A Mini Project Report on

Feet position identification using velostat

Submitted to the

DEPARTMENT OF ELECTRONICS AND INSTRUMENTATION ENGINEERING

In partial fulfillment of the requirement of the course

Bachelor of Engineering in Electronics and Instrumentation Engineering

By

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CERTIFICATE

This is to certify that the project work entitled **"Feet position identification using velostat"** is carried out by **Pragathi MP(1MS21EI038), Shaaru U(1MS21EI050), Sahana Naik(1MS21EI045)**, are bonafide students of Ramaiah Institute of Technology, Bengaluru in partial fulfilment for the award of the degree of **Bachelor of Engineering** in **Electronics & Instrumentation Engineering** of the Visvesvaraya Technological University, Belagavi, during the year 2023-2024. It is certified that all the corrections/suggestions indicated during Internal Assessment heve been incorporated in the report deposited in the department library. The project report has been approved as it satisfies the academic requirements with respect to Mini-Project work prescribed for the award of the said degree.

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Declaration

We hereby declare that the dissertation ***Feet position identification using velostat*** submitted by us to the department of Electronics and Instrumentation Engineering, RIT Bengaluru-560 054 in partial fulfillment of the requirements for the award of the degree of **Bachelor of Engineering** in **Electronics and Instrumentation Engineering** is a bona-fide record of the work carried out by us under the supervision of ***Dr M Jyothirmayi***.

We further declare that the work reported in this mini-project report, has not been submitted and will not be submitted, either in part or in full, for the award of any other degree or diploma of this institute or of any other institute or University.

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Date:

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Abstract

This project presents a cost-effective pressure sensing mat for foot posture identification. In this project a mat based on velostat is used which is a carbon-impregnated polythene material. The sensing unit is realized as a mat of a specific size. Orthogonal copper tapes are stuck up and down as a matrix and a velostat in between, creating 14x13 individual sensors. The copper tapes are connected with wires to a microcontroller through multiplexers. This sensing unit is used to capture the feet pressure. The mat pressure sensors have been interfaced with an Arduino microcontroller in order to monitor and control the variation of resistance as a measure of applied pressure. This pressure distribution across feet is projected on to the system screen. Based on the feet position, subject will be classified as- normal stance, tip toed, heel standing, over-pronation, under-pronation.

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Chapter 1

Introduction

1.1 Introduction

The accurate detection and analysis of foot posture are pivotal in understanding human gait and ensuring proper movement mechanics. In the realm of biomechanics and physiotherapy, the need for precise foot posture detection is increasingly recognized as a cornerstone for diagnosing, treating, and preventing a countless of musculoskeletal disorders. This project presents an innovative yet economical approach to capturing and analyzing foot pressure distribution using a pressure mat made of velostat, a carbon-impregnated polyethylene material renowned for its pressure-sensitive properties.[1]

Velostat is known for its excellent piezoresistive properties, meaning it changes its electrical resistance under applied pressure. This sensitivity allows for precise detection of pressure variations, which is essential for accurate foot posture analysis. Moreover, velostat's flexibility enables it to conform to the contours of the foot, providing comprehensive pressure data across the entire contact area. Its durability ensures that the mat can withstand repeated use, making it suitable for long-term monitoring applications. Additionally, velostat is lightweight and relatively inexpensive, which makes it an attractive choice for developing cost-effective and portable pressure-sensing solutions. By harnessing these advantageous properties, the velostat-based mat in this project promises to deliver reliable and detailed insights into foot posture and gait, thereby facilitating early diagnosis and intervention, enhancing rehabilitation processes, and improving overall movement health.

This project extends to many applications, it holds significant potential benefits in physiotherapy. Early detection of improper foot posture in children can prevent the development of long-term musculoskeletal issues and contribute to healthier growth patterns. Children are particularly susceptible to foot posture problems due to their developing bodies, and early interventions can correct abnormalities before they become ingrained. This can lead to improved posture, balance, and overall physical development, reducing the risk of future complications.

By leveraging this advanced pressure-sensing technology, we aim to classify foot postures into distinct categories: normal stance, tip toed, on heels, flat feet, over-pronation, under-pronation.This classification is not merely an academic exercise; it has profound implications for gait analysis. Understanding these postural nuances can lead to better-informed diagnoses of gait abnormalities and enhanced athletic performance by ensuring optimal pressure distribution.

1.2 Literature survey

The development of advanced systems for gait analysis and foot posture detection has been significantly propelled by recent research. Affordable and effective pressure sensing mat using velostat for the calculation of stance phases [2]. Their research highlighted the potential of utilizing cost-effective materials to capture and analyze foot pressure distribution accurately, thus making gait analysis more accessible to various applications in healthcare and sports science.

Expanding on the healthcare applications of pressure-sensitive mats, smart mats can be used to prevent hospital-acquired pressure injuries. [3] Continuous monitoring of pressure distribution could play a crucial role in preventing ulcers and other pressure-related injuries in hospital settings. This study underlines the significant impact of integrating smart mat technology into patient care protocols, enhancing both the safety and comfort of patients.

[4]Wearable pressure sensors can be used for real-time gait analysis and fall detection. This research is particularly significant for elderly populations, providing a practical solution for continuous monitoring and immediate feedback to prevent falls and related injuries. Their findings demonstrated how wearable technology could be effectively used to enhance mobility and safety in everyday life.

