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Project Title: SAIC (Synthetic Artificial Intelligent Clothes)

EE 497 Capstone Design

Project Report

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Abstract

Technology is developing at a fast pace, especially in the telecommunication and entertainment industries. According to eMarketer in 2014 about 4.55 billion people worldwide use a mobile phone and about 40% of these people use smart phones as means of communication. In this project we will design and build a portable wearable device that will be inexpensive, hands-free and will include new features and capabilities to interface human brain waves with the environment. What is novel about our design that it is standalone and will act as a replacement for mobile phones.

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1. Problem Statement

1.1 Need Statement

Most people have hard time concentrating on many of their daily activities (e.g. walking, driving, reading ...etc.) while using their mobile phones. In addition, we must not forget that the number of Alzheimer's disease patients is increasing everyday and they must be tracked everywhere along with children to prevent accidents that could happen to them. Imagine a technology where the user would be able to recall up (and share) everything the user has ever seen, or read the transcripts for every conversation the user ever had, alongside the names and faces of everyone the user has ever met. Imagine having supplemental contextual information relayed to the user automatically so he could win any argument or impress his friends. It will help people live their social experiences without having to take their eyes of anything they are doing.

1.2 Motivation

"The tragedy in life doesn't lie in not reaching your goals. The tragedy lies in having no goals to reach." - *Benjamin Mays.* From this quote we started on setting our goals and objectives to accomplish them with dedication and persistence. We are motivated and will take the leap of faith into developing this newborn technology to achieve better results and better standards than any similar product available. Desire maybe the key to motivation, but determination and commitment to the project will enable us to attain the success and excellence we seek.

1.3 Objective

The objective of this project is to design a device that will change the way people utilize their mobile phones. The device will be both portable and wearable and controlled via voice commands. It will do all basic functionalities of regular cellular phones. Additionally, it will give the edge to the user to control and interact with the environment using brain waves. It will also have a security functionality that will let the user notify quickly a relative or a police station that he/she is in a danger situation. The system will keep a record with all the activities on a private host given to the user including images, GPS locations and any other relevant data. Therefore; the device will be a replacement for the conventional bulky mobile phones in the relatively soon future with extra features.

1.4 Background and Related Work

1.4.1 Overview

Our research identified several products and technologies currently being developed that are similar in spirit to our project idea. Google Glass, which is similar to our design and has a lot features such as a touchpad, camera and head display all of these integrated together through Android operating system, also the glass is equipped with many different sensors, which will deliver the optimum experience to the user as promised by Google. What differentiate our design is utilizing brain signals to command and control the system. The device will be wearable and easily plugged in any type of clothes. It will be a standalone device rather than interacting with mobile phones, so it is a new approach. Also the cost will be relatively cheaper than available products in the market and it is discussed in details in the cost section.

1.4.2 Relevant Devices

- Google Glasses.
- Emotive Brain Headset.
- Epson's Wearable Device.
- Sony SmartWatch.
- iPod Nano 6th-Gen.
- iWatch (rumored).
- Nike + FuelBand.

1.4.3 Relevant Technologies

1.4.3.1 SD Card Memory

SD stands for Secure Digital memory. It is a non-volatile memory card format for portable devices. It is used to store different types and extensions of files. It is easy to use. There are also different classes of the SD card. These classes determine the top speed of the memory. Classes vary in speed between 2MB/s up to 30MB/s for 4K videos files. SD cards come in all different sizes starting from 1GB memory up to 128 GB.

1.4.3.2 GPS

The GPS or Global Positioning System is a network of 24 satellites that are in geosynchronous orbit. They are positioned so that transmissions can be read from at least four satellites from any point on Earth. The satellites transmit a time code, which is picked up and decoded by a GPS receiver. The GPS receiver measures the time delay taken to receive these signals and is then able to calculate its location on Earth.

1.4.3.3 GSM

GSM stands for Global System for Mobile Communications. The goal of the GSM network is to provide a mobile connection to communication and information services via radio waves. The services include voice communication (telephone), text communication (SMS), and Internet connectivity. The identity of a user in a GSM network is established with a Subscriber Identity Module (SIM) card. This card holds the user's subscription information and phonebook. These cards are assigned by the mobile service provider and are placed inside the mobile device.

1.4.3.4 Microcontrollers

A microcontroller unit (MCU) is a programmable integrated circuit that can be used in a nearly infinite number of applications. They take very little amount of power to function. They have general I/O ports 'Input/Output ports'. These ports are the interface between the microcontroller and the outside world. In addition, they have serial bus for communication with different modules.

1.4.3.5 EEG Headset

EEG stands for Electroencephalography. It is basically made of electrodes that are distributed around the head. These electrodes measure the change and fluctuations in brain voltages. This is very helpful to measure different waves that are generated by the brains and are associated with different mental states. There are four main waves that differ in their frequencies. They are Alpha, Beta, Delta, Gamma. The set can also using these waves measure the attention and meditation levels of the brain.

1.4.3.6 TFT Touch Screen

"A thin-film-transistor liquid-crystal display (TFT LCD) is a variant of a liquid-crystal display (LCD) that uses thin-film transistor (TFT) technology to improve image qualities such as addressability and contrast. A TFT LCD is an active-matrix LCD, in contrast to passive-matrix LCDs or simple, direct-driven LCDs with a few segments. TFT LCDs are used in appliances including television sets, computer monitors, mobile phones, handheld video game systems, personal digital assistants, navigation systems and projectors." [http://en.wikipedia.org/wiki/Thin-film-transistor_liquid-crystal_display]

1.4.4 Device Objective Tree

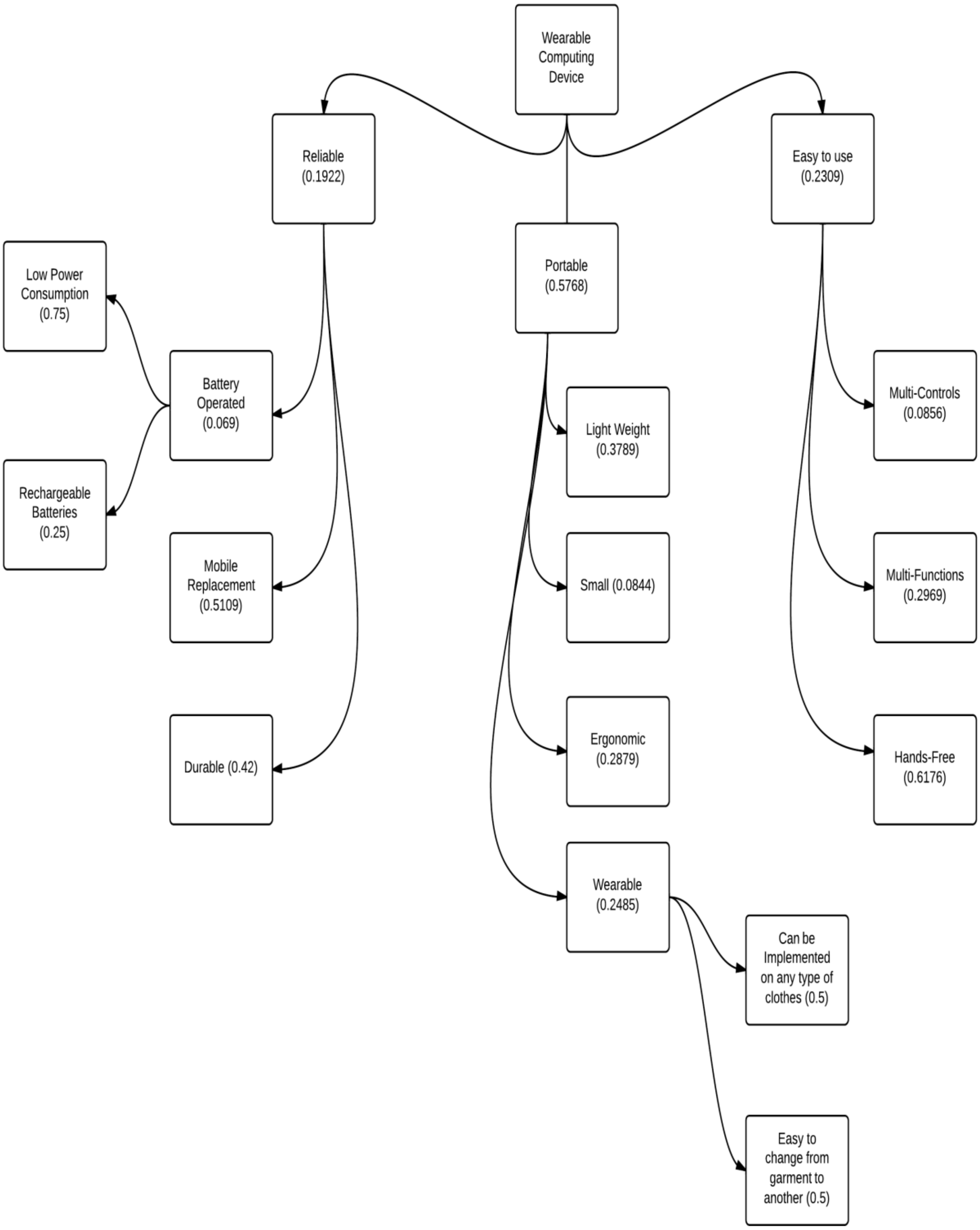

Fig 1.1: Device Objective Tree.

2. Problem Analysis

Our device is basically a computer that records your perspective of the world. It unobtrusively delivers information to the user through a head-up display using highly innovative design.

3. Technical Specifications

We will design a prototype of our device using a Microcontroller to function as the brain of the system. Several modules will be attached to the device that will perform the several functions. GPS module will be used to facilitate the tracking system and to identify the location of the endangered person. GSM module will be responsible for communication such as phone calls and messages. A touch screen will be used for input and feedback purposes. A camera attached to a location close to the eyes to capture photos and videos from the perspective of the wearer. Finally, an EEG headset will be used as part of the device to that will online measure brain waves. This is used to help the user to control several parts of the environment wirelessly by his brain only, i.e. (door locks, car engine, AC, TV). The overall system will be totally hands free that operates based using voice commands only.

4. Requirements Specification

4.1 Engineering and Marketing Requirements

The marketing requirements for this project are as follows:

1. GSM/GPS shield can be integrated with MCU.

2. Device stores Images on SD card.

3. Device can connect to FTP host server.

4. Battery can last up to 7 hours.

5. Bran data is transmitted wirelessly.

6. Device can store no less than 200 phone numbers.

7. Good voice fidelity that can be used by anyone.

8. Components can be easily plugged as Lego to give the user more control over the specific functionalities.

Table 4.1 compares the project's engineering requirements with the marketing requirements they cover as well as their respective justifications.

Requirements		Validation Rationale
Marketing	*Engineering*	
1,3,8	Utilize a GPS device to gather time, location, and velocity data.	The GPS location of the user has to locate using satellites for tracking functionality and to inform relatives whenever person is in danger.
1	Utilize a GSM unit to transmit data to a server.	The GPS location of the user has to be sent to a FTP server host.
2,6	System must have a storage space for no less than 8 GB.	This space of storage is used to store images captured by the camera, contact lists, and to store the voice commands that will be used.
5	Transmit power gain in antennas should be <= 1W.	This is important to meet the FCC regulations for point-to-point communication.

Requirements		Validation Rationale
Marketing	*Engineering*	
4	Battery should last for >= 7 hours a day.	This is important to let the user use the system for at least one full day without charging it.
9,8	TFT touch screen for feedback and interface.	The screen should be a touch screen to let the user answer incoming calls and hang ongoing calls by a simple button.
8	Camera's spatial resolution should be 648x488 pixels.	For better and good quality images that can be easily enlarged and printed without affecting its quality.

Table 4.1: Engineering and Marketing Requirements.

4.2 Constraints

4.2.1 Economic

The final system must not cost more than 250 KD.

4.2.2 Environmental

The System must store all and send all the GPS data to a web server that will keep tracking the device.

4.2.3 Sustainability

The final system must be reliable for everyday operation and have a long lasting battery.

4.2.4 Manufacturability

The final system must be modular and easy to integrate with any type of clothes.

4.2.5 Social

FCC regulations and IEEE standards regarding the use of both GSM and GPS protocols.

4.3 Standards

There are some set of standards associated with our project that pertains to the GPS data. There are two types of GPS data packets that are used. The first is the GGA protocol, Figure 4.1 describes the various entries in some examples.

Name	Example	Units	Description
Message ID	$GPGGA	-	GGA protocol header
UTC Time	161229.487	-	hhmmss.sss
Latitude	3723.2475	-	ddmm.mmmm
N/S Indicator	N	-	N=North or S=South
Longitude	12158.3416	-	dddmm.mmmm
E/W Indicator	W	-	E=East or W=west
Position Fix Indicator	1	-	See Table 3 Below
Satellites Used	07	-	Range 0-12
HDOP	1.0	-	Horizontal Dilution Of Precision
MSL Altitude	9.0	meters	-
Units	M	meters	-
Geoid Separation	-	meters	-
Units	M	meters	-
Age of Diff. Corr.	-	second	Null Field when DGPS is not used
Diff. Ref. Station ID	0000	-	-
Checksum	*18	-	-
<CR> <LF>	-	-	End-of-message termination

Fig 4.1: NMEA $GPGGA Standard Format.

The second GPS data packet is the RMC protocol. As detailed in Figure 4.2, this packet contains the recommended minimum specific data need to obtain a position.

