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DEPARTMENT OF
COMPUTER SCIENCE AND ENGINEERING
(ARTIFICIAL INTELLIGENCE)

SOLARNOVA AI

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Introduction

- SolarNova AI represents a pioneering fusion of renewable energy and artificial intelligence technology.
- SolarNova AI redefines the paradigm of solar energy utilization by integrating advanced AI-driven optimization with real-time environmental adaptation.
- Its intelligent features make it a sustainable and efficient solution for harnessing solar power, paving the way for a greener and more sustainable future.
- By dynamically optimizing solar panel orientation, it maximizes energy capture efficiency.
- Equipped with AI algorithms, it autonomously adjusts to changing environmental conditions for optimal performance.
- With its innovative dust detection and cleaning features, SolarNova AI ensures sustained efficiency and minimal maintenance, revolutionizing solar energy utilization.

Problem definition

- The problem addressed by SolarNova lies in the inefficiencies and maintenance challenges of traditional solar panel systems. By integrating automatic dust and dirt detection and cleaning mechanisms with dynamic panel orientation, SolarNova tackles two critical issues simultaneously.
- Dust accumulation reduces the efficiency of solar panels, leading to decreased energy production, while manual cleaning is labor-intensive and often overlooked. With SolarNova, real-time detection of dust and dirt triggers automated cleaning processes, ensuring optimal panel performance without manual intervention.
- Additionally, the system's dynamic panel orientation maximizes energy capture, further enhancing overall efficiency and sustainability.

Relevance of the project

- In India, millions of households still lack access to electricity. By leveraging SolarNova AI to enhance the efficiency of solar panels, we can contribute to addressing this issue by generating a reliable and sustainable source of electricity.
- Water scarcity affects the generation of electricity from hydropower plants, leading to reduced output. SolarNova AI offers an alternative solution that isn't dependent on water resources, providing a viable option for electricity generation even in regions facing water shortages.
- The presence of dust and dirt on solar panels significantly reduces their efficiency. By automatically detecting and cleaning these panels, SolarNova AI ensures optimal performance, maximizing the generation of solar energy.
- By improving the efficiency of solar panels, SolarNova AI contributes to the overall availability of energy, which can be crucial in areas where traditional power infrastructure is lacking or unreliable.
- Solar energy offers the advantage of distributed generation, meaning it can be deployed in remote or underserved areas where grid connectivity is limited.

Novelty

- SolarNova AI introduces AI-driven automation for detecting and cleaning solar panel debris, optimizing energy production.
- Real-time monitoring enhances system management, promoting transparency and efficiency.
- Utilizing solar power for operation underscores sustainability and cost-effectiveness.
- Scalability enables adaptation to various installations, from residential to commercial.
- Innovative integration of off-the-shelf components and AI technology delivers a practical and affordable solution.