Focusing on the pediatric population, [5] is a review synthesized existing studies on gait patterns in children with ADHD compared to their neurotypical peers. The findings pointed out that children with ADHD exhibit distinct gait characteristics, which can be effectively monitored using advanced pressure-sensing technologies. This research emphasizes the importance of early detection and intervention in improving motor skills and overall development in children with ADHD.

Furthering the application of gait analysis technology to special populations, gait anomalies in children with Autism Spectrum Disorder (ASD)[6] was considered. By eliminating the need for markers, their approach is particularly beneficial for children, allowing for comfortable and effective monitoring that facilitates early diagnosis and intervention.

Considering different methods for the same application, [7] reviews foot plantar pressure measurement systems. It discusses limitations of current wearable sensor systems and proposes a new design for an in-shoe wireless system. Initial results from the proposed system indicate a power consumption of 19.53 mW and a total chip size of approximately 1 mm^2. The design efficiently converts sensor data to digital signals and transmits them wirelessly, although further optimization is needed to reduce power consumption using a smaller CMOS process.

In summary, these studies collectively highlight the diverse applications and significant advancements in the field of gait analysis and foot posture detection. From low-cost and intelligent medical devices to applications in pediatric and elderly care, the integration of pressure-sensing technologies has the potential to revolutionize diagnostics, treatment, and preventive care. The continual development and refinement of these systems promise to enhance human movement analysis and overall health outcomes across various populations.

1.3 Problem statement and motivation

The motivation for our project lies in the cost-effective and unornamented(straight) method of posture detection for humans.

Since not many research papers are available on posture detection using velostat material and also its a good conductive material, realtively inexpensive, flexible and suitable for various applications such as touch sensitive interfaces and pressure sensitive mats.

So we have arrived to a problem statement- to identify different feet positions using pressure sensitive mat made of velostat material and to display the pressure distribution across the feet on GUI.

1.4 Scope of work

The scope of this project is to design and fabricate a pressure-sensing mat with a 14x13 matrix using velostat and orthogonal copper tapes. We work on system integration in which we interface the mat with an Arduino microcontroller using multiplexers. Followed by programming the Arduino to monitor and record resistance changes. Through data visualization we display real-time projection of foot pressure distribution. By doing posture classification we are trying to implement and classify foot postures into complete foot contact, standing on toes, standing on heels , feet pointed inwards, and feet pointed outwards and flat feet.

The current vision is to assist physiotherapists and pediatrists in diagnosing foot posture-related issues such as flat feet, high arches, and other posture abnormalities like over-pronation and under-pronation. It aids in developing personalized treatment plans based on accurate posture data.

This project will also help doctors to monitor patients' progress during physical therapy sessions.

For the musculoskeletal injuries caused during sports, this project will enhance athletic performance by optimizing foot alignment and pressure distribution. It helps in preventing sports injuries by identifying improper foot postures during training sessions. Early detection and correction of foot posture problems in children to promote healthy growth and development. It also helps in regular monitoring in schools to identify and address posture issues early.

1.5 Objective

- To design and fabricate a pressure-sensing mat using velostat and orthogonal copper tapes configured into an 14x13 matrix.
- Integrating mat with Arduino nano ATMEGA 328P microcontroller for real-time data acquisition interfacing through multiplexer.
- To project foot pressure distribution data onto a system screen using Python IDE.
- To classify foot posture based on pressure distribution across feet as normal stance, underpronation, tiptoeing, heel standing.

Chapter 2

Methodology

2.1 Methodology- Introduction

The approach towards solving the problem statement as mentioned in the introduction is quite non-invasive in terms of pressure measurement. This project focuses on the development and implementation of a pressure-sensing mat designed to detect and analyze foot posture . The methodology is meticulously structured to ensure the creation of a reliable, accurate, and user-friendly system. The process is divided into several key stages: design and fabrication, system integration, data acquisition, software development and implementation.

2.2 Hardware implementation

2.2.1 Hardware components

- Velostat sheet
  Velostat is a polymeric foil made of polyolefins impregnated with carbon black that can conduct electricity. It is a sensor where the resistance changes when pressure is applied. The Velostat is more effective than piezoelectric pressure sensors because, when the Velostat lies between two non-conductive sheets, e.g., a vinyl sheet, it can sense changes in pressure. The pressure mapping using Velostat is highly effective as it is flexible and gives an almost linear output. It is easy to build a sensor matrix using Velostat and consumes less time and less cost. Due to the sensing area is quite large compared to piezoelectric and FSR, consideration of the number of velostat decreases as it covers a large area of impact. Hence in our project Velostat is a polymeric foil made of polyolefins impregnated with carbon

black that can conduct electricity. It is a sensor where the resistance changes when pressure is applied.

