Epilepsy Monitering System using Accelerometer Sensor

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Abstract*:* Epilepsy is a neurological disorder characterized predominantly by an enduring predisposition to generate epileptic seizures. The apprehension about injury, or even death, resulting from a seizure often overshadows the lives of those unable to achieve complete seizure control. Moreover, the risk of sudden death in people with epilepsy is 24 times higher compared to the general population and the pathophysiology of sudden unexpected death in epilepsy (SUDEP) remains unclear. This thesis describes the development of a wearable electro dermal activity (EDA) and accelerometer (ACM) biosensor, and demonstrates its clinical utility in the assessment of epileptic seizures. We present the design of sensor nodes for human posture tracking purposes. Each sensor node is equipped with a microcontroller, an RF transceiver chip and two sensors: a 3D accelerometer and a 3D magnetometer. Based on the signals of these sensors, the orientation of a sensor node can be estimated. Combining several of these nodes into a sensor network, allows for complete human posture tracking, as the human body can be approximated as a rigid body consisting of 15 links. We present a novel method for monitoring sympathetic nervous system activity during epileptic seizures using a wearable sensor measuring electro dermal activity (EDA). The wearable sensor enables long-term, continuous EDA recordings from patients.

INDEX TERMS—Smart Phone,Bluetooth,Android app,Microcontroller.

I. INTRODUCTION

EPILEPSY is a common neurological disorder that involves repeated and spontaneous seizures. These seizures are the manifestation of abnormal, excessive or synchronous neuronal activity in the brain. Epileptic seizures are often associated with significant changes in autonomic nervous system (ANS) functioning [1]. Autonomic signatures such as flushing, sweating and piloerection often accompany partial seizures and auras [2-4].Incontrast,generalized tonic-clonicseizures(GTCS) are associated with severe increases in blood pressure and changes in heart rate and cardiac conduction [5]. Seizure-induced autonomic dysfunction can have serious clinical consequencesand potentially fatal effects when the cardiovascular or respiratory systems are involved [6]. There are distinct differences between the sympathetic and parasympathetic divisions of the ANS. While parasympathetic discharges produce responses to promote restoration and conservation of energy, the sympathetic nervous system increases metabolic output to adjust to external challenges. So far, autonomic alterations in epilepsy have mostly been studied using indirect parameters such as heart rate, respiratory rate and blood pressure changes that are dually modulated by both divisions of the ANS [5, 7-9]. Spectral analysis of heart rate variability (HRV) can provide a sensitive index of cardiac parasympathetic control via the vagus nerve [10], but its utility for uncoupling sympathetic activity remains controversial [11, 12]. On the other hand, sympathetic postganglionic fibers consisting of nonmyelinated class C nerve fibers surround eccrine sweat glands and their activity modulates sweat secretion[13].Thus, modulation in skin conductance, referred to as electrodermal activity (EDA), is a unique parameter that reflects purely sympathetic activity [14, 15].Several cortical structures with recognized seizure potential have direct or indirect connections with autonomic centers from the medulla oblongata [16]. Studies have shown that electrical stimulation of such structures can induce changes in EDA [17, 18]. For example, stimulation of the cingulate gyrus in humans produced strong palmar skin conductance responses. Increases in skin conductance were also observed when the frontal cortex was stimulated.
As such, we decided to perform long-term monitoring of EDA activity in patients with epilepsy to investigate ictalrelated changes in sympathetic activity. Our working hypothesis was that epileptic seizures, GTCS in particular,might induce large changes in EDA reflecting strong ictal sympathetic discharges. To this end, we designed a wearable EDA sensor suitable for long-term monitoring.The Seizure Monitor Device does not have a particular client. However, the group has been interviewing extensively various doctors along with people who suffer seizures to get a better idea as to how do go about creating the Seizure Monitor Device. The group felt it was important to both cater the project to the needs of patients who suffer from seizures and

also to get the input of experts. Creating a project with advice from these individuals will hopefully lead to a better device for potential clients.

