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Chapter 1

Introduction

1.1 Introduction to Stress

Stress is the body's reaction to any change that requires an adjustment or response. The body reacts to these changes with physical, mental, and emotional responses. It is a normal part of life and everybody has experienced it one way or the other. One can experience stress from the environment, their body, and their thoughts. The human body is designed to experience stress and react to it. Stress can be positive, keeping us alert and ready to avoid danger. Stress becomes negative when a person faces continuous challenges without relief or relaxation between challenges. As a result, the person becomes overworked and stress-related tension builds.

Stress that continues without relief can lead to a condition called distress which is a negative stress reaction. Distress can lead to physical symptoms including headaches, upset stomach, elevated blood pressure, chest pain, and problems sleeping. Research suggests that stress also can bring on or worsen certain symptoms or diseases. Early detection of this negative force on the body is very necessary to prevent chronic outcomes in the long run.

A stressful individual may also give in to bad habits like alcohol, drugs, tobacco to try to relieve their stress. Unfortunately, instead of relieving the stress and returning the body to a relaxed state, these substances tend to keep the body in a stressed state and cause more problems.

According to certain studies, 43% percent of all adults suffer adverse health effects from stress. 75% to 90% of all doctor's office visits are for stress-related ailments and complaints. Studies also show that 59% of the working class succumbed to stress related illnesses. Stress can cause a variety of illnesses ranging from obesity, heart disease, asthma to diabetes, etc. It is often most neglected area at work. Working individuals must be constantly monitored to make sure they’re alerted when they’re at the verge of reaching a stage that could cause a disruption in their working and personal lives.

1.2 Challenges and Opportunities

Given the widespread prevalence of stress in working individuals, there is a need for detection of the negative impact that stress has on an individual at early stages. Since stress is subjective to an individual there is no direct way to detect stress. A change in certain parameters like pulse rate, body temperature, sweat, etc are seen when an individual is stressed. There are some online questionnaires available that help detecting the stress level of an individual but these are totally dependent on how truthful the individual is. There are other devices that monitor body vitals. However, they don't take into consideration multiple personal factors that may have a huge impact on a person's stressful life. This presents a challenge to come up with solution to monitor stress in working individuals not only considering the changes in the body vitals of an individual but also taking into consideration the impact their work schedule and their personal lives have on them.

1.3 Problems Identified

There are a lot of statistics that prove that most illnesses in today's working class is due to stress. It is a major factor determining the health of a person. Studies in the UK show that 59% of the working class succumbed to stress related illnesses. Stress can cause a variety of illnesses ranging from obesity, heart disease, asthma to diabetes, depression, etc. It is often most neglected area at work. Working individuals must be constantly monitored to make sure they're alerted when they're at the verge of reaching a stage that could cause a disruption in their working and personal lives.

There are existing books on stress management, but frankly, no working individual would accept that he/she is under stress and decide to read a book on stress management. There are other stress management questionnaires like the ones from devised by Mayo Clinic, MSN and AOL but these don't consider the vital parameters at all which play an important role in identifying stress. We cannot entirely depend on the individual's assessment of themselves. Sometimes individuals might think they're not under stress when they look at a question because they may feel that it's not true. In such cases it is very important to consider vital parameters as vital parameters can never lie.

There are others like Biodots. These are relatively cheap and can be purchased almost anywhere online. These are plastic squares or circles which changes its color as the temperature warms up or cools down. To use it, a piece has to be peeled off and stuck to the skin (preferably in the skin between the thumb and index finger). Each color represents a state – red/brown is indicates stress, green/blue for the relaxed. But it doesn't consider the individuals personal background. Parameter like 'death in the family' strongly affect individuals' stress levels. Similarly, Stress meter/mirror monitors only body temperature change.

1.4 Problems to which the prototype is a solution

Amongst the above mentioned methods, none of them are open source and have everything that the project has to offer. It provide a way to find out the stress levels of an individual considering his/her background (through a questionnaire). There are different blocks of questions each targeting a specific area in their lives. Each of these questions have been given a weight.

Since the individual cannot be trusted completely based on the questionnaire, their body vitals are also monitored through a non-invasive stress jacket. Body vitals and his movement (to make sure the individual takes a break) through sensors. The vitals monitored include the body temperature, sweat monitoring, pulse monitoring and movement through an accelerometer.

Since each individual may have their own schedule, there is a customized calendar through which they can keep track of their daily activities and also rate it on a scale of three as to how stressful an activity is. There may be some meetings which are not so important and less stressful and the others that are very important and stressful.

Based on all these factors an algorithm run to find out an individuals' stress level constantly. There have been inputs from the doctors on how to manage the stress levels, which will then be displayed to the user through a voice and text output based on the level of stress they are experiencing. The suggestions include the doctors input as well as suggestions to reschedule their calendars if it has too many stressful activities lines up. The suggestions are also split into short and long term solutions accordingly.

Chapter 2

Problem Definition

Looking at the current scenario where

- There is a need to go to the doctor to go for a health problem but the actual reason lies in the work load.
- Stress is the most ignored but most important factor affecting the health of a person.
- There is no device used life which can both detect stress and at the same time provide solutions and suggestions to solve them which is cheap and non-invasive.

This project comes up with a prototype which detects the stress level of a person by checking the user's body vitals that include pulse rate, temperature and perspiration. The project also come up with a few possible immediate and long term solutions which the user can inculcate which will help in reducing his stress levels. It is a desktop based jacket system which is able to detect the body vitals in real time using a few sensors and according to the results received will provide solutions to the same. This is an attempt to enable both detection of stress and try to provide measures to solve it using a portable, inexpensive and non-invasive device.

Chapter 3

Literature Survey

3.1 Study and Exploration

Make a search on the internet for the term “stress” and one will see how many people are talking about it. With the global economic recession in our midst, the study of stress has become even more important. With stress affecting all major systems in the body, the lack of stress management skills has a huge impact on health and wellbeing. Our project ‘A first step towards developing a smart jacket’ is an approach to making a small but significant contribution towards this goal.

There was a lot of research done before the title was chosen. First, a week was taken to analyze all possible domains for the project. The domain is a category in which a topic was looked for. It was narrowed down to a healthcare domain. The next week involved reading multiple papers, journals, etc that were published in the recent few years to look for topics that would seem most interesting. Fifteen topics were shortlisted after which the guide helped narrow it down to twelve. The topics ranged from addiction, cerebral palsy, sleep related disorders, disorders related to children, stress related illnesses, gait tracking, cardio vascular monitoring, drug addiction, air quality monitoring, gaming addiction, and muscle related disorders and a few others. The papers were studied closely and eliminated based on feasibility of input data, intrusiveness and relevance to the current scenario. This also ensured eliminating those ideas that were already implemented. This helped shortlist about eight ideas. Further research was done on these eight ideas based on what kind of input can be taken for the idea, if any sort of hardware was required and what each idea could achieve. The ideas were grouped so that similar ideas could be grouped together to come up with a good project idea.

The shortlisted ideas included cerebral palsy, stress at work, gaming addiction, cardio vascular monitoring, indoor air quality measurement, muscle related disorder, etc. Among these, the projects for which a potential solution could be given were selected. Some ideas were eliminated based on this criteria like muscle related disorders. The ideas that needed absolutely no software solutions and those that needed a lot of data that had to be manually entered by the user were removed. The pre-final short list narrowed it down to three ideas.

The ideas that had passed all the previous evaluations were – Gaming addiction, Stress at work and Cerebral palsy. Cerebral palsy was observed only in children and it would be very hard to get input data from small children. Putting a wearable device on a child would also pose a problem and there was no solution that we could offer for such a disorder due to which this idea was also dropped. For the other two ideas, the possible hardware implementations, a complete set of input parameters that would be needed, proposal of the idea, the solution and a problem statement were documented. Gaming addiction was a new topic, there was lot of scope for this idea, lot of flexibility for implementation but the complexity of the project was very high. It would require a lot of algorithms that would need to be implemented which was not feasible due to our strict time constraints. Finally, the idea of "Stress at work" was decided. A prototype which is the first step towards developing a smart jacket.

There are a lot of statistics that prove that most illnesses in today's working class is due to stress. It is a major factor determining the health of a person. Studies in the UK show that 59% of the working class succumbed to stress related illnesses. Stress can cause a variety of illnesses ranging from obesity, heart disease, asthma to diabetes, depression, etc. It is often most neglected area at work. Working individuals must be constantly monitored to make sure they're alerted when they're at the verge of reaching a stage that could cause a disruption in their working and personal lives. The smartjacket prototype monitors certain body vitals of a working individual such as sweat, temperature, heart rate and develop a stress index that can be used to monitor an individual's stress levels. An accelerometer attached to the shoulder to constantly remind the individual to take frequent breaks at work.

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There are others like Biodots. These are relatively cheap and can be purchased almost anywhere online. These are plastic squares or circles which changes its color as the temperature warms up or cools down. To use it, a piece has to be peeled off and stuck to the skin (preferably in the skin between the thumb and index finger). Each color represents a state – red/brown is indicates stress, green/blue for the relaxed. But it doesn't consider the individuals personal background. Parameter like 'death in the family' strongly affect individuals' stress levels. Similarly, Stress meter/mirror monitors only body temperature change. Amongst these, none of them are open source and have everything that smartjacket has to offer. Smartjacket provides a way to find out the stress levels of an individual considering his/her background (through a questionnaire), body vitals and his movement (through sensors), give suggestions to reschedule his/her calendars and also provide long term and short term suggestions made by certified doctors based on the amount of stress.

The strong motivation towards building this project was that there are a lot of IT individuals, teachers, parents, etc who show symptoms of stress. IT companies don't realize the implications of stress. It is one major factor that is neglected. To stress on this fact, we are building a prototype that is a step towards reducing the impact of stress on an individual that would help in the long run. It is not a complete solution but a small significant step towards helping people with this illness. Some other studies done for the project include –

1. Arduino

The Arduino is an open-source electronics prototyping platform based on flexible, easy-to-use hardware and software. Arduino can sense the environment by receiving input from a variety of sensors and can affect its surroundings by controlling lights, motors, and other actuators. The microcontroller on the board is programmed using the Arduino programming language (based on Wiring) and the Arduino development environment (based on Processing).

2. Temperature sensor LM35

The LM35 is an integrated circuit sensor that can be used to measure temperature with an electrical output proportional to the temperature (in °C). The temperature sensor is used to measure the subject's hand temperature as it is commonly found that most people have temperature variations when going through emotional turmoil. This symptom is monitored through the temperature sensor.

3. Accelerometer and Gyrometer MPU-6050

The MPU-6000™ family provides integrated 6-axis MotionProcessing™ solution that eliminates the package-level gyro/accel cross-axis misalignment associated with discrete solutions. The devices combine a 3-axis gyroscope and a 3-axis accelerometer on the same silicon die together with an onboard Digital Motion Processor (DMP) capable of processing complex 9-axis MotionFusion algorithms. This data is used to check the relative position of a person. Whether or not he has taken a break in the past few minutes and has been continuously working.

4. Galvanic Skin Response

The Galvanic Skin Response (GSR) is defined as a change in the electrical properties of the skin. The signal can be used for capturing the autonomic nerve responses as a parameter of the sweat gland function. The combined changes between galvanic skin resistance and galvanic skin potential make up the galvanic skin response. Galvanic skin resistance (GSR) refers to the recorded electrical resistance between two electrodes when a very weak current is steadily passed between them. The electrodes are normally placed about an inch apart, and the resistance recorded varies according to the emotional state of the subject. Galvanic skin potential (GSP) refers to the voltage measured between two electrodes without any externally applied current. It is measured by connecting the electrodes to a voltage amplifier. Similarly, this voltage varies with the emotional state of the subject.

5. Easy Pulse Heart-rate sensor TCRT1000

This project is based on the principle of photoplethysmography (PPG) which is a non-invasive method of measuring the variation in blood volume in tissues using a light source and a detector. Since the change in blood volume is synchronous to the heart beat, this technique can be used to calculate the heart rate. Transmittance and reflectance are two basic types of photoplethysmography. For the transmittance PPG, a light source is emitted in to the tissue and a light detector is placed in the opposite side of the tissue to measure the resultant light. Because of the limited penetration depth of the light through organ tissue, the transmittance PPG is applicable to a restricted body part, such as the finger or the ear lobe. However, in the reflectance PPG, the light source and the light detector are both placed on the same side of a body part. The light is emitted into the tissue and the reflected light is measured by the detector. As the light doesn't have to penetrate the body, the reflectance PPG can be applied to any parts of human body. In either case, the detected light reflected from or transmitted through the body part will fluctuate according to the pulsatile blood flow caused by the beating of the heart. We capture the heart-rate of a person as an elevated heart-rate is a very evident indication of stress(Physical or emotional).

