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Paper Authors

PRAKRTI SHARMA, KEERTHI RAMKUMAR, KAVYA A S, VANI BP

Sir M Visvesvaraya Institute Of Technology, Bangalore

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AN EPILEPSY DETECTION AND MONITORING TOOL USING IMAGE PROCESSING AND EMBEDDED TECHNOLOGY

[1]PRAKRTI SHARMA, [2]KEERTHI RAMKUMAR, [3]KAVYA A S, [4]VANI BP
[1, 2, 3]Dept. of ECE, Sir M Visvesvaraya Institute Of Technology, Bangalore
[4]Assistant Professor, Dept. of ECE, Sir M Visvesvaraya Institute Of Technology, Bangalore.

ABSTRACT

Epilepsy is a chronic neurological disorder involving seizures (fits). These attacks can occur anytime and anywhere. Thus there is a necessity of predicting the occurrence of the seizure beforehand. Several solutions have been proposed in the literature to detect seizures and to monitor the patient; however, these approaches lack in ergonomic issues and in suitable integration with the health system. Our project makes an in-depth analysis of the main factors that an *epileptic detection and monitoringtool* should accomplish. It consists of an outdoor as well as an indoor system. Outdoor equipment consists of a wearable device including sensors such as accelerometer, heart rate sensor and temperature sensor. Indoor equipment consists of a camera which continuously monitors the patient, is capable of facial expression reading and classification. In case of any abnormal readings, the patient is notified via a buzzer and the doctor and caregiver are notified via an app on their phones, for further necessary actions to be undertaken. Thus, with this model, the patient can go about doing his/ her normal day to day activities with ease and will be alerted in case there is a possibility of an epileptic attack, and act accordingly.

KEYWORDS Epilepsy; seizure; temperature; pulse rate; body vibrations; facial expressions; ARM microcontroller.

1. INTRODUCTION

Epilepsy is a neurological disorder characterized by involuntary recurrent convulsions, also known as fits or seizures. This disease affects more than 65 million people across the world. These seizures occur randomly and are unpredictable, making the patient refrain from activities such as driving/ handling heavy equipment etc. as they can occur anywhere and anytime. The attacks can also occur in front of people, making it a cause for social stigma in several patients. Financial expenditure is very high and there are also chances of death, referred to as SUDEP (Sudden Unexpected Death in Epilepsy).

As you can see, this disease has a very high impact on the patient's quality of life. Unfortunately, in spite of intense research in the field, till today, there is no proper cure for epilepsy. It can only be controlled, that too to an extent.

Our proposed model is capable of predicting the onset of a seizure beforehand and notifying the patient and concerned personnel (doctor/ caregiver) so that the required actions can be taken.

2. METHODOLOGY

Our prototype model consists of an ARM LPC2148 microcontroller with power supply of 12V. Two systems have been proposed, which can be swapped with a switch:

A. OUTDOOR SYSTEM

This system is ideally present in the form of a wearable device, so that it does not interfere with the patient's day to day activities. It regularly monitors the temperature, heart rate and body vibrations of the patient. We use the following sensors for it:

1. LM35 temperature sensor
2. TCRT1000 pulse rate sensor
3. MEMS accelerometer

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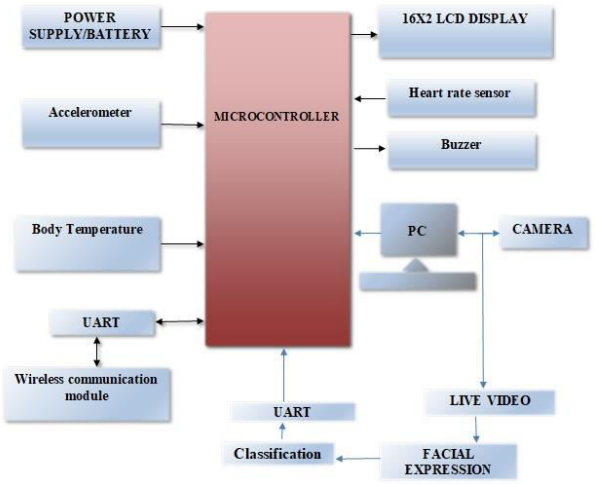

Fig 2.1 Block Diagram

Before the onset of a seizure there is fluctuation in the above said parameters. Defined thresholds have been set for the sensors as 'normal range' (see Table I). If any of the recorded values are not within this range, it indicates that there are chances of an epileptic attack. The buzzer starts ringing, an appropriate message gets displayed on the LCD and the doctor and caregiver are immediately notified via an app using the Wi-Fi module (ESP8266). The code is written in embedded C using Keil version 4 and installed through flash magic.

