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

PiezoFloor: Smart Flooring for Energy-Aware spaces

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Abstract: This project develops Piezoelectric Floor Tiles that generate electricity from human footsteps by converting mechanical stress into electrical energy. Integrated IoT sensors monitor footfall, energy output, and tile performance, sending data to a smart dashboard for real-time visualization. Machine learning predicts footfall patterns, energy demand, and detects faults to ensure timely maintenance. Features like user dashboards, heat maps, and engagement tools promote public participation. The system offers a scalable, intelligent solution for sustainable energy harvesting in smart urban environments.

Keywords: Piezoelectric Floor Tiles, Energy Harvesting, Smart Cities, IoT- enabled Monitoring, Machine Learning Analytics, Footfall Prediction, Renewable Energy Management, Predictive Maintenance, Sustainable Infrastructure, Intelligent Dashboard, User Engagement, Smart Urban Mobility.

I. INTRODUCTION

Piezoelectric flooring is an innovative approach that converts human footsteps into usable electrical energy. When pressure is applied on piezo sensors embedded beneath the tiles, mechanical stress is transformed into electrical charges, enabling continuous micro-energy harvesting in crowded environments. This project enhances the traditional piezoelectric concept by integrating IoT, analytics, and real-time monitoring using an ESP32 microcontroller. The system displays voltage, step count, and power generation while also supporting energy storage through rechargeable batteries. A smart dashboard, heatmap visualization, and predictive features help understand foot-traffic patterns and energy utilization. The concept promotes sustainability by converting everyday human movement into renewable energy, making it suitable for smart buildings, campuses, and public infrastructures.

II. LITERATURE SURVEY

Several studies highlight the potential of piezoelectric materials for small-scale energy harvesting. Research by Ming He et al. (2019) demonstrated improved performance using force-amplified piezo beams. Miandoab et al. (2021) proved that bending-type piezo placement enhances output. Zhong et al. (2022) explored multilayer beams achieving higher efficiency under small strokes. Other works show feasible implementation of piezo tiles for LED lighting and IoT sensor powering but emphasize low energy output per step. IoT-integrated systems, such as those by Neha Sharma et al. (2023), presented dashboards showing voltage, steps, and power patterns. Overall, literature indicates that piezoelectric floors are practical for micro-energy generation, real-time monitoring, and analytics, but still require advancements for large-scale power applications.

III. HARDWARE AND SOFTWARE REQUIREMENTS

Hardware requirements:

components	usage
ESP32 Microcontroller	Processes sensor data, controls dashboard and relay.
Piezoelectric Sensors	Generate voltage from footsteps.
Voltage Sensor	Measures and conditions piezo output.
ADXL335 Accelerometer	Detects vibration and verifies footsteps
LCD Display	Shows voltage, power, and step count.
Rechargeable Battery	Stores harvested energy.
Power Supply	Provides required DC power.

Software requirements:

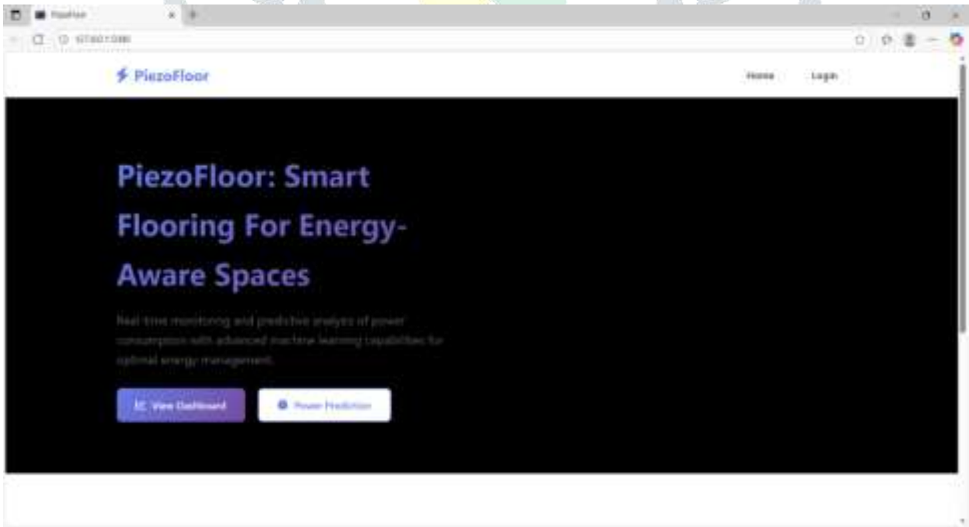
components	usage
Python	Data processing and analysis.
HTML/CSS/JavaScript	Dashboard UI development.
Flask	Backend and data handling.
CSV	Storing sensor and power data.