Chapter 4

Project Requirements Definition

4.1 Project Perspective

Stress at work has become a serious problem affecting many people of different professions, life situations, and age groups. The workplace has changed dramatically due to globalization of the economy, use of new information and communications technologies, growing diversity in the workplace, and increased mental workload. The problem of job stress is generally recognized as one of the major factors leading to a spectrum of health problems.

The project aims at analyzing stress levels in working individuals who are subjected to stressful working conditions and hence provide long term and short term solutions along with suggestions to reschedule their stressful activities. This is done based on the following observations.

i. Heart rate, body temperature, sweat are some of the important indicators of stress. Leveraging the sudden change in these parameters can help us detect stress in a comfortable way.

ii. The individual is made to answer a questionnaire that will help us to understand the background of the individual.

iii. To help analyze stress levels, daily activities play an important role. Hence we take inputs from the individual's calendar as well.

iv. Collectively, all these parameters will help us analyze the stress level of the individual. Using this, we can suggest some rescheduling methods in order to manage his calendar activities.

v. We also provide long term and short term solutions for the same.

Compared to the other types of stress management softwares, this can be used in the individual's working environment in a non-invasive way. The vital parameters are detected using a non-invasive glove.

4.2 Project Functions

The following are the functions the prototype performs:

1. Arduino board: The Arduino board interfaces with the desktop and exchanges data and commands in real time.
2. GSR Circuit: Captures changes in the electrical properties of the skin which varies according to the change in the emotional state of the person.
3. KY-039: Captures the pulse of the individual using a phototransistor.
4. MPU6050: Accelerometer and gyroscope combination that is used to measure displacement of the individual.
5. LM35: Is a temperature sensor that is used to measure the temperature of the individual.

4.3 User Classes and Characteristics

User: Person Taking the Stress Test

Type: Continuous

4.4 Operating Environment

During working hours when the user in his/her work place where there are possibilities of varied stress levels.

4.5 Design and Implementation Constraints

1) Detecting the heart rate of a person is not an easy job and can be done most accurately only by doctors. Since a sensor is used for this purpose in our project the accuracy may not be as perfect as required .The Easy Pulse HeartRate sensor uses a light source to check

variations in blood volume in tissues which is synchronous to the heartbeat because of which the light from outside can affect the efficiency of the circuit.

2) The temperature sensor may not be exactly the body temperature as the temperature of the environment will also affect the sensor.

3) The jacket is connected to the laptop through a USB Cable. So, the movement of the person is constrained to the length of the cable. A cable was used because there is continuous transfer of huge amounts of data within a few seconds so the use of Bluetooth or Wifi would impose a delay and would hence effect the processing.

4.6 User Documentation

1) Power on the arduino.

2) The user is required to wear the jacket along with the glove such that, the index finger is placed slightly inside the heartbeat sensor, the middle finger and the ring finger will have the copper strips wrapped around them and the little finger is covered with the temperature sensor.

3) Open the Web application on the laptop and connect the arduino to the laptop for serial transfer of data.

4) Fill in the questionnaire and Calendar schedule. Run the processing code for accessing data from arduino.

5) The Web Application has a User Interface to do the following functionalities:

   a) To access and fill in the questionnaire and calendar.

b) To view immediate solutions and long term suggestions for the current stress level.

c) To view a graphical representation of the stress level in the past few seconds and the variations in the persons schedule

4.7 Assumptions and Dependencies

1) The person is assumed to be stationary in a particular position during the first 36-40 seconds as the readings which follow are compared to these.

2) The galvanic skin response is calculated assuming the initial conductance measured is the conductance of the person who is not under stress.

3) Person using the prototype owns a laptop and is working on it.

Person should move around in the radius that the cable can reach.

Chapter 5

Software Requirements Specification

5.1 External Interface Requirements

5.1.1 User Interfaces

- Main page containing navigation to all functionalities.
- Interface to take a quiz during application setup.
- Interface to update schedule in the calendar.
- Interface to view Stress Graph for a particular time period.
- Interface to view Immediate solutions
- Interface to view long term suggestions.

5.1.2 Software Interfaces

- Operating system : Windows
- Database: MySql
- Language : Python for the desktop application
- Libraries such as pyserial for interaction with arduino
- Language specific to microprocessor - arduino
- Bootstrap styling library.

5.2 Hardware Requirements

1. Components to build the Stress Jacket:// haven't decided yet//a jacket to embed the required detectors
2. Detectors within the stress Jacket:
   Temperature sensors

   Heartbeat Sensors

Accelerometers

For GSR: copper wires, resistors, LEDs, capacitors, Batteries

3. Microcontroller: Arduino Mega
4. Laptop
5. External Power Supply: A 12V battery

5.3 Functional Requirements

1. Measure Electrocardiogram.

    - **Description:** Measure the heart-rate of the subject.
    - **Input**: Sensor input from the Arduino board.
    - **Output**: Level of the heart-rate based on a predetermined scale.

2. Measure Temperature.

    - **Description:** Measure temperature of the subject's hand.
    - **Input:** Sensor input through the Arduino board.
    - **Output:** Normal/Abnormal temperature based on the deviation from the expected value for a healthy person.

3. Measure Galvanic skin response.

    - **Description**: Based on the electric conductivity of the skin, sweat levels are measured
    - **Input**: GSR Circuit readings through Arduino board.

- **Output**: Index based on a predetermined scale

4. Evaluate Questionnaire once in 6 months
    - **Description**: Based on the questionnaire answered by the user
    - **Input**: Weighted answers to all the questions.
    - **Output**: Index based on a predetermined scale.

5. Assess Calendar Entries every 24 hours
    - **Description**: Based on the calendar entries of the user.
    - **Input**: Marked entries based on type and priority.
    - **Output**: Index based on a predetermined scale.

6. Calculate Stress Index every 60 seconds.
    - **Description**: Based on the combined indexes of the sensors, calendar events and questionnaire.
    - **Input**: Index derived from calendar entries, index from the questionnaire and pre-processed sensor input.
    - **Output**: Index based on a predetermined scale.

7. Display Stress Level Graph.
    - **Description**: Based on the calendar entries of the user.
    - **Input**: Marked entries based on type and priority.
    - **Output**: Index based on a predetermined scale.

8. Long term solution suggestions.
    - **Description**: Lifestyle alteration suggestions beneficial in the long run made based on expert consultation.
    - **Input**: Stress index.
    - **Output**: Predetermined suggestions based on the stress level.
9. Immediate solutions suggestion
    - **Description**: Immediate relieving suggestions beneficial in the long run made based on expert consultation.
    - **Input**: Stress index.
    - **Output**: Predetermined suggestions based on the stress level.

5.4 Non Functional Requirements

The non-functional requirements are:

5.4.1 Performance

1. Must collect data from vital parameters every 15mins.
2. Stress index generation algorithm must be real time.

5.4.2 Reliability

The real time glove system must be robust so that it doesn't break when used for long periods. The algorithm must be able to handle the data that is being generated. Database connection has to be maintained. The calendar input and questionnaire are assumed to be truthful.

5.4.3 Portability

The glove must be non-invasive and should be capable of being used without hindering any user activity.

5.4.4 Maintainability

The jacket must be easily wearable.

5.4.5 Implementation

All the existing software used in the project must be the latest versions.

