JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

# EARLY DETECTION OF DIABETES AND BONE DISORDERS

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**ABSTRACT-** The majority of individuals nowadays suffer from diabetes and bone abnormalities, two global illnesses that are detrimental to human health. These disorders will bring us a lot of issues because they make it difficult for us to perform our daily responsibilities efficiently. A calcium deficiency results in bone illnesses, which in turn create joint pains; diabetes produces fatigue and other symptoms that need additional medical treatment; and a number of other bone-related health problems. As a result, there is only one way to diagnose diabetes. In other words, measuring a person's blood sugar levels before and after meals can assist detect bone disorders and determine whether or not they have diabetes. Common techniques used for bone disorders are x-rays, CT scans, and MRI scans. The proposed solution for diabetes and bone disorder is to measure temperature, humidity, pressure, angle, and flex in order to identify the conditions early. The pressure is measured from the person's foot using a piezoelectric sensor, the temperature and humidity are measured from the index finger of the hand using a DTH11, the angle is taken from the foot joint using an MPU6050 sensor, and the flex is taken from the foot using a flex sensor. After that, the data is fed into the KNN algorithm, which is used to predict an individual's health more accurately and identify whether they are healthy or at getting diabetes or other bone disorders. The findings will be shown on the HTML, CSS, and Java script-developed website

***Key Words*:** Diabetes, Bone disorders, Calcium deficiency, Joint pains, Blood sugar levels, Diagnosis, Early detection, Piezoelectric sensor , DHT11 sensor, MPU6050 sensor, Flex sensor, KNN algorithm, , Real-time detection, Health monitoring.

## INTRODUCTION

A prominent consequence of rheumatoid arthritis (RA) is foot ulceration, which affects 10–13% of patients and is recurring in 47% of cases. The aetiology of foot ulceration in RA is still poorly understood, in contrast to diabetic foot ulcers, whose risk factors are well established. Peripheral neuropathy, vascular disease, and elevated plantar pressure are frequently associated with diabetic foot ulcers; however, these variables might not adequately account for ulcer development in RA patients. In order to improve preventative and management options, this study attempts to identify important predictors of foot ulceration in RA patients without diabetes.

A multi-centre case-control study was carried out in eight UK locations, involving 100 cases (RA patients with foot ulcers) and 200 controls. Clinical evaluations comprised sensory testing, diagnosis of foot deformities, and measurement of the ankle-brachial pressure index (ABPI). Significant factors, including aberrant ABPI, foot abnormalities, and loss of sensation, were found by statistical modeling. Furthermore, because corticosteroid use weakens the skin and slows its healing, it has been linked to an increased risk of ulcers.

The results highlight the necessity of patient education and foot care tailored to RA in order to improve early detection and prevention.

Furthermore, gait analysis was investigated for both security and medical applications. Using image processing, speech recognition, and movement pattern analysis, biometric gait recognition was employed for surveillance in order to spot questionable activity. Through customized gait profiling, a smart shoe system was used in healthcare to examine alcohol-induced changes in gait, improving detection accuracy. By tracking variables like step length, stride length, cadence, and joint angles, it became clear how alcohol impacts coordination and muscle reaction. Both studies emphasize the significance of specialized monitoring approaches, including RA foot ulcer prevention through improved care strategies and Gait Analysis for security and medical diagnostics.

## RELATED WORK

***Title***

Early Detection of Diabetics Foot Ulcer

***Authors***

V. G. Sangam, S. Hema Priyadarshini

**Publication:** 2021 Journal of Physics Conference Serial Number 1937 012049

## DESCRIPTION:

The study on diabetic foot ulcers (DFU) and early diabetes identification emphasizes the significance of tracking changes in temperature, blood flow abnormalities, and plantar pressure distribution. A well-known method incorporates several sensors for ongoing foot health monitoring and incorporates Tekscan Gait Analysis into a smart in-shoe device. Real-time plantar pressure distribution is recorded by the Tekscan Gait Analysis system, which identifies aberrant pressure points in high-risk regions like the metatarsal heads and heels. Since stride length, gait asymmetry, and abnormalities in foot movement patterns are powerful markers of the advancement of diabetic neuropathy, which raises the likelihood of developing DFU, they are examined. Early detection of high-risk diseases and prompt action before complications worsen are made possible by monitoring these markers.

Temperature sensors such as TMP35 and SHT1x have also been utilized to detect early signs of tissue injury and inflammation. The TMP35 sensor is renowned for its precision in temperature measurement, whereas the SHT1x sensor provides real-time temperature and humidity readings. Prolonged high temperatures in specific foot regions have been associated with pressure-related injuries and inflammation, which are early indicators of DFU formation. The ongoing monitoring provided by these sensors reduces the risk of ulcers and assesses foot health.

