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Solar Plants Inspection using Deep Learning Technique

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Abstract—

Using the cutting-edge, state-of-the-art object identification algorithm YOLO v5 in conjunction with traditional image processing methods, this study introduces a novel method for tracking solar power facilities' massive grid-connected photovoltaic modules. We have focused on a key component of the automated system that captures aerial footage of the solar park using a drone. After that Here you can view the clean and filthy panels detected by our trained YOLOv5. The procedure is planned to be executed on a specific location by means of Raspberry Pi. To ensure the safe and long-term functioning of solar arrays, this system collects photographs from drones, analyzes them, and delivers a report to the relevant department daily via email. Although the idea is straightforward, it stands out due to its innovative approach of inspecting massive solar power facilities. Reducing the inspection time for the same procedure from 120 hours to only five minutes demonstrates a time savings of 99.93% achieved via the use of vision and strong automation approaches. Solar panels, Yolo V5, algorithms for computer vision, IoT, Raspberry Pi, inspection, tracking, and contouring are some of the keywords.

I. INTRODUCTION

Pakistan, with 24° to 27°N latitude and 61° to 76°E longitude, lies in the sunbelt. It means that the country has the extended periods of sunshine all year round. Put simply, there is a tremendous opportunity for the nation to use solar energy in a sensible way. Solar energy resources have the potential to alleviate the country's energy issue, particularly in outlying areas [1]. As of right now, estimates put the number of Pakistani villages without access to power at forty thousand.

As per the data provided by the Alternative Energy Development Board (AEDB), an extensive 95% of the nation's landmass gets the necessary amount of sunlight. Solar radiation at sea level is about 900 to 1000 w/m². Based on solar mapping and studies conducted in conjunction with USAID, the nation has an energy potential of 2.9 million MW. Even more crucially, solar power is acknowledged all around the globe as an environmentally friendly way to generate power.

Power stations that rely on fossil fuels are now the main source of energy production in Pakistan. These solutions, which rely on fossil fuels, are bad for the environment and put too much pressure on the national economy via imports. Hence, renewable energy is growing in popularity in Pakistan. Many believe that solar power technology is the most immediate solution to the electrical energy shortage [2]. Clean, abundant solar energy is on the rise because of its many advantages, including the fact that it can be used from a distance and the abundance of sunshine it receives. [2] Similarly, the use of solar electricity has grown in Pakistan at an exponential rate. A growing number of individuals, from homeowners to business owners, are opting to put photovoltaic (PV) panels on unoccupied roofs or other surfaces. As a result, local businesses and suppliers of solar solutions are seeing an uptick in business due to this acceptance. People moving there and the nation as a whole will reap the benefits. In 2010, the Planning Commission and Pakistan Engineering Council Building commissioned the first on-grid solar plant with 178.08 kW. The National Assembly of Pakistan has a 2 MW system that feeds excess energy into the grid [3]. The first parliament in the world to switch to PV cells was the one in Pakistan [4]. At Bahawalpur, a 1,000 MW project known as Quaid-e-Azam Solar Park came online in 2015 and 2016 [5]. The proposed Quaid-e-Azam solar park, seen in Fig. 1 below, may generate 1,000 MW of electricity. A number of enterprises and Independent Power Producers (IPPs) are receiving letters of support (LoS) and letters of intent (LoI) from the government in an effort to increase the use of solar technology [6].

Fig. 1. Quaid-e-Azam Solar Park at Bahawalpur 1000 MW capacity

Maintenance and inspection of PV power plants are becoming more important as their demand continues to climb. In order to keep the PV panels from losing efficiency, it is important to clean them properly and keep dust particles away. When dust settles on panels, it reduces their overall efficiency [7]. A 40% drop in efficiency is seen for every 4 gm/sq-meter dust layer, according to research by Gaofa He, Chuande Zhou, and colleagues [8]. Keeping an eye on and cleaning up larger sites is a pain, but it's not that bad for smaller ones. Despite the fact that studies have moved on to water-free cleaning methods [9], the pharmaceutical industry's PV panels site in Karachi remains the primary focus of this effort. Drone technology allows for aerial imagery to do this. The task is split into two halves. First, using computer vision techniques, we identify and count the clean panels. At the location, the aerial photographs taken by the drone are processed using the Raspberry Pi microcomputer. The second step is to construct a pipeline that is based on the Internet of Things (IoT). Our vision program automatically generates reports and emails them to the relevant departments using pandas and a simple mail transmission protocol.

