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Fault Detection and Diagnosis in PV System Array

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Abstract— Solar energy has procurement increasing attention in modernistic year. The power generation from solar source is always clean and free from pollution. In recent year, the price of solar PV panel is going downwards which increased the attention to use solar PV application in the recent years. Machine Learning techniques are employed in photovoltaic (PV) systems to make full utilization of PV array output power which depends on solar irradiation and ambient temperature. For such a large-scale growing business it is necessary for it to be free of faults so that are ensured smooth and hassle-free working.

Keywords— *Faults, Detection, Solar, Arrays, Machine Learning*

1. INTRODUCTION

Renewable energy sources have ample supply Non-Renewable sources account for 75 percent of worldwide energy, which will get depleted in almost a day. Global energy consumption has increased three times due to increase in the number of developing countries and innovations in technology. Solar Energy an exclusive form of renewable energy source . Power production from solar energy pollution free.

Renewable energy sources have unlimited supply. In-creased attention to the photovoltaic (PV) energy systems during the last decade. PV systems have different varieties of failures. To ensure reliable and safe operation of PV , monitoring and fault diagnosis (MFD) must be included. Fault Detection and Diagnosis a fundamental task to protect the components of PVS from damage and eliminate various risks. Fault Detection and timely troubleshooting are essential for maximum performance in any power generation system including photovoltaic (PV) systems. Main goal of the system should be maximising power production, minimizing energy loss , minimizing maintenance cost and also ensure safe operation of the system. PV systems are subject to various faults and failures and hence early detection of such faults and failures are very crucial for building a productive system.

2. DESCRIPTION

Fault Detection and diagnosis of PV system array includes detection of faults that can hamper the progress of power and energy being converted into good use and being an obstacle in development of solar power energy. We have tried to implement a device which will get us snapshots of these faults which are not visible physically or by the naked eye and gather them all and put them through a Machine Learning - Artificial Intelligence component named as CNN (Convolution Neural Network)and use the images as dataset for our system to train and get results in the form of thermal images which get segregated into faulty and not faulty images so as to fulfill our goals .

- List Of Implementations
- Quadcopter using ATMega 328
- Getting images for our system
- Processing the images using CNN

Segregating results into benign and non-benign

3. OBJECTIVES

- To develop a dynamic product , which is least affected or not affected by the external environment
- To promote ecologically sustainable growth through use of renewable energy and helps us to keep them running for the betterment of the environment.

A. Specific Objectives

- To Analyse the existing fault detection methods
- Study various technologies by which fault diagnosis can be done
- Design a flexible fault detection system
- Test the system, locate errors and find solution
- Build a structure to support the design *B. Project Scope*

The project will revolve around detecting and diagnosing faults in the solar panels or PV system arrays as they are called The system will provide smooth detection of faults so that they can be rectified as soon as possible . . The project will rely on images which will be captured by the quadcopter (drone camera) which will be made by using ATMega 328 and will have a nRF24l01 wireless sensor module just to operate it and click images using the thermal camera/ high resolution camera . Gather the images in the form of datasets and then classifying them into benign and non-benign using the CNN algorithm which exists in Machine Learning.

4. METHODOLOGY

As explained in the project scope we will gather the images in form of datasets and then firstly we will bifurcate them as training and test datasets and then implement them .In training datasets the system will first segregate the images into faulty and non-faulty and after this procedure the images will be trained in CNN algorithm. The images in the test dataset will undergo the same procedure of segregation and then will be trained under build CNN algorithm and in this we will get the results for each solar panel or PV array clearly.

- **Fault Detection:** Fault Detection and timely trouble shooting are essential for optimum performance in any power generation system including photovoltaic (PV) systems. Main and Primary goal of the system should be maximising power production , minimizing energy loss , minimizing maintenance cost and also ensure safe operation of the system. PV systems are subject to various faults and failures and hence early detection of such faults and failures are very crucial for building a productive system.
- **Why ML for fault detection?:** The traditional manual inspection for faults in PV arrays only support the inspection frequency of once in three months/ Whenever physical inspection is possible. Because of the hostile environment ,solar panels may have defects, which can reduce the power output efficiency. Efficiency of PV panels must be high, which is critical for sustainability of the solar power generation model. The solution is to use machine learning models along with unmanned drones for inspection of solar panel infrastructure. A wide range of technologies exist for PV fault detection. Nowadays , most of the PV systems are built with a monitoring system and have a database constantly backed with huge historical data.
- **Aerial Imaging Drone:** The fundamental purpose of using Thermal Mapping is to recognize any fault or damage in the solar panels . For the same purpose the drone used for thermography should be reliable , affordable and accurate. We will be going through the process of building a quadcopter using an ATMega328 microcontroller which will be used to control four coreless DC motors. The whole PCB making process from designing of the schematic to custom circuit board will be done by using EasyEDA. Following is the schematic circuit diagram.
- **Machine learning for classification of faults:** Once the images from the aerial thermography have been taken , we will be using a CNN algorithm to classify the images. CNN is a feed forward network made up of several layers of connected neurons. The layer in the neural network that receives the input is based on con-volution function and hence the name convolutional neural network. The CNN model is generally formed by a succession of layers ruled by different mathematical functions to extract the pattern of images recognition and classify them. The CNN algorithm allows the automatic acquisition of training and test images, which are pre-processed through different techniques, and returns the output as probability that the image belongs to a category CNN receives as input a set of images collected in a dataset, which are automatically pre-processed to highlight their main recognition characteristics.

