DMD4DMD (Dystrophy Monitoring Device for Duchenne Muscular Dystrophy)

Background

Incurable disease when affects a person it also affects the people around them. Especially in case of Muscular dystrophy, to be more precise Duchenne muscular dystrophy shortly called as DMD.

Recent surveys has revealed appalling facts like some children at high risk of death from heart and lung problems are not receiving regular checks. In the initially stages of assessment nearly half of the patients surveyed revealed that their general practitioner did not understand their condition well. More than 1/3rd of the patient's survey had their condition misdiagnosed and had to wait for a longer time for an accurate diagnosis.

There are often difficulties with diagnosis in DMD because the symptoms may vary and where there is no family history DMD may not be suspected at first.

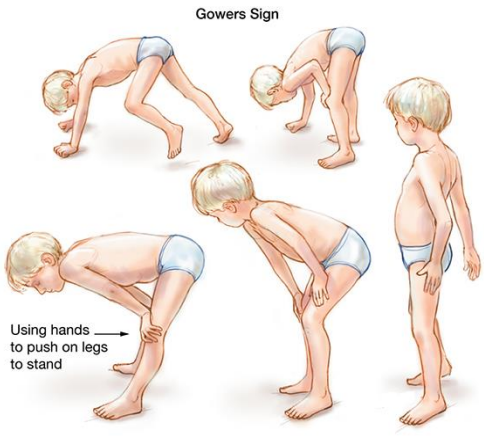

Fig. 1 Gowers Sign

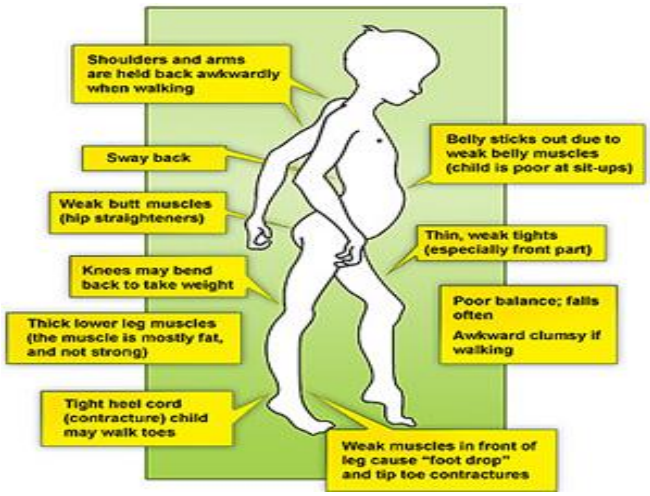

Fig. 2 Lordosis

Classic symptoms include enlargement (hypertrophy) of the calf muscles, which occurs in about 90% of cases. The patient may develop a tendency to walk on toes and this is often accompanied by a protruding abdomen and sway-backed stance, called 'lordosis' as shown in Figure 2. The patient will also experience difficulty getting up from the floor without help, he may use his hands to climb up his legs for support this is referred to as 'Gowers sign', shown in Figure 1. These symptoms generally begin to develop between the ages of one and three years and continue to progress until wheelchair support is required, most often between the ages of eight and twelve.

It is a unique case by itself because of the following reasons:

- No cure
- This particular muscular dystrophy affects only the children at a very early age.

- Predictability of life expectancy is uncertain because there is no qualitative quantification of the progressiveness of disorder.

Product Objective:

Though we cannot offer a solution for complete cure of the disease, our engineering team's objective is to provide a qualitative analysis to quantify the progressiveness of the disease. This we believe will add some certainty to the diagnostic process. The solution was to develop a light weight, wireless, wearable device connected to cloud which will monitor and analyze the muscle health to determine the rate of muscle degradation.

