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Satellite Data Analysis For Forest Detection

Progress Report

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1 Introduction

Large Area Landcover Mapping information is necessary for a large range of environmental applications related to climate mitigation and remediation. It can also be used to inform on value add processes, calibration, atmospheric correction, and data preparation. Satellite data can be used to distinguish treed areas from crops, grassland etc. which will allow forestry related measures of change detection to be applied to BC forests. How can we automatically distinguish forest areas from rest of the Landcover in a Sentinel-2 scene of BC hence determine which bands provides better accuracy? The system is designed for all satellite data but my focus data was from Sentinel2-L2A which consists of 2 satellites with multispectral imager. This sensor delivers 13 spectral bands, each of 10, 20 or 60 meters in pixel size. The goal of this project is to build a model that will be able to predict forest areas in a multispectral image captured by a satellite and determine what spectral features produce result with better accuracy.

2 Related Work

Many researchers have found good classification results using models like Convolution neural net, support vector machine, novel spectral spatial residual CNN to classify different satellite datasets. In The first paper(4)The research has put forward the deep learning model (CNN)for forest classification of satellite imagery with four major steps : defining forest class for Land Cover Classification, extracting optical image features using the forest class definition's contextual information, extracting image features from the Sentinel-2 satellite image, and classifying image object features using the CNN classifier The feasibility of the classification approach was assessed using overall accuracy. Based on CNN and Sentinel-2 satellite photos, this study developed a system for classifying forest types. The prominent index that was used as the measure of natu-ral space is the satellite-based Normalized Difference Vegeta-tion Index (NDVI). This index was calculated using the differ-ent wavelengths of light that were absorbed by vegetation

Increased temporal frequency of optical satellite data captures creates a data stream with the potential to improve land cover mapping, including tree species mapping. However, partial cloud cover and various image extents can be problematic for large-area operational mapping. As a result, strategies are needed to easily assimilate new images without requiring comprehensive spatial coverage for each new image. The methodology suggested in the paper(1) shows that Bayesian inference applied sequentially has the potential to solve this problem.A decision procedure based on an expression giving conditional probabilities of multiple classes given an observation is used to make maximum likelihood (ML) classification. With the assumption that observations were conditionally independent given a class, a decision procedure for performing an ML classification using multiple images was devised. Classification model accuracy was evaluated using leave-one-out cross-validation. The main measure of accuracy was overall accuracy, that is defined as the number of correctly classed elements divided by the total number of elements. There was no difference when using Level-1C and Level-2A data for classification

Sentinel-2 imagery makes multispectral imagery more available, enabling for improved glacier monitoring for climate change research, sea level rise, and human life. Nonetheless, due to considerations like as a complex environment, varied resolution bands, and noise or correlation in the spectral or spatial domain, automatic glacial categorization from Sentinel-2 is difficult. This research(2) proposes MSSUnet, an automatic glacier discrimination technique, was developed to solve a number of important research challenges. To begin, a spatial-spectral module is employed to adaptively learn the feature from multiple spectral bands and surrounding pixels, allowing for superior spatial-spectral feature learning and noise reduction. Second, to achieve fusion of multiple resolution bands in Sentinel-2 and decrease the interference of additional information, a band fusion method is used.

In this research(5), five supervised and a novel spectral spatial classification algorithms are evaluated and compared for generating residual convolution neural network LULC maps using two images from Sentinel-2. Sentinel 2 and Landsat 8.Sentinel-2 data with bands 2,3,4,8,11,12 and Landsat-8 data with image bands 1-7 are fed as training data to the 5 classifiers and then using then accuracy assessment is done using testing data from both sources and then LULC map is generated. The evaluations illustrate that the SVM algorithm yields higher overall accuracy compared to SVM, ANN, Maximum likelihood classification,Minimum distance and Mahalanobis algorithms.Also,Sentinel 2 date was slightly more accurate compared to Landsat. Test accuracies over the cross-validation repetitions are used to evaluate the generalization performance of the models.The steps invole‘ved in the accuracy comparison were: First, For SVM and ANN, algorithms were compared using optimal tuning settings. The non-parametric SVM technique delivers the best classification for both satellite datasets, as measured by overall accuracy and Kappa coefficient. However, as compared to the Landsat 8 OLI sensor, Sentinel 2 had a somewhat superior accuracy. The effect of input data on the end results is confirmed by comparison to other algorithms. Secondly, The influence of tweaking parameters on SVM and ANN classifiers was the focus of this research. The linear kernel provided the best output for both Sentinel 2 and Landsat 8, according to SVM results. Sentinel 2 and Landsat were given penalty parameters of 150 and 200, respectively. A radial kernel with the penalty parameter 100 had the lowest classification accuracy for Sentinel 2 pictures, whereas a sigmoid kernel with the penalty parameter 100 had the lowest classification accuracy for Landsat 8. In map classification, accuracy of each algorithm was calculated. The research revealed that with the right tuning settings, all algorithms can accurately distinguish the water body. Following that, in detecting the irrigated land class, the MLC method performed best for Sentinel 2 data, while SVM performed best for Landsat 8 data.