Chapter 6

Gantt Chart

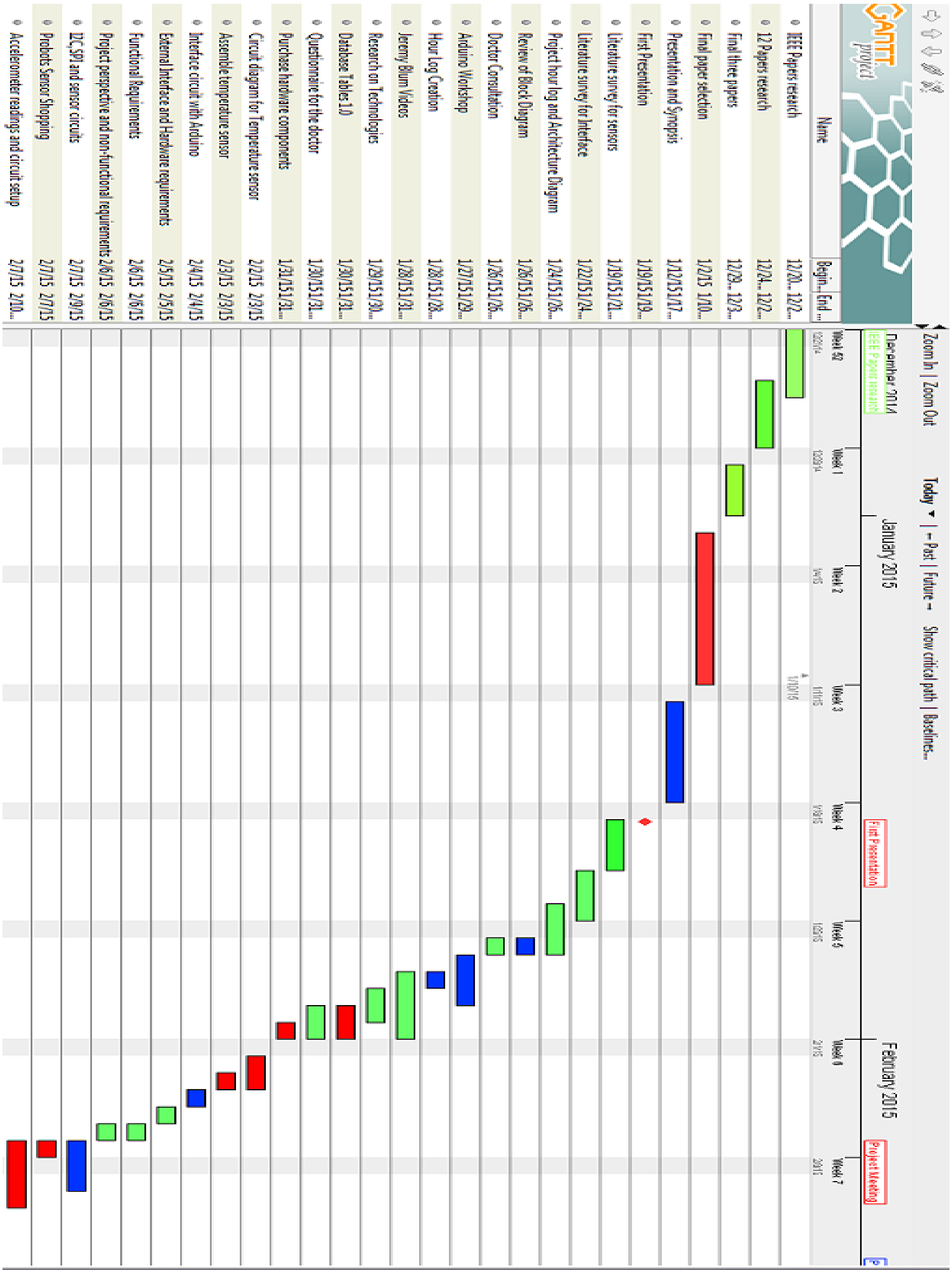

Fig 6.1 Gantt Chart December-February

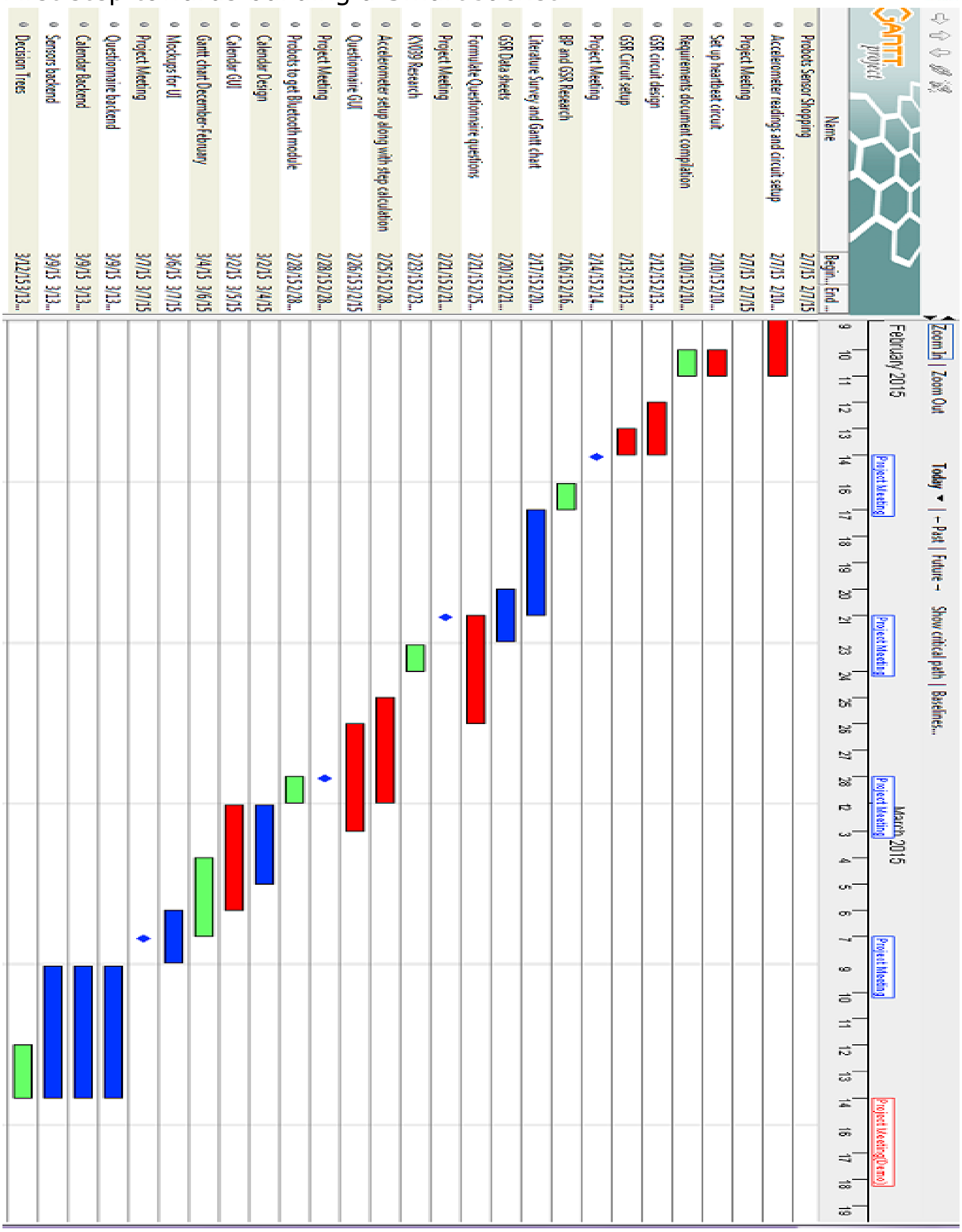

Fig 6.2 Gantt Chart February-March

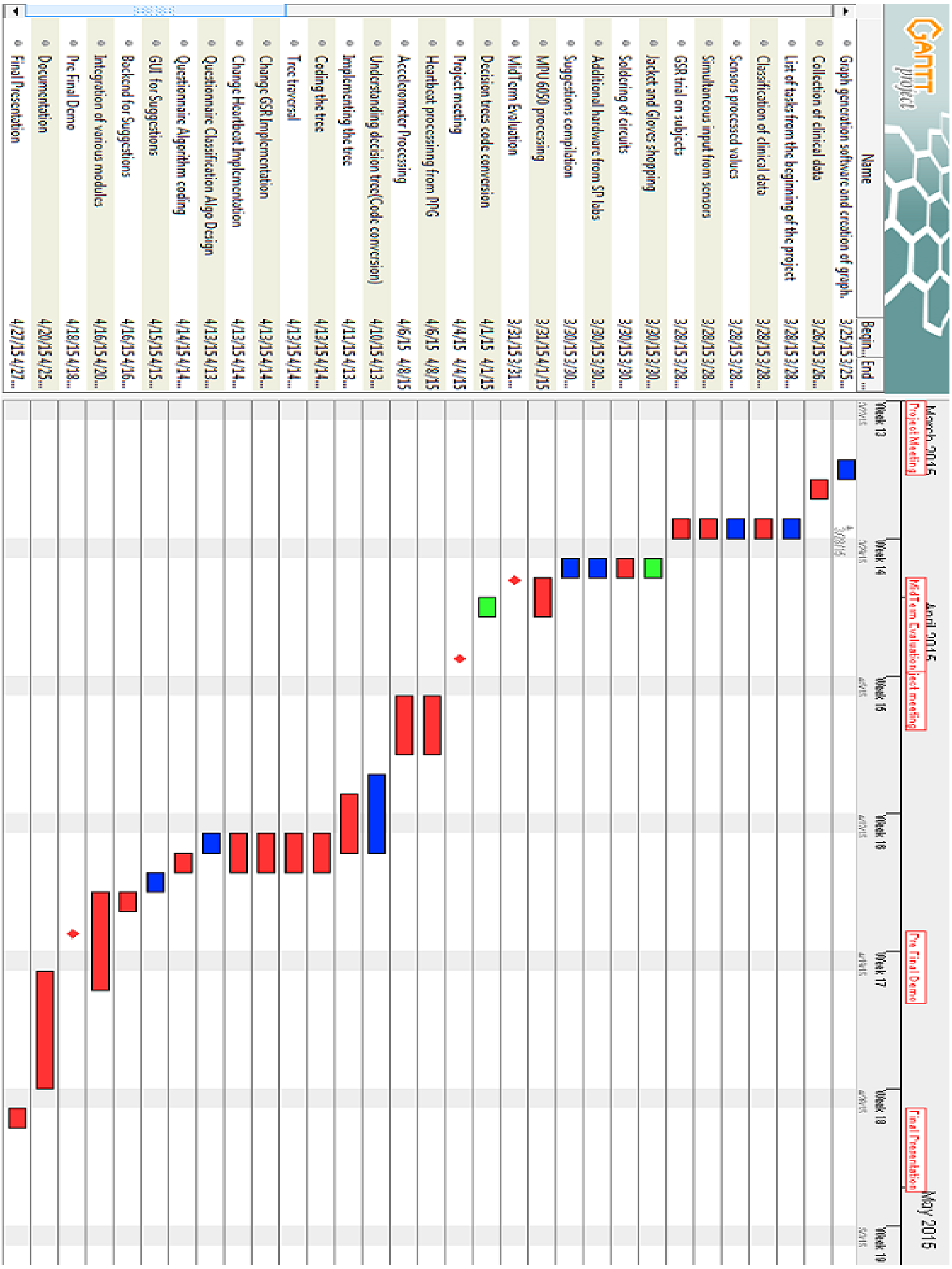

Fig 6.3 Gantt Chart March-April

Chapter 7
System Design

7.1 Block Diagram

The system is divided into the following subsystems:

- Smart Jacket
- Computer

With the arduino board forming the interface between Jacket and Computer.

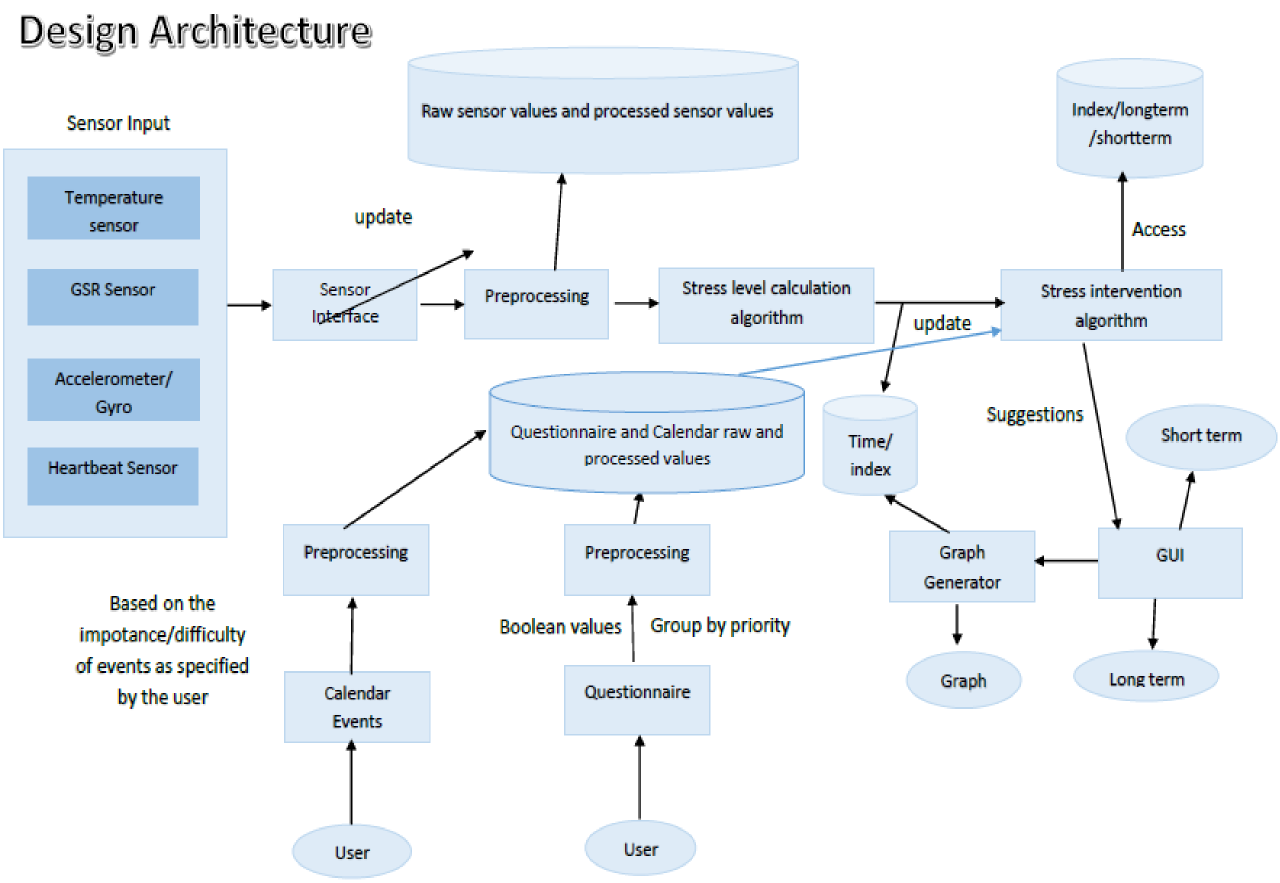

Fig 7.1.1 Block Diagram

7.2 Architecture

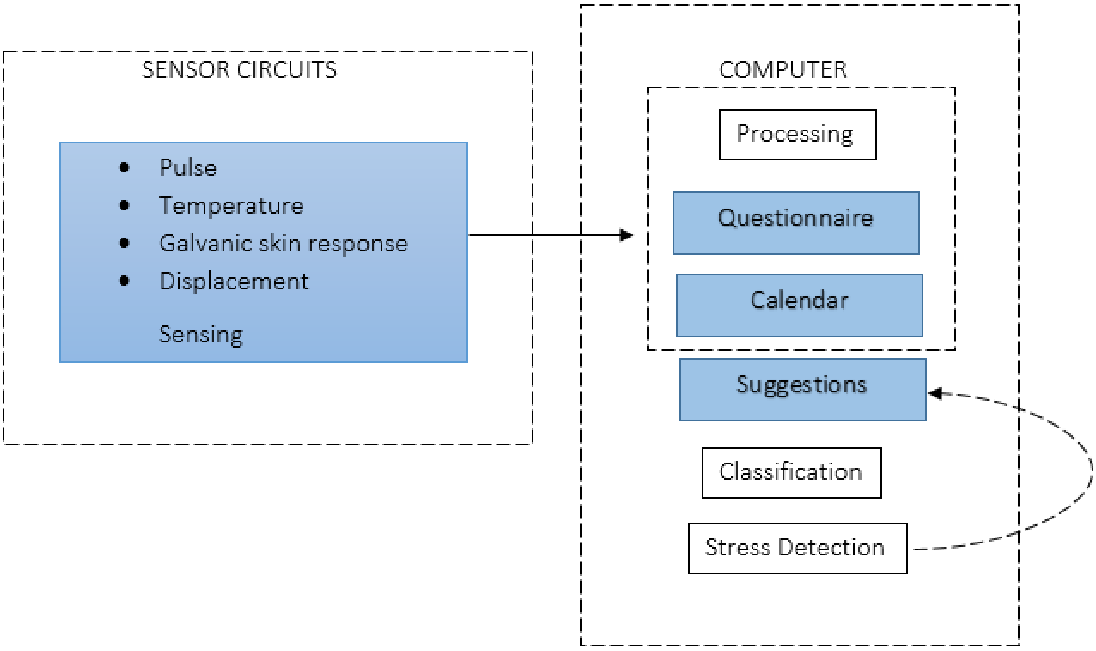

Fig 7.2.1 Architecture

The system is divided into the following subsystems:

- The Jacket with the sensors
- The laptop/desktop

A brief description of each component is as follows -

1. The Jacket includes four sensors to measure heartbeat, temperature, sweat and movement.

   a. Easy pulse – Heartbeat sensor

This is based on the principle of photoplethysmography (PPG) which is a non-invasive method of measuring the variation in blood volume in tissues using a light source and a detector. Since the change in blood volume is synchronous to the heart beat, this technique can be used to calculate the heart rate. Transmittance and reflectance are two basic types of photoplethysmography. For the transmittance PPG, a light source is emitted in to the tissue and a light detector is placed in the opposite side of the tissue to measure the resultant light. Because of the limited penetration depth of the light through organ tissue, the transmittance PPG is applicable to a restricted body part, such as the finger or the ear lobe. However, in the reflectance PPG, the light source and the light detector are both placed on the same side of a body part. The light is emitted into the tissue and the reflected light is measured by the detector. As the light doesn't have to penetrate the body, the reflectance PPG can be applied to any parts of human body. In either case, the detected light reflected from or transmitted through the body part will fluctuate according to the pulsatile blood flow caused by the beating of the heart.