That is the outline of this piece of writing. Section II provides a concise summary of the literature study on methods for inspecting solar modules. A full implementation of the YOLOv5 algorithm inspection approach for a mega solar system is shown in Section III. Results from the suggested approach's simulations are detailed in Section IV. The essay concludes and offers suggestions for further reading in the concluding part.

II. LITERATURE REVIEW AND BACKGROUND RESEARCH

For minor locations, manual inspections usually suffice. External services like problem detection, cleaning, and inspection are often contracted out to larger organizations working on mega-projects. In order to guarantee the optimal functioning of the renewable energy setup, it is essential to implement technology inspection methods. Various methods for checking solar panels have been suggested by various researchers. At its most basic, monitoring power production may reveal PV cell faults. We always look for anything out of the ordinary in the monitoring data. The presence of an outlier is often indicative of a problem that may be traced back to a particular panel [9]. It is being utilized more and more often. Concurrently, however, it is not practical for big sites, is highly passive, and is quite taxing. To find the problems and the drop in efficiency, several studies additionally employ string measuring devices [10]. Analytical data processing and this approach are also interconnected. One method put forward by Hicham Tribak and Omar El Kadmiri et al. [12] involves a robot using an HD camera to take a picture of a row of PV panels. They proceeded to use the trellis approach, which is based on convolutional encoding, and speed up the out-of-encoding process utilizing the spread spectrum technique. The discrete cosine transform DCT is used for picture watermarking. The photos undergo brightness balancing. Image stitching involves all of these processes. The next step is to use the SURF algorithm to identify the focus of each picture. In the last step, we apply RANSAC and homography to keep the actual matching spots. For system implementation, their system also makes use of Raspberry Pi microcomputers. Research on infrared thermography, a popular non-destructive alternative test, is ongoing [11][12]. At various PV intensities, radiation generates heat, which the thermal infrared camera subsequently records as an electromagnetic spectrum. This approach makes it easy to identify damaged or defective cells [13]. Thermal imaging and optical cameras may detect various flaws. The procedure is often handled by third-party suppliers using their labor force, since thermal guns are portable. Workers meticulously cover the whole site by visiting each panel individually and monitoring them with the thermal gun. The next steps include using UAVs in the same way as a thermal cannon or an infrared thermal camera [14]. By combining the same kind of manual work with drone technology, we can automate all of the thermal imaging operations. Now the flaws may be found even at high elevations, and every PV cell with excessive heat production can have its cause determined. Researchers and engineers are interested in this method because of the rapid development of UAVs and infrared thermal cameras. Unmanned Aerial Vehicles (UAVs) provide a suitable alternative for monitoring the expansion of PV systems. In order to detect solar panels and the hotspot zone using a dataset that contains photographs of solar power plants, Álvaro Huerta Herraiz et.al.[17] employs a deep learning algorithm based on R-CNN. Once the hotspot area is discovered by R-CNN, the final result is generated by combining the detected section with the telemetry data collected by IR-UAV systems. This data includes information such as altitude, orientation, GPS 3 location, camera angle, and vision angle. Finding the faulty power plant module is made easier with the findings. H.S. Nalamwar et al. [15] explore the idea of the Internet of Things (IoT) for the purpose of panel inspections. The writers of the provided study take into account the electrical characteristics acquired by using data collection modules, sensors, and block data. We provide an electrical parameter monitoring platform that is custom-built and integrates with the Internet of Things. Anomaly patterns of power production activate alarms with the use of mentioned framework. Similarly, a number of experts have suggested using Bluetooth technology in conjunction with Android phones to monitor readings and disturbances at tiny solar installations. [16]. Harley Denio [17] introduced panel aerial monitoring as a means to localize issues in a vast variety of panels. His findings also suggest that it may protect cells from fire and other potential harm. When it comes to checking solar panels, Pia Addabbo and Antonio Angrisano et al. [18] use a similar approach using UAVs and thermal photography. But the ground-breaking part is how the relevant panels' locations are pinpointed using the Global Navigation Satellite System. The drone is equipped with the U-Blox NEO-M8N for that specific function. The design of a system to examine mega-solar plants with the use of a UAV was suggested in this study paper. The drone flies over the locations at various heights, capturing aerial views. After that, the solar modules are detected by processing the photos using the YOLOv5 algorithm. Using the Raspberry Pi, the findings are transmitted via email. When processing data in real-time, our system delivered accurate results.