Photoplethysmography (PPG) sensors have been used to assess blood flow irregularities since impaired circulation in diabetic individuals is a significant contributing factor to delayed wound healing and an increased risk of infection. The technology uses machine learning algorithms that look at movement patterns, temperature variations, and abnormalities in blood flow to generate a risk score. If high-risk signs are discovered, the technology notifies patients and healthcare practitioners via a clinician dashboard or mobile application, ensuring timely medical intervention and preventive measures.

The study offers a real-time, non-invasive monitoring approach for DFU prevention and early diabetes detection using Tekscan Gait Analysis, TMP35, and SHT1x sensors. Combining blood flow evaluation, temperature monitoring, and plantar pressure analysis provides a thorough and proactive approach to diabetic foot care that enhances patient outcomes and lowers healthcare costs.

## EXISTING SYSTEM:

Diabetes and diabetic foot ulcers (DFU) are detected early using Tekscan Gait Analysis in conjunction with sensor- based monitoring. In order to identify anomalies in high-risk regions like the metatarsal heads and heels, the Tekscan Gait Analysis system, which is integrated into a smart in-shoe system, records the plantar pressure distribution in real-time. By examining stride length, gait asymmetry, and foot movement abnormalities, this aids in the early detection of neuropathy and foot ulcer risk.

Temperature sensors such as TMP35 and SHT1x are also used to track localized variations in foot temperature, identifying tissue stress and inflammation before ulcers develop. Because inadequate perfusion raises the risk of ulceration, photoplethysmography (PPG) sensors measure blood circulation. The device creates a risk assessment by analyzing blood flow, temperature, and gait data using machine learning algorithms. Alerts are given to patients and physicians in the event that high-risk markers are found, guaranteeing prompt intervention and the avoidance of DFU.

## DRAWBACKS:

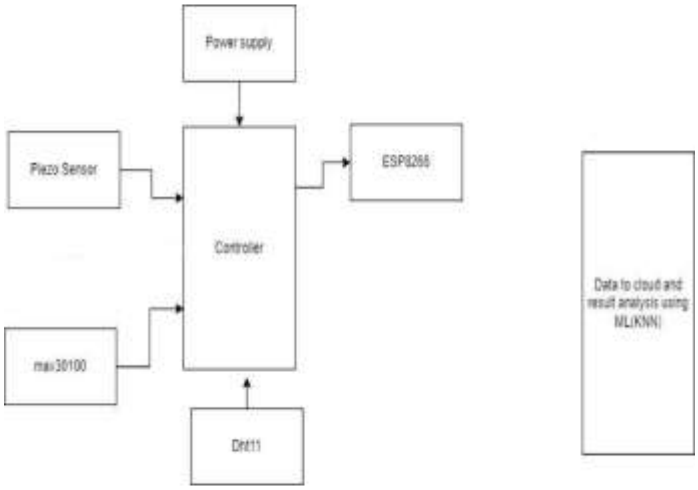
The accuracy of early detection is limited by the sensor-based monitoring system and Tekscan Gait Analysis. Although it can accurately identify changes in temperature, blood flow abnormalities, and plantar pressure, it could miss minor indications of diabetic neuropathy in its early stages. Intervention may be delayed if patients with moderate or erratic symptoms are not diagnosed. Inaccurate training data might result in false positives or negatives, which compromises the reliability of diagnoses. Furthermore, machine learning algorithms depend on high-quality datasets. The system's high cost and accessibility provide another difficulty. Healthcare settings with limited resources cannot afford the specialized technology and trained personnel needed to implement Tekscan Gait Analysis, TMP35, and SHT1x sensors. Due to lag in recognizing high-risk conditions caused by sensor calibration and data processing, real-time feedback restrictions may also postpone medical intervention.

There are also issues with wearability and patient compliance. Accurate monitoring necessitates regular and appropriate use of the in-shoe system; nevertheless, data accuracy may be impacted by discomfort, improper positioning, or user carelessness. Environmental elements that can further affect sensor performance and produce inconsistent readings include humidity, temperature swings, and footwear differences. The system's impact on comprehensive diabetes treatment is further limited by its inability to seamlessly integrate with other diabetic management tools, such as insulin pumps and continuous glucose monitors (CGMs). It does not offer a comprehensive strategy for managing diabetes, despite its emphasis on foot health. Its incapacity to integrate with larger healthcare monitoring systems diminishes its efficacy in preventing diabetic foot issues in a comprehensive manner.

