PROJECT ABSTRACT

IoT Gait Analysis Insole using Pressure Sensors

Smart insole with 8 thin-film pressure sensors streaming over BLE to a live web app with plantar-pressure heatmap, force curves and session analysis (gait cycle, symmetry, stride parameters). Built-to-order hybrid project with instrumented insole, app source, report, PPT and viva kit. Screening aid only -- not a medical device.

01. Title

IoT Gait Analysis Insole using Pressure Sensors

02. Introduction / Background

Clinical gait analysis uses force plates costing lakhs, confined to hospital labs -- far from a student project, a physiotherapy trainee or a sports coach. Yet the core measurement is simple: how pressure distributes under the foot through a step. Thin-film force sensitive resistors (FSRs) laminated into an insole can capture that distribution, and a Bluetooth microcontroller can stream it to a browser fast enough for a live pressure map. From the pressure signal, standard gait parameters fall out naturally: cadence, stance and swing percentages, double-support time, peak pressures per zone and left-right symmetry. This project builds that instrument: a sensor insole, a BLE streaming link, and a web app that visualizes and analyzes walking sessions for study and screening.

03. Problem Statement

Students studying biomechanics, sports science or rehabilitation have no affordable way to measure gait: observation is subjective, phone accelerometers are too coarse, and lab force plates are inaccessible. Without data, project reports on walking analysis are purely theoretical. The project addresses this with a wearable instrument the student builds, calibrates and validates themselves -- producing real session datasets with documented method and honest tolerances. It is explicitly a screening and learning aid, not a medical diagnostic device, and every document in the kit carries that boundary.

04. Objectives

- Build a flexible insole with 8 FSR pressure zones (heel, midfoot, metatarsals, hallux, toes) sampled at 50 Hz by an ESP32 over BLE.

- Develop the GaitLab web app: live plantar-pressure heatmap, per-zone kilopascal readouts and rolling left/right force curves via WebBluetooth.
- Implement session analysis: step detection, gait-cycle averaging with phase bands, left/right symmetry bars and stride parameters (cadence, stance/swing, double support).
- Define and document a body-weight calibration procedure converting ADC readings to kilopascals, with stated tolerances.
- Deliver the complete student kit: insole, electronics, app source, report, PPT and viva Q&A with a clear non-medical disclaimer.

05. Proposed Methodology

Eight FSR-402 sensors are laminated into a flexible insole substrate at anatomical zones and wired to an ESP32 that samples each channel at 50 Hz. The firmware applies the calibration curve from the body-weight procedure and streams pressure packets over BLE to the browser app. The live page renders the heatmap on a foot outline, updates zone readouts and plots total-force curves. A walk test (e.g. 10 m) is recorded; steps are detected from the force signal, cycles are time-normalized and averaged into heel/midfoot/forefoot pressure-vs-stance curves with loading, mid-stance and push-off bands. Symmetry is computed per zone as paired left/right peak pressures with a configurable flag threshold. Sessions export as CSV.

06. System Architecture / Working

The insole's FSR array connects through flex cabling to a small ankle- or shoe-mounted ESP32 board with LiPo power. Firmware handles sampling, calibration mapping and BLE notification streaming. The GaitLab web app has two pages: Live (heatmap, zone table, force chart, session metrics, shoe-camera panel) and Session Analysis (gait-cycle chart, symmetry bars, stride-parameter table, foot-strike assessment, AI-style narrative summary marked as screening aid). A reports concept page is stubbed for future export. Data never leaves the browser except as CSV the student downloads.

07. Hardware / Software Requirements

- 8x FSR-402 thin-film force sensors on flexible insole substrate, flex cabling.
- ESP32 BLE microcontroller, LiPo cell with charging module, optional 3D-printed enclosure.
- GaitLab web app (single-file HTML/CSS/JS, WebBluetooth); Chrome/Edge on desktop or Android (iOS browsers lack WebBluetooth).
- Kitchen or bathroom scale for the body-weight calibration procedure.

08. Expected Outcomes

The student delivers a working instrumented insole streaming live pressure maps, recorded walk-test sessions with gait-cycle plots, symmetry analysis and stride parameters, and a report presenting their own measured session data with the calibration method and its tolerances. No clinical claim is made anywhere: the app and report state screening-aid status prominently. The viva kit covers FSR principles, BLE, the gait cycle and signal processing choices.

09. Applications

- Final-year project in electronics, instrumentation, biomedical or IoT engineering.
- Physiotherapy and sports-science study aid for gait observation.
- Footwear and insole design experiments (pre/post comparisons).
- Teaching platform for wearable sensors, BLE and biosignal processing.

10. Future Scope

- Dual fully-instrumented insoles with synchronized left/right capture.
- IMU fusion for joint-angle and foot-progression estimates.
- On-device step counting and longer battery life for day-long studies.
- PDF report generation from the analysis page.