Name	Example	Units	Description
Message ID	$GPRMC	-	RMC protocol header
UTC Time	161229.487	-	hhmmss.sss
Status1	A	-	A=data valid or V=data not valid
Latitude	3723.2475	-	ddmm.mmmm
N/S Indicator	N	-	N=north or S=south
Longitude	12158.3416	-	dddmm.mmmm
E/W Indicator	W	-	E=east or W=west
Speed over Ground	0.13	Knots	-
Course over Ground	309.62	degrees	True
Date	120598	-	ddmmyy
Magnetic Variation2	-	degrees	E=east or W=west
Checksum	*10	-	-
<CR> <LF>	-	-	End of message termination

Fig 4.2: NMEA $GPRMC Standard Format.

5. Preliminary Design

5.1 Design Approach

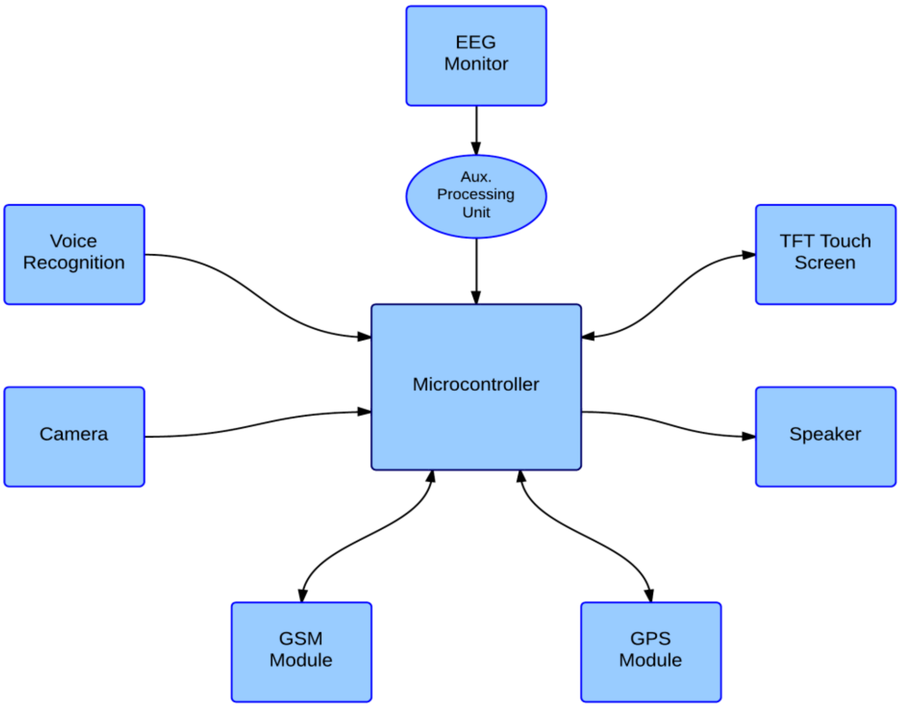

Fig 5.1: Wearable Computing System's Block Diagram.

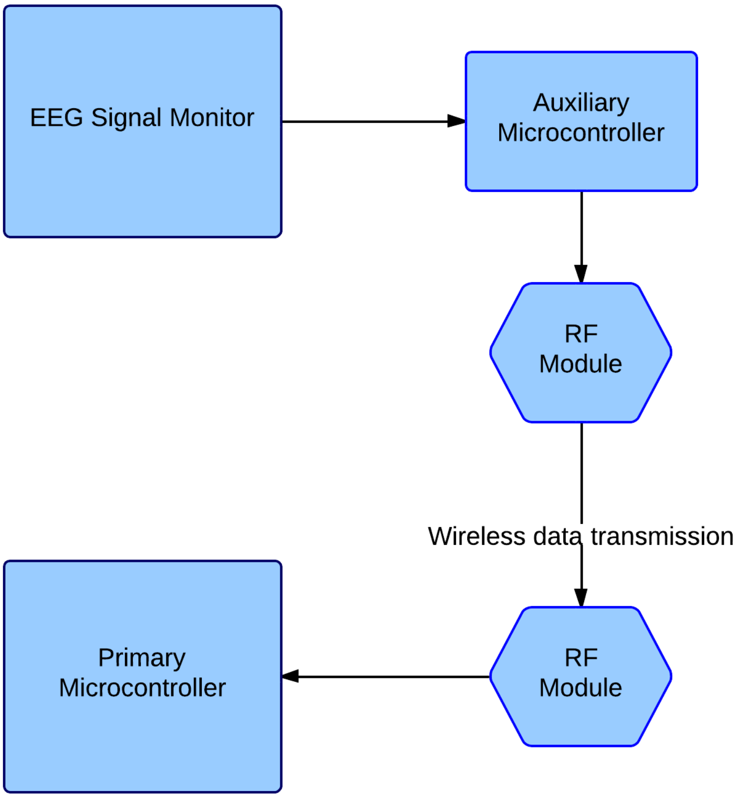

Fig 5.2: EEG Monitoring System.

6. Design

6.1 Functional Decomposition

6.1.1 Level 0

Figure 6.1 is the Level 0 diagram for our project. Here, our system receives five inputs – the GPS/GSM Signals, EEG Signals, Voice Commands, TFT Touch Input, and Power Signal – and produces five outputs – GSM/GPS Signals, Motor Drive, Visual Feedback, Internet Data Upload, and Images.

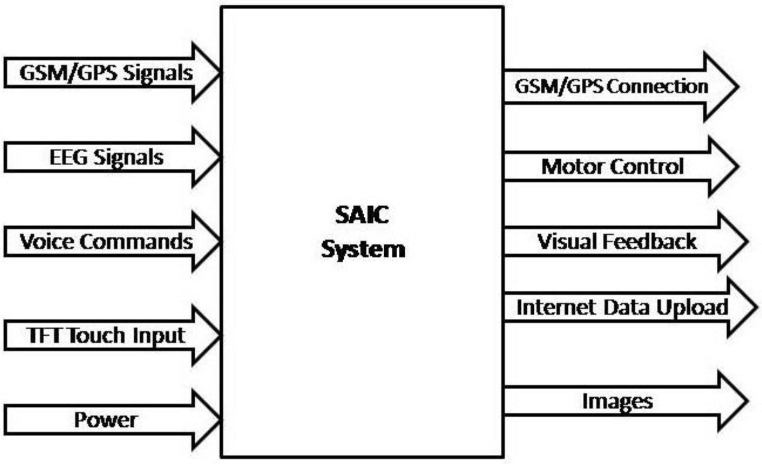

Fig 6.1: Level 0 : SAIC System.

6.1.2 Level 1

Figure 6.2 is the Level 1 diagram for our project. With this diagram, we can see the interaction of the components that lie within the system. The Microcontroller ATMEGA328 which is mounted on an Arduino platform is the main MCU. A similar microcontroller is used as a secondary one. The main MCU is powered by 11.1v Li-Poly (Lithium Polymer) battery. It receives data from voice commands using the voice recognition module. Based on these commands, the MCU initializes calls, sends SMS, or turns on/off GPS tracking system using the GSM/GPS module. The main MCU is also connected to a touch screen that displays the current operation under process. When the GSM receives a call, the MCU automatically pushes the TFT screen to display a phone call notification which gives the user the option to answer it. The user can also take photos using voice commands. The main MCU informs the secondary MCU about the operation to take.

As seen in figure 6, the secondary MCU is connected to a camera module, SD shield with an SD card mounted on it as well as 2 radio frequency modules. The secondary then communicates serially with the camera to take a photo and then stores the photo in the SD card that is connected using the SPI bus.

The EEG instantaneously monitors brain wave activity. Once, a certain threshold is reached, the secondary MCU then communicates with a motor to control its speed. The motor can be altered with any different desired application.

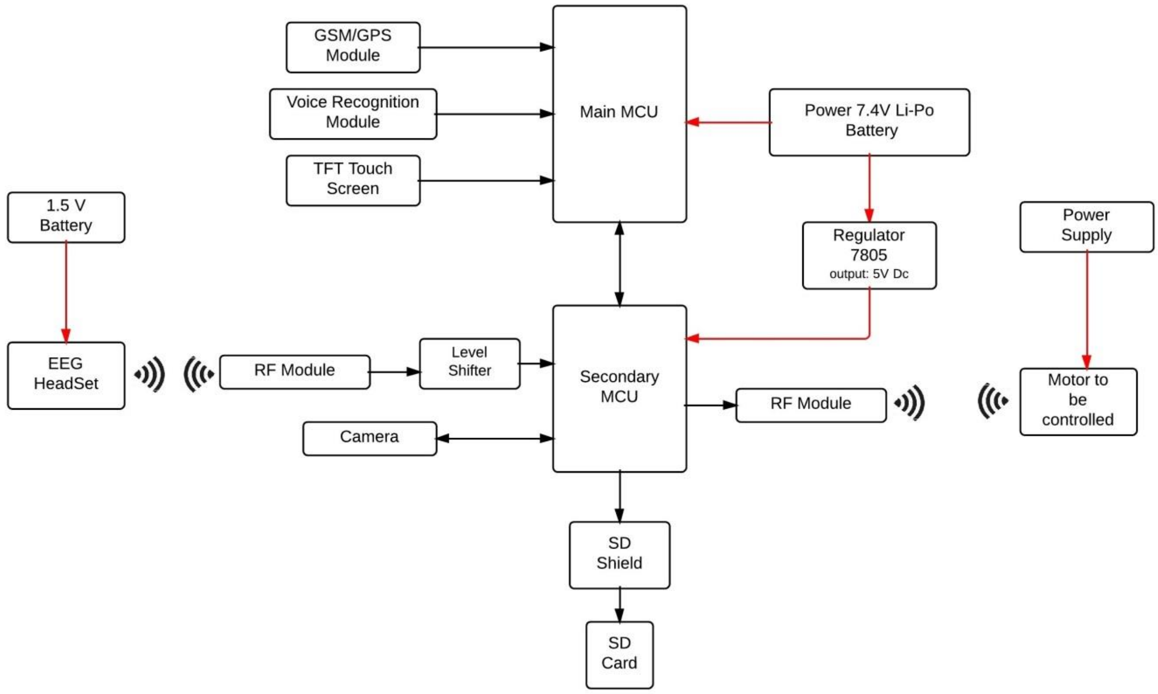

Fig 6.2: Level 1: SAIC Main Design.

6.1.3 Level 2

6.1.3.1 Main MCU

Figure 6.3 shows Level 2 of the main MCU with all the connections. As seen in the figure, the main MCU is connected via serial to the GSM/GPS shield, LCD screen and to the voice recognition module. Also a TX pin output of the main MCU will be connected to the RX of the secondary MCU which will act as a slave only taking commands from the main MCU. The voice recognition module has its (Tx,Rx) serial connected to pins (13,15) respectively on the main MCU. The LCD communicates with the main MCU in a two way serial communication on pins (11,12).The TFT screen informs the main MCU about the current displayed screen. It takes commands from the main MCU to which screen to display next. It takes input touch values from the user. The GSM/GPS shield is connected on the hardware serial pins (2,3).

The main MCU is responsible on organizing all the incoming and outgoing data packets among all the modules.

While the voice recognition is the main input source to the system, the LCD screen also works as an input via the touch button for hanging up current calls or answering incoming calls. As seen in the figure, the main battery supply is also connected to the Arduino which acts also as a power regulator to all other modules.

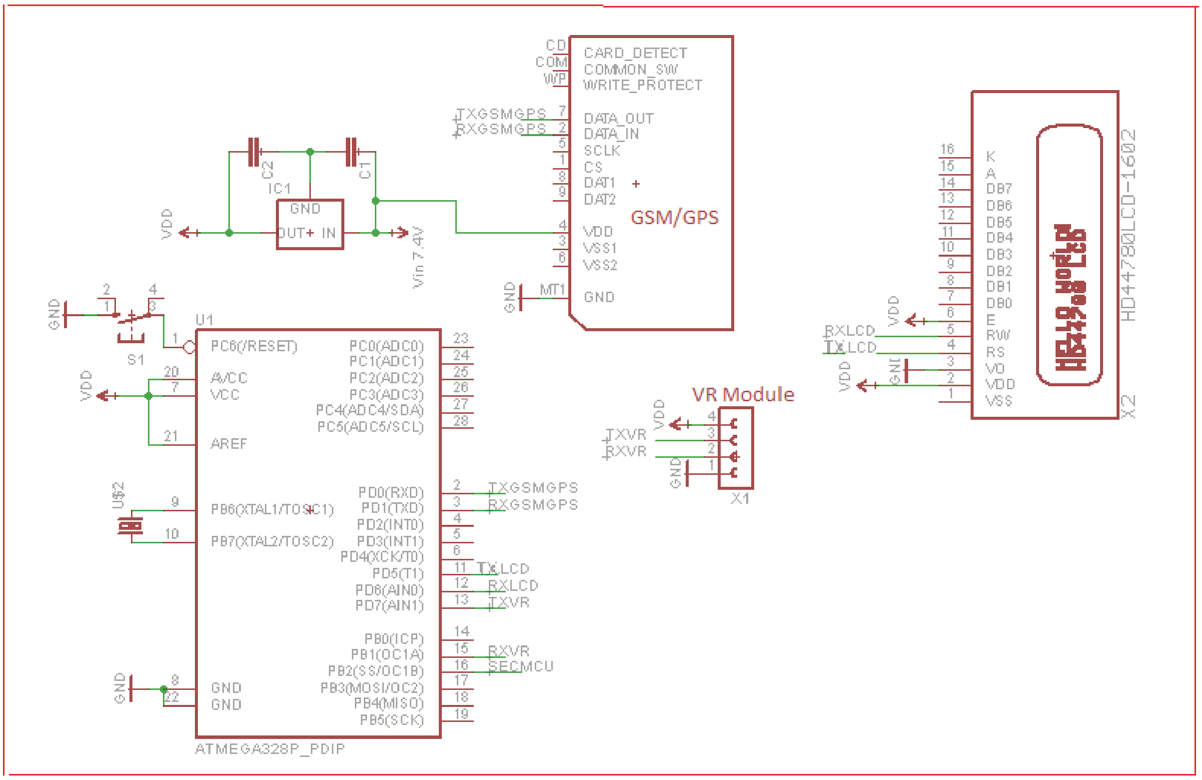

Fig 6.3: Level 2: Main MCU Design.