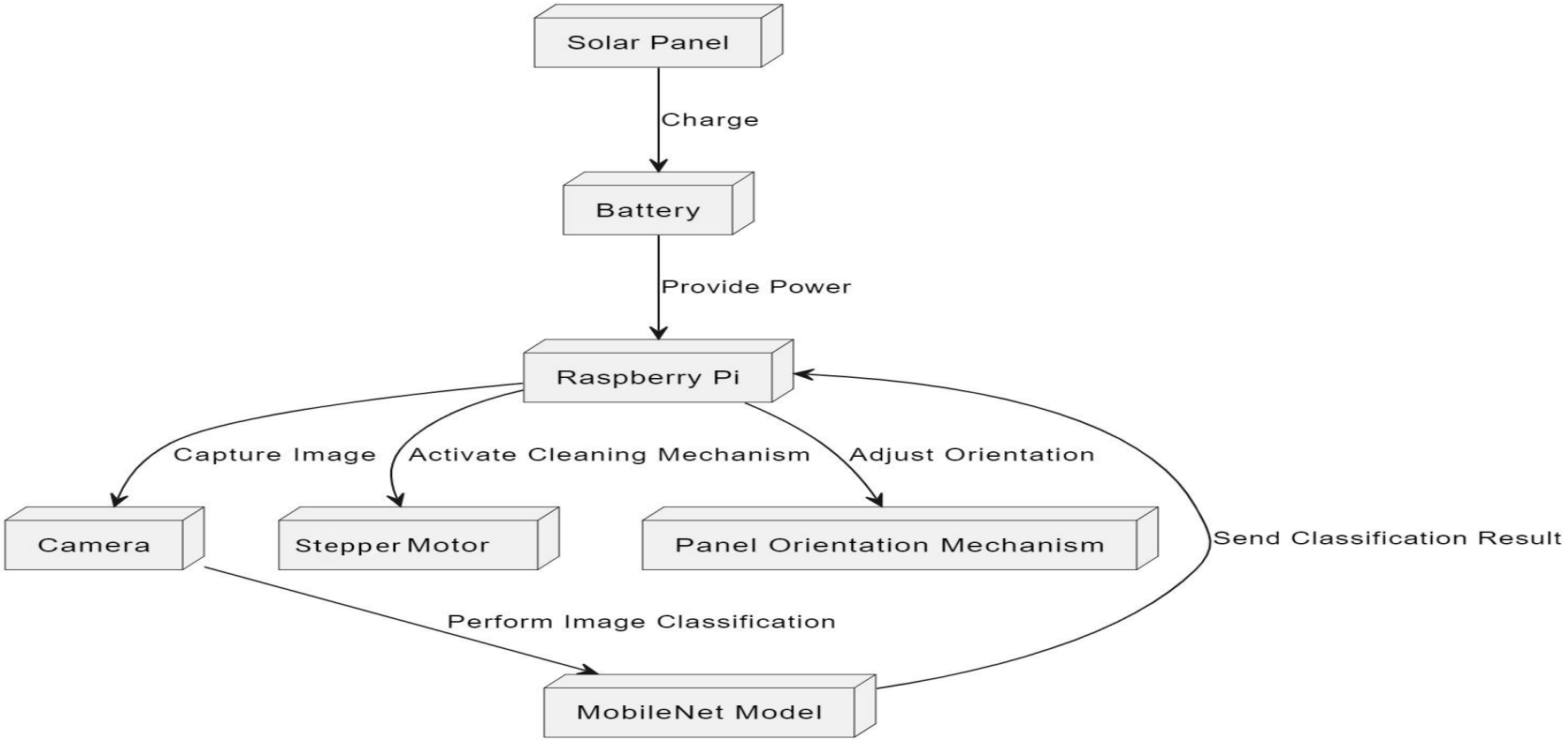
Related works

Model	Methodology	Advantage	Disadvantage
SolNet	Convolutional Neural Network (CNN) tailored for dust detection on solar panels.	boasts reduced complexity and faster training times compared to traditional approaches.	Not suitable for real time detection.
Automatic Solar Panel Cleaning System Based on Arduino for Dust Removal	employs an Arduino-based cleaning mechanism utilizing exhaust fans and soft cloth wipers.	system offers simplicity and affordability, catering to areas with water scarcity.	Manual power required
Solar Panel Surface Dirt Detection and Removal Based on Arduino Color Recognition	Using Arduino Uno and color sensors, the system identifies dirt accumulation and employs a rolling brush arrangement for efficient cleaning	high-speed	sensor sensitivity

Related Works

Automatic Solar Panel Cleaning System	This system, controlled via a mobile app, highlights the significant impact of dust on solar panel efficiency.	Robotic cleaning is emphasized as more economical and less cumbersome than manual methods, enhancing power generation efficiency.	Lower accuracy
Dust Detection in Solar Panels Using Image Processing Techniques	discusses various image processing techniques for dust detection on solar panels, emphasizing the importance of maintaining cleanliness for optimal efficiency	Optimal cleaning	High errors
IoT-Based Solar Panel Tracking System with Weather Monitoring System	This system utilizes Arduino Uno and a Wi-Fi module for data transmission and mobile application control.	Efficient	Less accuracy in real time.