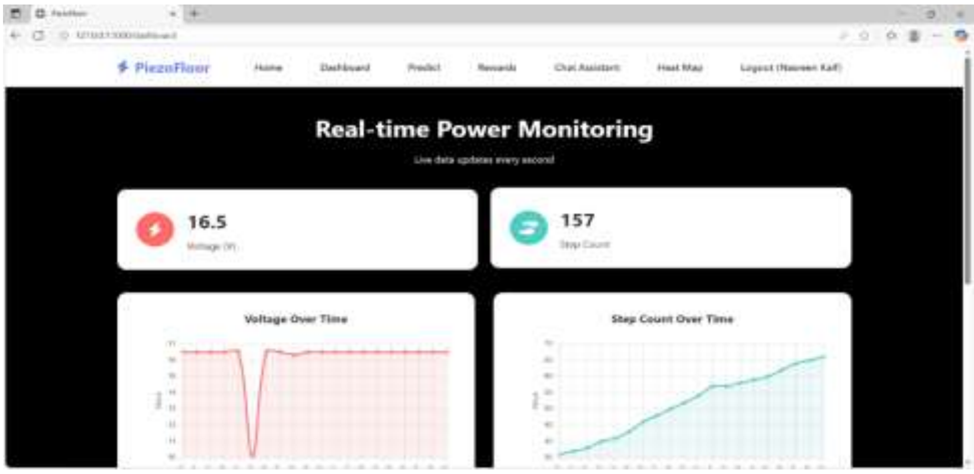
IV. METHODOLOGY

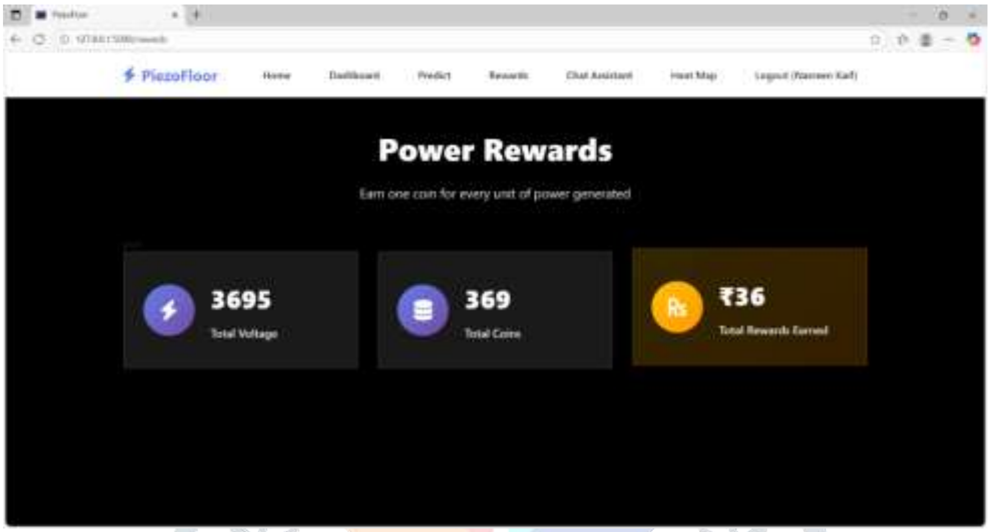
Footsteps applied on piezo tiles generate AC voltage, which is conditioned by a voltage sensor and read by the ESP32 microcontroller. The system also collects light data from the LDR and vibration information from the ADXL335 to verify authentic footsteps. The ESP32 processes voltage, step count, and estimated power generation, displays it on an LCD, and stores energy in a rechargeable battery. A relay automatically controls lighting based on threshold power or ambient conditions. Data is sent to a dashboard showing graphs, heatmaps, and rewards. The system also includes prediction and chatbot modules for enhanced interaction.