Figure 2.1: Velostat sheet

The main feature of Velostat is that the resistance changes on applying pressure on it. The pressure-sensitive material (Velostat) is sandwiched between rows and columns of copper tapes. The specification of the Velostat as mentioned below satisfies the requirement for sensing pressure, the size of the sensor for easy fitting, and medium temperature tolerance to sustain the body temperature of the human body. Velostat can be seen in figure 2.1

- Copper tapes

Figure 2.2: Copper tapes

It is the essential part of the sensory system as it forms a closed circuit that provides us with the output voltage based on the pressure applied. By using copper tape, the rows and columns of the sensor matrix are built. These copper tapes are conductive in nature, so we use this to obtain the output voltage equivalent to applied pressure. The visual picture of copper tapes is as shown in Figure 2.2

- Ribbon cables

  A ribbon cable, also known as a multiwire cable(in figure 2.3, is a cable in which many wires, one running parallel to the other on the same plane, are bundled together as shown in Figure. It's wide and flat. As a result, it will enable the internal wiring of various electronic appliances. Using this device, we can read voltages from copper tapes and send the data to an acquisition system. Using this method will help to reduce the wiring problem in our project.

FIGURE 2.3: Ribbon cable

- Polyester insulation sheet

  Polyester is a cost-effective and widely used form of insulation, suitable for ceilings, walls and under-floor in both new builds and renovations. Polyester has similar R-values to fibreglass for same thickness of material. Image is displayed in figure 2.4

FIGURE 2.4: Polyester insulation sheet

2.2.2 Designing of pressure sensor matrix

The main sensing material of the pressure sensor matrix is Velostat. The main components required to make pressure sensor matrix is as given below as a list:

- Velostat (pressure sensitive material)
- Conductive adhesive copper tapes
- Polyester sheet
- Scale

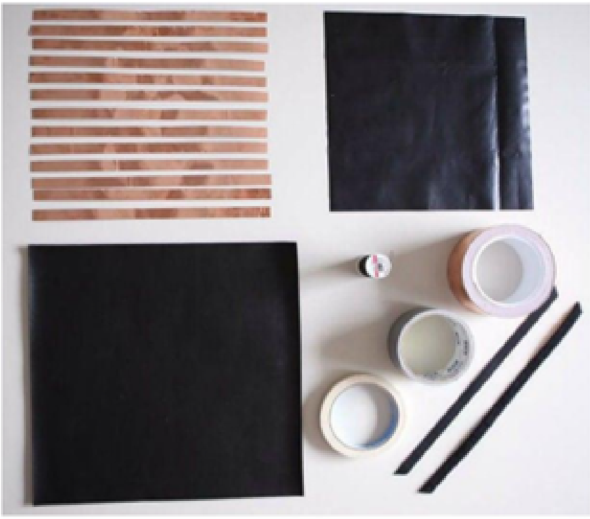


FIGURE 2.5: Requirements for Pressure sensor matrix

The Figure 2.5 above shows the requirements for making this sensor. Here Velostat is used for sensing purposes. The conductive adhesive copper tapes act as a conductive layer over Velostat. The polyester sheet is used as insulation for copper tapes and attaches them to the adhesive part.

The below mentioned procedure is used to make this senor matrix:

1. We took 2 feet by 4 feet of polyester sheet. The Velostat of standard size 28 cm by 28 cm was placed on the polyester sheet and cut into two pieces of length equal to Velostat with a 2 cm gap protruding out for connection with ribbon cables. One side of the polyesyer sheet is for rows and the other for columns.

2. We took 12mm copper tapes and measured the required length (30 cm) to insert on the Inner part of the polyester sheet. The copper tapes are cut to the necessary dimensions to make a 14x13 matrix i.e., 14 rows and 13 columns.

3. The adhesive of these 27 copper tapes is removed and placed on one of the part of Polyester sheet. The first 13 copper tapes are attached to one piece of the polyester sheet whose size is equal to the Velostat while the other 14 copper tapes are stuck to another side of the polyester sheet as shown in the figure 2.6.

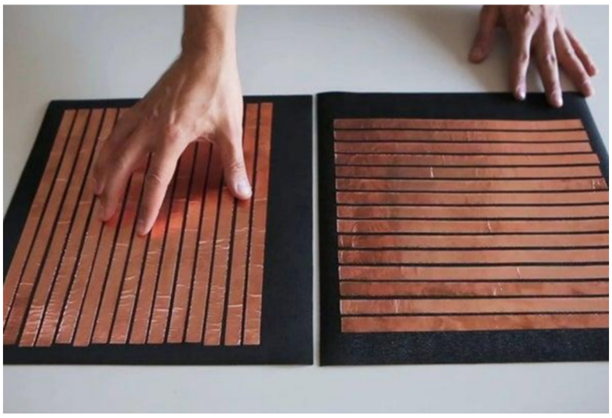


FIGURE 2.6: Rows and Columns copper tapes on vinyl sheet

4. After placing the copper tapes on their respective polyester sheet, the Velostat is placed on either one of the copper tapes contained sheets like a sandwich. The one sheet with copper tapes is placed on the sheet having Velostat as shown in the figure 2.7

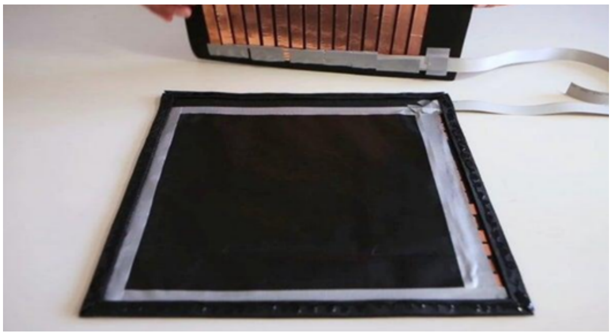


FIGURE 2.7: Overlapping the sheets on each other sandwiching Velostat

5. After overlapping the two sheets, the protruded copper tapes are soldered with the ribbon cables end for connection as shown in Figure below. After the above steps, the Velostat pressure sensor matrix connecting with multiplexer looks finally as shown in the figure 2.8

FIGURE 2.8: Velostat pressure sensor mat with circuit integrated

2.3 Block diagram and explanation

The block diagram represents how exactly this project works. It also tells how we interfaced the pressure mat with the circuits to get real time pressure distribution.

