

# **Project Proposal**

## **EpiCap - a wearable EEG**

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# Introduction

## *Problem Statement*

Electroencephalograms (EEGs) are procedures that measure electrical activity at the very perimeter of the brain. Physicians use the results of these tests to diagnose and determine courses of treatment for abnormal brain behavior, such as epilepsy. A typical EEG test, however, presents difficulties to the patient and physician. Patients can be admitted to a hospital, occupying an inpatient bed, while sleep deprived and off medication, in hopes a seizure occurs and can be assessed. Ambulatory options exist, where patients are sent home with equipment, and are tasked with wearing a very visible net of electrodes, a head stocking that protects the electrodes and their leads, and the measurement is performed by a device which fits in a fanny pack.

Both of these tests have a very high likelihood of failure, and patients are forced to hold off on other important tasks. Patients still have seizures, though, and have associated them with the stress of these day-to-day tasks that they must exclude themselves from when getting an EEG. This complicates the so-called "sample rate" a physician requires to determine what kind of activity is occurring, whether to titrate medication, or pursue a different therapy altogether. This hurdle has led to rising costs associated with epilepsy without any appreciable change in outcomes in nearly 30 years.

## *Solution*

If the present ambulatory technology was further miniaturized, we can create a device as discreet as a baseball cap that allows the wearer to carry on about their day while remaining monitored for activity. A device such as this would eliminate the odd "nightcap" of present ambulatory systems and draw less attention in public. People at work, where many feel most at risk, would be able to at least capture an event were it to occur. Children who are suspected or diagnosed with the condition can wear something that doesn't interfere with their self-esteem or most daily activities.

We propose an ambulatory EEG that can monitor patients, come off standby when an event is occurring, and measure brain activity while also utilizing a camera to further record muscle activity (or inactivity), essential data to arrive at a diagnosis and severity of an event. Moreover, the device will include on-board storage, as well as GSM connectivity, to alert patient contacts or even emergency services of an event. We can then use the onboard SD card to have the data be viewed on a physician's PC. The following are the goals, benefits, and high level requirements for the proposed EEG device:

1. Goals
  - a. A discrete ambulatory EEG device that helps monitor patients by detecting seizures.

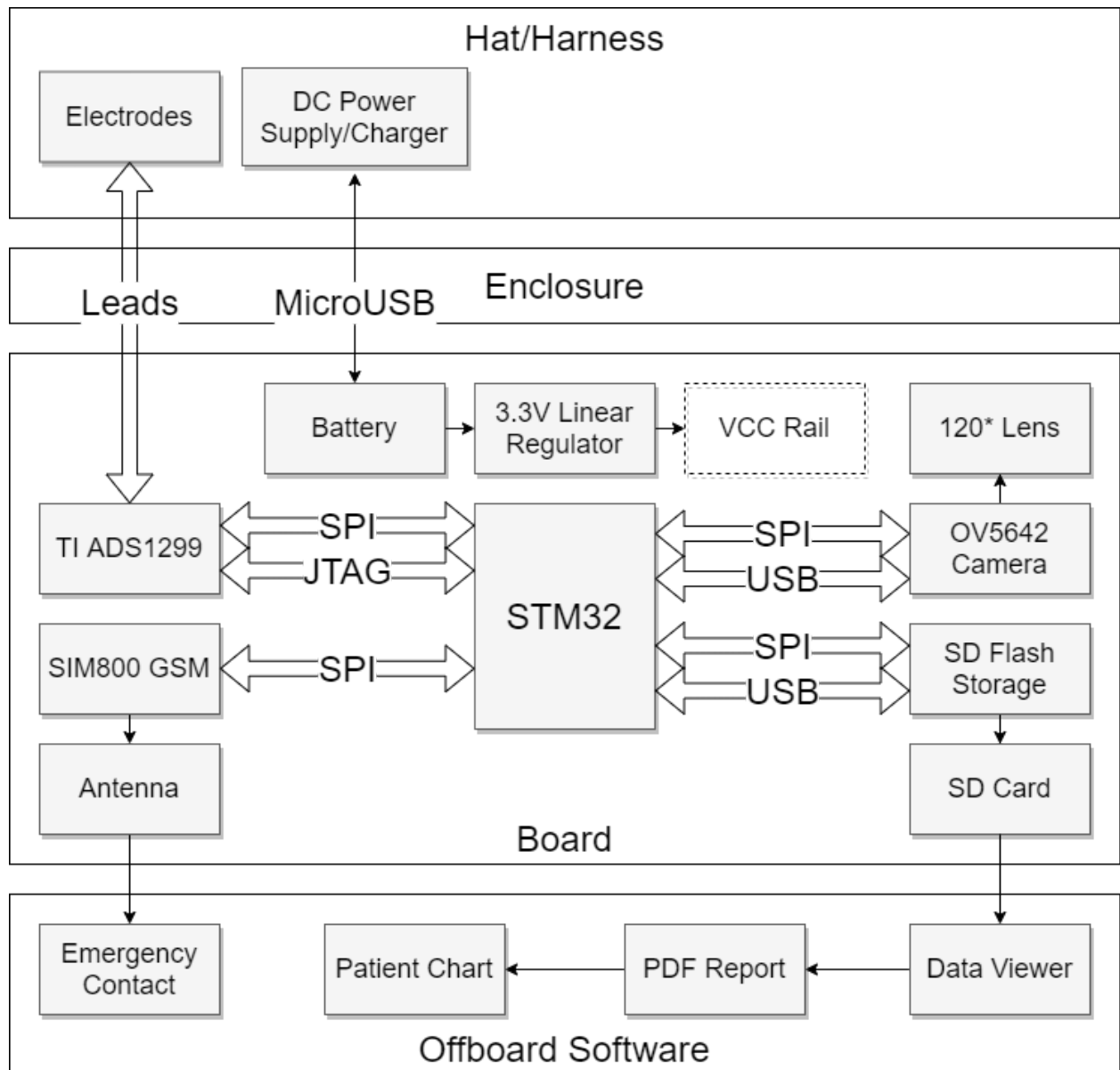
- b. Provide physicians with patient's medical data (EEG and camera footage) collected during wear time.
- 2. Benefits
  - a. Allows patients to go about his/her daily routine without attracting additional attention when wearing the EEG cap in public, while also being comfortable.
  - b. Allows physicians to analyze important medical data of seizure events while avoiding occupation of an inpatient bed and use of hospital equipment.
  - c. Ensure patient's safety by informing his/her emergency contacts in the case of a seizure event.
- 3. High Level Requirements
  - a. The EEG cap must be discreet and all the main devices components must be within the cap and cap visor.
  - b. Collect EEG data at 240 Hz sampling rate for 30 mins to a span of days and be able to store on the flash storage.
  - c. The EEG cap must include a 3.3V battery source that produces minimal noise to not interfere with data signals to allow accurate data transfer.
  - d. The EEG cap must include a wide-angle camera (minimum 240p) that will be located in the cap visor to capture the patient's eye and arm movements.

### *Visual Aid*



# Design

## Block Diagram



## *Design Specifications*

### 1. Battery

- a. Battery, chosen to be delivering 7200mAh or more, provides the main source of power to the SoC (system on chip).
- b. *Requirement 1: Supply a constant 3.3V to the SoC for more than 24 hours without recharging.*
- c. *Requirement 2: Battery must provide us with reasonably low noise ( $< \mu V$ ).*
- d. *Requirement 3: Battery must be mechanically enclosed and readily rechargeable, and not provide too much weight or bulk to the whole device.*

### 2. Electrodes

- a. Dry electrodes, attached to the cap, collect EEG data from the patient's scalp.
- b. *Requirement 1: Electrodes must be dry and remain in contact with the scalp in the event of a seizure.*
- c. *Requirement 2: Hat must remain snug and fixed to the wearer's hat in the event of a seizure/fall.*
- d. *Requirement 3: Electrodes, hat, and liner must be readily adapted to different ball caps and different sizes for wearers.*
- e. *Requirement 4: Minimum of 10 dry electrodes would be acquiring EEG data.*