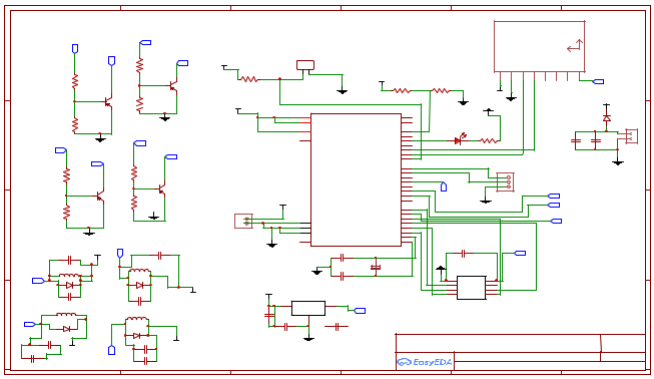

Fig. 1. Circuit diagram for Quadcopter

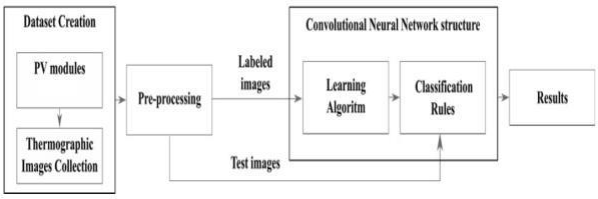

Fig. 2. CNN Model

5. TECHNOLOGY

Technological background for the proposed system is using following technologies:-

A. Quadcopter Components

- ATmega328 SMT: The ATmega328 SMD has low-power CMOS 8-bit microcontroller which is based on the AVR enhanced RISC architecture. By executing powerful instructions in one clock cycle, the AT-mega328P achieves throughputs approaching 1 MIPS per MHz which allows the system designer to optimize power consumption versus processing speed. It is Better known for its RAM,EPROM and EEPROM
- nRF24l01: The nRF24L01 is a wireless transceiver module, in which each module can both send as well as receive data. They operate on frequency of 2.4GHz, which falls under the ISM band and hence it is legal to use in almost all countries for engineering applications. Its frequency range is worldwide ISM frequency band at 2.400 - 2.4835 GHz It can be operated and configured through a SPI (Serial Pheripheral Inter-face). The register map, which is accessible through the SPI, contains all the configuration registers and is accessible in all operations modes.
- MPU6050: The MPU6050 is a Micro Electro-Mechanical Systems (MEMS) which has a 3-axis Accelerometer and 3-axis Gyroscope inside it, which helps us to measure acceleration, velocity, orientation, displacement and many other motion

related parameters of a system or object. It works on the power supply of 3V-5V. MPU6050 uses the I2C protocol for communication and transfer of data. This module has a built-in 16-bit ADC which provides more accuracy. A key component to make the quadcopter balance is an orientation sensor that periodically reports the yaw/pitch/roll which can be used as input to a PID controller that adjusts the RPM of the quadcopter motors.

6. LITERATURE SURVEY

A literature survey was conducted in order to get to know the need of fault detection techniques and the ways which they are implemented on solar panels which we have tried to achieve as a whole in our project.

A. Reasons for faults in PV arrays

Modules may fail because of unavoidable elements like thermal cycling, damp heat, humidity freeze and UV expo-sure. Thermal cycling can cause solder bond failures and cracks in solar cells. Humidity freezing can cause junction box adhesion to fail. Falling debris—even small debris like twigs, leaves, and dirt—can cause micro-scratches on your solar panels. These scratches dramatically lower the energy output by decreasing the amount of solar energy each panel can absorb because the scratches keep the sunlight from shining directly on the cells.

B. Wireless Module

We have used nRF24l01 module in our quadcopter to control it , the other alternatives were Zigbee which is a Bluetooth module but in this 5G generation Wi-Fi is more effective than Bluetooth. The only concern about this module is that its range is less in comparison to other modules i.e., 100-150 meters and its cost effective in various aspects .In case if we want to do this project on a large scale then we will have to opt for a better wireless module which would have a better range and better response time.