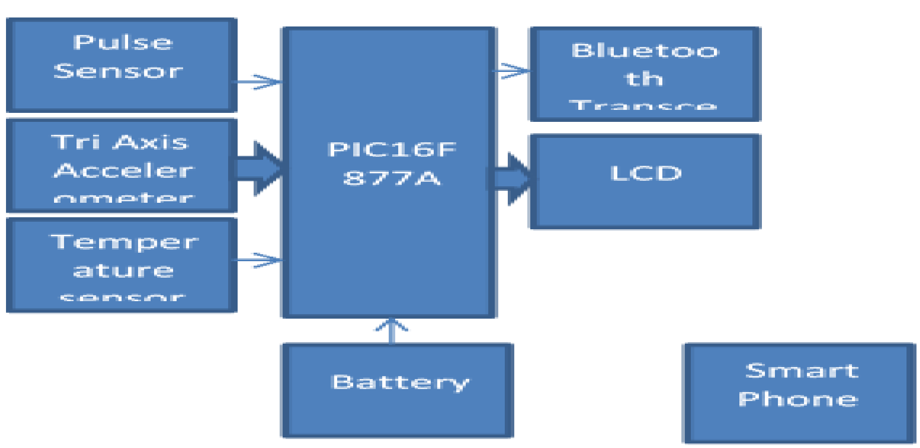
II. LITERATURE SURVEY

Implantable seizure monitor (United States Patent Application 20100210964) was a patent aimed at detecting seizure monitors. This is an implantable seizure monitor that can include at least one sensing electrode and an electronics module configured to detect, record and/or log neurological events. For example, the electronics module can be configured to detect brainwaves indicative of seizures, such as, for example, epileptic seizures, and to create a log indicating when such seizures occur. The implantable seizure monitor can include a cushioning member made of a soft material and configured to be implantable between the epidermis and cranium of a patient. Another patent is the Brain Signal Telemetry and Seizure Prediction (Pub. No US 2008/0077039 A1). This patent details an ambulatory intrinsic brain signal processor circuit which is coupled to many different electrodes placed on different regions of the brain. The electrodes, in conjunction with a digital multiplexer, feed data wirelessly to and from a remote transceiver. There is a controller that allows the user to decide: which of the electrodes contribute data, the resolution of that data, and whether the data includes one or both of the neural action and local field potential data. Correct placement of the electrodes can help predict seizures.At present, ambulatory EDA devices are often composed of a processing unit/analog-todigital converter (A-D) and external probes that reduce comfort levels. Commercial sensor systems at the time this work began included FlexComp [187], SenseWear [24], QPET [29] and Vitaport [184]; they offer high quality EDA recordings but their current bulky form factors and high prices limit their widespread use for long-term ambulatory studies. Similarly, Tronstad et al. [192] proposed a portable logger for EDA long-term measurements, but its size is still considerably too large (157 × 95 × 33 mm) to be practical for continuous monitoring or to be considered a wearable device. In other designs [12,100], the placement of electrodes on the fingers or palms is encumbering and highly susceptible to motion or pressure artifacts [147]. A recent proposal to measure EDA unobtrusively through imaging means [161] offers much promise, but the measurements carry substantial noise and quantification remains difficult.Over the years, the Affective Computing group has devoted much effort into developing wearable EDA sensors suitable for ambulatory measurements resulting in the Galvactivator [140], HandWave [173] and iCalm sensors [57,64]. The most recent iCalm design was a low-power wireless EDA sensor using the IEEE 802.15.4 wireless standard and represented a significant advancement. However, there were several drawbacks to the capabilities of the system that made it unsatisfactory for long-term clinical studies. Firstly, the iCalm relied entirely on a radio module for data forwarding to a base station (typically a laptop). This constrained users to staying within the wireless range of a base station and resulted in frequent loss of data due to dropped radio packets. In clinical studies of rare and unpredictable events such as epileptic seizures, it is necessary to have continuous measurements available round-the-clock. Moreover, the timing information of the recorded signals in the original iCalm were based on time stamps generated by the base station which was unreliable due to unpredictable radio transmission latency. Since the iCalm only contained an analog vibration/tilt sensor, it was not suitable for precise measurements of motor activity in three axes. To enable a very low-operational duty cycle and long battery life, the iCalm transmitted data at a low rate of 2 Hz, which is inadequate for measurement of rapid events. Another challenge in the design of wearable sensors is robustness and durability. The construction of the iCalm was not robust enough for unsupervised and continuous use over long periods of time. Furthermore, the sensor unit and connecting wires were not concealed and these could act as distractions.

