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POWER GENERATION THROUGH FOOTSTEPS USING PIEZOELECTRIC SENSORS ALONG WITH GPS TRACKING

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ABSTRACT:

In today's world, the need for renewable and sustainable energy sources is critical due to rising energy demands and environmental concerns. This paper proposes a hybrid system that generates electrical energy from human footsteps using piezoelectric sensors while simultaneously providing GPS-based location tracking. The piezoelectric effect is utilized to convert mechanical pressure into electrical energy, which is rectified and stored in energy storage devices such as supercapacitors or rechargeable batteries. A microcontroller coordinates the system by managing energy flow and processing GPS data for geotagging. Experimental results demonstrate effective energy harvesting and accurate real-time tracking. This innovative solution holds potential for deployment in smart cities, disaster response, and wearable electronics, enhancing both energy efficiency and intelligent data collection.

KEYWORDS:Piezoelectric sensors, energy harvesting, GPS tracking, footstep energy, microcontroller, smart cities.

HIGHLIGHTS:

- A system harvests electrical energy from a footstep using a piezoelectric sensor.
- A GPS module enables location tracking during energy generation.
- A microcontroller manages energy conversion and data processing.
- Energy is stored in a compact power storage unit for later use.
- The design supports use in a public walkway, a campus, or a remote location.
- The system operates without an external power source.
- Real-time data is collected for analysis and infrastructure planning.
- The setup promotes a sustainable and intelligent energy solution.

INTRODUCTION:

A growing demand for sustainable energy motivates exploration of alternative sources. Mechanical energy from a footstep provides an opportunity for energy harvesting. A piezoelectric sensor converts footstep pressure into electrical energy through the piezoelectric effect, which generates voltage under mechanical stress.

This work introduces a system that collects energy from a footstep and converts it into usable electrical output. No fuel is required, and no emission is produced. A GPS module adds functionality by capturing real-time location data, which enables tracking of energy generation based on position.

A microcontroller manages energy flow, sensor input, and GPS data acquisition. Power is stored in a small storage device such as a supercapacitor or battery. The combination of energy harvesting and location monitoring offers value in smart infrastructure, emergency response, and mobility analysis.

PROBLEM DEFINITION:

A conventional power source often depends on fossil fuel, which causes pollution and depletion of natural reserve. A need arises for a clean and independent power solution, especially in an outdoor or mobile environment. A mechanical footstep remains an untapped source of renewable energy.

A piezoelectric sensor produces only a small energy output, and energy harvesting remains inefficient in current implementation. A setup often lacks location awareness, limiting practical application in urban monitoring or emergency service. A GPS module consumes power and requires efficient management for real-world use.

A challenge exists in integrating energy harvesting with precise location tracking while maintaining low cost, high durability, and minimal maintenance. A system must function without reliance on an external power grid and operate under varied environmental condition.

This work addresses a gap by proposing a compact, dual-function unit that collects energy from foot pressure and captures geographic position in real time.

OBJECTIVE:

The objective of this work is to design and implement a self-powered system that converts mechanical energy from a footstep into electrical energy using a piezoelectric sensor. The system also captures real-time geographic data using a GPS module.

A microcontroller manages energy harvesting, power regulation, and GPS data acquisition. The system stores generated energy in a power unit and transmits or logs location data for further analysis.

This solution aims to support deployment in a high-footfall environment without dependence on an external power source. The design ensures low cost, modularity, and operational reliability in real-world application.

SUMMARY OF ISSUES:

- A footstep generates only low electrical output through a piezoelectric sensor.
  - A voltage level remains unstable and needs regulation.
  - An energy source from motion is inconsistent and unreliable.
  - A GPS module requires stable power, which is not always available.
  - An absence of integration prevents location tracking with energy harvesting.
  - An installation cost remains high due to specialized material.
  - A mechanical component faces wear under repeated stress.
  - An environment introduces risk from moisture, dust, and impact.
  - A conventional system lacks real-time data feedback and efficiency.
  - A design must overcome limitation in energy, cost, and durability.

EXISTING SYSTEM:

An existing energy harvesting system uses a piezoelectric sensor to convert mechanical stress from a footstep into electrical energy. A sensor is embedded under a walking surface such as a tile or a mat. When a person steps on the surface, a force is applied to the sensor. This mechanical input creates an electric charge due to the piezoelectric effect.