C. Machine Learning Algorithm

CNN :- In deep learning a convolutional neural network is a class of deep neural networks , which is most commonly used to process and analyse visual imagery just like in our project we have to analyse the given images and then segregate them into two different groups which are benign and non-benign respectively

D. Reviewed Papers

In [1] A comprehensive review on protection challenges and fault diagnosis in PV systems published by Dhanup S. Pillai and N. Rajasekar Classifies various faults depending on the nature of fault Conventional protection methods may fail at times

In [2] Detection and Prediction of Faults in Photovoltaic Arrays :A Review published by Kais Abdul Mawjood and Shady S. Refaat and Walid G. Morsi which has Compared various fault detection methods in detail but Largely discusses internal faults, fails to discuss effect of surrounding on PV.

In their paper [3] Electrical Detection and Specifica-tion of Failed Modules in PV Array written by Takumi Takashima and Kenji Otani which makes Modelling of PV cell quite easy and Focuses on issues based solely on Electrical Detection method

In [4] A comprehensive study on different types of faults and detection techniques for solar photovoltaic system published by Siva Ramakrishna Madeti and S.N Singh Studies briefly about faults and detection techniques Fault correction methods is not discussed

In [5] Fault detection and diagnosis methods for photovoltaic systems : A review published by A. Mellit and G.M. Tina and S.A. Kalogirou gives us Brief knowledge about types of fault and detection techniques . It Does not include advanced Real Time fault detection techniques.

7. FUTURE SCOPE

After conducting analysis of various faults , protection challenges and detection techniques for PV systems , we can say that protection of PV system is an area of research which has not yet explored to the fullest Among different advanced detection techniques used to detect faults in PV systems, Fault Detection techniques using Machine learning are more oriented and can be future solutions for fault free detection

8. RESULTS

Fig. 3. OHC (Over Heating Components Fault)

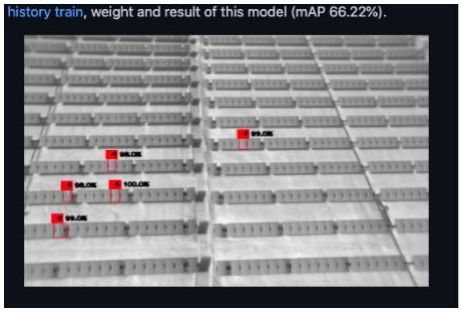

Fig. 4. Bypass Diode Fault

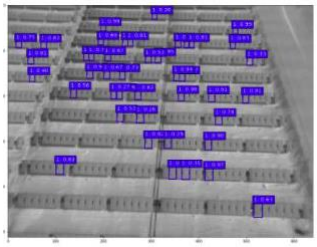

Fig. 5. Hot Spot

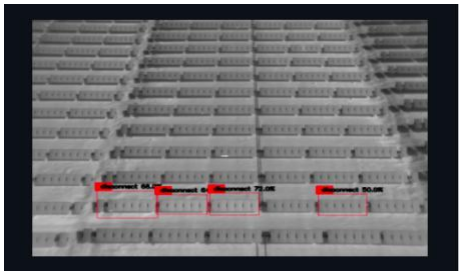

Fig. 6. Faulty Interconnections

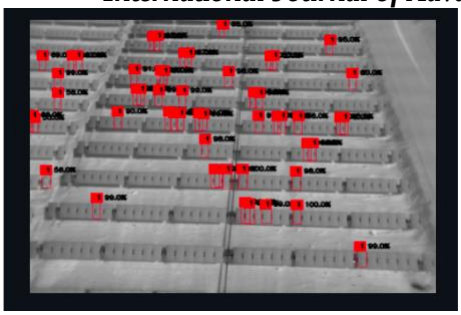

Fig. 7. Cluster of Thermal Anamolies

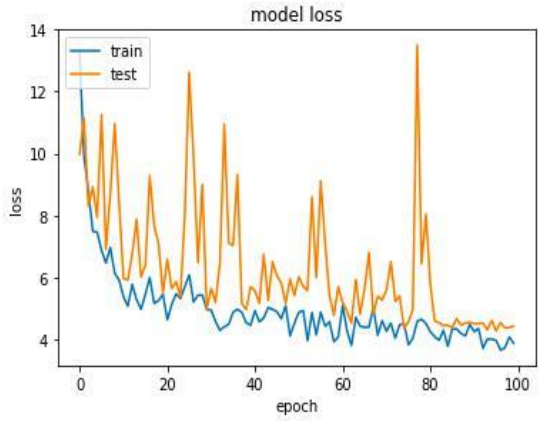

Fig. 8. Graph for Model loss

9. CONCLUSION

We discussed various faults occurring in photovoltaic (PV) systems and their detection methods. The faults were considered according to their characteristics Discussed various fault detection mechanisms. Imaging methods use different types of camera sensors to identify failure in PV module whereas Electroluminescence is used to detect defects in manufactured modules. Ultrasonic technique is used in fielded modules whereas thermal technique is used to identify degradation of the module Various modules are already available for fault diagnosis purposes we can use any one of them as per your convenience .Different types of algorithms of machine learning can be used based on how you are gathering data so that you can train the dataset accordingly and get the best results.

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