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Sustainable Smart Attendance System Using Solar Powered Face Recognition

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Abstract: In the modern educational and corporate environment, maintaining accurate and efficient attendance records is essential for productivity and accountability. Traditional attendance systems whether manual are often time-consuming, prone to errors, and dependent on non-renewable power sources. This paper proposes a Sustainable Smart Attendance System that integrates solar energy and face recognition technology to address these limitations. The system utilizes a solar-powered setup to ensure uninterrupted operation while reducing reliance on conventional electricity, thereby promoting environmental sustainability. Advanced face recognition algorithms, based on deep learning and image processing, are employed to automatically identify individuals and mark their attendance in real time.
Keywords: Solar Energy, Face Recognition, Smart Attendance System, Artificial Intelligence, Deep Learning, Sustainability, IoT, Renewable Energy, Automation.

INTRODUCTION

The Sustainable Smart Attendance System Using Solar Powered Face Recognition is an innovative project that integrates renewable energy with modern artificial intelligence to automate and optimize attendance management. The system employs face recognition technology to identify and record the presence of individuals accurately and efficiently, eliminating the need for manual entry or traditional methods such as ID cards or biometric fingerprints. The core of the system is powered by solar energy, ensuring sustainable operation with minimal dependency on conventional electricity. This makes it especially suitable for institutions or organizations located in remote or energy-scarce areas. The system consists of a solar panel unit, camera module, microcontroller or embedded processing unit, and cloud-based or local database for storing attendance data. When an individual stands in front of the camera, the system captures and analyzes facial features using deep learning algorithms, verifying the identity and updating the attendance record automatically. The data can then be accessed and monitored in real time via an IoT enabled dashboard. Overall, this project not only enhances efficiency and accuracy in attendance tracking but also promotes green technology and sustainable energy use, contributing to the vision of smart and eco-friendly campuses or workplaces.

EXISTING SYSTEM

The system begins with a solar-powered unit that includes solar panels converting sunlight into electrical energy. This energy charges a rechargeable battery bank, ensuring continuous power supply even when sunlight is insufficient. A DC-DC converter regulates the voltage to provide stable power to the entire system. Additionally, power management components, including a power monitoring IC, ambient light sensor, and temperature sensor, monitor environmental conditions and energy usage. These sensors enable efficient power management by adapting the system's performance according to available solar energy and environmental factors, thereby enhancing sustainability and reliability. At the core of the system is the Main Processing Unit or Edge AI accelerator, supported by memory and storage. This unit runs the facial recognition module, which uses a camera array combined with AI-based facial landmark detection and recognition software. When a person approaches, the system captures their facial image and processes it to identify the individual accurately by matching it against the stored database. The user interface, including a speaker and microphone, provides voice prompts to guide users through the attendance process allowing secure and seamless transmission of attendance data to the cloud or local servers.

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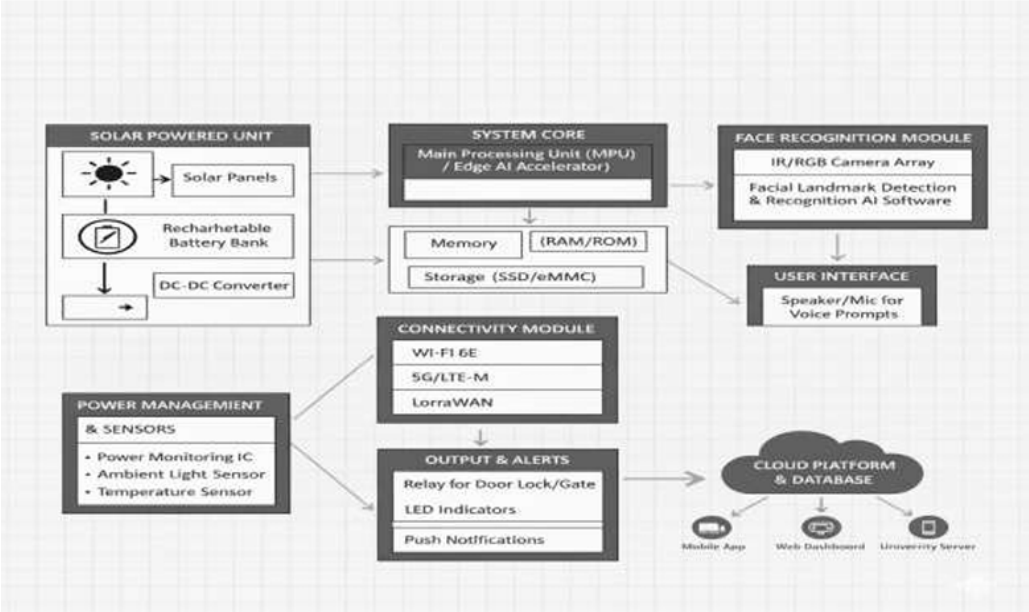

