EEE-1008

Bio-Medical Instrumentation

Detection of Diabetic Neuropathy using Thermography

Team Members

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Introduction

Diabetic neuropathy is nerve damage that is caused by diabetes. Over time, high blood glucose levels also called blood sugar, and high levels of fats, such as triglycerides, in the blood from diabetes can damage your nerves. Symptoms depend on which type of diabetic neuropathy you have. There are four types of diabetic neuropathy. In the proposed system, Peripheral Neuropathy has been used to detect diabetes.

Graphics of Diabetic Neuropathy:


Objectives

- To come up with a working hardware prototype to aid the people suffering from Type 2 Diabetes.
- To create a system to tackle the adversities of people suffering from Diabetic Neuropathy and aid the treatment and avoid any severities such as amputations with the analysis of collected information of the patient.
- To reduce the cost of treatment and care for patients suffering from Type 2 Diabetes

Need of the Project:

The International Diabetes Federation is an umbrella organization of over 230 national diabetes associations in more than 160 countries and territories. The Federation has been leading the global diabetes community since 1950. The organization has made a report for all the countries contributing to the cause and came up the predictive report keeping the current trends and condition in mind if not improved over time.

Every 30 seconds a lower limb is lost due to diabetes globally. In India, about 1 lakh leg amputations occur every year due to diabetes-related problems, reports the Vascular Society of India. Of the 62 million diabetics in the country, 25 percent develop sores, ulcers, and life-threatening infections on their feet at some point during their lifetime.

India

Diabetes report 2000 — 2045

At a glance	2000	2011	2021	2030	2045
Diabetes estimates (20-79 y)					
People with diabetes, in 1,000s	32,674.4	61,258.4	74,194.7	92,973.7	124,874.7
Age-adjusted comparative prevalence of diabetes, %	-	9.0	9.6	10.4	10.8
People with undiagnosed diabetes, in 1,000s	-	-	39,397.4	-	-
Proportion of people with undiagnosed diabetes, %	-	-	53.1	-	-

The major cause for the occurrence of amputations among the patients was found to be an infection. Almost 90% of the patients had infections. Patients had different types of amputations: major amputations accounting for 29.1% and minor amputations in 70.9% of patients. Among the subjects who underwent major amputations, more than 50% account for below-knee amputations and 11.9% for above-knee amputations. Out of total amputations, over half of the incident amputations were of toes and rays. The presence of claw toes was seen in 64% of patients. Prevalence of neuropathy (82%) was high and 35% had peripheral vascular disease.

Literature Review:

[1] It is estimated, that worldwide, diabetes mellitus (Type 2 diabetes) most often develops in people over age 45, but more and more children, teens, and young adults are also developing it, and at least half of them are unaware of the diagnosis. Among microvascular complications, diabetic neuropathy is the most prevalent, leading to the highest rates of hospitalization, atraumatic amputations, and incapacity.

[2] The study was based on the implementation of Infrared Thermal Imaging technology for early diagnosis of Diabetic Peripheral Neuropathy(DPN) and study the patterns based on the age and gender of the patients in comparison with a set of a healthy set of people. The infrared detection results of skin temperature corresponding to blood vessels showed excellent test-retest reliability. There was no significant difference in skin temperature between sex and age.

[3] The study determined the mean temperature of the toes and forefeet of the patients suffering from diabetes is significantly higher than the healthy bunch. The results indicate the potential of thermography for screening and early treatment.

[4] The study goes around the aid and treatment of Diabetic foot and demonstrates the benefit of encouraging the development of devices that can be widespread use by the patients to prevent serious pathology are highly welcome, and temperature measurements are obviously particularly promising using the Thermography techniques.

[5] The literature reviews the cause of foot neuropathy due to diabetes mellitus and it leads to ulcerations and amputations in cases. It discusses off-loading pressure, footwear modification for different types of diabetic foot deformities, and types of footwear and textile materials used in footwear insoles for healing purposes.

