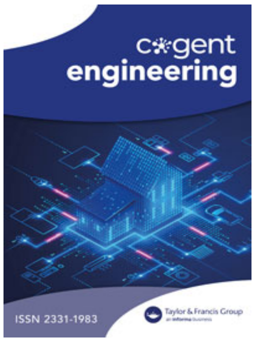

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Minimizing regain awareness time of the epileptic patient using a well-known phone ringtone

Nabeel Abdulrazzaq Fattah[123*]

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*Corresponding author: Nabeel Abdulrazzaq Fattah, College of Medicine, Hawler Medical University, 11/137 Ozal City, Erbil, Kasnazan, Iraq
E-mail: Nabeel.fattah@hmu.edu.krd

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Abstract: More than 65 million people worldwide are affected by epilepsy. There are numerous techniques to assist epileptics. The primary danger to their lives, however, is unconsciousness and convulsions. Novel techniques for shortening the time it takes to regain awareness are given in this research. This is accomplished by programming and fabricating the ARM Cortex M4F LPC4330 microcontroller in a six-layer printed circuit board (PCB) capable of detecting an early epileptic seizure. The suggested system gets real-time signals from two electrodes attached to the head. When the system detects seizures, it activates and broadcasts a familiar smartphones ringtone to the patient's earphone. In vivo test was effective, and the outcome was as expected. The average time for regaining a 22 years old patient was reduced from several minutes to 24 seconds.

Subjects: Biomedical Engineering; Electrical & Electronic Engineering; Technology; Health Conditions

Keywords: Epilepsy; awareness time; biomedical engineering; unconscious time

1. Introduction

Three diagnostic levels were established by the 2017 International League Against Epilepsy (ILAE) Classification of the Epilepsies, comprising (1) seizure type, (2) epilepsy type, and (3) epilepsy

Nabeel Abdulrazzaq Fattah

ABOUT THE AUTHOR

Nabeel Abdulrazzaq Fattah received his PhD in Biomedical Engineering from Newcastle University's School of Electrical and Electrical Engineering. He was focusing on recovering sight through the visual cortex, and he has developed the system for this purpose. A complicated PCB for data and power in the receiver end as an implant device was designed and manufactured as part of his system. That was a high-performance Quadro core electrical system designed for image processing. His innovative concept is the first fully functional mechanism for recovering sight. He also founded the OptoVis research group in the United Kingdom. He is now enrolled in the college of medicine at Hawler Medical University. His scientific interests are sight restoration, epilepsy, image processing, and active medical implant devices in general.

PUBLIC INTEREST STATEMENT

People suffering from epilepsy frequently face changes in their quality of life, such as decreased mobility, as well as effects on learning, school attendance, work, relationships, and social interactions. One in every ten persons will experience a seizure throughout their lifetime, and one in every 26 will be diagnosed with epilepsy. Seizures can last anywhere from a few seconds to many minutes. They can present with a variety of symptoms, ranging from convulsions and loss of consciousness to more modest signs such as blank gazing, lip smacking, or jerking motions of the arms and legs. This approach will motivate them to improve their life quality and engage and interact with people more than they have in the past. They will be more confident in themselves and their everyday routines. This will be my first step for helping people with epilepsy, the next step we wish more success.

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syndrome, with the emphasis that etiology and comorbidities must be taken into account at each level. The ILAE defined an epilepsy syndrome as "a characteristic cluster of clinical and EEG features, often supported by specific etiological findings (structural, genetic, metabolic, immune, and infectious)" (Wirrell et al., 2022).

Epilepsy is a disorder of the central nervous system, which regulates the behaviors of the brain by sending and receiving data from the central nervous system (Smithson & Walker, 2012). Electrical activity disturbances in the central nervous system induce seizures. Epilepsy can have an effect on both voluntary and involuntary nervous system functions (Miller & Goodkin, 2014). Epilepsy is a chronic neurological disorder marked by recurrent, uncontrollable seizures. A seizure is a sudden burst of electrical activity in the brain. It affects 65 million individuals worldwide (Razavi & Fisher, 2017).