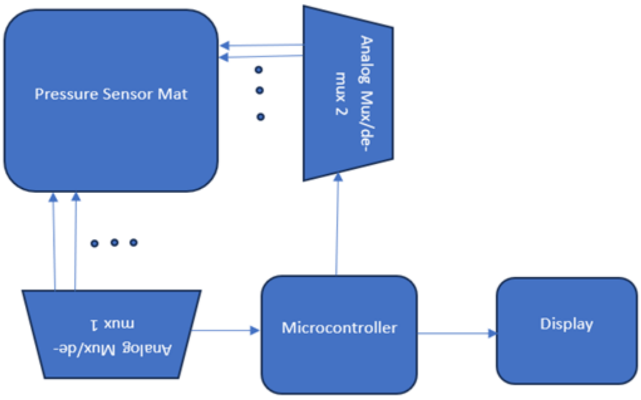


FIGURE 2.9: Functional block diagram

- Pressure mat- it is used to sense the pressure points when pressure is applied on it.
- Using Arduino nano we have programmed to read data from sensors.
- Data acquisition is done by an analog multiplexer, which collects the sensed inputs from the mat and then interfaces with Arduino. This is used because Arduino has a limited number of pins.
- Obtained data is displayed in the screen after the computation of the program

2.4 Basic operation of circuit

As shown in figure 2.6, copper tapes are arranged as rows and columns and are attached to the polyester sheet using one of the side. The Velostat lies beneath these two-polyester sheets having rows and columns of copper tapes. Here, the row copper tapes are powered with constant 5V using a demultiplexer which is programmed in Arduino. When the pressure is applied on the mat, row copper tapes come in contact with the Velostat and then the voltage changes due to change in resistance. This deformation of Velostat comes in contact with the column copper tapes that receive the reduced voltage. This voltage drop will be picked up by the column copper tapes through analog multiplexer which will be converted by ADC of Arduino.Circuit diagram can be seen in figure 2.10,2.11.

