ISLAMIC UNIVERSITY OF TECHNOLOGY

Emotion Recognition Using Built-in Sensors and Pressure on Touchscreen Smartphones

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Declaration of Authorship

We, Rasam Bin Hossain & Mefta Sadat, declare that this thesis titled,'Emotion Recognition Using Built-in Sensors and Pressure on Touchscreen Smartphones' and the work presented in it are our own. We confirm that:

- This work was done wholly while in candidature for a Bachelor degree at this University.
- Where any part of this thesis has previously been submitted for a degree or any other qualification at this University or any other institution, this has been clearly stated.
- Where I have consulted the published work of others, this is always clearly attributed.

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Abstract

Now-a-days touchscreen smartphones have become an essential part of billions of people. It has become necessary to know the user emotion so that their smartphone can interact with them in an efficient and regulated way. In this paper we discussed about a system that focuses on built-in sensor - accelerometer, logs the sensory data and tries to map the data according to the user emotion. We have built an android application to keep track of the users' position, more appropriately sitting positions with which the accelerometer data is being matched for further processing and calculation.

Keywords

Emotion, touchscreen, pressure, gyroscope, accelerometer, FSR sensor.

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Dedicated to our parents. . . .

Chapter 1

Introduction

1.1 Thesis Context

The rapid advancement of modern science has taken us to the peak of mobility. Vast improvement of hardware, integrated sensors and operating systems has increased the efficiency and usability of these devices. People are more and more confined to this handheld devices rather than sitting in front of desktop computers.[20] Since mobile phones have become an essential part of our day to day life they represent an ideal computing platform to monitor the behavior, movement, moods of the users. This processor embedded powerful smartphones will become even smarter if it can detect user emotion and act accordingly. Careful monitoring of log data from different built in sensors such as accelerometer, gyroscope and tap pressure data are the pre-requisite of any emotion detection approach. Since, the most common device that people carry all the time is a Smartphone; applications developed focusing the emotion of the user will be more dynamic and groundbreaking.

Current smartphones are becoming more and more touch sensitive. Nowadays a physical QWERTY keypad is rare in recent smart phones. For example, leading models such as iPhone 5, Samsung Galaxy SIII and HTC One X do not contain any additional physical QWERTY keypad for giving input. The main interaction between the user and the device is through the pressure given on the screen with the fingers while typing a message, playing games, browsing, switching applications etc. An efficient way of capturing user activity with the device is from the sensors. They provide information about any changes in orientation, applied acceleration, location of the user etc. The amount of variation is too less so we need to normalize these log data and make an appropriate value so that we can use the resulting output to draw conclusions about the users emotion.

Affective computing by different machines has been argued as one of the most essential part of Human Computer Interaction. Modelling the simultaneous affect aware behavior of human being has been recognized as important factor for successful man-machine communication [3, 4].

1.2 Motivation

Why Considering Mobile Scenario:
• Most frequently used device
• Processing Capability
• Rapid change of user location and Environment
• Experiencing Emotionally simulating Situations
• Encourages app developers
• Dominant Communication Medium
• Integration of various sensors in single device
• Examples: EmoVoice, Health Counseling, Robotic Systems, playing "just the right music", Emotion aware chat program

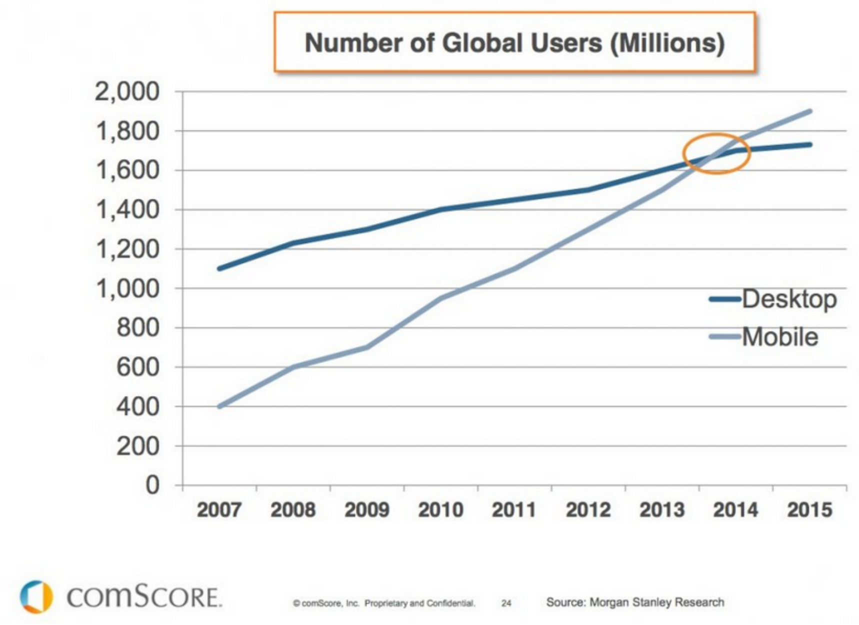

FIGURE 1.1: Mobile users vs. desktop users

1.3 The Problem

As the user's mental state changes with the context of his environment and surroundings there may lead to a situational impairment [10] as because the available smartphones aren't that much aware of the user's emotion. We pick smartphones rather than desktop computers or other devices as because this one of the most common things that people carry around. Research works regarding Smartphone are going on every now and then and we have found different touch patterns while typing on-screen keyboards [9]. In this paper we will consider the log data from built-in sensor like accelerometer. Variation in the log data will help us to identify the users' position - how is he sitting at different states and from them later on specific algorithm will be build up to map different sensor data with specific emotional states.

1.4 The Solution

In this paper we are going to present EmotionSense, a system that logs the accelerometer data from the user's mobile phone. This system will run in the phone in background as a service and upon request it will start logging the user data continuously and write these data into a file. These files will be collected later on for further processing. In our research we use Weka Tool (A well-known Machine Learning tool) which we used to test our train our system and test a random data that will be collected from the user. Researches have shown that the amount of pressure applied on the screen varies with the user's emotion and generally the amount increases when they are excited or angry than the normal state or neutral state [8]. Again, in case of "Excited" mood they will be less polite to their device and the changes in the gyroscope will be more abrupt. In our system we will log the signal data coming from accelerometer, normalize them, log the users positional state and make a specific relation between them so that in future we can detect the user's emotion based on this results. By examining the gyroscope signal we will be able to detect whether the phone is in stationary state either on the table or desk or in mobile state either in the hands of the users or the in the pocket. If the user is unstable or angry, surely the gyroscope readings will exhibit frequent variations in the log data. The reason behind this detection is to start or stop our system on the background of the phone as there is a huge battery draining issue related to the Smartphone if the system is always running in background.

1.5 Summary View

Here we want to draw some conclusions about what we are going to do in our system: (1) we will create a system that will log the signals coming from the built in sensors that are already available with the phone; (2) The system will be less battery consuming as there will be an effective algorithm to pause or start the system based on the states of the smartphone whether it is being used or not (3) The resulting outputs will be fetched in to a table to show the user's emotional state. (4) Test the data for a random user input to evaluate the accuracy of our system.

