Infrared Thermography for Automatic Hot Spot Detection of Photovoltaic Panels

Kody Bryan*, IEEE Student Member, Albert C. Cruz**, IEEE Member and Dr. Saeed Jafarzadeh***, IEEE Member
COMputer Perception LAB (COMPLAB)
California State University, Bakersfield
9001 Stockdale Highway, Bakersfield, CA, 93311 USA
*kbryan@csub.edu, **acruz37@csub.edu, ***sjafarzadeh@csub.edu

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 landmark 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.