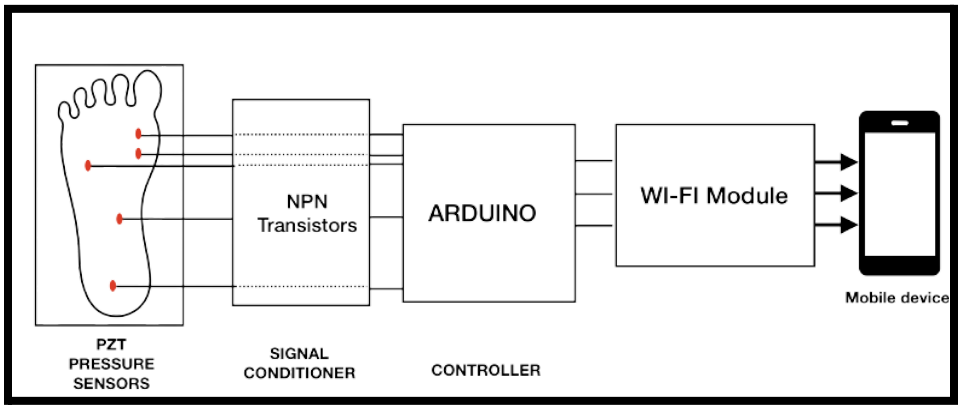
[6] The reviewed literature takes up various thermography methodologies that can be used for the detection of Diabetic Peripheral Neuropathy in the foot and early detection of ulceration. Thermography is a noninvasive imaging technique that is useful to measure temperature distribution in organs and tissues. And it is a useful tool in the medical field applied to the study of diseases such as diabetes.

Methodology

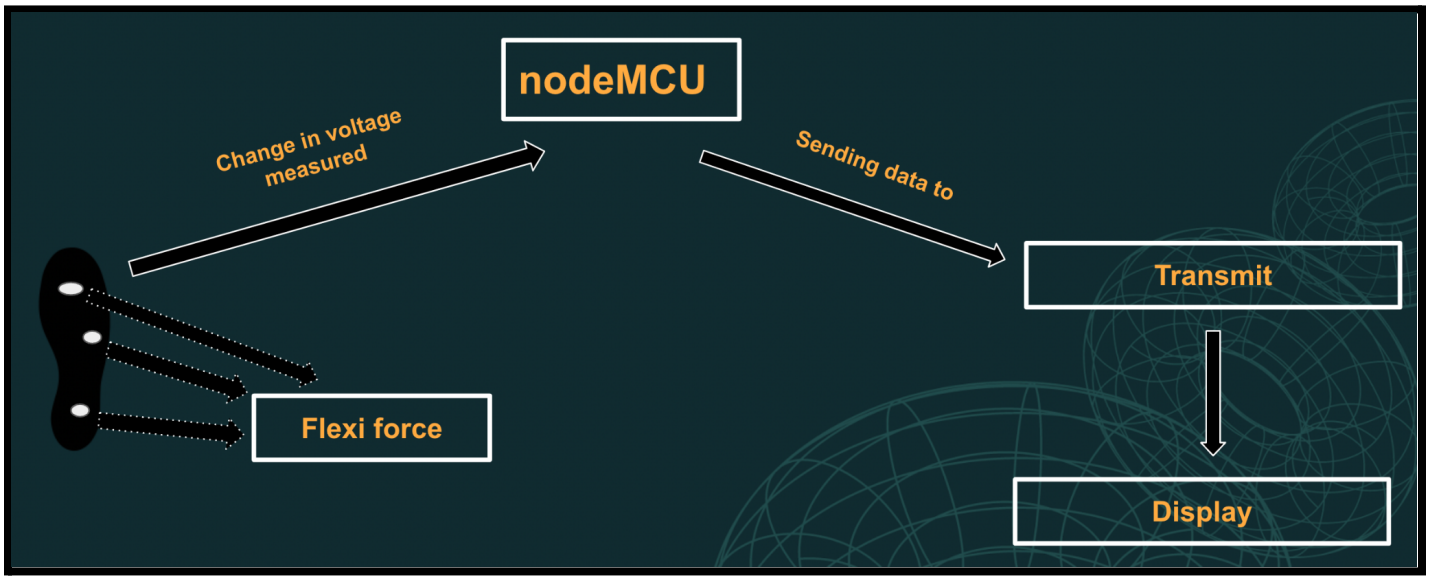
Our project will be based on nodeMCU and to build a low-cost pressure measurement and analysis system. Patients can use it at home and check his or her foot pressure. Just wearing normal footwear will measure their foot pressure.

