Classification of Depositional Environments using Satellite Images

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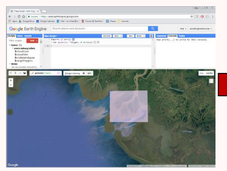
Motivation

- Understanding sedimentary depositional environments is very important for resource exploration as these are structures that have a major influence on the spatial distribution of resources.
- The goal of this project is to build a classifier that could take satellite images containing rivers, deltas, and lakes as input and determine the depositional environment as the output.
- To do this we tried five different classification schemes; *Linear Support Vector Machine*, *Support Vector Machine with Gaussian Kernel*, a *Softmax Regression Classifier*, a simple *Neural Network*, and a *Convolutional Neural Network*.
- We found the Softmax Regression Classifier to be the most accurate classifier, though it does not seem like a useful scheme for future work.

Data Mining & Preprocessing

Google Earth Engine

Create a list of depositional environments with Landsat 8 data



Pull 4-Band Images

Bands:
1. Near Infrared
2. Red
3. Green
4. Blue

Compression

Discrete cosine transform, compress to 250x250 px

Feature Extraction

Normalized Difference Water Index (NDWI)

Calculate NDWI from green & IR bands:

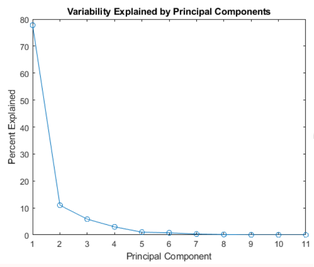
$$NDWI = \frac{green - IR}{green + IR}$$

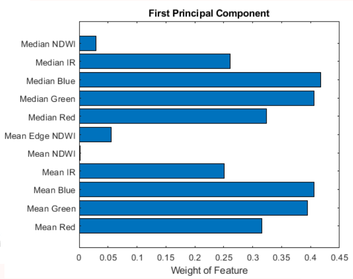
CNN

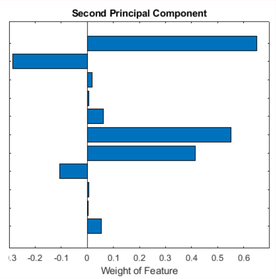
Features

Type of Feature	Image Type				
	Red	Blue	Green	Infrared	NDWI
Mean Value in Image	✓	✓	✓	✓	✓
Median Value in Image	✓	✓	✓	✓	✓
Mean Edge Value					✓

PCA

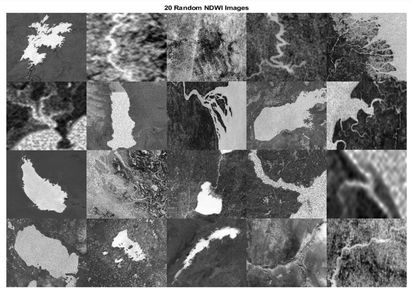






Data

Depositional Environment	Number of Images
Delta	84
Lake	67
River	82
Total	233



Supervised Learning Models

Multi-class SVM
- 1 vs 1 Encoding
- 3 SVM's trained
- Prediction from smallest total loss summed over all 3 SVMs
- 2 Models – Linear and Kernelized
- 1000 combinations of training/test data used and 95% confidence interval for accuracy plotted

Encoding Matrix

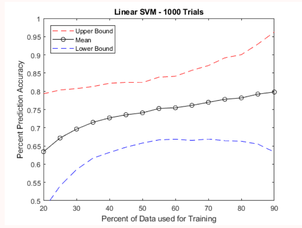
	SVM 1	SVM 2	SVM 3	
Delta	1	1	0	Total Loss Summed by Row
River	−1	0	1	
Lake	0	−1	−1	

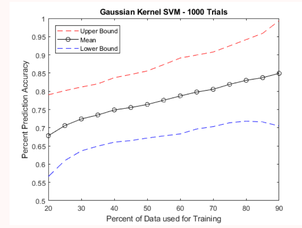
Hinge Loss = $\max\{0, 1 - t_j \hat{y}_i\}$

Encoding — Prediction

Softmax (Multinomial Logistic) Regression
- 1000 combinations of training/test data used and 95% confidence interval for accuracy plotted

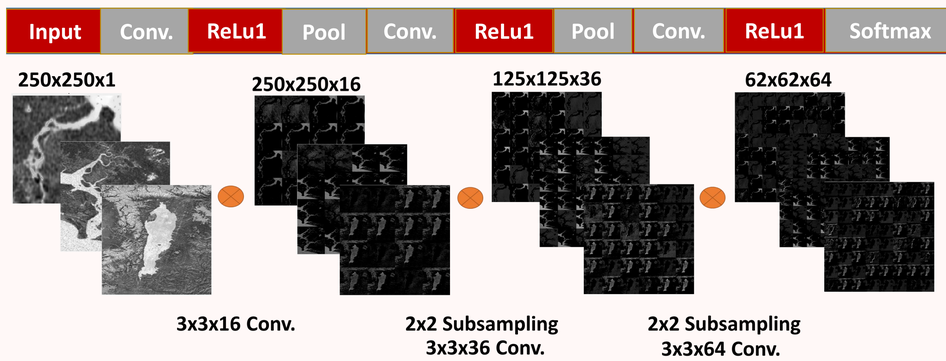
$$l_i = \frac{e^{\theta^T x^i}}{\sum_k e^{\theta^T x^k}}$$

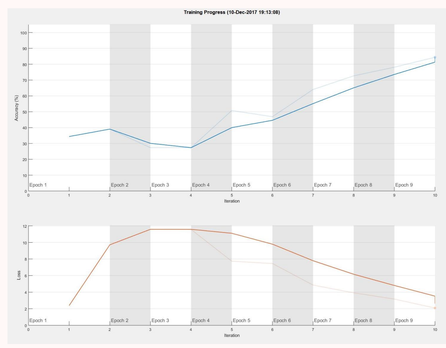




Deep Learning Models

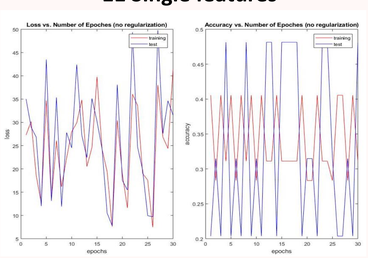
Convolutional Neural Network



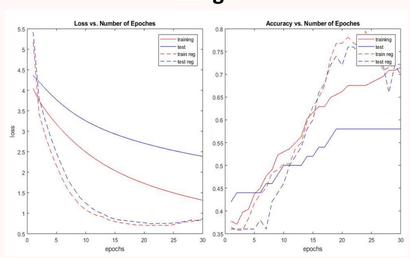


Neural Network (one 300-unit hidden layer)

11 Single features



Images



Discussion

Model	Accuracy*
Linear SVM	76%
Gaussian SVM	81%
Softmax	**89%**
NN (single)	41%
NN (image)	71%
CNN	76%

*Using 75% of images (175) for training, tested on other 25%

Conclusions
- Softmax with 11 features is the best classifier for these satellite images
- The simple Neural Network with the 11 features in our dataset is highly unstable.

Future Work
- The CNN can be improved
- Extend the CNN to locate dep. Environments regions on larger satellite images.
- Extend the CNN to be generative, conditioning on hard data such that it acts as an interpolator