

Pixel Based Image Classification

Goal

- Classify pixels in different 50 photographs that include the same classes.

Overview

- Sample Training, Testing, and Validation Set
- Pre-processed imagery
 - Color Space Transformations
 - Image Segmentation (Smoothing)
 - Texture Calculations (GLCM)
- Train random forest model
- Tune Model
- Classify all 50 images

Technology

- RStudio, tidyverse
- Python,
- Labelme
- Linux

Code

View code [here!](#)

<https://github.com/jackkrebsbach/classify-images>

```
# Color Space Transformations
library(tidyverse)
file_paths <-
  tibble(inpath = sprintf("clean_data/quadrats/%s",
                           1:50))

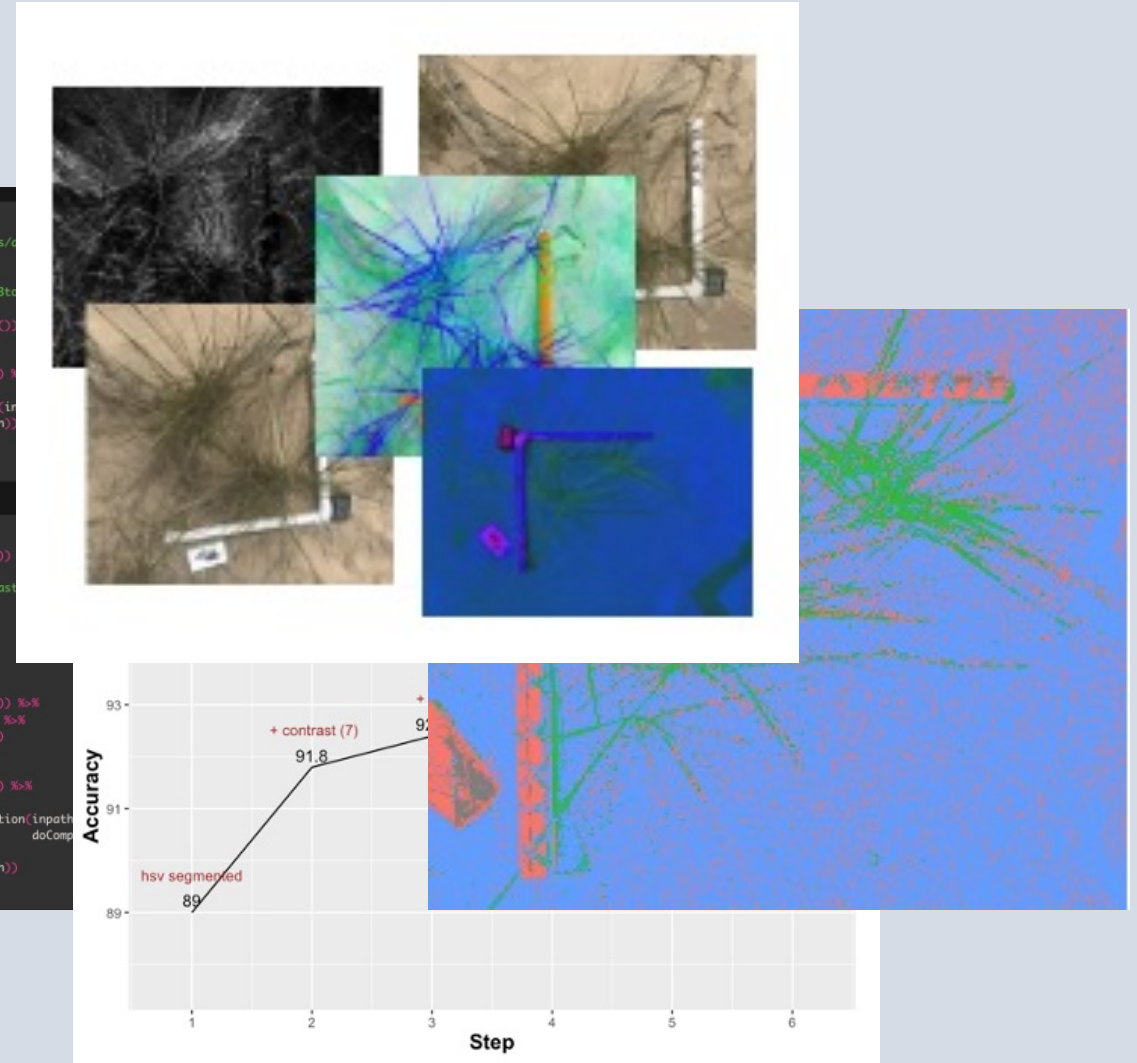
# Color Transform Parameters
color_transforms <- tibble(transform = c("RGBto",
                                         "HLS",
                                         "HSV",
                                         "L*a*b*",
                                         "L*u*v*",
                                         "L*u*v*",
                                         "L*u*v*"))
color_parameters <- file_paths %>%
  full_join(color_transforms, by = "character()")

color_out <- color_parameters %>%
  mutate(inpath_exists = file.exists(inpath)) %>%
  partition(cl) %>%
  mutate(outpath = color_transforms_function(inpath,
                                              outpath_exists = file.exists(outpath))) %>%
  collect()
color_out

# Texture Calculations
library(tidyverse)
# Texture Parameters
texture_windows <- tibble(window = c(5L, 11L))
texture_layers <- tibble(layer = c(3L))
texture_stats <- tibble(statistic = c("contrast",
                                      "dissimilarity",
                                      "homogeneity",
                                      "information",
                                      "max_diff",
                                      "mean_brightness",
                                      "mean_intensity",
                                      "mean_of_squares",
                                      "moment_invariant_1",
                                      "moment_invariant_2",
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                                      "moment_invariant_4",
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                                      "moment_invariant_97",
                                      "moment_invariant_98",
                                      "moment_invariant_99",
                                      "moment_invariant_100"))

# Perform Texture Calculations
texture_parameters <- color_out %>%
  dplyr::select(outpath) %>%
  rename(inpath = outpath) %>%
  dplyr::select(inpath) %>%
  full_join(texture_windows, by = "character()") %>%
  full_join(texture_stats, by = "character()") %>%
  full_join(texture_layers, by = "character()")

texture_out <- texture_parameters %>%
  mutate(inpath_exists = file.exists(inpath)) %>%
  partition(cl) %>%
  mutate(outpath = texture_calculations_function(inpath,
                                                  outpath_exists = file.exists(outpath))) %>%
  collect() %>%
  mutate(outpath_exists = file.exists(outpath))
texture_out
```