A commercial example, such as Pavegen, demonstrates this concept. A single footstep on a special tile generates a small amount of energy, which powers a nearby LED or stores energy in a battery. An application typically exists in a location with high foot traffic such as a transport station, a shopping area, or an event venue.

However, a system faces multiple technical and economic challenges. A generated energy is limited to a low power range. A high installation cost results from specialized material and structural modification. A frequent foot impact may cause sensor degradation over time.

A GPS tracking unit is not commonly integrated in such a system. A standard energy harvester does not track motion or location. A GPS module, if used, is often a separate device, such as one embedded in a shoe or a wearable band. An effort to combine GPS with footstep energy harvesting is in a research or prototype phase.

An existing system performs basic energy conversion, but it lacks multifunction capability, efficient power output, and integration with location awareness.

DISADVANTAGES:

- A generated energy from a footstep is low and insufficient for high-power use.
- A voltage output is unstable and needs complex regulation.
- An installation requires high-cost material and structural modification.
- A sensor undergoes mechanical stress and may lose efficiency over time.
- A system needs maintenance due to physical wear and tear.
- A GPS module is not present in a basic energy harvesting setup.
- A data tracking function is absent in most commercial implementation.
- A deployment is not suitable for a low-traffic or remote location.
- An energy storage method is inefficient or adds cost.
- An integration of energy harvesting with smart monitoring remains limited.

PROPOSED SYSTEM:

The proposed system is designed to harness mechanical energy generated by human footsteps using piezoelectric sensors and convert this energy into usable electrical power. Piezoelectric materials such as PZT or PVDF are embedded in floor tiles or shoe insoles, where mechanical pressure from walking or running induces an AC voltage output. This electrical energy is then routed through a bridge rectifier to convert it from alternating current

(AC) to direct current (DC), followed by a voltage regulator to stabilize the output to a consistent level suitable for electronic devices. The regulated energy is stored in energy storage units such as supercapacitors or rechargeable lithium-ion batteries, ensuring that the harvested power can be used efficiently over time.

In addition to energy harvesting, the system incorporates a GPS module to track and monitor the real-time location of individuals. The GPS receiver collects latitude and longitude coordinates and either stores them locally or transmits the data remotely to a cloud platform or central server. This allows for continuous monitoring and data logging of movement patterns, which can be invaluable in applications requiring precise location tracking. The microcontroller acts as the central processing unit, managing the energy harvesting process, controlling the charging circuit, processing GPS data, and handling communication protocols. It ensures efficient operation by switching between power sources and managing data transmission as needed.

Wireless communication modules such as GSM, Wi-Fi, or LoRa can be integrated optionally to enable remote data transmission, making the system suitable for off-grid environments or scenarios where real-time monitoring is crucial. The system can be scaled and customized depending on the application, ranging from smart city infrastructure where foot traffic powers public lighting and tracks pedestrian flow, to military use cases where soldiers' boots generate power and share location data in the field. Furthermore, disaster management teams can benefit from this technology by tracking rescuers and victims in areas lacking electrical infrastructure.

Overall, the proposed system offers a dual-functional platform that not only generates renewable energy from everyday human activity but also provides essential location tracking capabilities. This combination enhances energy efficiency, promotes sustainability, and improves safety and monitoring in various sectors. Future developments may include IoT integration for seamless data sharing, AI-driven analytics for predictive insights, and miniaturized wearable versions to expand the system's reach and utility.

ADVANTAGES:

- **Dual Functionality**: The system combines energy harvesting and GPS tracking into a single platform, providing both sustainable power generation and real-time location monitoring simultaneously.
- **Energy Efficiency**: By converting mechanical energy from footsteps into electrical energy, the system reduces dependence on external power sources, making it highly energy-efficient and suitable for low-power devices.
- **Eco-Friendly**: Utilizing renewable mechanical energy from human movement minimizes environmental impact and promotes sustainability by reducing reliance on fossil fuels and batteries.
- **Modular and Scalable**: The system's design allows easy expansion and customization, whether for large-scale installations like smart city infrastructure or compact wearable devices.
- **Remote Usability**: With optional wireless communication modules, the system supports remote monitoring and data transmission, making it ideal for off-grid or low-infrastructure areas such as disaster zones or military operations.
- **Enhanced Safety and Monitoring**: Real-time GPS tracking improves security, navigation, and management in applications like military missions, disaster relief, and public safety.
- **Cost-Effective**: By harvesting energy from everyday activity, the system can lower operational costs associated with battery replacements and power supply, especially in remote or difficult-to-access locations.