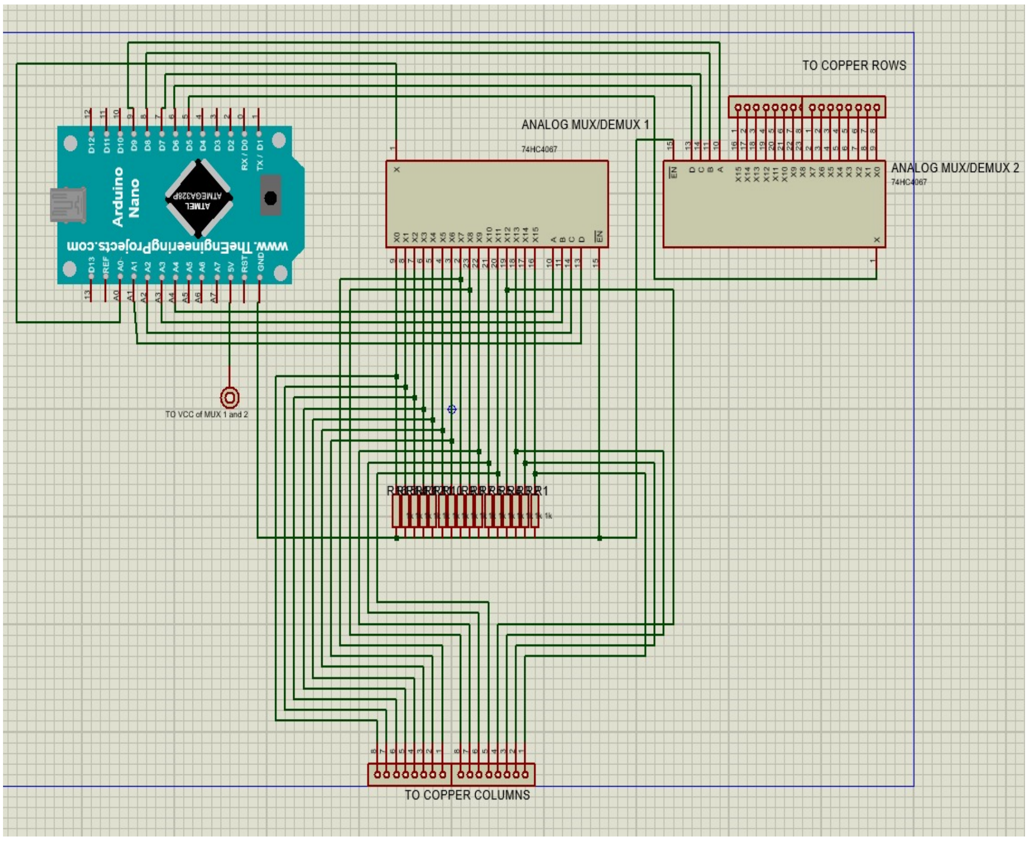


FIGURE 2.10: Circuit diagram

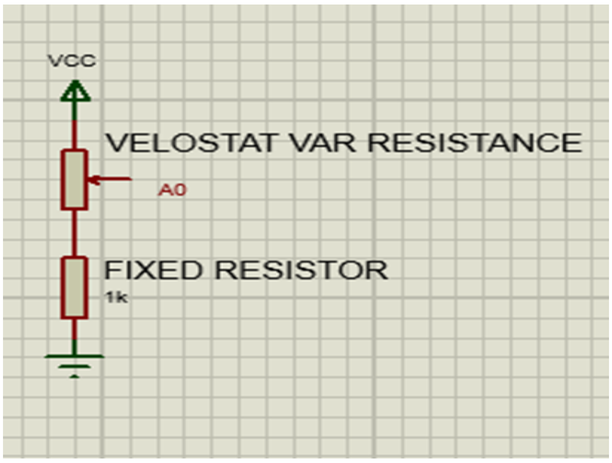


FIGURE 2.11: Circuit of one cell of Velostat

2.5 Working of Velostat mat

2.5.1 Design and Fabrication

Pressure-Sensing Mat Construction- The mat is constructed using velostat, a carbon-impregnated polyethylene material known for its pressure-sensitive properties. Copper tapes are utilized to create the sensor matrix. An 14x13 matrix of orthogonal copper tapes is formed, with one set placed horizontally and the other set vertically. Velostat is sandwiched between these layers to create individual pressure sensors at each intersection. The copper tapes and velostat layers are securely adhered to a flexible yet insulating material to maintain the structure and integrity of the mat.

2.5.2 System Integration

The ends of the copper tapes are connected to an Arduino microcontroller through multiplexer and demultiplexer, enabling the microcontroller to sequentially read voltage values from each intersection. The circuit is designed to minimize noise and interference, ensuring accurate resistance measurements. Appropriate pull-down resistors are employed where necessary.

2.5.3 Firmware Development

Voltage Measurement- The Arduino is programmed to measure the voltage changes at each intersection of the copper tapes, corresponding to the applied pressure.

Data Transmission- The measured data is transmitted to a connected computer or display device for further processing and visualization.

2.5.4 Data Acquisition and Processing

The mat is calibrated to establish a baseline resistance for no pressure and the expected range of resistance changes for varying pressure levels.

The Arduino continuously collects data from the mat, providing real-time pressure readings at each sensor intersection. Collected data is stored locally on the microcontroller or transmitted to an external storage system for further analysis.

2.5.5 Visualization Interface

A software interface, implemented using Python, is developed to graphically represent the pressure distribution across the mat in real-time. The interface highlights areas of high and low pressure. Users can interact with the visualization to analyze specific regions of the mat to review.

2.5.6 Mat design consideration

We have assumed and divided the pressure mat into the following 6 segments according to human foot posture to enable us to identify the feet positions for posture detection.
L1: Front of left leg

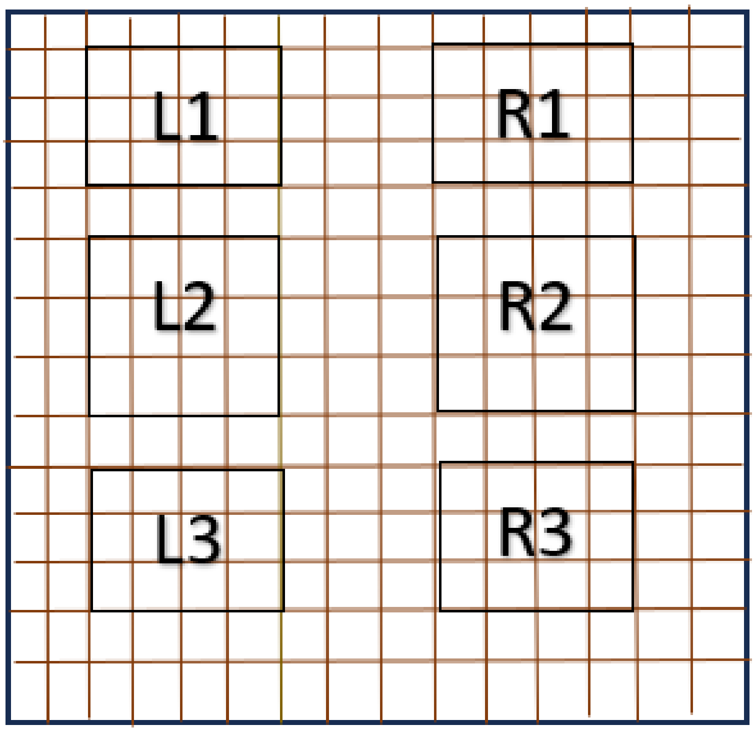


FIGURE 2.12: Division of mat into 6 regions

L2: Middle of left leg
L3: Bottom of left leg
R1: Front of right leg
R2: Middle of right leg
R3: Bottom of right leg

By following this comprehensive methodology, the project aims to develop a reliable, accurate, and user-friendly pressure-sensing mat that can effectively detect and analyze foot posture and gait patterns. Using python for visualization, ensures that the system can meet the diverse needs of healthcare, sports, and everyday applications.