III. METHODOLOGY

An industry-leading pharmaceutical company in Karachi implemented the PV inspection approach that was given. Consequently, the job at hand ensures cost-effectiveness by resolving the solar power plant's lower efficiency using minimal components. Two primary components make up the project. Solar cell detection at a height of around 200–250 feet, followed by contour tracing and classification using standard computer vision methods. A. YOLO v5 algorithm-based object detection The ability to create feature pyramids is a feature of the YOLOv5. The model used feature-based object scaling to a broader context. When seen from varying heights, the system is able to identify the same items. Drone flights above an industrial site building provided the data set. Using the free and open-source Roboflow labeling platform, we have individually labeled each batch of solar cells. A group of four to eight panels attached to each other on the roof makes up the batch of panels. Panel detection is the main use case for YOLOv5.

After detection, the area is clipped so that conventional computer vision methods may be used. Figure 2 shows the initial section of our block diagram, which focuses on the automated process demonstration. Our project's drone will fly from a designated spot to the whole site. There is no room for human mistake or outside interference since the drone's whole trajectory has already been planned. Flying over the designated building and taking aerial photos is the plan. The Internet of Things (IoT) will transmit the correctly captured frame to the Raspberry Pi microcomputers. After taking the photographs, our Pi-based image processing algorithms and Tkinter will assess them and then, with the help of the pandas library, add them to the Excel file. After sorting the items into clean and filthy, the overall count is determined. Using the company-provided open Wi-Fi, the report is immediately sent to the relevant department when the round is complete. Additionally, the installation of Raspberry Pi microcomputers on UAVs is unnecessary. At the location, the Raspberry Pi is constantly processing data, sending data, and acknowledging visual input over Wi-Fi.

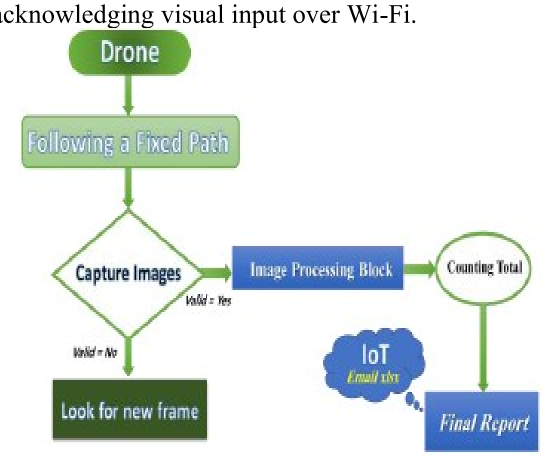


Fig. 2. Block Diagram of the automated process of Panels Inspection

The data-processing Raspberry Pi microcomputer is always operating in headless mode. A microprocessor receives all of the images taken by drones immediately. It executes the algorithm for detection and produces the outcome. The findings are delivered by the Raspberry Pi in auto-mode. The Image Processing node in our block diagram is now the central focus. In order to count and examine the clean panels, the image processing block employs a number of conventional image processing algorithms. Figure 3 explains the whole image processing procedure. We have attained the intended outcome using the stated step-by-step approach.