1.6 Structure of the Thesis

In this paper we have divided it into several sections to describe our research work precisely. In the next step we are going to discuss about the theoretical definitions and other related terms to our work. A brief description of our background study will also be added here and related works will be stated clearly in this section. After the state of the art we will head to define the problem statement more precisely and briefly so that can be easily understandable. We have already decided on what operating system we are going to build our system and how. In the next section after we will define the methodology we will follow and the reason behind these. In the last section we will state our future works.

Chapter 2

Background Study

2.1 Definition of Emotion

"Emotion" is an abstract term. It is an idea or expression that can define the current state or condition of human mind or behavior. Emotion can be characterized by psychological and physiological expressions, biological reactions, and mental states.

Emotion [23] is one of the fundamental components or characteristics of being human. Emotion can be derived from human experiences and expressions to represent different emotional states such as joy, hate, anger, pride, excitement, sadness and so on. The current research in psychology and technology suggest a completely different view of the various aspects of the relationship among human, computer and emotion. Emotion is no longer seen as limited to casual ebullition of rage and anger when a computer program crashes for inexplicable reasons, excitement when a video game character overcomes an obstacle or frustration when an incomprehensible error message appears on the screen. It is now understood that a wide range of emotions play a vital role in every computer related, goal oriented activity, from using drawing application and editing photos in a photo manipulation app, to browsing web pages and sending a message, to making an online purchase to playing games. The way the user carries out a task or uses an application is highly influenced by his emotional states.

Two generally agreed upon aspects of emotion are:

• Emotion is a reaction to events deemed relevant to the needs, goals, or concerns of an individual and

• Emotion encompasses physiological, affective, behavioral and cognitive components.

Recognition of emotion refers to the identification of emotional states. It can be done in various contexts. Facial expressions, gesture, posture, speech analysis, keystroke and pressure all of these can be used for emotion recognition.

2.2 Emotion Recognition Techniques

There are several emotion recognition techniques. First, there is emotion recognition from facial expression. It is a vast area of psychological studies for last several decades. It requires neuroscience, digital image processing, pattern recognition and a lot analysis and processing of collected data to generate probable emotion. There are also various differences in the facial expression patterns in different age groups of humans (such as children, adult, senior etc). It is also difficult to implement in smaller hardware or devices. Hence arises the necessity to detect emotion in some other convenient ways. [14]

Second, there is Vocal emotion recognition. The vocal aspect of a message or conversation carries significant variations or emotional information. If we do not consider how a sentence was verbally spoken, the meaning may change. From the input audio signals pitch, intensity, and pitch contours were estimated as acoustic features and then classified using some predefined roles and mapped to suitable emotional state. This model has some inaccuracies in case of neutral voice.

Third, another new method is Multimodal Emotion Recognition. Beyond the confines of the keyboard and mouse, new modalities for human-computer interaction such as voice, gesture, and force-feedback are emerging. Sometime people say specific sentence with particular facial expression to indicate an emotional state. The multimodal approach is much more dynamic but it has some constraints and it's an ongoing research. It has to combine multiple types of inputs and finally fuse with probabilistic models.

Forth, another approach is emotion recognition using pressure sensing keyboards and keystroke dynamics.

The context of our work is touch screen smart-phones. People use these devices as their daily commodities. Emotion frequently changes while using such a device depending on the scenario. The input for these devices is touch. The pressure applied on the screen by the user as touch stimuli vary according to the mood or mental state of the user. So, the idea is to find out the pressure data and after further processing, it can be useful information for emotion recognition.

2.3 Study about the Sensors

There are several types of built in sensors in today's smart phones. Some of them can be used to capture the pressure raw data. In most of the smartphones, these sensors exist-accelerometer, gyroscope, ambient light sensor, proximity sensor, GPS etc. The sensors are built into handsets using Micro-electromechanical systems (MEMS). [18]

2.3.1 Accelerometer

This sensor allows the device to detect the orientation of the device and adapts the content to suit the new orientation. It also measures the acceleration of the device relative to freefall. It actually controls the switching between portrait and landscape modes.

Mobile phone accelerometers are a form of three-axis microelectromechanical-system (or MEMS) and essentially consist of a series of three sensors which are fixed at right angles to each other. Each of these sensors is capable of monitoring the smallest of changes in force and pressure: as applied by gravity or movement and creating a corresponding electrical impulse. Development of this technology has allowed for the relatively cheap manufacture of increasingly accurate and sensitive accelerometers which can be easily integrated into all manner of applications. [27]

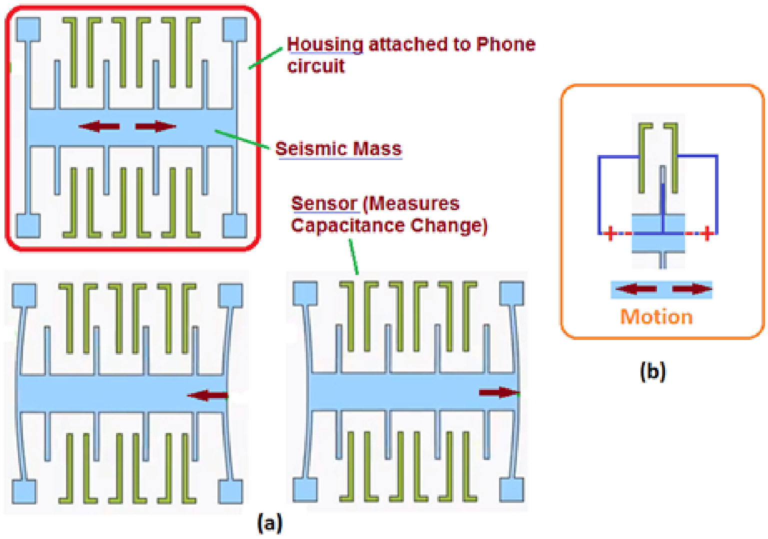

FIGURE 2.1: The working principle of a mobile phone accelerometer

2.3.2 Gyroscope

It is a device for measuring or maintaining orientation, based on the principles of angular momentum. This sensor is built into modern smartphones mainly for navigation systems and gesture recognition systems and also for finding the position and orientation of the device.

Gyroscope is capable of measuring angular rates [28] around one or more axes, these gyroscopes represent a fitting complement to MEMS accelerometers. Thanks to the combination of accelerometers and gyroscopes it is possible to track and to capture complete movements in a three-dimensional space. According to Wikipedia, this nifty device is able to detect angular movements such as the rotation around the X-axis, rotation around the Y-axis and the rotation around the Z-axis or also known as roll, yard and pitch in layman's terms. On the other hand, an accelerometer is only able to detect three linear axes of vectors, including left-right (X-axis), top-bottom (Y-axis) and up-down (Z-axis). Unlike a gyroscope, it measures translation of direction and cannot detect if a device made a full spin or is experiencing inertial change. Mechanical and Electronics Engineering today have managed to transform the mechanical gyroscope into a Microelectromechanical system (MEMS), also known as vibrating structure gyroscope. So, instead of having a spinning wheel inside the microchip, a vibrating mass is placed in the center of the chip. The mass will be vibrated whenever an electrical signal goes through it. Moving the phone will cause the changes of electrical signals that are picked by the sensors. The sensors will send instructions to be interpreted by the software to provide the necessary feedback to the user.

