User-Friendly Defective Solar Cell Detection using Artificial Intelligence
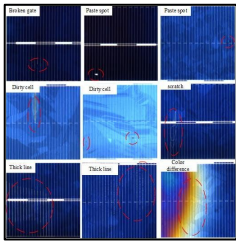
Project ID: #2677, Category: Earth and Environmental Sciences, Division: Senior, Math/Computer Type Project

Problem:

Challenges:

- Manual detection of defects in solar cells can be difficult and tedious
- Lack of detection can lead to solar system efficiency degradation, leading to an interruption in electric current and energy production

Surface Defects of Solar Cells
Image Credit: ResearchGate

Tasks:

1. Develop a high-accuracy (>80%) artificial intelligence model that can predict defect probability of a solar cell
2. Develop a web Django application in which users can upload solar cell images and receive rapid predictions
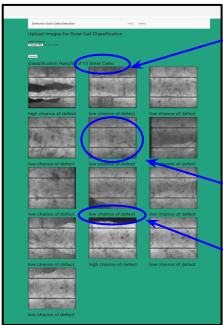
Experiments and Results

#Trained Images	# Tested Images	Image Processing Technique	Classifier	Prediction Accuracy
2099	525	grayscale, gaussian blur, thresholded	Random Forest	0.7886
2099	525	grayscale, gaussian blur, thresholded	CNN	0.77
2099	525	grayscale, gaussian blur, thresholded	SVM	0.781
2099	525	grayscale, gaussian blur, thresholded	Naive Bayes	0.2095
2099	525	grayscale, gaussian blur, thresholded	Decision Tree	0.7181
2099	525	grayscale, gaussian blur, thresholded	MLP	0.6952

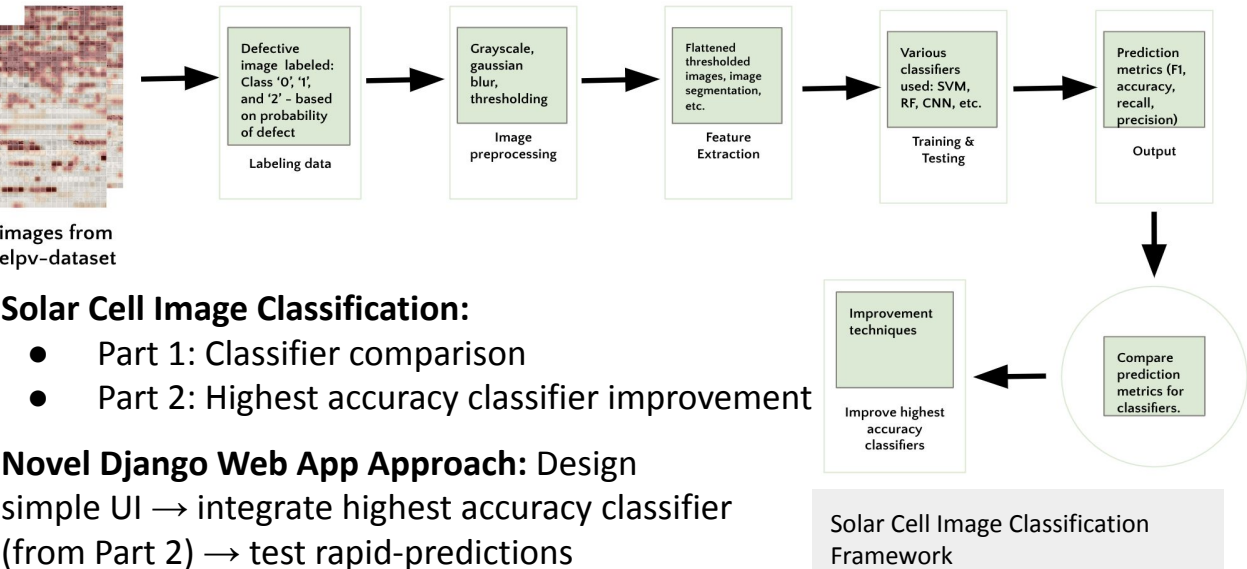| #Trained Images	# Tested Images	Trial Type	Image Processing Technique	Prediction Accuracy
2387	237	feature extraction (threshold flatten)	gaussian blur, threshold, no grayscale	0.8439

Part 2 Results: RF has the highest accuracy.

Part 1 Results: RF, CNN, SVM have the highest accuracies.

RF Classifier integrated into Novel Django Web application based on highest accuracy levels in Part 2.

- Number of predictions
- Inputted solar cell image
- Prediction of chance of defect

User receives rapid predictions

Framework

images from elpv-dataset

Labeling data — Defective image labeled: Class '0', '1', and '2' - based on probability of defect

Image preprocessing — Grayscale, gaussian blur, thresholding

Feature Extraction — Flattened thresholded images, image segmentation, etc.

Training & Testing — Various classifiers used: SVM, RF, CNN, etc.

Output — Prediction metrics (F1, accuracy, recall, precision)

Compare prediction metrics for classifiers.

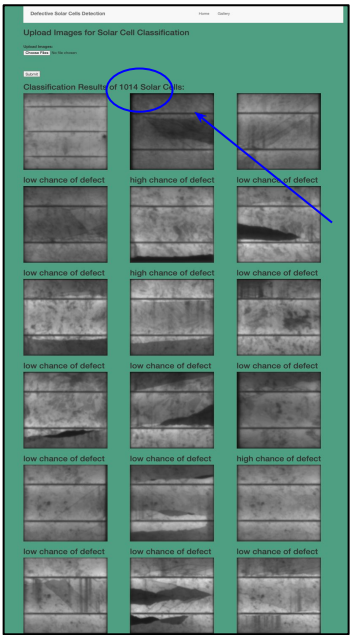Improve highest accuracy classifiers — Improvement techniques

Solar Cell Image Classification:
- Part 1: Classifier comparison
- Part 2: Highest accuracy classifier improvement

Novel Django Web App Approach: Design simple UI → integrate highest accuracy classifier (from Part 2) → test rapid-predictions

Solar Cell Image Classification Framework

Conclusion

- The novel web application is a valuable tool to classify solar cells as defective, leading to higher efficiency solar resources
- Criteria & Goals Reached
  - The model reports with 84.4% accuracy using RF classifier
  - The model takes an easy-to-use, user-friendly approach
- Applications
  - Solar panel maintenance systems
  - Unmanned aerial vehicles
  - Drone-mounted systems

Rapid predictions of >1000 images*

*Not all predictions are shown in screenshot