HACKEAM '18

Cost-free Therapies and Remote Patient Monitoring Using IoT and Mobile

CODE SOCIAL

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Introduction

Free, effective, fully-automatic and scalable. — *Our design mantra*

Rehabilitation of PTSD and motor impaired patients is heavily dependent on follow up therapies. While a PTSD patient goes through several psychotherapy sessions, a motor impaired patient takes up many physiotherapy sessions during their recovery period. There are two major problems that come in the way of a patient being able to take up therapy sessions:

- **Cost** — The average price of a physiotherapy session varies between Rs. 250 to Rs. 1500 and the same for psychotherapy is Rs. 500 to Rs. 2000. An effective and complete rehabilitation may require more than a dozen personal sessions with a doctor or medical practitioner. People from economically weaker sections of our society frequently find themselves at a disadvantage and, so, skip personal sessions to save costs.
- **Mobility** — Making it to a hospital or clinic for therapy sessions may not be possible due to a variety of reasons, such as inability to travel, distance from home or even laziness. Furthermore, medical practitioners charge extra for visiting patients personally.

Our solution addresses these problems through a system of applications that provide an effective and cost-free way of delivering professional-grade therapies to patients in the absence of a doctor, and automatically tracking their progress. It is to be noted that our solution is NOT MEANT TO 100% replace doctors and medical experts but rather aims to:

- save patients additional costs that they would otherwise spend doing follow up sessions, and
- make the entire process hassle-free and fun to improve motivation levels for taking up sessions at home.

As can be inferred, our solution is based on the assumption that the patient has had a few initial therapies during their medical treatment.

The architecture of all components of and the underlying technologies ensure that the solution is **extremely scalable**. So, although, our demonstration is based on a single patient, the exact same solution will work as-is for millions of patients.

Because therapies for the two classes of patients are entirely different — mental vs physical — we propose separate applications for both.

Software & Hardware Requirements

Hardware

- Android v5.0+ phone with front camera
- USB cable for debugging and deploying
- Raspberry Pi Zero W
- 16+ GB microSD card
- Pulse rate sensor (with ADC), or:
    - 1 x General Purpose Op Amp (MCP6002)
    - 5 x Resistors (3 x 1 MOhm, 1 x 10 kOhm, 1 x 1 kOhm)
    - 3 x Capacitors (1 x 10 nF, 1 x 560 nF)
    - 1 x Photodiode
    - 1 x IR LED
- Temperature sensor (DS18B20 wire-type)

Software

- Ionic 3 (for mobile app)
- node.js (for device app)
- Android Studio
- ssh / PuTTY
- IDE / text editor of choice
- Microsoft Azure subscription
- A pre-trained face and emotion recognition CNN

PTSD Rehabilitation App

This is a mobile app that provides real-world psychotherapies, recommended by top psychologists, and assess a patient's progress after each session.

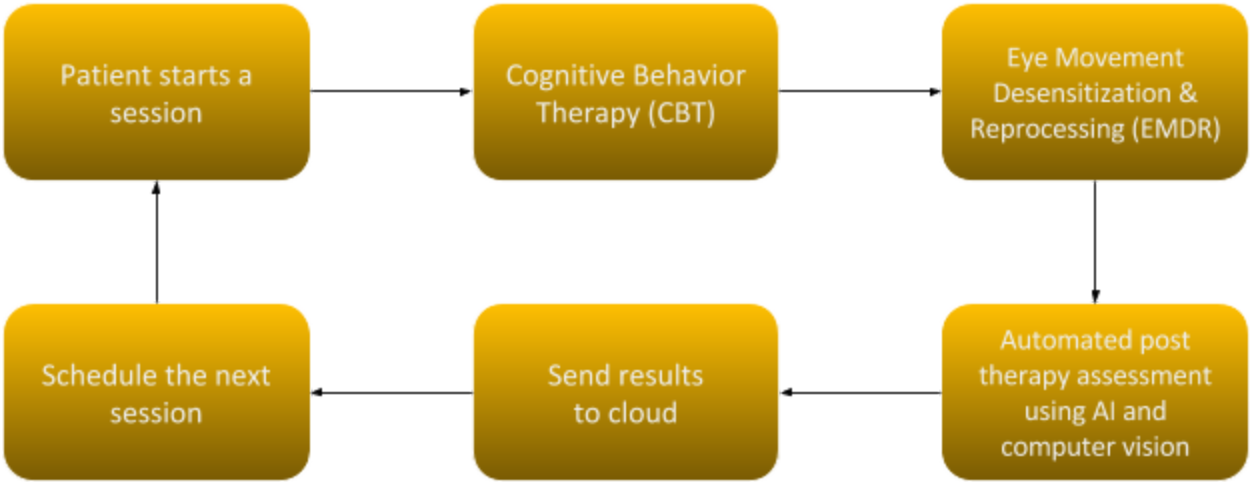

Figure 1. *Workflow of PTSD mobile app.*

Automated post therapy assessment

Patient is shown a series of images that are a mix of pleasant, neutral and provocative pictures. For each picture displayed, a photo of the patient is captured through phone's front camera. This photo is analyzed using AI and computer vision to detect emotions, such as degrees of anger, happiness, neutrality, sadness, etc. The assessment stops at the picture that invokes painful emotions on the patient's face, in which case a follow-up session is scheduled. The ultimate goal is to continue therapies until the patient stops getting provoked by any picture.