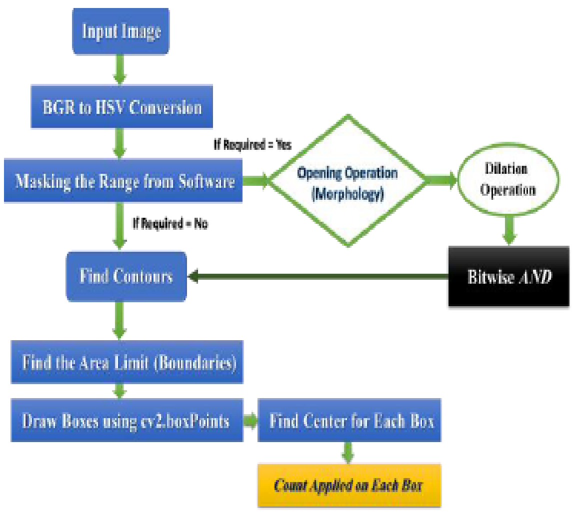
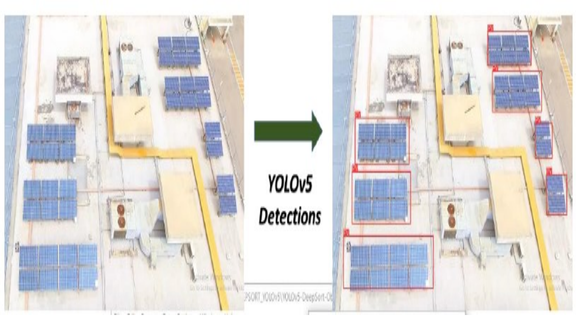


Fig. 3. Explanation of Image Processing Block of Panels Inspection

IV. RESULTS AND DISCUSSIONS

Here are two of the drone's aerial photos, shot from various vantage points. Different heights were used to get these two photos. The following steps are used to process the images:



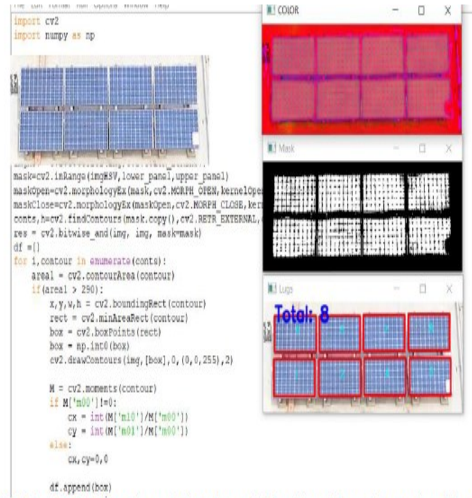


Fig.4. YOLOv5 Object Detection and Cropping with Traditional Image Processing Algorithms

algorithms for vision described in the technique. The processing time and picture capture time for mega project locations may be assessed.

Fig. 4. Aerial Image one captured from the drone

Figure 5 shows the final version with the tally. The findings are based on the practical implementation of the methodology's image processing block utilizing Python programming and the OpenCV library.

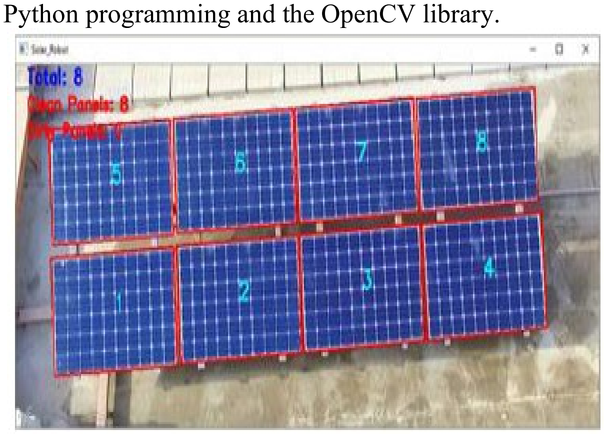


Fig. 5. Aerial Image one after Processing from Raspberry Pi

The second picture is perfect for use in real-time since it was taken from a great height.