### 3. SoC (System on Chip) /STM32 MCU [2]

- a. SoC manages the SPIs for GSM (global system for mobile), camera, flash storage, and the ADC (analog to digital) converter.
- b. SoC will include STM32 IC, for communicating and controlling with other subsystems.
- c. *Requirement 1: SoC must expose an SPI bus for peripherals as well as GPIO.*
- d. *Requirement 2: SoC must be able to handle monitoring the wearer on standby while also detecting and recording data off standby.*
- e. *Requirement 3: SoC must be capable of handling video and EEG traces and saving them to onboard storage, simultaneously.*

#### 4. ADC

- a. Analog to digital converter, chosen to be TI ADS1299 (8-channel) , will be used to convert and sample the EEG data to store on the flash storage.
- b. *Requirement 1: Must be isolated in order to not pick up any external signals from other peripherals on the board*
- c. *Must sample at 240Hz during events, but sample at a lower rate on standby*

#### 5. Onboard storage

- a. Onboard storage (flash storage) is used to store EEG data and camera footage during a seizure event; provided as a tool for physicians to analyze.
- b. *Requirement 1: Our storage must be able to hold both ~1GB of video data and the ~20MB of EEG traces recorded during an event.*
- c. *Requirement 2: Our storage must be easily removable by a physician and read on a computer in a presentable, publishable fashion.*
- d. *Requirement 3: Our storage and app interface must allow for the physician to configure some patient data, like emergency contacts, that can be later used by our device.*

#### 6. GSM/SIM800 [3]

- a. A GSM chip and SIM card to send emergency messages to the wearer's emergency contacts.
- b. *Requirement 1: The board antenna must have a reasonable range and be able to quickly send an alert in the event of a seizure.*
- c. *Requirement 2: The wireless subsystem must not create crosstalk with the leads of the EEG.*

#### 7. Camera

- a. Camera will be utilized to capture the patient's eye and arm movements during a seizure event.
- b. *Requirement 1: A camera with reasonable fidelity, minimum 240p and 60fps, that can record the eye and limb movements of a patient during an event.*
- c. *Requirement 2: Camera that draws minimal power (sub 50mA) and can save a reasonable amount of footage (~5mins) at the time an event is detected.*
- d. *Requirement 3: Camera that is small (less than a centimeter) and provides a wide angle to cover both the patient's face and limbs.*
- e. *Requirement 4: Need to mount the camera at a reasonable angle to capture both limb movement and eye movement.*

## **Tolerance Analysis**

We think the most risky scenario of our project is when the patient falls. How can our cap ensure that it stays on the patient's head and captures important information like EEG well? In fact, to solve this problem, we do not need to think about it complicatedly. For example, we can adjust the gap between the cap and the patient's head by using one of the most common ways of fixing an ordinary cap: an elastic strap, which can better keep the cap on the patient's head steadily and capture important EEG information in such a dangerous scenario.

## **Ethical Considerations and Safety**

We must have due diligence presenting this device as a medical product prototype. This device will not be fully vetted to use as a clinically valid EEG at the end of the semester.

We must make sure that the patient information collected can only be accessed by the doctor and is kept absolutely confidential to the outside visitors.

We must also be vigilant of the battery and board presenting no hazard to the wearer, in the event of high heat, moisture, and any sort of mechanical shock. We must ensure our harness keeps the hat on the wearer's head without presenting too much friction or discomfort for the wearer, and we must also take precaution that our device does not create more danger for a patient in the event of a fall.

We do not have any conflicts of interest with the work we are involved with. We must do our best to cite and license all the technology we create correctly, in line with the work already present with OpenBCI and various other ambulatory EEG devices. We must not plagiarize or borrow heavily from these references, but instead present novel work with layouts in line with the reference designs in our device's appnotes.

## References

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