2.6 Flowchart

The flow diagram represents the flow of process as the following steps given below:

1. Obtain the digital values for select lines from Arduino.
2. Port the data obtained in Arduino IDE with Python IDE for visual representation of the readings.
3. Check if mat senses pressure ,if not print waiting for data and display the heatmap with no values.
4. If the mat senses pressure and the data is available, check for the regions that are active in mat as shown in figure 2.12.
5. Display the identified feet position and heatmap.

Pause for updation in data and the heatmap, if still values are available from Arduino repeat the process else stop.

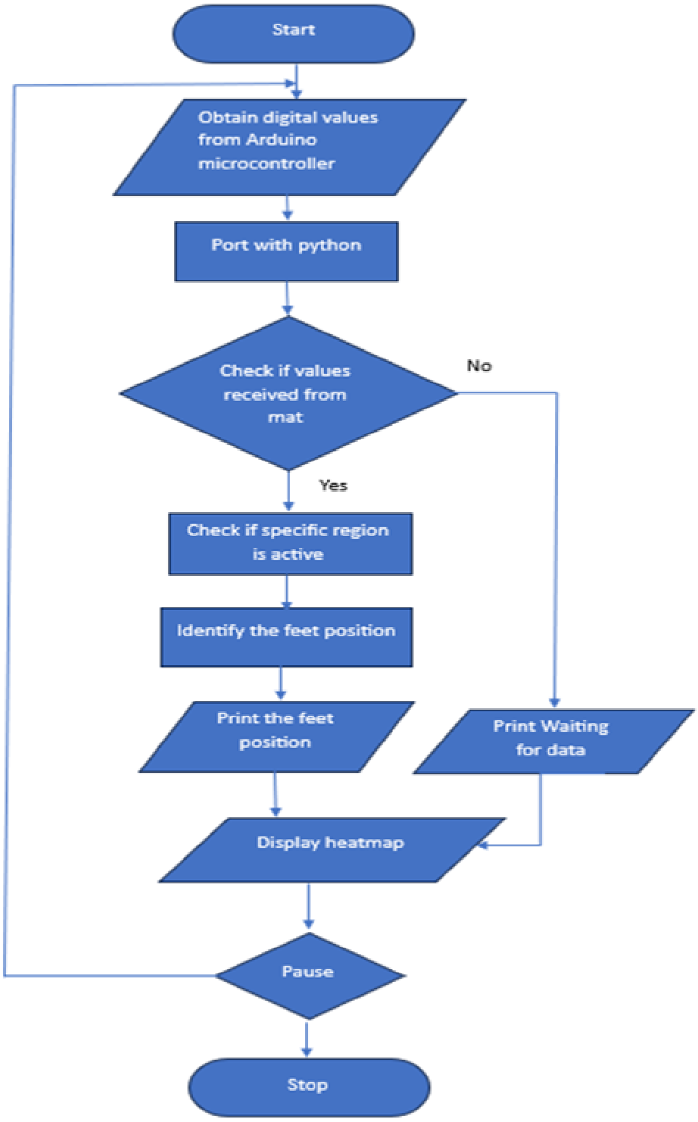


Figure 2.13: Flow diagram

Chapter 3

Results and Discussion

3.1 Introduction

The primary objective of this project was to develop a cost-effective, reliable pressure-sensing mat using velostat to accurately detect and identify various foot postures. The successful implementation of this system, including real-time data acquisition and visualization through Python, has led to significant findings and understandings.

1. Pressure Distribution Mapping:

   The pressure-sensing mat effectively captured the pressure distribution across the feet of various individuals standing on the mat. The velostat-based sensors demonstrated high sensitivity to pressure changes, providing detailed and accurate resistance variations corresponding to different foot postures. The data was processed and visualized in real-time, allowing for immediate feedback and analysis. This real-time pressure mapping is crucial for understanding the foot's interaction with the ground and identifying any deviations from normal posture.

2. Posture Classification Accuracy:

   The system accurately classified different foot postures based on pressure distribution patterns. The following classifications were identified and confirmed through testing:

   - Normal Stance: Evenly distributed pressure across the entire foot, indicating a balanced and neutral position.
   - Tip-Toed: High pressure concentrated at the toes, with minimal or no pressure on the heels.
   - On Heels: High pressure concentrated at the heels, with minimal or no pressure on the toes.

- Under-Pronation: Increased pressure on the outer sides of the feet, indicating a tendency for the feet to roll outward.

3. Real-Time Data Visualization:

   The Python-based software interface provided clear and interactive visualization of the pressure distribution data. Users could see real-time updates of their foot posture as they stood on the mat. The interface highlighted areas of high and low pressure, making it easy to identify specific posture types. This immediate feedback is crucial for both corrective and diagnostic purposes, offering users an intuitive understanding of their foot posture and allowing them to make necessary adjustments.