SYSTEM REQUIREMENT SPECIFICATION:

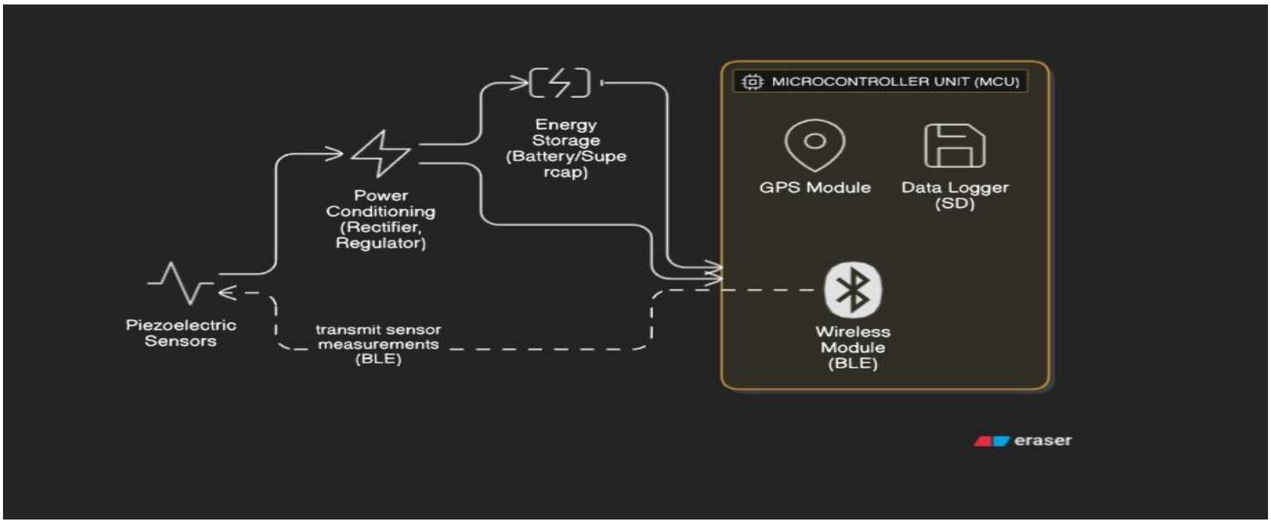
Hardware Requirements:

Piezoelectric Sensors: Materials such as PZT or PVDF embedded in floor tiles or insoles to convert mechanical stress into electrical energy.
Bridge Rectifier: To convert AC voltage from sensors into DC voltage.
Voltage Regulator: To provide stable voltage output suitable for powering electronic components.
Energy Storage Unit: Supercapacitors or rechargeable lithium-ion batteries for storing harvested energy.
Microcontroller Unit: Arduino, ESP32, or similar to control energy management, GPS processing, and communication.
GPS Module: Devices like NEO-6M for real-time location tracking.
Wireless Communication Module (Optional): GSM, Wi-Fi, or LoRa for remote data transmission.
Power Management Circuit: To regulate charging, discharging, and switching between energy sources.
User Interface Hardware: LCD/OLED display or connectivity to external devices for data visualization.

Software Requirements:

Firmware for Microcontroller: To handle sensor data acquisition, energy harvesting control, GPS data processing, and communication protocols.
GPS Data Handling Software: To interpret, store, and transmit location information.
Communication Protocols: Implementation of GSM, Wi-Fi, or LoRa protocols for remote monitoring.
Data Visualization Interface: Web or mobile application/dashboard for real-time display of energy and location data.
Power Management Algorithms: To optimize energy use, charging cycles, and sensor activation.

SYSTEM ARCHITECTURE BLOCK DIGRAM:



PROCEDURE:

Installation of Piezoelectric Sensors:
Piezoelectric materials such as PZT or PVDF are embedded into floor tiles or shoe insoles at designated locations where foot traffic occurs. These sensors convert mechanical pressure from footsteps into an alternating current (AC) voltage.

Energy Conversion and Storage:
The AC voltage generated by the sensors is fed into a bridge rectifier circuit that converts it into direct current (DC) voltage. This DC voltage then passes through a voltage regulator to maintain a stable output level. The regulated energy is stored in an energy storage unit like supercapacitors or rechargeable lithium-ion batteries for later use.