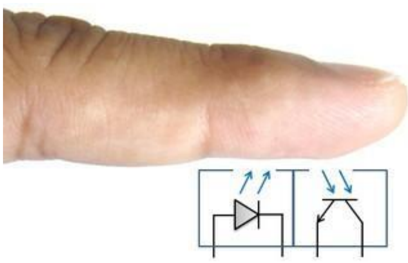

Fig 7.2.2 Pulse sensor working

The following picture shows a basic reflectance PPG probe to extract the pulse signal from the fingertip. A subject's finger is illuminated by an infrared light-emitting diode. More or less light is absorbed, depending on the tissue blood volume. Consequently, the reflected light intensity varies with the pulsing of the blood with heart beat. A plot for this variation against time is referred to be a photoplethysmographic or PPG signal.

The PPG signal has two components, frequently referred to as AC and DC. The AC component is mainly caused by pulsatile changes in arterial blood volume, which is synchronous with the heart beat. So, the AC component can be used as a source of heart rate information. This AC component is superimposed onto a large DC component that relates to the tissues and to the average blood volume. The DC component must be removed to measure the AC waveform with a high signal-to-noise ratio. Since the useful AC signal is only a very small portion of the whole signal, an effective amplification circuit is also required to extract desired information from it.

b. Temperature sensor

For certain people the finger tips tend to get cold under stress. In order to detect this the temperature sensor is used. The temperature is given out in degree Celsius. An LM35 sensor is used. It can measure temperature more accurately than a using a thermistor. The sensor circuitry is sealed and not subject to oxidation, etc. The LM35 generates a higher output voltage than thermocouples and may not require that the output voltage be amplified. It has an output voltage that is proportional to the Celsius temperature. The scale factor is .01V/°C. The LM35 does not require any external calibration or trimming and maintains an accuracy of +/-0.4 °C at room temperature and +/- 0.8 °C over a range of 0 °C to +100 °C.

c. Accelerometer

We are suing a 6DOF accelerometer which is used to detect movement of the user. Taking into the fact that the jacket is used at a work place, in order to find out if the user is taking breaks in between his working hours this sensor is used. The sensor gives out accelerometer values using which we can detect if there is motion or not.

d. GSR

Under stress there is sweat generation at the finger tips, this is monitored by the Galvanic Skin Response Circuit. This circuit basically checks the potential difference between the two fingers. As a person sweats the

conductance increases and the resistivity decreases this is monitored by the circuit. The circuit consists of a resistor and a capacitor in parallel, where one end goes to ground and the other end goes to one ring on the finger and the analog input pin on the arduino.

This raw data goes into the serial monitor from where it is accessed and used for processing.

2. Sensor Pre-processing

The data from the raw input table in the database is pulled continuously and all the sensor values are now separated. The sensor values are processed at regular intervals and the processed values are updated in the database for further use.

3. Calendar

A customized calendar is made such that the user can himself specify how difficult an activity is for him. An event which might be very stressful for one person may not be stressful for another so the calendar is made such that it learns how the activities are lined up for the days of that month and how it is affecting his/her stress level. The calendar has three priority values : high, medium and low. According to the priority level chosen by the user these values are processed.

4. Questionnaire

Stress is not dependent on only one factor. There may be multiple factors subjective to each individual that need to be considered. For instance history of a person plays a very crucial role in how soon a person can get stressed. The questionnaire consists of five sets of questions which include physical related, work related habitual, personal life related and health related questions. According to the answers given by the user these questions are validated and used. The questionnaire also takes into consideration factors like whether the person sweats at the time of stress. If he doesn't, GSR values are given lower priority during the processing.

The processed calendar and questionnaire are updated in the database for further use.

5. Stress level calculation

Based on the processed values of the calendar, questionnaire and sensors, decision tress are used to calculate the stress level of the individual based on the above inputs. As and when the algorithm runs, the tree learns from the previous values. There are are 4 levels of stress detected – Slightly stressed, mildly stressed, stressed and very stressed. These are again calculated at regular time intervals and stored in the database.

6. Stress intervention algorithm

A number of doctors were consulted regarding stress and they provided us with a number of short term and long term solutions. These solutions were classified based on the stress level detected. The suggestions are shown according to how stressed the individual is after constant monitoring.

7. GUI

   a. The user interface is simple and consists of a page to take up the questionnaire, a page to update his/her calendar details, a page for the suggestions and a page that shows the stress graph during the time of monitoring.

   b. There are two kinds of graphs – a stress graph that plots the graph based on the stress levels indicated and a graph of the calendar activities for the entire month to get a picture of how stressful his/her calendar entries are.

   c. The suggestions are also provided with a voice output. There is also an option to play soothing music to calm oneself down.

7.3 Use Case Diagram

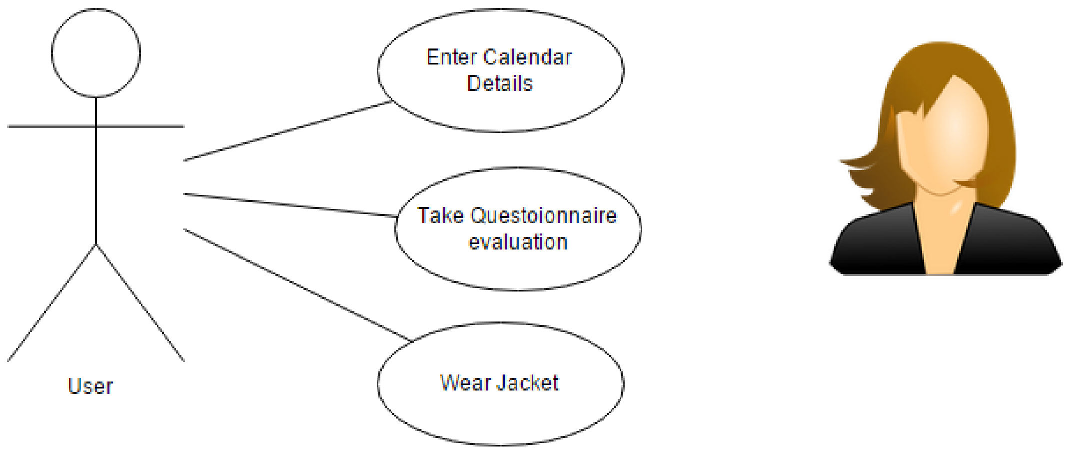

Fig 7.3.1 Use cases

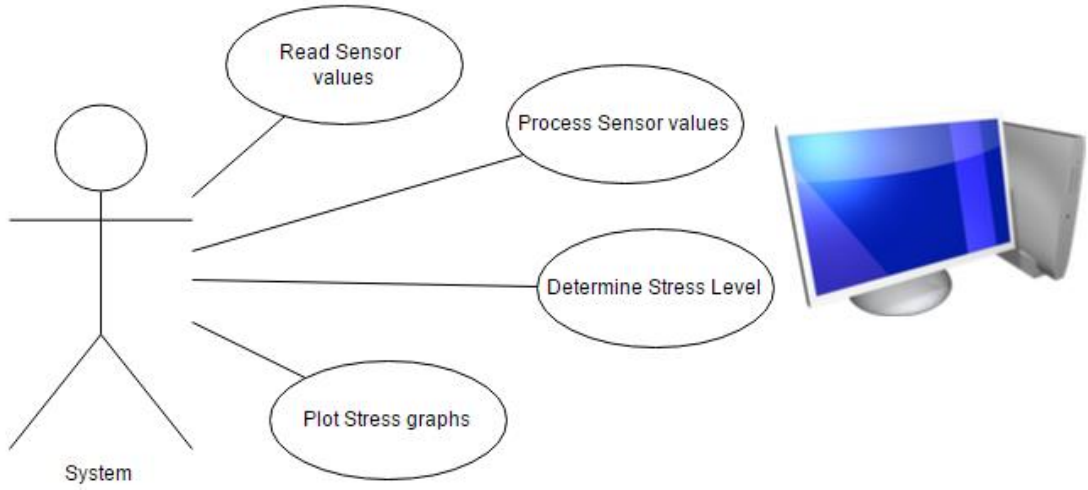

Fig 7.3.2 Use Cases

7.4 Database Design

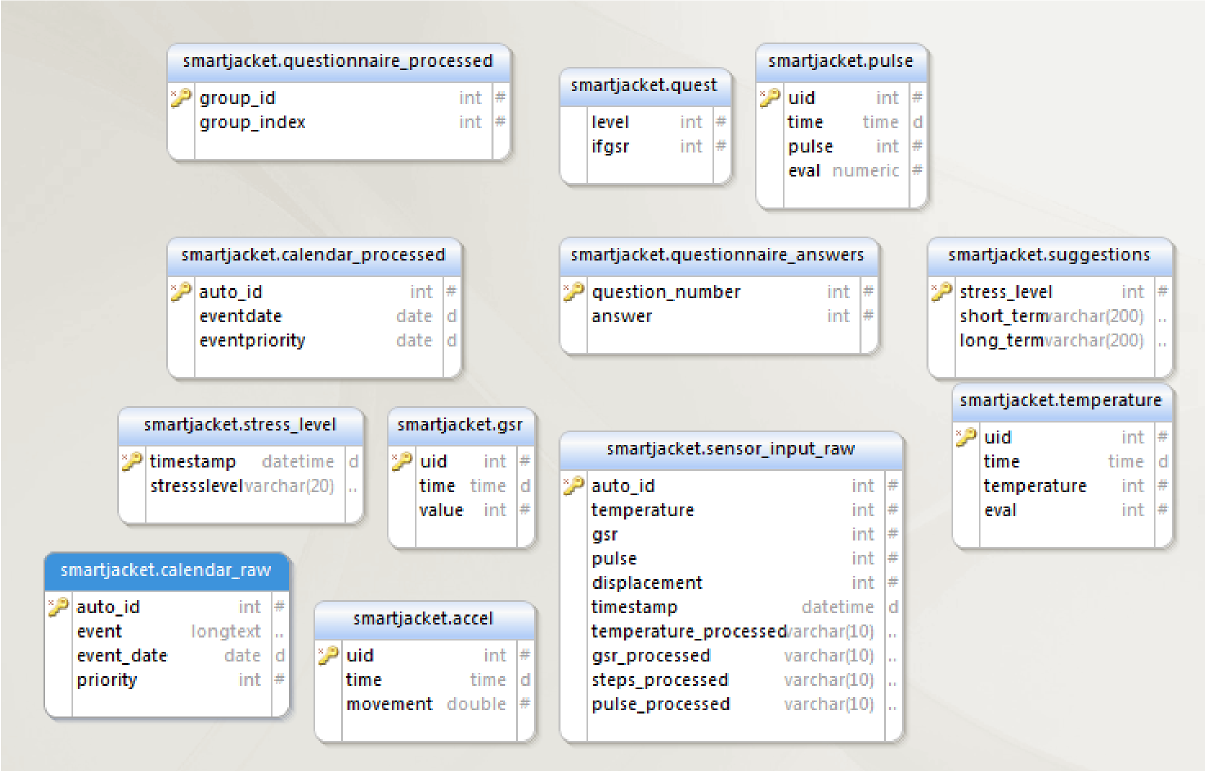

Fig 7.4.1 Database Design

Chapter 8

Detailed Design

This section deals with the detailed design of every subsystem

8.1 Sensors

8.1.1 Temperature Sensor LM35

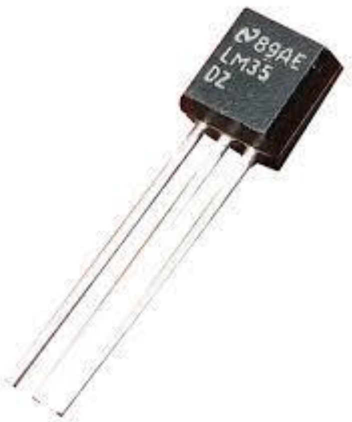

Fig 8.1.1.1 LM 35

LM35 is three terminal linear temperature sensor from National semiconductors. It can measure temperature from-55c to +150C. The voltage output of the LM35 increases 10mV per degree Celsius rise in temperature. LM35 can be operated from a 5V supply and the stand by current is less than 60uA. The pin out of LM35 is shown in the figure below.