6.1.3.2 Secondary MCU

Figure 6.4 shows Level 2 of the Secondary MCU with all the connections. As seen in the figure, the secondary MCU is connected via serial to the camera and 2 RF (Radio Frequency) modules. It is also connected to a level shifter that is connected to RF on pins (2,3). The level shifter is used because the RF module operates on a 3.3v level logic while the MCU operates on a 5v logic. The RF module that controls the motor - as an arbitrary application - is connected to pins (14,15). The secondary MCU is also connected via SPI bus to the SD shield on pins (16,17,18,19). As noticed the 7805 voltage regulator is connected to a voltage divider to provide an output of 3.3v that will supply the RF modules.

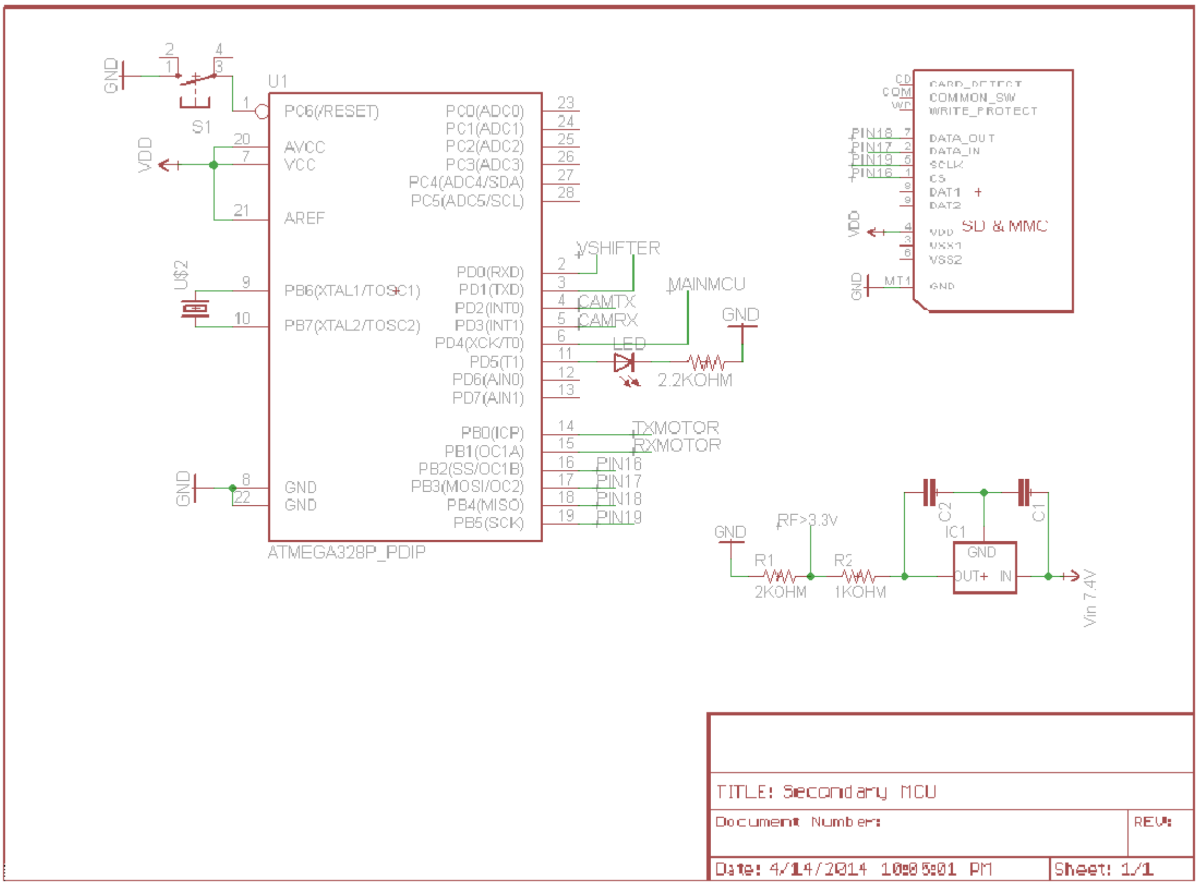

Fig 6.4: Level 2: Secondary MCU Design.

6.1.4 Level 3

6.1.4.1 Main Flow Chart

The voice recognition as mentioned earlier is the main input to the system. Table 6.1 lists all the voice commands stored in an EEPROM (Electrically Erasable Programmable Read Only Memory). A special software named "Access Port137" was used to save the voice commands in the EEPROM. The commands are divided into 3 groups. Each group has 5 commands. Note that the "X" represents a free space in the memory that was not utilized. The list of commands can increase by increasing the size of the on board EEPROM. The groups are connected using the code to activate the corresponding commands. As for example, if the user said "Call" this will automatically activate group 2 and waits another interrupt from the voice commands to activate the corresponding action in group 2.

Group 1	Group 2	Group 3
Call	Essam	Busy
SMS	Ashraf	Driving
Camera	Photo	Cancel
Tracker	Video	X
Danger	Cancel	X

Table 6.1: List of the voice commands stored.

As seen in figure 6.5, this is level 3 of the project. This resembles the main algorithm behind the code. The main input is from the voice recognition module. It receives commands from the user and based on pre-set commands the system will activate the co-responding functionality. The system will instantaneously check for input commands from the user in an infinite loop. The commands can either be “Call, SMS, Camera, Tracker, and Danger” each of which will activate a set of instructions. As for the tracker, the system will turn on the tracking system and upload the new GPS location every 2 minutes to a web server via FTP (File Transfer Protocol). The host is provided with a password for the user’s security to log his daily movements. The website is www.saic.oo.gd.

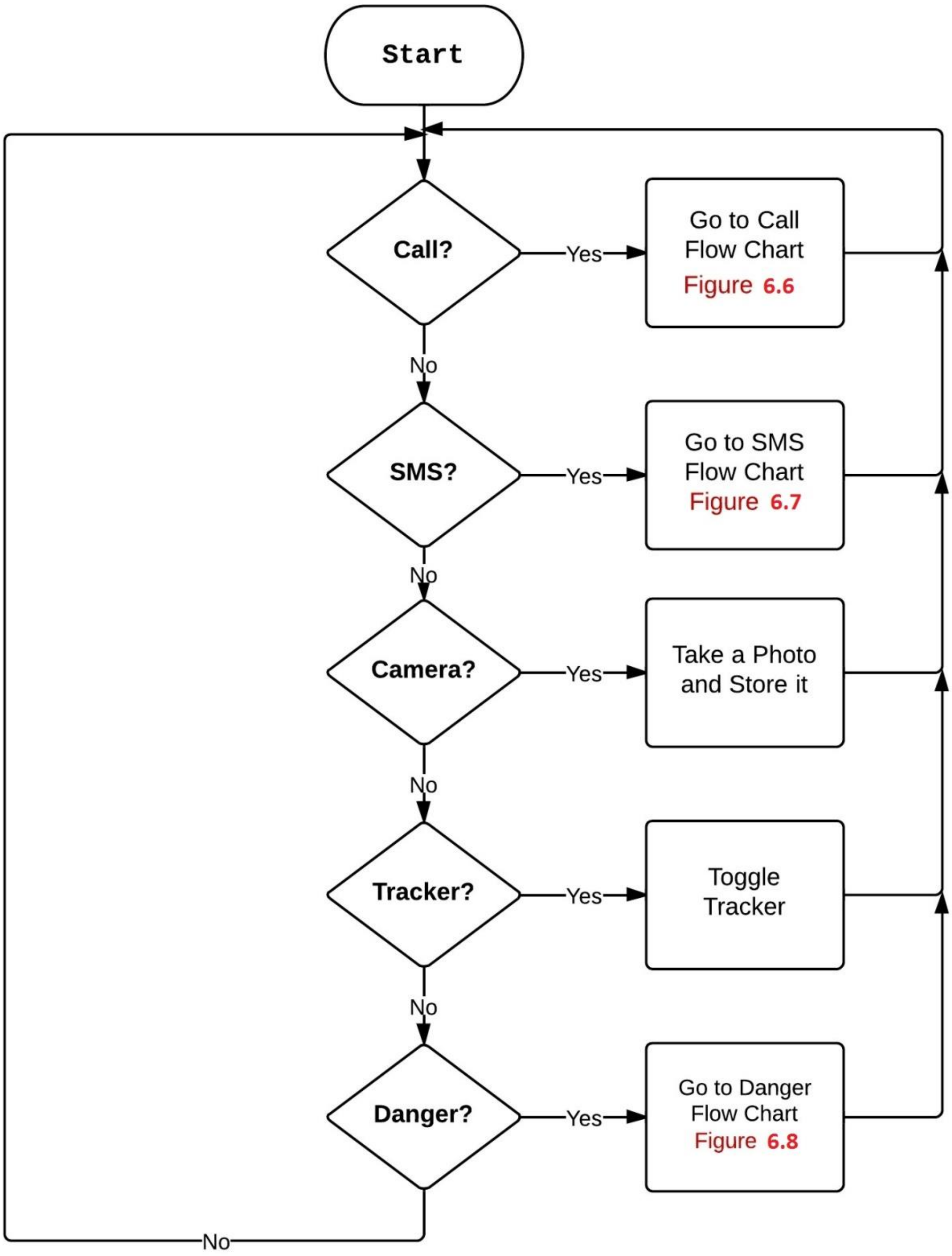

Figure 6.5: Main organization flow chart.

6.1.4.2 Call Function Flow Chart

As for the call functionality (shown in figure 6.6), the system will remain in a loop waiting the user to mention the name to be called. If the user said "Cancel" the system will go back to the main menu waiting the user to say one of the main commands.

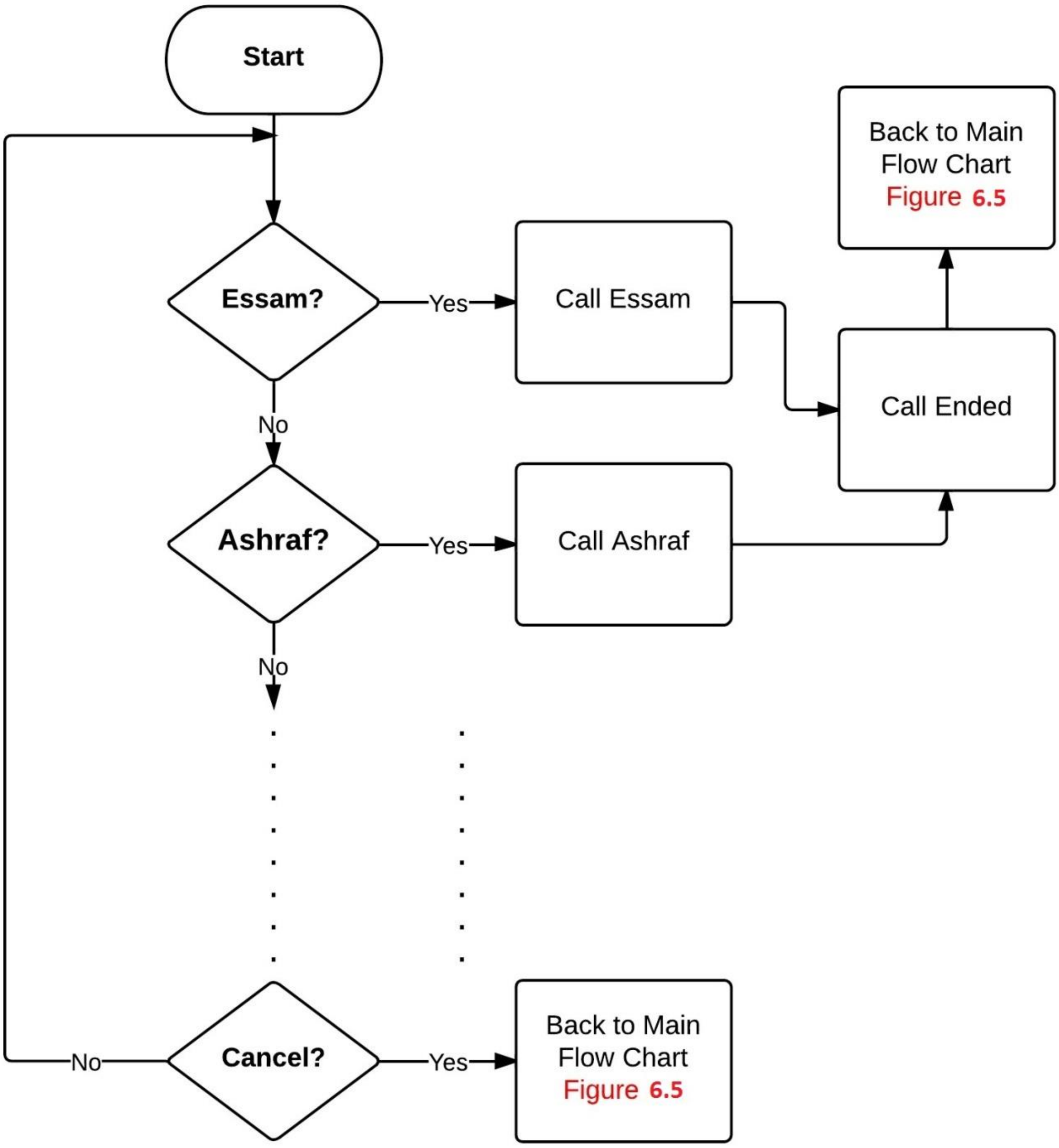

Figure 6.6: Call organization flow chart.

