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Real-Time Epileptic Seizures Detection and Recording Device

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Abstract:

Epilepsy is one of a neurological disorder induced by defective brain electrical activity. After an epileptic assault, the person will be unconscious and confused. Caregiver need to record the length of the patient's epilepsy assault and hence, need to be close with the patient all the time. The purpose of the project is to develop a device that is able to detect the epileptic seizure attack based on the patient'sskin conductivity. This project is usesgrove - galvanic skin response (grove-GSR) sensor as an input to detect the abnormal reading of patient's skin conductivity. Then, this signal will trigger the real-time clock (RTC) which produces the real-time information to record the duration of the epilepsy attack. Besides that, an SD card is used to store the collected data for the doctor to diagnose the patient's condition during monthly check-up. The project prototype functionality and effectiveness was tested on the normal patient as a test subject.Details on the project prototype development and results are discussed in this paper.

Keywords: *epilepsy, seizure, galvanic skin response, real-time record*

I. Introduction

Epilepsythat is characterized by seizure in unpredictable frequency is a common neurological disorder that often affects children and older adults [1]. Epilepsy can be categorized according to seizure type namely focal seizures and generalized seizures. The focal seizure happened due to abnormal neurological activity in one hemisphere of the brain while generalized seizure happened due to abnormal neurological activity in both brain hemispheres.According to [2], person with focal seizures will generally suffer from abnormal limb jerking for few minutes. Meanwhile, person with generalized seizures will become unconscious, fall on the ground, overall body shaking/stiff and mouth frothy.In normal cases, seizure attack lasts for 2-3 minutes and the person may feel sleepy or confused after the seizure attack. Due to these seizures effects and convulsions severity, person with epileptic seizures shall not be left unattended.

Other than physical examination, doctor or neurologist will be able to diagnose the condition of a person with epilepsy through investigation. Hence, the doctor or neurologist requires the patient's caregiver (e.g. relative) to daily record the duration of each seizure attack.Conventionally, the patient's caregiver uses a small notebook to record the patient's seizure attack within a month. Whenever the patient experiences seizure attack, the caregiver need to the attack duration and classify the attack as major or minor through his/her observation. An example of monthly seizure attack record from a real epilepsy person is shown in Figure 1. This manual daily record of seizure attack will be the input for the doctor or neurologist to diagnose the patient's condition during the monthly check-up.

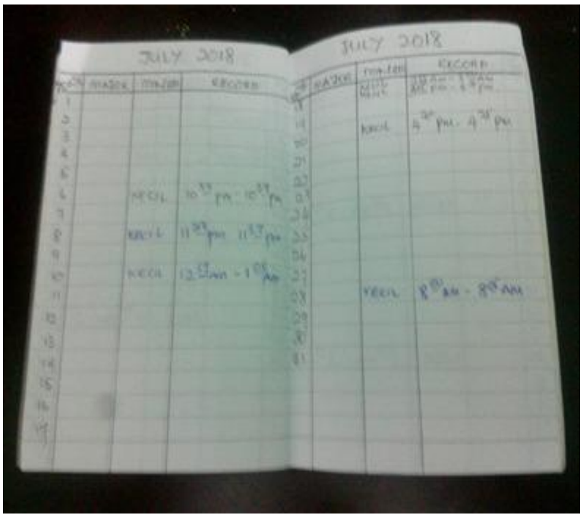

Figure 1. Monthly seizure attack record from a real epilepsy person

The conventional way of recording patient's seizure attack requires the caregiver to stay close with the patient. Unfortunately, seizure attack is irregular and unpredictable. Hence, the caregiver might not be able to accurately record the patient's seizure attack when he/she is away from the patient due to short duration of the seizure attack (i.e. 2-3 minutes only). Moreover, when the caregiver sleeps at night, he/she would missed out to record the patient's seizure attack during that sleeping interval. Inaccurate seizure attack recording will indirectly affect the doctor or neurologist to effectively diagnose the patient's condition and treatment progress.

Based on the above-mentioned seizure attack recording issues,there is a need for epilepticseizure attack detection and recording system. Several epilepsy detection methodswere proposed in prior works [4]-[6]. For instance, researchers in [3] proposed a highly accurate classification of epilepsy through a Matching Pursuit algorithm for electroencephalogram (EEG) signal extraction. To capture abnormality of brain electrical activity (i.e. brain disorder) of epilepsy patient, this non-invasive method requires the EEGelectrodes to be attached onto patient's scalp.This will cause discomfort to the patient and the procedure will typically takes up to 60 minutes [3].