3.2 Expected vs Obtained result

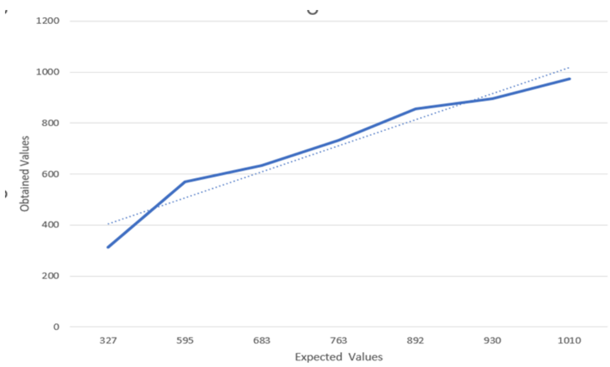


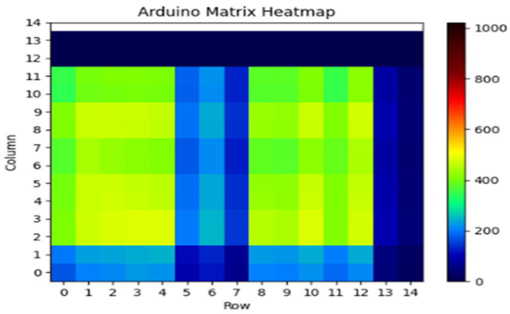
FIGURE 3.1: Expected vs obtained values

The above graph is obtained between comparing theoretically obtained ADC values(expected values) to practically measured ADC values(obtained values).

3.2.1 Identification of feet position

- When feet image looks like below-

(a) Feet image

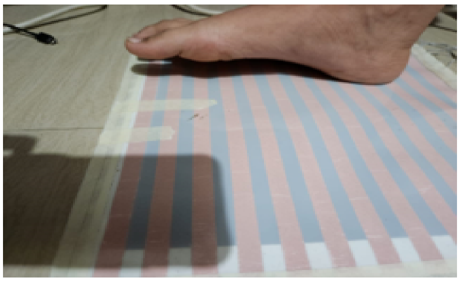


(b) Displayed image

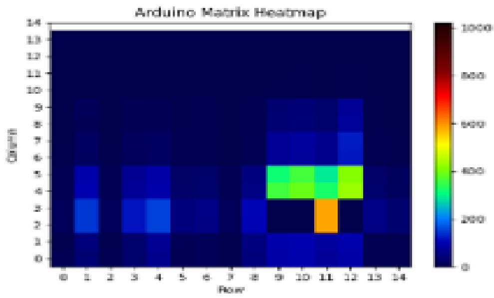
FIGURE 3.2: Normal stance

This posture is identified as “Normal Stance”

- When feet image looks like below-



(a) Feet image



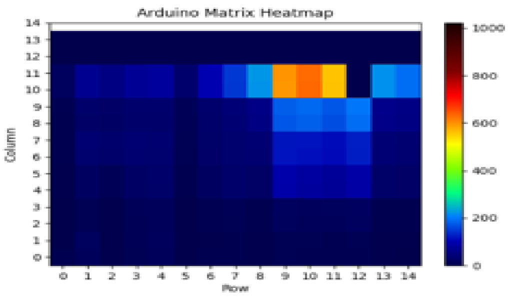
(b) Displayed image

FIGURE 3.3: Right leg in heel standing position

This posture is identified as “Right leg is in heel standing position”.

- When feet image looks like below-

(a) Feet image

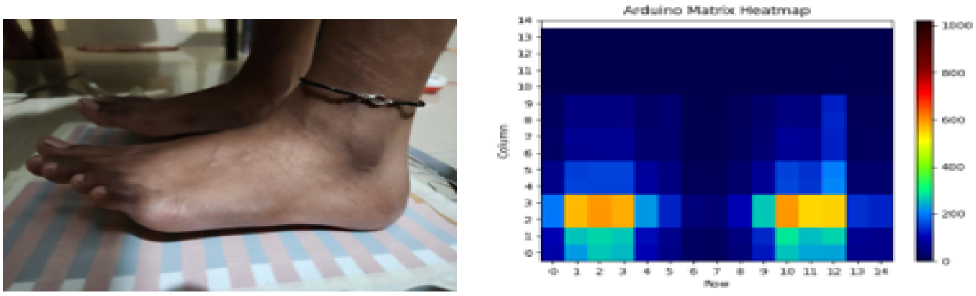


(b) Displayed image

FIGURE 3.4: Right leg is tip toed

This posture is identified as “Right leg is tip toed”.

- When feet image looks like below-



(a) Feet image (b) Displayed image

FIGURE 3.5: Heel standing

This posture is identified as “Heel standing”.

