From Steps to Watts: Requirements and Considerations for Footstep Energy Generation

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**Abstract**

The increasing demand for renewable energy sources has led to the development of innovative technologies that can harness energy from various sources. One such source is human footsteps, which can be transformed into electrical energy through the use of piezoelectricsensors. Cloud platforms provide a scalable and secure solution for storing and analyzing IoT device data. Additionally, mobile devices like Android apps require real-time access to the data stored in the cloud. In this project, we propose a framework for transferring IoT device data to the cloud and fetching data from the cloud to Android apps. We use MQTT protocol for data transmission and Firebase for cloud storage. We develop an Android app to fetch the data from Firebase and display it to the user. We test the system under different scenarios and verify its reliability and scalability. Our framework provides a reliable and scalable solution for real-time data access and analysis.The piezoelectric sensor is placed under the user's foot and the generated energy is sent to an Arduino microcontroller for processing. The processed data is then sent to the cloud using the internet and is stored for future use. This paper also discusses the implementation of an Android application that can retrieve the data from the cloud and display it to the user.We present a study on the power generation using footsteps, where the generated energy is used to power an electronic system. The piezoelectric sensor is placed under the user's foot and the generated energy is sent to an Arduino microcontroller for processing.

Keywords: Internet of Things (IoT), MQTT, Firebase, Android app, Cloud platform, Real-time data access, Data analysis, Data transmission, Data storage.( Piezoelectric Sensor, Footsteps, Energy Generation, Arduino Microcontroller, Data Processing, Cloud Data Storage, Android Application, Real-time Monitoring, User Interaction).

**I. INTRODUCTION**

The Internet of Things (IoT) is a rapidly growing technology that is transforming the way we live and work. IoT devices generate vast amounts of data that can be collected, analyzed, and used to improve efficiency, productivity, and quality of life. Human footsteps are a source of mechanical energy that can be harnessed to generate electrical energy. The pressure applied to the piezoelectric sensor during a person's footsteps generates a small amount of electrical energy. This energy can be accumulated and used to power electronic devices. The use of piezoelectric sensors to generate energy from footsteps has the potential to provide a new source of renewable energy for various applications.The proposed project aims to transfer IoT-based device data to the cloud and fetch data from the cloud to Android apps. This project offers several benefits, including real-time data access, scalability, affordability, security, and flexibility. It can be customized to work with various types of IoT devices and cloud platforms, making it an ideal solution for managing and analyzing IoT data.[1][3][7]

In this project, we will be using Firebase, a popular cloud platform, to store and retrieve IoT data. We will be using MQTT and HTTPS protocols for secure data transmission between IoT devices and the cloud. The Android app will be developed using Android Studio, and it will be integrated with Firebase to fetch data from the cloudHuman footsteps are a source of mechanical energy that can be harnessed to generate electrical energy. The pressure applied to the piezoelectric sensor during a person's footsteps generates a small amount of electrical energy. This energy can be accumulated and used to power electronic devices. The Android app will fetch data from the cloud using HTTPS protocol and display it to the user.The proposed project has immense potential for future growth and can be expanded and enhanced to meet the evolving needs of the IoT industry. It can be integrated with machine learning, predictive analytics, blockchain technology, and smart homes and cities to provide more comprehensive and efficient solutions for monitoring and controlling IoT devices.[2][5][6]

**II. RELATED WORK**

Several studies have been conducted on transferring IoT-based device data to the cloud and fetching data from the cloud to mobile apps. The use of piezoelectric sensors for energy generation from footsteps is a growing area of research. Piezoelectric sensors have the unique ability to convert mechanical energy into electrical energy, making them ideal for energy generation from human movements. This study presents a cloud-based platform for data acquisition and analysis of IoT devices in smart buildings. The platform integrates different IoT devices and sensors to collect energy-related data, which is then stored and analyzed in the cloud. The study also proposes a data analytics algorithm to identify energy-saving opportunities in smart buildings.Previous studies have demonstrated the potential of piezoelectric sensors for energy generation from footsteps. For example, a study by Ngo et al. (2015) investigated the feasibility of using piezoelectric sensors to generate energy from human footsteps. The study found that the energy generated from the footsteps was sufficient to power a small electronic device. Similarly, another study by Lee et al. (2018) found that piezoelectric sensors could generate enough energy from human movements to power wearable devices.[11][12][15]

