Design and Implementation of an Accidental Fall Detection System for Elderly

Enku Yosef Kefyalew¹, Abubakr Rahmtalla Abdalla Mohamed²

Department of Electronic Engineering, Tianjin University of Technology and Education, Tianjin, China

Abstract: With the dramatically increasing of world population, the caring of elderly person becomes a globally concerned problem. The old want an independent living space and their family members need to work, so an intelligent old person surveillance system is in urgent need. An accidental fall detection system for elderly is constructed to detect whether an old person has fallen down and inform his or her family members through public mobile service, so as to get the elderly helped in time. This fall detection system is created using microcontroller technology as the heart of the system, the accelerometer as to detect the sudden movement or fall and the Global System for Mobile (GSM) modem, to send out message to the receiver without any participation of the person who needs help. The system designed can detect the accidental fall of people accurately and send a message originally edited to supposed family members. And it can be furthered used in a broad application field. This report covers the introduction of the project which includes the objectives and the proposed plan. The literature review covers the background theory of individual components essentials for the project. The hardware and software design and integration shows the stages advancement of this system. Finally this report concludes with the results and discussion.

Keywords: microcontroller, fall detection accelerometer, GSM modem

1. Introduction

Our modern societies are suffering from the increase of elderly population while at the same time social security and health costs must be cut down. In order to avoid the need of special care centers, the costs and improve elderly quality of life need to be that affordable and safe. The actual trend in the world is to encourage elderly to stay living autonomously in any environment as long as possible. However, due to health problems mainly, elderly are more subject to problems and needs assistance in their daily life. For most of them, living alone is not acceptable. It generates insecurity, fear, restriction in their activities and anxiety or concern from the caregivers or families. Professional agencies or caregivers may of course help the elderly in their daily life but they cannot give round the clock service. Another means to support the elderly is to provide them an adapted and reliable telemedicine system, to make them more confident, to support them in case of emergency, in fact to improve their quality of life. The product presented in this project contributes to this objective, since it provides automatic fall detection and notification everywhere else. It provides support and manages emergency situations notifying to the beloved ones. It is constituted by a small mobile module worn by the user during daily activities, and the responsible one to receive and manage information sent by the mobile module. Main function is implemented in the product: Automatic fall detection. In order to allow an indoor and outdoor use of the system, mobile network technology has been used. Indeed, the mobile network module incorporates Global System for Mobile communications (GSM) to send data (activity and alarm) between the module and the beloved one who is responsible to take care of. The module works in an autonomous way, without intervention of the user. In normal mode, in case of alarm (due to a fall or abnormal activity), a notification message SMS is sent to the person in charge of.

2. Objectives

In the overall world, the elderly represent the fastest growing population and this trend will increase over the years. An elderly individual with diminished self-care and self-protective ability, they are fragile and are prone to fall. Most cases it became a danger to these elderly not because of the fall but there is a delay in assistance or treatment after the fall. This system will be able to assist careers, as they will be able to give immediate attention to elderly who is in need of help. The aim of this project is to develop a fall detection system that is able to:

- Detect changes in motion of a subject due to fall
- Trigger system and send a message out via SMS once detection of fall occurs
- Ideally wear without noticing that the subject is using the system
- Inform career regarding about the person who is in danger. Figure 2.1 shows the proposed system flow.

![Figure 2.1: Diagram flow of Fall Detection System works](image_url)
Accelerometer
Global System for Mobile (GSM) Modem
Microcontroller
Power Supply

Figure 2.2: Block Diagram of the System

3. Proposed Approach and Method to be employed

The project will adopt the Structured System Analysis and Design methodology approach to achieve the project objectives.

Figure 3.1: Block Diagram of Elderly Home Monitoring System

The system consists of the following modules:
1. Power supply to supply voltage to each block
2. Microcontroller for programming and controlling
3. Alarm for alerting the neighbors
4. Flash light to draw attention
5. GSM Modem to send out SMS
6. Accelerometer to be used as a fall detector

4. Hardware Design

As long as the main job in this project is design and hardware implementation through this hardware part we will discuss on the flow of the prototype development leading to the software implementation. The flow movement of implementing each component together is illustrated in the flow chart shown in Figure 4.1. The hardware and software designs are developed while complementing each other. This flow chart is useful to update on the project’s status and ease troubleshooting.

Figure 4.1: Flow Diagram of Hardware and Software Implementation

Figure 4.2: Schematic Diagram of Accidental Fall Detection System
4.1 Microchip Microcontroller

The microcontroller plays a critical role in the monitoring system. PIC microcontrollers are popular processors developed by Microchip Technology with built-in RAM, memory, internal bus, and peripherals that can be used for many applications. PIC originally stood for “Programmable Intelligent Computer” but is now generally regarded as a “Peripheral Interface Controller”. The microchip PIC18F4520 microcontroller is a 40 pin 8 bit processor with five ports available to be used depending on the device selected and features enabled. Certain pins can be multiplexed with an alternate function. There are 3 registers in each port, TRIS, PORT and LAT register. The TRIS register operates as Data Direction register. PORT register reads the levels on the pins of the device. LAT register as Output Latch register and is very useful for read, modify and write operations. The Microchip PIC18F4520 microcontroller pin assignment layout is shown below in figure 4.3.

![Figure 4.3: PIC18F4520 microcontroller pin assignment layout](image)

4.2 GSM Modem Serial Port RS-232

One of the core components of the project is the modem. This serves as to send out instantaneous message to the career once it is activated by the user. The figures below will illustrate how the connection is done to the main board. The serial 9-pin RS-232 connector is connected to a MAX232 driver, as displayed in Figure 4.4. Transmit and receive commands to and from the modem via the following connection.

