A Convolution Neural Network for Plant Species Identification

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Overview of the presentation

- Introduction
- Existing Research/Solution
- Experiments, Solution and Results
- Summary & Next Step

Introduction

- Project Goal : Machine Learning Model for Plant Species Identification based on the leaves, with target accuracy scores of > 96.8% within the top 5 results (top 5 error rate < 3.2%)
- Inspired by Greenstand (https://github.com/Greenstand)
- Dataset used for training & validation :
  - Leafsnap Dataset (https://www.kaggle.com/datasets/xhlulu/leafsnap-dataset/data)
  - Created by computer scientists from Columbia University and the University of Maryland, and botanists from the Smithsonian Institution in Washington, DC

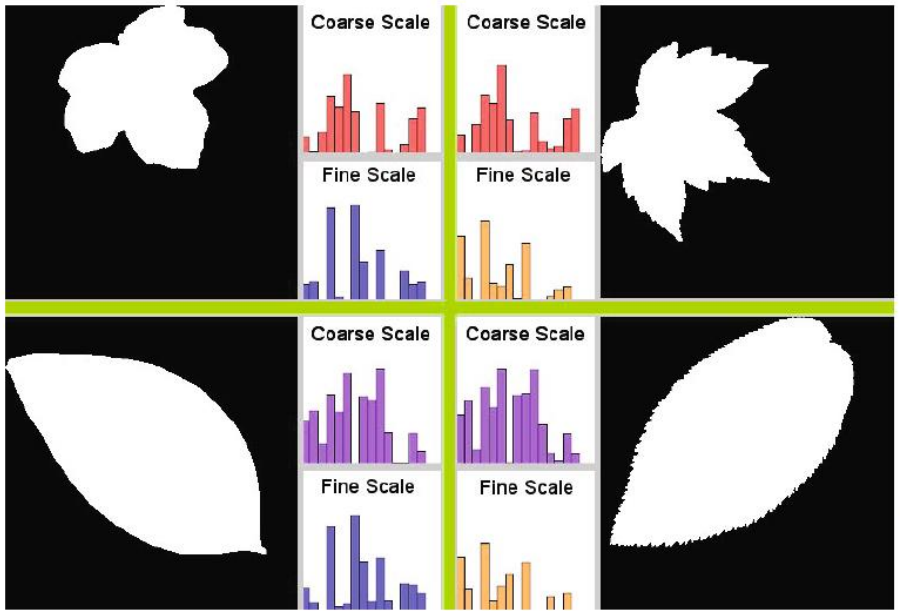
Overview of the Dataset

- Covers all 185 tree species from the Northeastern United States
- Images of leaves taken from two sources
  - “Lab” images – consisting of high-quality image taken of pressed leaves (Total of 23915 images)
  - “Field” images – lower-quality images taken in the field environment using mobile devices in the outdoor setting (Total of 5192 images)

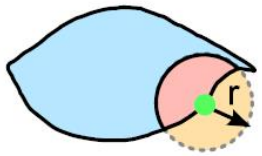
Existing Research / Solution

- The recognition process developed by the Leafsnap research team utilize a four-step process:
  - Step 1 – Classifying whether the image is of a valid leaf
  - Step 2 – Segmenting the image to obtain a binary image separating the leaf from the background
  - Step 3 – Compute the feature vector from the binarized image using histograms of curvature over multiple scales with integral measures of curvature
  - Step 4 – Comparing the feature vector with labeled database using nearest neighbor with histogram intersection as the distance metric
- Overall processing time = 5 seconds

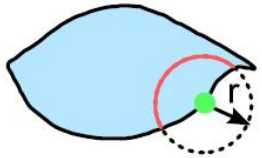
Existing Research / Solution



(a)

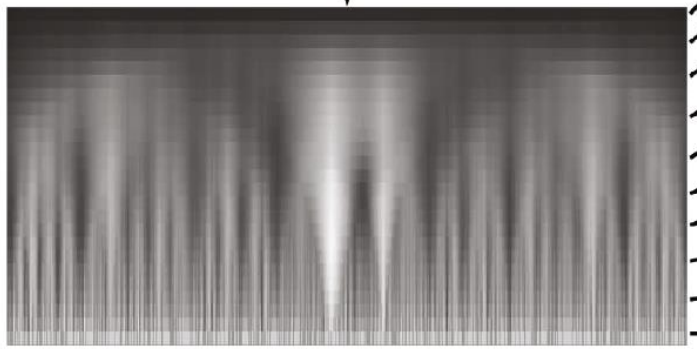


(b)

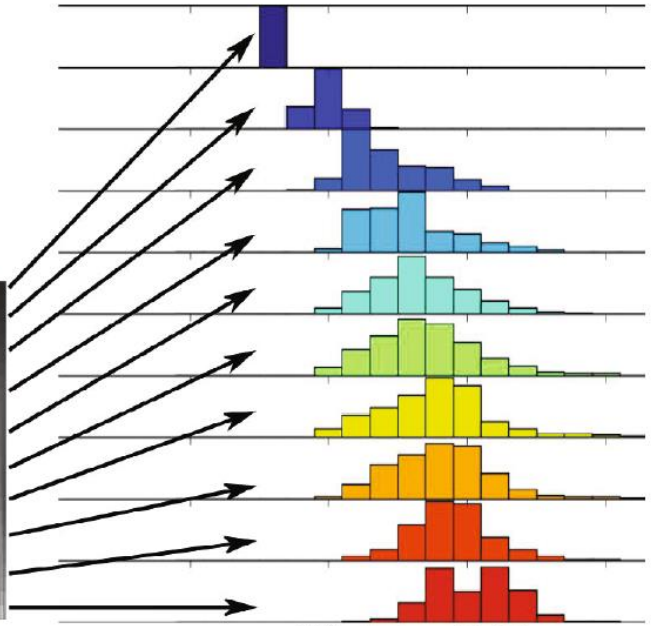


(c)

