Building an Image Classifier for Detecting Corrosion

DSB 602 – Capstone Project

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Corrosion

- Corrosion
  - A natural process that coverts a refined metal into a more chemically stable metal oxide
- Corrosion of oilfield equipment and processing facilities
  - Common occurrence that poses serious threat to integrity of the facilities
  - Direct total costs due to corrosion are in the billions of dollars each year
  - Visual inspection of corrosion can give insight into the degree of corrosion that is occurring
  - It is hoped to be able to use computer vision to be able to identify corrosion onsite

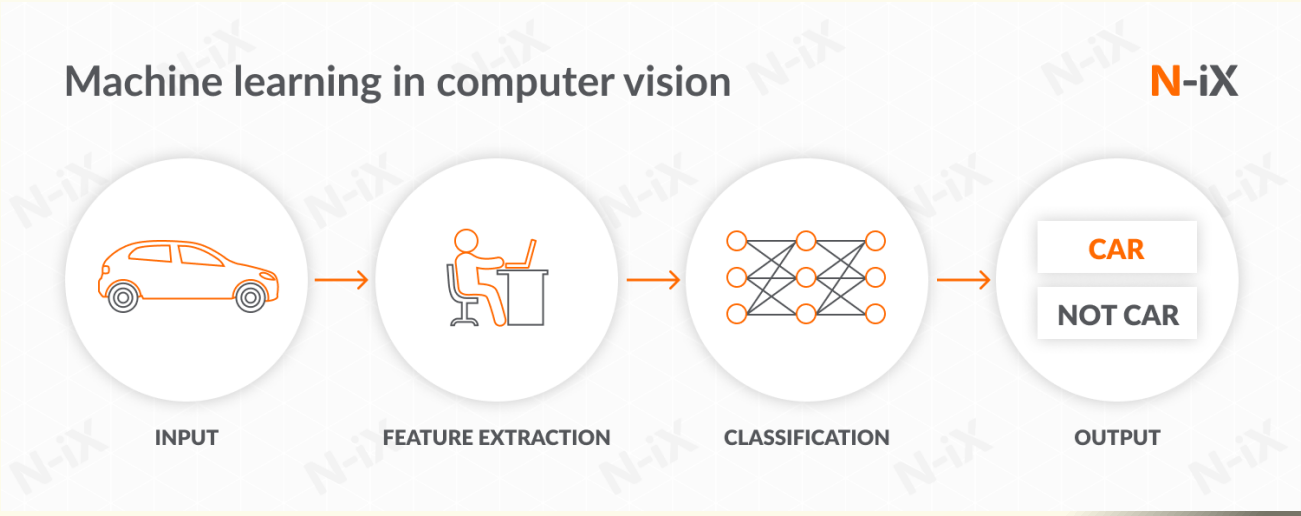
https://en.wikipedia.org/wiki/Corrosion
Martin, R.L., Stegmann, D.W., Sookprasong, P.A.;"Oilfield Corrosion Failures Analysis: Lessons Learned from Pitting Mprphologies"; International Petroleum Technology Conference, 2016, IPTC-18941-MS.
https://www.bmvc2021-virtualconference.com/assets/papers/1544.pdf

Problem Statement

- This project's goal is demonstrating proof of concept that computer vision can be used to identify corrosion
- Due to the lack of availability of open oilfield corrosion datasets, this project will use a generalized multi-class corrosion dataset with 5 different classes of corrosion
- This dataset has images that have been annotated with expert corrosion ratings obtained over 10 years of laboratory corrosion testing by material scientists
- Build an image classification model to detect corrosion from images
  - Classify images into multiple (5 different) categories
  - 5 being max corrosion
  - 9 being min corrosion
- Will use accuracy metric
  - Want to beat the baseline accuracy of 20%

