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Drone Assisted Forest Structural Classification of Kejimkujik National Park using Deep Learning

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Abstract

The wide array of terrestrial forest and wooded lands is one of the richest sources of biodiversity because of inherent structural diversity. Structure plays a significant role in a diversity indicator of a forest. We propose a transfer learning framework consisting of the ResNet-50 architecture for which we obtained a test accuracy of 75.86%. Analysis of structural diversity of the Kejimkujik National Park was done with the help of a drone using deep learning methods that predict the structural class of the forest. We used a novel forest structural diversity dataset collected using DJI Mavic drone to train the deep learning model.

Introduction

- Kejimkujik National Park is located in Nova Scotia within the Annapolis, Queens, and Digby counties and covers 404 square kilometers. Trees in this park include black and red spruce, white pine, speckled alder, eastern hemlock, balsam fir, red oak, and red maple[1].
- This park is classified as having a humid continental climate with four distinct seasons.The vegetation can be heterogeneous, both in terms of species composition and structure.
- Our aim is to assess patterns of vegetation structure in Kejimkujik National Park.
- Traditional field work involves sampling tree height and the cover of plant functional groups such as bryophytes, lichens and litter.
- Through this paper, we got to know that with the help of drones, we are able to take images that can be used to assess forest structure and compare the results with field data collected manually; drone imagery can be more efficient and eliminate the need for human interference.