(d) Segmented Leaf



(e) Curvature Image



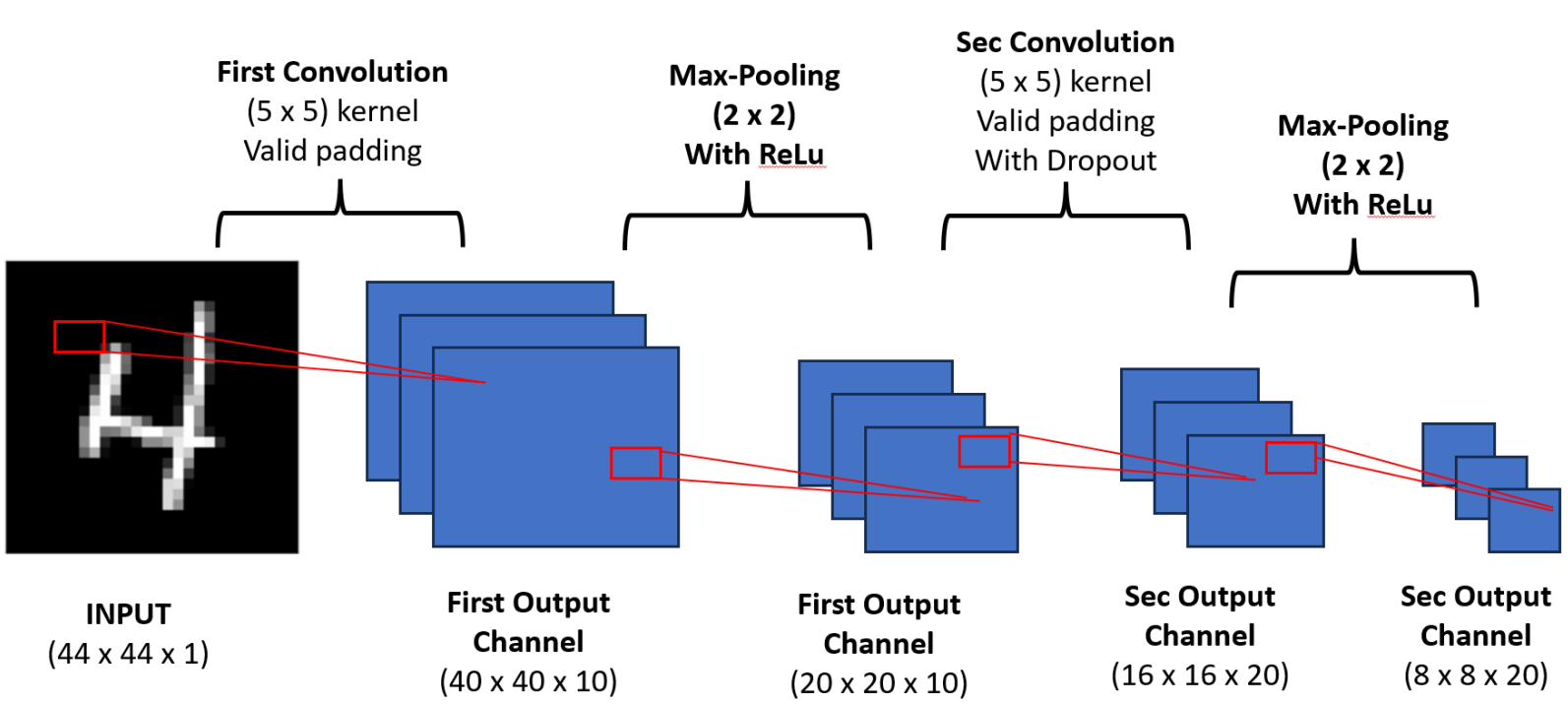
(f) HoCS

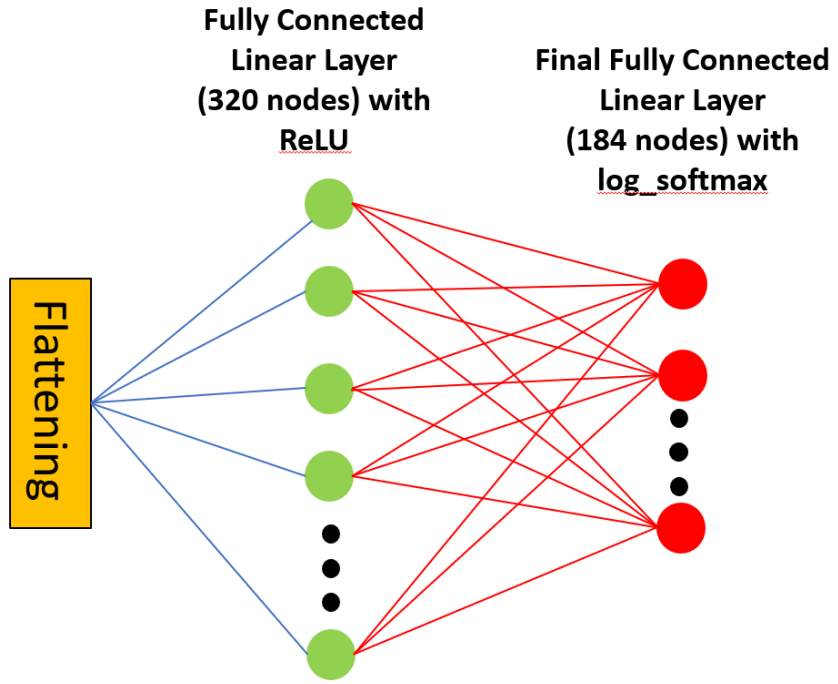
Images taken from Leafsnap: A Computer Vision System for Automatic Plant Species Identification

Experiments

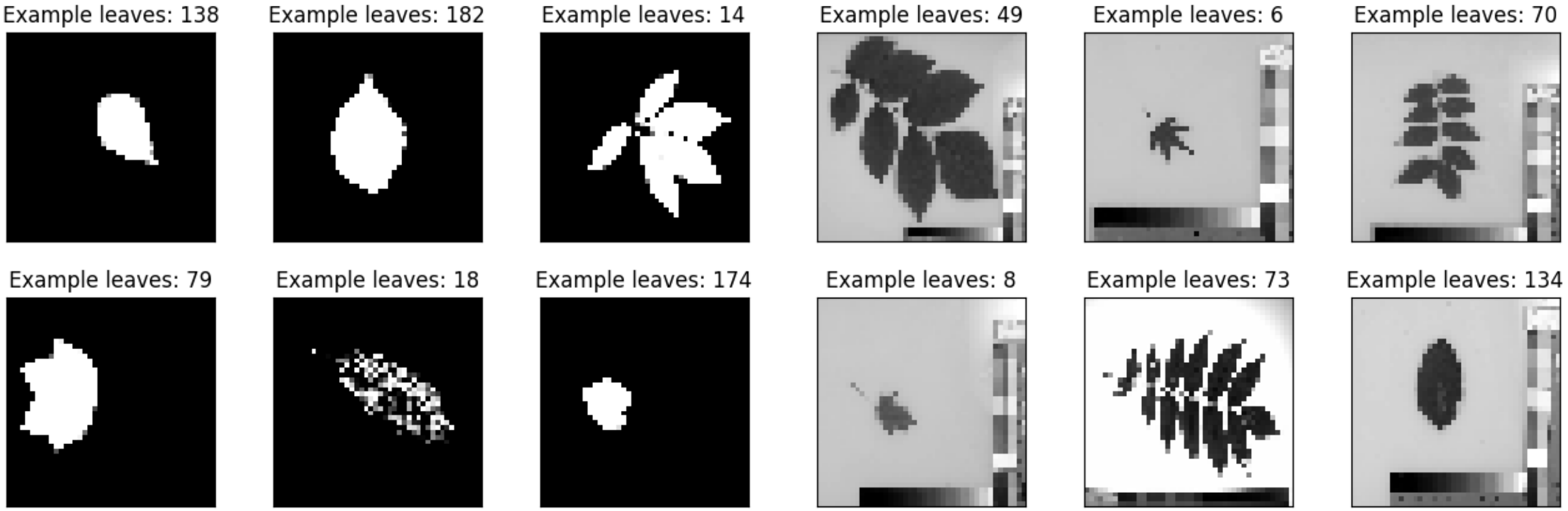
Model	Dataset	Results		
		Top1	***Top5***	***No epoch***
2CNN	Segmented Field			
2CNN	Original Lab			
2CNN	Original Lab + Field			
2CNN(Large)	Original Lab + Field			
2CNN(RGB)	Original Lab + Field			
3CNN	Original Lab + Field			
Resnet-50	Original Lab + Field			
Resnet-50	Original Lab + Field + Non Leaf			

Experiments (2CNN architecture)





