# Solar Panel Defect Detection Project Report

## 1. Introduction

This project focuses on building an image classification model to detect defects in solar panels. The model categorizes images into six classes: Clean, Bird-Drop, Dusty, Electrical-Damage, Physical-Damage, and Snow-Covered. The system is also deployed using a Streamlit application for real-time inference.

## 2. Data Cleaning and Preprocessing

The dataset contained images with various issues such as non-image files, corrupted images, and duplicates. These were removed during the cleaning phase. Label encoding was performed for all six classes. The cleaned data was then split into training, validation, and test sets.

## 3. Data Augmentation and Balancing

To tackle class imbalance, data augmentation techniques such as flipping, rotation, and brightness adjustments were applied. This helped balance the dataset and improve generalization.

## 4. Dataset and DataLoaders

Custom PyTorch Dataset and DataLoader classes were created to efficiently load and preprocess the image data. Transforms were used differently for training and validation/test sets.

## 5. Model Architectures

Multiple models were experimented with:  
- A basic CNN  
- ResNet  
- EfficientNet-B0  
- MobileNetV2  
EfficientNet-B0 showed the best performance and was selected as the final model.

## 6. Training and Optimization

The models were trained using cross-entropy loss and Adam optimizer. EfficientNet was further improved using regularization and a learning rate scheduling strategy to reduce overfitting.

## 7. Model Saving and Evaluation

Each trained model was saved for future use. Evaluation was done on the test set using accuracy and other metrics. EfficientNet achieved the highest accuracy among all tested models.

## 8. Streamlit Application

A user-friendly Streamlit application was developed and deployed using Pyngrok. The app allows users to upload images and instantly get predictions from the trained model.

## 9. Conclusion

This project successfully demonstrates a robust solar panel defect detection system using deep learning and deploys it for real-time usage. Future improvements can include expanding the dataset, applying ensemble methods, or incorporating explainability tools like Grad-CAM.