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QUEBEC IRON ORE

UBC Master of Data Science

QIO Geo-Detection Project

Segmenting rock types using Machine Learning

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I.R.O.N.N.

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Business Problem

Currently, a trained geologist is needed to identify different rock types.

QIO needs a prototype that will help:

- Segmenting rock types from an active mining face image

Data Science Objectives

Labeling the data:

- LabelMe

Understanding the data:

- Colour and camera feature analysis

Building the machine learning model:

- Image segmentation and classification

Improving the model:

- Design tools to improve data quality

Labeling the Data: Origin State

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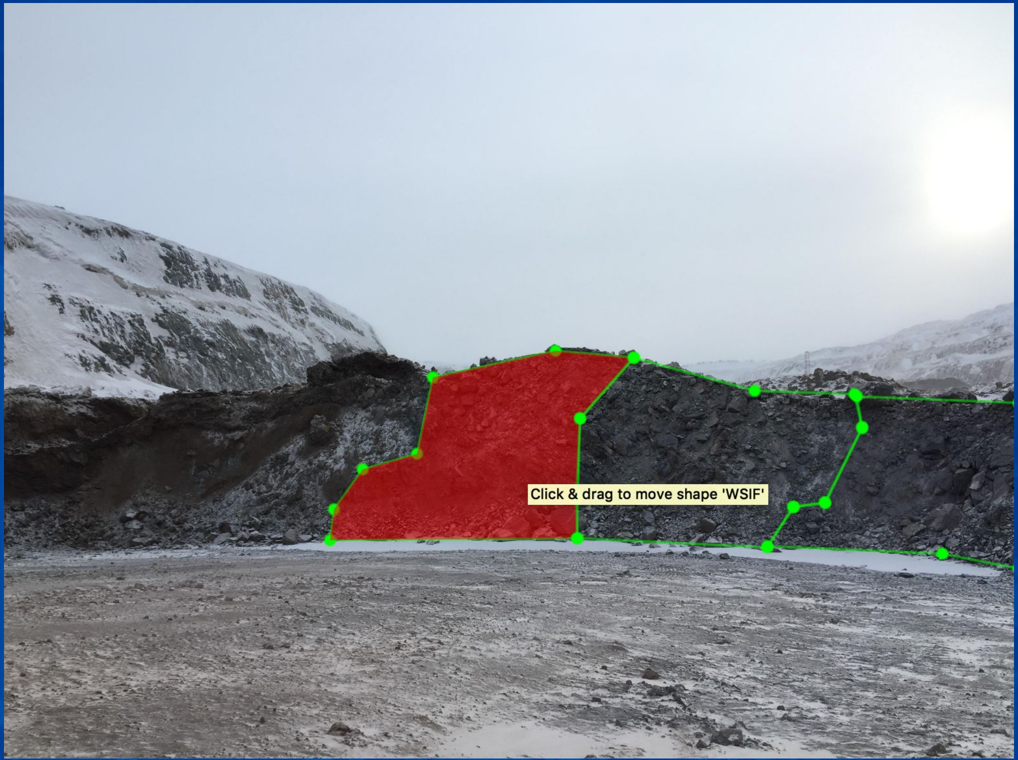
Hand annotations

- cannot be used to train a machine learning model

Labeling the Data: Solution

[LabelMe]

- Obtain coordinates that are useful for EDA and model training



Understanding the Data: Image 101

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Pixel:
- a small block on an image

Pixel value (0~255):

0: black
255: white

RGB Image:
- each image consists of 3 layers/channels (Red, Green, Blue)

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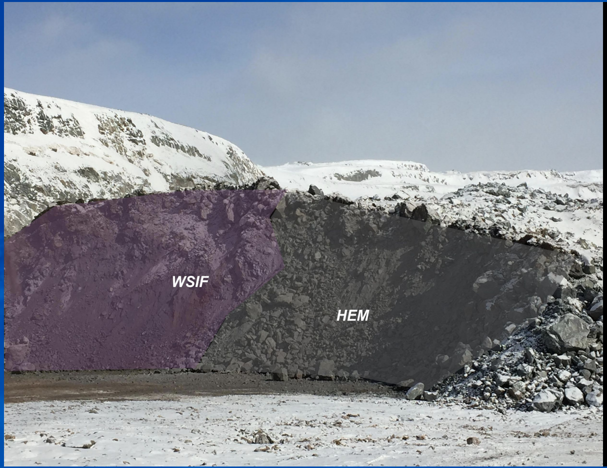
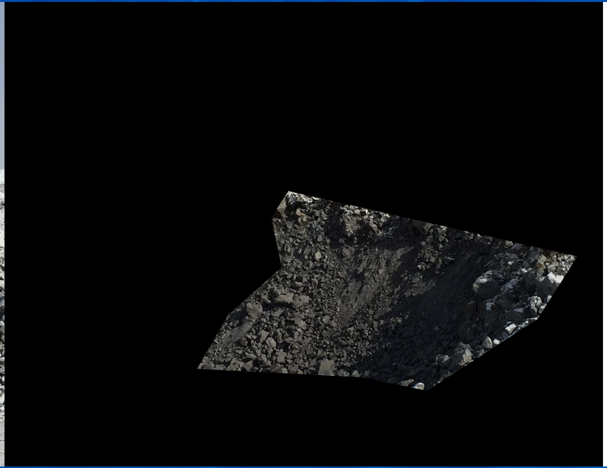
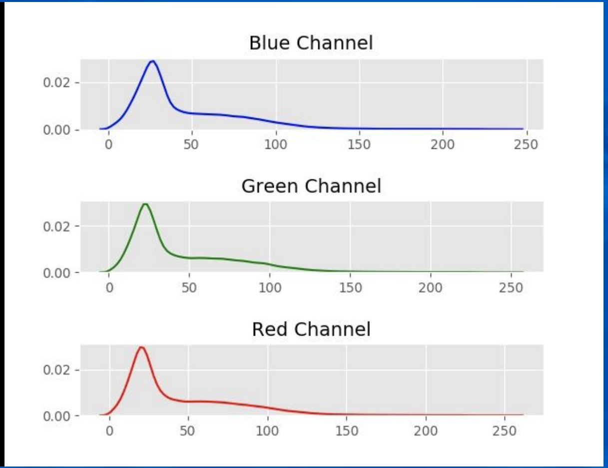
Understanding the Data: Colour Features