Fig. 6. Aerial Image Two captured from the drone

Figure 7 also displays the processed result. With the count on each solar panel, all the contours are effectively produced.

Fig. 7. Aerial Image two after processing from the Raspberry Pi

A. Real-Time Processing Speed Estimations

By using the project supervisor-defined standardized height, we were able to take the photo and determine the exact number of panels (74). The following is how it can be done mathematically.

Total count of panels = 74 panels

Time Taken for flight, capture, and processing = 5 seconds

One Batch/Frame of 74 panels = Total Time is 5 seconds

In 60 seconds = 12 batches can be covered

Total panels in 1 minute = 888 panels

Section B. YOLOv5 algorithm-based object identification

We have integrated data obtained from drones with data taken from solar panels on the internet [19]. To begin, we used the Robflow tool to annotate the dataset and get it ready for analysis [20]. When we first started, we trained with only 2,400 photos divided into the Clean and Unclean categories over the course of 100 epochs. Google Colab is used to generate testing weight files for testing results during initial testing and training. Video has been used to test the results [21]. In Figure 8, you can see a few test results.

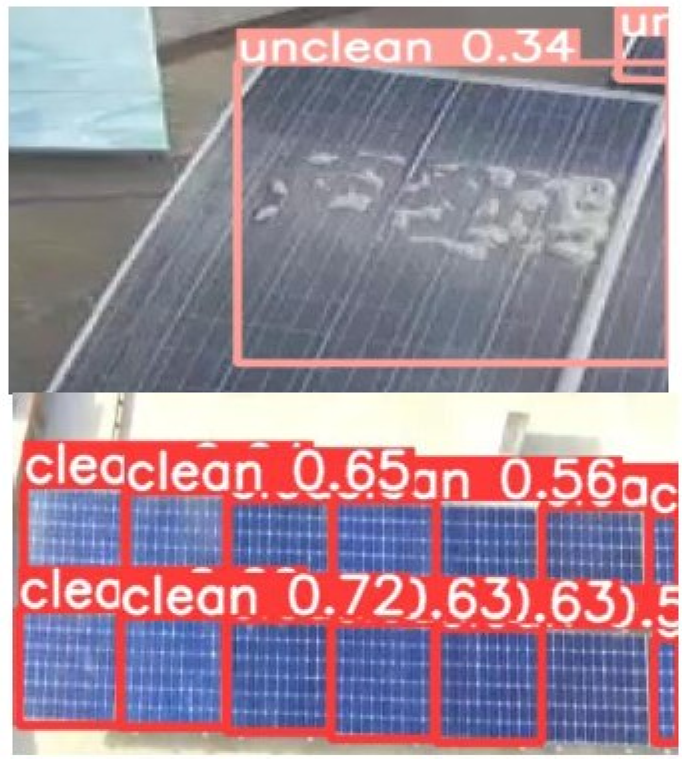


Fig. 8. Test result from trained YOLOv5 model

V. CONCLUSIONS AND FUTURE WORK

In terms of real-time testing, the suggested method is both easy to implement and quite reliable. Our continuing study includes this minor component. In addition, we are including a thermal infrared camera to identify spots, locate dirty panels, and process faults. Another benefit of counting approaches is that they may do away with the need for GPS, which is present in previous systems.
Based on the time estimates, it was clear that our automated procedure would save the vendors the

labor-intensive techniques of inspection and monitoring that were previously used. We found it to be dependable, unique, and inventive for our needs. In the future, we may enhance the proposed method by looking at additional picture aspects, such as locating the defective solar modules.

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