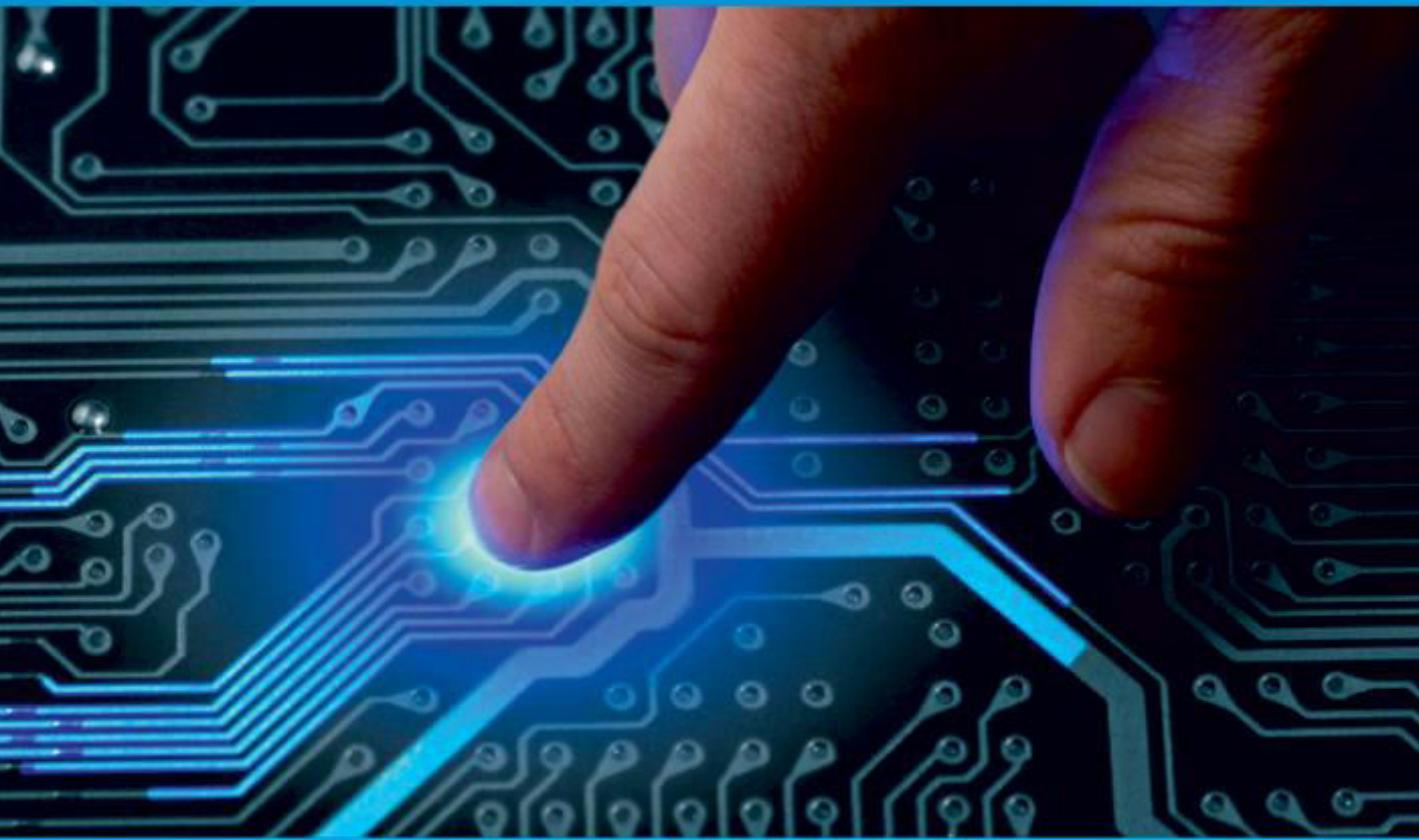
e-ISSN: 2320-9801 | p-ISSN: 2320-9798



INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN COMPUTER & COMMUNICATION ENGINEERING