Purpose: intuitive way to understand image data

Method: extracted 9 features including mean pixel on each of the 3 channels for each rock type in every image



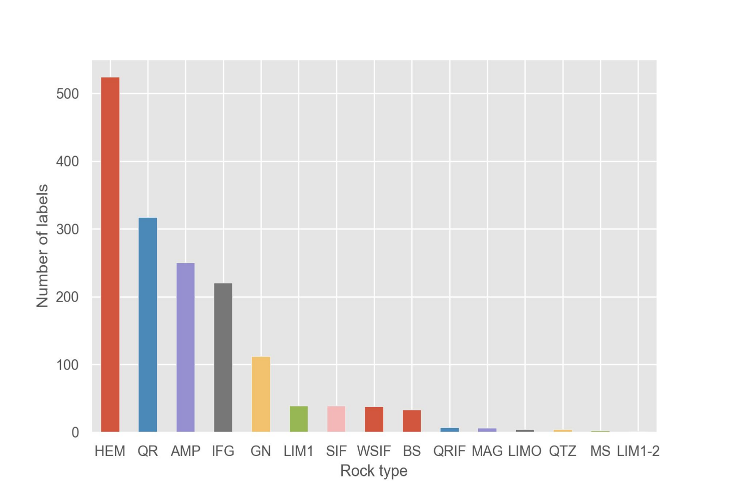


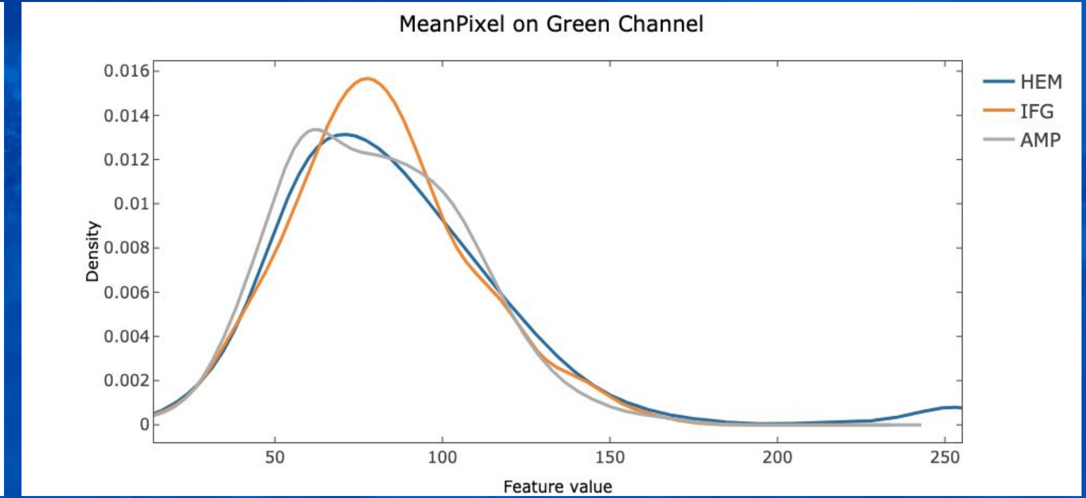


Understanding the Data: Colour Features

Statistical test: analyze if the rocks are “easily differentiable” from each other