Seizures are classified into two types. Epileptic seizures are seizures that affect the entire brain. A focal seizure, also known as a partial seizure, affects only one section of the brain (Monteiro et al., 2019). Minor seizures might be hard to detect. It may only take a few seconds and you will be completely unaware of it (Thijs et al., 2019). Seizures that are much more serious might cause muscle spasms and involuntary twitches that can last from a few seconds to a few minutes (Lasefr et al., 2017). Following a more severe seizures, many patients get confused or lose consciousness (Cascino & Sirven, 2011).

Epilepsy can attack anyone, but it is more common in children and the elderly. Men are slightly more affected than women (Asadi-Pooya & Farazdaghi, 2021). Although there is no cure for epilepsy, it can be managed with medications as well as other treatments. The majority of people might manage their epilepsy. The severity of your symptoms, your overall health, and how well you respond to therapy will all influence your treatment (Alarcón & Valentín, 2012).

Some treatment options are as follows: First, anti-epileptic (anticonvulsant, antiseizure) medications: These medications can assist you in having fewer seizures. Seizures appear to be a thing of the past for many people. To be effective, the medication should always be considered medication as prescribed. Second, a vagus nerve stimulator is a device that is surgically implanted beneath the surface of the chest and electrically stimulates the nerve that runs via their neck (Sopic et al., 2018). This could help with seizure prevention. Third, the ketogenic diet: Such a high-fat, low-carbohydrate diet helps more than half of those who do not respond to the medication. Finally, the region of the brain that causes seizure activity can be removed or altered surgically (Pack, 2019).

Deep brain stimulation, according to scientists, is a therapeutic option that has recently become available (Pack, 2019). Electrodes are implanted elsewhere in brain throughout that surgical procedure. After that, a device is implanted in the chest. To help reduce convulsions, the generator sends electrical signals to the brain (McIntyre et al., 2015). A pacemaker-like hardware is another field of study. It would examine the pattern of brain activity and deliver an electrical charge or medicine to stop a seizure.

A new successful technique for identifying and controlling seizures is presented in this study. This is accomplished by patching electrodes on the head outside the auditory cortex region to detect abrupt pulses. A six-layer printed circuit board then controls the seizure. The control unit will play a well-known mobile ringtone to which the user is already accustomed. The victim will be unconscious for a shorter period of time than usual, and they will wake up sooner.

2. System specification

The system's primary function is to detect and control seizures. The system diagram is shown in Figure Figure 1. The electrode attached to the head detects spikes and changes in brain activity.

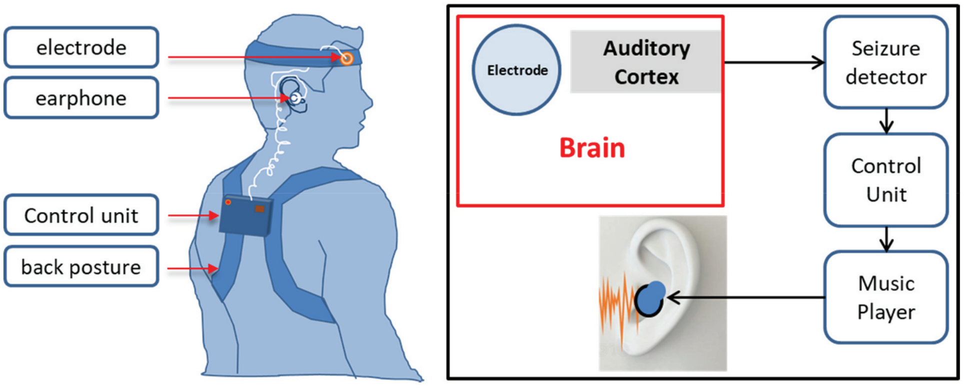


Figure 1. System schematic for seizure control including the implantable electrode.