BODY PARAMETER	SENSOR USED	NORMAL RANGE
Temperature	LM35	35-37 ^{o}C
Pulse Rate	TCRT1000	70-75 beats/min
Body Vibrations	MEMS accelerometer	450-590 Hz

Table 2.1 Sensors used and normal range specified

B. INDOOR SYSTEM

This part consists of cameras installed in various points in the patient's house, which constantly monitor the facial expressions of the patient. Before using the device, the patient is required to record all kinds of expressions into the system so that only his/ her face can be identified and the machine has higher accuracy.

Now the device can be used for monitoring. This involves 5 major processes, namely-

1. Image Acquisition
2. Image Pre-processing
3. Feature Extraction
4. Feature Selection
5. Classification

Recording is done through the camera and static images are extracted from the video. The images are enhanced and focus is given to the face of the patient. Facial images are then geometrically institutionalized, specific features are extracted and classification is done. Classification refers to an algorithmic approach for recognizing a given expression as one of a given number of expressions. We use Support Vector Machine classifier for this.

In the prototype, we use the webcam present in a PC/ laptop as a camera. Our code is written in MATLAB. In case of any abnormal expressions in the face, there are chances of epilepsy, upon which the buzzer rings, an appropriate message is displayed on the LCD and concerned personnel are notified via the app using Wi-Fi module (ESP8266).

3. RESULTS

A. OUTDOOR SYSTEM

All the parameters: temperature, pulse rate and body vibrations are continuously monitored and their values displayed on the LCD as well as doctor/ caregiver's phone (See Fig. 2). If the parameters go beyond the specified normal range, there are chances of a seizure. The message displayed is "CHANCES OF EPILEPSY" (see Fig 3) and the buzzer starts to ring.

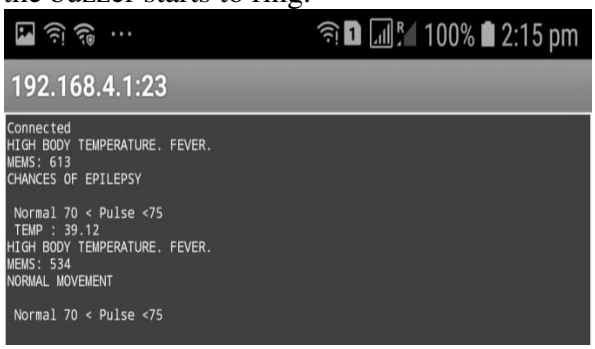

Fig 3.1 Messages shown on Doctor/ caregiver's phone

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Fig3.2 LCD displaying "chances of epilepsy"

B. INDOOR SYSTEM

When the MATLAB code is run, the camera records a video from which many images are extracted. Several figures will be displayed, each showing the original image, enhanced image, face detected image, mouth detected image and eye detected image. (See Fig. 4).

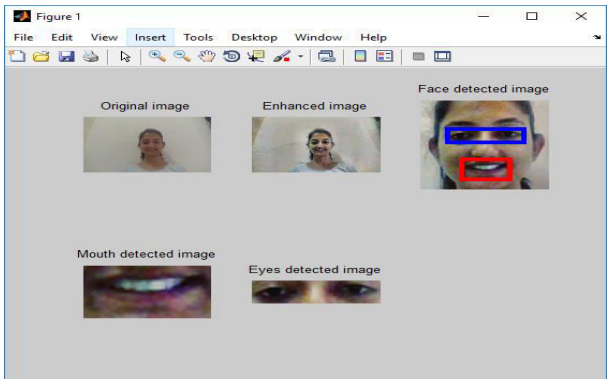

Fig. 3.3 Feature extraction in indoor system using MATLAB

From these, the features extracted are classified using SVM and appropriate messages are displayed on the LCD and phone (See Table II and Fig. 5).