Problem: hard to distinguish due to imbalanced data





Understanding the Data: Colour Features

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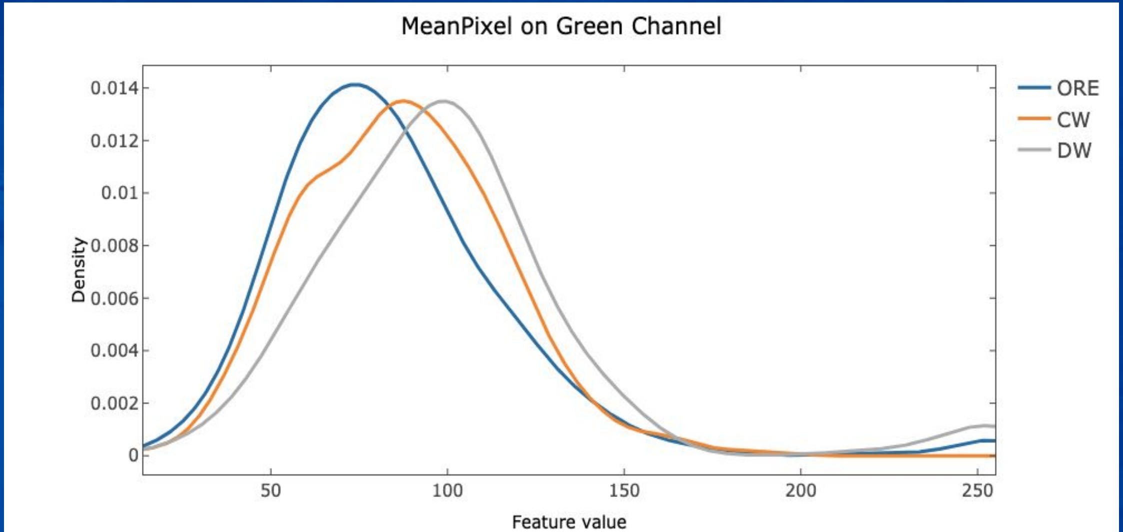
Combine rocks into 3 categories:

- Ore
- Dilution waste
- Contamination waste



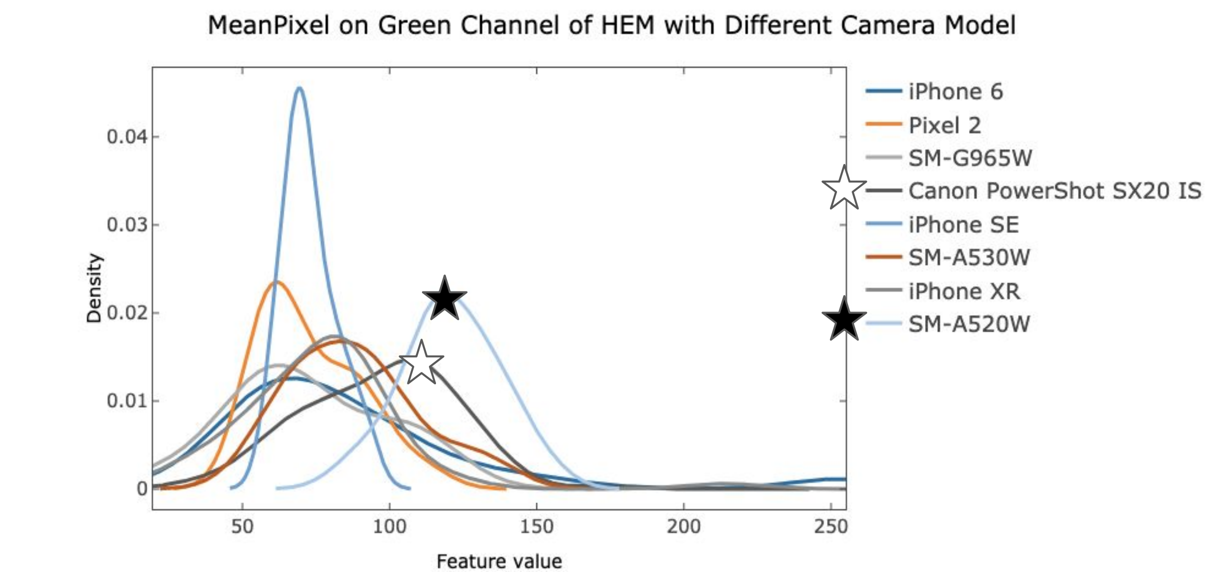
Understanding the Data: Camera Features

Purpose:

- Check camera effect

Method:

- Collected data such as phone type, exposure time, focal length, etc.



Camera Features: Impact

Images on the right:

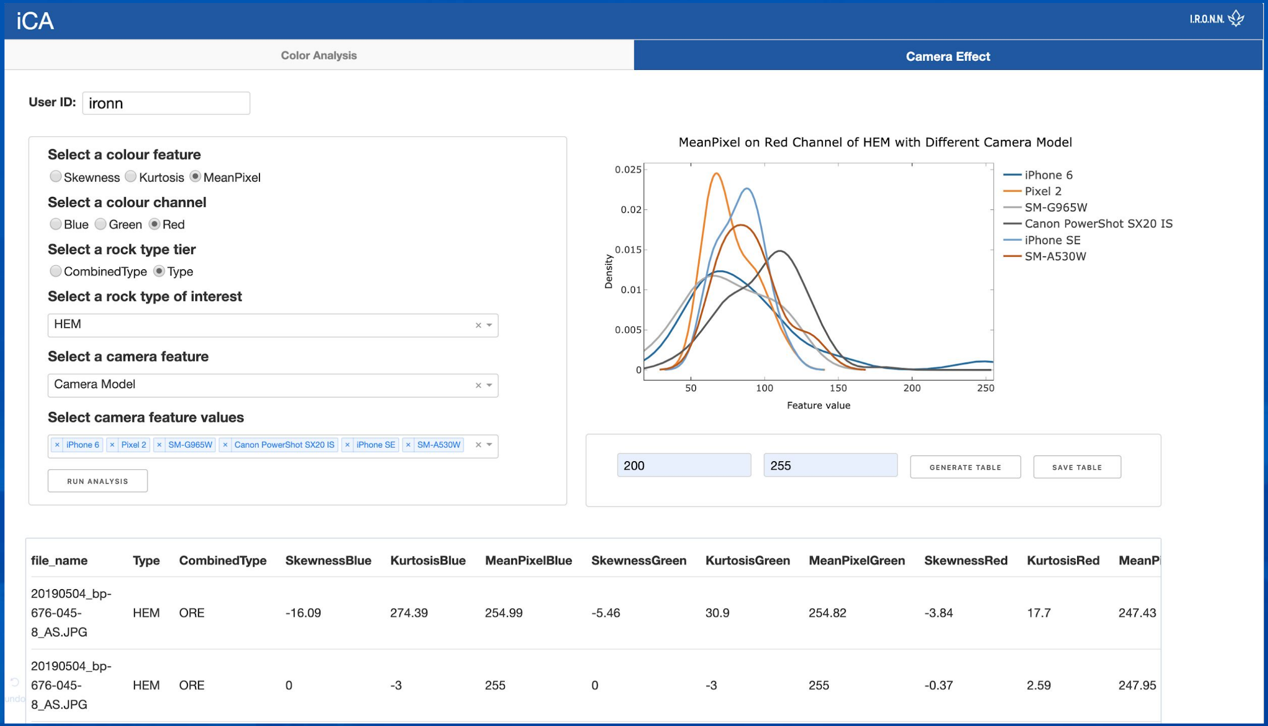
- Similarity: contain *hematite*
- Difference: red colour profile

Image	Camera	MeanPixelRed
	SM-A520W	148.13
	iPhone 6	70.53

Data Product: iCA

Plotly Dashboard

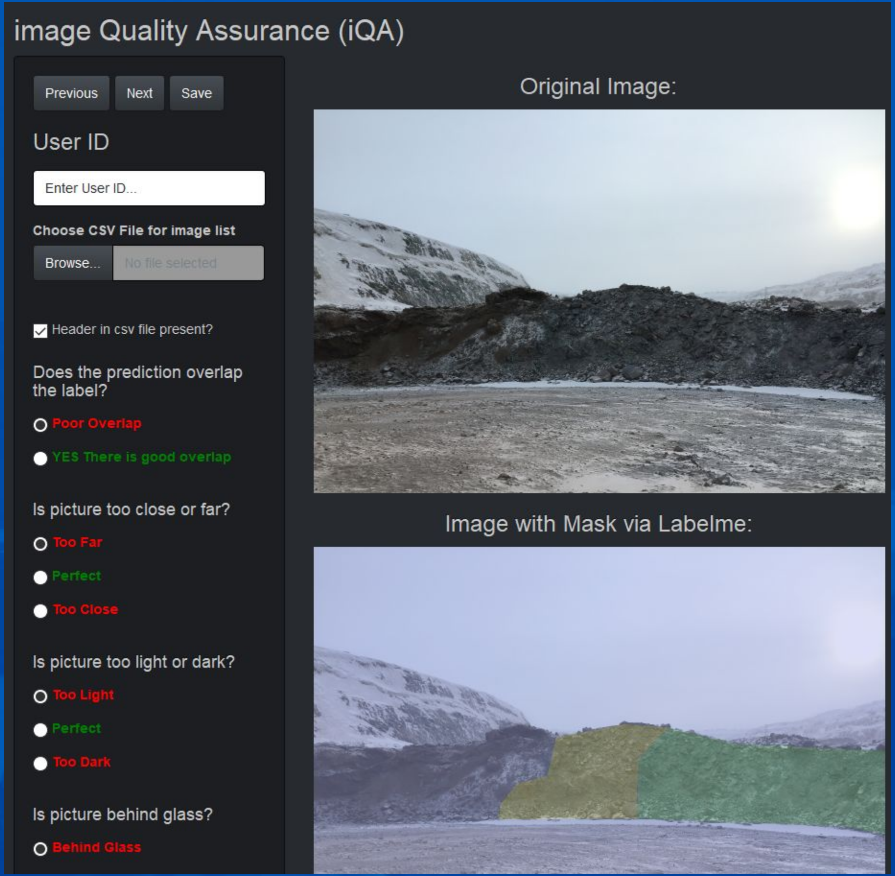
- Interactively identify images that have outstanding features (outliers)
- Can be used for image quality check with iQA



Data Product: iQA

Shiny Dashboard

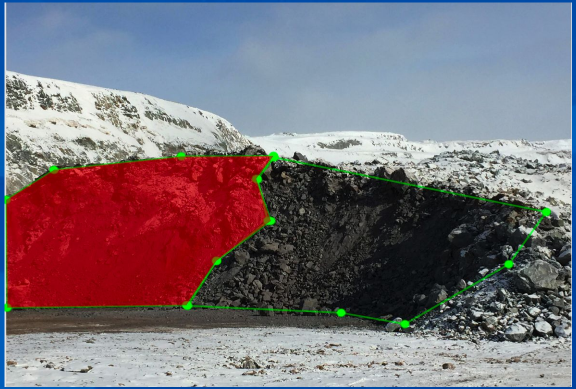
- Check if there are any qualitative issues with original images, labels, predictions (blurriness, machinery present, etc)