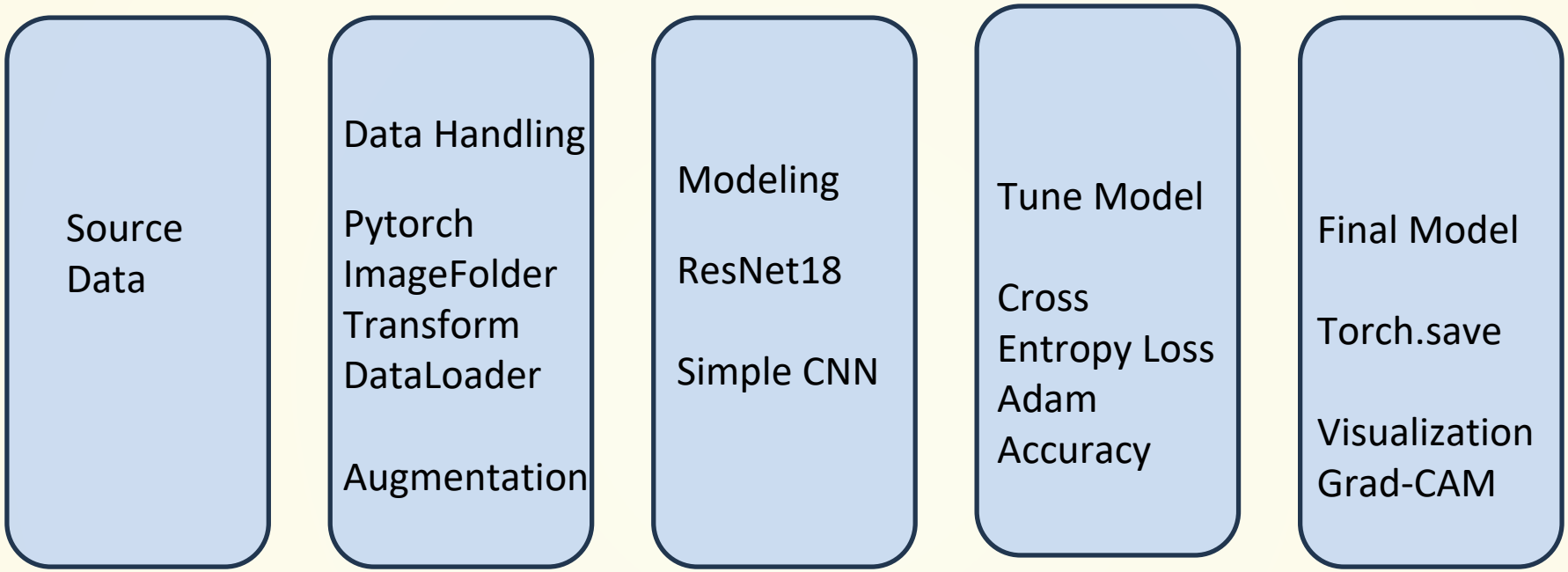
What is Computer Vision?

- Goal is to have computers see and understand pictures, videos, and other digital imagery, much like a human would
- Automating visual processing that is normally done by humans
  - Obstructions in road for autonomous vehicles
  - Detecting defects before shipping to customers
  - Reading a CT scan with better accuracy than a human
- Computer vision techniques identify patterns in data
- ML experts train complex models on vast amounts of visual data with the computer eventually learning to distinguish differences between images
- Well-annotated data is the foundation of training a good computer vision model



https://www.nyckel.com/blog/computer-vision/
https://www.n-ix.com/computer-vision/

Problem Solving Workflow



Corrosion Image Data

- The dataset is from WPI-ARL (Worcester Polytechnic Institute):
  - https://arl.wpi.edu/corrosion_dataset/
- Data is split into train, val, and test sets
  - 0.8, 0.1, 0.1 respectively
- Data specifics:
  - Images are of panels that have been scribed with a tungsten carbide pen and then placed in a corrosive environment
  - 600 images
  - Balanced classes (120 images each)
  - 5 classes of corrosion determined by expert materials scientists