III. EXISTING METHOD

Currently, there have not been any previous Seizure Monitor Device created by UConn students. However, the idea of the Seizure Monitor Device came from a senior design project from Rochester Institute of Technology. The main goal of their project was to develop and validate a motion data collection system. This essentially would track when the person was having a seizure and record the time and duration of on a computer. This was communicated to the computer using an existing modified wireless communication system. The FSI evaluation kit included an accelerometer data collector, which was used as the motion monitoring device, and a data concentrator module, which was used as the base device. Their data concentrator module was capable of receiving data from up to 16 accelerometer data collectors. Upon activation, the motion monitoring devices will continuously transmit motion data, via a ZigBee network, to the base unit. The base unit then transmits the data via an Ethernet (UDP) connection to a personal computer that will collect the data.There are a few products currently available that are similar our proposed seizure monitor. The first one is the Medpage ST-2. The Medpage ST-2 is a monitor designed to detect and raise an alarm from a sleeping person experiencing regular muscular convulsions such as an epileptic seizure or convulsions caused by hypoglycemia in a diabetic person. The ST-2 monitor provides dual detection functionality, seizure monitoring and bed occupancy detection. A sensor is placed under the user's mattress, bed or cot.During sleep movements from the patient are monitored by the ST-2microprocessor.Prolonged irregular movements result in an alarm being generated by the monitor with a signal transmitted to the alarm pager or other alarm in use with the ST-2 monitor. The transmitter also has a call button and a socket that allows connection similar to a standard hospital nurse call switch. The transmitter also has some specialized easy operation switches for the physically disabled. Finally, it has built in tone alarms that can be set to produce a sound alarm when a bed seizure monitor has detected a seizure or the person leaving their bed. Another product is the MP5 - Complete System - Bed Motion Alarm for convulsive movement such as Epilepsy Seizures. This system works by detecting shaking or jerking movements such as those encountered during convulsive seizures as well as sounds/noises. It will not detect mild seizures, and should not be used for people under 56lbs. However, if the mattress is thick, or the bed is large, the user would need to use two sensors to offer the same system features and functions. The system is set up by placing the sensors between the mattress and box spring. It is essential that the box spring be under the heaviest part of the user's body. From there, the pagers are turned on and given to the care takers and the sensitivity controls set. The bed monitor communicates with the wireless pagers up to a distance of approximately 328 feet.Another product is the Emfit Nocturnal Tonic-Clonic Seizure Monitor. The Emfit Movement monitor consists of a flexible and durable bed sensor (L-4060SL), which is placed under the mattress, and a bed-side monitor (D-2090-2G). The Movement Monitor detects when a person has continuous quick-paced movements over a preset period of time and then triggers a notification. The system also notices light movements, thus making it equally suitable for small children. The control unit can be placed next to the bed or on the wall using the included fastening bracket. It is operated with 2 standard AA size 1.5 V batteries.

IV. BLOCK DIAGRAM



4.1.PIC MICROCONTROLLER

Microchip provides a waste verity of Microcontrollers from PIC family. Each MCU has its own advantage and disadvantage. There are many parameters that one has to consider before selecting a MCU for his project. The below points are just suggestions which might help one to select a MCU.