Fig 8.1.1.2 LM 35 Pins

Temperature sensor LM35 is interfaced to the Arduino through the analog input pins A0, A1 and A2. Analog input pin A0 is made high and it acts as the 5V supply pin for the LM35. Analog input pin A2 is made low and it acts as the ground pin for the LM35. Analog input pin A1 is set as an input and the voltage output of LM35 is coupled to the arduino through this pin. This scheme is very useful because one can plug the LM35 directly into the analog input female connector and no external connection wires are needed. The arduino board is powered by the PC through the USB cable and no external power supply is needed in this circuit. The USB port also serves as the medium for communication between arduino and PC.

It is often used with the equation temp = (5.0 * analogRead(tempPin) * 100.0) / 1024;

8.1.2 Easy Pulse Heartbeat Sensor

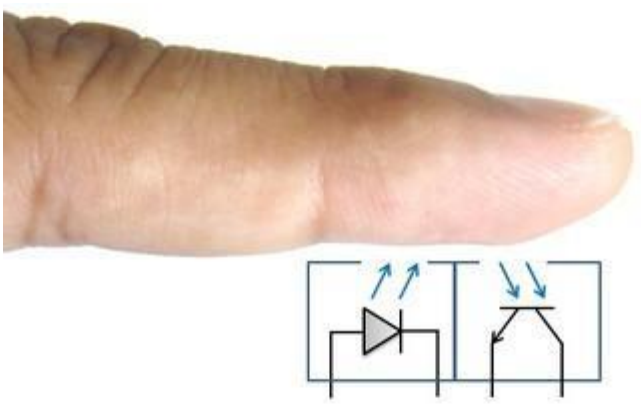

Fig 8.1.2.1 Led reflector and receiver

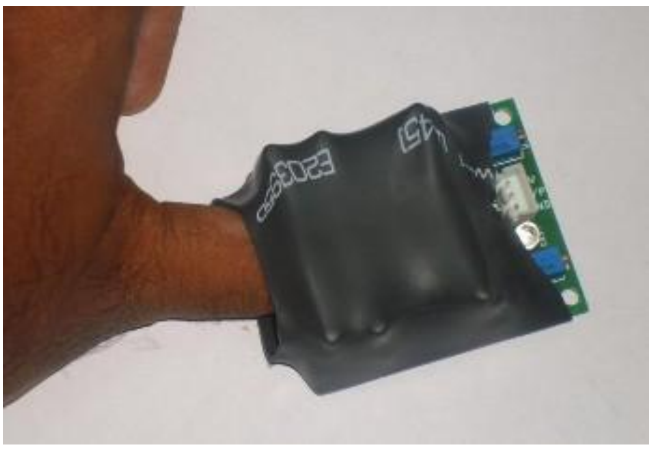

Fig 8.1.2.2 Sensor demo

This project is based on the principle of photoplethysmography (PPG) which is a non-invasive method of measuring the variation in blood volume in tissues using a light source and a detector. Since the change in blood volume is synchronous to the heart beat, this technique can be used to calculate the heart rate. Transmittance and reflectance are two basic types of photoplethysmography. For the transmittance PPG, a light source is emitted in to the tissue and a light detector is placed in the opposite side of the tissue to measure the resultant light. Because of the limited penetration depth of the light through organ tissue, the transmittance PPG is applicable to a restricted body part, such as the finger or the ear lobe. However, in the reflectance PPG, the light source and the light detector are both placed on the same side of a body part. The light is emitted into the tissue and the reflected light is measured by the detector. As the light doesn't have to penetrate the body, the reflectance PPG can be applied to any parts of human body. In either case, the detected light reflected from or transmitted through the body part will fluctuate according to the pulsatile blood flow caused by the beating of the heart.

The following picture shows a basic reflectance PPG probe to extract the pulse signal from the fingertip. A subject's finger is illuminated by an infrared light-emitting diode. More or less light is absorbed, depending on the tissue blood volume. Consequently, the reflected light intensity varies with the pulsing of the blood with heart beat. A plot for this variation against time is referred to be a photoplethysmographic or PPG signal.

The PPG signal has two components, frequently referred to as AC and DC. The AC component is mainly caused by pulsatile changes in arterial blood volume, which is synchronous with the heart beat. So, the AC component can be used as a source of heart rate information. This AC component is superimposed onto a large DC component that relates to the tissues and to the average blood volume. The DC component must be removed to measure the AC waveform with a high signal-to-noise ratio. Since the useful AC signal is only a very small portion of the whole signal, an effective amplification circuit is also required to extract desired information from it.

Circuit:

The sensor used in this project is TCRT1000, which is a reflective optical sensor with both the infrared light emitter and phototransistor placed side by side and are enclosed inside a leaded package so that there is minimum effect of surrounding visible light. The circuit diagram below shows the external biasing circuit for the TCRT1000 sensor. Pulling the Enable pin high will turn the IR emitter LED on and activate the sensor. A fingertip placed over the sensor will act as a reflector of the incident light. The amount of light reflected back from the fingertip is monitored by the phototransistor.

The output (VSENSOR) from the sensor is a periodic physiological waveform attributed to small variations in the reflected IR light which is caused by the pulsatile tissue blood volume inside the finger. The waveform is, therefore, synchronous with the heart beat. The following circuit diagram describes the first stage of the signal conditioning which will suppress the large DC component and boost the weak pulsatile AC component, which carries the required information.

In the circuit shown above, the sensor output is first passed through a RC high-pass filter (HPF) to get rid of the DC component. The cut-off frequency of the HPF is set to 0.7 Hz. Next stage is an active low-pass filter (LPF) that is made of an Op-Amp circuit. The gain and the cut-off frequency of the LPF are set to 101 and 2.34 Hz, respectively. Thus the combination of the HPF and LPF helps to remove unwanted DC signal and high frequency noise including 60 Hz (50 Hz in some countries) mains interference, while amplifying the low amplitude pulse signal (AC component) 101times.

The output from the first signal conditioning stage goes to a similar HPF/LPF combination for further filtering and amplification (shown below). So, the total voltage gain achieved from the two cascaded stages is 101*101 = 10201. The two stages of filtering and amplification converts the input PPG signals to near TTL pulses and they are synchronous with the heart beat. The frequency (f) of these pulses is related to the heart rate (BPM) as,

Beats per minute (BPM) = 60*f

A 5K potentiometer is placed at the output of the first signal conditioning stage in case the total gain of the two stages is required to be less than 10201. An LED connected to the output of the second stage of signal conditioning will blink when a heart beat is detected. The final stage of the instrumentation constitutes a simple non-inverting buffer to lower the output impedance. This is helpful if an ADC channel of a microcontroller is used to read the amplified PPG signal.

The operational amplifiers used in the instrumentation circuit described above are from the MCP6004 IC, which has got four general purpose Op-Amps offering rail-to-rail input and output over the 1.8 to 6V operating range. The picture below shows an assembled Easy Pulse board designed using the above circuit.

The board operates from 3-5.5V and therefore, it can be used with both 3.3V and 5.0V microcontroller families.

8.1.3 Accelerometer MPU 6050

Fig 8.1.3.1 MPU 6050

The MPU-6050 sensor contains a MEMS accelerometer and a MEMS gyro in a single chip. It is very accurate, as it contains 16-bits analog to digital conversion hardware for each channel. Therefor it captures the x, y, and z channel at the same time. The sensor uses the I2C-bus to interface with the Arduino. This sensor is used in the project to detect if the person is under movement from his/her original position.

8.1.4 Galvanic Skin Response

When people are anxious, they tend to sweat due to the activity of Sympathetic Nervous System. This is different from the typical sweating and it’s highly reflected at palms and foot. Because of this sweating, it causes a difference in conductivity of the skin, by reducing the resistance.

Hence, it is used as a measurement of anxiety, which in turns can be used in stress detection.

Circuit Setup

- Connect the 5V, GRND, A0 to the 5V, GRN and A0 pins in the Arduino respectively.
- Connect the ARef to the ARef pin in the Arduino, which gives the reference for the Analog readings.
- Use Copper or Silver plates to the finger 1 & 2. One may use a velcro cloth to make it steadily connects with fingers
- Use C = 0.1 μF, R = 2KΩ to 300KΩ (I have used 240KΩ).One may apply a little amount of Conductive Gel on two fingers, in order to increase the strength of the readings.

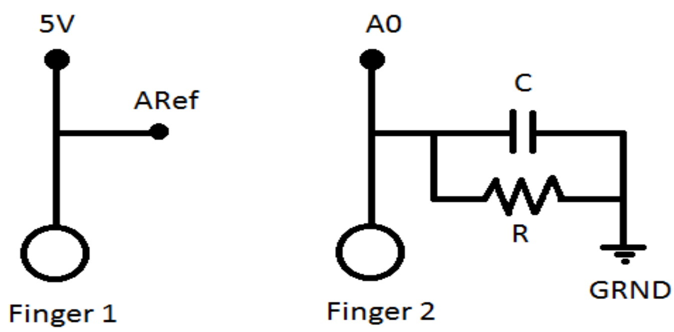

Fig 8.1.4.1 GSR Circuit Diagram

8.2 Arduino Mega 2560

Fig 8.2.1 Arduino Mega 2560 front

The Arduino Mega 2560 is a microcontroller board based on the ATmega256. It has 54 digital input/output pins (of which 15 can be used as PWM outputs), 16 analog inputs, 4 UARTs (hardware serial ports), a 16MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started.

The Mega2560 differs from all preceding boards in that it does not use the FTDI USB-to-serial driver chip. Instead, it features the ATmega16U2 (ATmega8U2 in the revision 1 and revision 2 boards) programmed as a USB-to-serial converter.

A summary of its specification is as follows

Microcontroller	ATmega2560
Operating Voltage	5V
Input Voltage (recommended)	7-12V
Input Voltage (limits)	6-20V
Digital I/O Pins	54 (of which 15 provide PWM output)
Analog Input Pins	16
DC Current per I/O Pin	40 mA
DC Current for 3.3V Pin	50 mA
Flash Memory	256 KB of which 8 KB used by bootloader
SRAM	8 KB
EEPROM	4 KB
Clock Speed	16 MHz

The Arduino Mega can be powered via the USB connection or with an external power supply. The power source is selected automatically.

External (non-USB) power can come either from an AC-to-DC adapter (wall-wart) or battery. The adapter can be connected by plugging a 2.1mm center-positive plug into the board's power jack. Leads from a battery can be inserted in the Gnd and Vin pin headers of the POWER connector.

The board can operate on an external supply of 6 to 20 volts. If supplied with less than 7V, however, the 5V pin may supply less than five volts and the board may be unstable. If using more than 12V, the voltage regulator may overheat and damage the board. The recommended range is 7 to 12 volts. The ATmega1280 has 128 KB of flash memory for storing code (of which 4 KB is used for the boot loader), 8 KB of SRAM and 4 KB of EEPROM.

