection() ? "MPU6050 connection successful"
: "MPU6050 connection failed");

// use the code below to change accel/gyro offset values
```

```
Serial.println("Updating internal sensor offsets...");
//reading current sensor's offset
Serial.print("\n");
accelgyro.setXGyroOffset(55);
accelgyro.setYGyroOffset(-28);
accelgyro.setZGyroOffset(-2);
accelgyro.setXAccelOffset(-2581);
accelgyro.setYAccelOffset(-3937);
accelgyro.setZAccelOffset(1199);
}


void Init_Wifi()
{
// Initialize Wifi_connection
WiFiMulti.addAP("Connectify-me", "hazeduh5");
Serial.println();
Serial.println();
Serial.print("Wait for WiFi... ");
while(WiFiMulti.run() != WL_CONNECTED) {
Serial.print(".");
delay(500);
}
Serial.println("");
Serial.println("WiFi connected");
Serial.println("IP address: ");
Serial.println(WiFi.localIP());
delay(500);
}

void sendData()
{
```

```
const uint16_t port = 8000;
const char * host = "192.168.85.1"; // ip or dns

// Use WiFiClient class to create TCP connections
WiFiClient client;

if (!client.connect(host, port)) {
Serial.println("connection failed");
client.stop();
return;
}
client.print(normAcc);
//     client.print(" , ");
//        client.println(normGyro);
//Serial.println("closing connection");
client.stop();
}

void setup(){
Serial.begin(115200);
Wire.begin();
init_IMU();
delay(10);
Init_Wifi();
}
void loop() {
accelgyro.getMotion6(&ax, &ay, &az, &gx, &gy, &gz);
rotX = ax / 16384.0;
rotY = ay / 16384.0;
rotZ = az /16384.0;
normAcc = sqrt(rotX*rotX + rotY*rotY + rotZ*rotZ);
gyroX = gx /131;
```

```
gyroY = gy /131;
gyroZ = gz /131;
normGyro = sqrt(gyroX*gyroX + gyroY*gyroY + gyroZ*gyroZ);
Print_IMU();
sendData();
}
```

B. Python Code for Data Acquisition Program

```
import matplotlib.pyplot as plt
import matplotlib.animation as animation
from drawnow import *
import socketserver

accel = []
gyro = []
plt.ion() #tell the matplotlib that we want to draw live data
def makeFig():
plt.subplot(2,1,1)
plt.plot(accel, 'r', label= 'Normalized Acceleration')
plt.legend(loc='upper left')
plt.ylim(0,5)
plt.subplot(2,1,2)
plt.plot(gyro, 'b', label = 'Normalized Angular Velocity')
plt.legend(loc='upper left')
plt.savefig('testplot.png')

class myTCPServer(socketserver.StreamRequestHandler):
def handle(self):
data = self.rfile.readline()
dataArray = data.decode().split(',')
normAcc = float(dataArray[0])
normGyro = float(dataArray[1])
accel.append(normAcc)
gyro.append(normGyro)
if len(accel) > 100:
accel.pop(0)
```

```
if len(gyro) > 100:
gyro.pop(0)
drawnow(makeFig)
#create TCP server
serv = socketserver.TCPServer(("",8000),myTCPServer)
serv.serve_forever()
```

References

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