Detecting Human Emotions Using Electroencephalography (EEG) using Dynamic Programming Approach

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Abstract— **The relation between human emotions and EEG signals have been actively studied during the last few decades. In this paper, we study a novel attempt to measure the human brain activity and analyze its signals using electroencephalography (EEG) in order to classify the human emotions indicated by the brain wavelets. The study will measure the brain wavelets of female students in order to detect the emotions of happiness, sadness, and fear. This study will use specially designed sensors placed around the scalp. The measured signals transfer to a computing device. The data collected analyze by a software system, which developed by our team. We use dynamic programming to extract the maximum number of quality service that provides to the user when the device captures specific signals for each emotion.**

Keywords— *Electroencephalography (EEG); Dynamic Programming; Human Emotions; brain waves.*

I. INTRODUCTION

Emotion Detection today is one of the most important directions for research papers in any specific field. It performs a very important role in organizing human-computer interaction. We as humans are able to understand the emotions of other person but it is impossible for the computer to do so. The current work is to meet the same as accurately as possible. Emotion detection can do either through textual content, speech, facial expression or features [1]. EEG is a test that measures and records the electrical activity of our brain using special sensors [2]. The computer records the brain electrical activity as wavy lines. Positive situations, such as seizures, possible to seen by the changes in the everyday pattern of the brain's electrical activity. EEG helmet uses a set of sensors to measure the signal changes generated by the brain to discover people's thoughts, feelings and expressions and connects wirelessly to the personal computer, It has 14 sensors which a put on particular places on the scalp to give acceptable detection accuracy [3].

Human emotion is very hard to find simply through looking on the face and additionally the conduct of someone [4]. This research paper conducted to discover or perceive human emotion through the take a look at the of brain waves. Additionally, the research paper aims to improve software program that can detect human emotions fast. This study aims at EEG signals of relationship and human feelings. Brain waves produced by a human to change from one person to another depending on their current activities. For instance, the brain waves of the relaxed person are different from the waves of the person doing the hard work and bad mood. These brain waves classified into five classification indicating various conditions which Delta, theta, alpha, beta, and gamma [1].

In our research paper, we mainly try to discover the relationship between EEG and human emotions. Instead of using the face directly, we apply a dynamic programming to extract the maximum number of quality service that provides to the user when the device captures specific signals for each emotion. The aim of this operation is to decrease the impact of factors irrelevant to emotion. In order to discover the features which are most related to emotion, we reduce feature measure through correlation degree whilst keeping a stable classification execution, and figure out the brain areas and frequency constraint according to with the positions to which they exposed. In addition to, we try to find the track of emotion changes with multiple models.

The structure of this paper as follows. In Section II we present some related works. In Section III show the methodology and experimental design. In Section IV illustrates the overview of the results and discussion of this present work. Finally, Section V summarizes the conclusions and briefly highlights future work.

II. RELATED WORK

The health-care application appears recently that demands the concept of the Internet of things(IoT). IoT-based smartphones give permanent and continuous health control such as electroencephalogram (EEG), electrocardiography (ECG), Electromyography (EMG), blood sugar, and blood pressure (BP), the goal is to detect the disease early and to reduce the costs of medical check-ups.

Farzad et al. [5] used dynamic programming approach which has three dimensions (i) the number of devices (ii) the total number of bandwidth (iii) the total number of processing. They focused on managing quality of service under three constraints which is bandwidth battery and processing policy. In this paper, they evaluate the dynamic programming throw case study by using health-care monitoring such as ECG. In

this paper, they had taken three readings for ECG signals. For each device, they took the efficient visible configuration to manage the situation when the battery is low or when the person stressful. In this paper, they show that there were three devices and the total number of the bandwidth was sex which illustrates R: the number of an electrode that placed on the chest. The total number of processing was sex which illustrates P: the number of electrodes the placed on the limbs. They suggest an algorithm to find an ideal solution based on recursive relation and the result was 22 that show the largest number of quality service that provides to the user when the device captures specific signals.

Xin et al. [6] used sensor node for wireless body area networks (WBAN) in ECG. WBAN is a very advanced technique in wireless communication signal processing and integrated circuits. The aims of ECG signal processing system is using ultra power and small silicon area for cardiovascular monitoring. The WBAN provide low environment noise by using noise suppression algorithm which leads to more accurate results in cardiovascular monitoring.

Bartolotti et al. [7] used ultra low-cost wireless sensor network (WSN) in ECG to check the cardiovascular signals. In this paper, they focused on using a device that reduces the energy consumption used in the operation and extends the battery shelf life. They focused on maximizing the using of non-volatile memory (NVM) by the store it in the device and reduce the energy use. They used Wireless sensor networks (WSN) to meet signal qualities in healthcare application especially ECG to take the most benefits of the energy and save powers as much as possible which keep the battery for the longest time. The experimental results show high effectiveness results up to 70% which is a very good result.