Approach Considered:

Electromyography (EMG) is a technique for evaluating and recording electrical activity produced in the muscles. There are two types of EMG, surface and intramuscular. In surface electromyography (sEMG) electrodes are placed on the surface of the skin. This method is completely noninvasive and requires a pair of electrode as EMG recording is the potential difference between two electrodes. Motor unit action potential (MUAP) is the sum of all electrical activities. MUAP size and shape depend on where the electrode is placed and it differs if the electrode position is moved.

sEMG acquired using electrodes is preprocessed and both time and frequency domain features like *RMS, standard deviation , energy, mean frequency, median frequency* and *peak frequency* were extracted to analyze the muscle strength.

When patients with DMD are compared against the healthy people, definitely the muscle strength of healthy person is superior to that of the patient. If a person can sustain N number of contractions or extensions then certainly a child or patient with DMD cannot sustain the same N contractions or extensions. The idea is to identify this N number of muscular movements a patient suffering from DMD can sustain.

Description of final approach and Design:

Before the entire concept was realized in hardware the logic or algorithm was tested using National Instruments Signal Express and data acquisition device NI 6363.

Fig. 3 EMG data acquisition via LabView

The acquired data was stored in a file and were analyzed offline. The results were consistent with 3 female and 7 male subjects. We were able to demarcate the exact fatigue setting point. The decrease in the slope as seen in figure 4 and 5 indicates weakening of muscle over time.

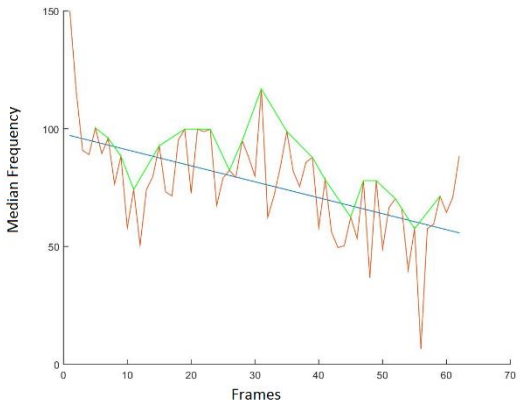

Fig. 4 Median frequency plot for Subject 1

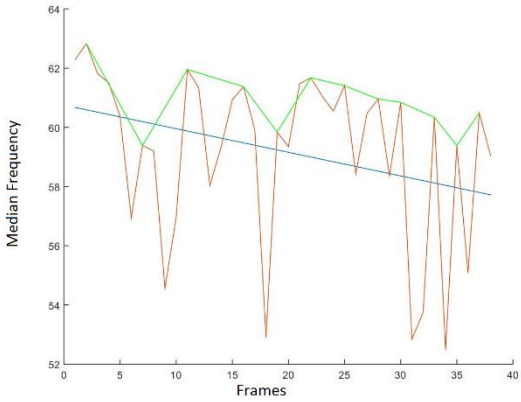

Fig. 5 Median frequency plot for Subject 2

Hardware Implementation:

The figure shown below is the block diagram representation of the hardware.

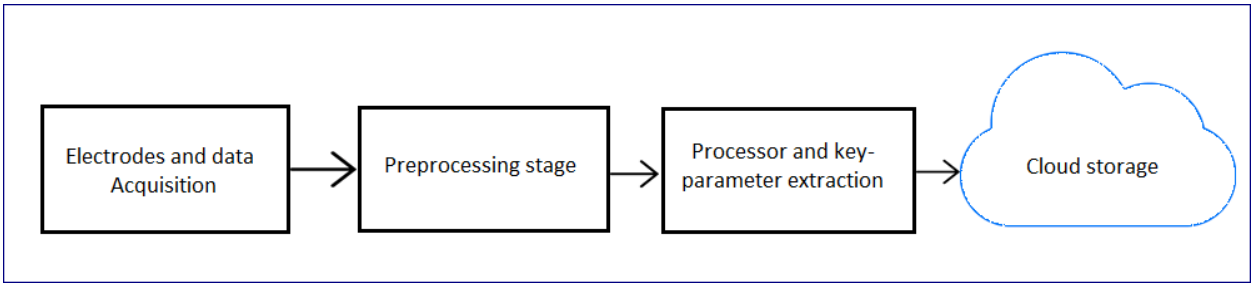

Fig. 6 Block diagram representation for the hardware implementation

Electrodes and data acquisition

Patch electrodes were placed on biceps brachii for acquisition of sEMG signal. These use and throw electrodes are very handy as they have integrated gel for conduction and stick to the body very easily.