Volume 12, Issue 8, August 2024

INTERNATIONAL STANDARD SERIAL NUMBER INDIA

Impact Factor: 8.625

www.ijircce.com | e-ISSN: 2320-9801, p-ISSN: 2320-9798| Impact Factor: 8.625| ESTD Year: 2013|

International Journal of Innovative Research in Computer and Communication Engineering (IJIRCCE)

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)

Diabistep Care- A Smart Insole

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ABSTRACT: aimed at improving diabetic foot care . This innovative insole integrates advanced sensors to keep an eye on important metrics such as pressure points and temperature levels in real-time. Paired with a convenient mobile device app, it provides continuous updates, empowering both users and healthcare providers with essential foot health information. This wearable device offers a proactive approach to managing foot-related complications in diabetic patients, potentially reducing risks and enhancing overall well-being. Gait analysis using smart sensor technology is a crucial medical diagnostic process with applications in rehabilitation, therapy, and exercise training. This paper presents a low-cost wireless smart insole system for analyzing different functional postures and gait characteristics while walking. The system includes an insole equipped with six pressure sensors and a temperature sensor, along with a Bluetooth communication for the greater system for data transmission collection using a smartphone in any environment. The proposed portable sensing system, coupled with an efficient low- power communication algorithm, enables detailed gait analysis. Experimental verification on multiple subjects with different gait patterns, including free gait, demonstrates the dormant of the system. The sensor outputs and the results of the gait analysis are presented in this paper.

KEYWORDS: smart insole, diabetes, Bluetooth communication.

I. INTRODUCTION

Diabetes can significantly impact a patient's gait cycle, leading to various consequences. Peripheral neuropathy, a common complication of diabetes, can cause numbness, tingling, and muscle weakness in the feet, affecting balance and coordination during walking. Additionally, diabetic foot ulcers and infections can result in altered gait patterns as patients try to avoid putting pressure on affected areas. With time, these modifications can increase the chances of falls and injuries, further complicating the oversight of diabetes.

Globally, diabetes affects approximately 422 million individuals, with this figure expected to rise to 642 million by 2040[1].Diabetic foot complications, including ulcers and infections, are a leading cause of hospitalization and lower limb amputations among diabetes patients, contributing to significant healthcare costs and reduced life quality.

The Diabistep Care project aims help the patient overcome with these issues by offering a proactive approach to foot care for diabetic patients. By integrating advanced sensors into a wearable insole, the project enables continuous monitoring of pressure points and temperature levels, crucial for early detection of foot issues. This real-time monitoring, coupled with a user- friendly smartphone app, empowers both patients and healthcare providers with vital foot health information, allowing for timely intervention and personalized care. Ultimately, the Diabistep Care project seeks to reduce the possibility of foot-related complications, improve overall well-being, and enhance the quality of living for those whoare diabetes.

Gait analysis is process used to collect quantitative information to comprehend the cause of gait abnormalities and aid in treatment decision-making. This process often involves specialized technology, such as computer-interfaced video cameras, electrodes present on the skin to monitor muscle activity, and force platforms in walkways to measure forces between the patient and the ground. Methodical gait analysis involves analysing sensor patterns while walking and has applications in medical programs like physical therapy and sports training. For instance, therapists may employ detailed gait analysis to quantify rehabilitation progress after surgery and tailor treatment accordingly. Gait analysis is typically

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conducted in a motion laboratory with precise tracking sensors present an office with visual observations, with the former being more costly and the situated less so but requiring more time and expertise.

Shoe-based gait analysis systems are increasingly replacing standard procedure for monitoring gait abnormalities and collecting quantitative information. Wearable sensors mounted on shoes utilized for activity monitoring, gait analysis, and post-stroke rehabilitation. Smart-shoe systems with smartphone-based gait monitoring are gaining popularity in both research and the commercial market. These systems use integrated smartphone sensors along with pressure sensors in the shoe to monitor activities without disrupting the user's normal routine. However, the need for low-energy communication systems for longitudinal studies of gait analysis using smartphones.

