10. PEER CARE – CHALLENGING THE MONITORING APPROACH THROUGH EMBEDDED SENSORS

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INTRODUCTION

With the rising count of dependent population, the necessity for ad hoc care and intensive monitoring has been gaining excessive attention lately. Care takers prefer a system that automatically reports on the activity of their peer and alert them on any mis-hap. Home environments that can monitor automatically the activities of their occupants ,can help extend independence, quality living and reduce healthcare costs. In particular , patterns of inactivity can be used to make inferences about health and to help detect falls. It is important to note that the significance of inactivity changes with context.

Detection of a falling person in an unsupervised area is a practical problem with applications in safety and security areas including supportive home environments and CCTV surveillance systems. Intelligent homes make use of a multitude of sensors including surveillance cameras. Currently used worn sensors include passive infrared sensors, accelerometers. However, they may produce false alarms and elderly people simply forget wearing them very often.

OBJECTIVE

Automatic semantic summarisation of human activity and detection of unusual inactivity are useful goals for a monitoring system operating in a supportive home environment. Our system aims at ***detection of fall****-one of the primary reasons for sudden inactivity*. The method presented here enables detection of inactivity outside usual zones of inactivity (e.g. chairs, beds). When combined with body pose and motion information this should provide a useful clue for fall detection. In addition, a human-readable description of activity in terms of semantic regions provides a useful summary of behaviour.

PROBLEM DEFINITION

- To develop a monitoring system that collects information about the occupants of a house who require special care and alert their care taker if a fall is detected.

- To develop a monitoring system that overcomes the drawbacks of the existing monitoring approaches, some of which are:

  - Use of cameras for monitoring may intrude the privacy of the person monitored. For example, placing of cameras inside lavatory might be unethical and might intrude the person's privacy. The cost of implementation is high and requires lots of cameras to monitor a large area and a house with large number of rooms. This method requires complex image processing algorithms.

  - Wearing of sensors along with the clothes is another existing system. It has lots of issues. For instance, Alzheimer's patients frequently strip themselves of clothing, including any wearable sensors. Elderly individuals are also more sensitive to small changes in environment.

APPLICATIONS OF THE SYSTEM

The primary applications of our project are highlighted below.

Figure 1. Picture depicting various situations where monitoring is necessary

- **REMOTE MONITORING OF DEPENDENT PEOPLE:** Remote monitoring of people with this system reduces the stress level of the care giver. This system can be used to monitor an aged person or a small child or people with physical or cognitive disorder. It gives details of their activity. It also alerts the care taker when a fall is detected.

- **SURVEILLANCE:** To monitor any intrusion inside the restricted area. To alarm a person about the status of his haunted house and to alert them in case of entry of aliens or robbers. To detect any intrusion in banks where valuables are placed.