On the other hand, researchers in [5] used surface electromyogram (EMG)to interpret the pathomechanism of the patient's tonic muscle activation during epileptic seizures.The findings provide additional insight on muscle activation (i.e. convulsion) during epileptic seizures. Last but not least, a prototype of epilepsy seizure detector was developed by authors in [6]. Patient's skin conductance, body temperature and body movement are used as parameters for epileptic seizure detection.Via buzzing alarm and phone messages, the detector was developed to help epilepsy patients to receive immediate help from the people around and automatically informthe doctor/family member when seizures happen.

Apparently, the existing epilepsy detection methods proposed by [4] and [5] are (i) costly due to the usage of EEG and EMG instruments and (ii) this approach could only be conducted at hospital under medical instrumentation technician/engineer for the placement of electrodes on the targeted spots. Conversely, the low cost epilepsy detector developed in [6] could only be activated when the patient is found collapsed or increased in body temperature.Hence, the device is only effective for patient with generalized seizure.Above all, none of the previous work covers the duration of epileptic seizure attack recording though this information is very important for doctors to diagnose the patient's condition during monthly check-up.

Based on the above-mentioned limitations found in the existing works, this paper proposes a prototype development of real-time epileptic seizure detection and recording device based on human skin conductance and has the capability to record the duration of real-time seizure attack. Hence, the proposed device is functional to accommodate the conditions of both focal and generalized seizures patients during the epileptic seizure attack.

II. Methodology & Prototype Development

A. *Block Diagram*

Figure 2 shows the block diagram of the proposed real-time epileptic seizure detection and recording device. The input readings will be taken from a grove - galvanic skin response (grove-GSR) sensor. The grove-GSR sensor is used to identify the occurrence of epileptic seizure attack through patient's skin conductance. Human skin conductance would be affected by the sweat glands in the skin in which a person would produce more sweat glands when he/she is in high emotional state (e.g. stress, scare etc). Readings on skin resistance are collected and converted into analog voltage values via grove-GSR sensor when it is placed onto two patient's fingers.

All input readings of patient's skin conductance will be processed by Arduino Uno microcontroller. The microcontroller will continuously read the patient's skin conductance. Whenever the patient experiences epileptic seizure, the microcontroller will command the LED to light up to alert surrounding people. At the same time, the microcontroller will also command real-time clock (RTC) module to track and record the real-time duration of the epileptic seizure attack into micro SD card. Hence, the micro SD card is used for the data logging in the proposed device.

Besides the triggering red LED to alert surrounding people; the data of epileptic seizure attack in terms of skin conductance readings, date and time would be a useful output for the doctor/neurologist to diagnose the patient's progress during monthly check-up. The SD card could be taken out from the SD module and inserted in laptop or personal computer to trace the recorded data.

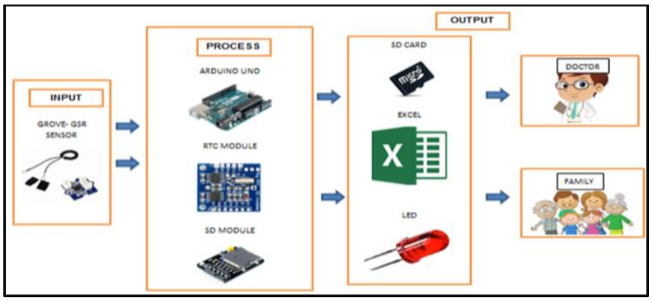

Figure 2. Block diagram of the proposed device operation

B. System Operation

As shown in Figure 3, system operation starts straight away when the device is turned on and grove-GSR sensor is placed onto the patient's fingers. The grove-GSR sensor would continuously capture the patient's skin conductance since epileptic seizure attack is irregular and unpredictable.