Fig. 7 Electrodes

Pre Processing Circuit

The circuit is divided into three stages. The first stage is the differential amplifier which takes input from the electrodes. The second stage is a Band pass filter. The final stage is the rectifier. A buffer stage is added between the filters and the rectifier to avoid loading effect. The gain of the circuit is decided such that the maximum voltage at the output will not exceed 1.8V. The output of the preprocessing circuit is passed to the ADC of processor.

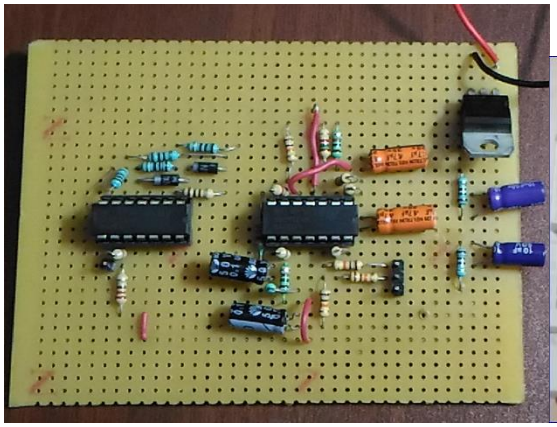

Fig. 8 Pre-processing circuit

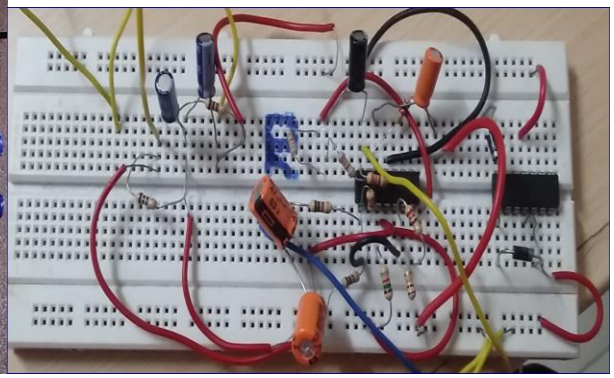

Fig. 9 Bread board implementation

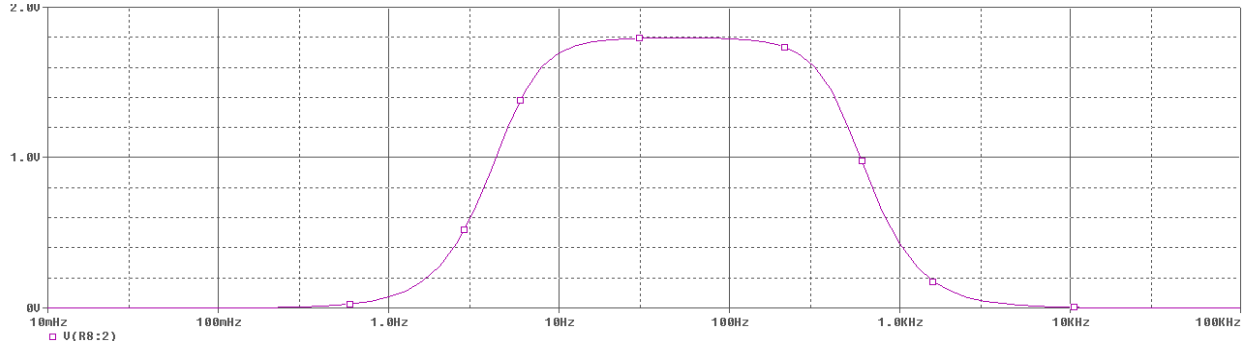

Fig. 10 Frequency response of the filter in PSpice

Processor