We will be using a Wifı module with nodeMCU so that the pressure readings can be sent to the Patient's mobile from where he will be alerted and asked to take a rest.

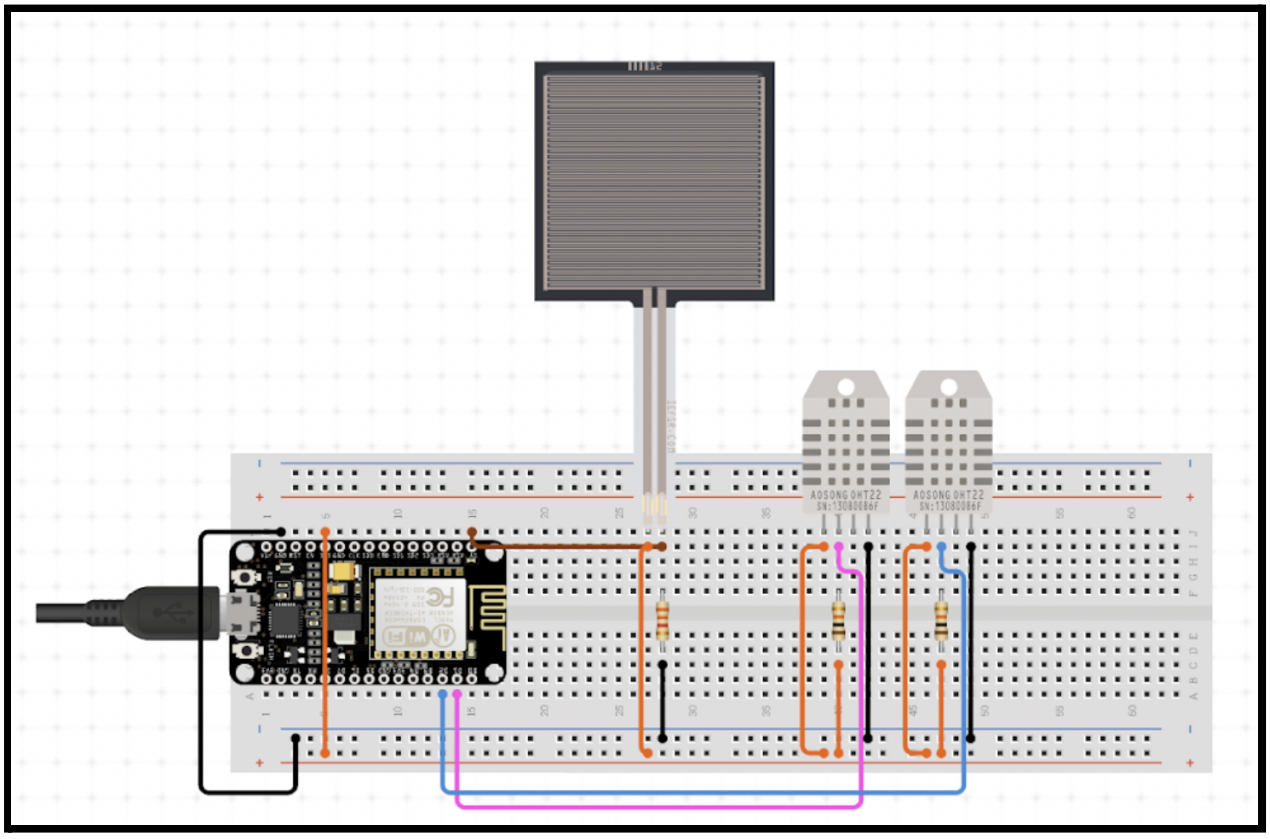
These data will also be transferred to Hospital's cloud through IoT. So that the readings can be monitored by the doctor and also graphs will be plotted accordingly along with Pressure.