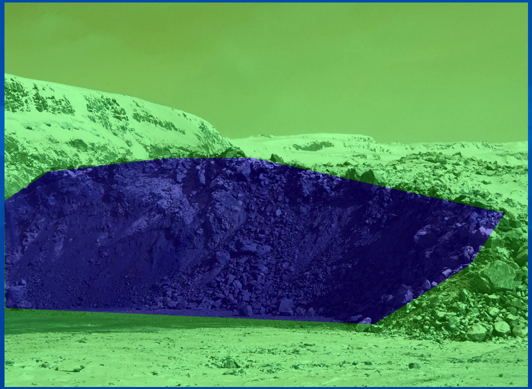


Main Data Product: I.R.O.N.N.

First model: I.R.O.N.N. V0.1

- See if we can distinguish whole rock face from background (sky, ground, etc.)
- Created convex hulls for polygons/blasted face
- Trained on ~430 images



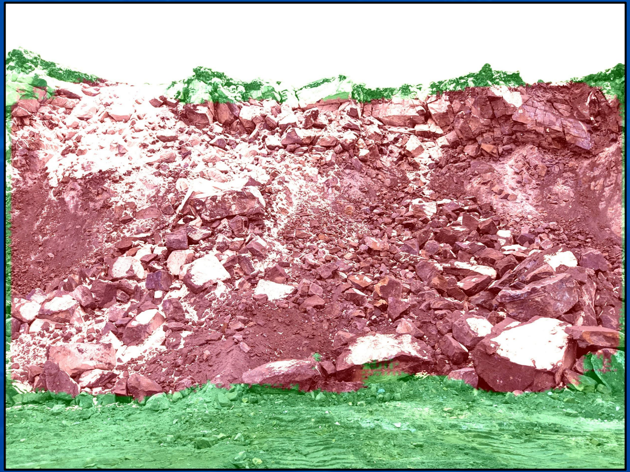


I.R.O.N.N. V0.1: Result

Original image and the model output for an example image where:

- **Red**: blasted face
- **Green**: rest of the image/background

Testing the model:



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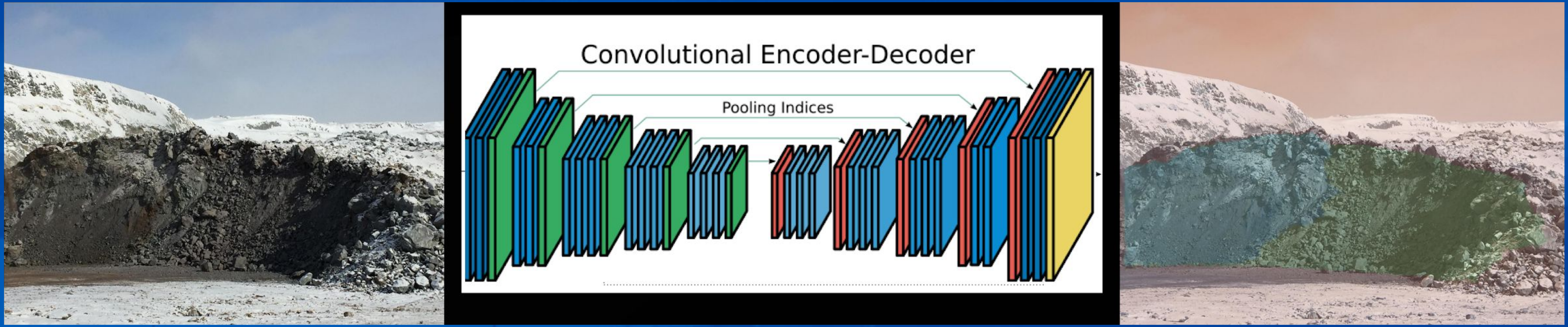
I.R.O.N.N. V1.0: Architecture