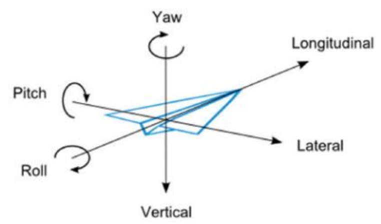

Figure 2.2: Gyroscope Working Principle

When combining both the accelerometer and the gyroscope, it will be a total of 6-axis motion sensing that is able to have precise motion detection by simply moving the phone naturally.

2.3.3 Proximity Sensor

It detects how close the screen of the phone is to our body. This allows the phone to sense when we have brought the phone close to ear. It is used to avoid unwanted input.

2.3.4 Ambient light sensor

It is mainly used to adjust the screen brightness automatically and for power saving.

2.3.5 Magnetometer

This sensor measures the strength of earth's magnetic field. Result is expressed in Tesla. Smartphones provide raw magnetometer data and compass bearing. It is used as compass to rotate maps, graphics, and orientation and also as recorder to detect magnets, force fields etc.

These are the main sensors typically found in modern smartphones. As we can see there is no dedicated pressure sensor built in to normal smartphones. Hence arise the need to get pressure data from elsewhere such as touch screens of the device.

2.4 Types of touchscreens

There are many types of touch screens in smartphones. But the most commonly used two are the Resistive and the capacitive touch screen. Resistive touch screen is used lower end smartphones and right now almost outdated. Resistive touch screens contain two layer of conductive material with a very small gap between them which acts as a resistance. When the resistive touch screen is touched with finger (or stylus) the two layers meet at the point of touch and create a circuit. This information is recognized by the mobile's processor. This kind of screens can be operated with a finger, a fingernail, a stylus or any other object.

Capacitive touch screen technology consists of a layer of glass coated with a transparent conductor (like indium tin oxide). When a capacitive touch screen is touched by human body (finger), an interruption is created in the screens electrostatic field (which is measurable as a change in capacitance) which is detected by phone's processor or chip and which in turn instructs phone's operating system to trigger an event or action accordingly. [17]

Haptic/Tactile touch screen is another technology used by Blackberry and Nokia targeted towards enterprise market. This technology provides a tactile feedback on a touch action on the screen thus providing an immediate and unmistakable confirmation to the user. Haptic technology has been found to significantly improve user performance, accuracy and satisfaction while typing on a touch screen.

Retina Display is another technology mainly used by apple for their IPS LCD (with backlit LED) in iPhone4. They call it the Retina display because its pixels cannot be individually identified by the human eye, thus making the display super sharp and brilliant. [16]

The enhancements of the capacitive touch screens are AMOLED and Super AMOLED. AMOLED stands for Active-Matrix Organic Light-Emitting Diode. AMOLED displays are a type of OLED displays for mobiles and are rapidly gaining popularity in top end smartphone segment. Super AMOLED displays are an even advanced version of AMOLED displays developed by Samsung. Super AMOLED display is built with touch sensors on the display itself, as opposed to creating a separate touch sensitive layer (as in capacitive touchscreen). This makes it the thinnest display technology on the market. This type of touchscreen reduces the visible distance (within millimeters) between the user's finger and what the user is touching on the screen, creating a more direct contact with the content displayed and enabling taps and gestures to be even more responsive. But Super AMOLED is targeted towards very high end market. For these reasons, we prefer the capacitive touch screens rather than the resistive one.

Chapter 3

Related Works

There are only few research works that have been done in the context of touch-screen smartphones. An emotion sensing approach has been recommended along with a proposed affective entity scoring algorithm [13]. This algorithm maintains affective scoring vectors for various entities in a mobile device. It keeps track of installed applications, multimedia contents and contacts of people and also calculates the difference between prior and posterior emotional states. Then some recommendation is proposed based on the emotional state. The emotion detection is accomplished by collecting sensory data from the device and analyzing contextual information for example emails and text messages. Then affective entity score is calculated from a target application. While mapping the score, the usage pattern of the user and timer interval between different applications is also considered.

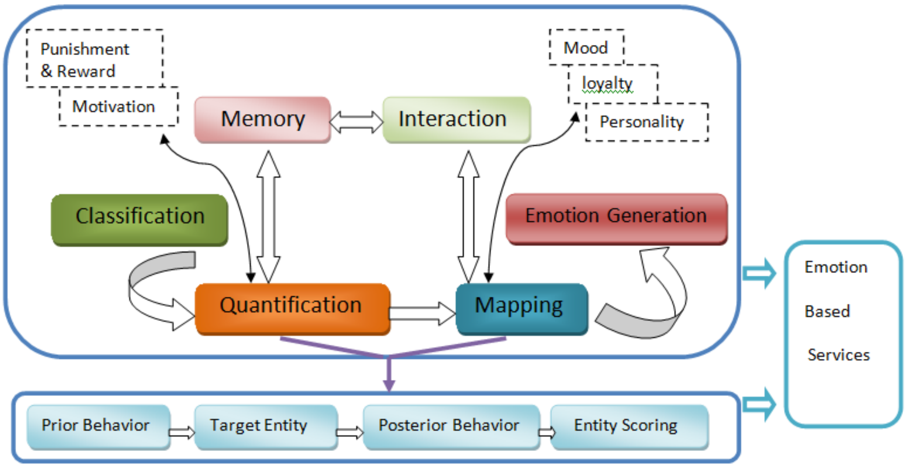

FIGURE 3.1: The conceptual process of emotion recognition, generation and affective entity scoring [13]

A model named OCC model[24] has been established to provide a structure of 22 conditions which influence emotions and variables which affects the intensities of the emotion. From the study of facial expression of emotions, Ekman[25] defined six emotions, 'Joy', 'Anger', 'Fear', 'Disgust', 'Surprise' and 'Sadness' as basic emotions which has been largely used in the field of psychology and robotics.

Since today's smartphones contain different low cost MEM sensors, the fusion of some of these sensors give accurate measurement of the orientation of the device. An orientation estimation technique is proposed by fusing[26] different MEM sensors of the smartphone. Orientation can be determined by the fusion of Accelerometer and Magnetometer but it is only effective when the device is stationary or not moving linearly. The device may also suffer from magnetic interference. Fusing gyroscope with the previously mentioned approach produces more accurate result of the orientation of the device. Gyroscope provides a quick response to change in angels and also does not suffer from problems like interference. But there are some bias and integration errors that can be overcome by applying a Drift and Noise removal filter. The successful estimation of orientation leads to successful development of mobile games, navigation apps, augmented reality and other kind of applications.

After the invention of pressure sensor keyboards for desktop computers some research works have been done also. One of them was biologic verification based on these keyboards [21] and their following paper was another approach to recognize emotion by analysis the pressure sequences when any keystroke occurs [22]. Global features of pressure sequences, dynamic time warping and traditional keystroke dynamics- these three features were combined using a classifier fusion technique.

The impact force on musical instrument is crucial. The built-in accelerometers, the pressure sensing capability of Android phones, and external force sensing resistors can be used to calculate this impact force on multi-touch devices such as smartphones. Some of these three approaches show great promises [19].