DESIGN APPROACH AND DESIGN

An illustration of our system is shown below

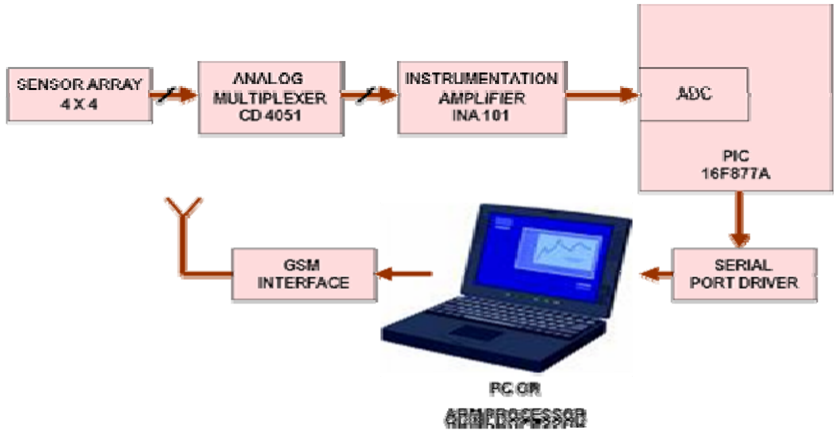


Figure 2. Block diagram of our system

The sensors are placed in the form of a matrix in between the tiles and the data is taken parallelly from all the points in a room. The sensors must be placed with a spacing of ½ feet between each other. The analog multiplexers(4051)are used to collect data from different sensors simultaneously. The analog multiplexers are used because the voltage output of the sensors will be in the range 0-100mv.The instrumentation amplifier is used to amplify the very small voltage produced by the sensors and are used to manipulate the differential voltage across the sensors. The analog voltage is amplified to such a level that they can be converted to digital form using the PIC. The PIC 16f877A is used to collect the amplified differential voltage from instrumentation amplifier and convert it to digital form. It stores the data. The data is collected every second and is stored. The PIC data is fed into the ARM processor or PC for applying our algorithm and manipulating results. We currently use ***MATLAB TOOL*** for implementing our algorithm. We make use of ***change detection*** as our key idea behind the fall detection.

SENSORS-STRAIN GAUGES

Strain gauges are devices whose electrical resistance varies in proportion to the amount of strain in the devices. The most widely used gauge is the bonded metallic strain-gauge which consists of a very fine wire or metallic foil arranged in a grid

pattern. The grid pattern maximizes the amount of foil subject to strain in the parallel direction .The cross-sectional area of the grid is minimized to reduce the effect of shear strain and Poisson strain. The grid is bonded to a thin backing, called the carrier, which is attached directly to the test specimen.

Therefore, the strain experienced by the test specimen is transferred directly to the strain gauge, which responds with a linear change in electrical resistance. The figure 3 on the left shows a metallic strain gauge and the strain gauge implemented in a cantilever system is at the right.

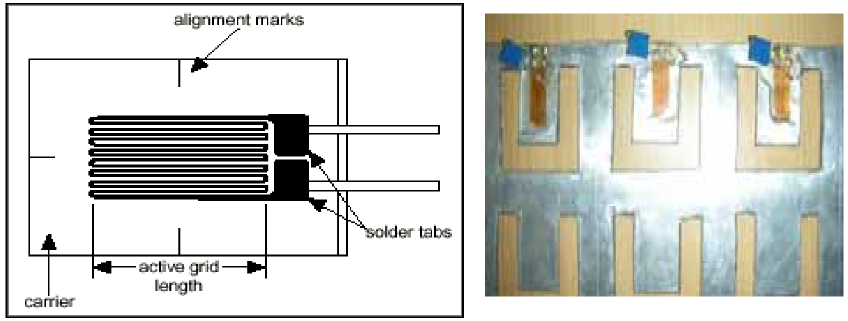


Figure 3. Strain Gauges

The strain gauges are bonded to an aluminium plate in a cantilever structure as shown and the voltage is measured across a bridge circuit. The bridge circuit is formed with strain gauge as one of the resistance forming the bridge. We have used strain gauges of value ***120 ohm.*** The bridge is balanced with the pot. When a strain is applied over the gauges the bridge gets unbalanced. There is a raise in the voltage from absolute zero to few milli volts.

The change in voltage will be only in the order of 0.1 milli volts for every 1 kg increase in weight placed on the cantilever system. This output is taken from every sensor node and fed into the multiplexer. The analog multiplexer 4051 switches between each sensor nodes and passes the analog input into the instrumentation amplifiers. The instrumentation amplifier is tuned to a gain of 100. The figure 4 shows the circuit design.

Instrumentation amplifier Gain = $1 + (40k\Omega/R_G)$

The resistance R_G is the resistance used to vary the gain of the instrumentation amplifier. Its value is tuned to around 404 ohm for a gain of 100.