Proposed Methodology



Proposed methodology

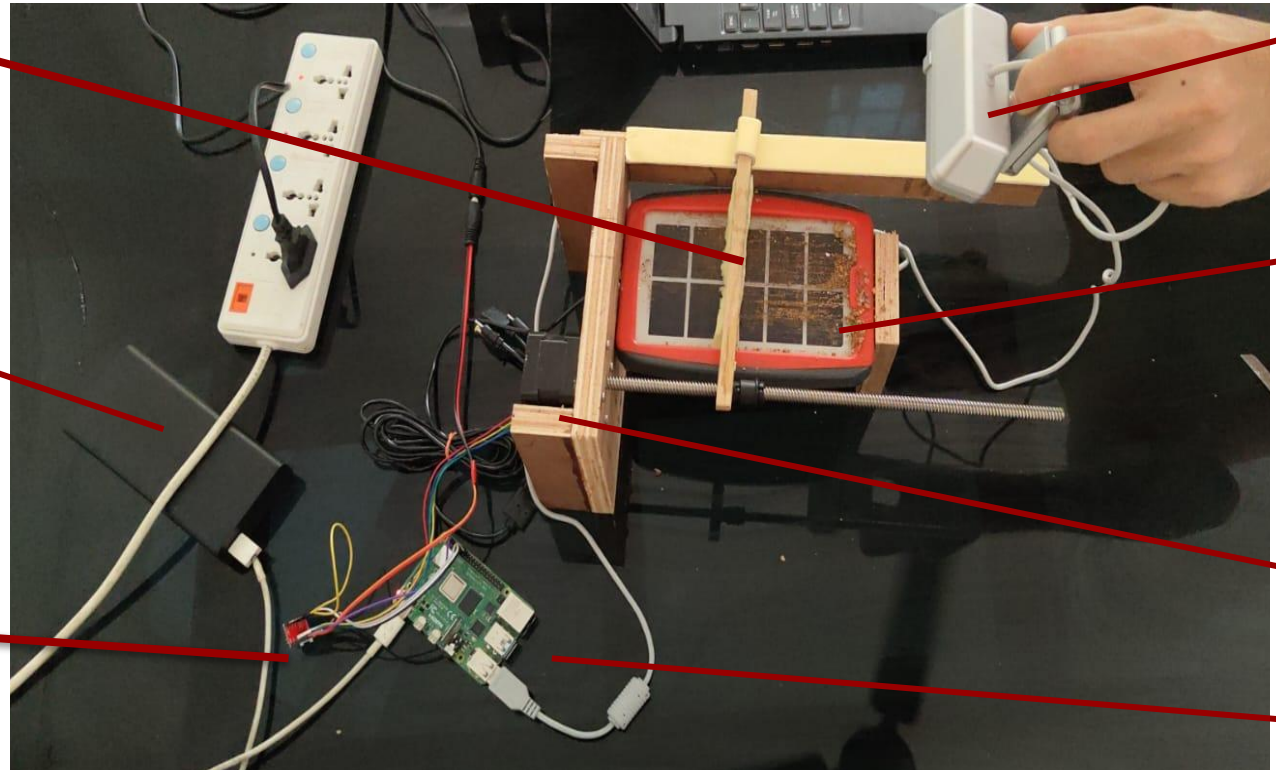
The SolarNova AI system operates through several key steps:

- Image Acquisition: The process begins with capturing images of solar panels using a webcam or similar camera setup. These images serve as input for the subsequent analysis.
- Preprocessing: Before analysis, the acquired images undergo preprocessing steps such as resizing, normalization, and potentially noise reduction. These steps ensure that the images are standardized and suitable for analysis.
- Feature Extraction: The preprocessed images are fed into a pre-trained MobileNet model for feature extraction. MobileNet is a convolutional neural network (CNN) architecture optimized for mobile and embedded vision applications. Using fine tuning with mobilenet the model efficiently extracts relevant features from the images, which are crucial for identifying dust and dirt on solar panels.
- Dust Detection: The extracted features are then used to classify regions of the images as either clean or containing dust. This classification is performed using machine learning algorithms integrated with the MobileNet feature extractor.