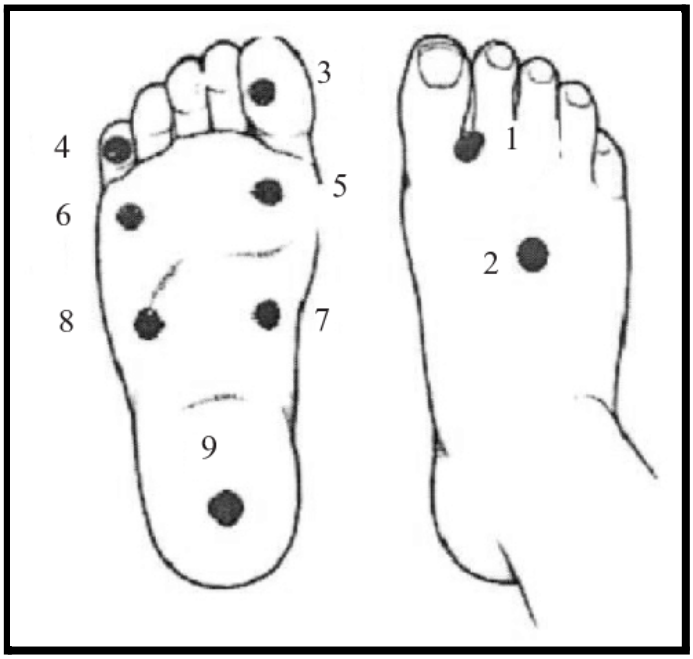
Flow Chart:

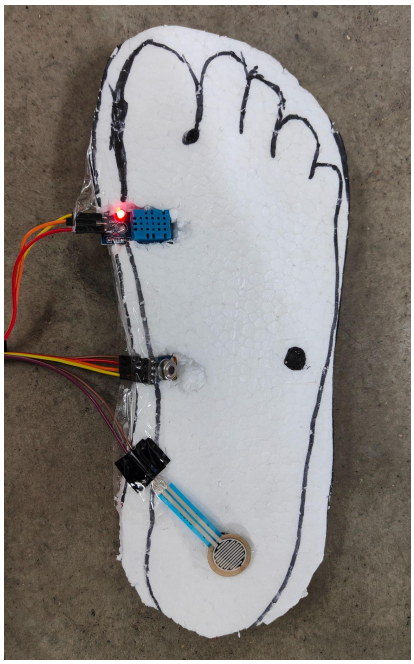


Circuit Diagram



Prototype

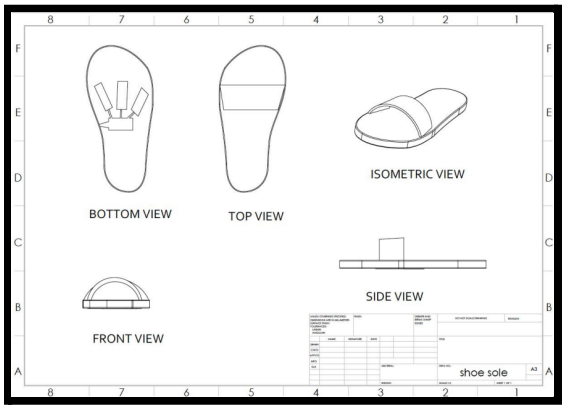




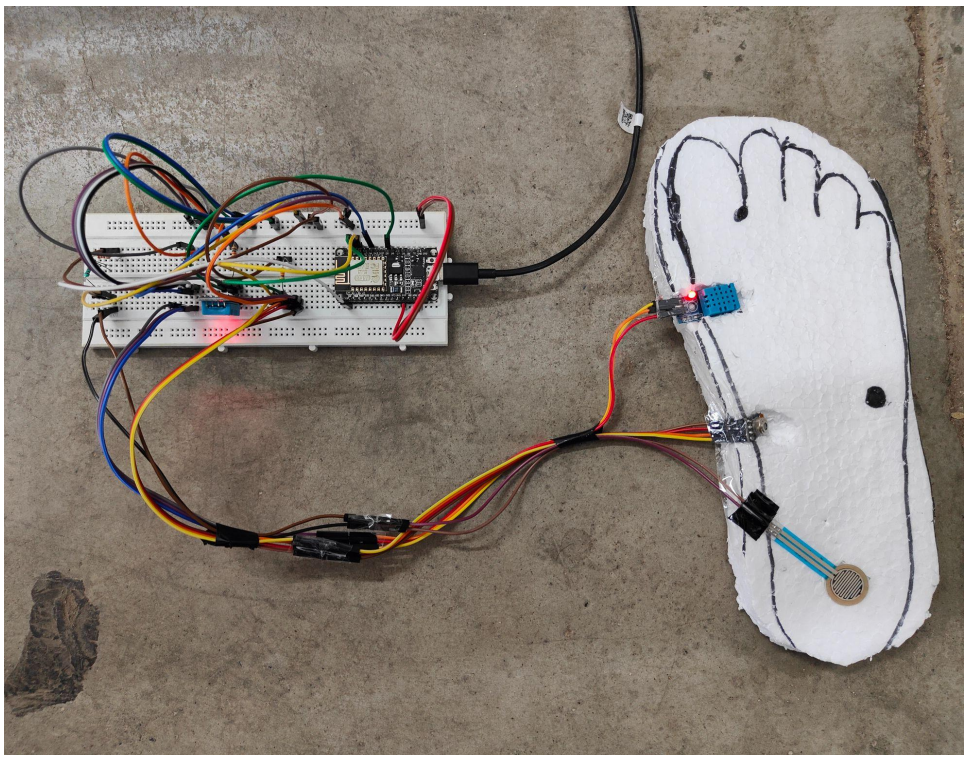
Upon referring to the medical research papers on DPN, we got an understanding of the pressure points where the loss of sensation starts and ulcer formations.

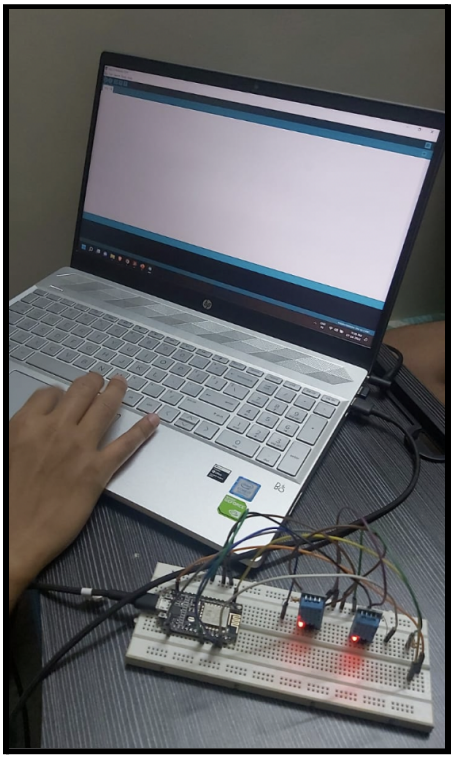
For our project, we are proceeding with point numbers 5, 6, 8, and 9 as shown in the figure.