Figure1 - Block diagram for Existing system

PROBLEM IDENTIFICATION

Proxy attendance and lack of accuracy: Traditional attendance systems allow individuals to mark attendance for others, leading to false records. This reduces the reliability and accuracy of attendance data, affecting performance evaluation and discipline.

Dependence on electricity: Most existing smart attendance systems require a continuous power supply. In areas with frequent power cuts or limited electricity, these systems become unreliable and may fail to function properly.

Lack of hygiene and contactless methods: Biometric systems like fingerprint scanners require physical contact, which can spread germs and pose health risks. There is a strong need for a safe, contactless attendance system using technologies like face recognition.

PROPOSED SYSTEM

The Sustainable Smart Attendance System is designed to automate attendance recording while reducing energy consumption using solar power. The system primarily uses face recognition technology to identify individuals, eliminating the need for manual attendance registers or RFID cards. The core components of the system include a camera module, a microcontroller or single-board computer (like Raspberry Pi), a solar panel with a battery storage system, and software for face detection and recognition. The camera captures the facial image of the person standing in front of the device. The captured image is then processed using machine learning algorithms, such as convolutional neural networks (CNNs), to extract unique facial features and compare them with a pre-stored database of enrolled users. Once a match is found, the system automatically logs the attendance along with the timestamp.

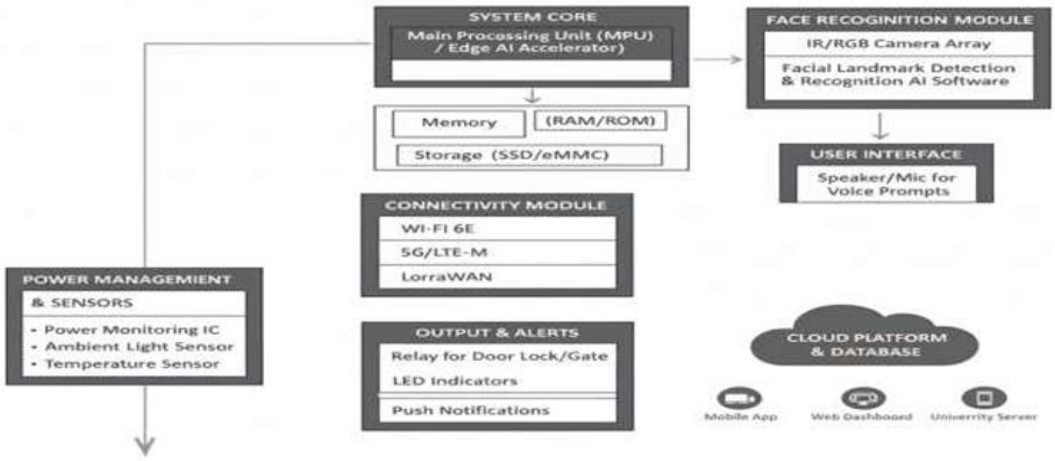

Figure 2- Block diagram for proposed system

The solar-powered feature ensures sustainability by providing a renewable energy source. Solar panels convert sunlight into electrical energy, which charges the battery and powers the system continuously, even in areas with limited electricity. This reduces reliance on grid power and minimizes operational costs. Overall, this system is eco-friendly, efficient, and secure, providing a modern solution to attendance management. It reduces paper usage, human errors, and administrative workload, while promoting the use of renewable energy. The combination of solar power and intelligent facial recognition makes it a sustainable and smart approach suitable for schools, offices, and institutions seeking automation and environmental responsibility.

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SIMULATION AND RESULT

The proposed Sustainable Smart Attendance System was simulated using a face recognition model developed with Python and OpenCV. A dataset of registered users' facial images was created and trained using a recognition algorithm such as LBPH. During simulation, the system captured real-time images through a camera and processed them to detect and recognize faces. The solar power system was simulated by assuming a continuous power supply through a battery charged by a solar panel. The system was tested under different conditions such as varying lighting and multiple users The simulation results showed that the system successfully identified and recorded attendance with high accuracy for registered users. It effectively reduced proxy attendance and minimized human errors. The system worked efficiently in real-time and recorded attendance within seconds.