Experiments – Datasets used for Training

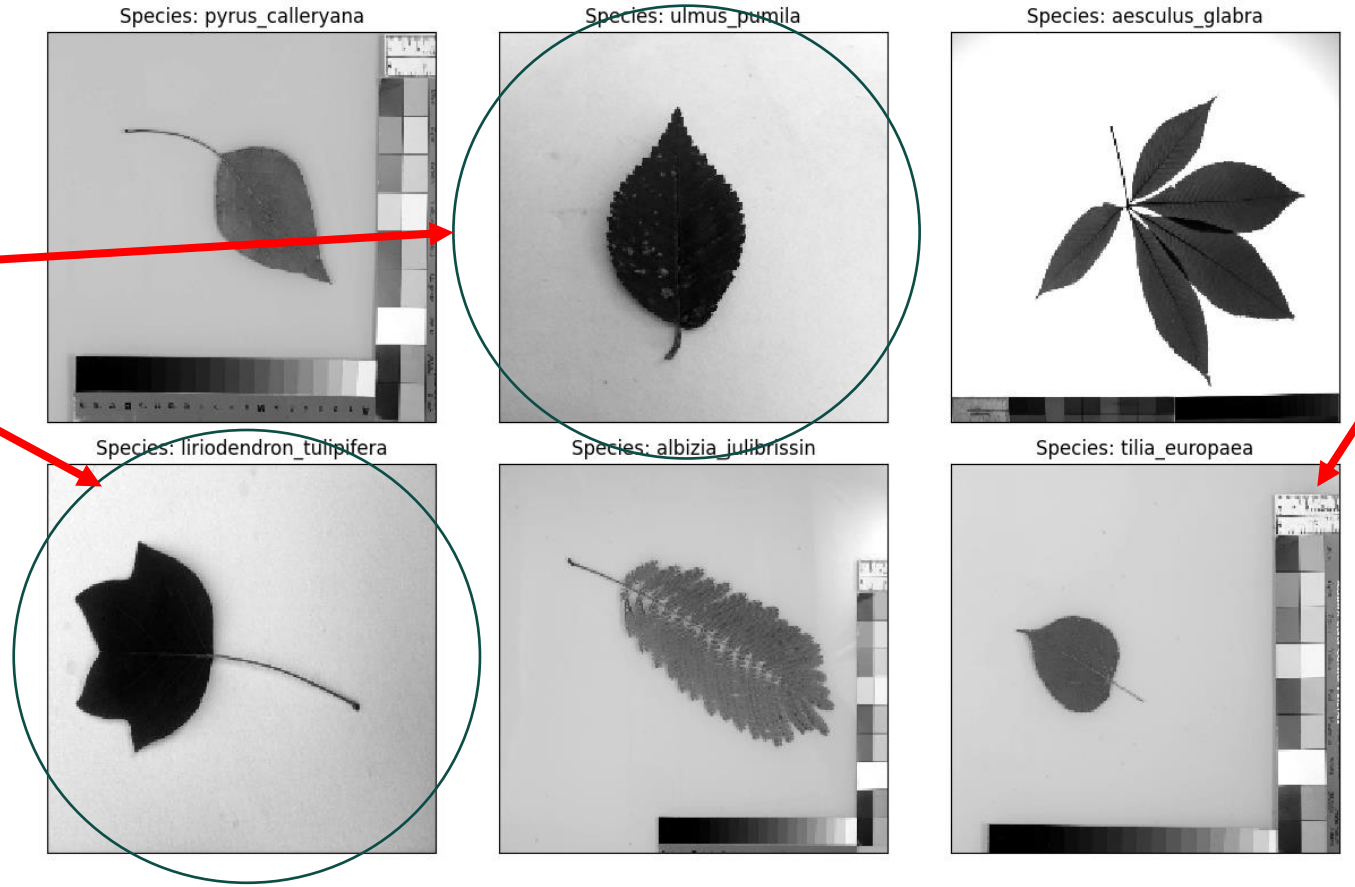


Segmented Images

Original Images converted to grayscale

Experiments – Datasets used for Training

Field Images
Total 5192

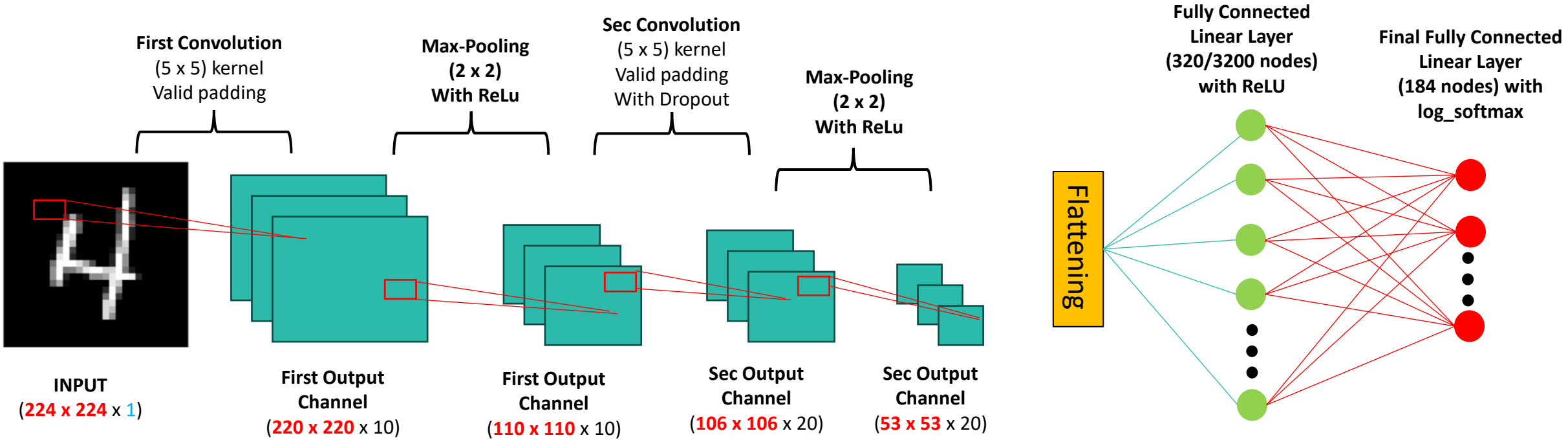


Lab Images
Total 23915
Mostly have the sidebar to help with segmentation

Experiments

Model	Dataset	Results		
		Top1	***Top5***	***No epoch***
2CNN	Segmented Field	37.82%	68.33%	N/A
2CNN	Original Lab	77.62%	97.75%	60
2CNN	Original Lab + Field	68.53%	91.25%	N/A
2CNN(Large)	Original Lab + Field			
2CNN(RGB)	Original Lab + Field			
3CNN	Original Lab + Field			
Resnet-50	Original Lab + Field			
Resnet-50	Original Lab + Field + Non Leaf			

