**Solar Panel Defect Detection – Project Report**

**1. Overview**

This project aims to develop a deep learning-based image classification system for identifying defects in solar panels. The model classifies input images into six distinct categories: Clean, Bird-Drop, Dusty, Electrical Damage, Physical Damage, and Snow-Covered. For real-time usage, the system is deployed via a Streamlit application.

**2. Data Preparation**

Initial preprocessing involved removing non-image files, corrupted entries, and duplicates from the dataset. Each image was labeled using encoded class identifiers. The cleaned dataset was then partitioned into training, validation, and test subsets.

**3. Handling Class Imbalance**

To address uneven class distribution, data augmentation techniques—such as horizontal flipping, rotation, and brightness modulation—were applied. These enhancements improved both dataset balance and model generalization.

**4. Dataset Loading**

Custom PyTorch Dataset and DataLoader classes were implemented to streamline image loading and preprocessing. Separate transformation pipelines were defined for training and validation/test phases to optimize performance.

**5. Model Exploration**

Several architectures were evaluated during experimentation:

* A basic Convolutional Neural Network (CNN)
* ResNet
* EfficientNet-B0
* MobileNetV2

Among these, EfficientNet-B0 delivered the highest accuracy and was selected as the final model.

**6. Training Strategy**

Models were trained using the cross-entropy loss function and the Adam optimizer. EfficientNet-B0 was further refined using regularization techniques and learning rate scheduling to mitigate overfitting.

**7. Evaluation and Persistence**

All trained models were saved for future use. Performance was assessed on the test set using accuracy and other relevant metrics. EfficientNet-B0 consistently outperformed the alternatives.

**8. Deployment via Streamlit**

A user-friendly interface was built using Streamlit and deployed with Pyngrok. The application enables users to upload solar panel images and receive instant defect predictions from the trained model.

**9. Final Thoughts**

This project successfully delivers a robust and scalable solution for solar panel defect detection using deep learning. Future enhancements may include expanding the dataset, integrating ensemble techniques, or adding interpretability features like Grad-CAM.