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ML Assisted Foot Step Power Generation using Piezoelectric Sensors

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Abstract: *In our rapidly evolving world, the escalating demand for energy coupled with the finite nature of traditional resources underscores the imperative for sustainable, pollution-free, and inexhaustible energy solutions. This paper introduces a pioneering approach to harnessing the kinetic energy expended during human locomotion through the innovative use of piezoelectric sensors. Leveragingthe piezoelectric effect, these sensors efficiently convert mechanical energy generated by footstep pressure into electrical energy, thereby mitigating wastage and addressing the increasing energy needs. Our model advocates for the deployment of an extensive sensor network along footpaths, complemented by an RFID-based mobile charging system for enhanced convenience and functionality. Moreover, we introduce an innovative method integrating Machine Learning (ML) techniques to enhance power generation efficiency through intelligent modulation of piezoelectric element resistance. Additionally, we leverage ML algorithms to enhance the requisite daily footstep count necessary to fulfill the energy demands of specific areas. This proactive approach ensures optimal deployment of footstep power generation devices based on actual foot traffic patterns. Our research underscores the significance of this technology in the context of urban energy sustainability,particularly in densely populated regions like China and India, where foot traffic is abundant. By harnessing mechanical energy and leveraging advanced ML algorithms, our approach promises to revolutionize energy harvesting paradigms, paving the way for greener and more efficient power generation systems*

Keywords: God's Boon, Real Heroes and Heroines, Nation Builders, Citizen

I. INTRODUCTION

The ever-growing energy demand poses a significant challenge in modern society, especially in densely populated countries like China and India. Rapid urbanization and large populations contribute to substantial energy consumption, primarily reliant on fossil fuels, leading to environmental degradation. To combat this, innovative energy harvesting methods are gaining traction to supplement existing resources and reduce dependence on non-renewable sources. Human activities, notably walking, represent an untapped source of renewable energy. Millions of people expend mechanical energy daily through footsteps, which often goes wasted. These sensors convert mechanical pressure from walking into electrical energy, contributing to the energy grid and providing a renewable power source.

At the system's core lies the Arduino Nano, a versatile microcontroller managing and optimizingthe energy harvesting process. It collects data from piezoelectric sensors, ensuring efficient energy conversion while continuously monitoring performance. A voltage sensor regulateselectrical output, preventing overloading and storing the energy in batteries for continuous supply,even during low foot traffic. Enhancing user interaction, auxiliary elements like LCD displays offer real-time feedback on energy generation, promoting awareness and engagement. An RFIDmodule adds sophistication, enabling personalized energy tracking and user identification for customized energy allocation or monitoring. The system's practical application includes mobile device charging, addressing common needs in public spaces while promoting sustainable energyuse.

Our proposal involves setting up a comprehensive sensor network along pedestrian paths, coupledwith an RFID-enabled mobile charging setup to offer improved usability and practicality. Furthermore, we introduce a novel strategy that integrates Machine Learning (ML) methods to boost power generation efficiency by intelligently adjusting the

resistance of piezoelectric elements. Additionally, we utilize ML algorithms to optimize the required daily footstep count needed to meet the energy requirements of particular locations. This proactive strategy guarantees the efficient deployment of footstep power generation devices based on real foot traffic data patterns. Implementing this system in high-traffic public areas offers advantages like reducing strain on traditional power grids, contributing to environmental conservation, and raising awareness about renewable energy sources. However, challenges such as optimizing efficiency, durability, and reliability must be addressed through ongoing research and development for widespread deployment.
levels.

II. RELATED WORKS

Enhancement of Power Generation From Electromagnetic Scavenging Tile:

In this work, we have improvised the energy scavenging tile and presented with the simulation results. Due to improvisation, power generation was increased. Load resistance and flywheel with different inertia's are tested with the output power generation. Optimal loadresistance of 7ohms is obtained by performing different operations with the load where itcouldn't generate from 1ohm and 50ohms. Different types of flywheels are used to determine the type of flywheel to be used with its moment of inertia to get better power output. Two unidirectional clutches are used to overcome the over damping of the scavenging device and the extension period of device working time. Performance of the device will be affected without clutches. Permanent magnet synchronous generator is used even though it is costlier due to its performance and due to its long-term use. Peak energy output from this device is generated more than 2 joules. An obtrusive result of 15Watts electrical power output is generated through this device which is more than previously generated within this dimensions and displacement as per mentioned literaturereview. The objective of increasing power output by using both upward and downward motion from the energy scavenging tile is satisfied with the match of the theoretical calculation.

Design of footstep power generator using piezoelectric sensors:

In this paper, they have presented the design of power generation using footstep based on available piezoelectric sensors. Human race requires energy at very rapid rate for their living and wellbeing from the time of their arrival on this planet, because of this reason power resources have been worn out and enervated. Proposal for the employment and application of extravagant energy in foots of human is very much to the purpose for extremely populated nations like China and India. Where the streets, rail and bus station are over peopled and packed like sardines moving around the clock. So, using such concept the power can be availed and deployed by converting mechanical energy to electrical energy. In this paper we have calculated the various methodologies for foot step generation using piezoelectric sensors. The Experimental setup is discussed with all sub equipments. The results have been discussed in terms of output voltages. The plot between current and voltage shows the extent of power generated. The various merits are power generation issimply walking on the step and no need of fuel, power may also be generated by runningor exercising on the step and battery may be used to store the conventional power. In future works one may attempt to overcome following limiting factors as it is only applicable for the particular place and limited power is generated using the conventionalICs present in market.