The detected pulses are processed by the controlling system, which then begins playing the ringtone set by the user after analysing the pulses.

The seizure detection, control unit, and music player are all housed on a single PCB. The microcontroller was then programmed to distinguish epilepsy seizures occurring in the auditory area of the brain.

2.1. Hardware design

The architecture of the control unit: The unit's PCB was designed and manufactured using NI Circuit Design 13.0 and Altium Designer 16.1.12 as shown in Figure Figure 2. The board weighs 4.6 g and has a diameter of 30 mm. All of the circuits were combined into a single coin-sized printed circuit board layout (PCB). For the AC to DC converter, a bridge rectifier was used. The output voltages were regulated using the LT1763CDE–3.3 and LT1763CDE–5.0. The implant device was controlled by an ARM Cortex M4 LPC4330 TFBGA100 dual-core microcontroller (Abuimara, 2015)–(Liu et al., 2019).

The ARM Cortex M4F LPC4330 model was chosen for its efficiency, small size, and low power consumption. It has an ARM M0 coprocessor. It is a central processing unit (CPU) that can run at speeds of up to 204 MHz. The LPC4330 is a 32-bit microcontroller. It has a low power consumption, improved debug features, a high level of block integration, on-chip memory up to 264 kB, and DSP (DSP). It supports floating points, which is critical for our image processing project. It can be programmed as a dual-core M4 and M0 for data control. The Internal RC oscillator (IRC) has

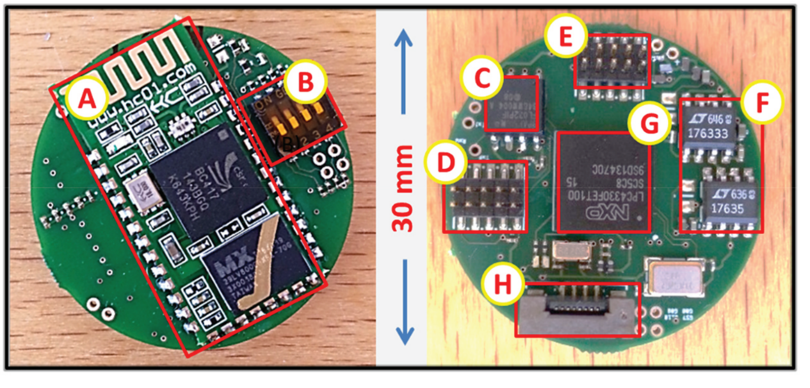


Figure 2. The control system printed circuit board. It includes the (A) Bluetooth module (B) Switch to select the booting options (C) External flash memory (D) Serial Peripheral Interface header (E) Joint Test Action Group (JTAG) interface connection port (F) the 3.3 V and 5 V voltage regulators (G) Dual-core LPC43xx series microcontroller (H) Ribbon cable header for external devices.

a frequency of 12 MHz and an accuracy of 1.5 percent that varies with temperature and voltage. It has one Fast-mode Plus I2C-bus interface and can support data rates of up to 1 Mbit/s.

The power management system was meticulously designed and simulated to provide dual fixed output voltages. First, an AC signal has been converted to DC using a full-wave rectifier, and then the output voltage was regulated. The fixed output voltage is provided by the LT1763CDE–3.3 and LT1763CDE–5.0. The 3.3 V output voltage powers the microcontroller, flash memory, and Bluetooth module, while the 5 V voltage powers external devices like the iPod music player.

2.2. Software programming

The C++ was used to program the frequency of normal activities and epilepsy seizures. The Kinetis® Design Studio (KDS) is used to program the microcontroller to detect incoming pulses every 5 seconds.

2.3. The patient

After going unconscious for two to five minutes, feeling dizzy, and experiencing blurred vision, A young male university student 22-year-old who had undergone an episode of absence seizures, was taken in for routine medical care. The patient asserted that the giddiness persisted even after returning to consciousness following a brief period of unconsciousness. The patient had a few involuntary movements but no other symptoms, like nausea, palpitations, headaches, fevers, or incontinence of the urine.