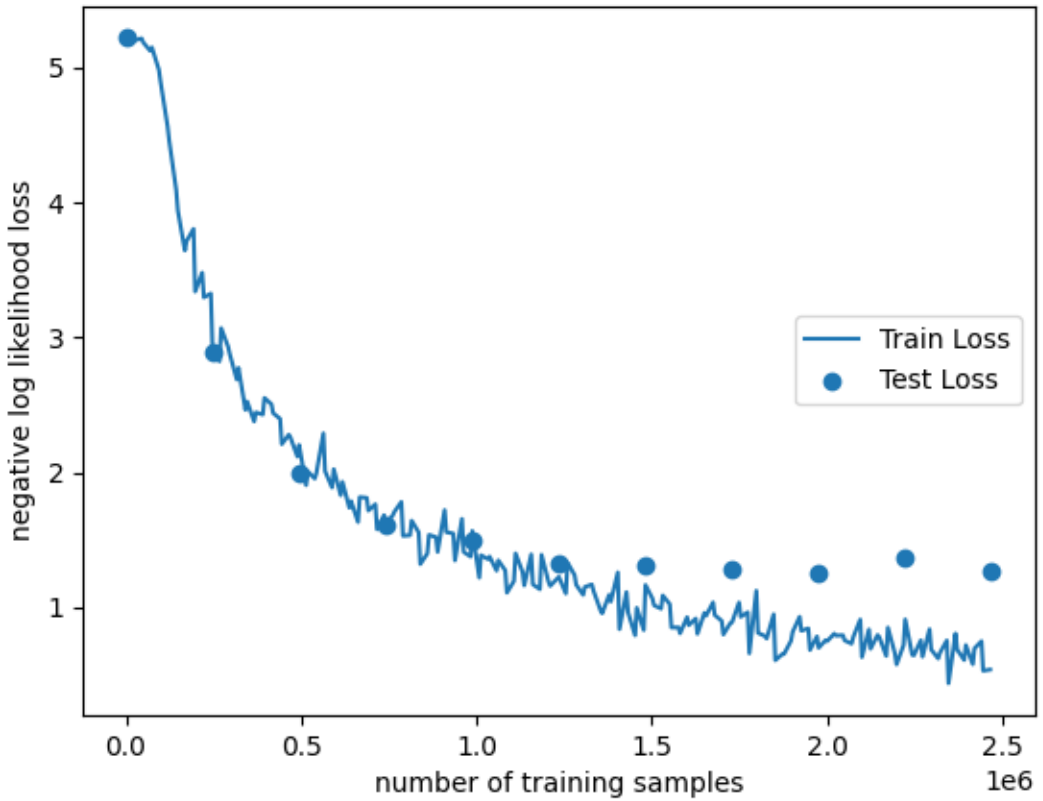
Experiments (2CNN architecture)