In this research(3), For six Sentinel-2 tiles, a tree map was built using unsupervised classification. Thematic accuracy was examined for two of the six tiles based on the agreement between the tree map and the relevant national forest inventory as a function of the band combination chosen. The results suggest that bands 2, 3, 6, and 12 have the best agreement with the current tree map and the national forest inventory. When compared to prior estimates with other methodologies, the current tree map has a relative difference in tree cover of between 8 percent and 79 percent which highly scattered result. The overall thematic correctness of the current map is up to 90 percent, with user accuracy ranging from 34.85 percent to 92.10 percent and producer accuracy ranging from 23.80 percent to 97.60 percent for the various thematic classes.

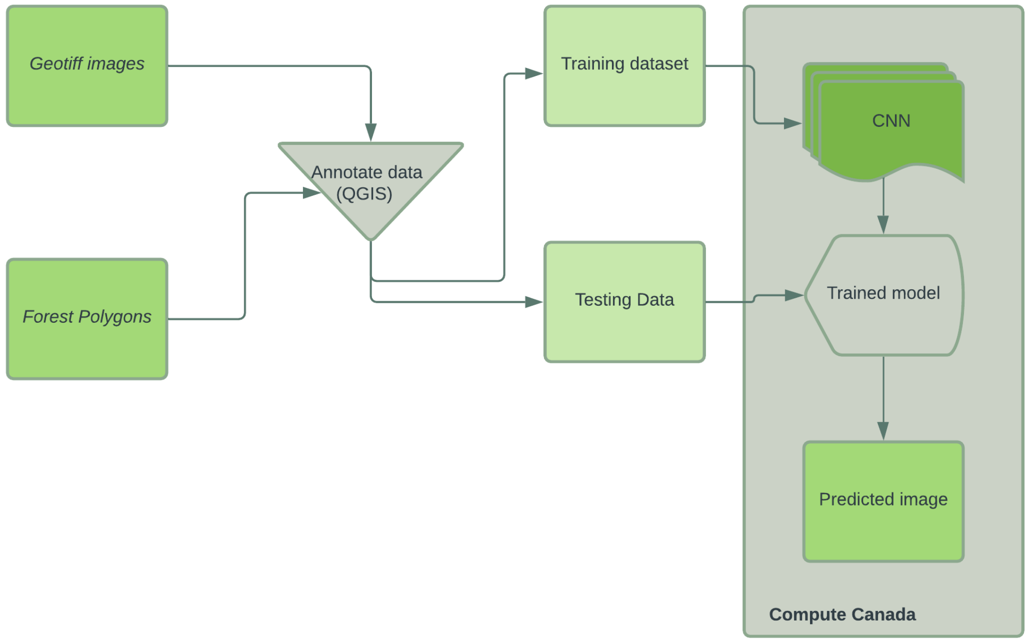

Figure 1: System Design

3 Methodology

3.0.1 Data Retrieval

I retrieved geotiff data from Sentinel hub and forest polygons from open data by government of Canada.Sentinel hub provide an open access to the data obtained through Sentinel-2 on any given duration with a choice to choose percentage of cloud coverage and bands on the data.

3.1 Data Pre-Processing

Figure(1) shows the flowchart of the system design of this project.I used QGIS to annotate the forest regions using the polygons obtained on the geotiff images. The were over 2000 annotated images which was split into training and testing datasets with 70:30 ratio.

3.1.1 Model Training

I used VGG19 and Dense model with The loss function as categorical cross entropy and optimizer as adaDelta. The training dataset was fed into the model to train for 240 epochs with learning rate of 0.001. I used the storage and gpu resources from compute canada to obtain the results.

3.1.2 Inference/Evaluation

The training dataset is used to train the neural net and then the inference is run with the test data and the predicted Output is compared with ground truth of the test data. The accuracy was computed using the testing data and it's analysis is discussed in the following section.