**PROPOSED SOLUTION:**

The proposed method, which incorporates numerous sensors, a microcontroller, wireless connectivity, and machine learning-based analysis, is intended to detect diabetes complications and bone diseases early. The early detection of possible health hazards is made easier by this system's ability to monitor important physiological markers and gait patterns in real-time.

The device uses a piezoelectric sensor to monitor the distribution of foot pressure, which is essential for identifying aberrant stress spots associated with diabetic foot ulcers (DFU) and neuropathy-related abnormalities in gait. In order to evaluate mobility impairments, the MPU6050 sensor, which consists of a gyroscope and an accelerometer, also measures stability, angular displacement, and foot movement. Since environmental conditions have a substantial impact on foot health, especially in diabetic individuals who are more susceptible to infections and skin issues, the DHT11 sensor is utilized to measure temperature and humidity.




**MERITS:**

A real-time, non-invasive monitoring system for early detection of bone abnormalities and diabetic consequences is provided by the suggested solution. It improves patient care, accessibility, and accuracy by leveraging wireless connectivity, sensor-based technology, and machine learning. This system's main advantages are as follows:

- Early Detection & Prevention – Enables real-time monitoring to identify diabetic complications and bone disorders before they worsen.
- Non-Invasive & Comfortable – Uses sensors for painless, continuous health tracking, eliminating invasive procedures.
- Machine Learning-Based Analysis - The KNN algorithm guarantees accurate risk prediction and prompt medical action.
- Wireless & Remote Monitoring – ESP8266 Wi-Fi enables cloud-based data access for patients and healthcare providers.
- Comprehensive Multi-Sensor Integration – Piezoelectric, MPU6050, and DHT11 sensors provide a detailed foot health assessment.
- Cost-Effective & Scalable – Because it is less expensive than MRI scans or X-rays, it can be used widely.
- Automated & Continuous Monitoring – Reduces frequent hospital visits, saving time and resources.
- User-Friendly & Low Maintenance – Wearable smart insole design ensures ease of use with minimal upkeep.
- Improves Patient Outcomes – Facilitates early diagnosis, remote care, and better mobility, enhancing quality of life.

**MODULE DESCRIPTION:**

A structured system that combines cloud connectivity, machine learning analysis, and various sensors enables the early diagnosis of bone problems and diabetic consequences. The following essential modules comprise the detecting process:

1. Sensor Activation and Data Gathering Module:
   This module sets up and uses a number of sensors to gather motion and physiological data in real time:
   - MPU6050 (Accelerometer and Gyroscope): Measures X, Y, and Z motion to aid in gait analysis

and neuropathy identification.
- DHT11 (Temperature & Humidity Sensor): Monitors temperature changes to detect early signs of inflammation
- Flex Sensor: Tracks joint motion and flexibility to detect limits in mobility.
- Piezoelectric Sensor: Detects plantar pressure distribution, identifying high-risk locations for ulcer formation.

2. Cloud Communication Module:

The sensor data is sent for remote processing after it has been gathered:
- The ESP8266 Wi-Fi module is used to deliver real-time data to the cloud.

3. Data Processing:

Sensor data is processed and arranged for analysis by this module:
- Validates, cleans, and organizes sensor data.

4. Machine Learning Classification Module:

This module uses the K-Nearest Neighbors (KNN) algorithm to evaluate sensor data:
- Recognizes patterns that correspond to diabetic foot issues and bone anomalies.
- Determines risk level by comparing real-time patient data to learned models.
- KNN's distance-based categorization is used to accurately predict potential health risks.

5. Results Module:

The last module provides users with useful
- A web dashboard shows the results.

***HARDWARE DESCRIPTION:***

Our system uses a microprocessor, wireless communication technology, and several sensors to enable early identification of bone problems and diabetic consequences. In order to ensure real-time monitoring and risk assessment for diabetic patients, each component is essential to the collection, processing, transmission, and analysis of data.

1. Buck Converter (DC-DC Step-Down Voltage Regulator)

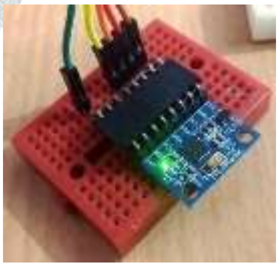
To maintain a steady voltage supply, power distribution to all components is controlled by the Buck Converter. It protects delicate devices like the NodeMCU, MPU6050, and DHT11 sensors by converting excessive DC voltage to a lower voltage. By lowering heat dissipation and extending battery life, it also improves energy economy and increases system dependability for continuous operation.