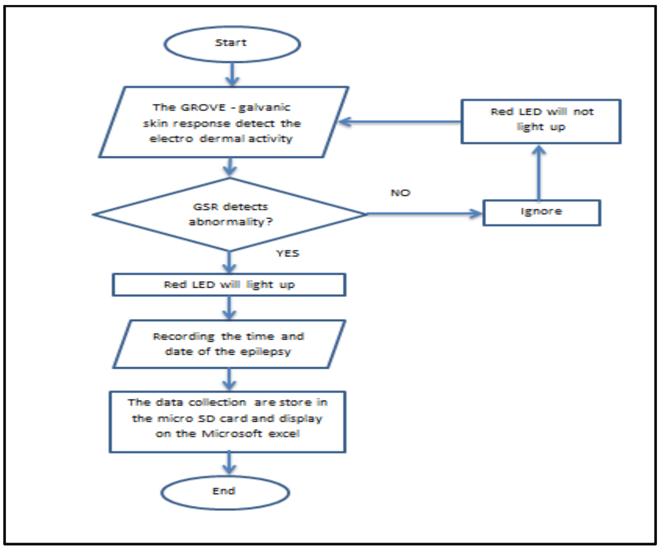

Figure 3. System operational flow chart

Generally, the epilepsy attack conductance activity threshold is from 0.7µS and up to 20µS [7]. Since the prototype is tested on a normal person, the baseline of grove-GSR sensor is set to 500mV. Hence, the test subject condition is classified as epileptic seizure when the grove-GSR sensor captures any readings ≤ 500mV.If the GSR reading is at a 500mV, the sensor will continue to monitor the skin activity. If the electrical signal is achieved the abnormal limit which is below 500mV, the microcontroller will command the LED to light up. The LED is functioning as an indicator to the surrounding people near the patient whether the patient is having an epilepsy attack or not.

Pseudo code below shows how the epileptic seizure attack is recorded in SD card based on real-time.This code will follow the programmable code but in simple language. First of all, all parts of the component used have to be declared. Then, in the void setup, the system will run once the program was started. The internal RTC will start detecting the real-time which displays "couldn't find RTC" and also "RTC is not running!" In this void setup also will display the "card failed or not present".

Whenever the grove-GSR reading falls below 500mV, the file in the SD module will open up and display "datalog3.txt". Then, it starts to write the data. Then, after the file was available, the LED that acts as the indicator will light up during the epilepsy attack and the data will be displayed on the serial monitor. All data displayed in the serial monitors which are GSR reading, time and date will automatically save in the SD card.

This program will record the duration and date of epilepsy attack and save it into the micro SD card

```
initialize
gsr sensor at pin A0
    the chip select at pin 4
    the dayoftheweek
(sunday,monday,tuesday,wednesday,thursday,friday
,Saturday)
          led at pin 9
void setup
     led as output
     if internal rtc begin --> display "Couldn't find
RTC"
     If internal rtc begin --> display "RTC is NOT
running!"
     --> Display "Initializing SD card..."
     if the SD begin --> display "Card failed, or not
present"
```

```
void loop
    a long calculation for average measurement gsr
    sensor which the average measurement divide
    by 10 --> display as gsr_average (value)
      the led not light up
          if the gsr value below that 500
          the file in SD card will open--> display
"datalog3.txt" and ready to write the data
             if the file is available→ the led will light up
           start display the time ,date and gsr_average
           save the data (time, date and gsr_average) in
the SD card
          else
             if the file no available or not open--> display
        "error in  opening data log"
end of program
```

III. Results and Discussions

As portrayed in Figure 4, evaluation on a healthy test subject through experiment was conducted to evaluate the effectiveness of the developed device to detect any skin conductance abnormality and provide a real-time skin abnormality recording. The experiment goal is to obtain sets of data which can be used as a benchmarks for epileptic seizure attack experienced by the real patient. Grove-GSR sensor readings presented in Table 1 shows that the developed device is prove to be functional when it shows the respective state of red LED for skin conductance value lay between 410mV and 503mV. As described in the system operation section, epileptic seizure attack is classified as TRUE when the person's skin conductance readings fall below 500mV.

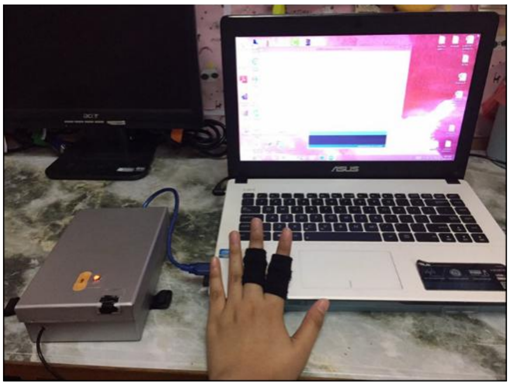

Figure 4. Project prototype testing

On the other hand, Figure 5 depicts two points which are declared to be the skin conductance values during epileptic seizure attacks. Hence, the developed device has successfully detected any skin conductance abnormalities as the input readings were captured below 500mV.

Figure 6 and Figure 7 show the examples on how the recorded epileptic seizure attack details from the SD card were interpreted into graphs by using the Microsoft Excel. The graphs help the doctor/neurologist to analyze the frequent rate of epilepsy attack experienced by the patient in a respective month. The "X" notations in the graphs marked the normal skin conductance readings (i.e. ≥ 500mV).

Based on the presented graphs, the experiments conducted on skin conductance abnormalities of the test subject have shown that the developed device is capable to record a longer duration (i.e. 4, 5 and 6 minutes) of skin abnormalities provided that the test subject is under epileptic seizure attack. As highlighted by [2], seizure attack would typically lasts for 2-3 minutes only. Hence, the device is reliable to continuously record epileptic seizure attack if in case the attack is longer and more severe.