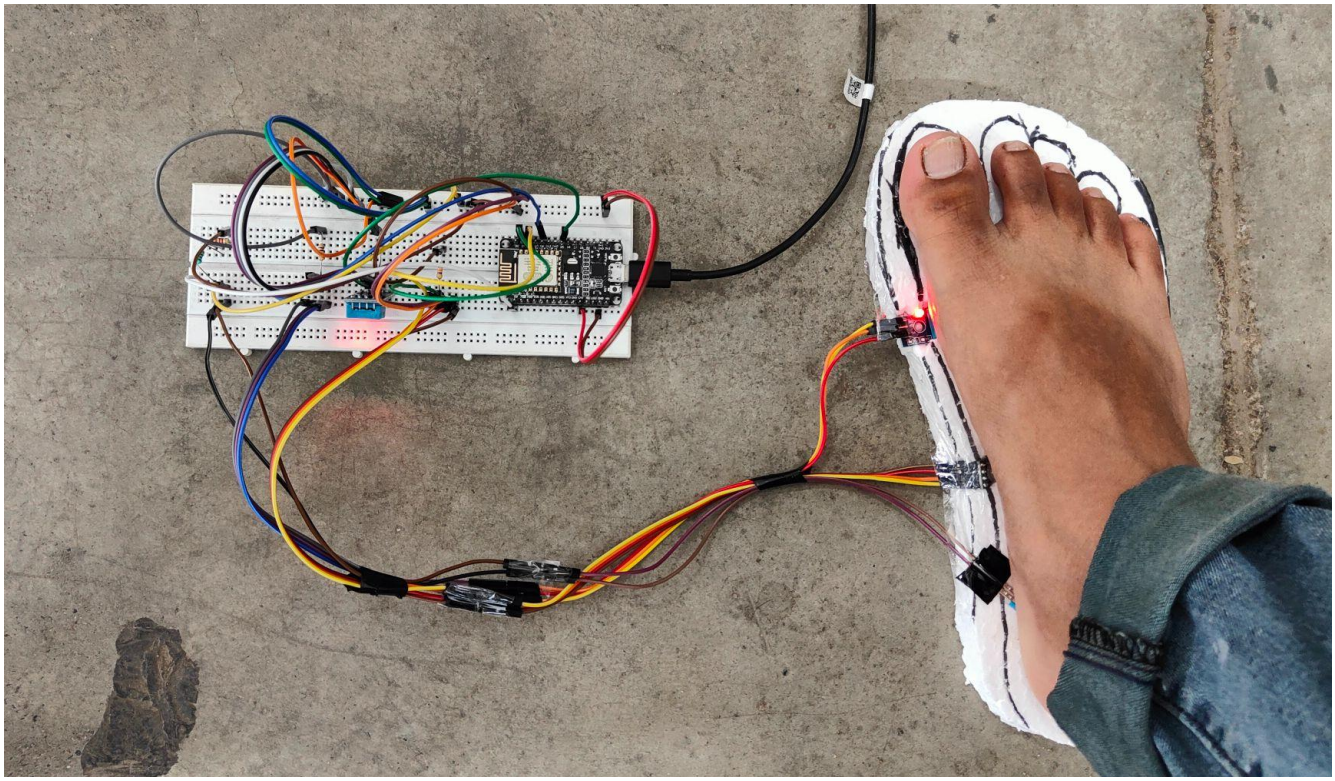
Upon determining the points on foot to be focused on, as the next step, we started to convert the first prototype into a wearable footwear form. For this we are considering slide-on slippers, with a layer of cushioning so the patient using the prototype does not face uncomfort in wearing it and the sensors still get an accurate data reading for real-time indications and the calibration henceforth.



Hardware







Hardware Used:

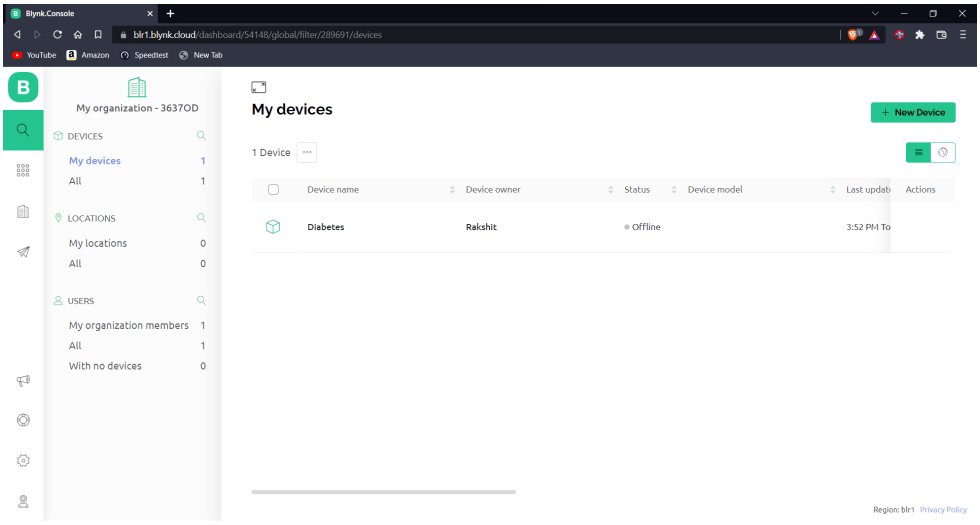
1. NodeMCU ESP8266
2. Battery (Power Bank- 5V)
3. Resistors (3.3k, 4.7k, 10k Ohm)
4. Slipper
5. Temperature sensor(IR Temperature Sensor)
6. Force sensors (Flexiforce Sensor)
7. Humidity Sensor (DHT 11)
6. Soldering iron
7. Bread Board
8. Connecting wires