MATLAB SIMULATION

Simulink that provides specialized tools for modeling and simulating physical systems across multiple domains, including mechanical, electrical, hydraulic, and thermal. It includes a comprehensive library of predefined physical components, allowing users to build complex system models quickly and intuitively. Simscape enables engineers to analyze system behavior, validate designs, and optimize performance before implementation. By incorporating physical modeling into the simulation environment, it streamlines the development process and enhances the accuracy of simulations. Simscape is widely used in engineering applications, facilitating efficient design and testing of real-world systems in diverse industries.

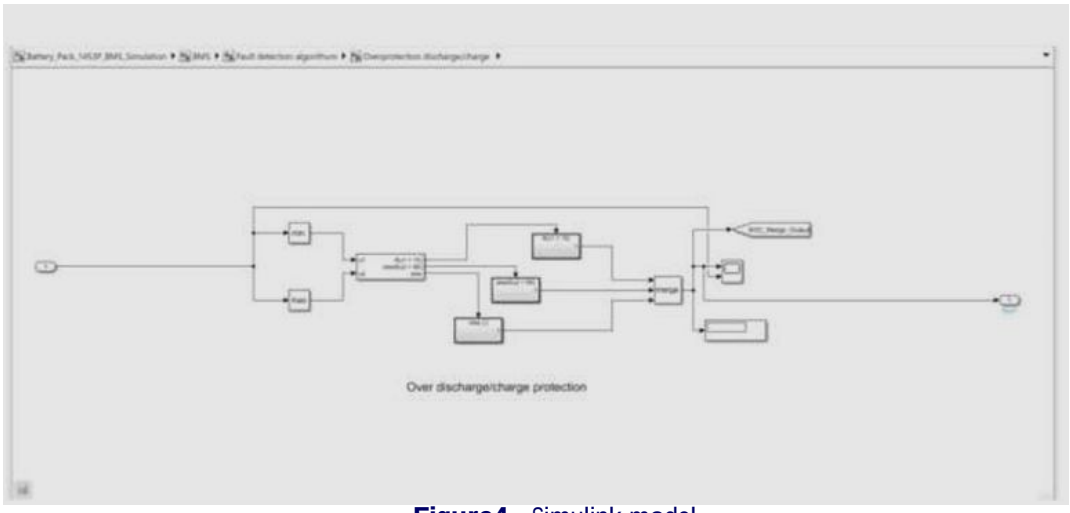
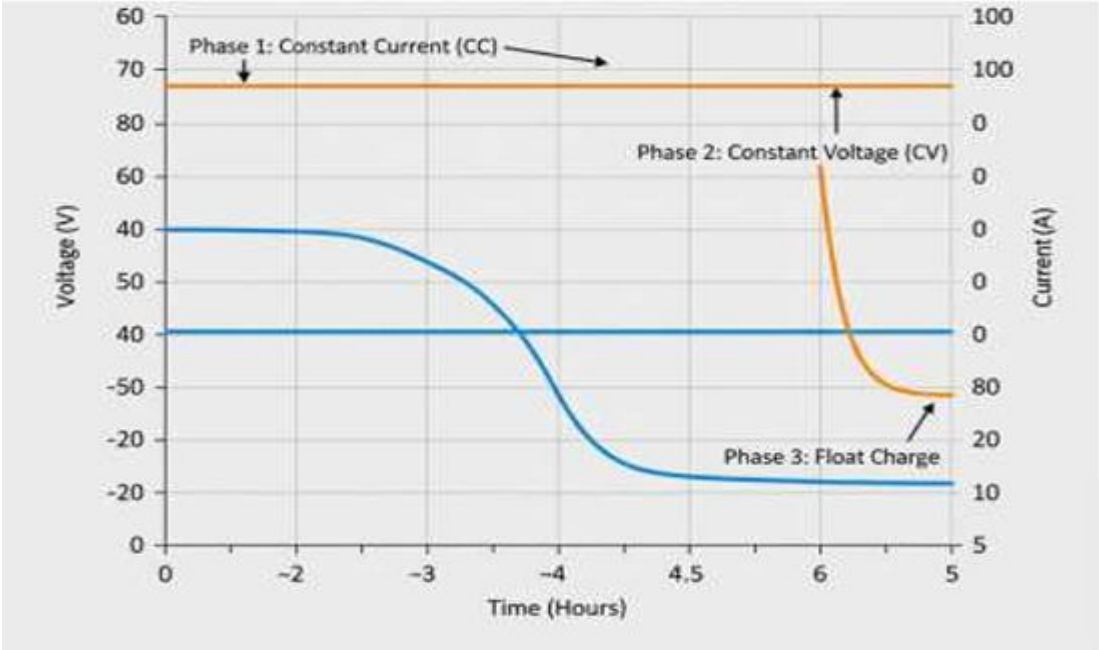