6.1.4.1 SMS Function Flow Chart

As for the SMS functionality (shown in figure 6.7), the system will remain in a loop waiting the user to mention the name to send SMS to him, and when the name is specified then the system will await another voice command which specifies one of the pre-set messages to be sent to them. If the user said “Cancel” the system will go back to the main menu waiting the user to say one of the main commands.

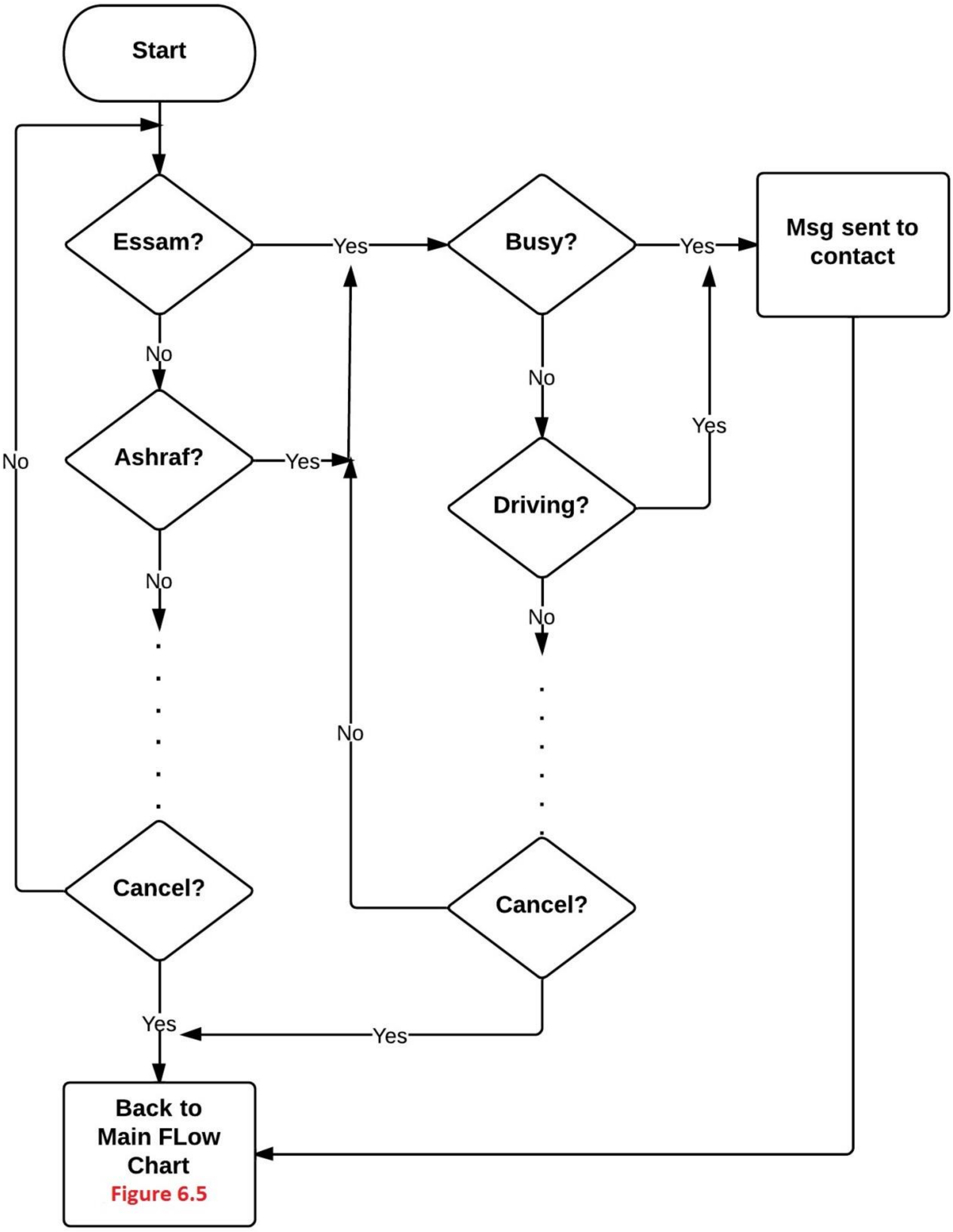

Figure 6.7: SMS Organization Flow Chart.

6.1.4.2 Danger Function Flow Chart

As for the danger command (shown in figure 6.8), once activated the system will send an SMS message to one of the relatives informing that the person is under stress and might be in a danger situation. A GPS location is sent along with the message and a snap shot via the camera will be taken in on the spot.

Figure 6.8: Danger Organization Flow Chart.

6.2 Device Selection

As there were lots of constraints as mentioned in section 4.1, and both marketing and engineering requirements have to be met, we as a team had few selection options.

The devices to be selected are the MCU, the GSM/GPS, voice recognition, EEG Headset, and batteries.

6.2.1 MCU

The MCU selection was constrained by several aspects. It needed to support not less than five serial connections and be compatible with to RS232 with internal TTL convertor. The MCU should be compatible with a higher language compliers such as C++, C#, and a hardware level language that is the AT (Attention) commands. We chose to use ATMEGA as for the main MCU because the design team was already familiar with these types of MCU's. The Arduino Uno R3 meets all of the above requirements.

As for the secondary MCU, it needed to be a low tech with support of high level compiler. It also had to have 3 serials and an SPI bus for communication. The boot loaded ATMEGA 328P was chosen for this application.

6.2.2 GPS/GSM

Cost was the main constraint behind choosing this module. Mostly they are sold separately as a GSM module and GPS module not both together. Our team looked for a one device with lower cost and can be easily dealt with. It should also be compatible with our Arduino Uno R3. The GSM module has to be compatible with Kuwait's GSM band of frequency 900/1800 MHz It should also have FTP service to upload data to a web host server. It should be also programmed by AT commands to reduce complexities which make the system rigid and robust. A GPS/GSM quad band SIM900 shield for Arduino offered by Cooking Hacks was selected.

6.2.3 Battery

The Arduino microcontroller can be powered by an outsource of 7-12

Module	Average Current withdrawal
GSM/GPS	100 m A
Voice Recognition	40mA
TFT Screen	250 mA
Camera	90 mA
Total	480 mA

Table 6.2: Components Current Withdrawal.

In order for the system to stand long periods of operation a capacity of the battery has to be carefully chosen.

For 7 hours operation:

$$C(battery\ capacity\ in\ mAH = Total\ Current\ I * Time\ for\ operation$$

$$C = 480 * 7 = 3360\ mAh$$

A battery's capacity should be no lower than 3360 mAh with a voltage of 7-12v. The device will be wearable therefore; weight is a major constraint.

Battery	Capacity	Voltage	Cost	Weight
Li-Po RC Battery	3300 mAh	11.1v	$45.90	200g
Panasonic CGR18650C	8800 mAh	7.4v	$47.95	425g
8- Li-Ion pack	5200 mAh	8.4v	$35	600g

Table 6.3: Batteries Specifications.

According to table 6.3, Li-Po RC battery was chosen for this project.

6.2.4 EEG Headset

As seen in table 6.4, a criteria was set by the team. The main factors that are relevant in this part were the "Attention/Meditation" values, raw wave values, and the cost. The MindWave offered by Neurosky met the criteria.

Description	Plans and software for building an EEG from scratch	Levitating ball game from Uncle Milton	Levitating ball game from Mattel	MindWave headset from NeuroSky
Attention / Meditation Values	No	Yes	Yes	Yes
EEG Power Band Values	Yes	No	Yes	No
Raw wave values	Yes	No	No	Yes
Cost	$200+	$75	$80	$80

Table 6.4: Comparison between different EEG headsets.

6.3 System Installation

This section will provide some figures that indicate the system and how it was installed.

Figure 6.9 shows the microcontroller board mounted to a platform to simplify working with it.

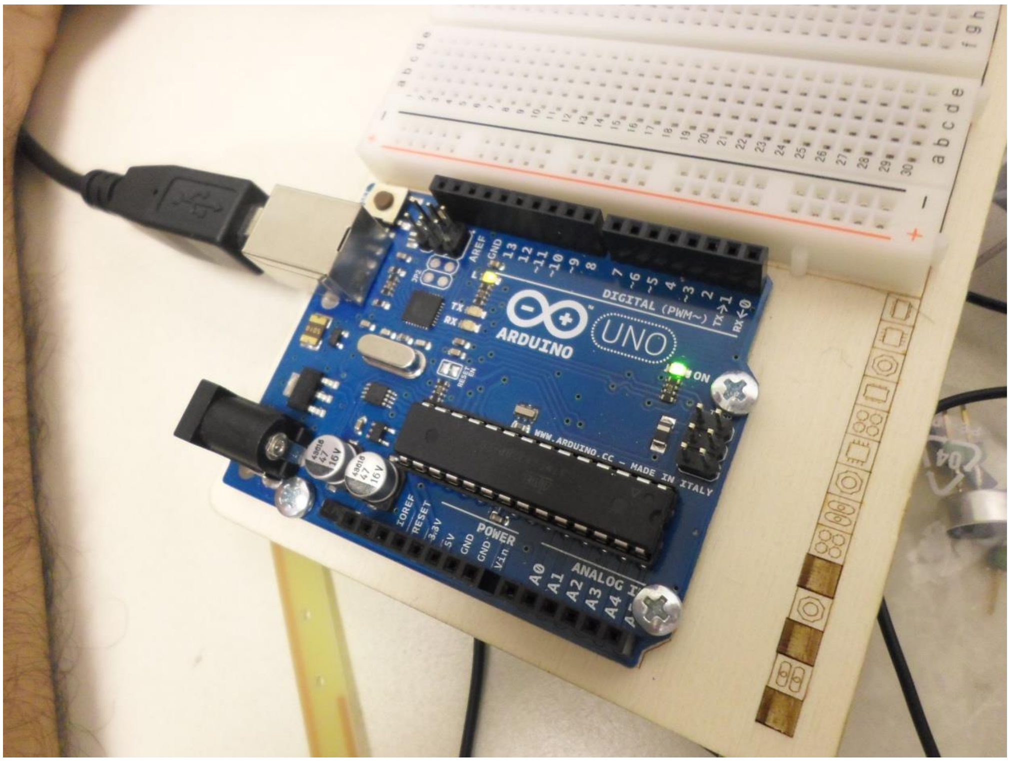

Figure 6.9 : Microcontroller Platform.

Figure 6.10 shows the GSM/GPS Module mounted on the microcontroller that was connected to the voice recognition module.

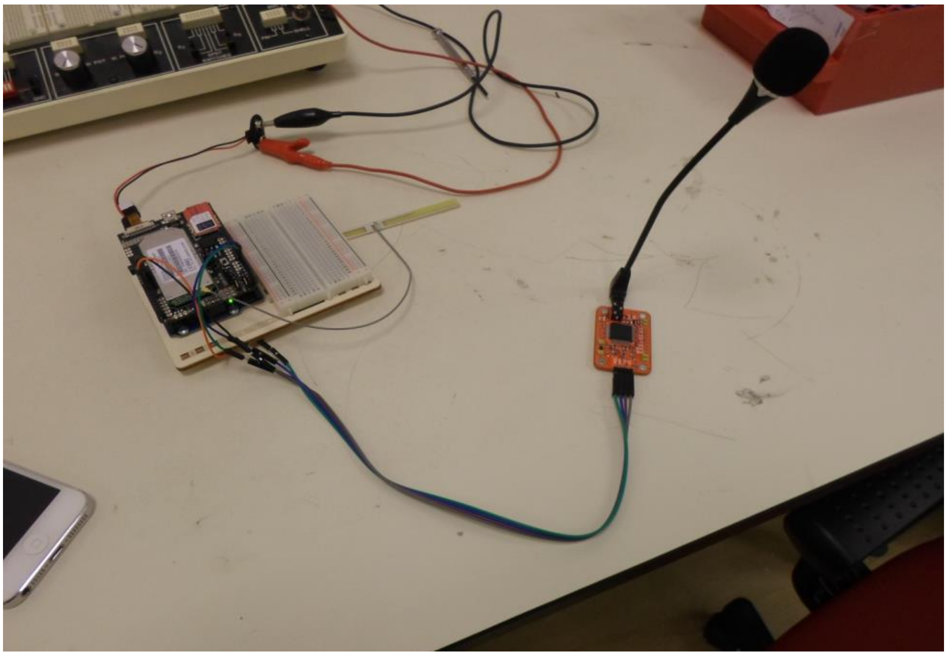

Figure 6.10: GPS/GSM module along with the voice recognition Unit.