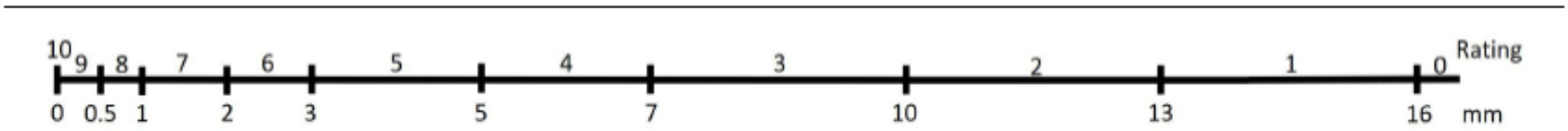
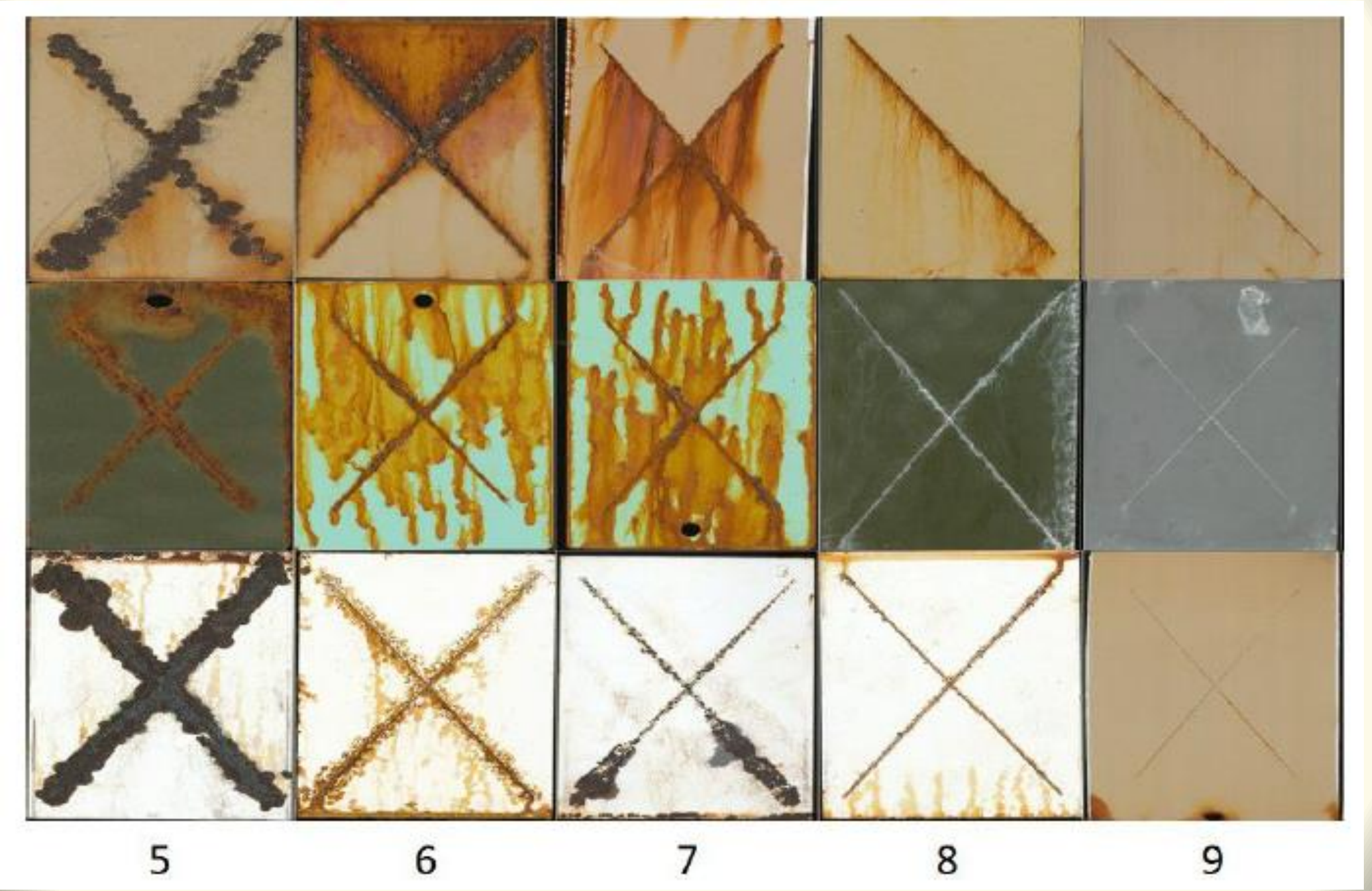


Figure 3: Scribe corrosion rating scale. *Top:* Discrete corrosion rating assigned for each mm measurement range, i.e. rating 10 is 0 mm, rating 0 is 16+ mm (higher ratings mean less corrosion). *Bottom:* mm measurements of average scribe corrosion width for a panel.