8.3 Laptop Based Controller

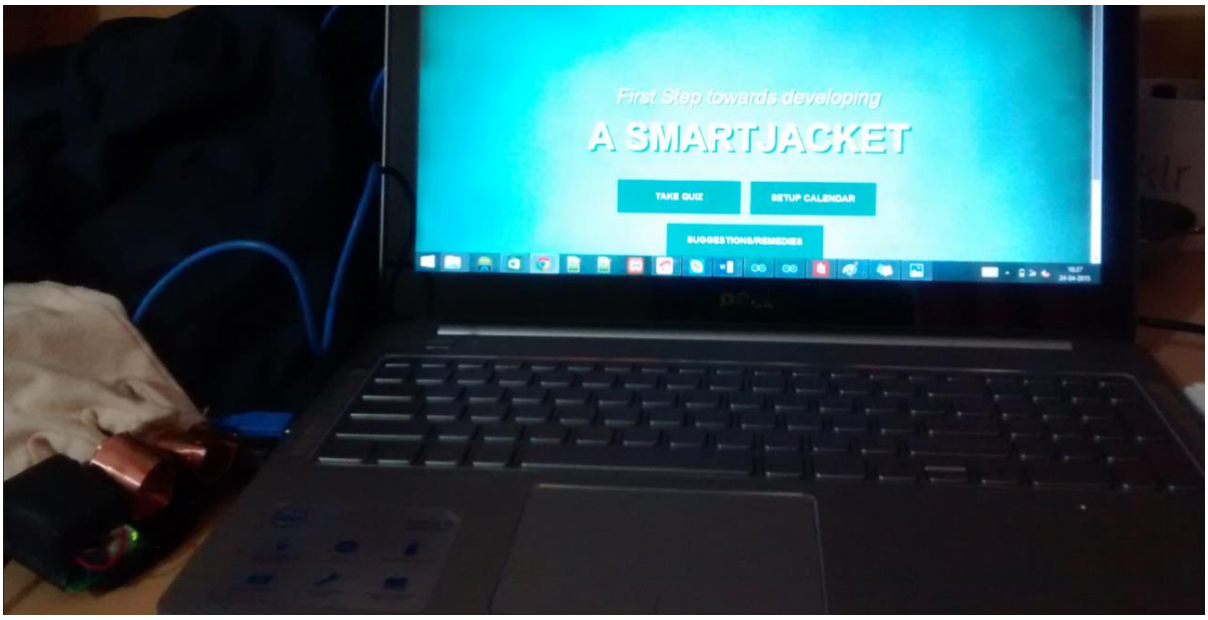

Fig 8.3.1 Laptop Based Controller

The laptop /Desktop acts as the central controller for the smartJacket. First, the jacket connected to the four sensors namely the Easy Pulse sensor, GSR(galvanic skin response),Temperature Sensor and Accelerometer get data continuously and sends the collected data to the laptop through a USB connection , where processing takes place to make sense out of the raw data received. Along with the sensor data the controller also takes questionnaire and Calendar input from the user. Now the sensor data along with the custom data received from user is checked and compared to the reference data already available, using which the module decides the stress level of the user. Using the result obtained certain immediate and long term suggestions are presented to the user.

8.4 Jacket

The jacket has been designed such that it acts as a very non-intrusive wearable device where the person does not really realize that his vitals are being checked. The components of the smartJacket include:

1. A jacket
2. Glove for one hand
3. Sensors connected to the Jacket :
    a. Accelerometer(stitched at the waist)
    b. Pulse Sensor(Index Finger)
    c. Galvanic Skin Response(Middle Finger and Ring Finger)
    d. Temperature sensor (Little Finger)

Fig 8.4.1 Glove part of the Jacket

Fig 8.4.2 Jacket

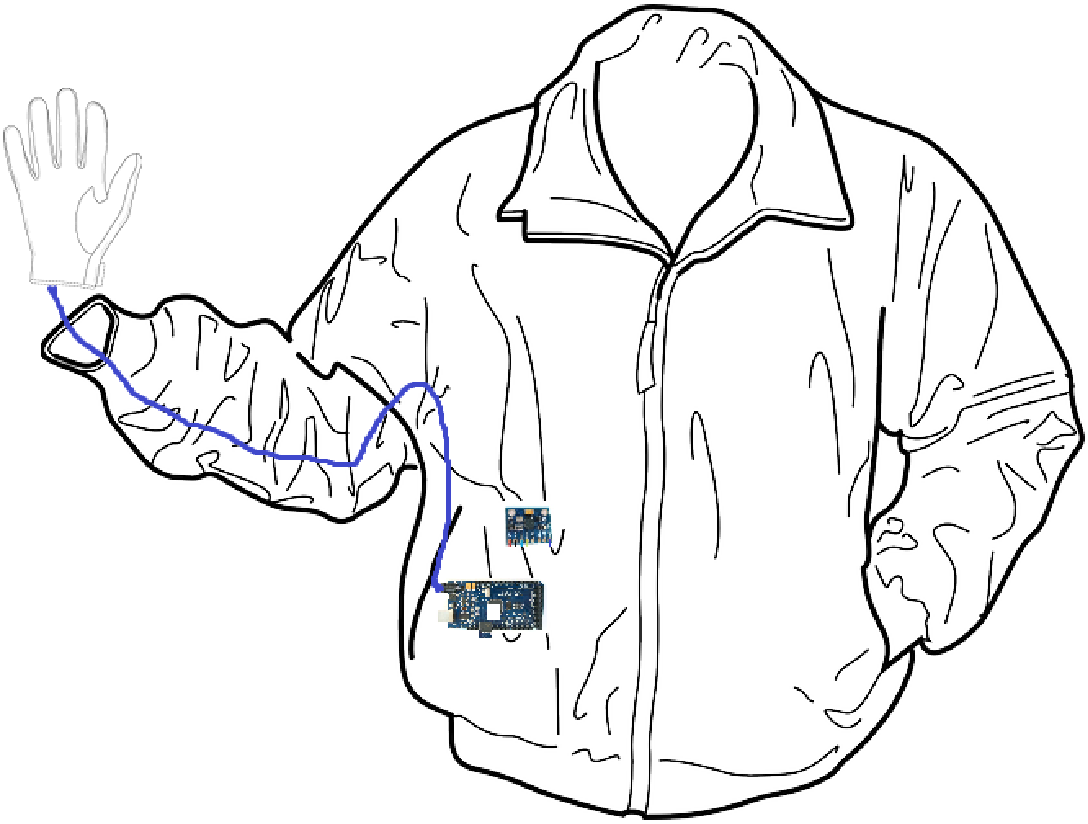

Fig 8.4.3 Internal Jacket Wiring

Chapter 9

Implementation

9.1 Building the Circuits

9.1.1 Galvanic Skin Response

The following circuit has been used to build the Galvanic Skin Response Circuit required to sense a stressful condition using the conductance.

Circuit Setup

1. Connect the 5V, GRND, A0 to the 5V, GRN and A0 pins in the Arduino respectively
2. Connect the ARef to the ARef pin in the Arduino, which gives the reference for the Analog readings
3. Use Copper or Silver plates to the finger 1 & 2. One may use a velcro cloth to make it steadily connects with fingers.
4. Use C = 0.1 μF, R = 2KΩ to 300KΩ (I have used 240KΩ).
5. One may apply a little amount of Conductive Gel on two fingers, in order to increase the strength of the readings.

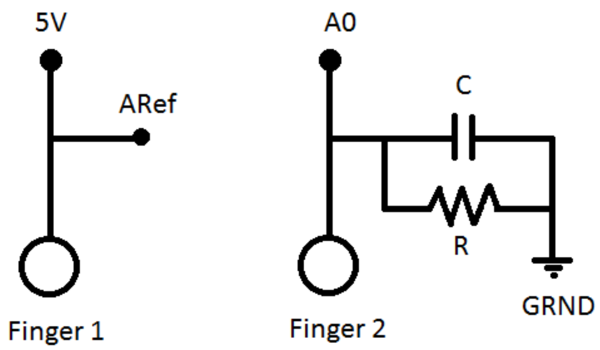

Fig 9.1.1.1 GSR Circuit

9.1.2 LM 35 Sensor Circuit

The temperature sensor has three output pins. Keeping the flat face to the top, the leftmost pin is the input of 5V, the middle pin goes to the analog output pin A4 and the rightmost pin goes to Ground.

9.1.3 Easy Pulse Heartbeat Sensor

- The Easy pulse heart beat sensor has three pins.
- The left most pin goes to the analog pin on the Arduino.
- The middle pin goes to the input of 5V.
- The rightmost pin goes to ground.

9.1.4 Accelerometer Sensor

The MPU6050 is used to check for movement of the person. The pins used here are:

The SDA is connected to SDA of the arduino

The SCL is connected to SCL of the arduino

The interrupt is connected to digital pin2 of arduino

The Voltage pin is connected to 5V

The Ground pin is connected to ground of arduino

9.1.5 All circuits together

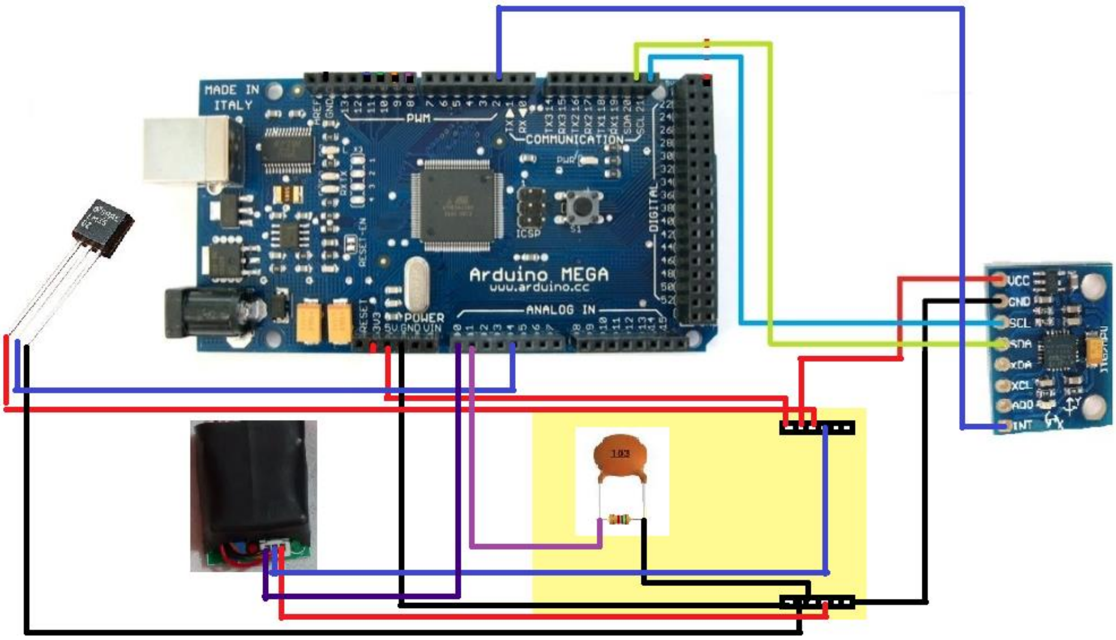

Fig 9.1.5.1 All Circuits

9.2 Arduino Mega 2560 Controller

The analog signals received from the all the circuits are converted to digital for further processing. Care has to be taken to ensure that the input analog signals are in the range of 0-5V. Analog signals are read using analogRead() method. The Arduino has a circuit inside called an **analog-to-digital converter** that reads analog voltage. Data is received from the different circuits through the analog pins.

The data received from the Easy Pulse Heartbeat sensor is in the form of PPG values from which the heart rate has to be found out. The temperature sensor gives out the temperature value in the form of degree Celsius. The Galvanic Skin Response Circuit shows the change in resistance when there is sweat generation. The MPU 6050 Accelerometer gives the gyro values from which the accelerometer has to be inferred. These values are fed into the Serial Monitor from where the values are accessed for processing.

9.3 Pseudo code of Modules Implemented

Algorithm 1: Sensor

Algorithm 2: Questionnaire

Algorithm 3: Creation of custom Calendar an processing the values

Creation:

A Web page is created using bootstrap library. The current date is accessed and used as a base to show a calendar of the current month.

On clicking any of the date in the calendar a modal window pops up to the front. Here the user has to enter the event for that particular date and the priority level that is how difficult the event is for the person. This data is accessed and added as a div element to that day. The user is made to enter difficulty level because for every user the emotional and physical stress for that particular activity may vary. Every time an event is added it should get appended into the calendar for that day.

Send to Server:

Once the calendar entries are done, on click of the submit button data has to be saved. The data is sent to the server using an xhr object where the data is now save into a database using sql queries.

The Reset button when click should clean the calendar and allow for new entries to the calendar.

Processing Values:

Weightage is provided to each of the priority levels of the calendar events. The database containing calendar data is accessed. According to the priority levels chosen the data base is filled in with the appropriate weightage. This table is then accessed to collaborate a value for that particular day. Using this database a graph is plotted to know how exactly the users schedule is affecting his life.