Power Generation Through Footsteps Using Piezoelectric Sensors Along with GPS Tracking:

This technique of power generation is easy and can be used in areas where thepower is in short fall. The power generated in response to the applied pressure is given tothe streetlights controlled by a switch and can be used for the basic needs like charging of lights, mobile phones without causing any adverse effect to the environment and depletion of natural resources. In this proposed work model, GPS tracking has been addedand also streetlights switching technique comparing with existing model.

Harvesting kinetic energy of footsteps on specially designed floor tiles:

The paper presents an experimental model for harvesting kinetic energy of footsteps. A feasibility analysis were performed to evaluate the expected power generation if commercial tiles are installed at the University of Jordan. A piezoelectric model for electric energy harvesting was built. Its output voltage was analyzed

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with represent to power output and pressure. Also feasibility study was made to find the expected power generation if commercial tiles are installed at the faculty of engineering which can be extended to other parts of the university which has around 40,000 students. The obtained results show that if the produced power is stored it will amount to an energy of 1270 Wh.

Human Footsteps for Energy Generation by using Piezoelectric Tiles: The purpose of our project is to develop such a device that can convert pressure into electrical energy based on the piezoelectric element. This project will also show that the presence of waste vibration energy might have some values to be used. The system of this energy generating project includes the conversion of continuous compression of floors by human pressure across piezoelectric materials into electrical energy. In this project, the main objective was to find an approach to generating electrical energy from mechanical stress using piezoelectric elements. It was seen that mechanically excited piezoelectric materials were giving high voltage spike but low current. Using the design system energy was generated effectively and the output was observed carefully. But the amount of time to charge was too long as only 12 piezoelectric elements were used in the experiment set up. Thoroughly calculations were done and it was seen that for the results a large array of the piezoelectric element needed to be connected in series. Some calculations were made with 10-15% error and some approximation but it can be modified and still beneficial for a green source of energy.

Maximum energy harvesting from electromagnetic micro generators by footsteps using photo sensor: This technique can be used for many applications in areas where availability of power is less or totally absent. This can also be used for mobile charging, street lighting, bus station lighting and shopping malls. As India is a developing country where energy management is a big challenge for huge population. This can be used for numerous applications in rural and in metros where power availability is less or totally unavailable. Both the AC and the DC drives can be used based on the force applied to the piezo electric sensor. Here boosting and rectification of voltage are done. A photo sensor is also used to detect the day and night condition. The energy created during daytime is boosted by the boost converter and stored in the battery for the future use. During night time energy produced from the piezo electric crystals along with the energy stored in the battery is used to turn on the load.

Electrical Energy Harvesting from the Foot Stress On Foot Overbridge Using Piezoelectric Tile: In this paper, Power generation from the foot overbridge using piezoelectric tile, which is constructed with the piezoelectric transducer, is being discussed. Often more, it is seen, people walk on foot overbridge. Installing piezoelectric tile (Piezotile), we can achieve the huge amount of power, a single piezotile, which has the capability to produce up to 7-watt power, eventually installing numerous piezotile, will provide us with much power, and so power generation from this way is an easy way out. To analyze the mechanical system of the piezotile convert to the electrical circuit and PID controller is used to making the system more stable and increase the accuracy in the piezoelectric transducer. It has the possibility to generate a huge amount of power and this power source has various applications in the home, street lighting, buildings, store energy, emergency power grid and so on. Energy is inconstant and furthermost energy has vanished in nature, the thought of green-energy is to renovate numerous energy into electrical energy. Piezotile is one kind of piezoelectric transducer, which transform foot stress into electric energy.

Numerical Design of Novel piezoelectric generating structure that effectively utilizes the force generated from human motion: The piezoelectric energy harvesting (PEH) module proposed in the present study consists of a novel mechanical structure with beams and helical compression spring. The mechanical structure and beams are made of SUS304 steel and the beams are glued with PZT 5A disks. The structure is optimized to generate maximum deflection in the beams with the applied force resulted from human walking. The maximum deflection in the beams, results in maximum output voltage generation in the PZT disks. The generated voltage is fed to the load through a full-wave rectifier. The restoring force for the mechanical structure is provided using phosphor bronze helical compression spring. A total of 40 PZT disks are used in the present energy harvesting module. The whole structure is enclosed in a wooden structure. The complete PEH module is numerically simulated in COMSOL 5.4. The optimized PEH module resulted in an output power of 0.64 mW for an applied force of 500 N which is equivalent to one step of human walking. In the present work, a novel piezoelectric energy harvesting structure is designed using COMSOL 5.4. The proposed energy harvester consists of 40 piezoelectric disks mounted on the steel beams. The proposed design resulted in an output power of 8.05 mW for an optimum load resistance of 50 k with an applied force of 500 N at a frequency of 5 Hz and

0.64 mW for one footstep when an optimum load resistance of 141.4 k at a frequency of 1.5 Hz. The PEH module can supply power for ultra-low frequency applications .

III. CONCLUSION

The footstep power generation system represents a significant advancement in renewable energy, providing a sustainable solution to urban energy challenges. By converting kinetic energy from human footsteps into electrical power using piezoelectric sensors, this system reduces reliance on fossil fuels and minimizes carbon emissions and air pollution. Its scalability and adaptability make it ideal for diverse urban spaces, enhancing local energy resilience and efficiency. Environmentally, it lowers urban carbon footprints by displacing fossil fuel-based electricity, improving air quality. Community engagement is fostered through real-time feedback mechanisms, empowering individuals to participate in energy conservation. Additionally, integrating Machine Learning (ML) techniques optimizes power generation by modulating piezoelectric resistance and analyzing foot traffic patterns, ensuring effective device deployment. Economically, the system offers long-term cost savings, job creation, and technological innovation. Overall, this transformative approach blends innovation with sustainability, paving the way for a cleaner, more resilient future in urban energy management.

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