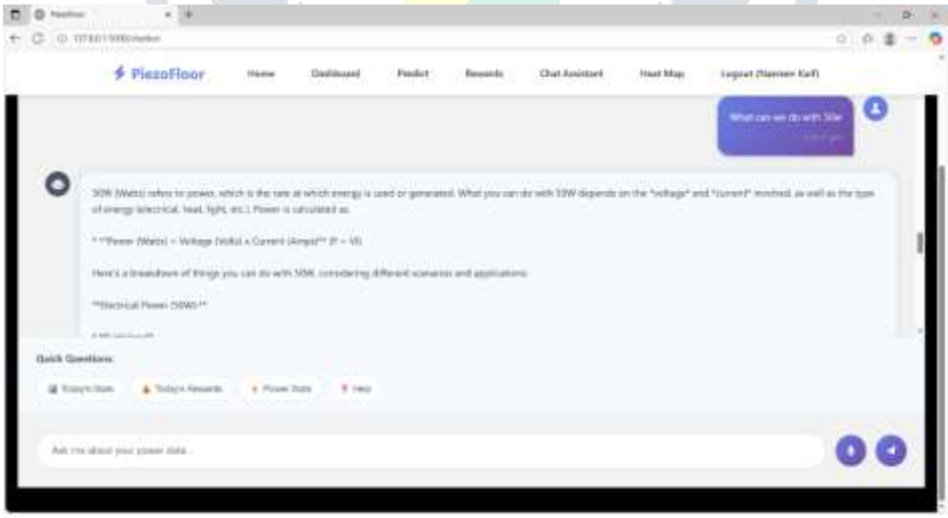
V. RESULT AND DISCUSSION

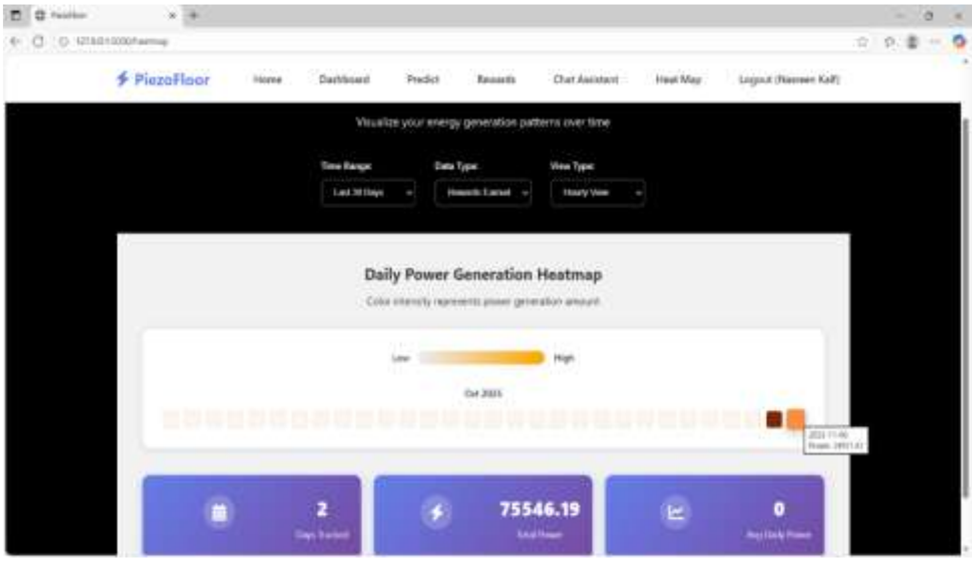
The prototype successfully demonstrated energy harvesting from footsteps using piezoelectric sensors. The system generated measurable voltage for each step and was able to power LEDs and store energy in a small battery. Real-time dashboards displayed voltage, step count, power, rewards, and historical trends accurately. The heatmap analysis effectively highlighted high foot-traffic periods, and predictive models estimated future energy generation. Although the electricity produced is small, the project validates the feasibility of micro-level renewable energy harvesting combined with IoT analytics. The results confirm that piezo floors can be effectively used for low-power applications, awareness systems, and smart-monitoring environments.




PiezoFloor
Home
Dashboard
Predict
Rewards
Chat Assistant
Heat Map
Real-time Power Monitoring
16.5
157
Voltage Over Time
Step Count Over Time


PiezoFloor
Home
Dashboard
Predict
Rewards
Chat Assistant
Heat Map
Power Rewards
Earn one coin for every unit of power generated
3695
Total Voltage
369
Total Coins
₹36
Total Rewards Earned


PiezoFloor
Quick Questions



VI. CONCLUSION AND FUTURE WORK

This project demonstrates a smart and sustainable flooring system capable of converting human footsteps into electrical energy while providing digital insights through IoT. Although the power output is low, the system successfully supports LEDs, sensors, and data visualization, proving its potential for smart buildings and public areas.
Future improvements include using high-efficiency piezo materials, multilayer tile structures, hybrid solar-piezo systems, large-scale installation, and wireless energy transfer. Enhanced AI-based analytics and stronger energy storage modules can further extend real-world applications.

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