Algorithm 4: Tree

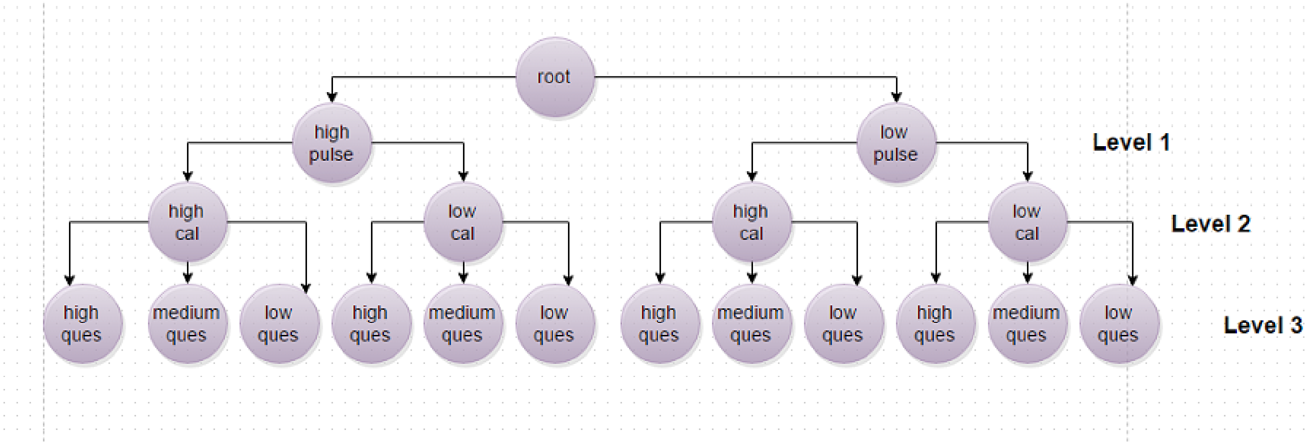

Fig 9.3.1 Tree Part 1

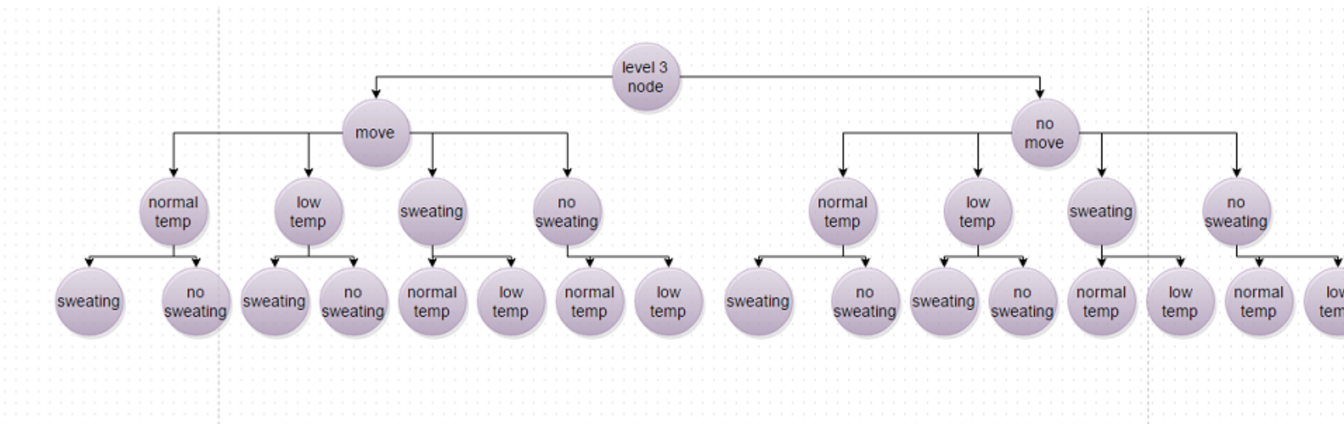

Fig 9.3.2 Tree Part 2

Algorithm 5: UI Code

Navigation:

Option to take up quiz

Option to Set up Calendar

Option to View Current Stress Level and Suggestions/Remedies

Graph:

Option to View Stress Level Graph

Graph UI:

Display Stress Level Graph.

Display Schedule Graph.

Suggestions/Remedies:

Option to Play Music

Option to get audio suggestions

Sticky notes containing suggestions for the particular Stress Level.

Chapter 10

Integration

10.1 Integration Strategies

Individual part or modules of the project were created first. A mix of top down and bottom up integration has been used. As and when each part was ready it was tested individually and with the other completed parts that were available often simulating data when not available. Initially the calendar and questionnaire module were tested individually. Once the sensor processing module was completed, dummy data was added into the calendar and questionnaire modules to calculate stress levels using the sensors. Initially the setup was not real time. As and when the modules were complete, the setup was modified to process real time data.

For the hardware part of the project, each sensor was connected using removable wires. Since the sensor input is subjective to a person, the sensors were individually tested on multiple people to understand a common pattern to consider as base. Arduino code for each sensor was tested individually and then tested together gathering data from a single COM port. The raw input from the sensors was then processed and given to the stress level calculation algorithm. Once the sensors were working, they were stitched to a jacket and a glove. The removable wires were then soldered into a PCB. The jacket was tested for different stress levels by simulating high pulse rate, sweat, change in temperature, etc.

Chapter 11

Testing

11.1 Test Case Design

11.1.1 Unit Testing

Hardware Components

Test Case	Expected Result	Actual Result	Conclusion
Temperature Sensor	25-35 deg C	25-32 deg C	Success
Heartbeat Sensor	65-100 PPG /min	40-100 PPG/min	60% accurate
GSR	Readings falling by greater than 350 units	Readings falling by around 200 units	75% accurate
Accelerometer	Showing +ve or –ve accelerometer	Showing +ve or –ve accelerometer readings	Success

Hardware Processing Algorithm

Test Case	Expected Result	Actual Result	Conclusion
Plotting graph showing pulse	Graph showing variation of pulse	Processing gave blank window	Fail

Calculating heartbeat	Heart rate around 65-100	Heart rate around 40- 105	60%accurate
Plotting graph of movement	Graph being plot by movement	Graph plot showing movement overriding old graph as time passes	85%accurate
Calculating movement by accessing values from graph	Able to access the x and y coordinates of graph	Error in accessing coordinates	fail
Detecting sweat change in values in GSR	Change in values detected	Change in GSR Values detected	Success

Software Processing Algorithm

Test Case	**Expected Result**	**Actual Result**	**Conclusion**
Taking questionnaire and getting processed values	Database populated with original and processed values	Database populated with original and processed values	Success
Submitting questionnaire	Error message from php	Error message from PHP	Success

without providing any inputs			
Filling Schedule in calendar according to users priority level	Able to add events to that day. Populates db and generates table with processed values	Able to add events to that day, reflected in UI. Populates db and generates table with processed values	Success
Resetting entire calendar to add new entries	The values previously entered in calendar removed	The values previously entered in calendar removed	Success
Deleting individual entries for each day	The entry is removed from calendar and db.	Entry present in the calendar	fail

11.1.2 Integration Testing

Test Case	Expected Result	Actual Result	Conclusion
Running all sensors together	The different threads containing different sensor should run and provide proper values as expected from individual sensor circuits.	The different threads containing different sensor should run and provide proper values as expected from individual sensor circuits.	Success.

Combining sensors, GUI , processing	The stress level to be detected and provides the expected output with suggestions and graph	The stress level to be detected and provides the expected output with suggestions and graph and populates db	Success
Check for Very Stressed Person	UI to show suggestions for that level of stressed and a graph showing variations of stress over time and calendar of events which may have effected it	UI to show suggestions for that level of stressed and a graph showing variations of stress over time and calendar of events which may have effected it	Success
Check for Stressed Person	UI to show suggestions for that level of stressed and a graph showing variations of stress over time and calendar of events which may have effected it	UI to show suggestions for that level of stressed and a graph showing variations of stress over time and calendar of events which may have effected it	Success
Check for mildly	UI to show suggestions for that level of stressed and	UI to show suggestions for that level of stressed and	Success

Stressed Person	a graph showing variations of stress over time and calendar of events which may have effected it	a graph showing variations of stress over time and calendar of events which may have effected it	
Check for Slightly Stressed Person	UI to show suggestions for that level of stressed and a graph showing variations of stress over time and calendar of events which may have effected it	UI to show suggestions for that level of stressed and a graph showing variations of stress over time and calendar of events which may have effected it	Success
Check for calm Person	UI to show that the person is calm and suggests to take care to keep himself at that stage	UI to show that the person is calm and suggests to take care to keep himself at that stage.	Success

11.2 Test Execution Planning

Data of Hypertensive and cardiac patients collected from Excel Care Hospital was used. This data was used as a reference for the algorithm. A few doctors were consulted to get the optimum range of body vitals and suggestions they would give to their patients in stressful situations. The tree used for getting the stress level was verified by doctors.

11.3 Test Results

Classification accuracy 60-65%

Chapter 12

Story Board

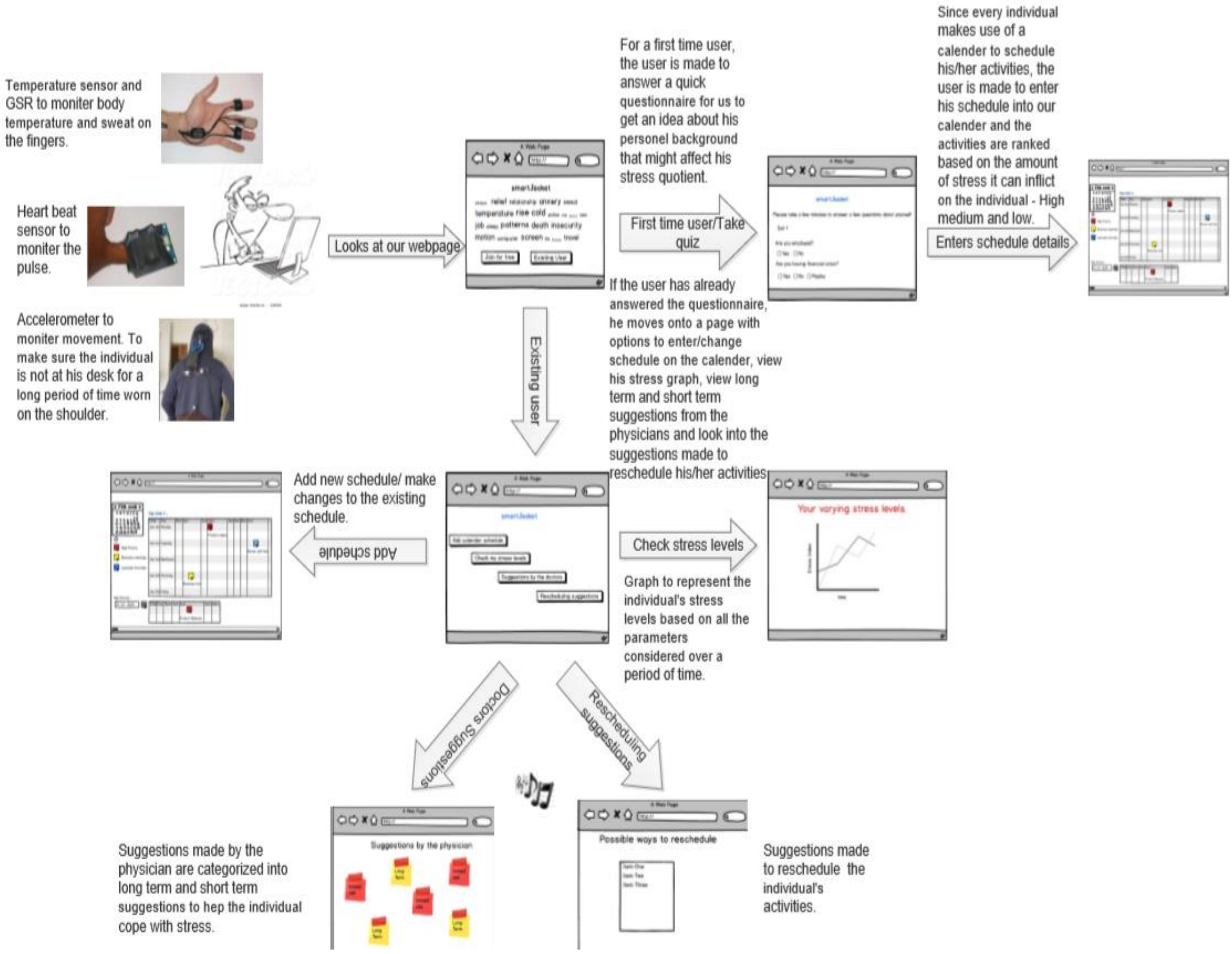

Fig 12.1.1 Project Flow

The flow of events from the time the patient wears the jacket is follows:

1. When the user wears the jacket by placing his index finger in the heartbeat sensor, middle finger and ring finger in the GSR and little finger on the temperature sensor the values are passed to the arduino.
2. This raw data is sent to the laptop through a USB Cable.
3. This data is process to make sense out of the raw data and used to populate the data base.