- If you are a beginner who is learning PIC then, selecting a MCU that has good online community support and wide applications will be a good choice. PIC16F877A and PIC18F4520 are two such MCUs
- Consider the operating voltage of your system. If they are 5V then select a 5V MCU some sensors or devices work and communicate on 3.3V in such case a 3.3V MCU can be selected
- If size and price is a limitation then you can choose small 8-pin MCUs like PIC12F508. These are also comparatively cheaper.
- Based on the sensors and actuators used in your project, verify which modules you might need in for MCU. For example is you are reading many Analog voltages then make sure PIC has enough ADC channels and supportive resolution. The details of all modules are given in the table above.
- If you project involves communication protocols like UART, SPI ,I2C, CAN etc make sure you PIC can support them. Some MCU can support more than one module of the same protocol

Fig:4.1 (a)

One of the most useful features of a PIC microcontroller is that you can re-program them as they use flash memory. You can also use the ICSP serial interface built into each PIC Microcontroller for programming and even do programming while it's still plugged into the circuit. You can either program a PIC microcontroller using assembler or a high level language and I recommend using a high level language such as C as it is much easier to use (after an initial learning curve). Once you have learned the high level language you are not forced to use the same processor e.g. you could go to an AVR or Dallas microcontroller and still use the same high level language.

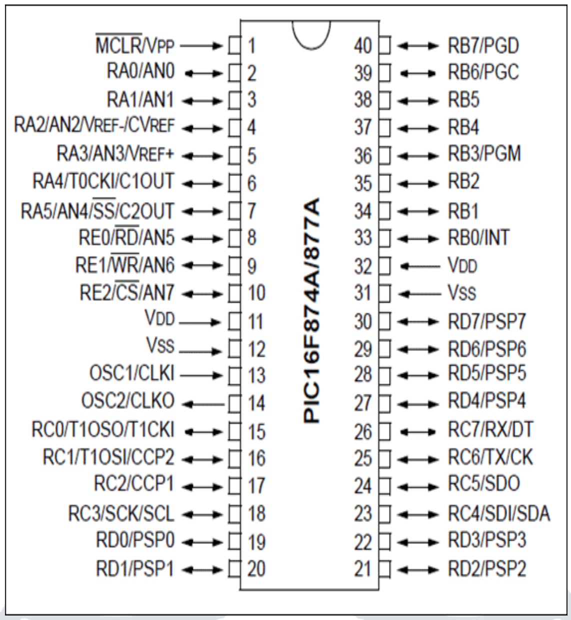


Fig:4.2 (b) Pin Diagram

4.2.1Applications

- Multiple DIY Projects
- Very good choice if you are learning PIC
- Projects requiring Multiple I/O interfaces and communications

4.3 LCD

LCD (Liquid Crystal Display) screen is an electronic display module and find a wide range of applications. A 16x2 LCD display is very basic module and is very commonly used in various devices and circuits. These modules are preferred over seven segments and other multi segment LEDs. The reasons being: LCDs are economical; easily programmable; have no limitation of displaying special & even custom characters (unlike in seven segments), animations and so on.

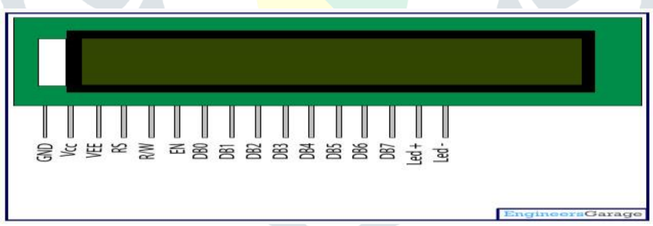


Fig:4.3 (a)

Fig :4.3 (b)

A 16x2 LCD means it can display 16 characters per line and there are 2 such lines. In this LCD each character is displayed in 5x7 pixel matrix. This LCD has two registers, namely, Command and Data.The command register stores the command instructions given to the LCD. A command is an instruction given to LCD to do a predefined task like initializing it, clearing its screen, setting the cursor position, controlling display etc. The data register stores the data to be displayed on the LCD. The data is the ASCII value of the character to be displayed on the LCD. Click to learn more about internal structure of a LCD.