Energy Management and Control:
A microcontroller continuously monitors the energy harvested and stored. It manages the charging process, ensures efficient power usage, and controls the activation of other components such as the GPS module and wireless communication units. The microcontroller also handles the processing of sensor data and GPS coordinates.

GPS Data Acquisition and Transmission:
At predefined intervals or based on motion detection, the GPS module activates to acquire the current location coordinates. These coordinates are either stored locally on the system or transmitted in real-time via wireless communication modules such as GSM, Wi-Fi, or LoRa to a remote server or cloud platform.

Data Visualization and Monitoring:
Collected data on energy output and location is displayed through a user interface, which can be a web-based dashboard or a mobile application. This allows users or system administrators to monitor the performance of energy harvesting and track movement patterns effectively.

Maintenance and Scaling:
The system is designed for easy maintenance and scalability. Additional piezoelectric sensors or communication modules can be added as needed to expand the coverage area or improve system capabilities. Regular checks ensure all components function optimally and data integrity is maintained.

CONCLUSIONS:

The project “Power Generation Through Footsteps Using Piezoelectric Sensors Along with GPS Tracking” successfully demonstrates the integration of renewable energy harvesting with real-time geospatial monitoring, providing a novel approach to decentralized energy generation. The implementation of piezoelectric sensors embedded in walking platforms validates the concept of converting mechanical energy from human footsteps into usable electrical power, highlighting the practical feasibility of this technology for public spaces and urban environments.

In addition to energy harvesting, the incorporation of GPS tracking enables precise spatial mapping of energy-producing events, offering valuable insights into pedestrian movement patterns and energy generation hotspots. This dual functionality not only enhances the utility of the system but also opens avenues for applications in smart city infrastructure, disaster management, and wearable technologies.

The system's eco-friendly nature aligns with global sustainability goals by promoting clean energy production without additional environmental burdens. Furthermore, its modular and scalable design ensures adaptability for diverse settings and facilitates future integration with IoT and data analytics platforms. Overall, this work underscores the potential of user-driven, sustainable energy solutions that engage the public in contributing to energy generation through everyday activities, paving the way for smarter and greener urban ecosystems.

REFERENCE:

1. Sharma and G. Kaur, "Smart Footstep Power Generator Using Piezoelectric Sensor and Microcontroller," Int. J. Sci. Res. Sci. Technol. (IJSRST), vol. 7, no. 2, pp. 501–506, 2020.
2. Arduino.cc, "Arduino UNO Board Overview," 2024. [Online]. Available: https://www.arduino.cc
3. SparkFun Electronics, "GPS Modules for Microcontrollers," 2023. [Online]. Available: https://www.sparkfun.com
4. Texas Instruments, "LM317 Adjustable Voltage Regulator Datasheet," 2021. [Online]. Available: https://www.ti.com
5. P. Mishra and A. Tiwari, "A Smart Walking Platform for Energy Generation and Crowd Monitoring," J. Green Eng., vol. 9, no. 3, pp. 443–458, 2019.
6. R. Kumar and P. Saini, "Design and Implementation of IoT Based Energy Harvesting System using Footstep," Int. J. Eng. Res. Appl. (IJERA), vol. 12, no. 5, pp. 1–7, 2022.
7. V. Bhatia and R. Jain, "Energy harvesting from human footsteps using piezoelectric sensors: A review," Mater. Today Proc., vol. 46, no. 7, pp. 10401–10405, 2020.
8. R. Khare and M. Gupta, "Smart Footstep Power Generation System Using Piezoelectric Technology Integrated with GPS," Int. J. Adv. Res. Comput. Commun. Eng. (IJARCCE), vol. 10, no. 1, pp. 23–28, 2021.
9. M. Kaur and D. Singh, "Design and Analysis of Energy Harvesting Floor Using Piezoelectric Material," J. Electron. Commun. Eng. Res., vol. 14, no. 2, pp. 76–82, 2022.
10. Dong and T. Wang, "Piezoelectric Energy Harvesting Technologies: A Comprehensive Review," Renew. Sustain. Energy Rev., vol. 107, pp. 254–267, 2019.
11. Y. Zhao, Y. You, and Z. L. Wang, "Hybrid Energy Harvesting Strategies for Self-Powered Smart Systems," Nat. Rev. Mater., vol. 5, pp. 870–889, 2020.
12. Thomas, "Design and Application of GPS-Enabled Sensor Systems for Real-Time Monitoring," Embedded Syst. J., vol. 33, no. 4, pp. 211–220, 2021.