Figures 6.11 and 6.12 shows exactly the secondary microcontroller connected and then soldered into a board.

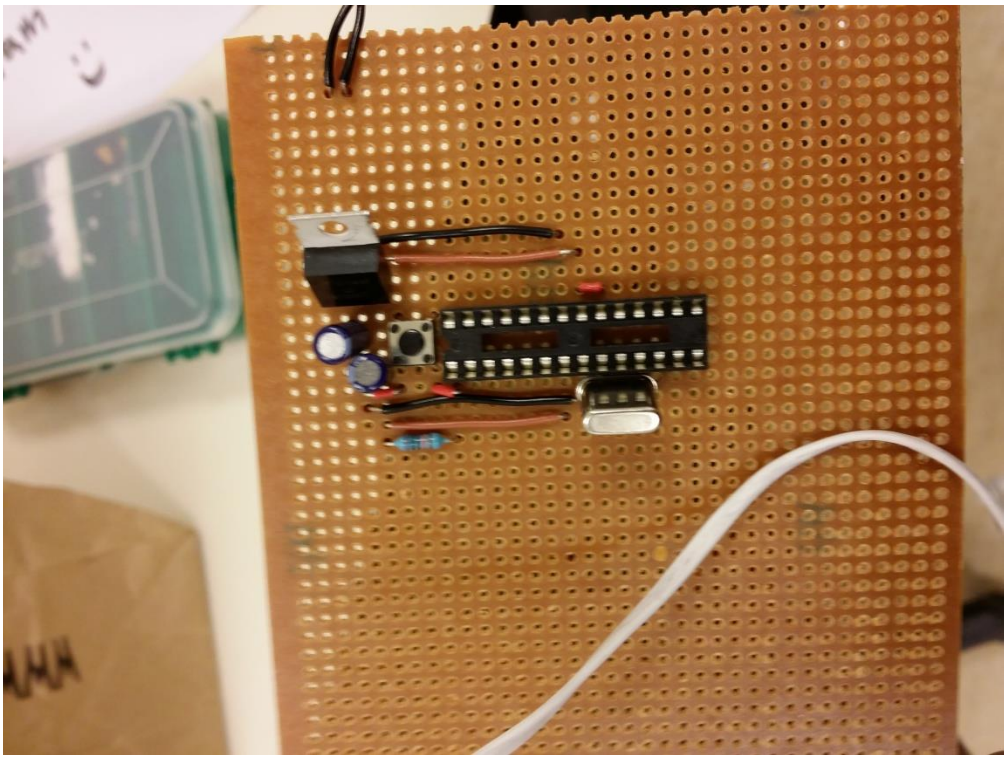

Figure 6.10: Secondary microcontroller unit.

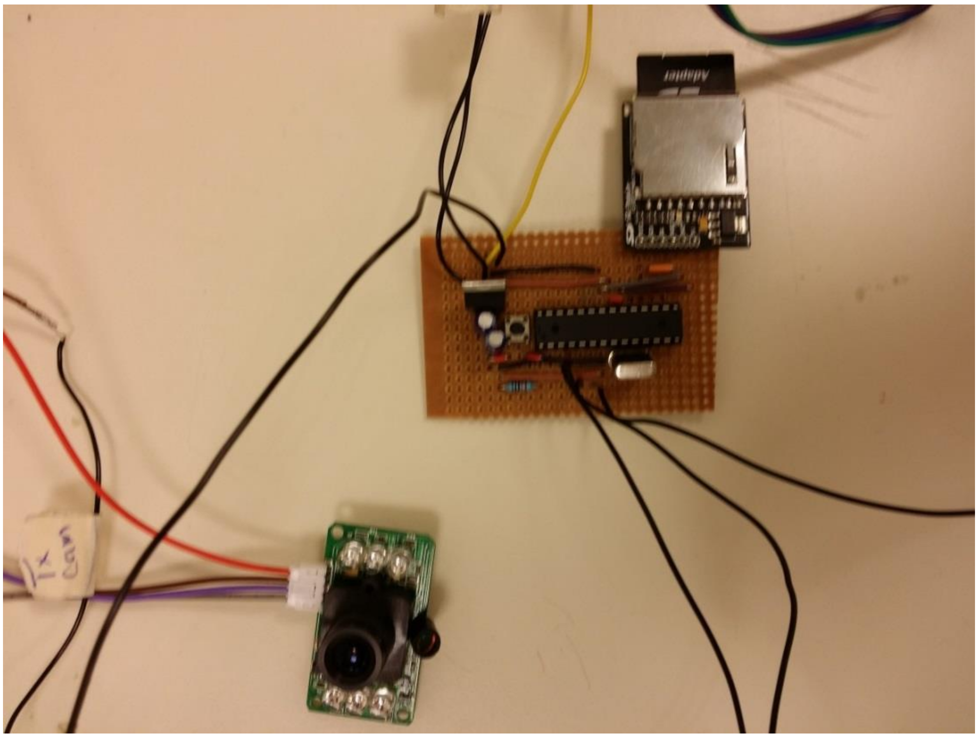

Figure 6.11: The microcontroller unit compressed along with the SD shield and the camera on the board.

Figures 6.12 and 6.13 shows the TFT screen unit wired to the Arduino Mega microcontroller which controls the TFT unit.

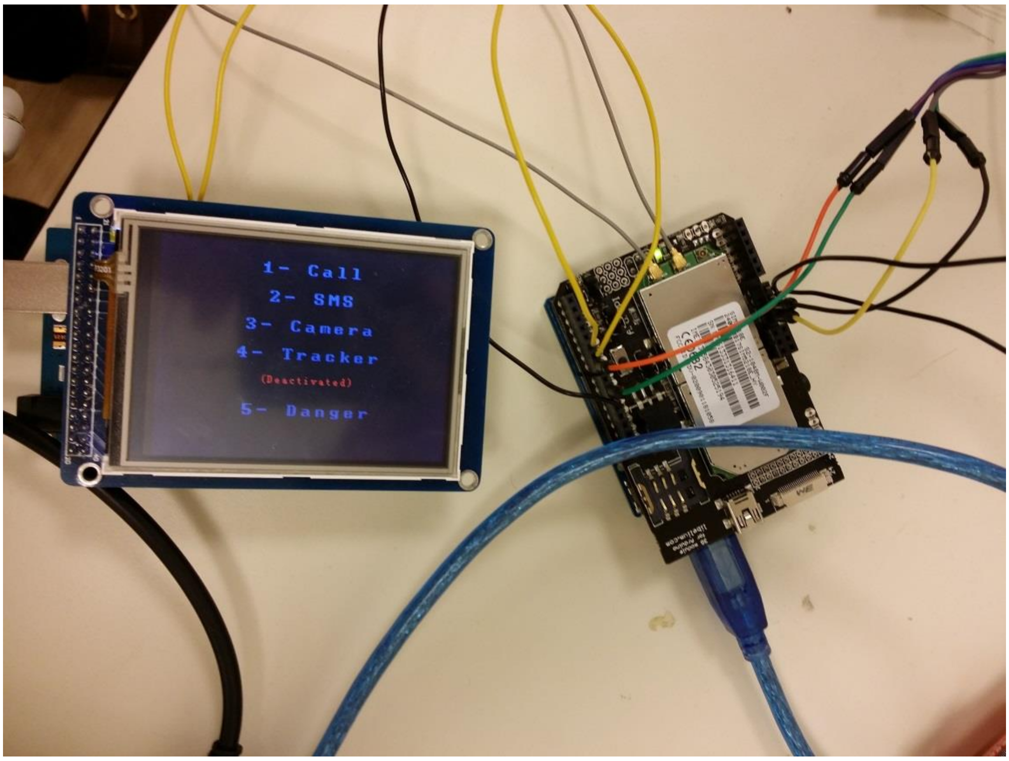

Figure 6.12: TFT unit.

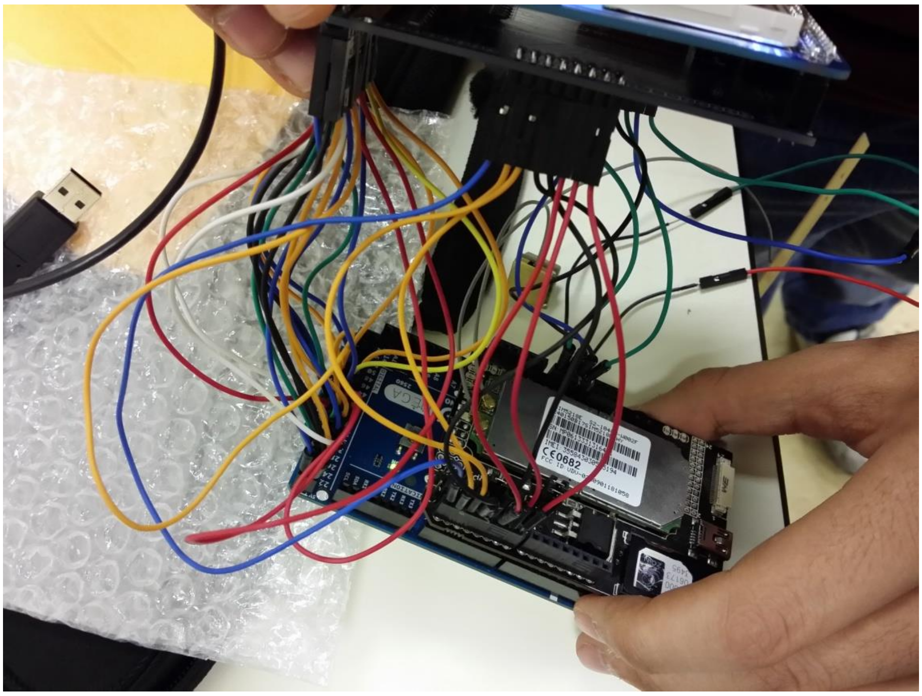

Figure 6.13: A closer look into the TFT wiring.

Next we have figure 6.14 which shows the primary microcontroller unit connected to the secondary unit which is connected to the camera and SD module.

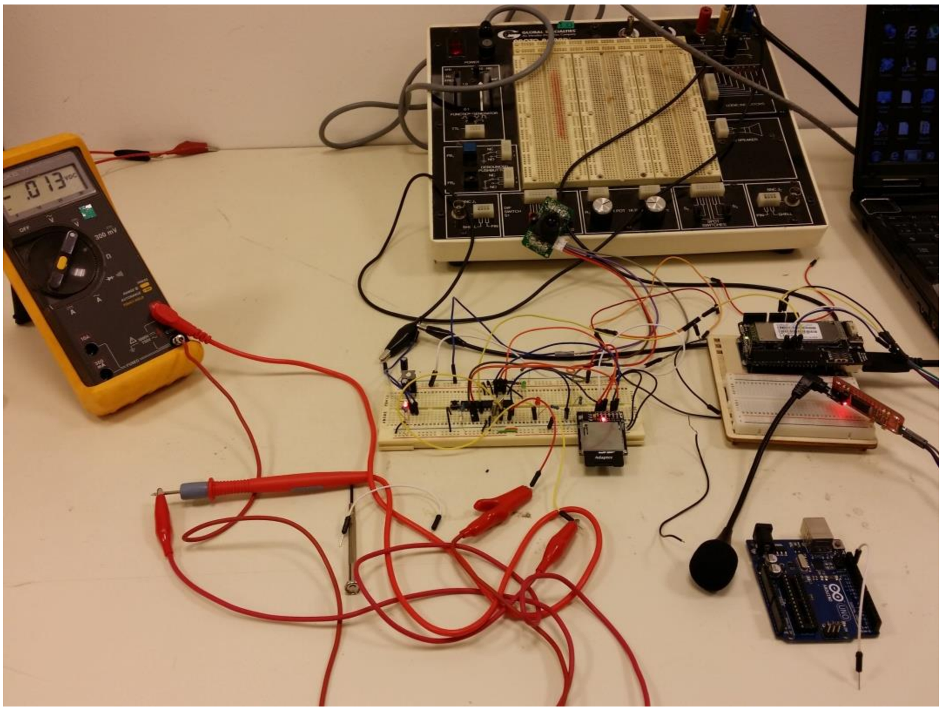

Figure 6.14: Main MCU Connected to the Secondary MCU before soldering the secondary MCU.

Figure 6.15 shows the EEG set that is provided by Neurosky. As can be seen the electrode will be placed on the top left eye.

