NANDHA ENGINEERING COLLEGE

ERODE–638052 (Autonomous)

(Affiliated to Anna University, Chennai)

DEPARTMENT OF ARTIFICIAL INTELLIGENCE AND DATA SCIENCE

22AIC14 – INTERNET OF THINGS AND ITS APPLICATIONS

MINI PROJECT REPORT ON

TOPIC – EARLY DETECTION OF FOOT ULCER

Submitted by

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BONAFIDE CERTIFICATE

This is to certify that the project work entitled "EARLY DETECTION OF FOOT ULCER" is the Bonafide work of DEEPIKA L(22AI009), KAVITHA S(22AI021), THANISTA S(22AI054) who carried out the work under my supervision.

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Submitted for End semester PBL review held on _____

EARLY DETECTION OF FOOT ULCER

AIM:

To design and develop a smart insole system using IoT to monitor foot pressure, temperature, and humidity, enabling early detection of diabetic foot ulcers and providing real-time alerts to prevent complications such as amputations.

SCOPE:

The scope of this project is to develop a smart insole device for diabetic patients, enabling real-time monitoring of foot pressure, temperature, and humidity through IoT technology. It aims to provide early detection of foot ulcers, reducing the risk of severe complications like amputations. The system offers instant alerts and data feedback via smartphones, promoting self-care and preventive healthcare solutions.

BRIEF HISTORY:

Diabetic foot ulcers (DFUs) are common and serious complications of diabetes that result from a combination of peripheral neuropathy, ischemia, and infection. According to the National Center for Biotechnology Information, the annual incidence of DFUs ranges from 9.1 to 26.1 million cases globally, with a significant number requiring hospitalization or leading to amputations. Early detection of ulcers is crucial to preventing such complications. Traditional monitoring methods rely on physical examinations, but IoT-enabled smart systems can provide real-time data and early alerts, enhancing self-care and medical outcomes.

PROPOSED METHODOLOGY:

1. **Sensor Integration:**
    - Use Force-Sensing Resistors (FSRs) to measure pressure at critical points like the heel and metatarsal regions.
    - Employ a DHT11 sensor to monitor temperature and humidity inside the shoe.
2. **Microcontroller and Connectivity:**
    - Use an ESP32 microcontroller for its Wi-Fi and Bluetooth capabilities.
    - Transmit sensor readings to a mobile application via IoT protocols

3. **Real-Time Monitoring and Alerts:**
    - Implement threshold-based alerts for abnormal temperature, humidity, and pressure.
    - Display readings and alerts on the Blynk app in real-time.
4. **Data Logging:**
    - Store data on cloud servers for analysis and tracking patient trends over time.

COMPONENTS REQUIRED:

S.NO	COMPONENTS	NO'S
1	ESP32 microcontroller	1
2	Force-Sensing Resistors (FSR)	2
3	DHT11 temperature and humidity sensor	1
4	Smartphone with Blynk app	1
5	Jumper wires	As required
6	USB cable (B-type)	1

DESCRIPTION:

Sensor placement is important to maximize the effectiveness of the system. This section describes different locations for sensor placement and the reasoning behind selection of sensor placement positions. There are 4 main pressure points based on foot plantar pressure distribution such as Toe, Heel, metatarsal and metatarsalgia. These regions support most of the body weight and experience majority of pressure changes. The measured force at these positions can be used to derive physiological, structural, and functional information of limbs and whole body. Hence, it is very natural to select the sensor position from these location. We are using FSR sensors for this.

FSR A covers the area of metatarsal and metatarsalgia, FSR B covers the area of heel region though it covers the maximum area of three main pressure points. By applying pressure on our foot, we get the analog signals from the sensors FSR A and FSR B, the analog signals are transmitted to the ESP32 and It controls the output. Temperature and humidity sensors send

the analog input to the ESP32. The analog signals are converted into digital and transmitted to the mobile application connecting to the bluetooth or Wi-Fi of our smart phone. Acquiring the required parameters with the sensors. Transferring the real time data to the cloud-based servers using IOT technology, gives instant data feedback to our smartphones and warns the patient.