4 Result and Analysis

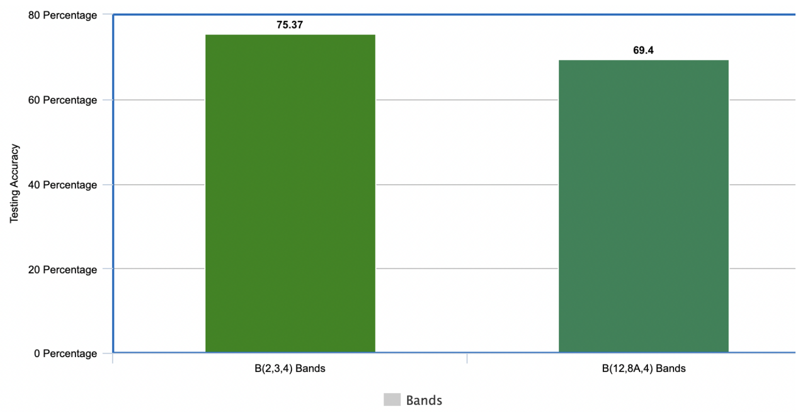

Figure 2: Accuracy vs Band Combinations

4.1 Accuracy of CNN model with Combination of Sentinel-2 bands

The model was tested with Sentinel-2 images with band combinations 2,3,4 and 12,4,8A, as plotted in the Figure2, bar graph, the testing accuracy produced using the band combinations 2,3,4 is 75.37 percent and with the band combinations 12,4,8A it's 69.4 percent.

4.2 Model Accuracy

The model was trained for 240epochs with learning rate of 10^{-3}.

Accuracy was computed using Confusion Matrix.

$$Accuracy = \frac{TP + TN}{P + N} \tag{1}$$

P -> Total number of positives in the dataset

N -> Total number of negatives in the dataset

TP -> True Positives (Model correctly predicts the output class)

FP -> False Positives (Model doesn't predict the correct output class)

Figure(3) shows the Loss computed over 200 epochs and Figure(4) shows the accuracy computed over 200 epochs. The accuracy increases from below 10 percent to 75.37 percent over 200 epochs and the loss reduces as the model gets trained by the dataset as shown in the graphs below.

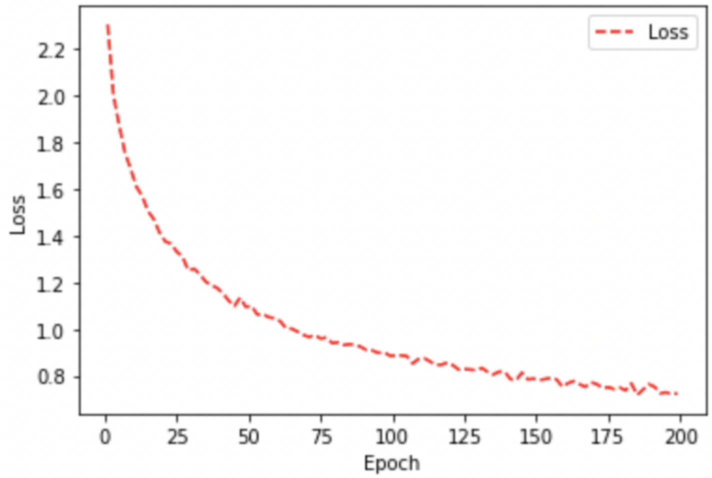

Figure 3: Loss vs Epoch

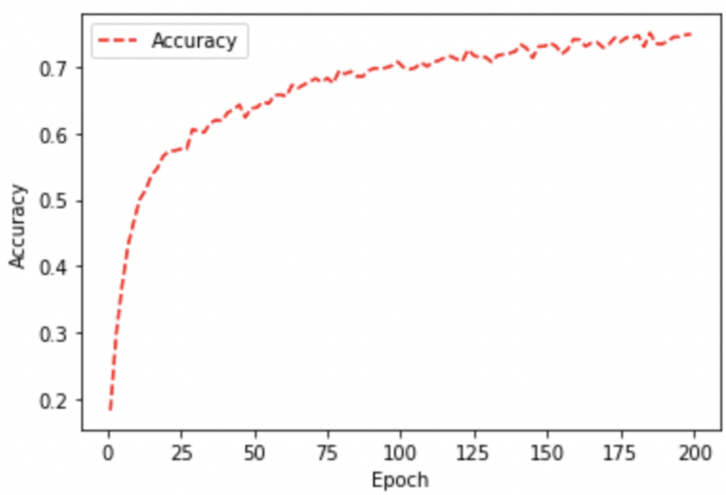

Figure 4: Accuracy vs Epoch

4.3 Predicted Output

4.3.1 CNN

Convolution neural net is a deep learning supervised model that is mainly used for image classification. I have used Dense model, VGG19.Figure(5) shows predicted output where the regions in blue are predicted forest class.This was for the band combination of 2,3 and 4 with the neutralized background.

Figure 5: CNN Output of BC Clip

4.3.2 K-Means

K-means, also known as clusterization, is an unsupervised classification algorithm that divides objects into k groups based on their characteristics. The sum of the distances between each item and the group or cluster centroid is minimised during grouping.Figure(6) shows the predicted output where the regions in green are predicted forest clusters.

Figure 6: K-Means Output of BC Clip

5 Future Work

The next task will be to to pre-process and train the CNN model with geotiff images of different band combinations and compare their testing accuracies. To use these images and train other supervised models like R-CNN and determine which model produces better results. To process Mosaic, which a multispectral RD product that is built from hundreds of Sentinel-2 scenes and train the CNN model to predict forest regions in it.

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