Recent advances in mobile technology have made smartphones powerful tools for gait monitoring [2]. Smartphone-based systems can function almost anywhere, as they are highly portable and can integrate with users' daily lives. Smartphones now come fitted with a range of sensors, such as accelerometers, gyroscopes, and GPS, which, when combined with pressure sensor shoes, enhance the capabilities of smart-shoe systems. The challenge lies in designing a low-energy communication system for efficient gait analysis using smartphones, especially for long-term monitoring studies.

II. RELATED WORK

This research aimed to quantify the annual levels of health care resource utilization and treatment patterns pertaining to the management of diabetic foot ulcers (DFUs) used clinical practice by the National Health Service (NHS) of the United Kingdom (UK), along with the associated costs of patient management. This study involved a retrospective cohort examination of 130 patients' medical records from The Health Improvement Network (THIN) database who has been noted with DFU recently. Quantification of patient characteristics, health outcomes connected to wounds, and utilization of medical resources was done. The entire cost of patient management for the NHS was estimated based on pricing from 2015 to 2016 [1]. With a prevalence of between 12 and 15 percent among all diabetics, foot ulcers are the most prevalent medical consequences encountered in patients with the disease. More cases than any other diabetes complication end up in hospitals when they have diabetic foot ulcers. Since ulcerations account for up to 90% of lower extremity amputations in persons with diabetes, they can have disastrous consequences. Therefore, it is crucial for the early detection of diabetic foot ulcers in patient. This paper's primary objective is to develop a wearable Smart Sole-based forecasting system that can compute plantar pressure in real time at various key foot areas and provide physicians with the information they need to make the necessary decisions based on other clinical data [2]. To demonstrate how a diabetic foot ulcer (DFU) prevention device could contribute to the cost- effective management of patients who are at more risk of recidivism Techniques: At three and eighteen months after DFU closure, decision tree models were utilized to assess the chance of clinical outcomes and related expenditures, comparing standard of care (SOC) with the utilization of Surro Sense Rx® as an adjunct to SOC**.** The study's inputs were from a prospective cohort of twenty patients who had suffered (within the last twelve months) had DFU. The third- party payer viewpoint were utilized for the analysis, and expenses were expressed in US dollars for the year 2017 [3]. Among the most costly and incapacitating consequences of diabetes are the common but long-ignored diabetic foot ulcer (DFU) and its associated complications. The DFU is complicated to manage and needs ongoing observation from patients, caregivers, and medical professionals. Our approach to care and the language used in medical literature need to adapt in light of the startlingly high rates of ulceration recurrence in diabetic feet. Our focus should be on maximizing the number of days the patient is free from ulcers while in diabetic foot remission, in addition to the healing of open sores. The growing advancement and integration of technology into many facets of our existence offers a chance for innovative approaches to avert or more effectively handle this debilitating illness. Specifically, current developments in wearable and mobile health technology seem to have potential in monitoring and controlling hazardous foot pressure and inflammation to prolong remission and enhance these patient well being . In order to better treat and prevent DFUs, this review paper examines how wearables and digital technologies might be employed to identify high- risk patients for triage and prompt intervention, customize offloading prescriptions, and increase adherence to protective footwear. Though they are still in their infancy, we envision a future network of skin-worn, jewelry-worn, and implantable sensors that could have a significant impact on foot ulcers (DFU), causes loss of protective feeling and is associated with very high plantar pressures. The goal of DFU preventive techniques is to lower these elevated plantar pressures. Nevertheless there are a several of limitations to the evidence that supports the connection between plantar pressure and DFUs, which could