Currently using Fully Convolutional Networks for Image Segmentation

Takes in images and spits out images

Framework: PyTorch



I.R.O.N.N. V1.0

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1. Original unlabeled image

I.R.O.N.N. V1.0

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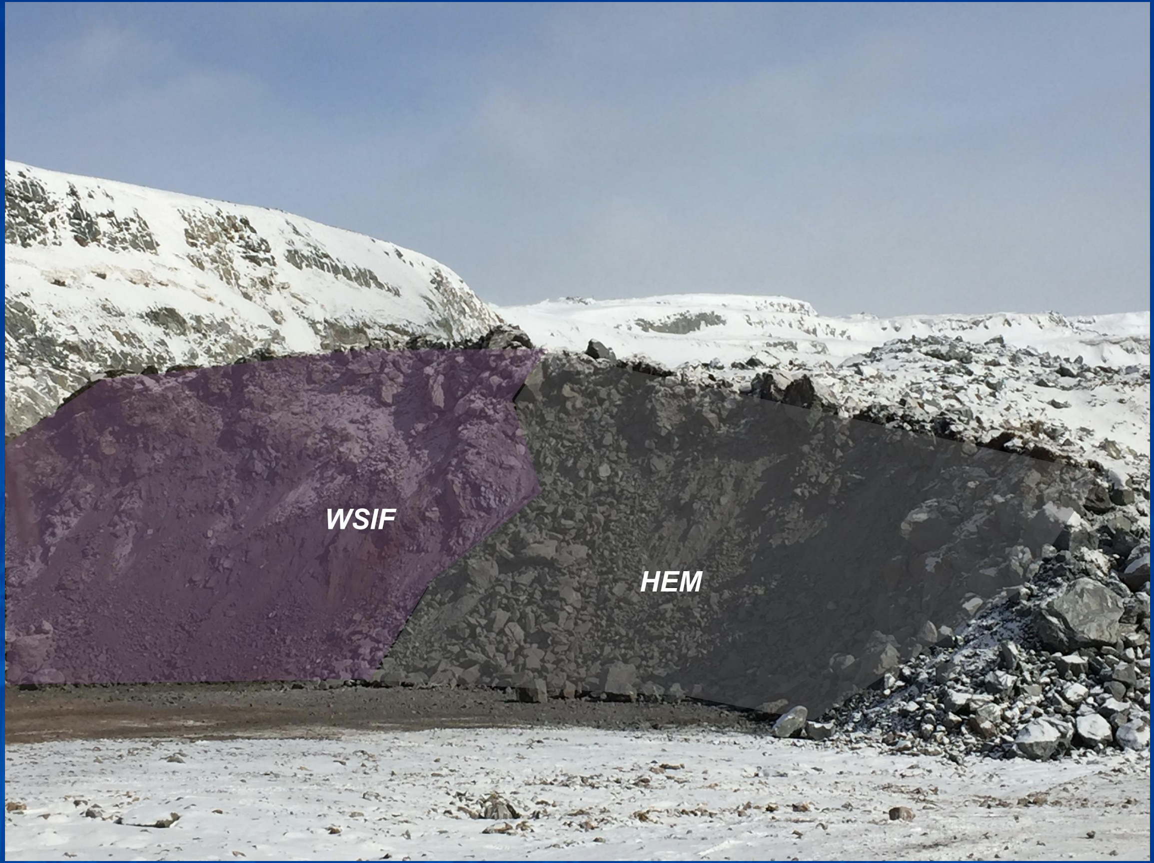
2. Labeled image