Softwares Used:

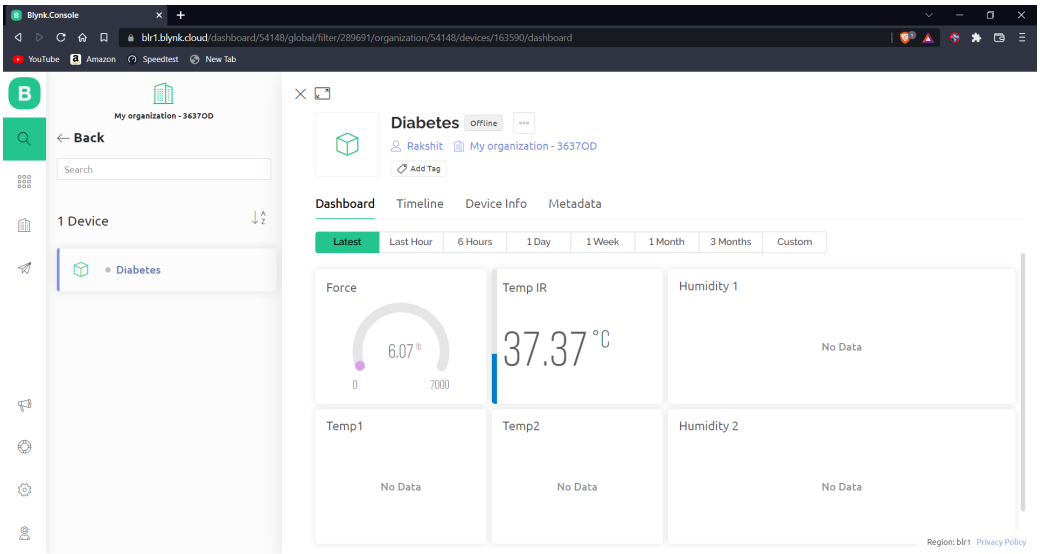
1. Blynk Cloud
2. Blynk mobile App
3. Arduino IDE
4. Circuit.io (website)
5. AutoDesk Eagle

IoT Connectivity

We started the IoT platform interfacing. We are using **Blynk Cloud** and **Blynk App Data** as the IoT platform for real-time updates and display the message regarding the rest time and overexertion by the person.