Modeling Dune Vegetation

Goal

- Generate vegetation density map across an entire coastal dune complex

Overview

- Acquire initial vegetation estimates
- Create Normalized Difference Vegetation (NDVI) orthomosaic map
- Create model prediction live vegetation coverage from average NDVI values
- Calculate vegetation density o

Technology

- RStudio, tidyverse
- QGIS (Information Geographic System)
- Linux

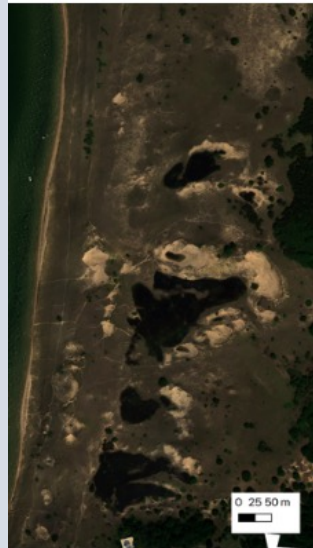
Code

Code not yet available

Mapping Dune Vegetation Using Drones and Machine Learning

Jack Krebsbach, Dr. Brian Yurk, Dr. Paul Pearson, Dr. Edward Hansen, Eric Leu

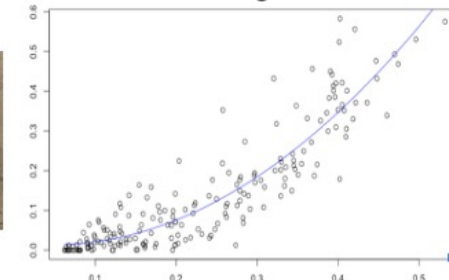
Dune Complex (SHNA):
Orthomosaic



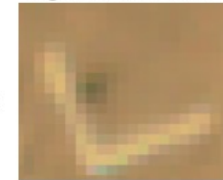
Ground Based Photo



Empirical model predicting vegetation coverage

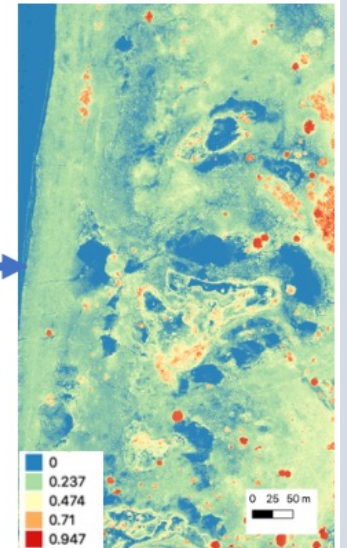


High-Altitude Photo



1. Use machine learning to estimate vegetation coverage in ground-based imagery
2. Calculate Normalized Difference Vegetation Index (NDVI) in high-altitude imagery
3. Create Empirical Model predicting coverage from Ave. NDVI Values
4. Apply model to the entire orthomosaic

Vegetation Coverage Map



Single Layer Neural Network

Goal

- Learn how Neural Networks works
- Implement a single layer neural network in python
- Classify ground cover in an orthomosaic acquired from a drone

Overview

- Acquire training set (QGIS)
- Implement a single layer ANN
 - Back propagation (gradient descent)
 - Activation Functions (Relu, SoftMax)
 - One hot encoding
- Classify orthomosaic
- Achieved 99% accuracy with 3+ classes

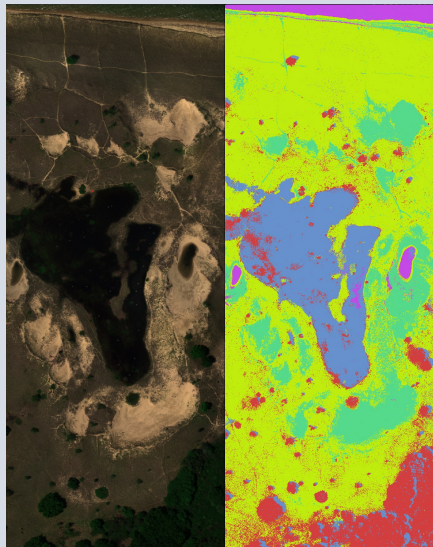
Technology

- Python, Anaconda
- Jupyter
- QGIS (Geographic Information System)

Code

View code [here!](https://github.com/jackkrebsbach/neural-network)