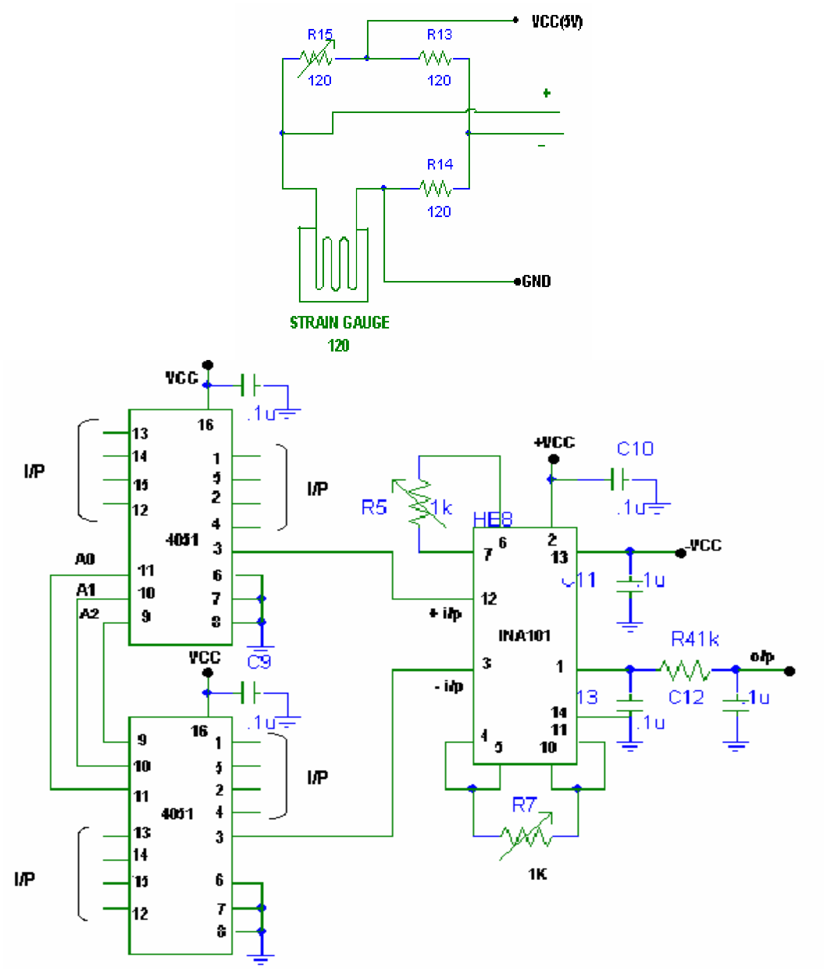


Figure 4. Bridge circuit and the instrumentation amplifier circuit

The PIC 16f877A has analog to digital converters. The pins 2 to 7 are adc channels. We can make use of any one of the channels to feed the analog input. The PIC is programmed to acquire the data and the digital output is stored and forwarded to the personal computer. The personal computer makes use of the ***matlab tool*** for processing. The figure 5 shows the PIC circuit and the serial interface.

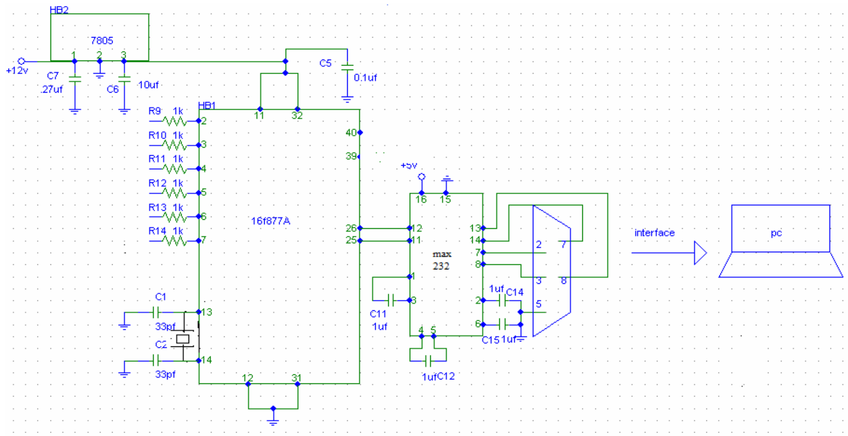


Figure 5. PIC circuit and serial interface

TESTING AND IMPLEMENTATION

TEST RESULTS

The sensor data is taken for processing every second. The voltage levels in digital form are compared with its previous frame for any change. The difference in the frames is stored in the database for future reference. If the change is catastrophic, then there is an indication of abnormality. The threshold is fixed based on the real time data taken from the sensors.