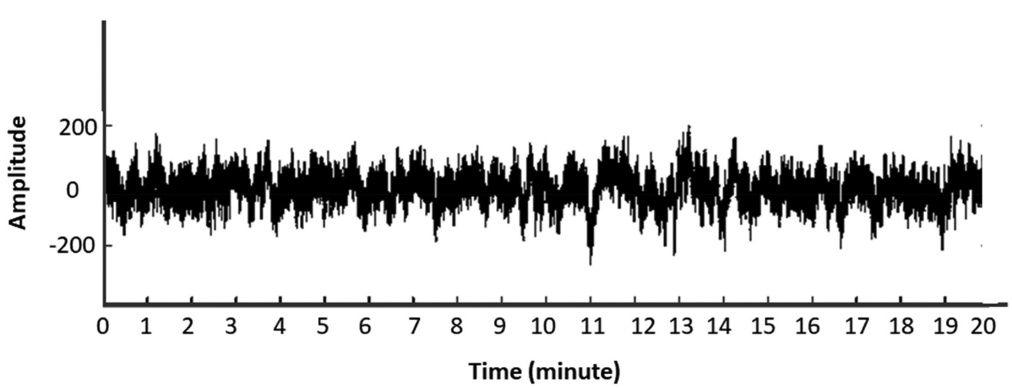
3. System setup

Two electrodes were attached to the head of a volunteer in order to record normal brain activity. The C++ code is used to program the microcontroller to record neural activity. A volunteer with no epilepsy had normal brain activity recorded as shown in Figure Figure 3. The minimum and maximum amplitudes were both around 200 µV. The recording estimated time was approximately 20 minutes. This test was repeated several times to ensure accuracy.

The system then looked for a second volunteer who had epilepsy. After converting the data to a plot, there were some sharp peaks that appeared in the test. The individual was well-known and was receiving epilepsy medication. The epileptic patient will be subjected to an EEG test is shown in Figure Figure 4. This examination was conducted at Erbil Teaching Hospital.

Dealing with brain activity is a bit difficult when it comes to predicting seizure tasks. Designing and manufacturing an electro-stimulation system for an epileptic patient is a critical challenge. The prediction setting for approaching real-time performance is accomplished by combining two strategies. The first one involves the addition of two-level filters for incoming values above a certain threshold 200 µV and below −200 µV as shown in Figure Figure 5.

Figure 3. Normal brain activity the pulses was between −200 µV to 200 µV.