2. NodeMCU (ESP8266 Wi-Fi Module - Microcontroller)

The microcontroller and wireless communication unit is the NodeMCU (ESP8266). It uses its integrated Wi-Fi module to gather and interpret real-time sensor data before sending it to the cloud. In IoT-based remote health monitoring, the NodeMCU is essential because it allows patients and medical professionals to obtain real-time foot health data from any location.

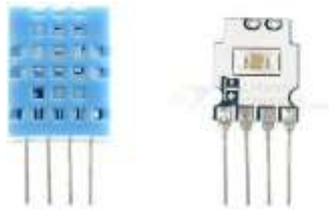
3. MPU6050 Sensor (Accelerometer & Gyroscope for Motion Tracking)

The MPU6050 sensor tracks gait patterns, balance, and foot movement. It has a gyroscope and accelerometer. It records motion data in the X, Y, and Z axes, which aids in locating abnormalities in stability and gait. Diagnosing diabetic neuropathy and mobility limitations is essential since these conditions frequently result in consequences like foot ulcers.



4. DHT11 Sensor (Temperature & Humidity Monitoring)

As temperature and humidity have a big influence on diabetic foot health, the DHT11 sensor is utilized to monitor these variables. While high humidity levels may exacerbate skin infections, an elevation in the local foot temperature may be a sign of inflammation or tissue damage. Foot ulcers can be prevented and detected early with the help of monitoring these indicators.



5. Flex Sensor (Joint Movement & Flexibility Monitoring)

The Flex Sensor is an essential tool for evaluating bone health and mobility since it detects joint movement and foot flexibility. It identifies stiffness or limited mobility, which in diabetic individuals may be an early indicator of musculoskeletal problems. Additionally, the sensor aids in posture evaluation, guaranteeing that foot mechanics are operating as intended.

6. Piezoelectric Sensor (Plantar Pressure Measurement)

The Piezoelectric Sensor measures plantar pressure, which is crucial for detecting incorrect weight distribution and ulcer formation hazards. It enables real-time foot pressure analysis by converting mechanical pressure into electrical information. This ensures early preventive therapy by assisting in the identification of high-pressure areas that are vulnerable to ulcers.

7. Integration and System Functionality

These elements all cooperate to make cloud-based processing, machine learning analysis, and real-time data collection possible. To forecast any health hazards, the NodeMCU processes the sensor data, sends it over Wi-Fi, and uses a KNN-based machine learning model to assess it. Early intervention and preventative care are therefore made possible by the results being shown on a web dashboard or mobile app.

**SOFTWARE DESCRIPTION:**

Software Components Used in Our System:

Our system's software is essential for programming, data collection, transmission, processing, and analysis in order to identify diabetic complications and bone problems early.

1. Arduino IDE & Sketches

The Arduino Integrated Development Environment (IDE) is used to create, develop, and upload sketches that interface with hardware components. These drawings, saved as.ino files, make use of built-in and custom libraries to efficiently process sensor data from MPU6050, DHT11, Flex, and piezoelectric sensors.

2. Data Transmission & Communication

The ESP8266 Wi-Fi module enables wireless data transfer to the cloud and remote access to sensor information. The Serial Monitor in the Arduino IDE facilitates real-time debugging and monitoring of sensor values, resulting in smooth data collection and validation.

3. Machine Learning Analysis with KNN

The K-Nearest Neighbour's (KNN) algorithm is used to interpret sensor data, classify the risk levels of bone problems and diabetes complications, and compare real-time readings with pre-trained datasets. Early detection and prompt intervention are guaranteed by our predictive model.

4. Python for Data Processing & Visualization

Data preprocessing and visualization are done using Python (v3.7) and modules such as NumPy, Pandas, and Matplotlib.This increases forecast accuracy, allowing for more effective analysis and decision-making.

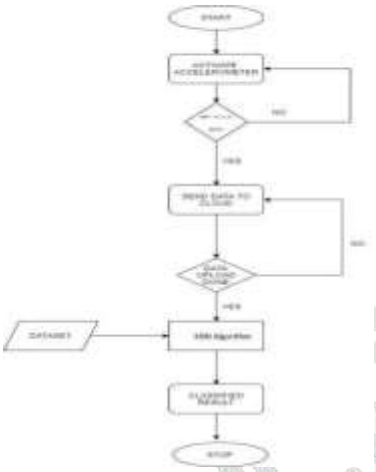
5. User Interface & Cloud Integration

The final results are shown on a mobile application or web dashboard, enabling patients and healthcare professionals to monitor them remotely. When anomalous sensor readings are found, automated alarms and messages are produced to guarantee timely medical attention.