Technology stack

- Ionic 3 / Angular 5
- Cordova
- Android
- Computer Vision

Design mockups

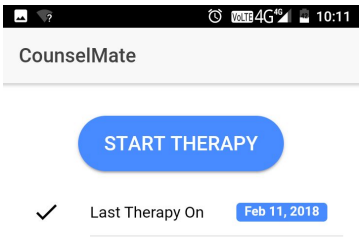

Figure 2-a. *Home screen.*

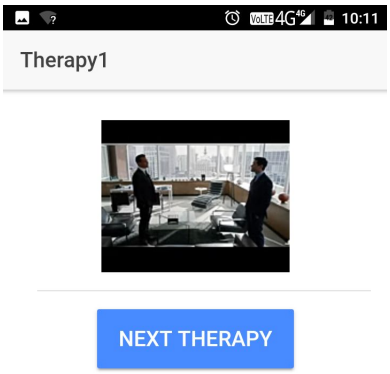

Figure 2-b. *A therapy in progress.*

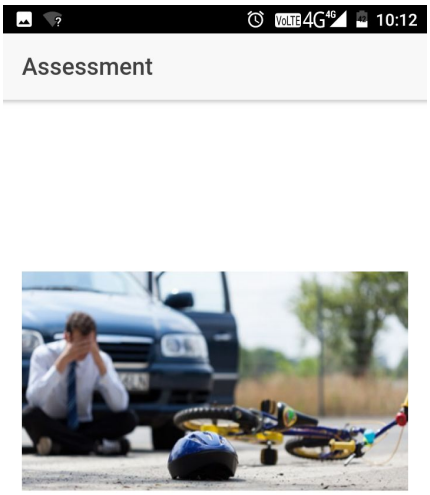

Figure 2-c. *Post therapy assessment.*

Motor Impairment Rehabilitation Device

This is an IoT device that tracks patient's vitals — heart rate and body temperature — during a therapy session. For each patient:

1. The patient wears the device around their finger.
2. A host of sensors start collecting telemetry data.
3. Data is sent over to a cloud backend after 10-second intervals.
4. Cloud backend performs real-time stream analytics to check for abnormal conditions based on patient's vitals.
5. Abnormal conditions are reported in a storage database.
6. A medical professional examines abnormal conditions by analyzing graphical dashboards and takes appropriate actions.