SR. NO.	EXPRESSION/ CONDITION	MESSAGE DISPLAYED
1	Normal	"STRAIGHT FACE"
2	Happy	"HAPPY FACE"
3	Abnormal	"CHANGES"
4	No one present in front of camera OR someone else in front of camera.	"NO FACES"

Table 3.1 Messages displayed according to expressions

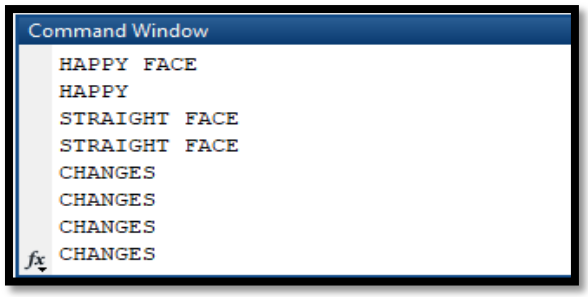

Fig 3.4 Messages displayed in command window in MATLAB according to facial expressions

4. CONCLUSION

A prototype is built which can predict a seizure beforehand, indoors and outdoors. Indoors, the patient is constantly monitored and his/ her facial expressions are recorded and classified. Outdoors, temperature, pulse rate and body vibrations are regularly measured. In both systems if any unusual readings are recorded, the patient and concerned personnel are immediately notified and necessary actions are taken. The final model will be compact and wearable around the wrist. This model can drastically change the way of life for an epileptic patient. There are no sudden outbursts of seizures. Patients always get to know prior to an attack and can act accordingly, making life much easier, flexible and tension free.

Below mentioned are the merits, demerits, applications and future scope of this project.

A. MERITS:

1. Flexible and easy to use.
2. Budget friendly.
3. Does not interfere with day to day activities.
4. Notifies patient in case of a seizure, 5-10 minutes before the attack.
5. Patients need not be worried of getting an epileptic attack while doing risky activities such as driving, handling heavy machinery etc.
6. Social stigma affecting several patients due to occurrence of attacks in public is eliminated.
7. The Doctor and caregiver are immediately notified and can take necessary actions to control the seizure.

8. Recording the attacks becomes easier as every reading is stored in the database, which will give a clearer idea on foreseeing seizures.
9. The Doctor can easily get the record of the occurrence and duration of all the attacks, which is necessary to get more information about the type of seizures and for treatment.
10. The fits which occur during sleep and in most cases go unidentified are also detected by this model.
11. Helps in drastically reducing chances of SUDEP (Sudden death during epilepsy).

B. DEMERITS

1. Fluctuations in body vibrations, temperature and pulse rate can occur during physical exercise, and give false readings. Thus this device cannot be used while doing rigorous physical exercise.
2. Cameras will be installed in different positions of the house for full area coverage, but in cases where patient is covering face with hands or lying down inverted with head facing the bed, facial expression cannot be read.
3. Making abnormal faces on purpose will lead to false readings.

C. APPLICATIONS:

This system is of great advantage to patients suffering from epilepsy. It notifies the patient before the onset of a seizure so that the he/ she can stop any action, go to a safe environment away from people and be only with their caregiver/ doctor who will take required actions. The doctor and caregiver will be notified via their phones on an app. This ensures safety of the patient as well as others (in case the patient is driving, handling dangerous equipment etc.). Sudden episodes of epileptic fits occurring in front of people, lead to social awkwardness and this can be avoided as patient is notified before the attack and can go to an isolated place. The final wearable device is portable and does not interfere with patient's day to day activities. It also prevents chances of death which may occur during epilepsy (SUDEP).

D. FUTURE SCOPE:

The prototype model has bigger equipment, for demonstration purposes and budget reasons. We hope to, in the future, condense the model into a device as small as possible and in the form of a wearable device around the wrist. We also want to embed all components into a single chip, designed specially, which can be used in the device. Final system will be a full-fledged model which can be used very easily and will be of humungous help to people across the globe suffering from this condition.

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