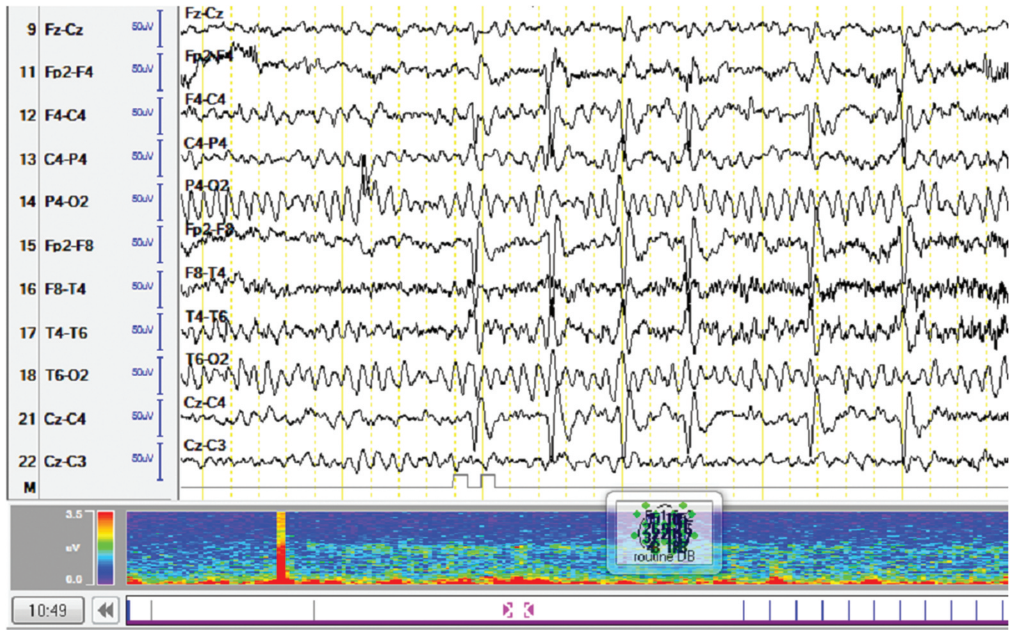


Figure 4. The EEG test for the epileptic patient in Erbil teaching hospital.

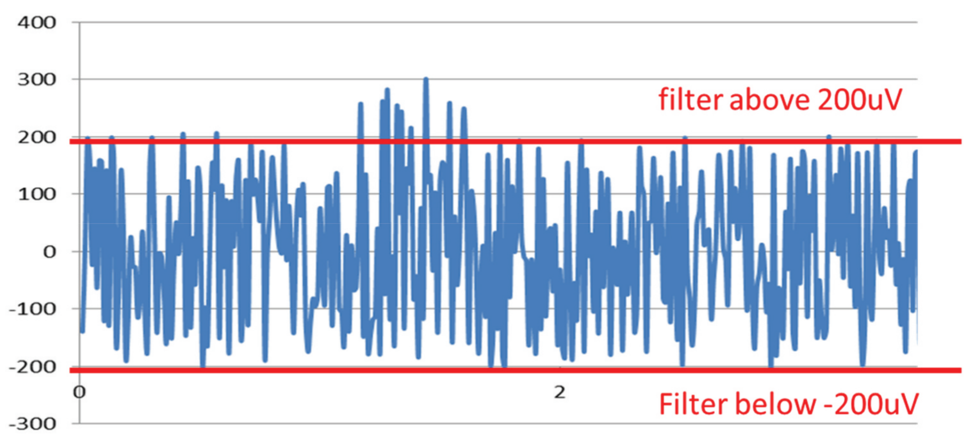


Figure 5. Adding two filters for real-time data for monitoring seizures.

The two filters were applied to real-time data. The first is for real-time numbers above 200 μV, and the second is for real-time numbers below −200 μV. The program is set to notify for incoming seizure activity if there are a few continuous numbers above or below 200 μV. In order to distinguish between sharp and wide seizures, the delay time between every number is also taken into account.

4. Result and discussion

The system is tested on a 22-year-old male who suffers from epilepsy. In the auditory area of his head, two electrodes are attached. The headphone is plugged into his ear and then into the system. The well-known ringtone is saved to the microcontroller's external memory. The detected pulses are shown in Figure Figure 6 for the real-time data received from the electrodes.

The entire system is shown in Figure Figure 1. The volunteer patient went into a typical state of unconsciousness and convulsions after such a seizure, and he remained unconscious for several minutes as his brain recovered from the status epilepticus. He appears to be sleeping or snoring.