Rizman et al. [4] used EEG to discover the personal emotions based on the brain signals. The main goals of their study were: (i) learning to cope with emotions by using classification process (ii) study brain waves based on electricity (iii) check the relations between the brain and the facial expression. In this paper, they classified the brain waves into five types of waves which is: delta, theta, beta, alpha, and gamma each one of them have the specific frequency range which starts from 0.5 to 27 HZ. The method for this paper is: (i) extract the data at the time of respond (ii) image capture with the camera (iii) pre-processing for data (iv) features extraction. Finally, they want to connect between the brain signals and waves with the facial expressions.

Nie et al. [8] aim to find the relation between EEG signals and emotion status. In this paper, they classified the emotions either positive or negative by extracted features using a liners dynamic system approach. The results were either positive or negative and the accuracy was 87.53% which is a very accurate result.

III. METHODOLOGY AND EXPERIMENTAL DESIGN

We used a similar approach to [5n], in which a dynamic programming solution to find the best solution to QoS management problem based on the recursive relation. The dynamic programming the most appropriate solution for their problems because of :(1) It supplies a quick and best solution to the problem. (2) Allow reusing some computations. The dynamic programming approach has three dimensions: one for the number of devices and the others two for the constraints include data rate and processing power. They concentrate on ECG detection which formulated a realistic use case for evaluating the efficiency of the proposed IoT resource management solution. They suggested a scenario of IoT-based health-care monitoring device solved by using dynamic programming which captures and transmits an ECG signal to the Internet through a Smartphone.

The ECG is the process of recording the electrical activity of the heart using electrodes placed on the chest and limbs [2].ECG has 12 electrodes: - six electrodes from V1 to V6 placed on the chest (V means the vector which the electrode direct to it) as shown in Figure 1.The other six electrode AVR, AVL, AVF, I, II, and III placed on the limbs (aV mean augmented vector that responsible for increasing the size of the image as shown in Figure 2.
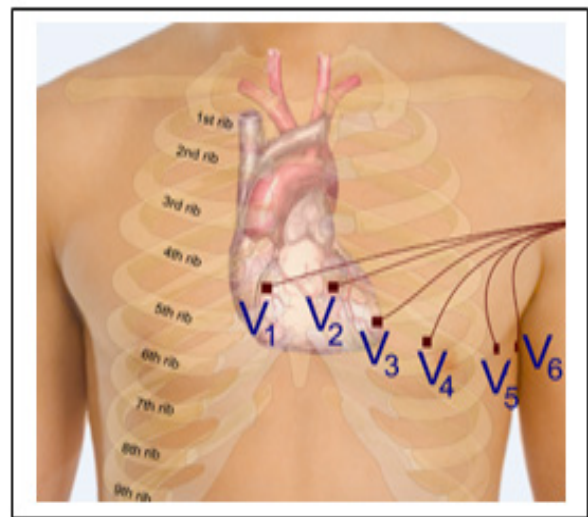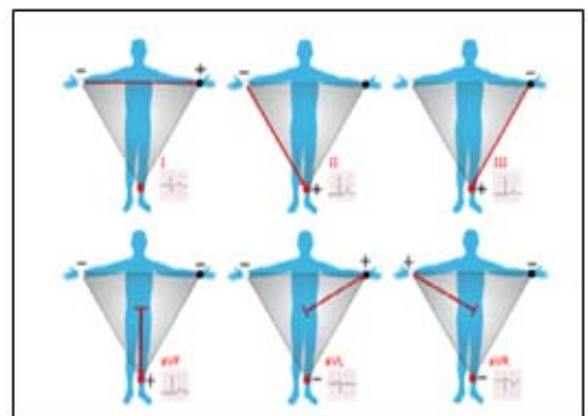

Fig. 1. The electrodes placed on the chest *[2]*.