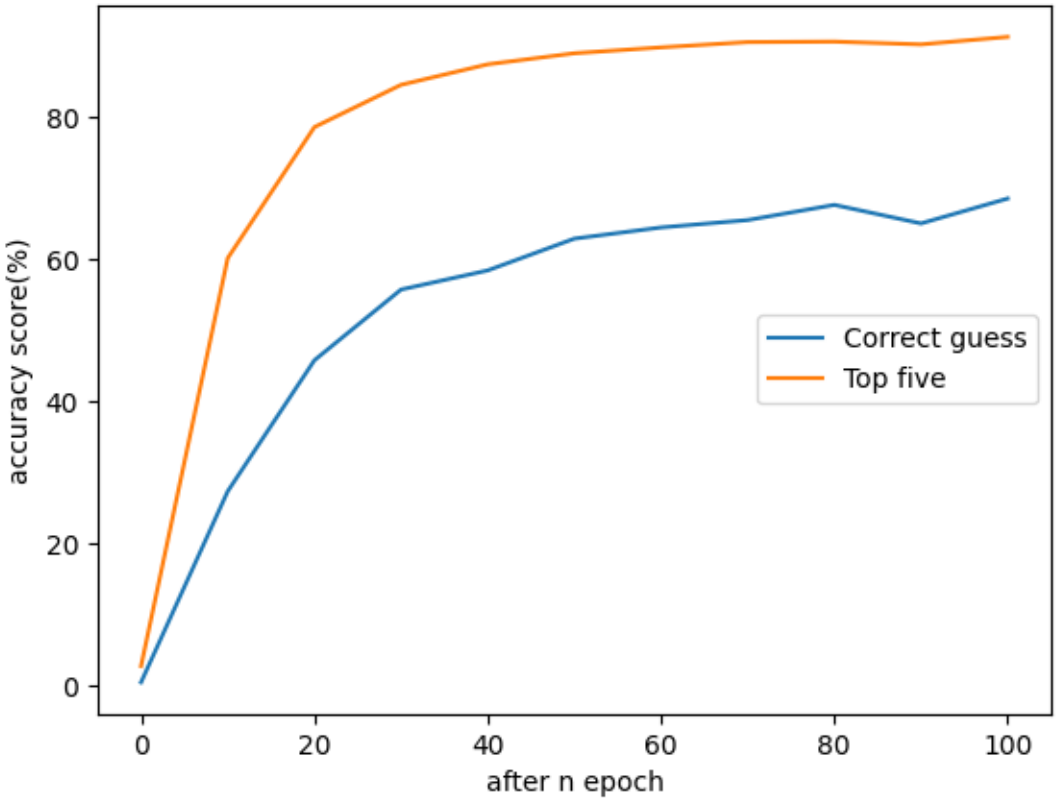


Going wider – change input size into the model from 44 x 44 to 224 x 224

Going deeper – change the input depth from 1 (grayscale) to 3 (RGB)

Experiments (2CNN architecture)

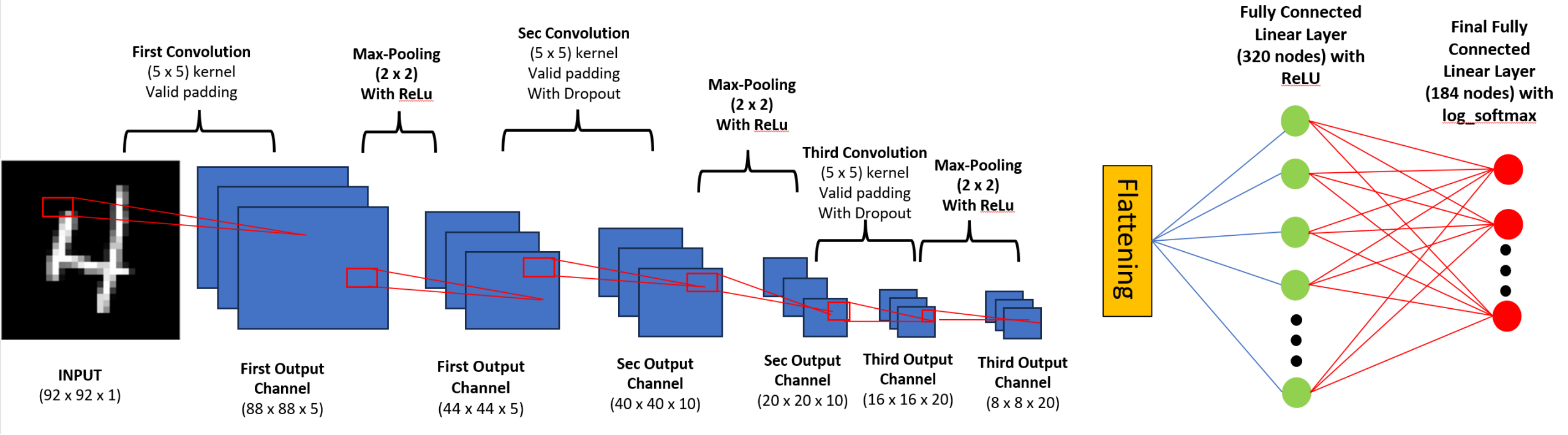




Experiments Result

Model	Dataset	Results		
		Top1	***Top5***	***No epoch***
2CNN	Segmented Field	37.82%	68.33%	N/A
2CNN	Original Lab	77.62%	97.75%	60
2CNN	Original Lab + Field	**68.53%**	**91.25%**	**N/A**
2CNN(Large)	Original Lab + Field	**70.10%**	**89.39%**	**N/A**
2CNN(RGB)	Original Lab + Field	**70.96%**	**92.86%**	**N/A**
3CNN	Original Lab + Field			
Resnet-50	Original Lab + Field			
Resnet-50	Original Lab + Field + Non Leaf			

Experiments (3CNN architecture)