https://www.bmvc2021-virtualconference.com/assets/papers/1544.pdf

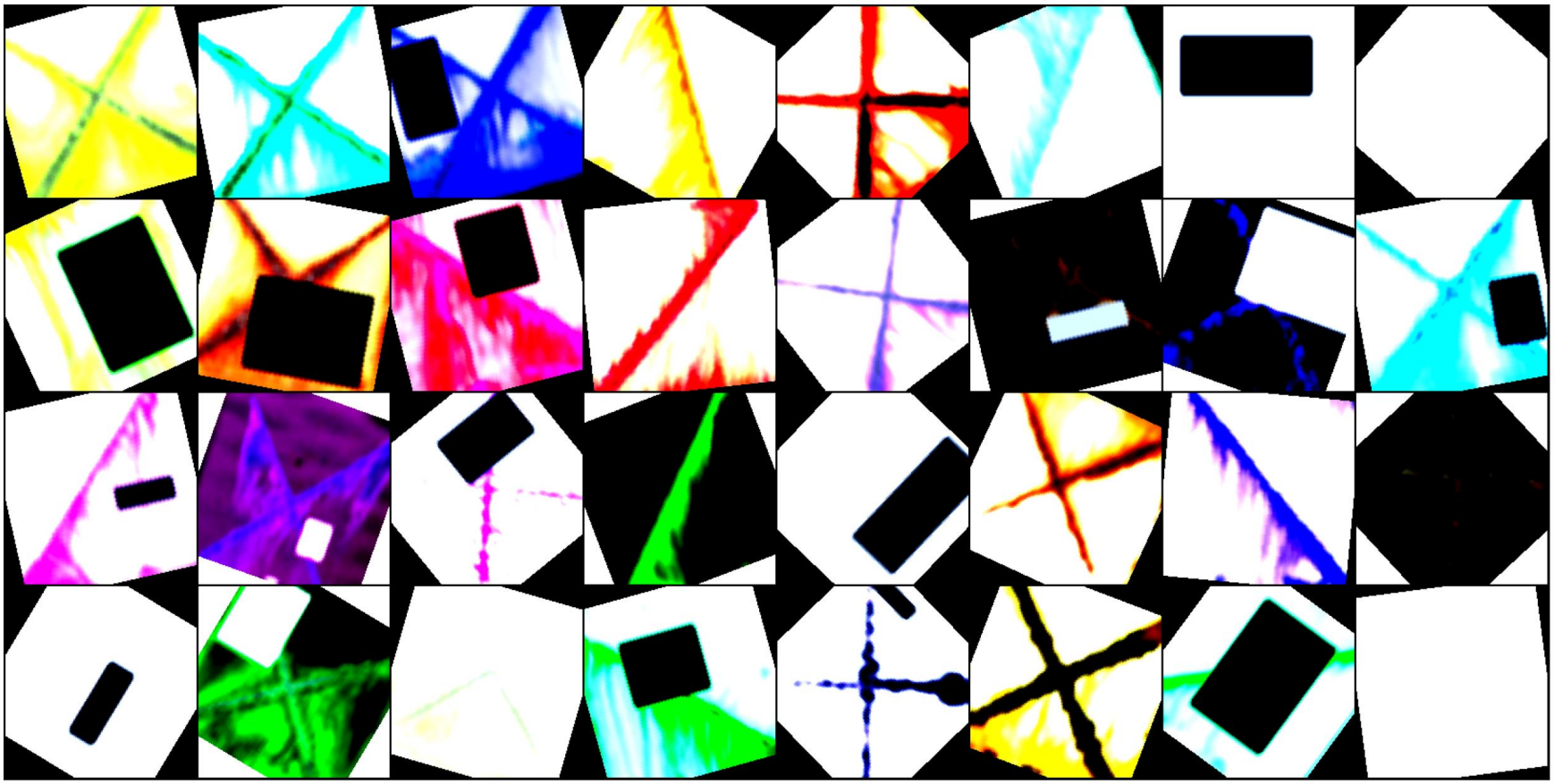
Corrosion Image Data – Three sample images per corrosion rating class 5 – 9 from the data set



https://www.bmvc2021-virtualconference.com/assets/papers/1544.pdf

Augmentations – A batch (32 samples) of augmented train set

Labels: ['6', '6', '5', '8', '6', '7', '9', '9', '7', '6', '7', '8', '7', '5', '6', '6', '8', '9', '5', '8', '7', '6', '7', '6', '9', '6', '6', '8', '7', '5', '9', '7']