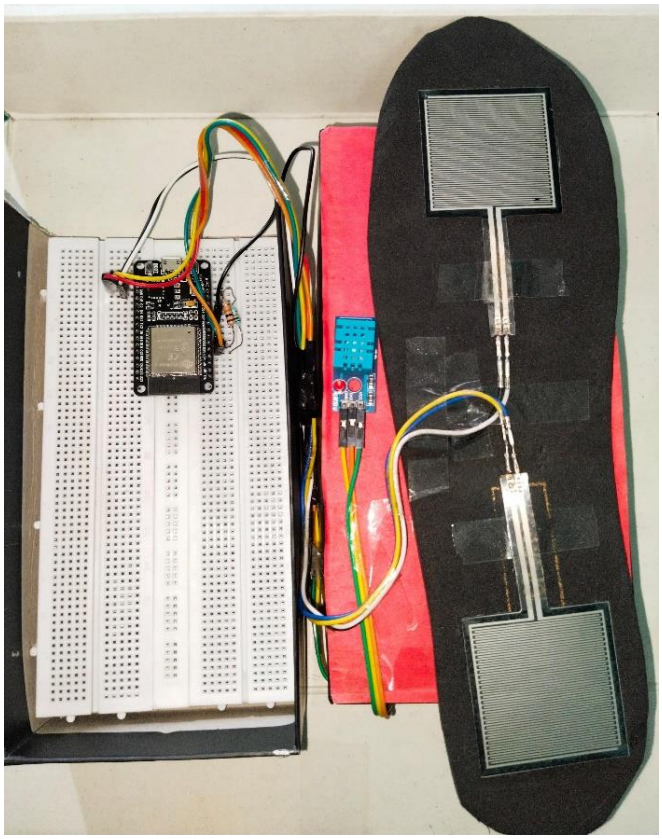
CODING:

```
// Define Blynk Template ID and Name
#define BLYNK_TEMPLATE_ID "TMPL3mIIQhKuo"
#define BLYNK_TEMPLATE_NAME "insole"
#define BLYNK_AUTH_TOKEN "H9fLE7xlcNq305fBf_NhbHOQ9Z9dzKFD"
// Include libraries
#include <WiFi.h>
#include <WiFiClient.h>
#include <BlynkSimpleEsp32.h>
#include <DHT.h>
// Define Blynk Auth Token and WiFi credentials
const char* ssid = "Kavitha";
const char* password = "kavi2004";
// Define pins
#define DHTPIN 27       // Pin for DHT11
#define HEEL_FSR_PIN 35 // Analog pin for Heel FSR
#define META_FSR_PIN 32 // Analog pin for Metatarsal FSR
// Sensor thresholds
#define TEMPERATURE_THRESHOLD 37.0   // Temperature in °C
#define HUMIDITY_THRESHOLD 60        // Humidity in %
#define PRESSURE_THRESHOLD 500       // Threshold for FSR sensor readings
// DHT11 setup
#define DHTTYPE DHT11
```

```
DHT dht(DHTPIN, DHTTYPE);
BlynkTimer timer;
// Function to check sensors
void checkSensors() {
  // Read temperature and humidity
  float temperature = dht.readTemperature();
  float humidity = dht.readHumidity();
  // Read pressure values from FSR sensors
  int heelPressure = analogRead(HEEL_FSR_PIN);
  int metaPressure = analogRead(META_FSR_PIN);
  // Send readings to Blynk
  Blynk.virtualWrite(V0, temperature); // Temperature on V0
  Blynk.virtualWrite(V1, humidity);    // Humidity on V1
  Blynk.virtualWrite(V2, heelPressure); // Heel FSR on V2
  Blynk.virtualWrite(V3, metaPressure); // Metatarsal FSR on V3
  Serial.println("Temperature: " + String(temperature) + " °C");
  Serial.println("Humidity: " + String(humidity) + " %");
  Serial.println("Heel Pressure: " + String(heelPressure));
  Serial.println("Metatarsal Pressure: " + String(metaPressure));
  if (temperature > TEMPERATURE_THRESHOLD) {
    Blynk.logEvent("high_temperature", "ALERT!");
    Blynk.setProperty(V0, "color", "#FF0000"); // Set color to red on Blynk
  } else {
    Blynk.setProperty(V0, "color", "#00FF00"); // Set color to green if normal
  }
  if (humidity > HUMIDITY_THRESHOLD) {
    Blynk.logEvent("high_humidity", "ALERT!");
  }
  if (heelPressure > PRESSURE_THRESHOLD) {
```