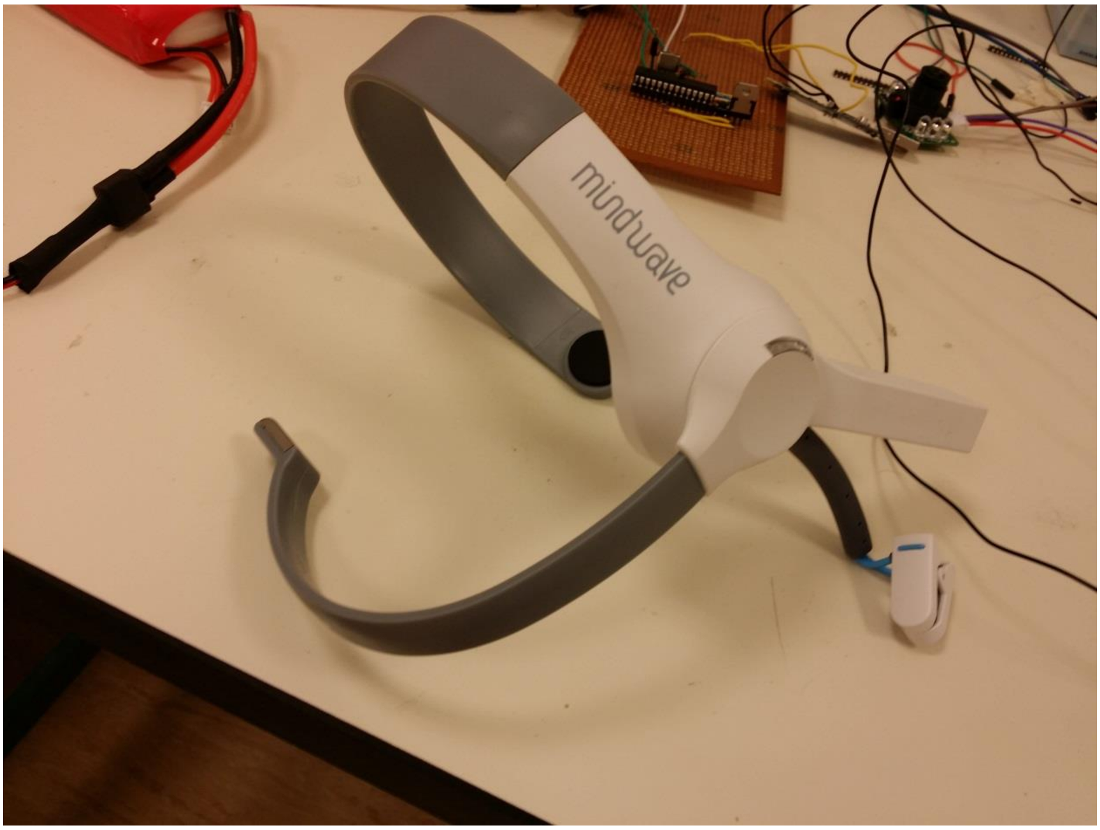

Figure 6.15 : Mindwave EEG set.

Figure 6.16 shows the connection of the RF dongle that receives data from the brain, microcontroller unit, and a level voltage shifter where components are mounted on the car. Two 4.8v 1300 mA batteries were used to power the car and the circuitry are hidden beneath the board. It also has a motor drive that is the H-bridge L293D which is used to control the motor.

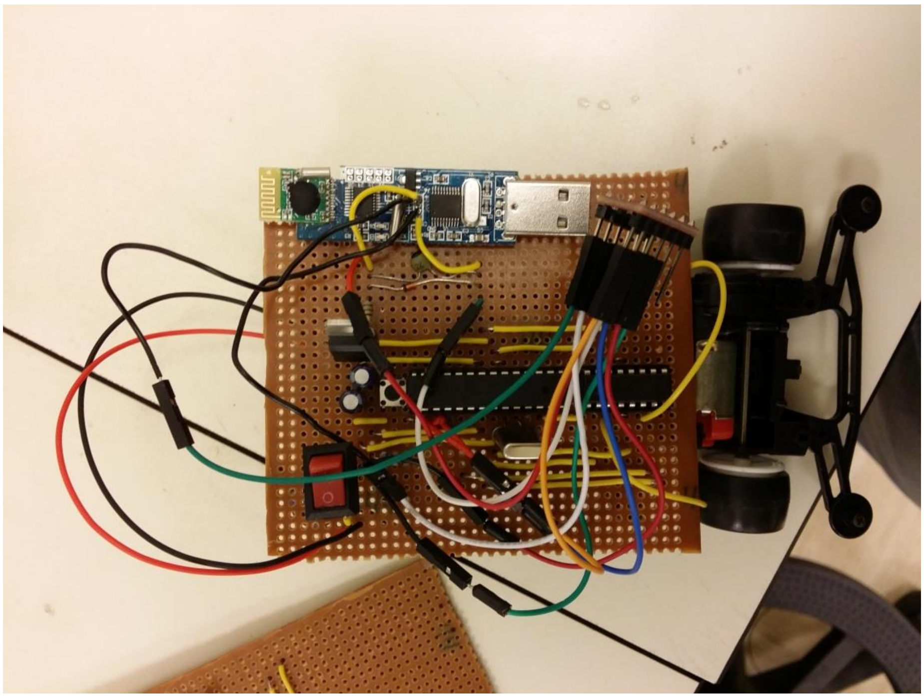

Figure 6.16 : Car controlled using attention levels.

Figure 6.17 shows how the final design looks with the components hidden inside the t-shirt. Note that the locations in the picture are the actual locations where the hidden pockets in the t-shirt will be.

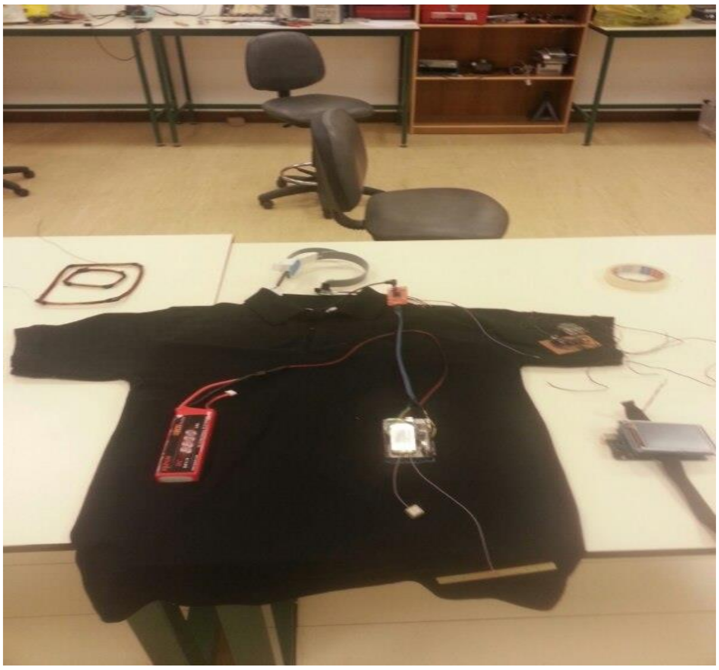

Figure 6.17 : SAIC (Synthetic Artificial Intelligent Clothes).

7. Design Verification

7.1 Test Results

Individual module test was done at the beginning of the work. This was important to make sure all the devices were running perfectly with no failures or manufacturers defections. As time progresses and modules start to combine, test scripts were run during the progress to test the compatibility of the modules and that everything is working as it should be.

7.1.1 Microcontrollers

All microcontrollers have been tested using the standard test offered by the manufacturer. The test was to run a simple code that will generate square wave pulses on all ports at once. It will also generate different duty cycles on ports that support PWM.

7.1.2 GPS

A simple code has been run on the module to make sure that the module obtains correct GPS data. The data has been verified by an online test.

7.1.3 GSM

The GSM module have been tested by writing different codes that will make phone calls and send SMS messages.

Fig 7.1 : Simple SMS testing.

7.1.4 Voice Recognition

Several test has been done to the voice recognition. One of which was to record set of commands specifically (A,B,C) in the EEPROM. Then these commands were used to light up 3 LEDs color coded (Red, Yellow, and Green). Based on the voice command the correct LED should light up. Figure 7.2 shows the connection and the test.

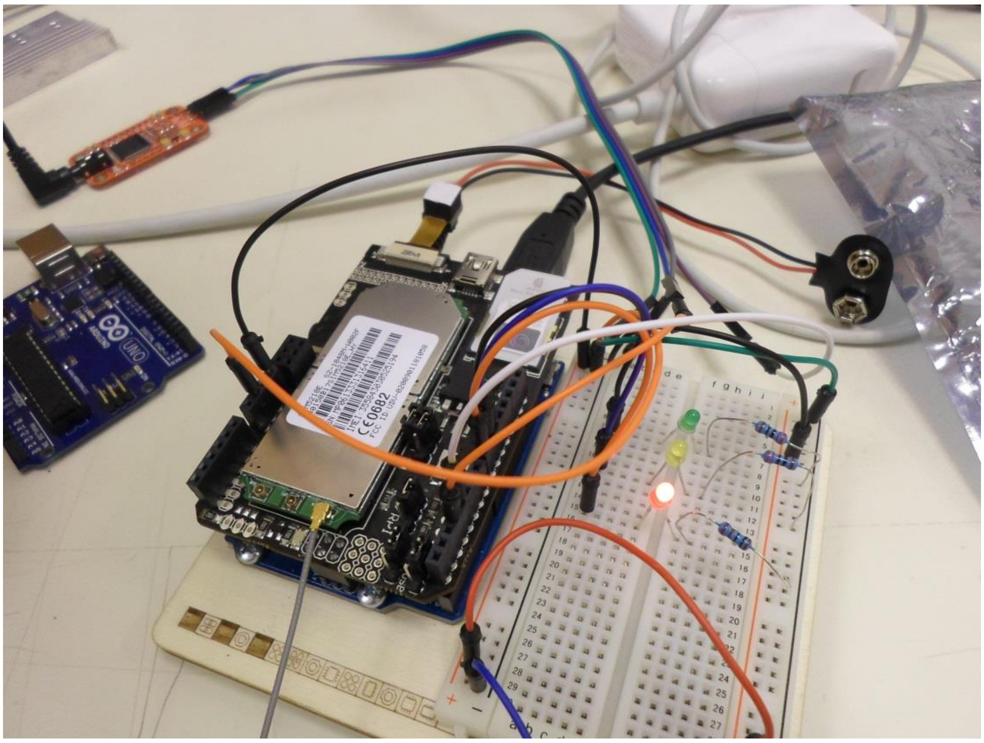

Fig 7.2 : VR testing using a simple LED circuit.

7.1.5 Camera and SD Module

These two modules were tested by running a simple code that will take a snap shot from the camera every 3 seconds and store them on the SD card. The test was successful and both modules are operating as expected.

7.1.6 FTP Data Transfer

Verifying the operation of the FTP service was done by running a simple script that will upload the current GPS Location to the webhost (As shown in Fig 7.3). The website was <www.saic.oo.gd>.

Fig 7.3: Screenshot that shows the host along with some uploaded GPS data.

7.1.7 EEG Headset

The EEG Headset was tested by running a simple code that displays the values obtained from the set on a serial monitor. All data was displayed correctly including (Attention, Meditation, High Alpha, Low Alpha, High Beta, Low Beta, High Gamma, Low Gamma, Delta, and Theta).

7.1.8 TFT Screen

Two different tests have been done to the TFT screen. One is used to make sure the display is working along with all the colors. That was done by displaying at first different texts with different colors and displaying 620x480 pixels images. The other test was done to make sure the input feedback of the screen was working as it should be. Figure 7.4 shows the first test working successfully.

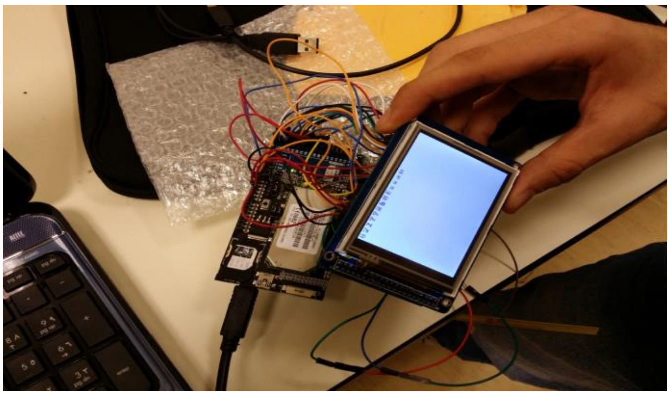

Fig 7.4: Showing a string using the TFT.

7.2 Requirements Verification

Table 7. lists each of the engineering requirements from section 4.1 with respective verifications on how the requirements have been met. It must be denoted that all of the specific system requirements have been met in the final implementation.

Requirement	Verification
Utilize a GPS device to gather time, location, and velocity data.	The GPS module can gather all the required data (Time, Longitude Altitude, and Latitude). It can pin point your exact location at any time when accessed in the web-server
Utilize a GSM unit to transmit data to a server.	The GSM module used in the system has 3G capabilities which allows it to transfer data to the cloud. It also has the FTP feature to upload data to FTP servers.
System must have a storage space for no less than 8 GB.	The SD module used in the system provides the capability to read up to 64 GB SD cards.
Transmit power gain in antennas should be <= 1W.	The antenna has transmission power of less than 2mW as indicated in the data sheet.
Battery should last for >= 7hours a day.	The Li-Po RC battery that was used can easily provide up to 8 hours of operation in low usage conditions. (see section 6.2.3).
TFT touch screen for feedback and interface.	The Spark Fun TFT screen used provides touch capabilities so it acts as both a feedback and an input device in the system. It is colored and can provide good quality image displays.
Camera’s spatial resolution should be no less than 648x488 pixels.	The camera module uses VGA resolution which is 640x480 pixels which is the minimum required resolution for clear still Images. It can also be adjusted to lower image qualities for faster capture and save procedure.

Table 7.1 : Engineering Requirements Verifications.

8. Extra Work

Extra work has been done to the project that was not included in the proposal and is considered to be a plus to the project are:

1- Wireless Power Charger.

2- Study on the effects of fear on brain wave activities.

8.1 Wireless charger

The target was to build a wireless charger that can charge the overall system with no hardware connection or wires. The idea behind this is to build a simple transformer. As seen in figure 8.1 the overall system is made of 2 copper coils, MCU, and amplifier. The MCU is needed to generate an AC source.