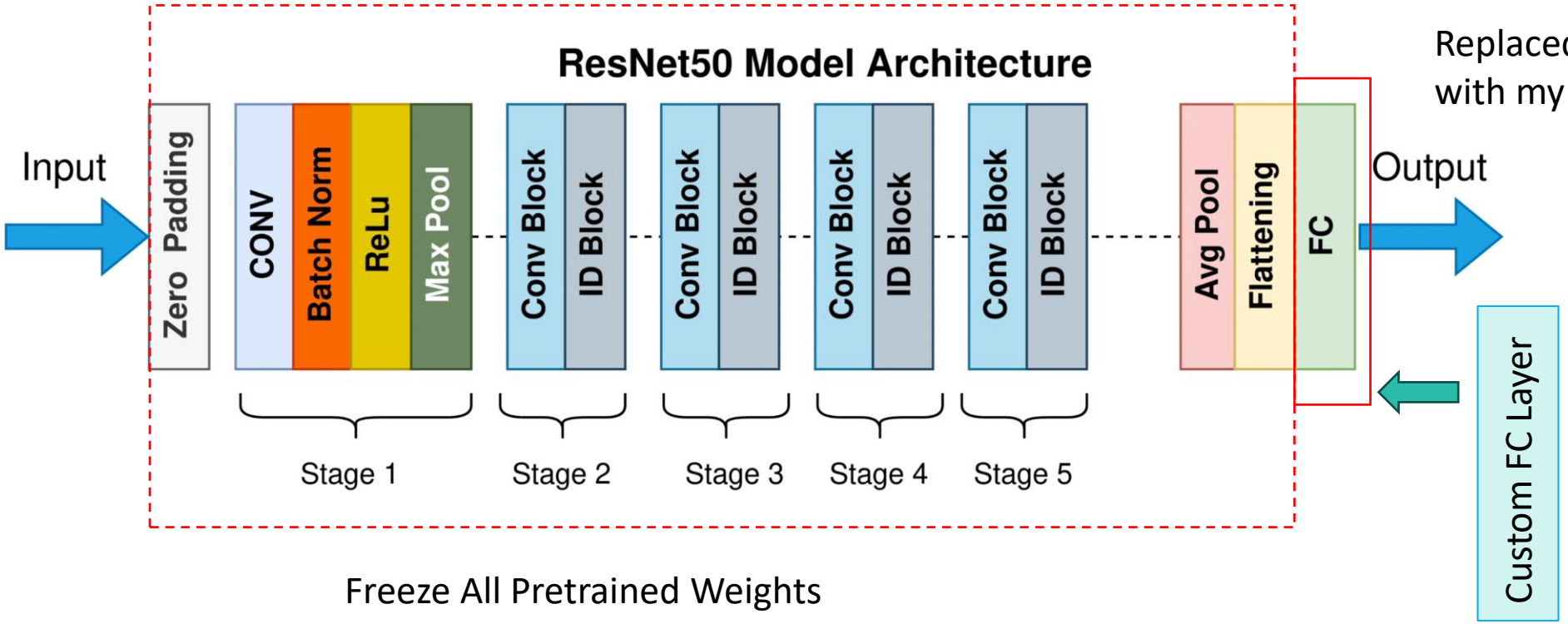
Note the number of output node is the same as 2CNN

Experiments Result

Model	Dataset	Results		
		Top1	***Top5***	***No epoch***
2CNN	Segmented Field	37.82%	68.33%	N/A
2CNN	Original Lab	77.62%	97.75%	60
2CNN	Original Lab + Field	**68.53%**	**91.25%**	**N/A**
2CNN(Large)	Original Lab + Field	70.10%	89.39%	N/A
2CNN(RGB)	Original Lab + Field	70.96%	92.86%	N/A
3CNN	Original Lab + Field	**71.91%**	**92.48%**	**N/A**
Resnet-50	Original Lab + Field			
Resnet-50	Original Lab + Field + Non Leaf			

Average prediction time for Resnet-50 model = 0.03s

Experiments (ResNet50)



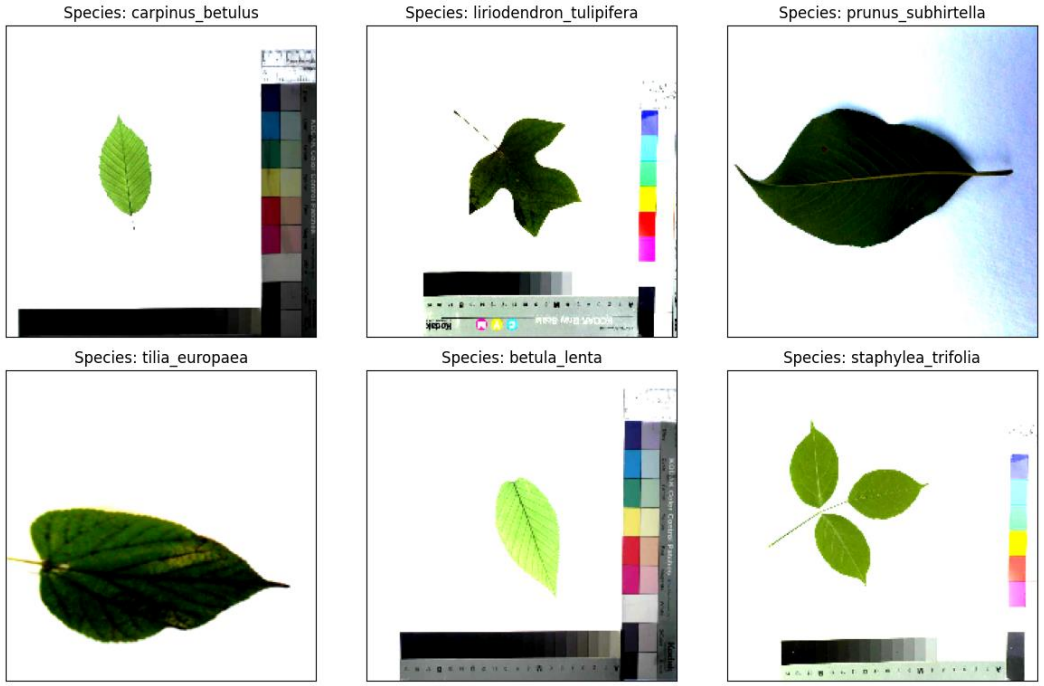
Replaced the last FC layer with my own FC layer

Custom FC Layer

Freeze All Pretrained Weights

Resnet50 architecture reference from Mukherjee, S. (2022, August 18). The annotated resnet-50. Medium. https://towardsdatascience.com/the-annotated-resnet-50-a6c536034758

Example Data for Resnet50



Original Images
(mixed of field and lab)