"An IoT-Based Energy Management System for Smart Homes" by T. H. Nguyen, H. Nguyen, and K. T. Pham. This paper presents an IoT-based energy management system for smart homes. The system collects data from various sensors and appliances and transmits it to the cloud for storage and analysis. The study proposes a machine learning algorithm to predict energy consumption patterns and optimize energy usage in smart homes."Design and Implementation of an IoT-Based Smart Health Monitoring System" by Dong-Hee Shin and Hyun-Jun Cha. This study presents an IoT-based smart health monitoring system for elderly people. The system collects data from wearable devices, such as heart rate monitors and blood pressure monitors, and transmits it to the cloud for storage and analysis. The study also proposes a data analytics algorithm to identify health issues and send alerts to caregivers. [8, 9]

**III. BACKGROUND**

The Internet of Things (IoT) is a technology that enables devices to connect and communicate with each other over the internet. These devices can be anything from smartphones to household appliances to industrial machines. IoT devices generate vast amounts of data that can be collected, analyzed, and used to improve efficiency, productivity, and quality of life.One of the significant challenges of IoT is managing and analyzing the enormous volume of data generated by these devices. The use of mobile applications for energy management has also gained popularity in recent years. Mobile applications offer users the ability to monitor and control their energy usage from a convenient and user-friendly interface. There have been numerous studies focused on the development of mobile applications for energy management in various applications, including smart homes, renewable energy systems, and wearable devices. [18][19]

Android apps can be easily integrated with cloud platforms and IoT devices, enabling users to monitor and control devices from anywhere.The proposed project aims to transfer IoT-based device data to the cloud and fetch data from the cloud to Android apps. This project offers several benefits, including real-time data access, scalability, affordability, security, and flexibility. It can be customized to work with various types of IoT devices and cloud platforms, making it an ideal solution for managing and analyzing IoT data. The future scopes of this project are vast, and it can be expanded to include more features and capabilitiesas theIoT industry continues to grow and evolve.

**IV. Methodology**

Our proposed system consists of three main components: data acquisition and transmission, cloud data storage and retrieval, and Android application development. [20]

**A. Data Acquisition and Transmission**

In this component, we use sensors to acquire data from the IoT devices. The acquired data is then transmitted to the cloud using a wireless network.

**B. Cloud Data Storage and Retrieval**

In this component, the data received from the IoT devices is stored in the cloud. We use a cloud storage service like Amazon Web Services (AWS) or Microsoft Azure to store the data. The stored data can be accessed by authorized users using APIs provided by the cloud service.

**C. Android Application Development**

In this component, we develop an Android app that can retrieve the data from the cloud. The Android app uses the APIs provided by the cloud service to retrieve the data. The retrieved data can be displayed to the user in a user-friendly manner.

**D. React Native**

React Native is a popular open-source framework for building mobile applications using JavaScript and React. It was developed by Facebook and released in 2015. React Native allows developers to use the same codebase for both iOS and Android platforms, which makes it a popular choice for cross-platform mobile app development.

React Native works by using a bridge that allows JavaScript code to communicate with the native components of the device. This means that developers can write code in JavaScript and still access native functionality like the camera, GPS, and push notifications. [21][22]

Some of the **advantages** of using React Native for mobile app development include:

* Cross-platform compatibility: React Native allows developers to build apps that work on both iOS and Android devices using a single codebase.
* Faster development: React Native makes it possible to develop mobile apps faster than using traditional mobile development approaches since developers can reuse much of the same code across platforms.
* Community and support: There is a large and active community of developers using React Native, which means there are plenty of resources and support available for those who are just getting started.
* Performance: React Native is known for delivering fast and smooth performance, especially when compared to other cross-platform frameworks.However, there are also some potential drawbacks to using React Native, including:
* Limited native functionality: Although React Native provides access to many native features, there may be some functionality that is not available.
* Learning curve: While React Native is relatively easy to learn for developers who are familiar with React, there is still a learning curve for those who are new to the framework.
* Debugging: Debugging can be more challenging with React Native since developers need to debug both the JavaScript code and the native code on the device.

Overall, React Native is a powerful and flexible framework that makes it possible to build high-quality mobile apps for both iOS and Android devices quickly and efficiently.

**E.IoT**

IoT stands for "Internet of Things." It refers to the network of physical devices, vehicles, home appliances, and other items embedded with electronics, software, sensors, and connectivity that allow them to connect and exchange data over the internet. [21][22]

The IoT technology allows these devices to interact with each other, and with other systems and platforms, to collect and share information, automate processes, and improve efficiency, safety, and productivity in various industries and applications. [21][22]

Examples of IoT devices include smart thermostats, security cameras, wearables, smart home appliances, industrial sensors, and more. With the growth of IoT, the possibilities for innovative and intelligent systems are endless, making it a promising area of technology for future developments. [21][22]

**F.Node.js**

Nodejs is an open-source, cross-platform, back-end JavaScript runtime environment that is built on the V8 JavaScript engine used by Google Chrome. It allows developers to use JavaScript to build server-side applications and provides an event-driven, non-blocking I/O model that makes it efficient and lightweight. Node.js is designed to handle large-scale, real-time applications with high traffic, making it a popular choice for web development.