3.3 Discussions

The successful achievement of the project’s aims underscores the potential of using velostat-based pressure mats for foot posture analysis. The key discussions from the results are as follows:

a. Importance of Early Detection and Correction:
The ability to accurately detect and classify foot postures has significant implications for preventing and treating musculoskeletal disorders. Early detection of abnormal postures such as over-pronation and under-pronation allows for timely interventions, reducing the risk of long-term injuries and improving overall movement health. For children, this can be particularly beneficial, as early correction can prevent the development of more serious conditions later in life.

b. Applications in Various Domains:
The system’s applications extend beyond clinical settings. In sports science, it can be used to enhance athletic performance by ensuring proper foot mechanics. Athletes can use the system to identify and correct postural imbalances, potentially improving performance and reducing injury risk. In everyday use, it can help individuals monitor their posture and make necessary adjustments to avoid discomfort and potential injuries. Additionally, the system can be integrated into rehabilitation programs to track progress and adjust treatments accordingly, offering a practical tool for physiotherapists and healthcare providers.

c. Cost-Effectiveness and Accessibility:
The use of velostat, coupled with the integration of an Arduino microcontroller and Python-based software, makes this system both cost-effective and accessible. The affordability of materials and the ease of implementation ensure that the system can be widely adopted, making advanced foot posture analysis available to a broader audience. This democratization of technology allows for widespread application, from home use to professional healthcare settings.

d. Future Improvements and Research:
While the system has proven to be effective, there are opportunities for further improvement. Enhancements in sensor resolution and the development of more sophisticated machine learning algorithms can increase the accuracy and reliability of posture classification. Future research could also explore the integration of additional sensors to capture more comprehensive data on foot movement and pressure dynamics. Additionally, expanding the system's capabilities to analyze dynamic movements, such as walking or running, could provide deeper insights into gait mechanics and further applications in sports and rehabilitation.

In conclusion, the development of the velostat-based pressure-sensing mat and its successful application in foot posture detection marks a significant advancement in gait analysis technology. The system's accuracy, real-time feedback, and cost-effectiveness position it as a valuable tool for various applications, from clinical diagnostics to everyday posture monitoring. By leveraging the unique properties of velostat and the power of Python-based visualization, this project offers a practical solution for improving foot health and overall movement mechanics.

Chapter 4

Conclusion

Introduction

This project successfully developed a cost-effective and reliable pressure-sensing mat using velostat to accurately detect and classify various foot postures. Through meticulous design, implementation, and testing, we achieved our objective of creating a sophisticated yet accessible system capable of real-time foot posture analysis and visualization.

4.1 Key Achievements

4.1.1 Innovative Use of Velostat

The utilization of velostat as the core material for pressure sensing proved highly effective. Its piezoresistive properties allowed for precise detection of pressure variations, which are critical for accurate foot posture analysis. The flexibility and durability of velostat ensured that the mat could accommodate various foot sizes and shapes while maintaining consistent performance.

4.1.2 Effective System Integration

The integration of the pressure-sensing mat with an Arduino microcontroller and multiplexers enabled efficient data acquisition and processing. The system's architecture ensured reliable communication between hardware components, facilitating real-time monitoring and data collection.

4.1.3 Real-Time Visualization

The development of Python-based software for data visualization provided users with an intuitive and interactive interface. Real-time pressure distribution mapping and posture classification offered immediate feedback, enhancing user engagement and understanding of their foot posture.

4.1.4 Accurate Posture Classification

The system accurately classified different foot postures, including normal stance, tip-toed, on heels, over-pronation, and under-pronation. This capability is crucial for identifying and correcting postural abnormalities, thereby preventing potential musculoskeletal issues.

4.2 Practical Implications

4.2.1 Clinical and Rehabilitation Applications

The system holds significant potential for clinical use, particularly in diagnosing and treating foot-related disorders. Healthcare professionals can leverage this technology for early detection of abnormal foot postures and design personalized intervention strategies. In rehabilitation settings, the system can track patient progress and adjust treatment plans based on real-time data.

4.2.2 Sports Science and Performance Enhancement

Athletes and coaches can benefit from the system's ability to monitor and analyze foot posture. By identifying imbalances and correcting them, athletes can enhance their performance and reduce the risk of injuries. The system's real-time feedback mechanism allows for immediate adjustments, making it a valuable tool for training and performance optimization.

4.2.3 Everyday Posture Monitoring

The affordability and ease of use of the system make it suitable for everyday posture monitoring. Individuals can use the mat at home to maintain proper foot posture, preventing discomfort and potential long-term health issues.

4.3 Future Work

While the project achieved its primary objectives, there are several avenues for future research and development:

4.3.1 Enhanced Sensor Resolution

Improving the resolution of the pressure sensors can provide more detailed and granular data, further increasing the accuracy of posture classification.

4.3.2 Advanced Machine Learning Algorithms

Incorporating sophisticated machine learning algorithms can enhance the system's ability to recognize and classify a wider range of foot postures and movements. This would also allow for predictive analysis and more personalized feedback.

4.3.3 Dynamic Gait Analysis

Expanding the system's capabilities to analyze dynamic movements, such as walking or running, can provide deeper insights into gait mechanics. This extension would be particularly useful in sports science and rehabilitation.

4.3.4 Comprehensive Foot Health Monitoring

Integrating additional sensors to monitor other aspects of foot health, such as temperature and humidity, can offer a more comprehensive analysis. This holistic approach can lead to better overall foot care and health management.

In conclusion, the development and implementation of the velostat-based pressure-sensing mat represent a significant advancement in foot posture analysis technology. The project's success demonstrates the viability of using affordable and accessible materials to create a sophisticated system capable of real-time monitoring and classification. The implications of this technology extend across clinical, athletic, and everyday applications, highlighting its versatility and potential impact. By continuing to refine and expand upon this foundation, future innovations can further enhance the capabilities and applications of this promising technology.

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