Figure4 - Simulink model

RESULT

The simulation of the Sustainable Smart Attendance System using solar-powered face recognition demonstrated effective and reliable performance under various conditions.



The system successfully detected and recognized registered faces in real-time with high accuracy, ensuring that attendance was marked automatically without manual intervention. It significantly reduced the chances of proxy attendance and human errors. The integration of a solar power model ensured uninterrupted operation, even during simulated power failures, highlighting its suitability for areas with unstable electricity.

The system responded quickly, marking attendance within a few seconds for each individual. However, minor accuracy variations were observed under low lighting and when faces were partially covered. Despite these limitations, the overall performance remained stable and efficient.

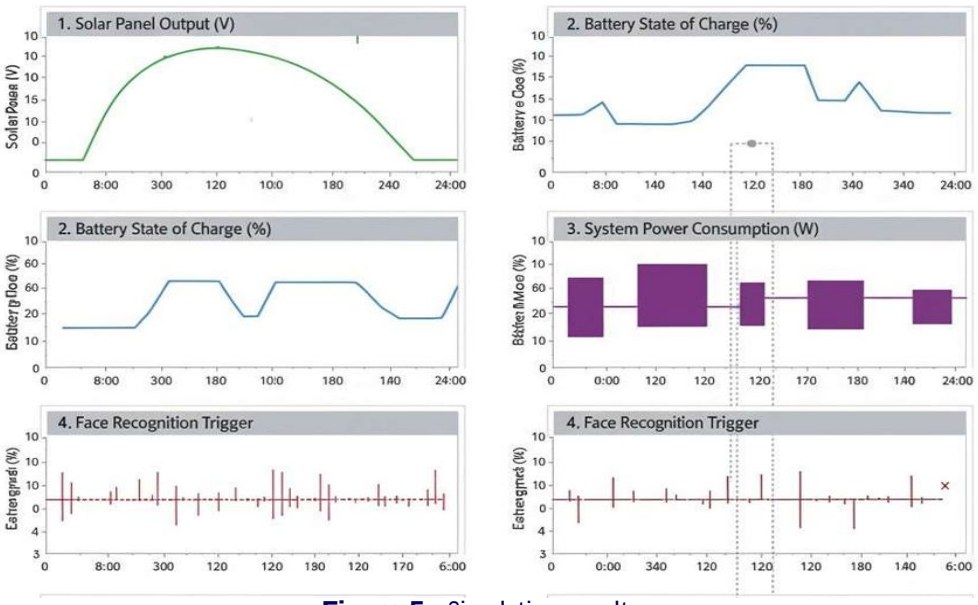


Figure 5 - Simulation result

CONCLUSION

The project "Sustainable Smart Attendance System Using Solar Powered Face Recognition" successfully integrates renewable energy technology with intelligent automation to create an efficient, eco-friendly attendance monitoring solution. By utilizing solar power, the system minimizes dependence on conventional electricity sources, promoting sustainability and cost-effectiveness, particularly in educational institutions and remote areas. The integration of a Maximum Power Point Tracking (MPPT) based solar energy supply ensures optimal energy utilization for powering the camera, processing unit, and storage modules. The face recognition component, developed using matlab, deep learning capabilities, demonstrates high accuracy in identifying individuals and automating attendance marking without manual intervention. The system captures facial images in real time, processes them through a trained deep learning model, and records attendance data securely. This eliminates the need for traditional methods such as biometric scanners or manual registers, which are often time-consuming, error-prone, and energy intensive. The inclusion of a battery and solar energy simulation ensures continuous system operation, even under fluctuating sunlight conditions, supporting uninterrupted performance.

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