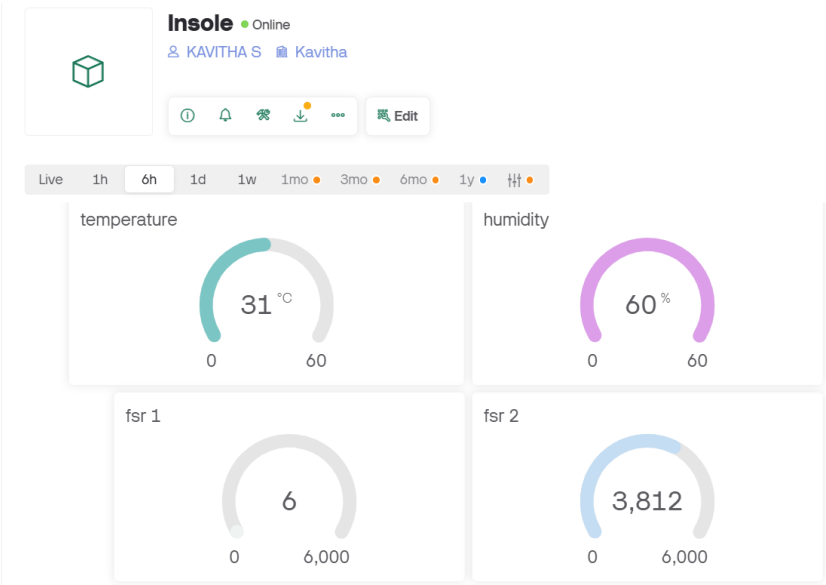
```
    Blynk.logEvent("high_heel_pressure", "ALERT!");
  }
  if (metaPressure > PRESSURE_THRESHOLD) {
    Blynk.logEvent("high_metatarsal_pressure", "ALERT!");
  }
  Blynk.logEvent("insole", "foot ulcer detected slightly, Risk of ulcer!!");
  Serial.println(); // Blank line for readability
}
// BLYNK_WRITE function to handle commands from Blynk app
BLYNK_WRITE(V0) {
  int userCommand = param.asInt(); // Read value from app
  if (userCommand == 1) {
    Serial.println("Manual Check Initiated from App");
    checkSensors(); // Manually trigger sensor check
  }
}
void setup() {
  // Start Serial and DHT
  Serial.begin(115200);
  dht.begin();
  Blynk.begin(BLYNK_AUTH_TOKEN, ssid, password);
  // Set up a timer to check sensor data every 5 seconds
  timer.setInterval(5000L, checkSensors);
  Serial.println("Diabetic Foot Ulcer Monitoring System Initialized.");
}
void loop() {
  Blynk.run();
  timer.run();
}
```

SCREENSHOTS:



OUTPUTS:

This Screenshot defines the dashboard that displays the temperature , humidity and pressure values in the blynk dashboard:



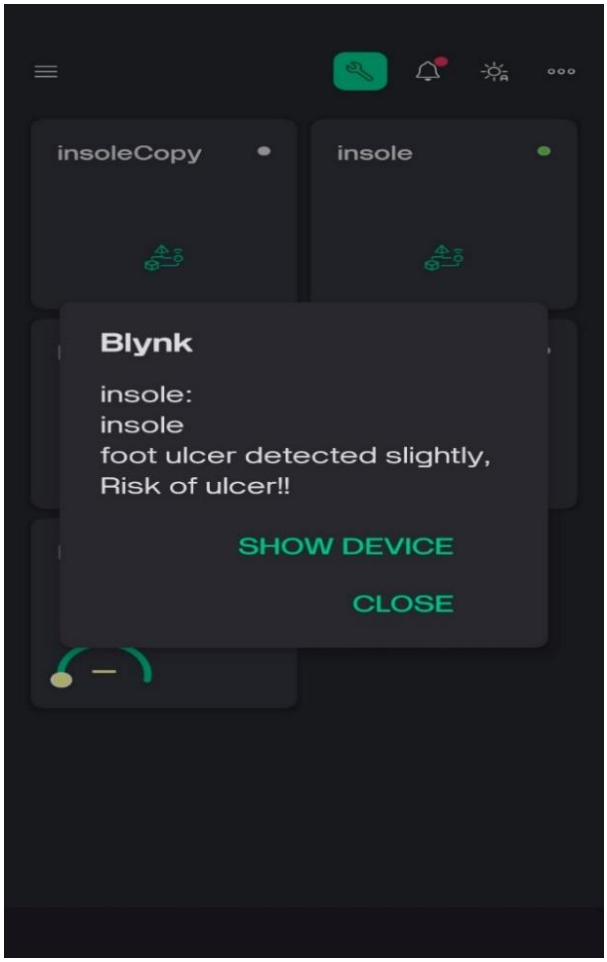
This screenshot defines the output that is displayed in Arduino Ide – Serial Monitor:

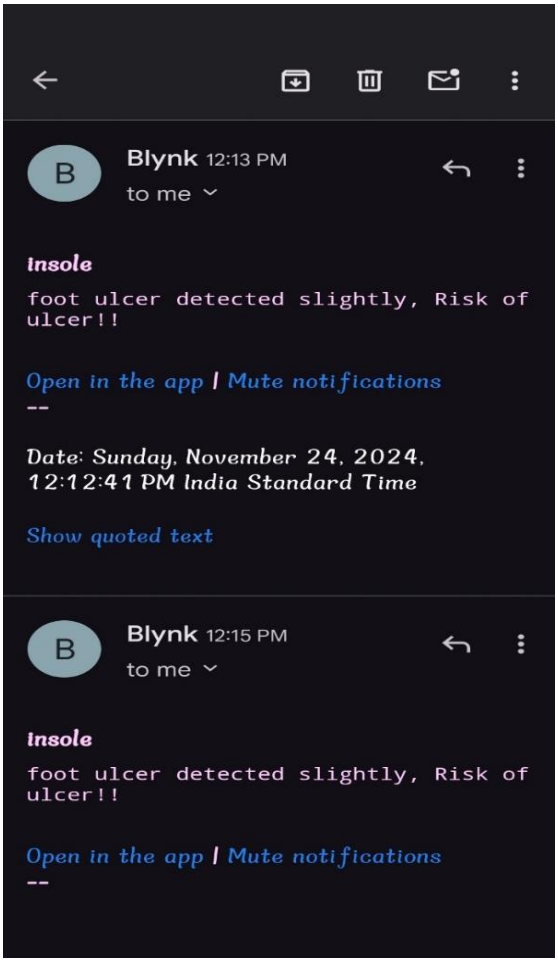
```
Diabetic Foot Ulcer Monitoring System Initialized.
Temperature: 30.80 °C
Humidity: 68.00 %
Heel Pressure: 9
Metatarsal Pressure: 3932

Temperature: 31.30 °C
Humidity: 69.00 %
Heel Pressure: 0
Metatarsal Pressure: 4095
```

This is the dashboard of the measured temperature, humidity and pressure values that is displayed on Blynk app in our Mobile Phone :

Alert message displaying in Blynk app through Notifications:





LIMITATIONS:

1. Smartphone Dependency: Requires a smartphone for data display and alerts, which may not be accessible for all users.
2. Battery Life: Continuous operation and data transmission may lead to frequent recharging.
3. Limited Coverage: The sensors may not cover all foot areas at risk of ulceration.
4. Environmental Factors: External factors (e.g., footwear, humidity) may affect sensor readings.
5. Clinical Validation: The device has not been extensively tested in real-world clinical settings.

FUTURE ENHANCEMENTS:

1. AI Analytics: Implement cloud-based AI for advanced analysis and more accurate alerts.
2. Healthcare Integration: Share data with healthcare providers for remote monitoring and early intervention.
3. User Experience: Add voice commands and personalized feedback for better accessibility.
4. Full Foot Coverage: Design insoles that cover the entire foot for comprehensive monitoring.
5. Data Security: Strengthen encryption and privacy measures for secure data handling.
6. Global Accessibility: Reduce costs to make the device accessible to a wider range of patients, including in developing countries.

CONCLUSION:

This project demonstrates the effective use of IoT technology in healthcare. The smart insole device provides an innovative solution for diabetic foot ulcer prevention by enabling real-time monitoring of temperature, pressure, and humidity. The integration with the Blynk app ensures patients receive timely alerts, reducing the risk of complications such as infections and amputations. This lightweight, affordable, and user-friendly device empowers diabetic patients to take proactive steps in managing their foot health.