

SMART SHOE WITH HUMIDITY SENSOR FOR SWEAT DETECTION

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ABSTRACT

The proposed project, Smart Shoe with Humidity Sensor for Sweat Detection, focuses on developing an intelligent footwear system capable of monitoring humidity levels inside a shoe to detect sweat accumulation. Excessive sweating in the feet can cause discomfort, unpleasant odor, and various skin infections such as athlete's foot. The smart shoe aims to overcome these issues by integrating a DHT11 humidity sensor with an Arduino microcontroller and a Bluetooth (HC-05) communication module. The system continuously monitors the humidity inside the shoe and transmits the data wirelessly to a smartphone for real-time analysis. When the detected humidity exceeds a predefined threshold, the system alerts the user through visual or sound signals such as an LED indicator or buzzer, promoting timely action to maintain hygiene and comfort. The device is powered by an MB102 power supply module, ensuring stable operation and portability. By incorporating low-cost, lightweight components, the design maintains user comfort and affordability. The smart shoe system not only enhances personal health monitoring but also contributes to the advancement of wearable technologies in healthcare and sports applications. The project demonstrates how the combination of IoT and sensor technology can be effectively applied to everyday accessories to improve quality of life. Future developments could include data logging, temperature sensing, and integration with cloud-based health platforms for continuous monitoring and advanced analysis.

KEYWORDS: Smart Shoe, Humidity Monitoring, Wearable Sensors, Arduino, IoT Healthcare, Sweat Detection.

INTRODUCTION

In recent years, the use of smart wearable devices has rapidly increased due to their ability to collect and analyze real-time data related to human health and lifestyle. Among various types of wearable technologies, smart shoes have gained attention because they can monitor physical activities and environmental conditions directly from the feet, which play a vital role in human movement and balance. This project, titled "Smart Shoe with Humidity Sensor for Sweat Detection," aims to design and develop a system that can detect the level of sweat inside the shoe using a humidity sensor and provide feedback to the user through alerts or Bluetooth connectivity.

Excessive sweating of the feet, also known as plantar hyperhidrosis, can cause discomfort, odor, and various

skin problems if not properly managed. Conventional shoes do not provide any way to monitor humidity levels, making it difficult for users to maintain proper foot hygiene. With advancements in sensor technology, it is now possible to measure environmental parameters such as humidity and temperature in real time. The integration of these sensors into footwear can help detect sweat accumulation and alert the user before discomfort or infections occur.

In this project, a DHT11 (Digital Humidity and Temperature) sensor is used to measure the humidity inside the shoe. The data collected by the sensor is processed by an Arduino Uno (or MB102 board), which acts as the main control unit. The system also includes a Bluetooth module (HC-05) to transmit the humidity data to a smartphone or other Bluetooth-enabled devices.

When the humidity exceeds a preset threshold, the system can activate an LED or buzzer to alert the user instantly. This allows continuous and automatic monitoring of foot conditions without requiring manual checking.

The proposed smart shoe system offers several advantages. It is low-cost, compact, and energy-efficient, making it suitable for daily use. The device not only helps individuals maintain hygiene but can also be beneficial for diabetic patients or athletes who are more prone to foot-related issues caused by excess moisture. In addition, the Bluetooth-based communication enables real-time tracking, which can later be expanded for data logging or health analysis applications.

Overall, this project demonstrates how the combination of Arduino technology, humidity sensors, and wireless communication can be used to create an innovative solution for foot health monitoring. It represents a small but significant step toward smart healthcare and wearable technology development. With further improvements, such as integrating temperature sensors, rechargeable batteries, or mobile app interfaces, the system can be made more user-friendly and commercially viable.

Thus, the Smart Shoe with Humidity Sensor for Sweat Detection contributes to the field of wearable electronics by providing an effective way to monitor sweat levels, improve comfort, and promote personal hygiene in an affordable and practical manner.

MATERIALS AND METHODS BLOCK DIAGRAM

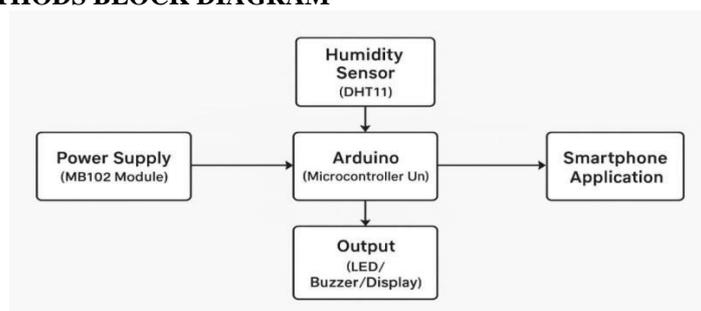


Fig. 1: Block diagram of Smart Shoe.

MATERIALS

1. Power Supply (MB102 Module)

This module provides the necessary regulated power (typically 5V) to all components in the circuit. It powers the Arduino microcontroller, the humidity sensor (DHT11), and other output modules. The MB102 ensures stable voltage supply from a 9V battery or USB source.