- Random horizontal flipping
- Random cropping
- Random erasing
- Color jitter

- Gaussian Blur
- Random rotation by 45o
- Random invert

Modeling

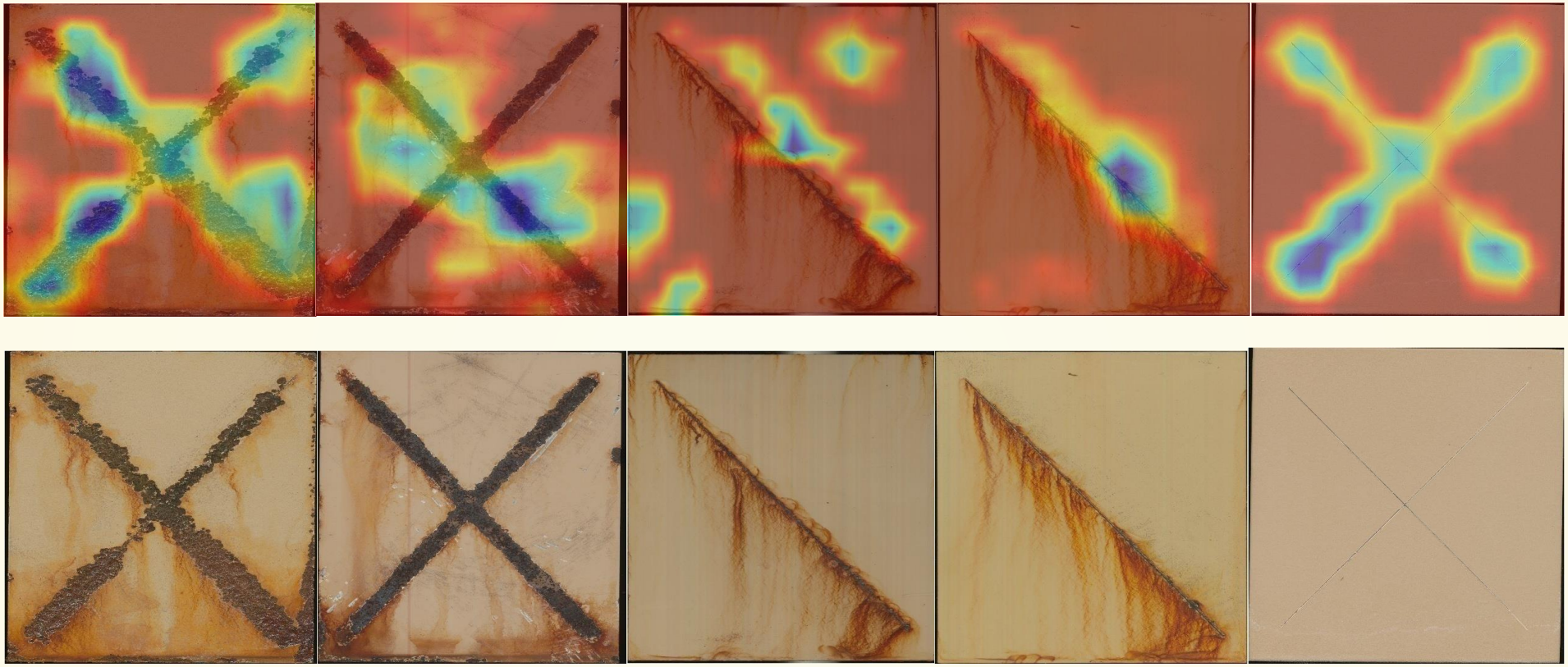
- Technologies used
  - pandas
  - os
  - cv2
  - glob
  - Sklearn confusion_matrix
  - Torch
    - AutoImageProcessor
    - Transforms
    - TensorDataset
    - DataLoader
  - **Resnet18**
    - **Accuracy → 43.33%**

Grad-CAM (Gradient-weighted Class Activation Mapping)

- What is Grad-CAM?
  - A visualization technique that provides visual explanations for decisions from CNNs
  - It produces course localization maps that highlight important regions in the input image for predicting a particular class
- Why is Grad-CAM important for visualizations?
  - Understanding why a model makes certain predictions can enhance transparency and trust
  - Highlighting regions on the input that were significant for the prediction makes the decision process of the Model more interpretable
  - Investigating why a model misclassified an input can provide insights into how to improve it
- How does it work?
  - Preprocess input image
  - Perform a forward pass
  - Identify target layer
  - Backward Pass
  - Compute heatmap
  - Visualize the heatmap