This can be achieved by creating square waves on one of the ports with a certain frequency. An amplifier was used at the transmitter side to amplify the input voltage before transmission. It was tested that on the receiver side, but it was inefficient as the amplifier has amplified the noise as well. LED was used as a simple application of the wireless power. For different DC powered gadgets full wave rectifier is needed.

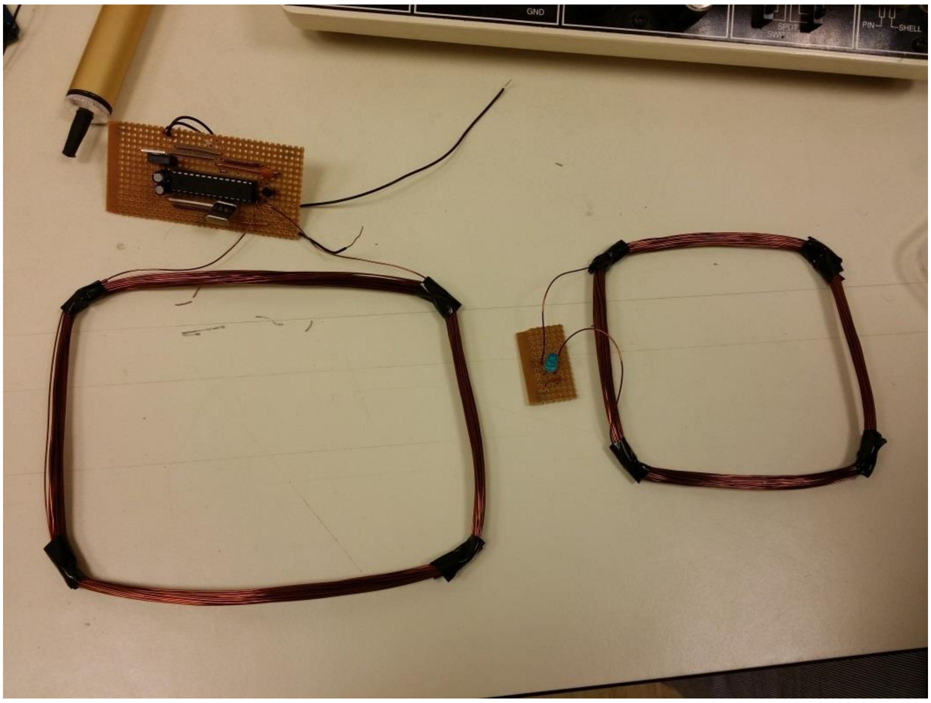

Fig 8.1: Wireless power charging platform.

8.2 Study on the effects of fear on brain wave activities

The first idea behind using the brain waves was to actually determine when a person is endangered by detecting familiar brain wave activity patterns. Therefore; several tests were done to test the hypothesis. A video has been made that is 6 minutes long. The video is relaxing in nature. At minute 5:45, a disturbing, shocking scene is displayed. This video is presented to a subject while measuring his brain wave activity. The aim of the first 5:45 minutes was to set the subject in a relaxed state. The head set measured (High Alpha, Low Alpha, High Beta, Low Beta, High Gamma, Low Gamma, Delta, Theta). The most important readings were the High Beta, and Low Beta as they are known to be associated with fear and shock. All the data was measured, and plotted on MATLAB.

Some of the good results will be presented in the following figures:

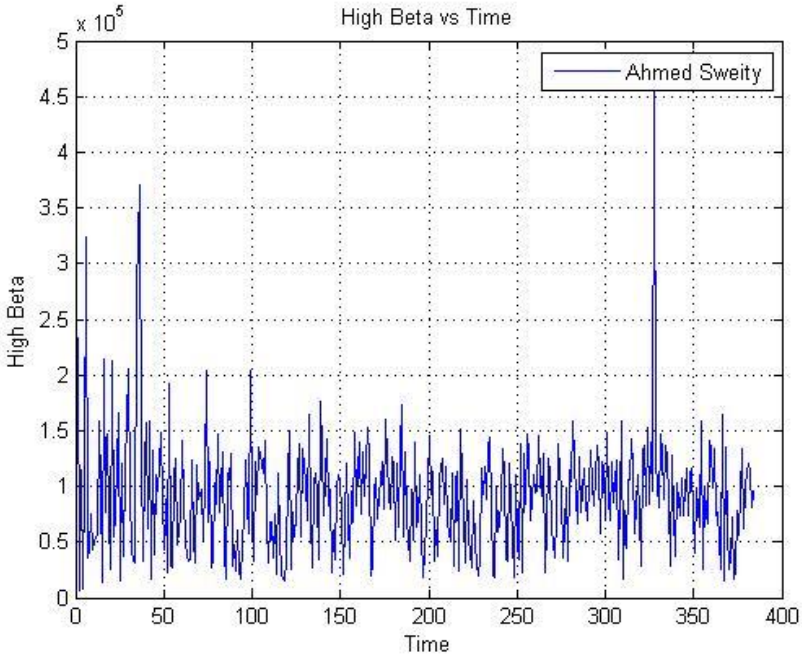

Fig 8.2: High Beta wave testing results (1).

As can be seen from figure 8.2, a major disturbance has occurred between the second 330 and 340. This was an expected result. This test has been done on 27 different people from different ages, and genders. The results came to be really bad as some people weren't affected at all by the shock, and hence there was no pattern deduced. The following figures are some un-expected results:

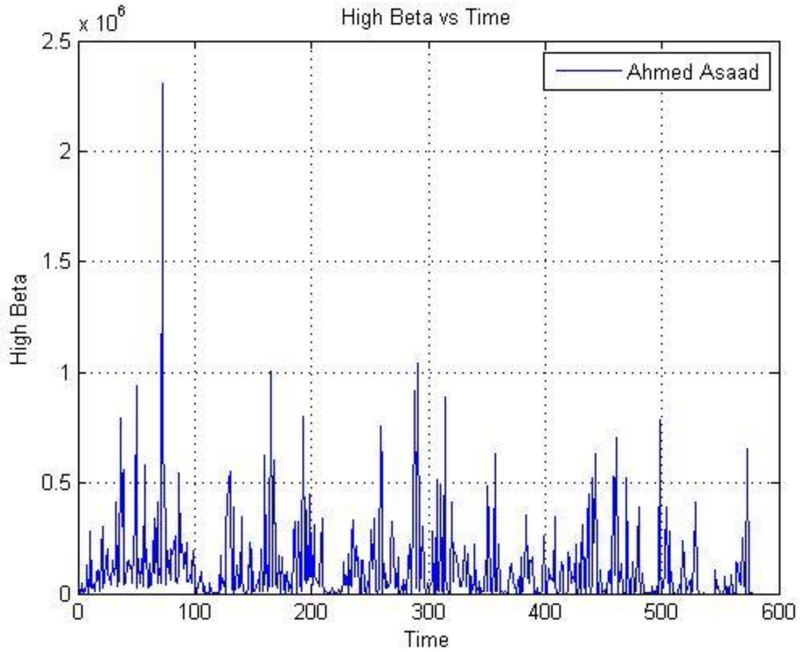

Fig 8.3: High Beta wave testing results (2).

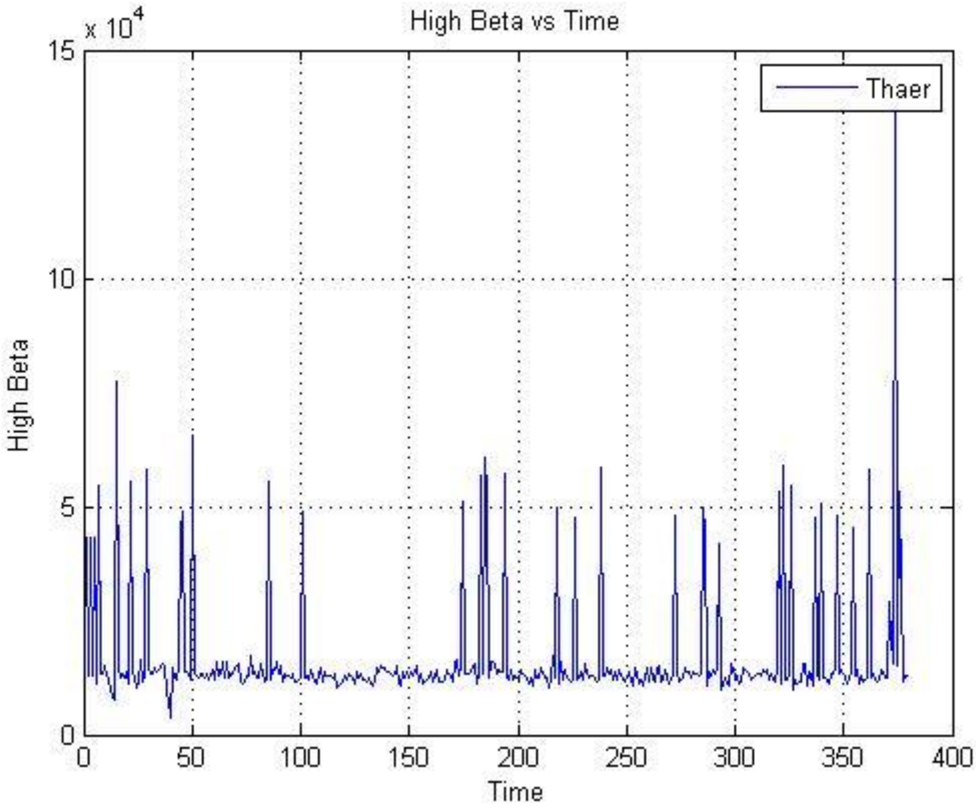

Fig 8.4: High Beta wave testing results (3).

The results seemed odd. Therefore; the team managed to make a meeting with Dr. Mohammed Al-Orabi the head of the epilepsy department in Ibn-Sina Hospital. It was a 1 hour meeting. The conclusion out of that meeting was disappointing. Following is a list of the outcomes of the meeting:

1. The problem was that until nowadays science cannot distinguish between brain activity and muscle activity. Hence; these shocks may be due to movements the subject has done during the video. The idea of such a functionality is not efficient especially that the person will be using the device on a daily basis while walking, talking, eating, drinking, etc.

2. The device used in the test had only one electrode placed on the forehead. This was a problem because these brain waves don't have a specific place to originate from. It changes from a person to another.

Testing was stopped at this point and using brain waves to control different applications wirelessly was used as a replacement.

8.3 Future Development

As previous sections discussed detailed explanation of the make of this project, next will be a discussion of the future developments. This was intended to be a proof of concept project where multi-functional system can be all put together to serve the objective. There are lots of tweaks and adjustments that can be done tom improve the robustness, efficiency, and quality of this project. Future improvement includes:

1. Optimizing the design: This can be achieved by turning all the soldered boards into PCB. This will decrease the size of the system. This will help in making the device more portable.

2. TFT Screen: The TFT screen can be altered with a smaller sized screen with lower power consumption.

3. Voice Recognition: The voice recognition could be replaced by a different module that is inexpensive and has no memory and has access to SD card data. With this tweak, all voice commands will be stored in the on board SD instead of using the limited EEPROM storage.

4. Extra features: Adding different extra features – like apps - that work on voice commands will help in making a more appealing product.

5. Wireless power charger : The wireless power charger as mentioned earlier was a plus to this project. There weren't any good testing done to it that target improving the efficacy. It can be modified with a stable circuitry to charge the Li-Poly batteries.

6. EEG headset: The main part of the EEG relevant to the system is the electrode. The set can be replaced with a single electrode, and all the circuitry that measures brain wave activities can be moved to be part of the project circuitry in the clothes.

7. EEG headset safety application: The brain waves readings can be used to detect when a person is endanger. As a team, several tests have been conducted on the effects of different feelings such as fear with the activity of the brain waves. This can replace the command "Danger" and be automatically triggered when a threshold on the brain activity is reached. Test results can be found in appendix (A).

9. Summary and Conclusions

Our Plan to develop a wearable computing system was successful. With constant and accurate communication with our Supervisor, we were able to develop this plan; with guidance from our faculty advisor and persistence as a team, this plan came to reality. We are proud to say this project represents the culmination of our unique skills, especially those developed during our academic years at Kuwait University. We learned that our system is the proof of concept for another system that will be developed in the coming years.

If any further work were considered for the device we developed, we suggest working with different types of cameras, voice recognition systems and EEG headsets, as more costly devices may yield more consistent results. Also, using the originally intended Processing Computer would be advised so that creating a High-speed system would be practical.

This project was an excellent experience for the three of us. Some of the lessons we learned in the course of this project include:

- Even with all equipment available in the lab, unexpected problems regarding the environment can happen.
- There are many ways to reach the same results.
- No plan is perfect and that being flexible and thinking radically is often the key to achieving success.
- Automated testing can reveal hidden bugs.
- Creating custom function libraries makes working with external devices much more tolerable.
- No test is perfect, there is always one more aspect to verify and validate.

The most rewarding part of this project was seeing its components work in unison; seeing that made all the time and effort spent in the laboratory and the classroom a worthwhile investment.