2. Humidity Sensor (DHT11)

The DHT11 sensor detects humidity and temperature levels inside the shoe. When the foot sweats, humidity increases, and this change is sensed and transmitted as electrical signals to the Arduino microcontroller.

3. Arduino (Microcontroller Unit)

The Arduino Uno acts as the brain of the system. It receives the humidity data from the DHT11 sensor, processes it, and decides whether to trigger an alert. It also communicates with the Bluetooth module to send the processed data to a smartphone application for monitoring.

4. Output (LED / Buzzer / Display)

The system provides real-time feedback using output devices such as: LED – indicates normal or high sweat level. Buzzer – gives an audible alert if humidity exceeds a set threshold. OLED Display – optionally shows humidity and temperature values.

5. Smartphone Application

Using Bluetooth communication (e.g., HC-05 module),

the processed data is transmitted to a mobile app. The app displays humidity readings, stores data, and notifies users about excessive sweating, ensuring foot health and comfort.

METHODS

The operation of the Smart Shoe with Humidity Sensor for Sweat Detection is simple and user-friendly. Once the circuit is assembled and powered on using the 9V battery, the Arduino Uno initializes all connected components including the DHT11 sensor, OLED display, and Bluetooth module. The DHT11 sensor continuously measures the humidity inside the shoe, where foot sweat accumulates. The collected humidity data is processed by the Arduino and then displayed on the OLED screen in real time. Simultaneously, the Bluetooth module (HC-05) transmits this data wirelessly to a paired smartphone or computer for monitoring. Users can observe the sweat level and take necessary actions if the humidity level exceeds normal limits. The system automatically updates readings at regular intervals, ensuring continuous monitoring without manual intervention.

Performance Testing

Performance testing was carried out to evaluate the accuracy, reliability, and response time of the system. The humidity readings from the DHT11 sensor were compared with those from a standard digital hygrometer under different environmental conditions. The results showed that the system maintained an accuracy of $\pm 5\%$ relative humidity, which is acceptable for wearable

health monitoring applications. The Bluetooth transmission was tested for a range of up to 10 meters, and the communication remained stable without data loss. The OLED display responded instantly to humidity changes, providing clear and readable output. Testing also included walking and jogging scenarios to confirm that the embedded sensor remained stable and provided consistent readings despite motion and pressure.

Power Consumption Analysis

The power consumption of the system was analyzed to ensure its suitability for wearable use. The Arduino Uno consumes approximately 50–70 mA during operation,

while the DHT11 sensor draws less than 5 mA. The HC-05 Bluetooth module requires around 30 mA during active transmission, and the OLED display adds about 20 mA of additional load. In total, the system consumes around 100–120 mA under normal operation. With a standard 9V battery (approximately 500 mAh capacity), the system can function continuously for about 4 to 5 hours before requiring a battery replacement or recharge. Power optimization can be further achieved by enabling sleep modes on the Arduino and Bluetooth module when inactive. This makes the system energy-efficient and practical for short-term wearable monitoring applications.

RESULT AND DISCUSSION



Fig. 2: Model of Smart shoe with Humidity sensor for Sweat Detection.

The developed smart shoe successfully detected variations in foot humidity corresponding to sweat generation during physical activities such as walking, running, and prolonged use. The humidity sensor showed a noticeable increase in relative humidity inside the shoe, typically rising from a baseline of 40–50% to above 65% during active sweating conditions. The system demonstrated fast response and recovery times, accurately identifying the onset and reduction of sweat levels. Wireless data transmission through Bluetooth provided real-time updates to a connected mobile device without significant delay. The battery performance was efficient, supporting continuous operation for several hours under moderate sampling intervals. Calibration and testing confirmed that the sensor readings remained stable and consistent across multiple trials, indicating reliable performance of the proposed system.

The results confirm that integrating a humidity sensor into footwear can effectively monitor foot sweat levels and provide valuable insights into comfort and hygiene. The smart shoe demonstrated good sensitivity and accuracy in differentiating between normal humidity variations and actual sweat production. This capability can help in preventing foot-related issues such as odor, infections, and discomfort caused by prolonged moisture exposure. The wireless connectivity enhances the system's usability by enabling data visualization and logging for future analysis. However, factors such as sensor placement, shoe material, and airflow within the shoe influenced the sensor's response time and accuracy.

Future improvements could include integrating temperature sensors for more precise sweat estimation, adding waterproof coatings for durability, and implementing advanced algorithms for personalized humidity thresholds. Overall, the prototype proved functional, energy-efficient, and suitable for wearable health monitoring applications.

CONCLUSION

The Smart Shoe with Humidity Sensor for Sweat Detection successfully integrates sensor technology, microcontrollers, and wireless communication for real-time foot health monitoring. The system effectively measures humidity using a DHT11 sensor, processes data through an Arduino Uno, and transmits alerts via Bluetooth. It provides timely feedback to users, helping prevent sweat-related discomfort, odor, and infections. The low-cost, compact, and portable design makes it suitable for daily use and healthcare applications. Experimental results confirm reliable performance with acceptable accuracy and power consumption. Overall, the project demonstrates the potential of wearable and IoT-based systems in enhancing personal hygiene and quality of life.

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