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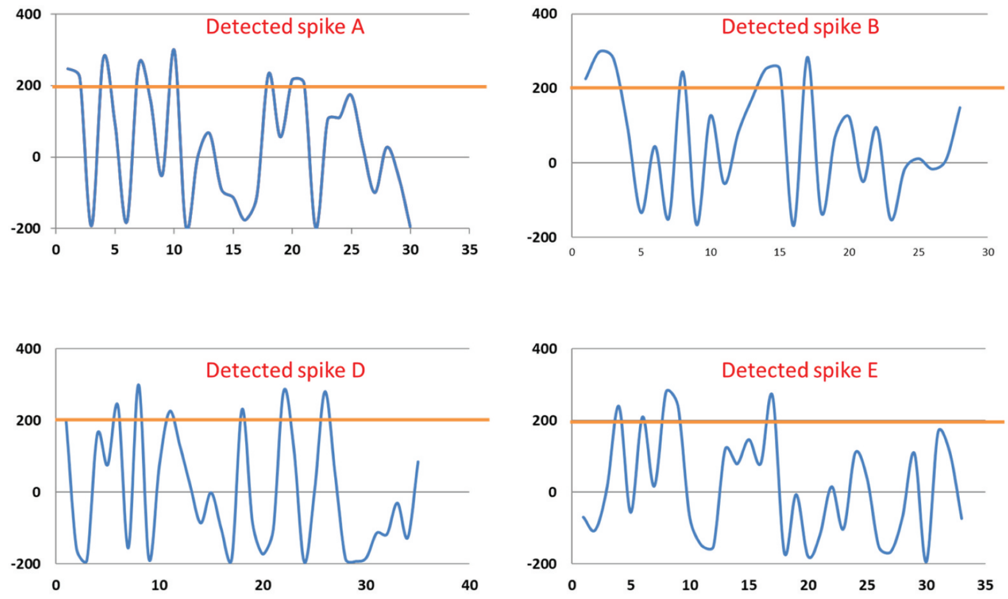

Figure 6. Detecting spikes from real-time raw data.

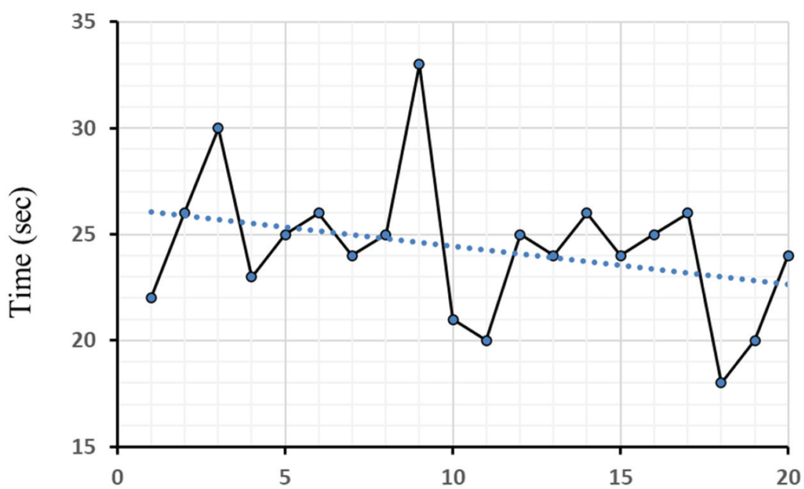

Figure 7. Recovering time in second of the volunteer after the seizure.

He gradually regains consciousness, but he may feel confused, tired, physically sore, depressed, or embarrassed for a few hours. However, once we implemented the system, we discovered that the patient recovered fully only after 24 seconds on average, despite the fact that cell phone ringtones had been playing continuously since the seizure began. This test was repeated several times over the course of a few days. It indicates that the volunteer engaged on the system for more than seven hours in it for at least two weeks. The patient's frequent recovery time is shown in Figure Figure 7. It is clear that the patient's awake regain time has also improved.

5. Conclusion

In this study, it was discovered that utilizing a well-known phone ringtone can dramatically reduce the epileptic patient's regain time of awareness. This may only help for seizures that originate in the auditory cortex portion of the brain. The length of time it took for the recovery to improve was significant. We were able to assist a patient in waking up in less than 30 seconds, compared to his usual recovery time of several minutes.

Author details
Nabeel Abdulrazzaq Fattah[1][2][3]
E-mail: Nabeel.fattah@hmu.edu.krd
ORCID ID: http://orcid.org/0000-0002-2805-6933
[1] College of Medicine, Hawler Medical University, Erbil, Iraq.
[2] Pharmacy Faculty, Tishik International University, Erbil, Iraq.
[3] School of EEE, Newcastle University, Newcastle Upon Tyne, UK.

Disclosure statement
No potential conflict of interest was reported by the author.

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