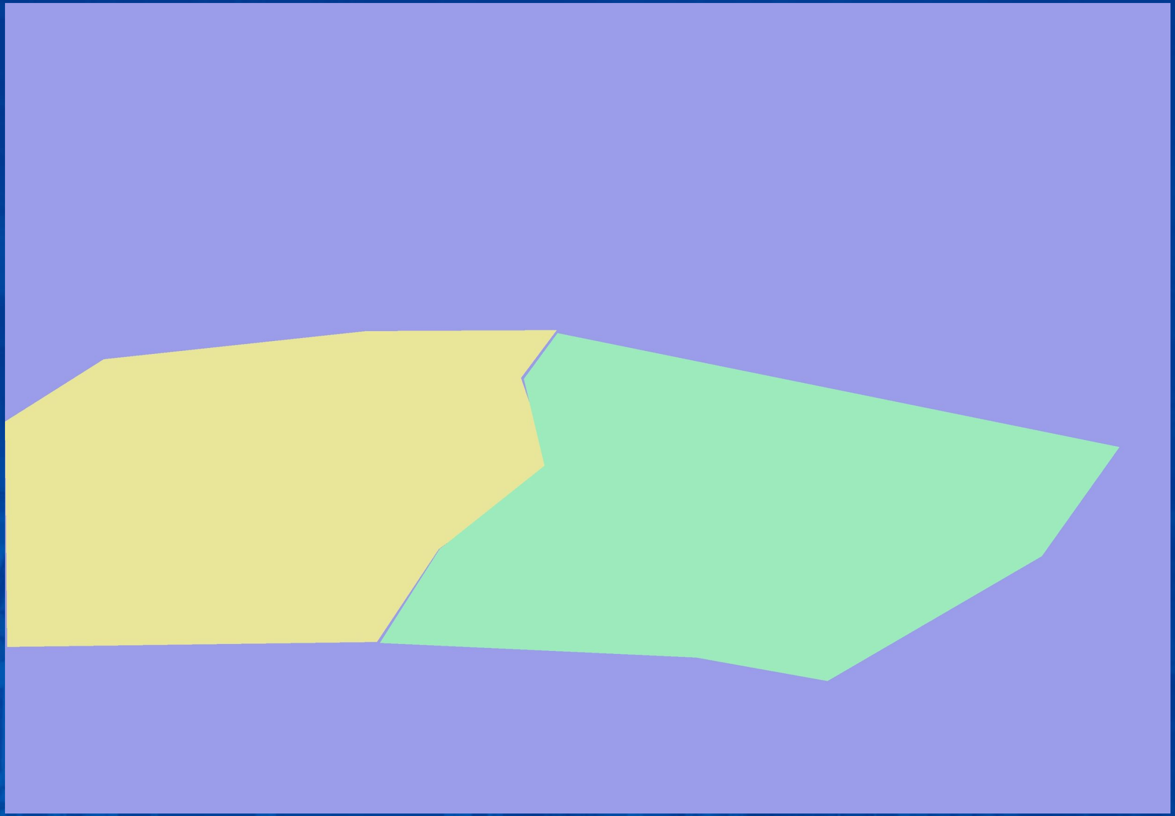
HEM: Ore

WSIF: Contamination waste



I.R.O.N.N. V1.0

3. Created mask from the label



I.R.O.N.N. V1.0

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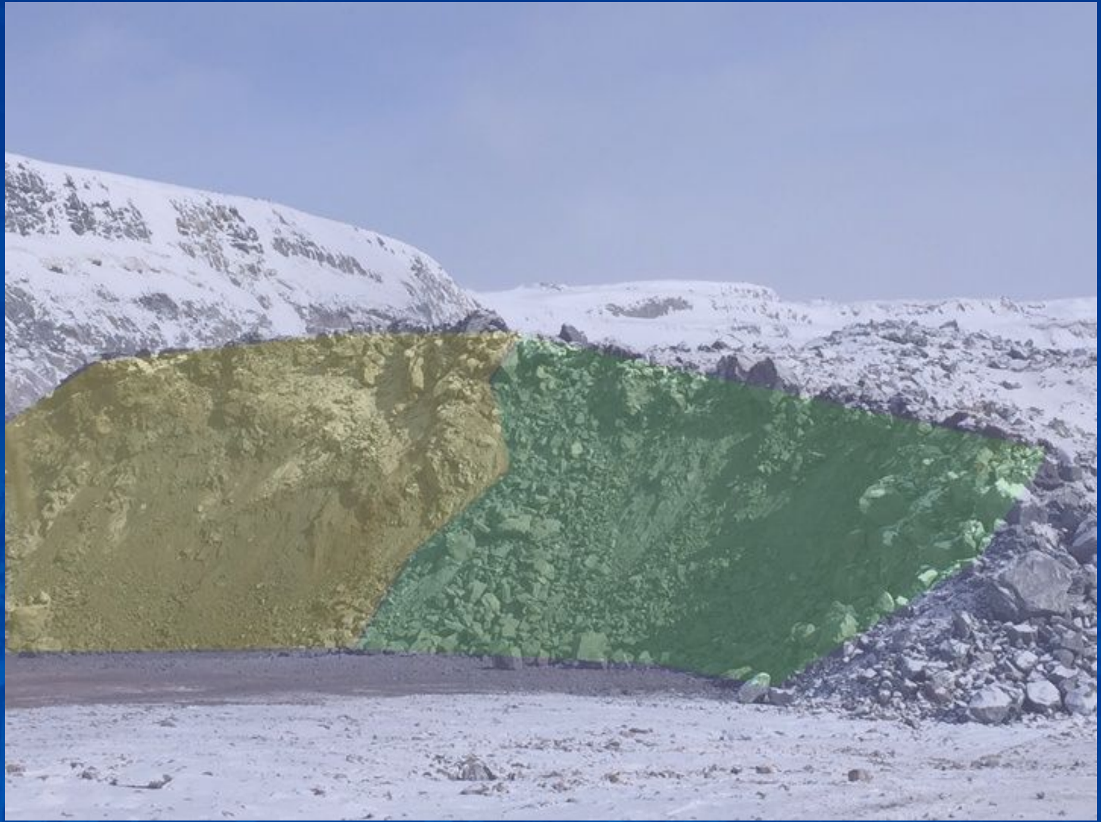
4. Mask is superimposed over the original image



I.R.O.N.N. V1.0

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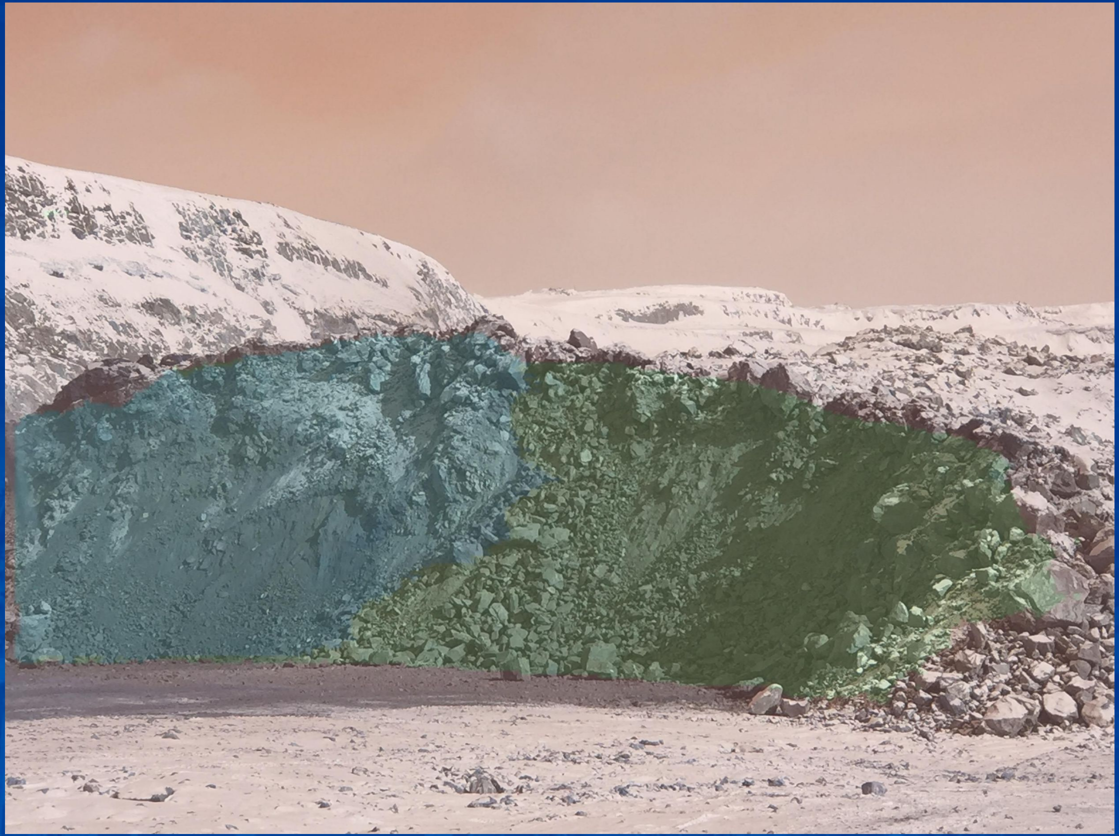
5. Prediction after training