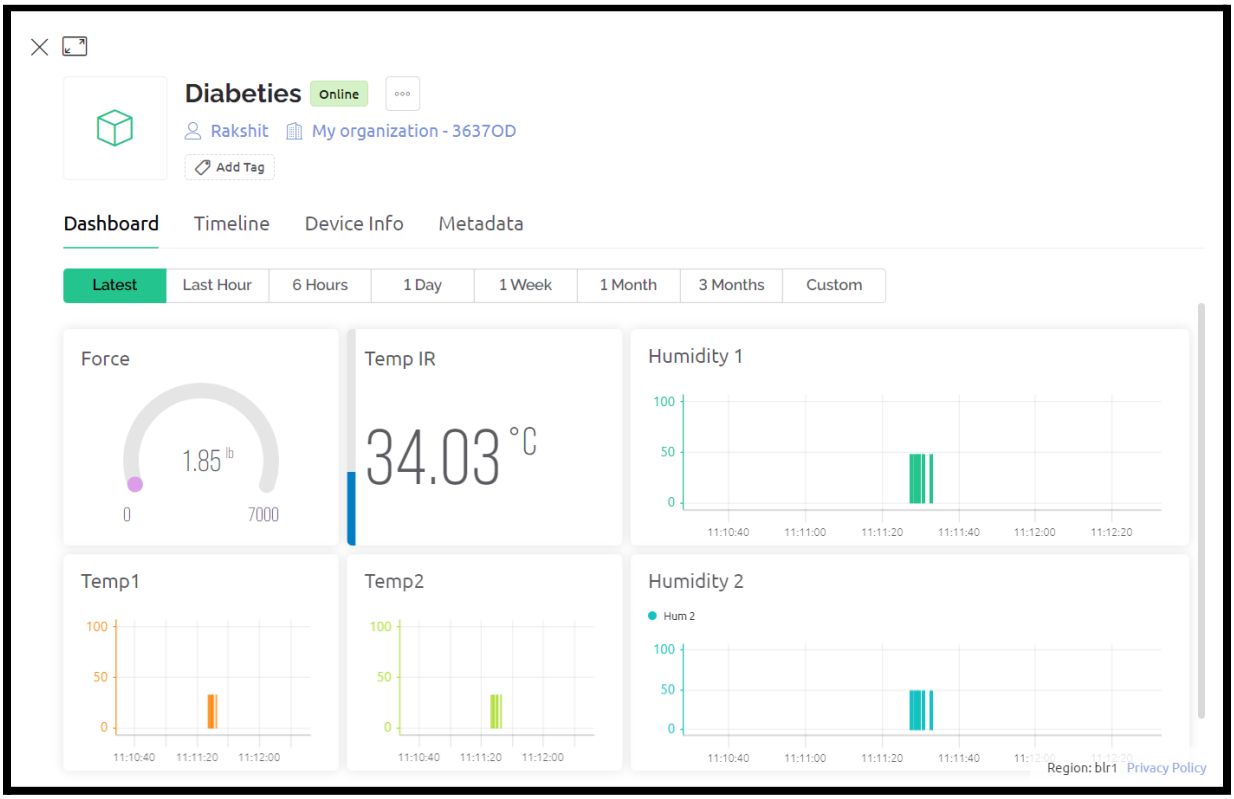
The platform has 4 Channels for now, namely
Channel 1- Pressure/force exerted on the foot (Flexi Force)
Channel 2- Foot Temperature (IR Temperature Sensor)
Channel 3- Humidity for sweating on foot (DHT 11)
Channel 4- Humidity for the surrounding (DHT 11)
Channel 5- Temperature for the surrounding (DHT 11)



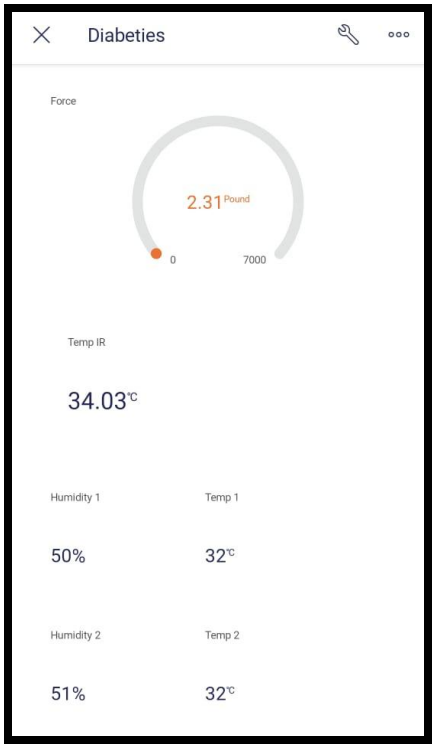
Result and Conclusion

We are able to successfully implement and monitor the condition of the diabetic patient at regular intervals of time with the help of the real-time data which is provided by the device. Since we are uploading the data to the cloud, this data can be accessed by anyone sitting anywhere including the doctor, patient, and patient's guardian.

We will have a better understanding of the patient's condition. This will help us keep in check Patients' sugar levels and also hopefully, we will be able to prevent any type of medical emergencies. The results show that it can accurately measure the foot pressure distribution to detect anomalies.



Web Dashboard View



Mobile Dashboard View

There can be many applications for this Arduino-based foot neuropathy analyzer. It can also be used to detect and then help in control neuropathy, analyze areas of possible ulceration, monitor foot disorders, assist in footwear research and assess the effects of orthotics on feet. The low production cost can allow it to be beneficial in poorer countries, where diabetes is currently reaching the scale of an epidemic.

Future Scope:

1. Early Detection of Ulcers in diabetic patients.
2. Real-time Notification alerts according to the thresholds set by doctors.

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