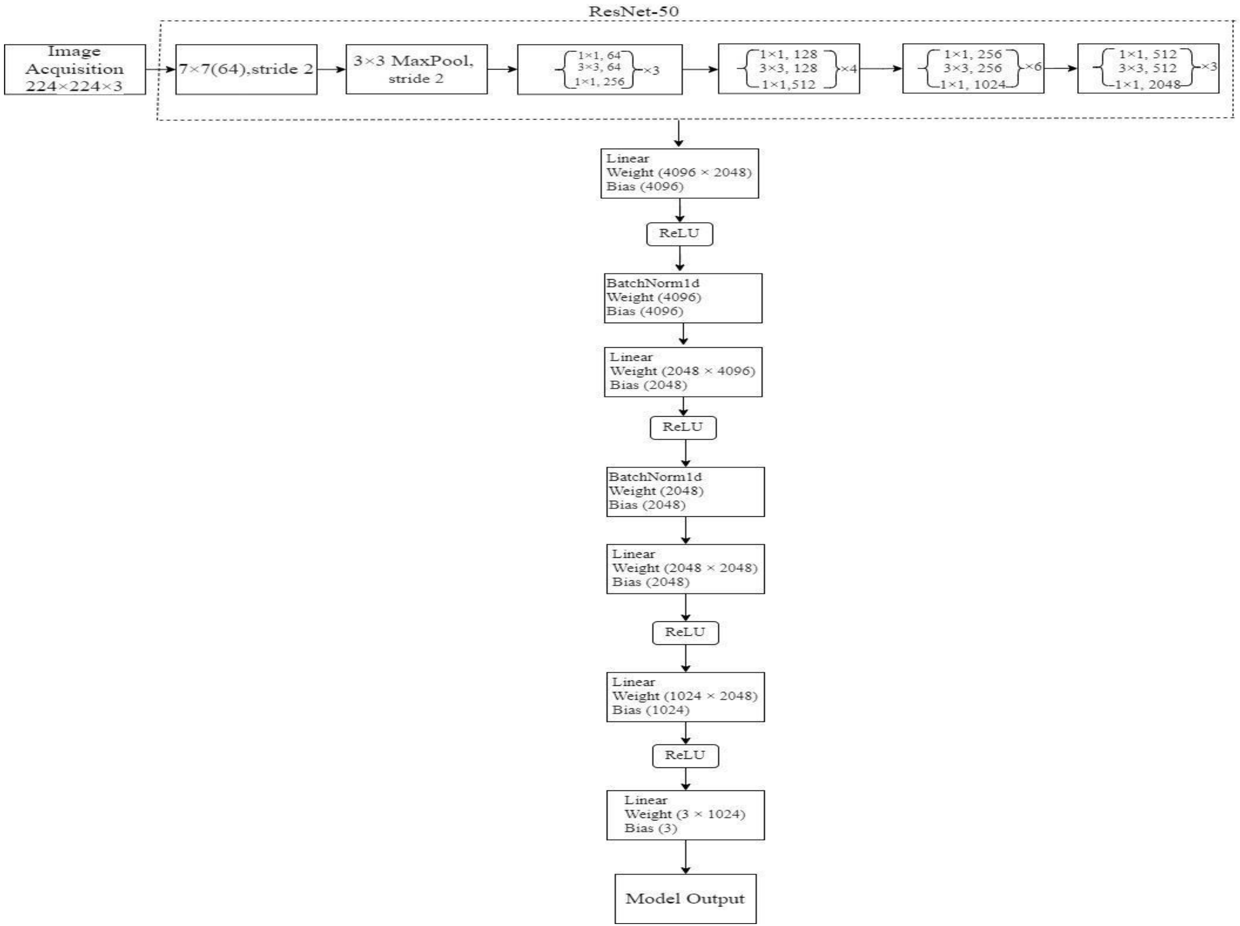
Problem Statement

- An efficient deep learning model to assess patterns of vegetation structure in Kejimkujik National Park.
- Classification of forest structure into three categories.

Existing Solutions

- Earlier methods used to detect the change in structural diversity of a forest can be classified into two categories.
- The first one is a low-level feature-based method that uses multispectral images and perform a pixel-wise contrast comparison to detect changes in the temporal sequence of images.
- This method also uses landsat time-series using statistical base indices approaches, such as a vegetation index, spectral mixture analysis, and vector analysis to predict the structural diversity of a forest[6].
- The second one is an object-based method, which incorporates contextual knowledge by processing spatial and appearance homogeneous pixels together.
- This approach performs better than the first method, using unsupervised machine learning techniques via segmentation to obtain pixel clusters that overcome spatial and spectral variations due to noise or geo-referencing[7].

Proposed Work



Proposed Work

The pre-trained backbone shown in Fig 3. We employ the ResNet 50 architecture and add 5 fully connected layers on top of it. We found this architecture to be optimal for all our experiments while simultaneously not being too bulky and hence preventing overfitting on the dataset. During data pre-processing, we assigned 294 images into 3 preliminary classes: low structure (75 images), mixed structure (111 images) and tall structure (108 images), out of which 235 images were used for training and 59 for testing. We applied horizontal flipping and magnification for data augmentation during data pre-processing[11].

Implementation Details

Pre-Processing-We resize the input images from their original dimesions of 5472x3648 to 224x224 for it to satisfy the model input criterion (i.e, ResNet 50). We further normalize and perform some augmentation on these images to reduce the effect of noisy images on the model.

Architecture-We add 5 fully connected layers on top of the pre-trained ResNet 50 architecture. This helps us extract learnable features from our dataset. To ensure that our model does not overfit on the dataset, we also add a couple of regularizers such as Batch Normalization to ensure a stable training process.

Experimental Setup-We perform all our experiments using the PyTorch framework. We kept a batch size of 64 for all our experiments, employ the adam optimizer, keep a constant learning rate of 1e-4 and train our model for 15 epochs.

Results and Discussions

TABLE I

SUMMARY OF THE PERFORMANCE OF MODELS ON THE DATASET OF A FORESTED WETLAND LANDSCAPE IN SOUTHWESTERN NOVA SCOTIA ON WHICH THE MODELS WERE PRE-TRAINED AND USED FOR TRANSFER LEARNING.

Model	Train Accuracy	Test Accuracy	Parameters(in Millions.)
ResNet-50	82.64%	75.86%	23.00
ResNet-101	80.64%	70.00%	44.50
ResNet-152	57.87%	51.56%	60.00

The results obtained using various models shown in Table 1. We compare across a variety of factors: the accuracy obtained, the computational cost involved and the pros and cons for each of these models. We also set the corresponding benchmark on the KejimKujik National Park Dataset.

Conclusion and Future Scope

- With continuous improvement and development in the field of technology, we can improve the prediction of structural diversity with the help of a two-stream deep learning models that works continuously on the RGB (3 channel) data and depth (1 channel).
- We can also use a Nvidia Jetson Nano developer board that can be mounted on the drone and act as an Edge AI Device the entire deep learning model can be compressed and embedded onto the board.
- This will add a state of the art real time forest structure prediction feature to the module.
- For larger area, we can calibrate other drones to accompany similar drones, which can help in faster and more efficient forest structural diversity prediction both for real time prediction as well as for collecting a larger amount of image data for dataset building in a very short span of time.

Conclusion and Future Scope

- Communication between these drones can be done with the help of drone compatible software ArduPilot and its compatible boards that can act as a flight controller.
- The required image data would be collected using high-definition cameras embedded in the drones and would be controlled through a cluster of networks.
- In the base station, we would have a single PAN coordinator and a cluster of different drones acting as FFD (full function devices) routers, which would further relay information to RFDs (reduced function devices) like sensors, controllers and activators[17].

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Thank You,

Any Questions