Another approach was to detect hand postures and pressure with the help of accelerometer and gyroscope. In this paper they also implemented the system in such a way that it could use the pressure applied on the screen when the vibration motor is pulsed [20]. The accuracy result was different in different cases. Their system accurately differentiate device usage on a table vs. in hand with 99.7% accuracy; when in hand it inferred the hand posture having 84.3% accuracy. They could differentiate among three types of pressure by using gyroscope sensor. Higher and lower frequencies were generated from touch-induced vibrations increase with increase in pressure. A figure describing the high pass and low pass frequencies are given below:

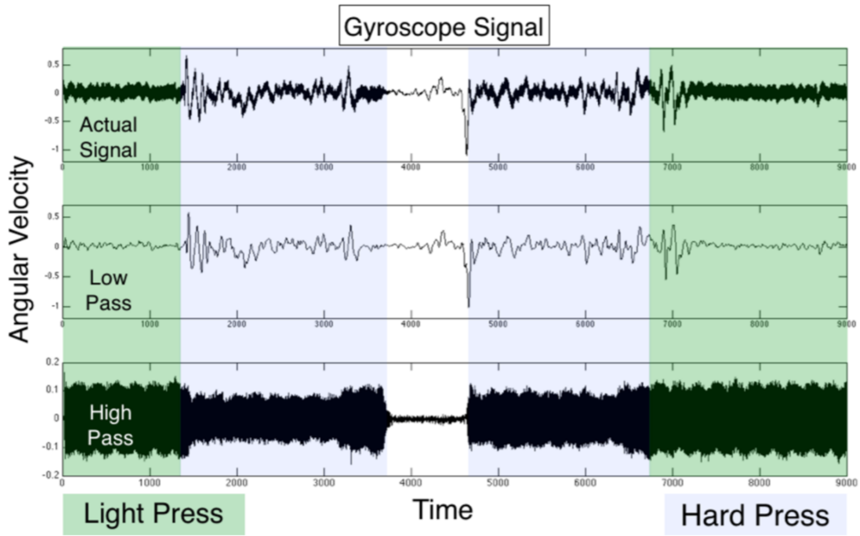

FIGURE 3.2: An approach to detect different types of hand postures using gyroscope

Chapter 4

Problem Statement

While using a touch screen phone user usually don't need any button to perform any task in his phone. Rather the interface is built in such a way that the user will have to touch specific portions of the screen to complete different actions. For example, while typing a message a keyboard will be shown on the screen where he will touch desired letters to write the message. While typing a message due to change of his emotional states he will apply a different amount of pressure to the screen. Normally larger touched area is also responsible to show a larger amount of pressure value and vice-versa. Again, due to anger he may shake the phone harder than the usual and may be less in case of sadness. So, the accelerometer signals will vary according to his emotional states. The accelerometer will exhibit continuous changes of the orientation of the device. We will also log the interactions of the user with the device. In our research we will try to log all the data coming from the accelerometer and the resulting outputs are necessary to detect the users' emotion as these results will be mapped with different emotional states of the users.

So we can formulate the problem statement as, "Detecting human emotional states by collection of log from built-in sensors while users interacting with applications on smart phones"

Chapter 5

Proposed Methodology

5.1 Developing Environment

We have already defined that we are going to build our system for touch screen smartphones. In the current market there are a vast number of smartphones with powerful processors and touchscreen having high resolution embedded with a good amount of RAM. The smartphone creating companies are using different types of operating systems for their phones depending on their choice and computability. Some of the best operating systems for these smartphones are ios (Apple products like Iphone, Ipad), android (an open source project of google), windows, symbian and blackberry OS. [1, 2, 3, 4, 5, 6, 7]. We decided to build our project focusing the android operating system. The reason behind this decision are: (1) Android is an open source project of google, so resources are quite easy to gather, (2) as an open source project most of the leading devices are running on this OS, leading smartphone companies like Samsung, HTC, Motorola, Sony are building their phone focusing this OS, so it will be easier to test our dataset and many user will be able to use our system.

We will test our system with one of the flagship devices of HTC, that HTC One X which is powered with a Quad Core 1.5 GHz processor, 1 GB RAM and a capacitive touchscreen having 312ppi. [2]

5.2 Initial Architecture of our System

An architecture of our full work is shown in the next figure. In this architecture we are dividing our proposed work into 5 major modules - Data gathering module/technique, Data Storing Module, Data analysing module, Emotion Detection module and presentation module. We are going divide our work formally in two different processes. The first one is from the touch stimuli and the second one is movement of the device. We are now going to describe about this two types of methodologies here.

5.2.1 Case: 1 - Using Android API

In the first case the data will be collected based on the touch and pressure applied on the screen. It is assumed that due to different emotional states user will give different amount of pressure on the screen. So depending on the pressure we will map the emotional states later on. The first approach will again be divided in 2 process. One is using android resources and other is using external sensors. In case of using android resources we are going to use the MotionEvent class of android [8].The MotionEvent class is responsible to report the movement of mouse or finger events and a set of axis values are shown. The axis values actually describes the exact or relative positions of the touched portion and some other properties.