<https://github.com/jackkrebsbach/neural-network>



```
In [ ]: #Activation function softmax for forward propagation. The regular softmax function overflows whenever any input data
#I've modified it to shift the input vector to ensure calculations are stable.
def softmax(x):
    z = x-np.max(x,axis=1).reshape(x.shape[0],1)
    return np.exp(z) / np.exp(z).sum(axis=1, keepdims=True)

Now, we code the algorithm that trains the neural network weights and biases. This function takes the training data along with its targets, along with a
variety of hyperparameters. number_hiddennodes gives the number of nodes in the hidden layer, number_outputnodes gives the number of nodes
at the output layer, learningrate contributes to the step size, and epochs gives the number of iterations that the model completes. Notice that
number_outputnodes must be equal to the expected dimension of the output.

In [ ]: #Neural network for our classification problem. It is fit through a set of training data then outputs the final opt
def NeuralNetwork(TrainData, TrainVal, number_hiddennodes, number_outputnodes, learningrate = 0.001, epochs=3000):
    np.random.seed(8675309)
    bands = TrainData.shape[1]

    #We want to use one hot encoded classes in order to adjust the weights of an artificial neural network by apply
    OH_Encoded = np.zeros(shape=(TrainVal.shape[0], number_outputnodes)).astype(int)
    for index in range(TrainVal.shape[0]):
        OH_Encoded[index] = np.identity(number_outputnodes)[TrainVal[index].astype(int)].astype(int)

    #Initialize layer weights and bias. Keep in mind we want to take random values upon a normalized Gaussian distr
    relu_weights, relu_bias = np.random.rand(bands, number_hiddennodes), np.random.randn(number_hiddennodes)

    #Output layer: Softmax
    softmax_weights, softmax_bias = np.random.rand(number_hiddennodes, number_outputnodes), np.random.randn(number_out

    #Remember that epochs is just the naming sense of how many times we train a model for artificial neural network

    for iteration in range(epochs):
        #Perform forward propagation
        Weighted_bands = np.dot(TrainData, relu_weights)+relu_bias
        Relu_layer = relu(Weighted_bands, 0)
        Softmax_layer = softmax(np.dot(Relu_layer, softmax_weights)+softmax_bias)

        #Perform backpropagation
        softmax_weight_error = np.dot(Relu_layer.transpose(), Softmax_layer-OH_Encoded)
        softmax_bias_error = Softmax_layer-OH_Encoded
        Relu_layer_derivative = relu(Weighted_bands, 1)
        #Remember the derivative is the slope in stochastic
        relu_weight_error = np.dot(TrainData.transpose(), Relu_layer_derivative+np.dot(Softmax_layer-OH_Encoded, soft
        relu_bias_error = np.dot(Softmax_layer-OH_Encoded, softmax_weights.transpose())+Relu_layer_derivative

        #Adjust weights with error in relation to Training data. 0.001 is the standard learning rate for the layers
        relu_weights -= learningrate*relu_weight_error
        softmax_weights -= learningrate*softmax_weight_error
        relu_bias -= learningrate*relu_bias_error.sum(axis=0)
        softmax_bias -= learningrate*softmax_bias_error.sum(axis=0)
        return relu_weights, relu_bias, softmax_weights, softmax_bias

#Accuracy. This takes the weights obtained through a Neural Network and uses them to classify a set of testing data
def accuracy(weights, TestData, TestVal, TrainData, TrainVal):
    # Perform forward propagation for training set
    Relu_layer_train = relu(np.dot(TrainData, weights[0]) + weights[1], 0)
    Softmax_layer_train = softmax(np.dot(Relu_layer_train, weights[2]) + weights[3])

    # Perform forward propagation for testing set
    Relu_layer_test = relu(np.dot(TestData, weights[0]) + weights[1], 0)
    Softmax_layer_test = softmax(np.dot(Relu_layer_test, weights[2]) + weights[3])

    # Calculate accuracy
    correct = 0
    for i in range(TestVal.shape[0]):
        correct += np.argmax(Softmax_layer_test[i]) == np.argmax(TestVal[i])
    accuracy = correct / TestVal.shape[0]
```



culated using all of the nodes in the
5
possible pair of nodes from

Neural Networks: Drone Imagery Classification

$$2W_3 + \dots + x_n W_n = y$$

- Activation functions are used to modify the values of the nodes after they have been calculated
- For the hidden nodes, the rectified linear units function (ReLU) is used

$$f(x_i) = \begin{cases} x_i & \text{if } x_i < 0 \\ 0 & \text{if } x_i \geq 0 \end{cases}$$