Various weights like 1kg, 2kg upto 80 kgs are placed on the cantilever system. The voltage is acquired by the PC using the data acquisition system. The voltage matrix is first stored in the database.Then change in weight for every kg is plotted. This data gives us a static response of the system. The voltage levels obtained will be in the order of millivolts. The difference for each kilo gram rise is in the order of few micro volts. The threshold is fixed based on this value.

The graph is plotted with the test data and shows the linear increase in the sensor voltage for a constant increment in the weights. The data obtained every second is compared with the threshold matrix and the previous frame. If an abnormal peak is detected an alert message is swiftly sent to the care taker through the GSM system.

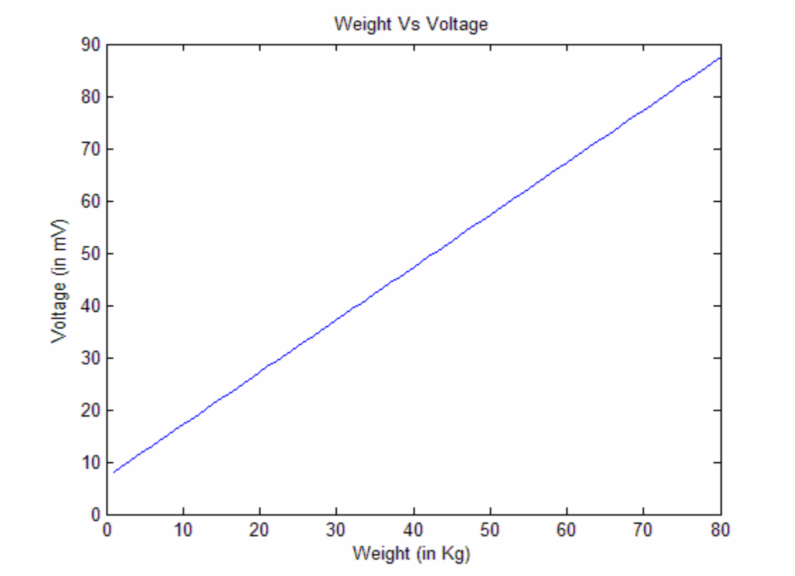


Figure 6. weight vs voltage plot

IMPLEMENTATION

For child monitoring, an average weight of 20Kg is assumed. From the results of testing, it is quite evident that the corresponding static response would be around 27mV.The threshold voltage is set to approximately 35mV, considering all the likely issues to be encountered. The sensor data are compared with the previous frame and the threshold value. As the above sequence of frames hold the voltage values falling below the threshold voltage and comparable with the previous frame voltage values, it is identified as a normal activity. Considering the sequence of frames, a peak voltage

of about 40mV is noticed, which obviously exceeds the threshold and so is identified as an abnormal activity. Whenever there happens to be an abnormal condition, the GSM module is activated, which immediately sends an SMS to the care-taker. Further, a warning window too appears intimating the care-taker about the abnormal activity.