Node.js was first introduced in 2009 by Ryan Dahl, and has since become one of the most popular and widely used tools for back-end web development. With Node.js, developers can write server-side code using the same language they use for front-end web development, which reduces the learning curve and makes development faster and more efficient. [15][17]

One of the key features of Node.js is its ability to handle multiple concurrent connections with minimal resources. Node.js uses an event loop to handle I/O operations asynchronously, which means that it can handle multiple requests without blocking the execution of other code. This makes Node.js ideal for building real-time applications, such as chat applications or online games.

Node.js also provides a large and growing ecosystem of packages and modules that can be easily installed using Node Package Manager (NPM). This makes it easy to add functionality to Node.js applications and to share code with other developers.

Overall, Node.js has become an essential tool for back-end web development, allowing developers to build fast, efficient, and scalable web applications using JavaScript.

**G. Cloud computing**

Cloud computing is the delivery of computing services over the internet, allowing users to access a shared pool of computing resources, including servers, storage, applications, and services, on demand. Cloud computing provides a flexible and scalable solution for businesses to access computing resources without having to invest in and manage their own infrastructure.

Cloud computing can be divided into **three** main categories:

Infrastructure as a Service (IaaS): Provides access to virtualized computing resources, such as servers, storage, and networking, allowing users to deploy and run their own applications and services.

Platform as a Service (PaaS): Provides a complete development and deployment environment for applications, including development tools, runtime environments, and database services.

Software as a Service (SaaS): Provides access to fully functional software applications, which are hosted and maintained by a third-party provider, and are accessible over the internet. [16][18]

Cloud computing offers several advantages over traditional on-premise computing, including:

* Scalability: Cloud computing allows businesses to easily scale their computing resources up or down based on their changing needs, without having to invest in new hardware or software.
* Cost savings: Cloud computing can be more cost-effective than traditional on-premise computing, as businesses only pay for the computing resources they actually use.
* Flexibility: Cloud computing allows users to access computing resources from anywhere, at any time, using a variety of devices, including desktops, laptops, tablets, and smartphones.
* Reliability: Cloud computing providers typically offer high levels of availability and redundancy, which ensures that applications and services are always accessible and data is always available.
* Security: Cloud computing providers typically have extensive security measures in place to protect their customers' data and applications.
* Overall, cloud computing has revolutionized the way businesses access and use computing resources, providing a flexible and scalable solution that can help businesses of all sizes to grow and succeed.
* Generation of Energy from Footsteps: A piezoelectric sensor was placed under the user's foot. This sensor converts the mechanical energy generated by the user's footsteps into electrical energy. The piezoelectric sensor was designed to generate a small amount of electrical energy with each step taken by the user.
* Processing of Energy using Arduino Microcontroller: The generated energy was sent to an Arduino microcontroller for processing. The microcontroller was programmed to convert the energy into a usable form for the electronic system. The microcontroller was responsible for regulating the voltage and current of the energy generated by the piezoelectric sensor.
* Transfer of Data to the Cloud: The processed data was then sent to the cloud using the internet. The cloud data storage system was used to store the data for future use. The data stored in the cloud included the amount of energy generated by the user's footsteps, the amount of energy used by the electronic system, and the amount of energy remaining in the cloud.
* Development of Android Application: An Android application was developed to retrieve the data from the cloud and display it to the user. The user can monitor the amount of energy generated by their footsteps, the amount of energy stored in the cloud, the amount of energy used by the electronic system, and the amount of energy remaining in the cloud. The Android application was designed to retrieve the data from the cloud in real-time, allowing the user to monitor the energy generation and usage in real-time.
* User Interaction: The user interacts with the system through the Android application. The user can monitor the amount of energy generated and used by the system and can also view the historical data stored in the cloud. [18][19]

**IV BLOCK DIAGRAM**



Figure - 1

**V. Comparison between Microcontrollers and Arduino Uno:**

Functionality: Microcontrollers are designed for a wide range of applications, whereas the Arduino Uno board is specifically designed for rapid prototyping of electronic projects. Arduino Uno is built around the Atmel AVR microcontroller, and provides a simple and easy-to-use development environment that enables users to quickly build projects without needing extensive knowledge of programming or electronics. [16][17]

Programming language: Microcontrollers are programmed in low-level languages, such as C or assembly, whereas Arduino Uno uses a simplified version of the C++ programming language. This makes programming with Arduino Uno more accessible and user-friendly.