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account for the poor prediction accuracy found in prospective studies. Most research measures the vertical, as opposed to the shear, barefoot plantar pressure in lab Minimum frequency of alerts—one every two hours—are necessary [6] . Peripheral neuropathy, the primary factor for diabetic settings as opposed to in real-world activities. Previous DFU location- specific pressure was not well studied [7] . With Peak foot pressure reliability in individuals with a background of diabetic foot ulcers, Yong-Hao Pua c, Pui-Wah Kong b, and Pei-Yueng Lee a, 2019. Prior research on the consistency of highest plantar pressure measurement in patient with a history of diabetic foot ulceration (DFU) did not classify the results of their analysis drawing from the presence of a prior ulcer on the foot. Does the test-retest reproducibility of peak foot pressure readings from different foot area differs between feet that have ulcers and those that do not Techniques. In this test the reliability comparison study, data from 23 people with a healed plantar DFU and peripheral neuropathy were analyzed. With a mean interval of 7 days (SD = 1.6) Across two sessions, plantar pressure was recorded using the Pedar®-X in-shoe system in a test- retest reliability comparison study involving 23 people with cured plantar diabetic foot ulcers (DFU) and the fringe neuropathy. The mean interval between session was 7.2 days (SD = 1.6). The study aimed to assess the reproducibility of peak foot pressure measured at different foot area in the middle of feet with prior ulcers and those without. The same class correlation coefficient (ICC) and their coefficient of variation (CV) obtained were preconceived for regions with ten feet. Overall, the test-retest reliability was excellent for all peak pressure variables (ICCs,0.82 to 0.95). However, in the ulcer infected foot, the CV obtained was greater than 15% over the medial forefoot and hallux regions (18.3% and 16.4%, respectively), ranging from 6.3% to 18.3%. The obtained hallux peak pressure CV was considerably higher than the ulcer foot compared to the non-ulcer foot (5.7%, 95% CI, 1.7%–10.2%). Peak pressure CV also tended to increase over the forefoot relative to the ulcer foot (lateral forefoot: 4.1%, 95%CI, -0.7%–11.1%; medial forefoot: 6.1%, 95% CI, - 0.5%–14.5%). The study suggests that peak plantar foot pressure measurements may be helpful in differentiating between patient groups with healed plantar DFU and those with peripheral neuropathy. However, caution should be exercised when interpreting clinical judgments based on ulcer foot hallux and forefoot peak pressure measures. Across two sessions, the study computed the intraclass correlation coefficient (ICC) and coefficient of variation (CV) for regions with ten feet. The test-retest reliability for all peak pressure variables was excellent overall (ICCs, 0.82 to 0.95). However, in the ulcer foot, the CV was higher than 15% over the medial forefoot and hallux regions (18.3% and 16.4%, respectively), ranging from 6.3% to 18.3%. Compared to the non-ulcer foot, the hallux peak pressure CV was considerably greater (5.7%, 95% CI, 1.7%–10.2%) over the ulcer foot. Peak pressure CV over the forefoot also tended to increase relative to the ulcer foot (lateral forefoot: 4.1%, 95%CI, - 0.7%–11.1%; medial forefoot: 6.1%, 95% CI, -0.5%–14.5%). Peak plantar foot pressure may be helpful in differentiating between patient groups with healed plantar DFU and those with peripheral neuropathy. However, care has to be taken when interpreting clinical judgments based on ulcer foot hallux and forefoot peak pressure measures

III. METHODOLOGY

The methodology diagram depicts the hardware and communication designing of the smart insole system designed for monitoring plantar pressure and temperature. Here's a detailed explanation of each component and their interactions:

1. Pressure Sensor

Measures the plantar pressure at six major points on the foot. Outputs from the pressure sensors is connected to analog input pins (A0, A1, and A2) of the ATmega2560 microcontroller.

2. Temperature Sensor :

Monitors the temperature of the foot, which helps in identifying potential inflammation or other abnormalities.
The obtained output from temperature sensor is connected to analog input pins (A11 and A12) of the ATmega2560 microcontroller.

3. ATmega2560 Microcontroller :

Function: Serves as the central processing unit of the system, responsible for collecting data from the sensors, processing it, and transmitting it. Receives a 12V power supply which is regulated to the required voltage levels for the sensors and the microcontroller. Analog input pins A0, A1, A2 (for pressure sensors), and A11, A12 (for temperature this data, and prepares it for transmission. Utilizes Tx sensor) are used to gather data from the sensors. Converts the analog signals from the sensors into digital data, processes (transmit) and Rx (receive) pins for communication with the Bluetooth module.

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4. Bluetooth Module (HC-05) :
Facilitates wireless communication between the ATmega2560 microcontroller and mobile devices. The Rx (receive) and Tx (transmit) pins of the HC-05 module are connected to the corresponding Tx and Rx pins of the ATmega2560 microcontroller. Receives processed data from the microcontroller and transmits it to the mobile devices via Bluetooth.