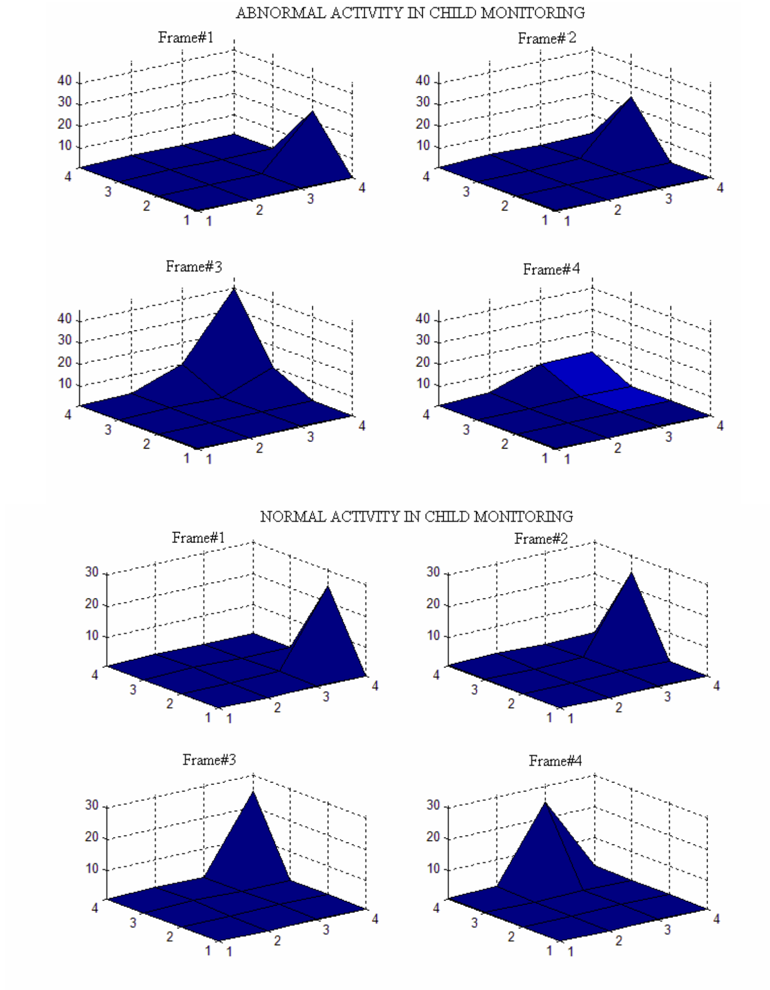


Figure 7. Graphs plotted for the data manipulated for a small child

SNAPSHOTS OF THE SYSTEM

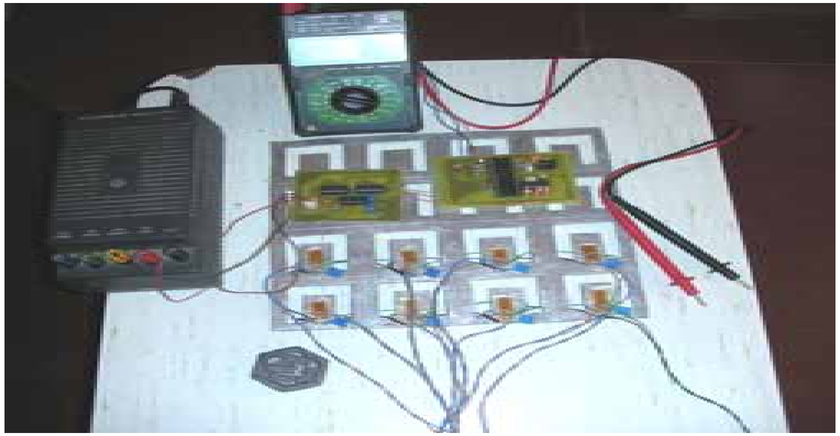
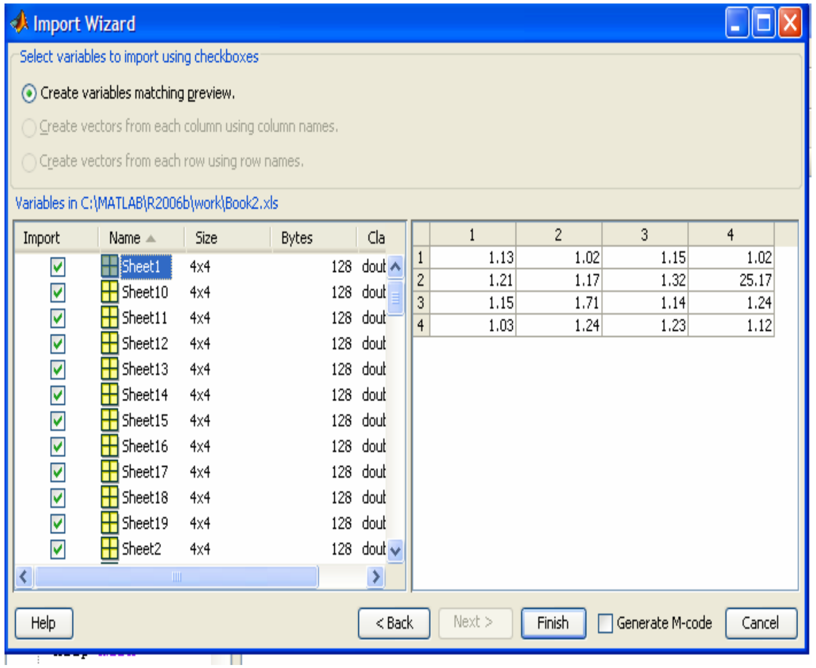