Fig. 2. *The electrodes placed on the limbs [2].*

In this paper, we have two experiments: the first experiment we convert a pseudo-code based on a dynamic programming (DP) to C++ programming language and used the same input that used in this research paper [5n] and the result was the same. We have run the code on online C++ compiler [9n]. In the second experiment, we apply the dynamic programming as shown below in Figure 3 of the EEG readings that taken for three girls and each girl has three emotions which happiness, sadness, and fear by using some effects such as video.

```cpp
int Z(int d,int r,int p)
{
if ((r<=0) || (p<=0))
return -1;
else if (d==0)
return 0;
for(int f=1;f<=d;f=f+1)
{

    if ((s[d].trans_rate[f]<=r) && (s[d].proc_rate[f]<=p))
    {
        if (TB[d-1][r-s[d].trans_rate[f]][p-s[d].proc_rate[f]]<0)
        TB[d-1][r-s[d].trans_rate[f]][p-s[d].proc_rate[f]]=
        Z(d-1,r-s[d].trans_rate[f],p-s[d].proc_rate[f])+ TB[d-1][r-s[d].trans_rate[f]][p-s[d].proc_rate[f]];
    }

if ((TB[d-1][r-s[d].trans_rate[f]][p-s[d].proc_rate[f]]+s[d].utality[f]) > TB[d][r][p])

    TB[d][r][p]= TB[d-1][r-s[d].trans_rate[f]][p-s[d].proc_rate[f]]+s[d].utality[f];
}
}
int main()
{   fill_the_TB_value();
    built_devices_value();
    N=Z(d,r,p);
    return 0;
}
```

Fig. 3. Code snippet of dynamic programming (DP) Implementation.

Let function Z(d, R, P) show the maximum overall utility that we can get from the d devices whilst the constraints on the data rate and processing capability of the gateway are R and P, respectively. For the d device, we need to choose one of its configurations from its EFC set whose size is |EFCd|. Considering the f element of the EFC set is EFC(udf, rdf, pdf), its utility, data rate, and processing capability respectively. For the f configuration, we first find the overall utility of a solution with d−1 devices whose overall required bandwidth and processing resources are R−rdf and P −pdf, respectively. Then, we add it to the provided utility by f configuration (Udf). We investigate all the possible configurations of device d and select the one that maximizes the overall utility [5n]. In this paper, we collect the real EEG data using a helmet for female students, whose age varies between 20-24. The EEG data related to three emotions measured using any induction method such as video clips, smelling some kind of perfume and others. Then, we comparison procedure accomplished by extracting the similarities and differences between these waves.

The following tools are used in this research paper:

A) We used the tool in EEG to convert data from EDF format to CSV.

B) We implement a C++ program based on dynamic programming to extract the maximum number of quality service that provides to the user when the device capture specific signals for each emotion.

C) We implement java programming to compare data and save the result on the text file.

IV. RESULTS

In this paper, we study a novel attempt to measure the human brain activity and analyze its signals using EEG in order to classify the human emotions indicated by the brain wavelets. The study will measure the brain wavelets of female students, whose age varies between 20-24 in order to detect the emotions of happiness, sadness, and fear. This study will use specially designed sensors placed around the scalp. The measured signals transfer to a computing device. The data collected analyze by a software system, which developed by our team. Every person (barring those with a brain disorder) knows what it feels like to move by something to feel happiness, sadness, anger, and fear. There are two types of it:

A. Natural Emotion.

It is difficult to do, because the natural emotion or mode of the student may change during the test, which may last for few minutes. This type of test will be out of the scope of this paper.

B. Induced Emotion.

We are creating emotion for a particular person by "Stimulus". To stir happiness we see the video which causes happiness or asks you to talk about someone you love. To stir sadness we use a picture someone you love is dead or ask you to talk about issues such as the Palestinian issue. To stir fear we used to hear a story that causes fear or See a video cause fear.

After our first experience of ECG readings using dynamic programming solution according to [5n]. The second experience we will take three different EEG readings for three girls and each girl has three emotions which happiness, sadness, and fear by using some effects such as video.

The results of the EEG readings using the dynamic programming shown in section III in Figure 3. These results showed the maximum number of quality service that provides to each girl when the device captures specific signals for each happiness, sadness, and fear.

Table1 shows the result of three girls in three emotional statues using dynamic programming.

TABLE I.   *RESULTS OF THREE GIRLS IN THREE EMOTIONS.*

Girls/Emotions	Happiness	Sadness	Fear
First girl	89	70	64
Second girl	90	68	65
Third girl	86	71	68

In Figure 4 shows the percentage of shipments of the EEG device for three girls in different emotions and the results were close in each emotion and used the same effects its two-minute video for three girls for each emotion. The happiness rate was between 80-90 %. The rate of grief ranges between 68-71%.The fear rate ranges from 60-67%.   We implement java programming to compare the reference data with another student other than the three girls data and calculate the range similarity as shown in Figure 5.