5. Mobile Devices :
Serve as the user interface for the smart insole system. Connects to the Bluetooth module to receive real-time data. Displays real-time plantar pressure and temperature data to user. It may also provide alerts and store historical data for further analysis.

The methodology diagram outlines a clear flow of data starting from the sensors, which measure plantar pressure and temperature, through to the microcontroller (ATmega2560) that processes this data. The processed data is then transmitted wirelessly via the HC-05 Bluetooth module to mobile devices, where it can be monitored in real-time by the user. This architecture ensures efficient, real-time monitoring of foot health parameters, aiding in the early detection and prevention of diabetic foot complications.

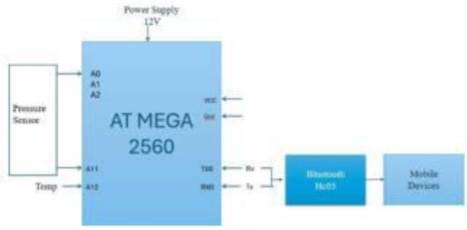

FIGURE 1 BLOCK DIAGARM.

The algorithm automatically generates mask image without user interaction that contains only text regions to be inpainted. arrive at 80% of the elderly population by 2020 [4]. Smartphones have become integral to daily life, functioning as personal computers in a portable form [3]. The combination of smartphones and smart-shoe technology is increasingly used for gait analysis research, indicating a need for upcoming investigations to develop new, energy-efficient systems with extended battery life [3].

Scenario 2 illustrates the impact of gait abnormalities on individuals, such as Alex, a 70-year-old experiencing a "spastic gait abnormality." This condition has led to multiple accidents due to his unbalanced walking, requiring frequent visits to a gait lab for assessment [3]. LPcomS could significantly benefit individuals like Alex by identifying unbalanced gait patterns over an extended period, allowing for a more independent and normal life [3].

These challenges, a smartphone-based low-energy gait analysis system using smart-shoe technology is proposed. This system aims to prevent gait-related injuries and ensure a long-lasting connection among mobile devices, healthcare applications, and smart-shoe systems [3]. Initially, a Wi-Fi module was considered for wireless data collection, but due to higher battery consumption, LE Bluetooth was selected for its low-power consumption . The research is intended to be compatible with both iOS and Android , utilizing the Core Bluetooth framework for iOS and standard Bluetooth for Android .

In conclusion, LPcomS offers a cost-effective and user- friendly solution for gait analysis, replacing the need for costly laboratory equipment and dedicated staff. It provides flexibility and freedom for elderly individuals to engage in daily activities while their gait is monitored, without the discomfort of wearing body markers. The low- power communication module ensures longer battery life and increased sampling rate for longitudinal gait monitoring [3].

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IV. EXPERIMENTAL RESULTS

Data acquisition plays a central role, involving the assortment of data from subjects during walking trials. After then, this data is processed to generate detailed maps of temperature and pressure, providing valuable insights into foot health and potential complications. A comprehensive framework is designed to encompass all aspects of the smart foot sole system, including sensor integration, multiplexing, communication, and data logging. This ensures a cohesive and functional device capable of reliable performance. Real-time monitoring is emphasized, enabling prompt interventiocase of detected abnormalities. Additionally, There's a focus on potential benefits with artificial intelligence to enhance diagnostic capabilities and enable early identification of foot complications.

Efforts are made throughout the implementation to grow a low-cost and portable solution, making the device accessible for widespread use and remote health monitoring, particularly benefitted for individual with limited access to healthcare facilities. Overall, the implementation strategy is designed to create a practical, accessible, and effective foot monitoring device, addressing key aspects such as sensor selection, data processing, and real-time monitoring to improve foot health management, especially for people with diabetes.