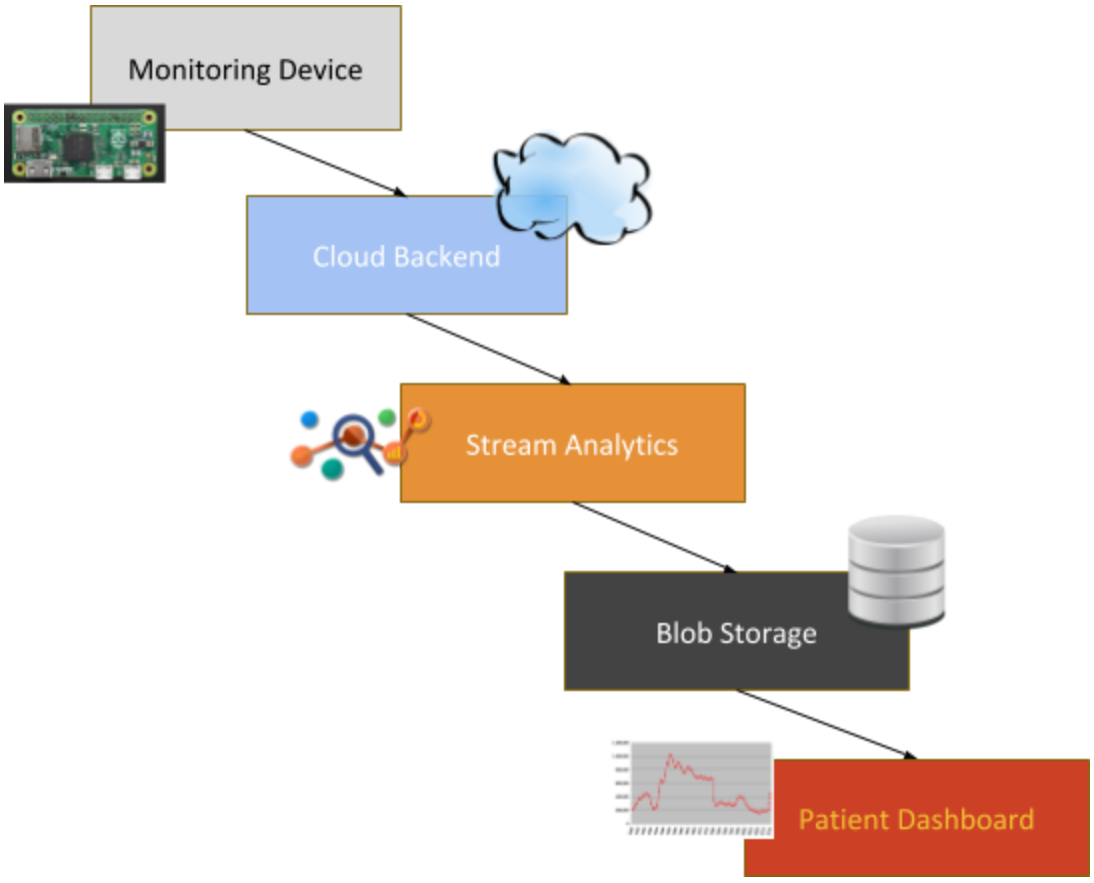

Figure 3. *Architecture diagram for the monitoring device.*

Custom pulse rate sensor

If it is not possible to get a ready-made sensor, a custom one can be made using the components mentioned in the Hardware & Software Requirements section above.

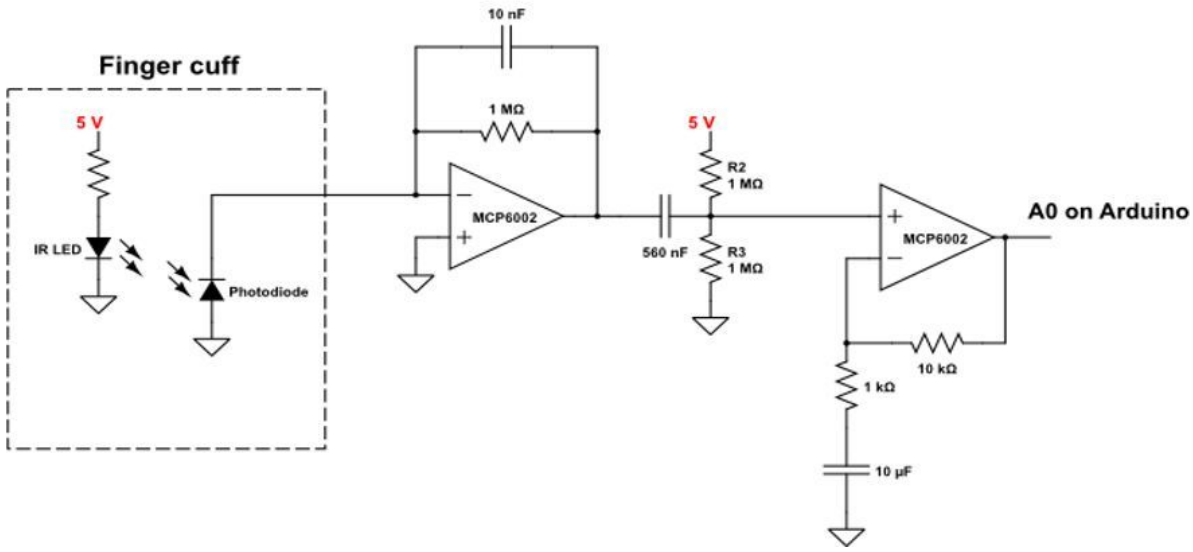

Figure 4. *Reference circuit diagram for a custom pulse rate sensor.*
Credit: http://www.instructables.com/id/Simple-DIY-Pulse-Sensor

Technology stack

- Device app
    - node.js
    - Azure IoT Device SDK (npm packages)
- Cloud Backend
    - Azure IoT Hub
    - Azure Stream Analytics service
    - Azure Blob Storage service
- Patient Dashboard app
    - Bootstrap 4.0.0
    - jQuery 3.x

Conclusion and Future Work

In a short span of 24 hours, we developed a working prototype for cost-free and reliable fully-automatic rehabilitation solutions for PTSD and mobile impaired patients, people who are otherwise likely to miss therapy sessions owing to cost and mobility factors.

This done, we are still several steps from taking his solution to the next level and making it ready for general public use. Some future next steps include:

- Improving the UI/UX (user experience) of both monitoring device and mobile app. The device will look better and be more usable when inside an enclosure. The mobile app's can use some UI enhancements to make it attractive and more engaging.
- A more interactive Cognitive Behavior Therapy (CBT) that allows patients to express themselves through speech-enable conversational interface.
- Detecting whether physiotherapy exercises are performed correctly (**computer vision**).
- Setting up a not-for-profit NGO that will take care of the cloud backend deployment, maintenance and costs. A system to accept public donations must also be set up.
- Uploading the PTSD mobile app to Google Play Store and Apple App Store.
- Generating enough data, through real-world deployments, that hospitals can use as turnkey data for predictive analytics to serve future patients proactively (**machine learning**).

Corrigendum

During the hackathon, we could not make use of an actual pulse rate sensor. A third team member who had the entire apparatus and electronic components to build our custom sensor had to drop because of a personal emergency. We regret this since we had a working and thoroughly tested custom sensor. In lieu of the sensor, we created a software-based **simulated sensor** to generate mock real-world values for patient vitals.