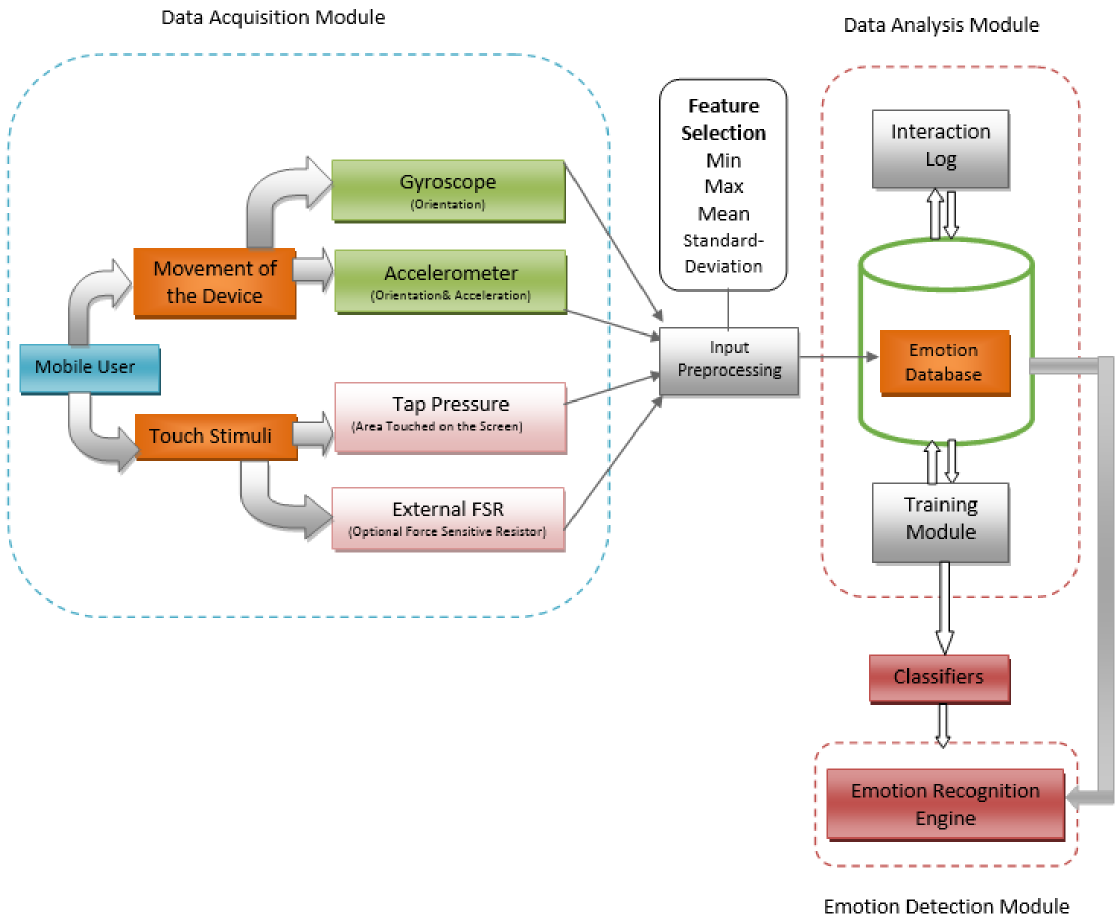

FIGURE 5.1: Architecture of Emotion Sensing System

5.2.2 Case: 2 - Using External FSR Sensor

Now the second approach of this case is we will work with an external sensor which is called Force Sensing Resistor (FSR). The idea is that we will attach an FSR in the back side of our mobile device. The back side of FSR will face the back side of the phone that means the front side on the opposite direction. It is estimated that when the user will hold the device in his hand and use it for tapping on the screen he will also give some amount of pressure on the device. From Newton's third law of motion we can say that the pressure he applies on the screen or on the device from the front side of the device he also needs to give same amount of pressure from the backside to hold it correctly. When the user is little bit aggressive or in an angry mood he will generate more pressure on the device. The pressure applied on the device will passed on the FSR and we will get some reading from that sensor. An "Arduino board" will be attached with the FSR and the data will be passed into the board with specific cables. Later on these data will be either sent to the device or to the computer for normalization and further processing.

Examining different types of FSR sensors we come in to decision that the 1.5 inch square sized FSR will be perfect for our work. This sensor will be first attached to the back of the device. Using some jumper cables we will connect it with a RobotGeek Voltage divider and then with Arduino mega board. This voltage divider is a special device which can regulate the amount of pressure sensor. The force Sensing Resistor is a material whose resistance changes when force is applied to it. So after connect it to the arduino board it will pass the pressure data to the arduino board and later on using a Serial to usb cable it will connected to computer. Using C# we will build the interface for the devices attached and run some more scripts to determine what output we are getting from the sensor. This sensor data will be normalized and categorized according to our methodologies.

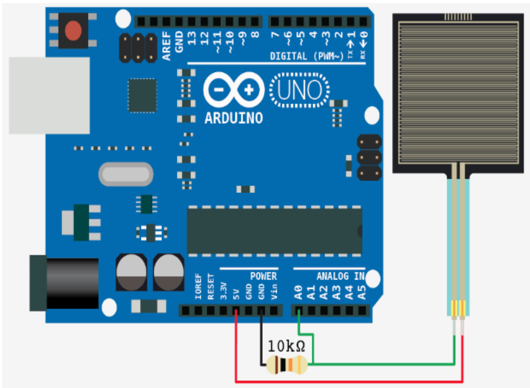

FIGURE 5.2: FSR sensor connected with Arduino Mega Board

Now after getting these data we need to log this data into specific file so that later on we can extract and use these data for further experiment. In this case we will log both types of pressure values in xml file. The xml files will be rewritten and modified according to our necessity.

5.2.3 Case: 3 - Using Built-in Sensors

Now the third case - reading the accelerometer and gyroscope data and logging them. Due to the movement of human being and due to changes in emotional states there will be severe fluctuation in the accelerometer that is built in with high end touch screen smartphones. So we will use this data to analyse for recognising the emotion. Another approach is we will also collect the interaction log. Depending on the interaction log we will get the idea about what type of application the user is using and also the amount of time that he is spending on each application. These interaction log data will be fused with the data collected in xml file for further analysing.

5.2.4 Final Mapping and Classification

In the architecture of our proposed methodology we are defining an emotion detection module where there will be emotion detection algorithm which will analyse the data. Later on the data will be normalised to a certain value that will be mapped based on several emotional states of human being. In this phase categorization and mapping will be done effectively.

5.3 Revised and Final Architecture

After evaluating our previous proposed methodology, we have reached to the conclusion that the accelerometer sensor will be used to collect the data from the users. The gyroscope sensor has not been used since it generally detects the orientation only, based on a single axis whereas accelerometer does detect orientation and acceleration both things. The force sensitive resistor was also not available in due time. For this reason, we have to discard that option as well. Our final system architecture comprises of following modules:

- Data Acquisition Module
- Data Analysis Module
- Training Module

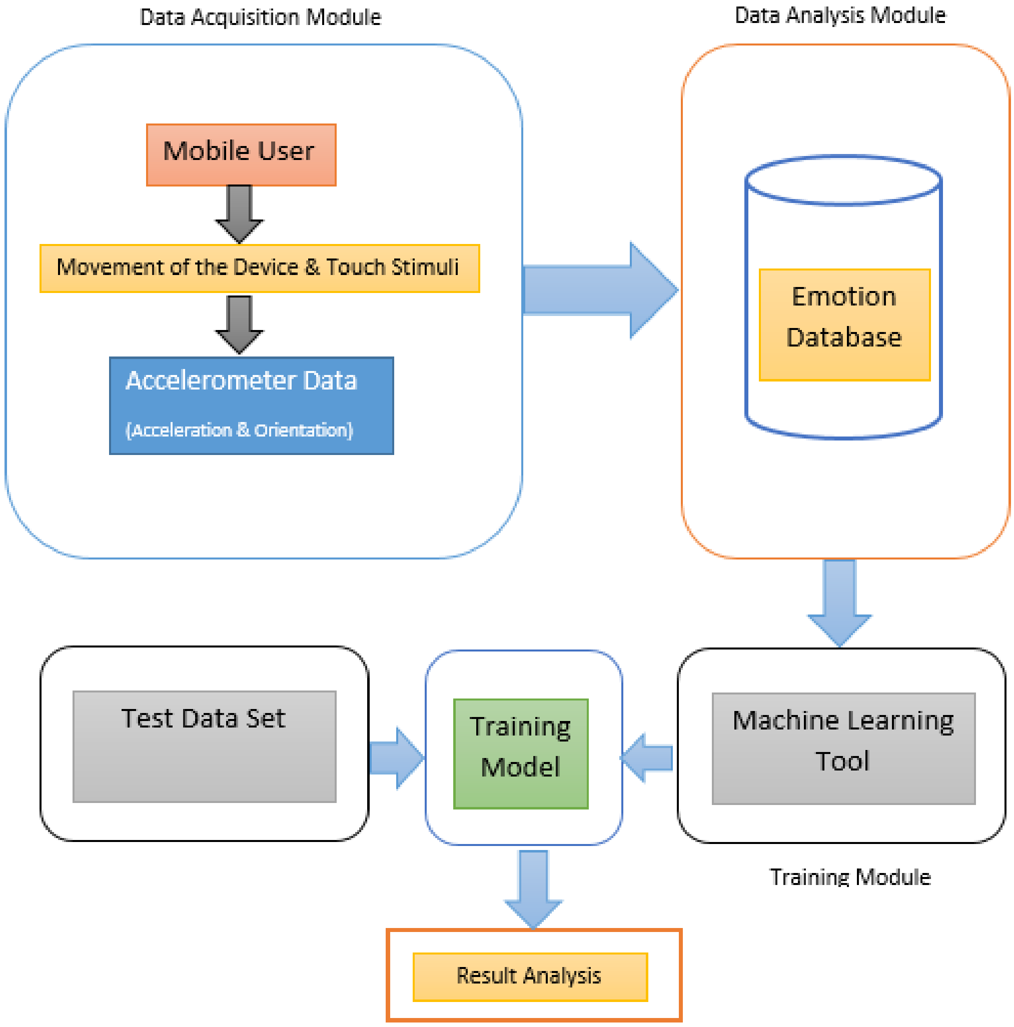

FIGURE 5.3: Architecture of Emotion Sensing System

5.3.1 Data Acquisition Module

In this module, data collection is done by providing the user with the training application. Accelerometer data is collected from the user's activity. The output of this module is the input to the data analysis module. Basically, what we have done is we built a mobile application in android platform and installed on HTC One X. Later on we let the users use our application (while the application was running at the background) and they write messages/browse websites/chatting in facebook based on specific sitting positions. The detailed procedure is discussed in the next section.

5.3.2 Data Analysis Module

The collected data from the user is stored in a .CSV file. This database in .CSV file is used to create the final dataset that we have used in our machine learning process. The .CSV file was converter to .ARFF format in order to build the training model using machine learning software, the WEKA Tool.

5.3.3 Training Module

We have used the WEKA Tool to build our training model. After successfully building the training model we have evaluated test datasets against the training set. A fair amount of accuracy was found in our training set.

Chapter 6

Data Collection

6.1 Data Collection Procedure

We have developed a training application to collect the data from the user. We have collected data from 50 users according to their ages. Age was between 21 to 30 years both male and female. We considered frequent smartphone users to collect our data. We have collected the data from the users considering 8 sitting positions.

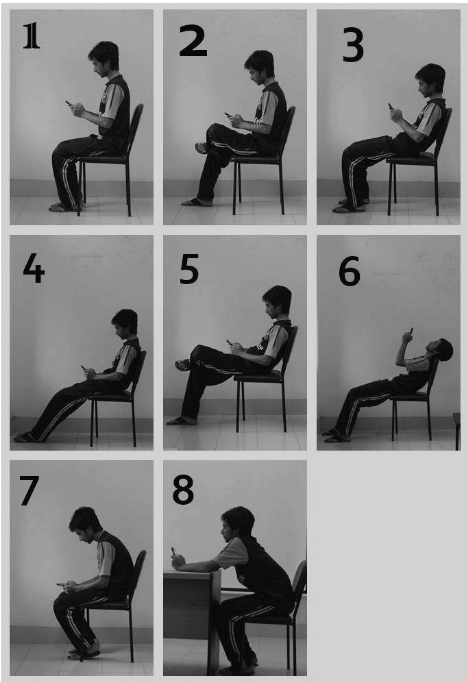

FIGURE 6.1: 8 Types of Sitting Positions

6.2 Time period for Data Collection

We have collect the data for 3 weeks and each user was given 15 minutes to contribute.

6.3 Data Collection Tool

We have built an android application that will log the data accelerometer. We already described about the class that will be used to build up this application. Here, we are going to give the flow diagram that will show the data acquisition procedure.

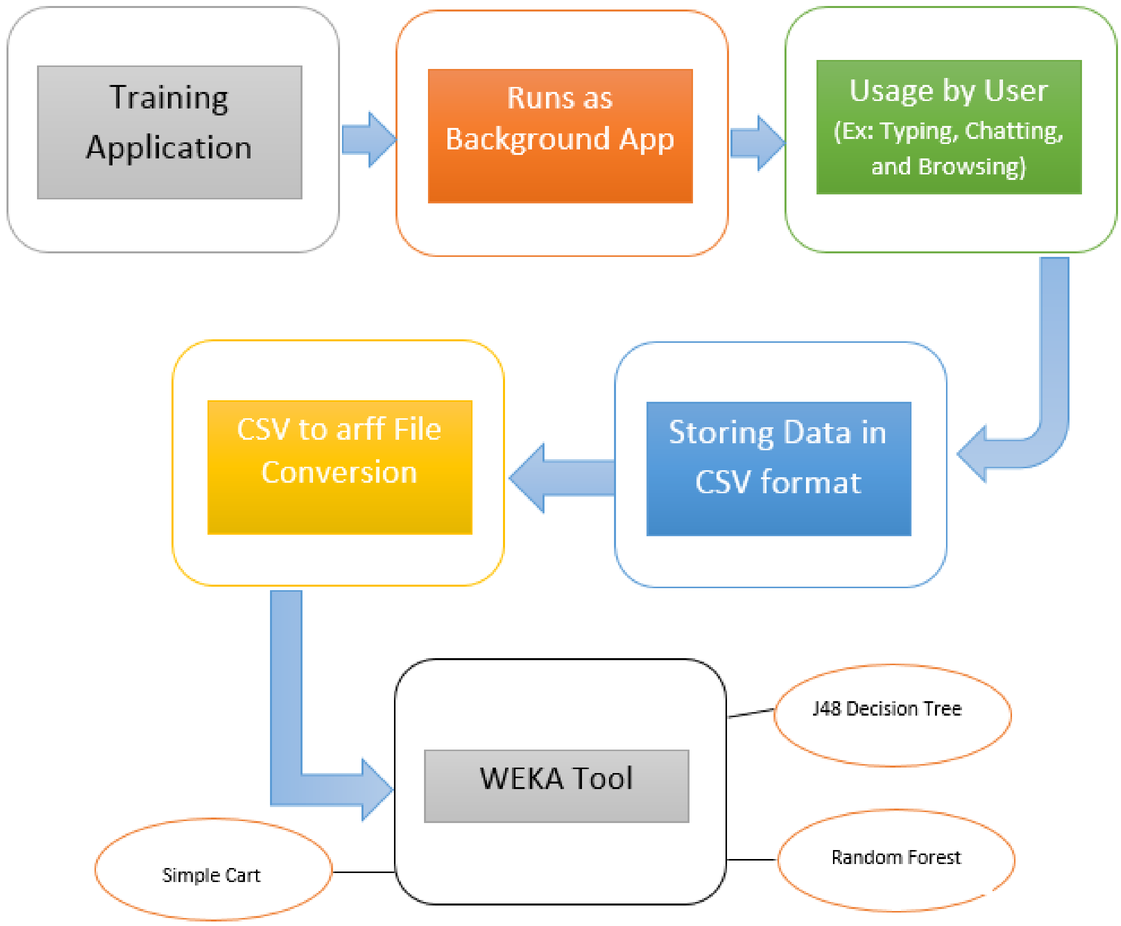

FIGURE 6.2: Data Collection Architecture

6.4 Training Application

In the training application user first reads a random story. Then depending on his current emotional state he gives 2 inputs on the form and starts the app as background service. Then he do his normal work on his phone such as texting, writing notes, browsing etc. The usage of that random story was on a simple idea that is when the user will read the story he will be some kind of emotionally motivated to be our pre-selected 3 types of emotion, use the phone according to that emotional state and that data will be used for training our system.