- for the output nodes, the softmax function is used because $f(x_1) + f(x_2) + \dots + f(x_n) = 1$

$$f(x_i) = \frac{e^{x_i}}{e^{x_1} + e^{x_2} + \dots + e^{x_n}}$$

PCA Analysis

Goal

- Learn how Principal Components Analysis can be used
- Explore results of dimensionality reduction using PCA on RGB and NIR remote sensing data

Overview

- Acquire pixels of varying class from remote sensing data
- Plot original data
- Perform principal components analysis
 - Numpy for tensor manipulation
 - Eig function to find Eigen Vectors
- Compare Principal Components with original data
- Write report using overleaf / LaTeX

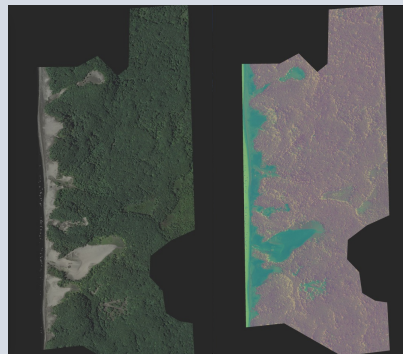
Technology

- Python, Jupyter
- Rasterio, Numpy, Pandas
- QGIS (Geographic Information System)
- Overleaf / LaTeX

Code

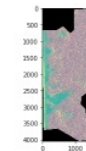
View code [here!](https://github.com/jackkrebsbach/principal-component-analysis)

<https://github.com/jackkrebsbach/principal-component-analysis>



```
In [8]: r = 0
g = 1
b = 2
PrincComp = Y
infile = outfile
outfile = './outPCA.tif'

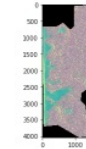
dispPCAIm.dispPCAIm(PrincComp,
                    '/Users/jackkrebsbach/.conda/e
NodataShadowWarning: The data
asks will be determined by th
out_image = raster.read(win
```



Covariance and Correlation matrix fo

Using the given modules we take the Pi

```
In [9]: infile = './outPCA.tif'
shapefile = './HopePreserveGMLby rasterio, rasterio, numpy
outfile = './outPCA.tif'
r = 0
g = 1
b = 2
no_data = 0
Z = dispCropIm.dispCropIm(infile, shapefile, r, g, b, no_da
```



Finding correlation co-variance matrices of the PCA output.

Figure 3: Cropped region of interest (left), Principle components false color image (right).

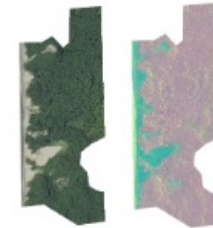
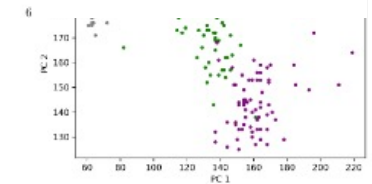
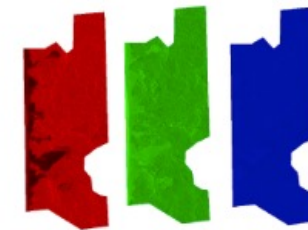


Figure 4: Principle Components separated as RGB (PC1 left, PC2 middle, PC3 right).



These plots compare the three categories (grey is sand, green is GCSD, and purple is IFC) using the two different variable systems. Both of these show 169 pixels in areas chosen to be representative of the image. Figure 5 shows them plotted using red and green as axes, Figure 6 shows them plotted using PC1 and PC2 as axes. The pixels in the principle component space do not separate them by class any better than in red and green space. In fact, the classes are not as clustered as tightly together.

4 Discussion

By the method of PCA, the first principle component is the most important for distinguishing data points, followed by the second, and so on. Because of this, we are only using the first two principle components in this analysis. Observing Figure 5 and 6 shows a comparison between standard Red-Green distinction and this new distinction using the first two principle components (PC1 and PC2). By observing the shape of these points selectively chosen to represent the data, we can observe how well each graph distinguishes between the colors.