**Automated Classification of Steel Surface Defects for Shipbuilding Applications Using Deep Learning**

## Background & Motivation

In the shipbuilding industry—particularly in the construction of submarines and large naval vessels—steel quality is critical. Surface defects such as inclusions, creases, and oil contamination can compromise weld quality, coating adhesion, and structural integrity. Currently, much of this inspection is done manually, which is labor-intensive, inconsistent, and time-consuming. This project explores how deep learning can be used to automate defect classification as a precursor to real-time quality assurance in shipyard environments.

## Project Objective

Develop a convolutional neural network (CNN) using TensorFlow to classify 10 types of steel surface defects from grayscale images in the GC10-DET dataset. The model simulates a vision-based QA system capable of identifying material defects before welding or modular assembly in a shipbuilding context.

## Dataset

Source: GC10-DET Metallic Surface Defect Dataset  
Contents: 3,570 grayscale images labeled across 10 defect types:  
Punching, Weld Line, Crescent Gap, Water Spot, Oil Spot, Silk Spot, Inclusion, Rolled Pit, Crease, Waist Folding.  
  
These defects commonly appear in steel coil processing and are analogous to those encountered during panel fabrication and outfitting in shipyards.

## Methods

- Model: Transfer learning with MobileNetV2, fine-tuned for defect classification.  
- Preprocessing: Image resizing, normalization, and augmentation.  
- Explainability: Grad-CAM visualizations to highlight areas of interest in defect detection.  
- Evaluation: Confusion matrix, class-wise precision/recall, and qualitative analysis of misclassifications.

## Relevance to Shipbuilding

The project simulates a QA pipeline applicable to:  
- Pre-weld steel panel inspections  
- Inline robotic visual inspection systems  
- Reducing downstream rework due to overlooked surface issues  
- Supporting digital thread efforts in Teamcenter with automated defect logging

## Planned Deliverables

- A trained and validated TensorFlow model  
- Visual dashboard (optional) for uploading and classifying steel defect images  
- Summary report including insights into the types of defects most relevant to shipbuilding

## Future Extensions

- Adaptation to RGB or high-resolution industrial camera imagery  
- Integration with AR tools for overlaying defect heatmaps on scanned parts  
- Incorporation of defect severity scoring or segmentation for localization

## Optional Defect Class Grouping for Shipbuilding Context

To improve interpretability and simulate real-world QA workflows, the 10 defect types can be grouped into higher-level categories based on their likely impact in shipbuilding fabrication processes:

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| --- | --- | --- |
| Group | Classes Included | Relevance to Shipbuilding |
| Physical Deformation | Punching, Crease, Waist Folding, Crescent Gap | Panel fit-up issues, weld distortion, or surface flatness concerns |
| Surface Contamination | Water Spot, Oil Spot, Silk Spot | May interfere with paint/coating adhesion and corrosion protection |
| Structural/Embedded Defects | Inclusion, Rolled Pit | Potential welding faults, fatigue points, or surface weaknesses |
| Process Marker | Weld Line | Alignment feature, not a defect—needs to be tracked or avoided during cuts |