4. The Web Application also takes the a questionnaire input and the schedule of the user

5. Using the sensor data and the data received from the questionnaire and calendar processing is done to get the current stress level of the user.

6. This is accessed by the Web Application to show the current stress level and show suggestions for the same.

7. The Application also provides immediate solutions like playing music and providing audio suggestions.

Chapter 13

Screenshots

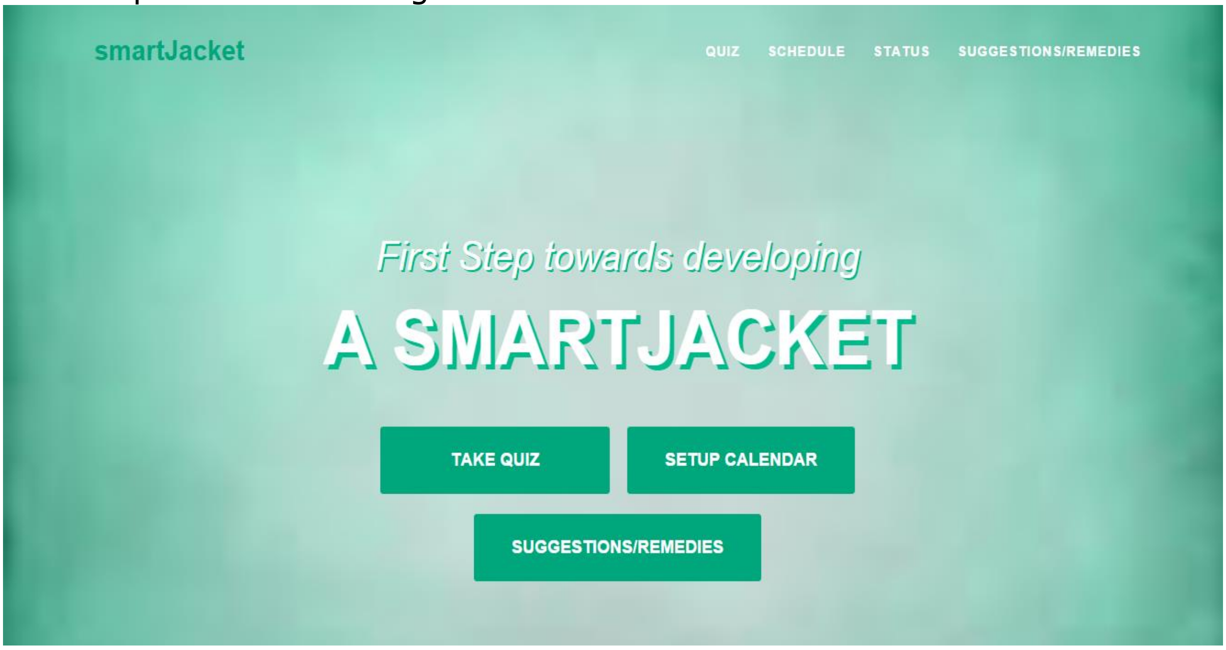

Fig 13.1 Main Page

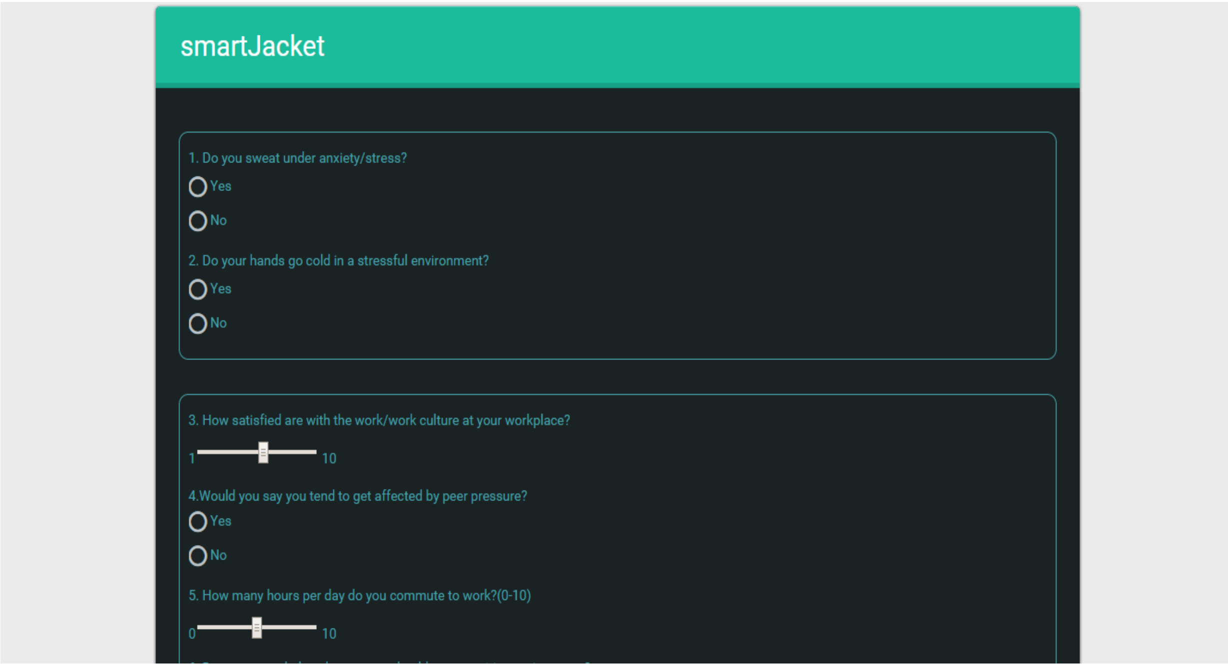

Fig 13.2 Questionnaire

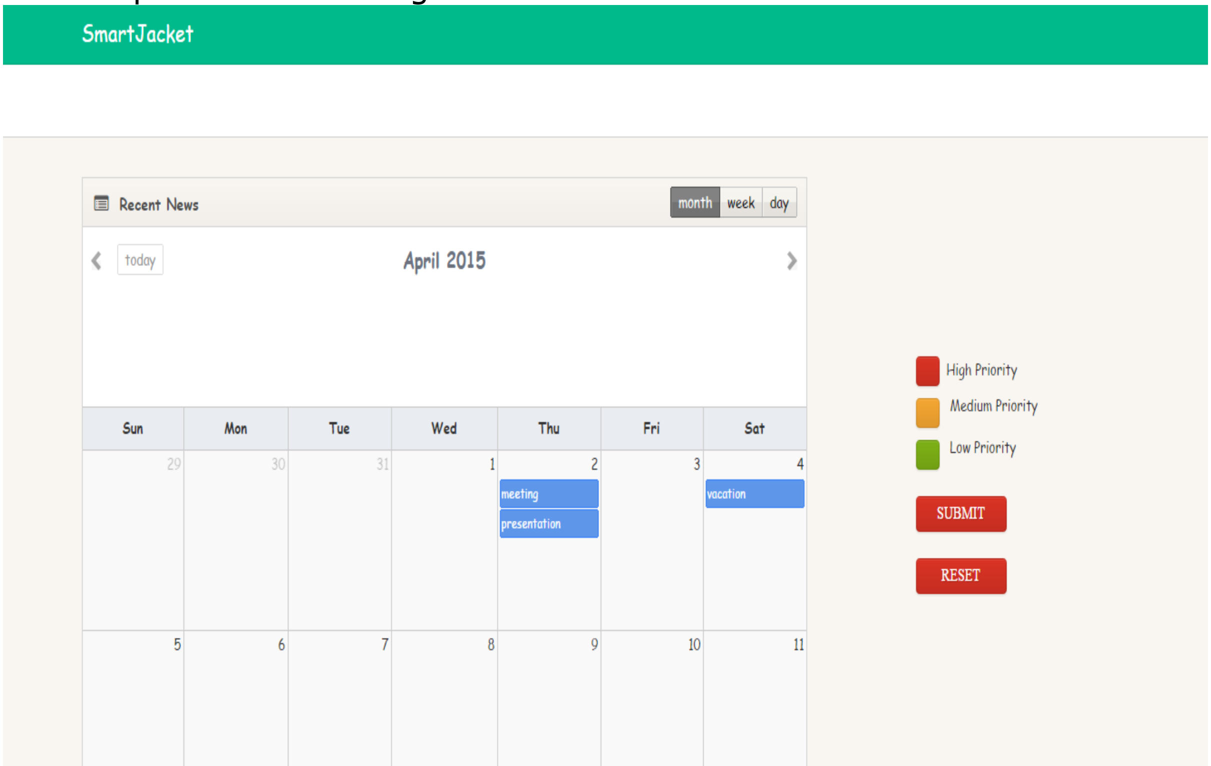

Fig 13.3 Custom Calendar

Fig 13.3 Suggestions and Result Screen

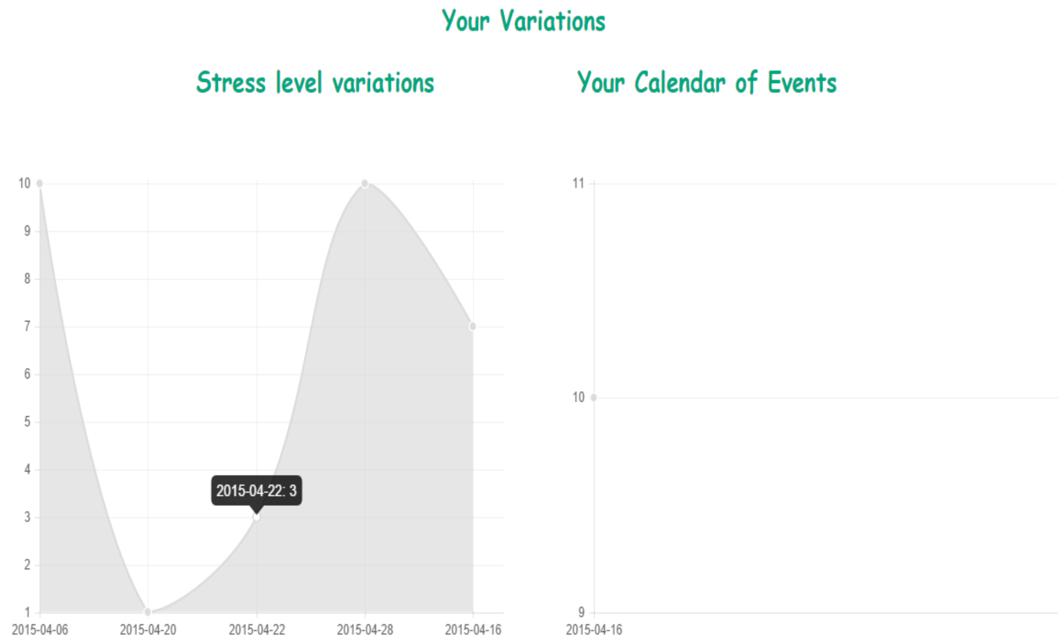

Fig 13.5 Stress Level Graph

Fig 13.6 Galvanic skin Response

Chapter 14

Conclusion

Stress is the body's reaction to any change that requires an adjustment or response. The body reacts to these changes with physical, mental, and emotional responses. With stress affecting all major systems in the body, the lack of stress management skills has a huge impact on health and wellbeing. The project 'A first step towards developing a smart jacket' is an attempt to making a small but significant contribution towards this goal.

The prototype is capable of evaluating the stress level of an individual based on their schedule, real time body vitals input and a psychological evaluation. This is achieved in a non-intrusive manner in order to create a biofeedback therapy as an alternative to pharmacological intervention.

The prototype idea has been discussed with physicians and therapy specialist has been received very well.

Chapter 14

Future Scope

The future scope of this project is to try and include other parameters such as age, gender, body type and work environment specifications as part of the evaluation while determining the stress level.

Wireless module can be included to improve the non-intrusiveness.

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