Surface Defect Detection Using CNN on NEU-DET Dataset

D Girishkanna

Introduction

The detection of surface defects is important for quality assurance in manufacturing, particularly in the steel sector, where quality and client expectations are paramount. Manual inspection of defects is a common method, yet it can be typically slow and unproductive, leading to eventual errors in judgement. This project will improve quality checking and provide more accurate classifications by way of a Convolutional Neural Network (CNN). The dataset used in this study was taken from a publicly available NEU-DET dataset.

Dataset Description

Dataset Name: NEU-DET (Northeastern University - Defect Dataset)
Source: Kaggle
Total Classes: 6

Image Size: Grayscale images resized to 224x224 pixels

Annotations: Image folders named by defect type (no separate `.xml` or `.json` needed)

Defect Types:

Defect Type	Description
Crazing	Network of fine surface cracks
Inclusion	Foreign material embedded in the surface
Patches	Localized surface imperfections
Pitted Surface	Small holes or pits
Rolled-in Scale	Oxide scale rolled into the surface
Scratches	Linear abrasions or grooves

Preprocessing and Data Augmentation

Images are normalized and resized to (224x224)

One-hot encoding is applied to categorical labels

Training, validation, and test splits: 64% / 16% / 20%

Augmentation techniques:

- Rotation
- Shifting
- Zooming
- Flipping

CNN Model Architecture

The CNN is designed using TensorFlow's Keras API.

Layers:

- Conv2D (32 filters) + MaxPooling
- Conv2D (64 filters) + MaxPooling
- Conv2D (128 filters) + MaxPooling
- Flatten
- Dense (128) + Dropout (0.5)
- Output Dense layer with Softmax (for 6 classes)

Compilation:

- Loss: Categorical Crossentropy
- Optimizer: Adam
- Metrics: Accuracy

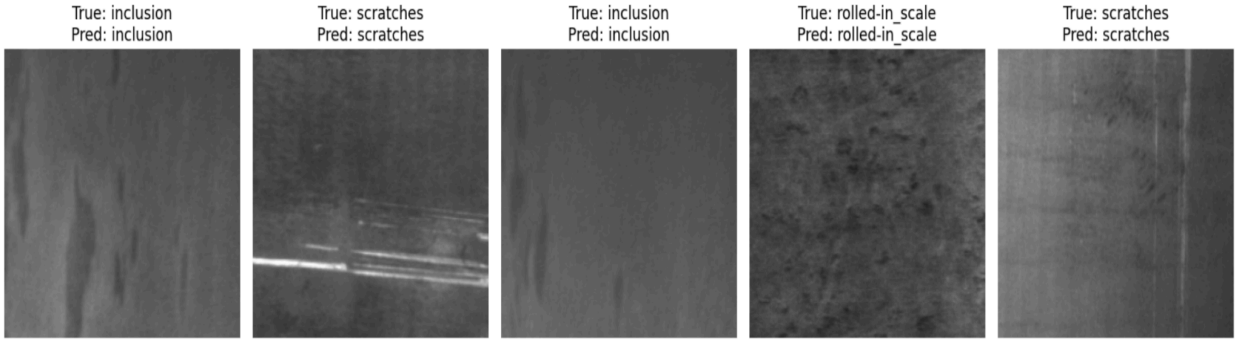
Training:

- Epochs: 30
- Batch Size: 32
- Early stopping with patience = 5

Results and Evaluation

Final Test Accuracy:

94.44%



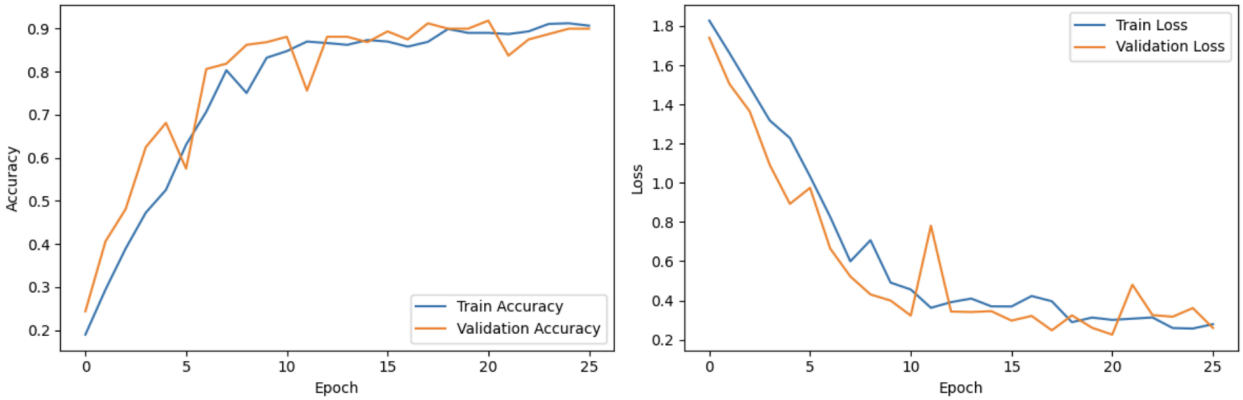

```
6/6 ━━━━━━━━━━━━━━━━━━━━ 6s 944ms/step

Classification Report:
                precision    recall  f1-score   support

       crazing       0.96      0.93      0.95        28
     inclusion       0.85      0.93      0.89        30
       patches       0.94      1.00      0.97        34
 pitted_surface      0.88      0.75      0.81        20
rolled-in_scale      1.00      0.97      0.98        29
     scratches       1.00      1.00      1.00        39

      accuracy                           0.94       180
     macro avg       0.94      0.93      0.93       180
  weighted avg       0.95      0.94      0.94       180
```

Training Curves:



Interactive Defect Prediction Tool

The second part of the project introduces a web-app style function:

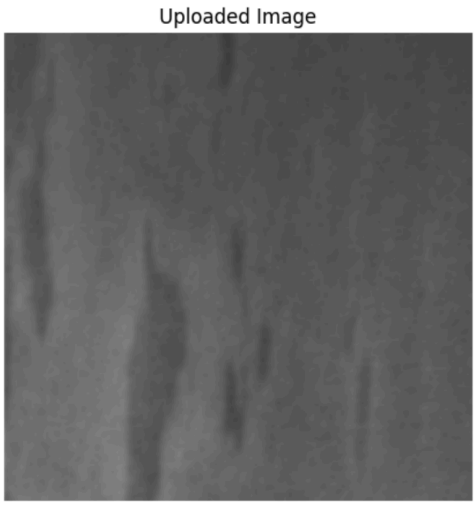
Allows users to upload a new image

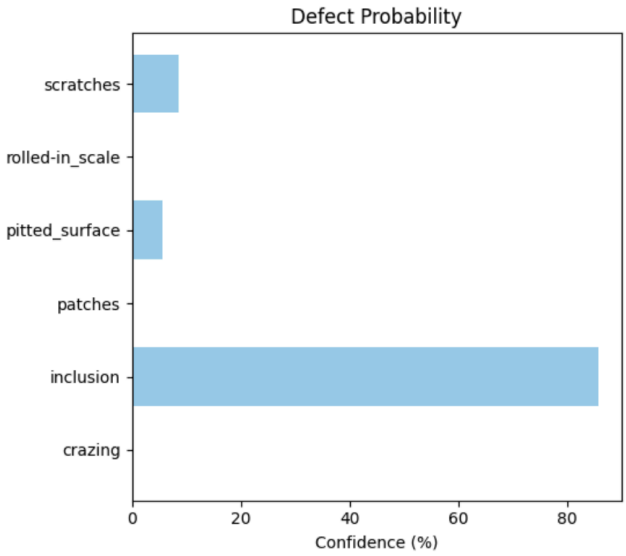
CNN makes a prediction and shows:

- Bar chart with defect probabilities
- Visual confirmation of image

A defect report with:

- Defect type
- Confidence
- Description
- Recommended action





Report:

Detected Defect: Inclusion
Confidence: 85.72%
Description: Foreign materials embedded in the surface
Recommended Action: Remove contaminated material. Improve filtration during production.

Conclusion

The project shows a strong systematic and practical approach to surface defect detection with CNNs. The NEU-DET dataset allowed us to develop a reliable classifier with over 94% accuracy. The ability of the package to provide real-time predictions gives it even more potential for use in industry, simplifying the defect identification process when recommending actions.