This paper provides an in-depth examination for developing a smart insole system aimed at monitoring temperature and plantar pressure to detect difficulties related to diabetic feet early. It underscores the importance of wearable sensor systems in healthcare, proposing an innovative solution that integrates readily available sensors for dynamic measurement. Throughout the study, it meticulously outlines the procedure of sensor selection, characterization, and system framework development. Notably, it highlights the potential of the suggested remedy for real-time monitoring, offering prompt diagnosis of foot-related issues. This research significantly advances wearable sensor technology in healthcare, offering hope for enhancing the standard of living for people susceptible to foot complications, particularly those with diabetes.

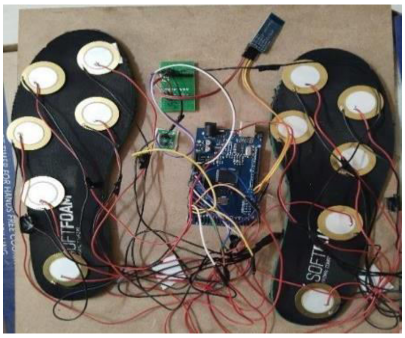
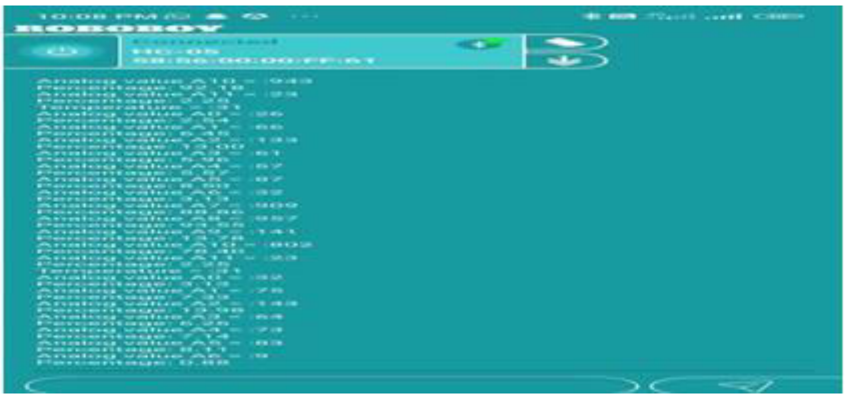


Figure 2: Working Model



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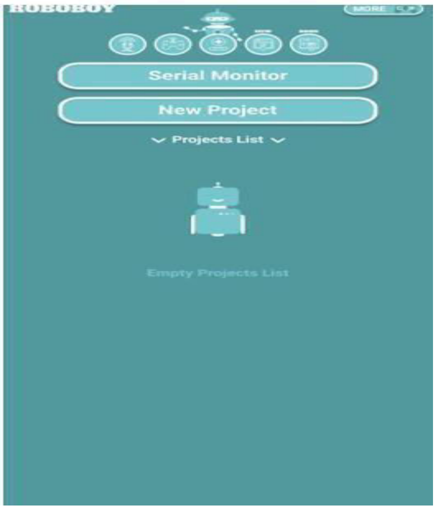

FIGURE 3 ROBO BOY APP INTERFERENCE

V. CONCLUSION

The creation smart insole system designed specifically to monitor temperature and pressure at the plantaris, with a focus on aiding in the early diabetes foot diagnosis and treatment issues. It emphasizes the need for constant monitoring, particularly for individuals at risk of diabetic foot ulcers, to prevent serious complications.

What sets this study apart is its aim to create a solution that's not only effective but also affordable and portable, making it accessible for continuous observation of the foot health. By utilizing readily available sensors, the researchers propose a novel approach to diagnosing and managing foot-related problems. The study meticulously examines various sensors suitable for inclusion in the smart insole design and outlines detailed procedures for characterizing these sensors. Additionally, it presents a comprehensive framework for the entire system, from sensor integration to data analysis.

Among the main highlights of the research is its potential to provide real-time observation the foot status through the analyses of temperature and pressure patterns disparities between feet. This could empower individuals to monitor their foot health from the convenience of their homes, enabling early intervention when necessary. Ultimately, the study's conclusions contribute significantly by the field of wearable sensor technology in healthcare. By obtaining a practical and affordable solution for foot monitoring, it holds promise for upkeeping the standard of living for those vulnerable to foot-related complications, especially in conditions like diabetes mellitus.

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