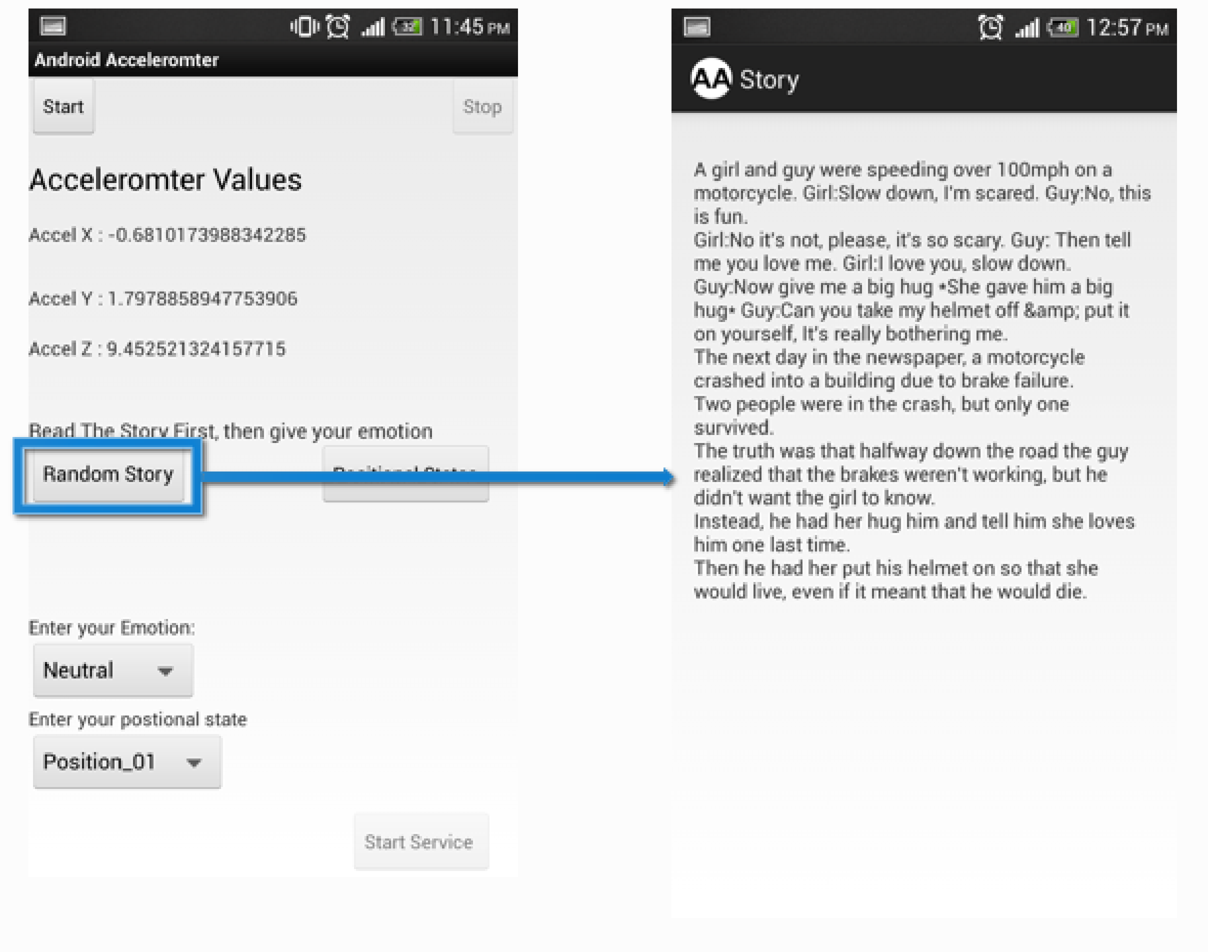

FIGURE 6.3: Android app that collects Accelerometer data

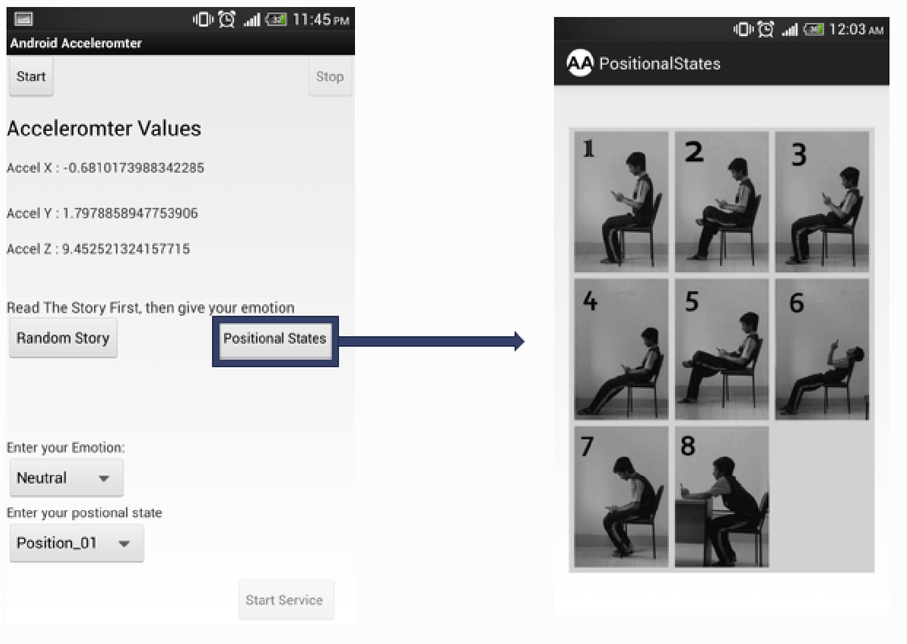

FIGURE 6.4: The Flow when the postional state button is clicked

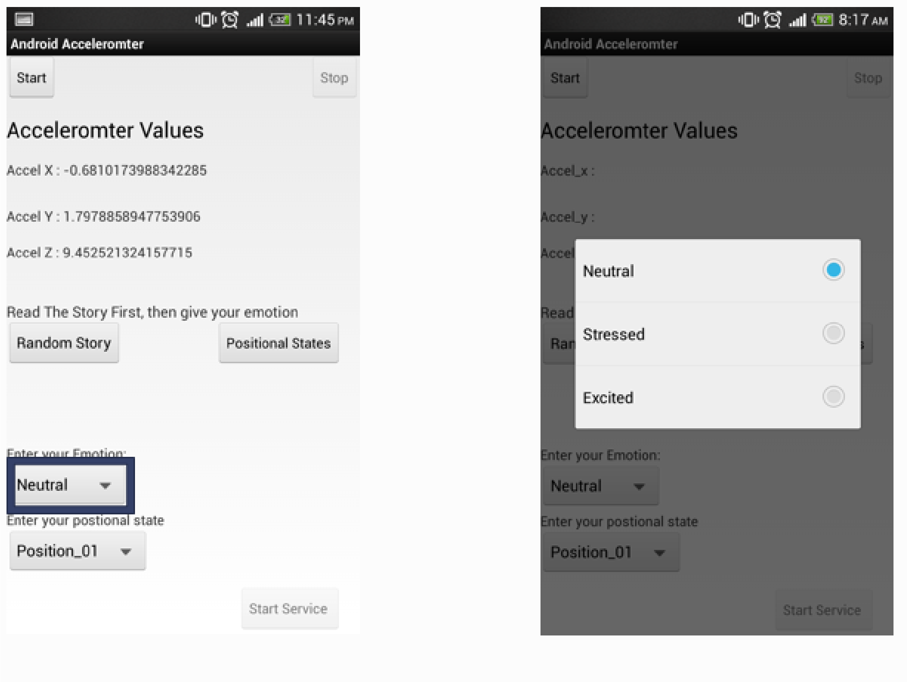

FIGURE 6.5: Options of Emotional States

6.5 Developed DataSet

We have developed a data set containing 17,762 instances. There are 3 attribute values and 1 categorial value that is the class. The class can be Stressed, Neutral or Excited. Here we can see in the dataset there are 5 types of data which are- Position, x-value, y-value, z-value and Emotion. The x-value, y-value and z-value are the values of accelerometer. The position value are set programmmatically inside the program that was selected by us.

```
@RELATION mood

@ATTRIBUTE X real
@ATTRIBUTE Y real
@ATTRIBUTE Z real
@ATTRIBUTE class {Stressed,Neutral,Excited}

@DATA
Position,    x- value,          y-value,         z-value,         Emotion
140,-0.9942854046821594,6.6194891929626465,7.123441696166992,Neutral
140,-0.6810173988342285,6.469665050506592,7.15068244934082,Neutral
140,-0.5720546245574951,6.537766933441162,7.232404708862305,Neutral
140,-0.7218784093856812,6.578628063201904,6.742072105407715,Neutral
140,-0.6401563286781311,6.510526180267334,7.000858783721924,Neutral
140,-0.5720546245574951,6.578628063201904,7.041719913482666,Neutral
140,-0.6401563286781311,6.6194891929626465,7.232404708862305,Neutral
140,-0.2587866187095642,6.347082138061523,7.082581043243408,Neutral
140,-0.217925563454628,6.578628063201904,7.000858783721924,Neutral
140,0.3813697397708893,6.6194891929626465,7.1915435791015625,Neutral
140,0.108962781727314,6.810173988342285,6.9327569007873535,Neutral
140,0.34050869941711426,7.1915435791015625,6.197257995605469,Neutral
140,0.7627394795417786,7.232404708862305,5.625203609466553,Neutral
140,0.9125633239746094,7.082581043243408,6.660349845886230,Neutral
140,0.2587866187095642,7.5729131698608,6.047434329986572,Neutral
140,0.40861043334007263,7.654635429382324,7.232404708862305,Neutral
140,1.1849702596664429,7.314126491546631,5.625203609466553,Neutral
140,0.871702253818512,7.736357688903809,5.924851417541504,Neutral
140,1.7161637544631958,7.082581043243408,5.897610664367676,Neutral
140,0.871702253818512,6.469665050506592,7.232404708862305,Neutral
140,0.8308411836624146,7.695496559143066,6.578628063201904,Neutral
```

Figure 6.6: Graphical view of the developed dataset - only a snap is shown here

Chapter 7

Result Analysis and Research Challenges

7.1 Data Collection Procedure

We have developed a training application to collect the data from the user. We have collected data from 50 users according to their ages. Age was between 21 to 30 years both male and female. We considered frequent smartphone users to collect our data. We have collected the data from the users considering 8 sitting positions.

The result is shown here in tabular view.

In the Training Data Set the total Number of Instances are 17762.

No	Label	Count
1	Neutral	5282
2	Stressed	7638
3	Excited	4842

TABLE 7.1: Status of the Training Data Set

Algorithm	Correctly Classified Instances	Incorrectly Classified Instances	Accuracy(%)	Error(%)
J48	13058	4704	73.5165%	26.4835%