Figure 8. The monitoring system



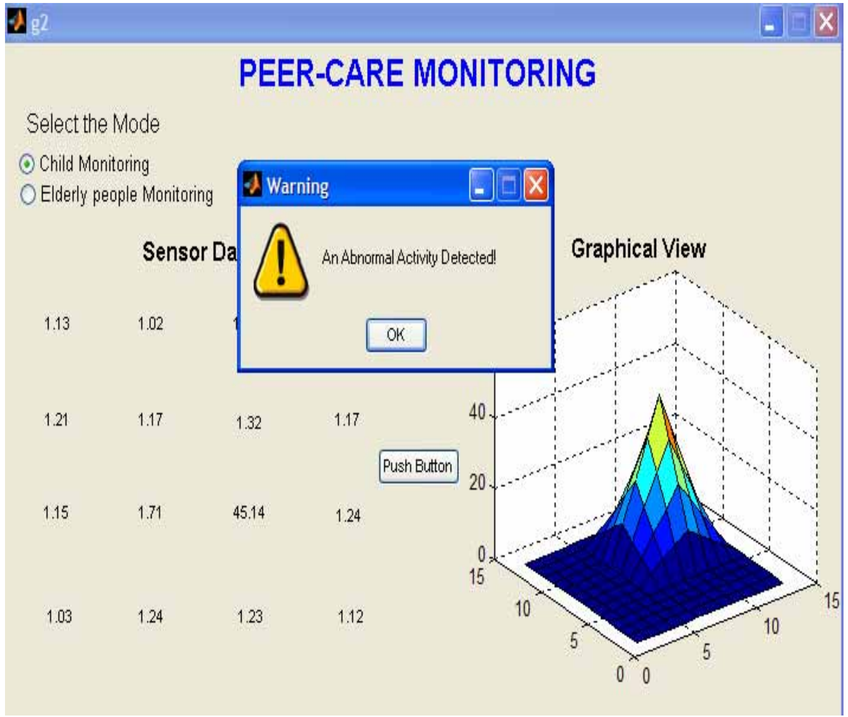


Figure 9. The data display window and the database display

PROBLEMS ENCOUNTERED

The project was proposed to be done with piezo electric sensors. But their acquisition was found to be difficult. So we had to go for strain gauges. The strain gauges are highly temperature sensitive. They tend to shift the bridge balance often. But this is overcome by the placement of pot in the bridge to tune the ratio formed by the sensor and pot to be equal to the resistor ratio.Fixing of the sensors in the form of cantilever system is a major requirement. The cantilever design required great mechanical work and its application. The metal we chose to make the cantilever was aluminium. But it couldn't recover from the strain applied swiftly. This produces a shift in the output. Changing the metal with greater elasticity is an apt solution.

FUTURE WORK

- This system is currently tested for remote monitoring of elders and young children. This will be extended for surveillance. The algorithm will be remodified for the purpose of surveillance.
- This is currently tested in pc it can be implemented in ARM processor and can be made portable and cost effective.
- The system makes use of strain gauges. It will be tested with the piezo electric sensors.

CONCLUSION

Thus we have designed a system that monitors the elders and the children. This system can be implemented anywhere inside the house on the floor. The reliability of the system can be interpreted from the real time data acquired. The system is designed in such a way that it aptly alerts the care giver and reduces his stress levels and worries about his peer.

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