As denoted in Figure 6, the developed device is capable to record multiple seizure attacks in a day since it is known that the seizure attack is irregular and unpredictable. Besides that, the proposed device hasovercomethe problem face by the caregiver in conventional way of seizure attack recording which the caregiver is sleeping and missed out to record the patient seizure attack at night. As shown in both Figure 6 and Figure 7, epileptic seizure attack was automatically recorded around 4 am and 1 am in the morning.

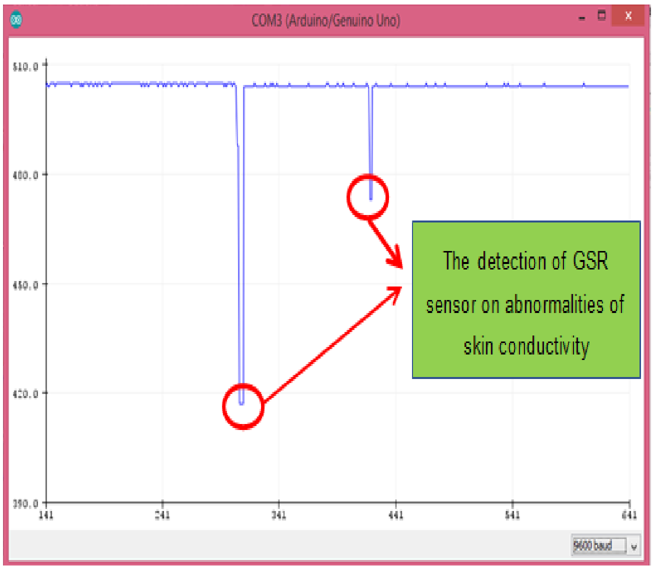

Figure 5. Detection of epileptic seizure attackbased on the grove-GSR readings on the test subject

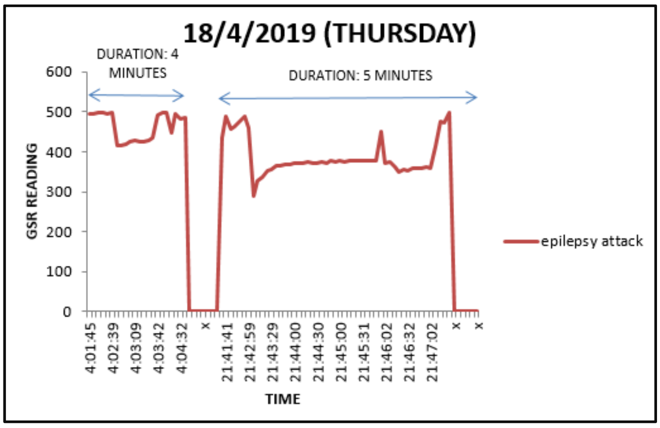

Figure 6.Epileptic seizure attack recorded on April 18, 2019

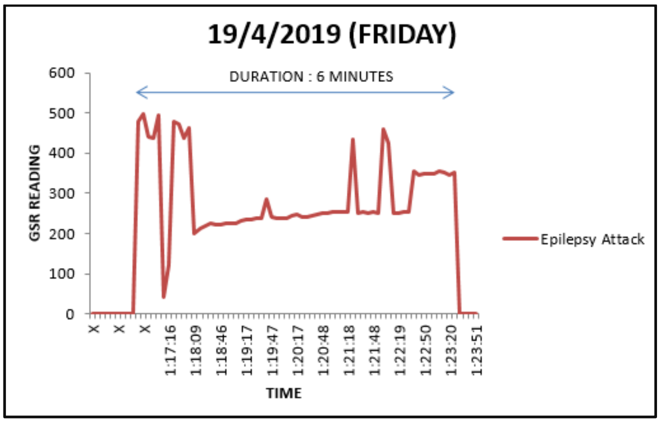

Figure 7.Epileptic seizure attack recorded on April 19, 2019

IV. CONCLUSION

From this project, it can be concluded that:

i) a prototype of real-time epileptic seizures detection and recording device was developedby using grove-GSR sensor to capture any abnormalities on human skin conductance, andhas the capability to record the duration of real-time seizure attack using RTC and SD card module.

ii) the experimental results performed on a normal person as a test subject have shown the overall functionality ofdevice components during healthy condition (i.e. skin conductance reading $\geq$ 500mV) and during epileptic seizure attack (skin conductance reading < 500mV).

iii) theexperimental results also proved the effectiveness of the developed device to continuously record the real-time epileptic seizure attack for more than 3 minutes at anytime (day or night) as long as the patient puts on the device to the assigned body part.

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