4.4.BLUETOOTH

HC-05 module is an easy to use the Bluetooth SPP (Serial Port Protocol) module, designed for transparent wireless serial connection setup. Bluetooth module is fully qualified Bluetooth V2. 0+EDR (Enhanced Data Rate) 3Mbps Modulation with complete 2.4GHz radio transceiver and baseband. It uses CSR Bluecore 04-External single chip Bluetooth system with CMOS technology and with AFH (Adaptive Frequency Hopping Feature). HC-05 Bluetooth Module is one of the most popular Bluetooth module used in embedded projects. It can be easily interfaced with Arduino Board, Raspberry Pi, Microcontrollers through serial UART interface. HC-05 module is an easy to use Bluetooth SPP (Serial Port Protocol) module, designed for transparent wireless serial connection setup.

4.5.THERMISTOR

A **thermistor** is a type of resistor whose resistance varies significantly with temperature, more so than in standard resistors. Thermistors are widely used as inrush current limiter, temperature sensors self-resetting over current protectors, and self-regulating elements.

Thermistors differ from resistance temperature detectors (RTDs) in that the material used in a thermistor is generally a ceramic or polymer, while RTDs use pure metals. The temperature response is also different; RTDs are useful over larger temperature ranges, while thermistors typically achieve a higher precision within a limited temperature range, typically −90 °C to 130 °C.

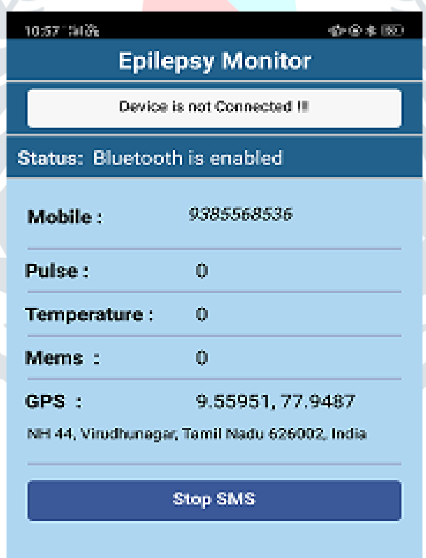
Thermistors are inexpensive, easily-obtainable temperature sensors. They are easy to use and adaptable. Circuits with thermistors can have reasonable outout voltages not the millivolt outputs thermocouples have. Because of these qualities, thermistors are widely used for simple temperature measurements. They're not used for high temperatures, but in the temperature ranges where they work they are widely used.

Thermistors are temperature sensitive resistors. All resistors vary with temperature, but thermistors are constructed of semiconductor material with a resistivity that is especially sensitive to temperature. However, unlike most other resistive devices, the resistance of a thermistor decreases with increasing temperature. That's due to the properties of the semiconductor material that the thermistor is made from.

V. RESULT AND DISCUSSION

- our propsed project display the details about the patient like temperature, pulse , hand movement and sound detection.
- The result shows daywise report and can be recorded on things speak.

5.1. Control App



VI. CONCULSION

In this paper, the design of flexible, low-power and wireless sensor nodes has been presented. The sensor nodes are equipped with a 3D accelerometer, an ultralow-power microcontroller and an RF transceiver, allowing for full 3D orientation tracking. Careful implementation of the functionality and maximal use of the low-power modes, has resulted in an average current consumption of less than 3 mA for each node. A TDMA-like protocol allows 10 nodes to transmit data wirelessly at a rate of 100 Hz to a single receiver. The communication protocol still exhibits a weak spot which can mainly be attributed to the synchronization with the master. If the master would malfunction, all slaves would be numbed and the system would no longer work. A more improved version of the protocol in which this problem is avoided, is currently the subject of further work. In an inpatient study, data logged to an online database automatically by an accelerometer provided more detailed and accurate data than did caregiver self-reports or a paper diary. The automated diaries generated by accelerometers are subject to occasional technical and user-induced failures, and do not currently detect seizures lacking rhythmical shaking.

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