I.R.O.N.N. V1.0

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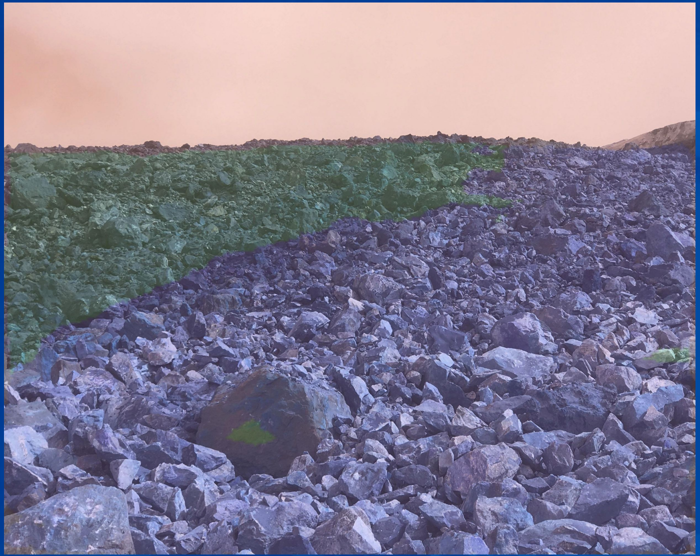
An example on an unseen image

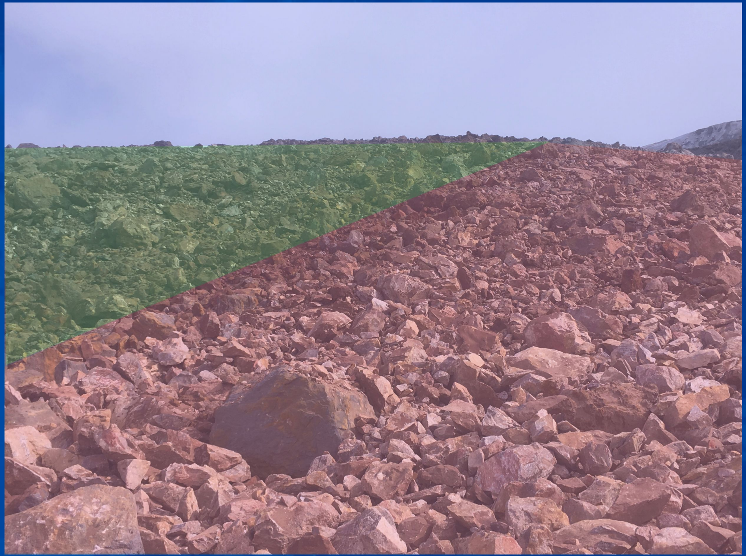
Model Results

I.R.O.N.N. V1.0: pixel-wise accuracy of **77%**

I.R.O.N.N. V2.0 (Outliers removed): pixel-wise accuracy of **85%**



Prediction



Actual superimposed label

Cost of Training on AWS:

- Cost of using the GPU ~ $1 per hour of training (active use time)
- Time to train (using 600 images): 2.5 - 3 hours
- Cost of GPU + Cost of storage ~ $4 + $1 = $5
- Expected training frequency = 2 times a month
- Total a month: Approx $15 (with 650-700 images)

Difficulties & Challenges

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- Some images are unsuitable for training (bad lighting, angles, and background noise)
- May not have enough training data due to a large number of rock types
- Model's current performance might not be the same when we introduce more classes
- Model might not be able to handle fine-grained differences from textures between rock types

Next Steps

Pipeline has been created

- Train a model with all the different rock types
- Improve model’s performance

Train mine operators to capture images in a standardized format

Develop a user friendly interface that can be used by the operators and predict in real-time

Summary of Pipeline

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Merci beaucoup!