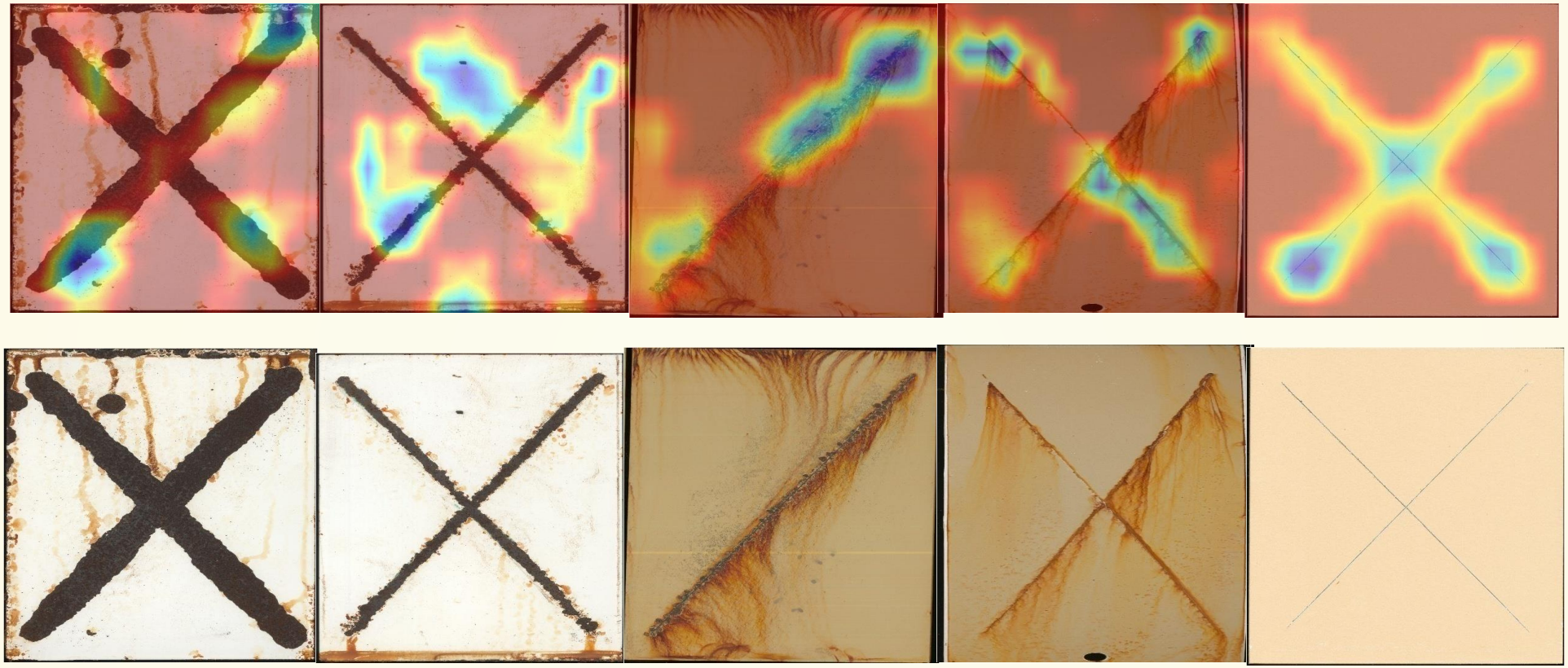
https://medium.com/@codetrade/grad-cam-in-pytorch-a-powerful-tool-for-visualize-explanations-from-deep-networks-bdc7caf0b282

Grad – CAM Visualization (Test set)



5 6 7 8 9

Grad – CAM Visualization (Train Set)



5 6 7 8 9

Conclusions

- Data set was a source of images with labeled classes of corrosion by expert corrosion materials scientists
- PyTorch provided a convenient methodology to preprocess, classify, and transform images in addition to augmentation with class labels to carry out computer vision modeling
- A model using Resenet18 was developed that surpassed the metric of greater than baseline accuracy of 20%
- This proof on concept indicates that it could be possible to use computer vision technology to automate corrosion detection from images

Future Work

- Collect more images to improve the accuracy of the model
- Experiment with the augmentation parameters to see if accuracy can be improved
  - A very aggressive augmentation transform was used
  - This could be introducing noise into the model
- Expand technology to look at oilfield corrosion
- Once expanded to oilfield corrosion, build a dashboard or visualization interface for the end users, i.e. the oilfield operators.

Questions?