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Cost-Effective Dust Detection on Solar PV Panels through Deep Learning: A Step Towards Automated Maintenance Systems

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Abstract : Accumulation of dust on solar panels impacts the overall efficiency and the amount of energy they produce. Detecting and mitigating dust accumulation is, therefore, crucial for optimizing solar energy production. While various techniques exist for detecting dust to schedule cleaning, many of these methods use licensed software like MATLAB, which can be financially burdensome. This study proposes the use of a modified pre-trained ResNet-50 model architecture with an adjusted fully connected layer for binary classification. An experimental setup was installed utilizing a single 75 Wp panel with an inclination maintained at a 30-degree angle. The fine dirt particles were artificially introduced and datasets of images of clean and dusty panels were collected from five different sides were taken, to compensate for the surface reflectance from the PV panel due to camera angles. Those datasets were used to train and test the model, and the accuracy achieved was 90%. The model's ability to detect dust with minimal false positives ensures more efficient maintenance scheduling. This research demonstrates the potential of AI-driven dust detection systems to enhance the operational efficiency of solar PV installations. Future work will focus on integrating the model with real-time monitoring systems to enable automated maintenance alerts in Bhutan. This open-source solution provides a cost-effective and accessible alternative to commercial image processing tools, offering solutions for optimizing solar panel maintenance and enhancing energy production.

Keywords : AI, dust detection, deep learning, image processing, Resnet-50, solar panels
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