Random Tree	11912	5850	67.0645%	32.9355%
Simple Cart	13096	4666	73.7304%	26.2696%

TABLE 7.2: Testing with the original Data Set by Cross Validation

Algorithm	Correctly Classified Instances	Incorrectly Classified Instances	Accuracy(%)	Error(%)
J48	792	729	52.071%	47.929%
Random Tree	1061	460	69.7567%	30.2433%
Simple Cart	779	742	51.2163%	48.7837%

Table 7.3: Testing with our Test Data Set-1

Algorithm	Correctly Classified Instances	Incorrectly Classified Instances	Accuracy(%)	Error(%)
J48	1858	3906	32.2346%	67.7654%
Random Tree	1833	3931	31.8008%	68.1992%
Simple Cart	1826	3938	31.6794%	68.3206%

Table 7.4: Testing with our Test Data Set-2

7.2 Research Challenges

7.2.1 Building Up Accurate Data Set

As there is no existing dataset that we can use so by proper training we need to build the dataset which will have the accurate values.

7.2.2 Relating the data set with actual emotional states

The second challenge was we have to map correct emotional state with correct types of values with that can be done using effective algorithm.

7.2.3 User can pretend or biased result

In case of these types of research works while training the dataset user may pretend to show a fake emotional state and hide his original emotional state. So it is a mandatory that we should be more careful while collecting the data.

7.2.4 Sensor Values may differ

The Sensons buit in the mobile phones are still not accurate and may differ in different phones. So the valaues with we have trained our system may also differ with the values that are gained in the test data.

7.2.5 Privacy Concerns

Users are too much concern with their emotional states and may not like thier computing devices to know that as these values may be spread out and may be a direct attack to the users privacy issues. We make the users believe that the data we are logging are only for test and research purpose.

Chapter 8

Future Works and Conclusion

8.1 Future Works

So, far we have developed the total system based on only sitting positions and using one sensor of the mobile phones. Only one sensor values aren't enough for detecting emotions and it can create severe biased emotional states. We will try to expand our system that will take also the other sensor values along with the FSR Sensor that we discussed in the previous architecture system. There are several application areas that can be exploited using our research work such as Emotion aware call log, music player that can generate playlist based on user's emotion. Some other recommendation services can also be implemented based on emotional considerations. Messaging and chatting systems will also be more dynamic if they are built considering this research.

8.2 Conclusion

Smartphones are still power hungry and battery drains much faster than the regular devices. So, we need to keep in mind that we need to set time limit accurately while running the system on the background. Another thing about the data acquisition phase the result set may be biased as users don't like to express and let others know about their emotion. So we think, considering the biased values the approach of emotion recognition is a big drawback.

Chapter 9

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