Proposed methodology

- Decision Making: Based on the dust detection results, the system makes decisions regarding whether cleaning is necessary for each panel. If dust is detected above a certain threshold which is the confidence value here, the system proceeds to initiate the cleaning process.
- Cleaning Mechanism Activation: Upon determining the need for cleaning, the system activates the cleaning mechanism, which may involve servo motors or other actuators to move cleaning tools across the surface of the solar panels. This process ensures thorough removal of dust and debris, thereby optimizing the panels' efficiency.
- Automation and Control: The entire process is automated and controlled by a Raspberry Pi or similar microcontroller. The Raspberry Pi coordinates the image analysis, decision-making, and cleaning actions, ensuring seamless operation without human intervention.
- Power Management: In some configurations, a battery charged by solar energy may be used to power the Raspberry Pi and associated components, providing a self-sustaining solution.
- Monitoring and Feedback: Throughout the process, the system may provide real-time monitoring and feedback, allowing users to track the cleaning progress and the overall performance of the solar panel array.

SOLARNOVA AI



SOLARNOVA AI

Step 1:Model initializes the webcam connected to the Raspberry Pi for capturing frames. This webcam serves as the primary input device for the system, providing real-time images of the solar panels.

Step 2:Once the camera is set up, the script enters a continuous loop where it captures frames from the camera. These frames are then preprocessed to prepare them for inference using the loaded mobile net model.

Step 3:Every 2 seconds,the model analyzes the image and predicts whether the solar panel is clean or covered with dirt.

Step 4:f the confidence level of a "dirt" prediction is above a predefined threshold (in this case, 90%), the script triggers the cleaning mechanism. This mechanism is activated by controlling a stepper motor connected to the Raspberry Pi. The stepper motor rotates to initiate the cleaning process, ensuring that any accumulated dirt or debris on the solar panel surface is removed.

Tech Stack

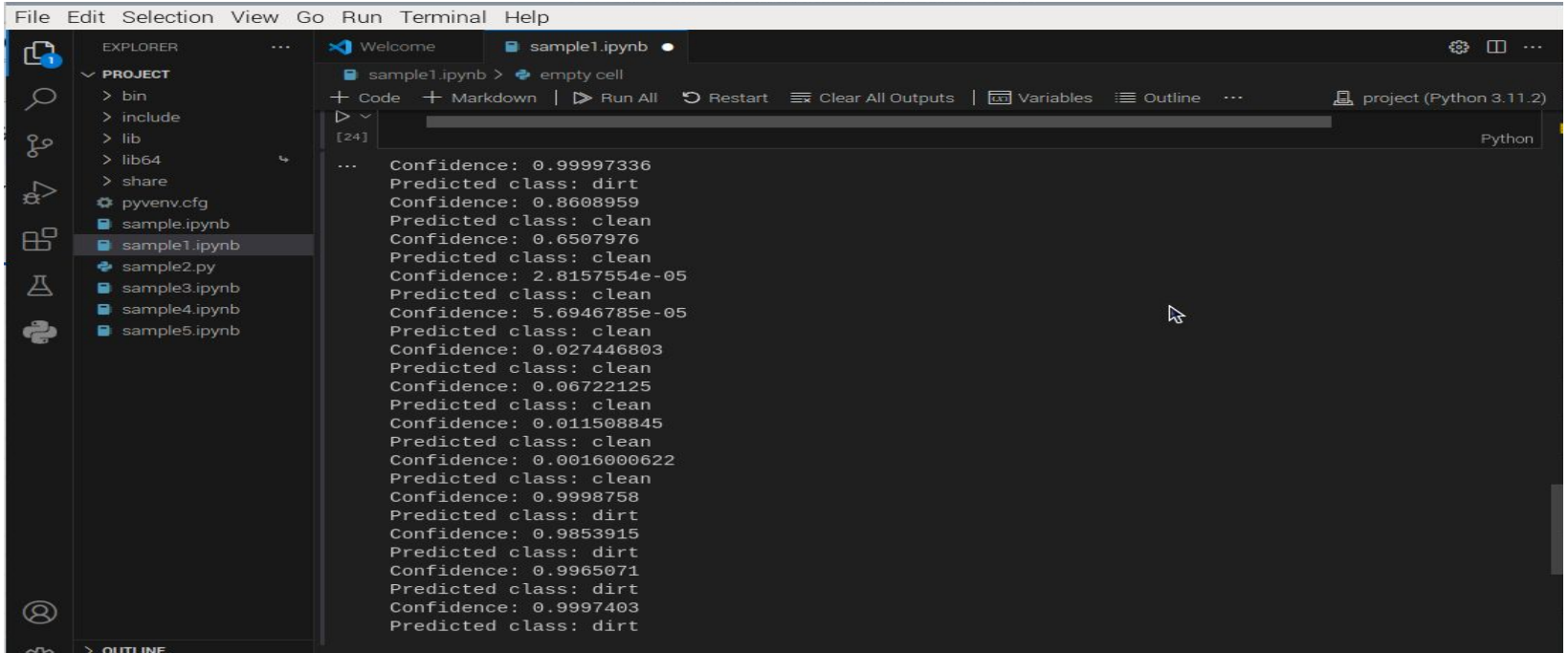
- Programming Language: Python for AI algorithms and system control.
- Deep Learning Framework: TensorFlow for training and deploying machine learning models.
- Image Processing Library: OpenCV for image acquisition and preprocessing.
- Hardware Platform: Raspberry Pi for system control and automation.
- Motor Control: Stepper motors for actuating cleaning mechanisms.
- Power Management: Battery system charged by solar panels for energy autonomy.
- Webcam: Used for capturing images of solar panels.
- MobileNet: Pre-trained deep learning model for feature extraction.
- Data Storage: Local storage or cloud services for storing training data and model checkpoints.