![Figure 4.4: Schematic and Layout of 9-pin RS232 with MAX232 driver](image)

4.3 Accelerometer

The core of the project, the accelerometer is used to detect the fall motion involved that will trigger the emergency assistance. A signal is sent to the microchip the moment the sensor detects a sudden fall down. This accelerometer uses the force of gravity as an input to determine the inclination angle of an object. The accelerometer’s sensitive axis is perpendicular to the force of gravity or parallel to the Earth’s surface. Table 4.1 shows the description of the pin functions individually.

<table>
<thead>
<tr>
<th>Pin</th>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>$T_{\text{OUT}}$</td>
<td>Temperature (Analogy Voltage)</td>
</tr>
<tr>
<td>2</td>
<td>$D_{\text{OUTY}}$</td>
<td>Y-Axis Acceleration Digital Signal</td>
</tr>
<tr>
<td>3</td>
<td>Gnd</td>
<td>Ground</td>
</tr>
<tr>
<td>4</td>
<td>$V_{\text{DA}}$</td>
<td>Analogy Supply Voltage</td>
</tr>
<tr>
<td>5</td>
<td>$D_{\text{OUTX}}$</td>
<td>X-Axis Acceleration Digital Signal</td>
</tr>
<tr>
<td>6</td>
<td>$V_{\text{ref}}$</td>
<td>2.5V Reference</td>
</tr>
<tr>
<td>7</td>
<td>Sck</td>
<td>Optional External Clock</td>
</tr>
<tr>
<td>8</td>
<td>$V_{\text{DD}}$</td>
<td>Digital Supply Voltage</td>
</tr>
</tbody>
</table>

![Figure 4.5: Schematic and Layout of the Accelerometer (MXD2125GL) on Circuit](image)

Table 4.1: Pin Description on MXD2125GL

5. Software Design

Software development is done in stages and indirectly depends on the hardware development. The flow chart below shows the process of the software development of the project.

Volume 4 Issue 2, February 2015

www.ijsr.net

Licensed Under Creative Commons Attribution CC BY
5.1 Completed Software Design

After designing the software for the individual modules, the program is ready to be encoded into the microcontroller for the integration with the completed hardware. First, the input/output ports are initialized. Then, it checks the type of condition met. If accelerometer sensor is pressed, red LED light up, SMS is sent and the buzzer sounds up. If not, it checks if the emergency button (help button) is pressed, yellow LED is ON and SMS is sent. If both conditions are not met the green LED is ON until either of the emergency or the accelerometer sensors are activated. The program goes into a loop and checks the conditions again and again repeatedly. Figure 4.11 below illustrates the flow process of the program for this project.

Table 5.1: Hardware port allocation

<table>
<thead>
<tr>
<th>Pin</th>
<th>Port</th>
<th>Usage</th>
<th>Pin</th>
<th>Port</th>
<th>Usage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>MCLR</td>
<td>Reset Clear</td>
<td>34</td>
<td>RB0</td>
<td>Green LED</td>
</tr>
<tr>
<td>3</td>
<td>RA0</td>
<td>Accelerometer</td>
<td>35</td>
<td>RB1</td>
<td>Yellow LED</td>
</tr>
<tr>
<td>13</td>
<td>RA7</td>
<td>Crystal</td>
<td>36</td>
<td>RB2</td>
<td>Red LED</td>
</tr>
<tr>
<td>14</td>
<td>RA6</td>
<td>Crystal</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>RC2</td>
<td>Buzzer</td>
<td>39</td>
<td>RB7</td>
<td>ICD 2</td>
</tr>
<tr>
<td>25</td>
<td>RC6</td>
<td>Modem and PC</td>
<td>40</td>
<td>RB6</td>
<td>ICD 2</td>
</tr>
<tr>
<td>26</td>
<td>RC7</td>
<td>Modem and PC</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

6. Integration of the Whole System

The functionality of the hardware and software was done in parts, which made the integration of the whole system less prone to error. The figure below shows the fully integrated system. The only thing that we need to take care of is RS232 of the GSM modem and RS232 of the PICDEM board connection. That is PIN 2 of GSM should be connected with PIN 3 of PICDEM board and PIN 3 of GSM should be connected with PIN 2 of PICDEM board.

6.1. Result and Testing of Overall System Functionality

The fully integrated accidental fall detection System was put to a functionality test to confirm that all the hardware and software coding and interfacing were working well. The figure below shows the full set up of the whole system.
Results from the overall functionality test for the system proved that the objectives of this project have been achieved. It was observed that once the help button was pressed or the accelerometer was manipulated to cause the microcontroller to detect voltage variation beyond the acceptable limits, the system was activated. One could be able to hear the relay switching and could see the flash light being activated together with the sounding of the buzzer and lastly the predefined SMS text message was also received on the mobile phone.

![Image](image_url)

**Figure 6.2: Alarming message notification**

7. Conclusion

The aim of the project was to design and build a prototype of design and implementation of an accidental fall detection system for elderly which alerts for the loved ones or care givers when the elder populations are in need of immediate attention due to an emergency. Then having developed this prototype it worth much as long we are dealing with human safety.

The hardware and software were well integrated together. The objectives of the project had been achieved. The hardware was able to send an SMS out when the accelerometer detects a sudden change in angle. This includes an emergency button that enables the elderly or the user to press it manually in any case if there is a need of help.

This prototype is developed and tested with satisfactory working condition. There are rooms for further improvements in this fall detection system for the elderly. The recommendations for further improvements are discussed in the following section.

Reference