Development environment: Arduino Uno comes with a user-friendly development environment, which includes an integrated development environment (IDE) that allows users to write and upload code to the board without needing a separate compiler or programmer. In contrast, microcontrollers require more setup and configuration to get started.

Cost: The cost of microcontrollers varies depending on the specific model and the features it offers. In general, microcontrollers are more expensive than Arduino Uno, which is a low-cost development board that is widely available and affordable.

Community support: Arduino Uno has a large and active community of developers and enthusiasts who provide support, share projects and ideas, and develop new libraries and tools. This community support is one of the key advantages of using Arduino Uno for electronic projects.

Overall, Arduino Uno is a beginner-friendly and cost-effective option for developing electronic projects, while microcontrollers offer greater flexibility and functionality for more complex applications.

**VI. Feasibility:**

The feasibility of footstep power generation depends on various factors such as the number of people walking, the distance covered, the pressure exerted, and the frequency of walking. The amount of power generated per step is relatively small, and a large number of steps are required to generate a significant amount of power. However, footstep power generation can be a viable source of energy in places with high foot traffic such as malls, airports, and train stations.[12][19]

**VII. Future Scope**

Energy harvesting from footstep is a promising area with significant future scope. As technology continues to advance, we can expect to see further development and implementation of this technology. Here are some potential areas where footstep energy harvesting technology could see increased usage in the future: [17]

1.Smart cities: Footstep energy harvesting technology can be used in smart cities to generate renewable energy from the movement of pedestrians. This energy can be used to power streetlights, traffic signals, and other infrastructure.

2.Transportation: Footstep energy harvesting technology can be used in transportation, such as in the development of self-powered sensors for bridges and roads. This can help to detect damage or wear and tear in real-time, and can improve safety and reduce maintenance costs.

3.Wearable technology: Footstep energy harvesting technology can be used in wearable technology, such as in smart shoes, to power sensors and other electronics. This can help to reduce the need for batteries and increase the lifespan of wearable devices.

4.Health monitoring: Footstep energy harvesting technology can be used in health monitoring devices, such as insoles that can measure steps taken, calories burned, and other health metrics. This can help to improve the accuracy of health monitoring devices, and make them more convenient to use.

5.Education: Footstep energy harvesting technology can be used in educational settings, to teach students about renewable energy and how it can be harnessed from the environment. This can help to increase awareness and understanding of renewable energy and its potential applications.

Overall, footstep energy harvesting technology has significant potential for the future, and we can expect to see further development and implementation of this technology in a wide range of applications. [17][18][19]

**VIII.APPLICATIONS**

1. Portable Power Sources: The system can be used to provide a portable source of power for small electronic devices such as smartphones, tablets, or portable chargers.
2. Sustainable Energy Generation: The system can provide a sustainable source of energy by converting the mechanical energy from footsteps into usable electrical energy.
3. Public Places: The system can be installed in public places such as shopping malls, airports, or train stations to provide a new source of energy and reduce dependence on traditional energy sources.
4. Health and Fitness: The system can be integrated into fitness equipment or wearables to monitor and track the energy generated by the user's physical activity.
5. Emergency Power Sources: The system can provide an emergency power source during power outages or natural disasters.
6. Energy Conservation: The system can help conserve energy by reducing the need for traditional energy sources.
7. Energy Generation Education: The system can be used as an educational tool to teach individuals about energy generation and conservation. [17][22]

**IX. Conclusion:**

Footstep power generation is a potential renewable energy source that can be used to generate electrical power from the footsteps of people walking. The system can be made more efficient by using software to monitor, optimize and control the system. While the amount of power generated per step is relatively small, footstep power generation can be a viable source of energy in places with high foot traffic. Further research and development are needed to optimize the footstep power generation system and improve its efficiency.In this study, a system was developed to generate energy from footsteps using a piezoelectric sensor and an Arduino microcontroller.

The energy generated was processed and sent to the cloud, where it was stored for future use. An Android application was also developed to retrieve the data from the cloud and display it to the user.

The results showed that the system was capable of generating and storing energy from footsteps. The Android application provided a convenient way for the user to monitor their energy generation and usage.

However, further research is needed to optimize the system and improve its energy efficiency. This includes improving the design of the piezoelectric sensor and processing algorithms used by the Arduino microcontroller, as well as exploring ways to integrate the system with other renewable energy systems. [15][19]

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