Infrared Thermography for Automatic Hot Spot Detection of Photovoltaic Panels

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According to Sandia National Laboratories, by 2050, the world will need an estimated 27.6 TW of non-CO_2 energy. Photovoltaic (PV) solar technology has the potential to deliver this desperately needed green energy. One work estimates that if 2% of the United States was dedicated to photovoltaic collection it would potentially produce 7,500 TW of clean non-CO_2 energy. A noteworthy concern is the operation and maintenance of PV panels. Our work focuses on thermographic analysis of PV panel. Components will heat up before failure and this phenomenon is observable in the long-wave infrared (IR) band. The goal of maintenance is to collect diagnostic data of PV panels before a panel imbalance occurs that could reduce system performance or even render the device inoperable. Currently, IR inspection of PV panels is carried out with manual analysis by human expert. The devices used for manual analysis are hand-held mobile units but the results are subjective and collecting data is time consuming and costly for large-scale PV farms. There are some computer vision systems that allow utility companies to remotely and automatically inspect PV panels in the IR domain but these systems are cost prohibitive. We propose a system based on the Raspberry Pi that is mobile, cost efficient, objective and fully automatic. The system employs a FLIR Lepton to capture images and the computation is carried out on the Raspberry Pi. The FLIR can actively view the panel and detect hotspot phenomena that would contribute to the panel failure. Development of our system occurred in three phases: (i) Hardware integration of IR sensor (FLIR Lepton) with an embedded computer (Raspberry Pi). The Lepton is a recently released microbolometer thermograph that enables low cost imaging. The sensor cost is $250, whereas comparable commercial systems cost ranges in the tens of thousands of dollars. (ii) Development and testing in the field with linear data acquisition. Experiments found that the FLIR Lepton has too low of a resolution for analysis.

To address this challenge we developed a linear slider system. The FLIR Lepton is mounted on a slider arm that sweeps over the entire surface of the panel and captures multiple images. (iii) Testing and implementation of computer stitching algorithms. A computer stitching algorithm is employed to combine the images in phase (ii) to create a larger composite image. This final image is large enough to allow inspection of the complete PV system. Stitching was carried out with the Scale Invariant Feature Transform method (SIFT) for detecting land mark points. This system has been successfully deployed at California State University, Bakersfield and hot spots were located. Our system increases PV inspection capabilities by propagating automatic analysis by computers, allows for mobile analysis, is more objective than current manual analysis techniques by employing a threshold to detect hot spots, and reduces cost. Future work will investigate machine learning algorithms for early detection of failure, planar data acquisition for a more efficient inspection and potential implementation of the Speeded Up Robust Features (SURF) algorithm for better stitching results.