We collected data for three girls after we find the reference for the emotions of happiness, sadness, and fear. For example, If we want to measure for anybody other than the three girls after we find the data we compare it with the reference for the three emotions, the system will discover this person with which emotion matched as shown in Figure 6.
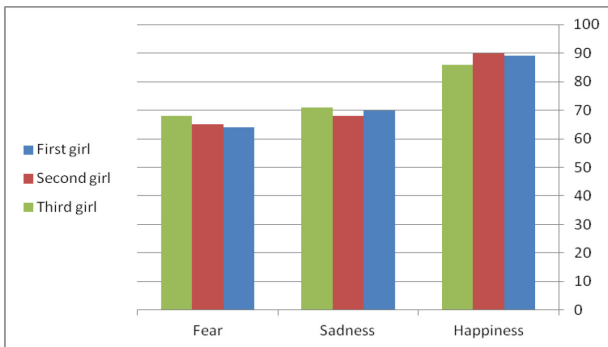

Fig. 4.   Results of three girls in three emotions.

Fig. 5.   Code snippet of calculated reference.

```java
public void writeReference() throws IOException
{
    String excelFileName = "reference.xlsx";
    String sheetName = "result";

    XSSFWorkbook wb = new XSSFWorkbook();
    XSSFSheet sheet = wb.createSheet(sheetName) ;

    //iterating r number of rows
    for (int r=0;r < maxRow; r++ )
    {
        XSSFRow row = sheet.createRow(r);

        //iterating c number of columns
        for (int c=0;c < COLS; c++ )
        {
            XSSFCell cell = row.createCell(c);
            cell.setCellValue(reference[r][c]);
        }
    }

    FileOutputStream fileOut = new FileOutputStream(excelFileName);
    wb.write(fileOut);
    fileOut.flush();
    fileOut.close();
}
```

Fig. 6.   Code snippet of write reference.

EEG system is a very important System to record the electrical activity of the brain to classify the human emotions indicated by the brain wavelets. We are looking for defining the similarities and differences between humans, whose are experiencing the same emotion. This accomplished by collecting real data for different subjects under the same stimulus. Then extract their patterns in order to define a unique signature for each emotion. In Figure 7 shows the facial expressions for each emotion and in Figure 8 shows the average of EEG waves for each emotion x-axis: time and y-axis: EEG waves.
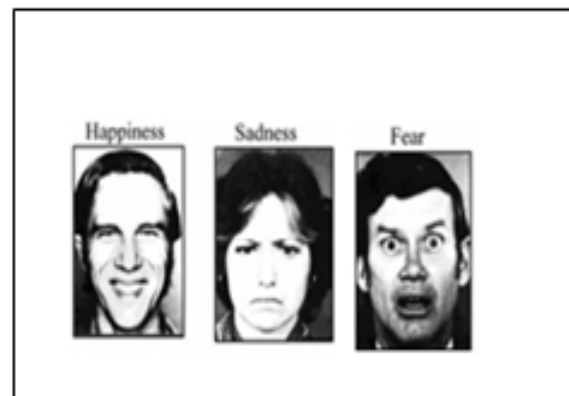
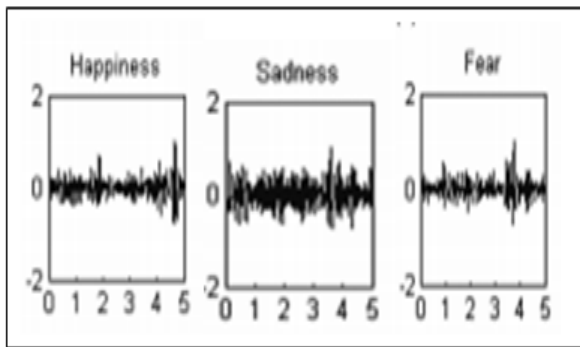

Fig. 7.   Facial expression [17].

Fig. 8.   The average of emotions[17].

The result that found after we try EEG to another person which show he was happy and the average of emotion was 78%.

Expected results illustrate the following; (i) to study brain waves for the purpose of emotions, (ii) Based on the results that we reached during studying the three emotions for three girls. (iii) we used these results as the reference point to compare the new cases with it to know this case related to which emotion and to know how much the percentage of the emotional status. (iv) it is very helpful to your doctor in a hospital and the police criminal investigation department, and (v) help develop software packages based on the study.

V. CONCLUSIONS

The EEG used in hospital and prisons to know the emotions of the offenders and patients. They find that there some relations between the characteristics of EEG and all emotions. These data managed by the doctor in hospital and policeman in case of crime. Based on the results that we reached during studying the three emotions for three girls. We implement a C++ program based on dynamic programming to extract the maximum number of quality service that provides

to the user when the device captures specific signals for each emotion. We used these results as the reference point to compare the new cases with it to know this case related to which emotion and to know how much the percentage of the emotional status by using java programming.

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