10. References

Links:

- Cooking Hacks documentations and forum, Available at <http://www.cooking-hacks.com/>.
- Main website for the Arduino manufacturer, Available at <http://arduino.cc/>.
- “Google Glass”, Available at <http://www.google.com/glass/start/>.
- “Wearable Computer”, Available at <http://en.wikipedia.org/wiki/Wearable_computer>.
- “Wearable Technology“, Available at <http://en.wikipedia.org/wiki/Wearable_technology>.
- “How to hack brain waves”, Available at <http://frontiernerds.com/brain-hack>.
- “http://en.wikipedia.org/wiki/Global_System_for_Mobile_Communications.
- “Vin output voltage of an Arduino”, Available at <http://electronics.stackexchange.com/questions/78608/vin-output-voltage-of-an-arduino>.
- “Battery voltage drop”, Available at <http://electronics.stackexchange.com/questions/106122/overcoming-voltage-drop-in-a-battery>.
- “Powering using a voltage divider”, Available at <http://electronics.stackexchange.com/questions/109514/resistive-loading-effect-voltage-drop>.
- “Zener diode as a voltage regulator”, Available at <http://electronics.stackexchange.com/questions/109674/zener-diode-as-voltage-regulator>.

Research Papers:

- Device Interface for People with Mobility Impairment "IEEE 7th GCC Conference".
- Rahn, Cornelius (28 June 2012)."Google's Brin to Offer Eyeglass Computer to Consumers By 2014".
- Newman, Jared (4 April 2012)."Google's Project Glass' Teases Augmented Reality Glasses".
- Albanesius, Chole (4 April 2012)."Google 'Project Glass' Replaces the Smartphone With Glasses".

11. Appendix A: Project Management Plan

11.1 A.1:Work Schedule

Table A.1 shows how work was divided throughout the semester.

Tasks	Timeline Table														
	February				March				April				May		
	W 1	W 2	W 3	W 4	W 5	W 6	W 7	W 8	W 9	W 10	W 11	W 12	W 13	W 15	W 16
In-Depth searching															
The initial proposal															
Specifying components needed															
Components arrival															
Testing the components															
Programming															
Milestone (1)															
Designing the wearable prototype															
Trial and error to achieve optimal operation															
Milestone (2)															
Demo and final Presentation															

Table 11.1: Preliminary Schedule.

11.2 A.2:Member Contributions

Adel

Adel is known as the "Debugger" in the team. He was responsible for the theoretical part of the project. That includes any electrical, hardware, software understanding that will help in solving different problems. He has contribution to design optimization, code debugging, and alternative electronic design solutions when certain components are not available.

Mohammed

Mohammed is known as the "Handy Man" of the group. He was responsible for doing all the soldering in the system. That includes unplugging 3 microcontrollers from their manufacturer boards and design board circuits that meets the requirements perfectly based on a circuit analysis. He was also responsible in building the wireless power charger that was used as a plus for the project.

Essam

Essam is known as the "Coder" in the team. He was responsible for the software based problem solving and writing down the algorithms and flow charts. He was responsible in writing the code for the project. He used different languages for the project including C++, AT commands, and HTML. That being said, he wrote no less than 3500 lines of codes for the project.

Ashraf

Ashraf is known as the "Logistic Co-coordinator" in the team. He was responsible for all the paper work which includes reports, follow ups, meetings, approvals, funding, presentations, and components online ordering. He has also contributions to solving different parts of the project including the camera, and serial baud rates adjustments.

As a Team

Working as a team, we wrote and debugged code, identified system problems and discussed solutions, wrote our design reports and related documents and, of course, gave the required presentations to reflect this project's progress.

11.3 A.3:Cost Analysis

Aside from a lot of time, McDonald's, Subway, and cigarettes, this project incurred certain development costs. Table 11 describes the costs related to the development of the final system.

Cost Analysis

No.	Item Description	Quantity	Unit Price (KD)	Shipment Price (KD)
1	GPS/GSM Module	1	60.5	14.8
2	Arduino Mega	1	17.25	
3	TFT LCD Touch Display	1	10.2	9.25
4	Voice Recognition Module	1	8.75	
5	GPS + GSM Antennas	1	5.5	
6	Jumpers	1	5.5	
7	SIM Card holders	2	1.25	-
8	Camera Shield	1	12.7	4.25
9	SD Shield	1	2.3	
10	NeuroSky Headset	1	22.26	TBO
	Total Cost (KD):			152.25

Table 11.2: Cost of the Project.

11.4 A.4:Decision Matrix Criteria

The following tables include and explain all the voting that has been done at the begging of the project. This includes setting the goals, criteria and scores for each criterion. Decision matrices for the objective tree with criteria weightings as follows:

1 = Equal , 3 = Moderate , 5 = Strong , 7 = Very strong , 9 = Extreme .

All features scores

Criteria	Reliable	Portable	Easy to use	Geometric mean	Scores
Reliable	1	1/3	1	0.6933	0.1922
Portable	3	1	3	2.08	0.5765
Easy to use	1	1/3	1	0.83268	0.2309

Table 11.3: Features Scores.

Portable features scores

Criteria	Wearable	Light weight	Small	Ergonomic	Geometric mean	Scores
Wearable	1	1	5	1/3	1.1362	0.2485
Light weight	1	1	3	3	1.73205	0.3789
Small	1/5	1/3	1	1/3	0.38609	0.0844
Ergonomic	3	1/3	3	1	1.31607	0.2879

Table 11.4: Portable Features Scores.

Wearable features scores

Criteria	Easy to change from garment to another	Implemented in any type of clothes	Geometric mean	Scores
Easy to change from garment to another	1	1	1	0.5
Implemented in any type of clothes	1	1	1	0.5

Table 11.5: Wearable Features Scores.

Reliable features scores					
Criteria	Battery Operated	Durable	Replacement for Mobile Phones	Geometric mean	Scores
Battery operated	1	1/5	1/9	0.28114	0.069
Durable	5	1	1	1.70997	0.42
Replacement for Mobile Phones	**9**	**1**	**1**	**2.08008**	**0.5109**

Table 11.6: Reliable Features Scores.

Battery features scores				
Criteria	**Rechargeable**	**Low power**	**Geometric mean**	**Scores**
Rechargeable	1	1/3	0.5773	0.25
Low power	3	1	1.73205	0.75

Table 11.7: Battery Features Scores.

Easy to use features scores					
Criteria	**Multi controls**	**Multi functions**	**Hands free**	**Geometric mean**	**Scores**
Multi controls	1	1/5	1/5	0.34190	0.0856
Multi functions	5	1	1/3	1.18560	0.29688
Hands free	5	3	1	2.46620	0.61755

Table 11.8: Easy to use Features Scores.

11.5 A.5: List of Used AT-Commands and Standards

This section will include all the AT-Commands used by the microcontroller to control the modules.

Command	Response	Description
AT	Null	
AT+CPIN="****"	OK	If the SIM card is locked with PIN (**** is the pin number)
AT+COPS?	Null	Operator information
AT+CPTONE=**	OK	Plays a DTMF tone or complex tone on local voice channel device . ** is the number of the tone.
ATD*********;	Null	********* is the number to call.
ATA	OK	Answer an incoming call.
AT+CHUP	OK	Cancel voice calls.
AT+CNSM	OK	Enable/disable noise suppression.
AT+CQCPREC=*,&&&	Null	Starts recording sound clips . Answers with the path and the name of the clip. * is the path and &&& is the format.
AT+CQCPPAUSE	OK	Pauses record sound.
AT+CQCPRESUME	OK	Resumes record sound.
AT+CQCPSTOP	OK	Stops record sound.
AT+CCMXPLAY=”*****”	OK	Plays an audio file . ***** is the name of the file.
AT+CCMXPAUSE	OK	Pauses playing audio file.
AT+CCMXRESUME	OK	Resumes playing audio file.
AT+CCMXSTOP	OK	Stops playing audio file.
AT+CGSOCKCONT=**,&&&	OK	** is the protocol and &&& Access Point Name.
AT+CGPS=*,&	OK	* sets on (1) or off (0) and & is the GPS mode.
AT+CGPSINFO		Gets current position information.
AT+CGPSURL=”***”	OK	Sets AGPS default server URL . *** is the URL.
AT+CGPSSSL=*	OK	Select transport security, used certificate (*=1) or not (*=0).
AT+CGPSSWITCH	OK	Choose the output port for NMEA sentence.
AT+CMGF=	OK	Specifies the input and output format of the short messages. 0 for PDU mode and 1 for text mode.
AT+CMGS	Null	Sends a message.
AT+CPMS=***	Null	Selects memory storages. *** is the memory type.
AT+CMGR=*	Null	Reads a message. * is the number of the message.

Table 11.9: List of All Used AT-Commands

11.6 Standards

To allow for efficient data storage and processing, this system follows specific criteria when dealing with asset data (Photos, Videos, GPS data, ...etc) which will be explained for both the SD card and the web-server in details.

11.7 Data Storage in the SD Card

This section will show exactly how the MCU (Arduino) communicates with the SD card to save data on it. The communication between the microcontroller and the SD card uses Serial Peripheral Interface (SPI) which is a synchronous serial data protocol used by microcontrollers for communicating with one or more peripheral devices quickly over short distances.

It must be noted that a library specifically for the SD is used to allow reading from and writing to the SD card, also as it was mentioned before SD cards work only at 3.3V so the module used in the system uses FETs for level shifting and a 3.3V regulator for power when operating from 5.0V. Some of the commands used will be clarified in Table 11.10 .

Command	Description
Available()	Check if there are any bytes available for reading from the file. available() inherits from the Stream utility class.
Close()	Close the file, and ensure that any data written to it is physically saved to the SD card.
Flush()	Ensures that any bytes written to the file are physically saved to the SD card. This is done automatically when the file is closed. flush() inherits from the Stream utility class.
Print()	Print data to the file, which must have been opened for writing. Prints numbers as a sequence of digits, each an ASCII character (e.g. the number 123 is sent as the three characters '1', '2', '3').
Println()	print data, followed by a carriage return and newline, to the File, which must have been opened for writing. Prints numbers as a sequence of digits, each an ASCII character (e.g. the number 123 is sent as the three characters '1', '2', '3').
Size()	Get the size of the file.
Read()	Read a byte from the file. read() inherits from the Stream utility class.
Write()	Write data to the file.

Table 11.10 : SD Library Commands.

11.7.1 Data Storage in the Web-Server using FTP

Once a connection is established between the microcontroller and the Web-Server, the data needed to be transferred is streamed to the server and parsed into the FTP format, this format is specifically demanded by the Web-Server to be able to upload the data correctly so before listing the commands associated with the process , the FTP standard will be clarified first.

File Transfer Protocol (FTP) is a standard network protocol used to transfer computer files from one host to another host over TCP-based networks such as the internet , where it is built on a client-server architecture and uses separate control and data connections between the client and the server. Normally the user must provide a username and password to gain access to the specified host and this is called clear-text sign-in protocol. However regarding the security level of the FTP it is not that strong compared to the new protocols used over the servers but a secure version called FTPS (File Transfer Protocol Secure) is what we are using with our system to protect the users sensitive data from any possible attacks.

FTP uses a set of commands to communicate between the host and the computer which are based on AT-Commands that uses GSM communication to communicate directly with the host to be able to send the data anywhere and anytime seamlessly using 3G/4G data communication. The commands used are shown in table 7. , also it must be noted that the GSM module used in our system supports this protocol which was the reason we choose it in the first place it must be also noted that all the used AT-Commands will be listed in Table 11.11.

Command	Response	Description
AT+CGSOCKCONT=**,&&&	OK	** is the protocol and &&& Access Point Name.
AT+CFTPSERV=”****”	Null	Sets FTP server domain name or IP address. **** is the domain name or the IP.
AT+CFTPPORT=***	OK	Sets FTP server port. *** is the port.
AT+CFTPUN=”***”	OK	Sets user name for FTP server access. *** is the user name.
AT+CFTPPW=”***”	OK	Sets password for FTP server access. *** is the password.
AT+CFTPMODE=	OK	Sets FTP mode. 1 for passive or 0 for proactive.
AT+CFTPTYPE=	OK	Sets the transfer type on FTP server . A for ASCII or I for binary.
AT+CFTPPUT=”***”,&&	Null	Puts a file from FTP server to serial port . *** is the path with the name of the file and && is the length.
AT+CFTPGET=”***”	Null	Gets a file from FTP server to serial port . *** is the path with the name of the file.
AT+CFTPPUTFILE=”***”,&	Null	Uploads a file to FTP server from module . *** is the path and & is the storage directory.
AT+CFTPGETFILE”=***”,&	Null	Downloads a file from FTP server to module . *** is the path with

		the name and & is the storage directory.
AT+CFTPSSTART	OK	Acquires FTPS protocol stack.
AT+CFTPSLOGIN=”**”,&&&,”xxx”,”yyy”	OK	Logs in FTPS server. *** is the host address, &&& is the port, xxx is the user name and yyy is the password.
AT+CFTPSPUT=”***”,&&	Null	Puts a file from FTPS server to serial port . *** is the path with the name of the file and && is the length.
AT+CFTPSGET=”***”	Null	Gets a file from FTPS server to serial port . *** is the path with the name of the file.
AT+CFTPSPUTFILE=”***”,&	Null	Uploads a file to FTPS server from module . *** is the path and & is the storage directory.
AT+CFTPSGETFILE=”***”,&	Null	Downloads a file from FTPS server to module . *** is the path with the name and & is the storage directory.

Table 11.11 : AT-Commands for FTP and FTPS.

12. Appendix B: Software

The attached disc contains all the software for this project, as well as relevant technical documentation, and test data (Photographs, Videos, and raw data). The code for the microcontroller is in C/C++ which is the main programming language that the MCU (Arduino) uses.