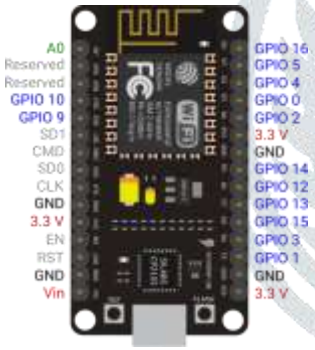
**IMAGE LABELING AND DATASET DISTRIBUTIONS:**

A popular Wi-Fi-enabled microcontroller for sensor-based and Internet of Things applications is the ESP8266 NodeMCU. It has a single analog pin (A0), several GPIO (General Purpose Input/Output) pins, and integrated communication interfaces such as SPI, I2C, and UART.

The board runs at 3.3V, and Vin can accept power inputs between 5V and 12V. It features dedicated SPI and I2C pins for attaching external devices, such as sensors and displays, as well as TX (GPIO 1) and RX (GPIO 3) for serial communication. While GPIOs 9 and 10 are set aside for flash memory, GPIOs 0, 2, and 15 are involved in boot mode selection. The FLASH button aids in firmware updates, whereas the RST button resets the board.




The ESP8266 NodeMCU is perfect for wireless data transfer, home automation, and real-time Internet of Things applications because of its Wi-Fi functionality, several GPIOs, and support for sensor interfaces.




1. Dataset Description

The dataset employed in our approach consists of specified features that allow for the early diagnosis of diabetic complications and bone problems. These characteristics, which are gathered from various sensors and mapped to predetermined result categories for classification, include pressure, temperature, humidity, angle, and flex.

2. Features in the Dataset

A piezoelectric sensor is used to gather pressure data, which aids in locating high-pressure areas on the foot that may be a sign of a higher risk of developing foot ulcers. The DHT11 sensor records temperature and humidity, which track unusual changes in temperature and moisture content. These measurements are essential for identifying infections, inflammation, and skin-related issues. The MPU6050 accelerometer and gyroscope were used to record the angle feature, which examines foot movement and gait patterns to identify abnormal postures and mobility problems. By measuring joint stiffness and movement, the flex sensor can reveal early indicators of bone problems and mobility limitations.

3. Predefined Results for Classification

In order to classify patients into various health states, such as healthy, at-risk, or impacted by diabetic foot problems, the dataset has preset labels. The K-Nearest Neighbors (KNN) algorithm can precisely classify and forecast the risk levels of diabetic complications thanks to this structured data

## RESULTS:

The system analyzes real-time sensor data and compares it with a predetermined dataset to predict the likelihood of early-stage diabetes and bone problems using the K-Nearest Neighbors (KNN) model. Sensors built within the device continuously collect vital physiological characteristics, such as pressure, temperature, humidity, joint angle, and flex. These metrics aid in the early detection of abnormalities in foot health and mobility, which are frequently suggestive of bone diseases such osteoporosis, osteoarthritis, and joint stiffness as well as issues associated to diabetes.

The method analyzes changes in these variables to determine if a person is at risk, normal, or exhibiting early signs of bone diseases or diabetes. By ensuring that diabetes and bone abnormalities are identified early on, this non- invasive, continuous monitoring device lowers the risk of serious side effects including neuropathy, foot ulcers, joint degeneration, or mobility difficulties. The strategy improves patient outcomes, reduces hospitalization risks, and permits proactive medical care by using machine learning-based prediction, thereby raising the standard of living for those who are at risk.


**CONCLUSION AND FUTURE WORK:**

In order to continually monitor the distribution of plantar pressure in diabetic patients, this team created a wireless device that uses a pressure-sensitive conductive rubber sensor. By giving real-time input on foot pressure, the technology, which is intended for use in clinics, research labs, and other settings, helps avoid diabetic foot ulcers, which are caused by extended high-pressure zones on the foot.

Through an easy-to-use interface, the pressure distribution is examined, and the system notifies users when anomalous pressure levels suggest a high risk of ulcer development. A decompression insole can subsequently be adjusted to redistribute pressure, specifically by removing hexagon-shaped modules close to the high-pressure area. By assisting in the restoration of normal pressure levels, this adaptive mechanism considerably lowers the risk of ulceration and skin injury.

The accuracy of the system's risk assessment is improved by machine learning techniques, especially the K-Nearest neighbour’s (KNN) classifier. High accuracy in clinical classification trials indicated the possibility of real-time diabetic foot monitoring. Diabetes patients' quality of life is improved, hospital visits are decreased, and diabetic foot care is improved by this technology, which makes continuous assessment, early warnings, and preventive treatments possible.

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