Beagle Bone black is used as the system on a chip which has an AM3358 ARM Cortex-A8 Sitara processor. The processor acquires the preprocessed data through an onboard 12 bit ADC and further computes the parameters. This information is sent to the cloud by means of an USB Wi-Fi adapter with a RALINK 7601MU chipset. The processor is powered using a portable power source.

Based on afore mentioned parameters, a graph is generated that shows set point of weakness during an exercise session. These graphs and data can be seen by the end user on the cloud.

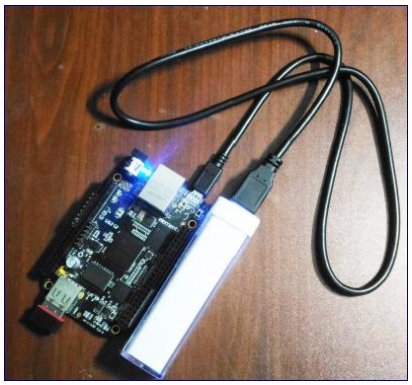

Fig. 11 Beagle Bone Black

Cloud platform

The cloud platform used for storing the data is Parse. It provides a secured user-friendly, tabular based interface where a person who is authorized to check the data can login and monitor the progressiveness of the disease after each exercise session.

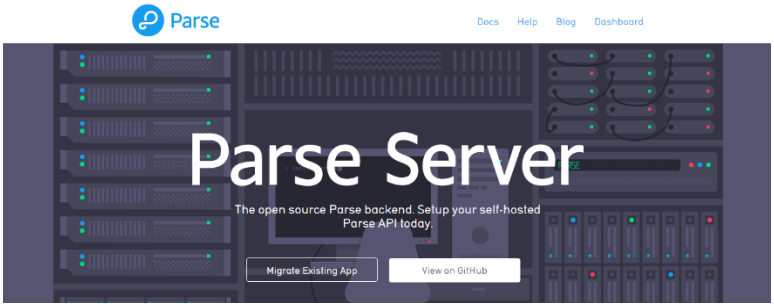

Fig. 12 Cloud used for storing data

Outcome:

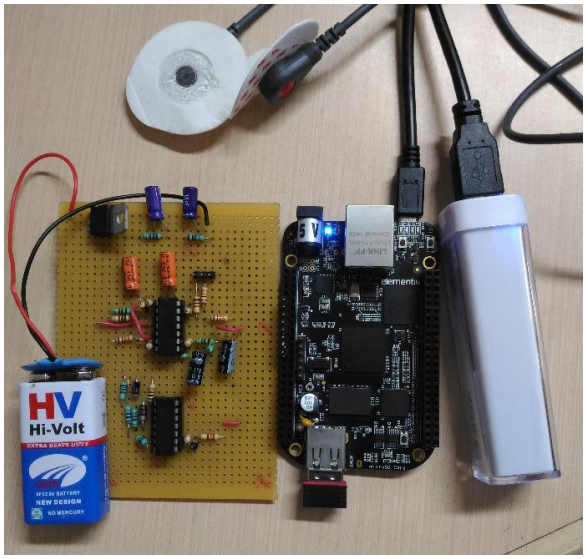

Fig. 13 The final product

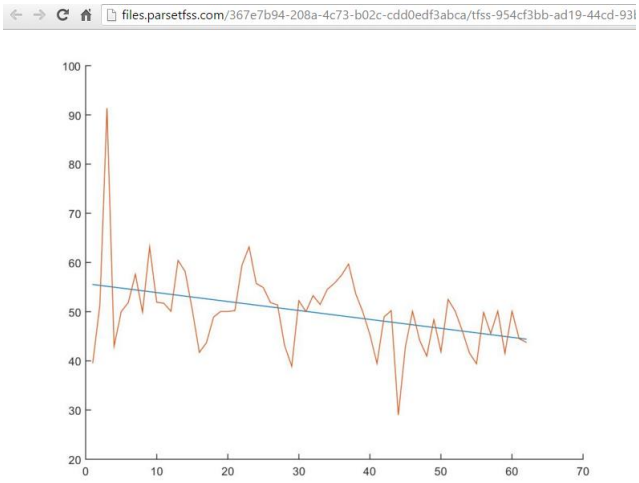

Fig. 14 Graph on cloud

The data acquired from the hardware as shown in Figure 13 is uploaded to the parse cloud. The data in Parse is protected and it has tags such as Name, age and gender to identify individuals. The graph obtained was as shown in figure 14. The maximum dip is the set point of weakness in muscle. With regular exercise, if this set point is almost constant for each session we can conclude that the disease is not progressing quickly.

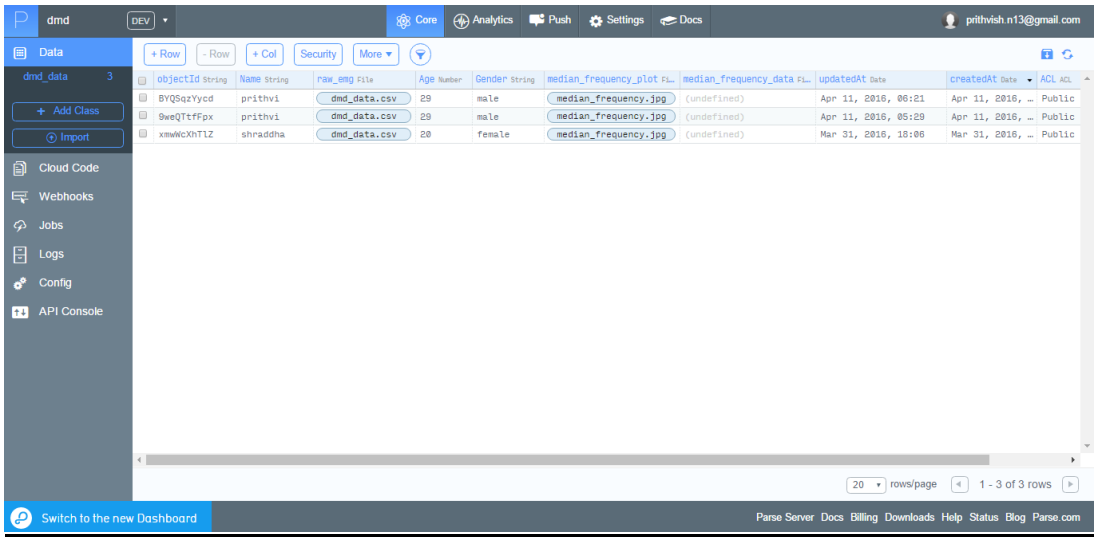

Fig. 15 Data uploaded on cloud

Cost of Materials:

Pre Processing Circuit	$3
PCB	$4.5
Processor	$53
Electrodes	$2
Portable power source	$7.5
TOTAL	$70

Significance:

A global repository can be created which has data and details of the patient such as age, gender and the place they belong to. This will help researchers and doctors all around the world to understand the disease better and come up with a cure for the same.

This device will add certainty in finding the muscle strength and will help physician and parents to manage the dosage or physiotherapy which might slow down progressiveness of the disease. Even a day in extension of life is critical when people are working continuously on finding a cure.

Acknowledgement:

Our team would like to thank our faculty advisor, Prof. Venkatasubramanain K and Prof. Umamaheswari V from School of electronics in VIT University for guiding us through the project.

References:

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