Budget

Hardware	Cost
Raspberry pi 4	5500
Web Camera	2500
Solar panel	500
Stepper motor with rod	7000
Micro SD	650
Micro HTML	500
Stand with Brush	1000
Total	17650

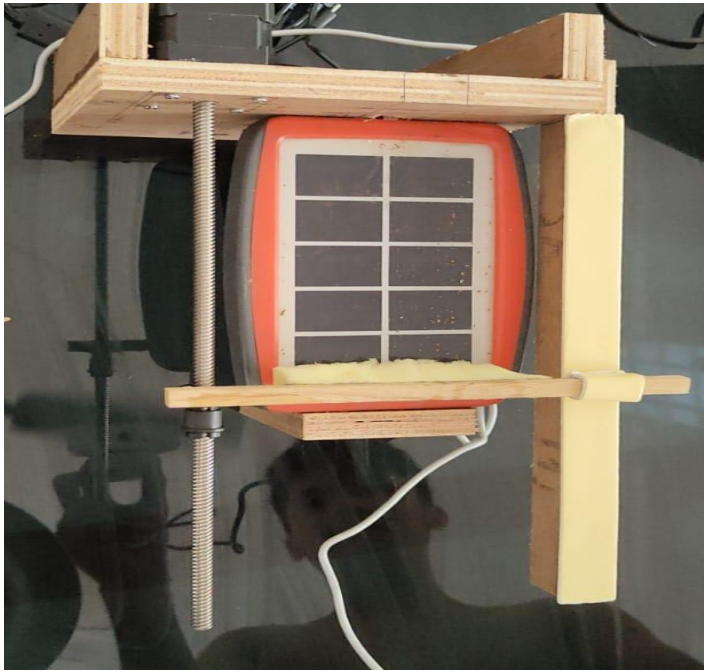
Results and Inference

Model predicting the surface of panel as clean or dirt with an accuracy of 90%.



Results and Inference

After detection of the dut the cleaning process starts , the brush will go up and down for cleaning the panel surface.



Future Scope

- Enhanced AI Algorithms: Continued refinement and optimization of machine learning algorithms for dust detection and cleaning decision-making can further improve the accuracy and efficiency of the system.
- Predictive Maintenance: models trained on historical data can enable the system to anticipate maintenance needs based on factors such as weather patterns, panel degradation trends, and energy output variations. This proactive approach can minimize downtime and maximize the lifespan of solar panels.
- Autonomous Cleaning Robots: Research and development efforts can focus on designing and deploying autonomous cleaning robots equipped with AI vision systems.
- Integration with IoT and Cloud Platforms: Integration with Internet of Things (IoT) devices and cloud-based platforms can enhance data collection, analysis, and remote monitoring capabilities.
- Expansion to Other Renewable Energy Systems: The AI-powered maintenance framework developed for solar panels can be adapted and extended to other renewable energy systems such as wind turbines and hydroelectric generators.

Reference

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Thank You.