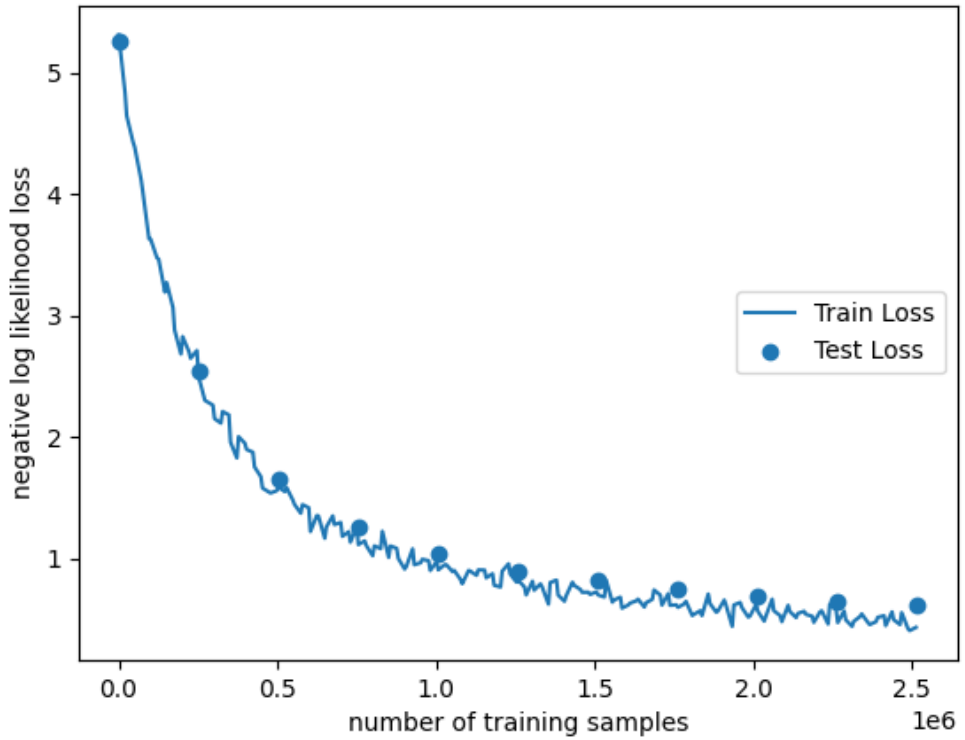
Images Used for Leaf / Non-leaf classification

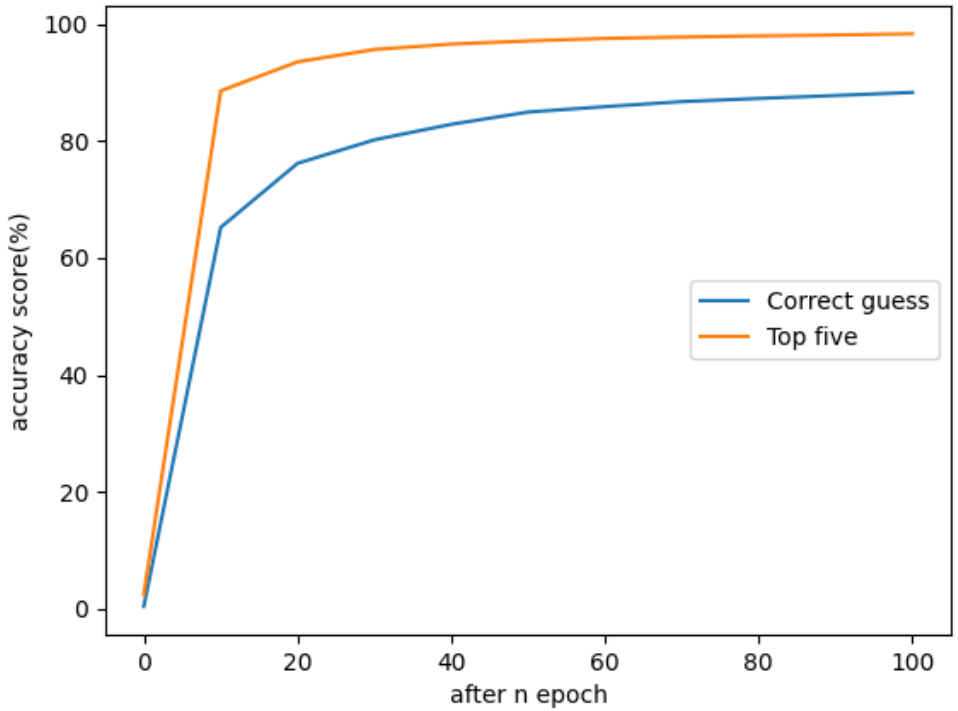
Experiments Result

Model	Dataset	Results after 100 epochs		
		Top1	*Top5*	*No epoch*
2CNN	Segmented Field	37.82%	68.33%	N/A
2CNN	Original Lab	77.62%	97.75%	60
2CNN	Original Lab + Field	**68.53%**	**91.25%**	**N/A**
2CNN(Large)	Original Lab + Field	70.10%	89.39%	N/A
2CNN(RGB)	Original Lab + Field	70.96%	92.86%	N/A
3CNN	Original Lab + Field	71.91%	92.48%	N/A
Resnet-50	Original Lab + Field	**87.64%**	**98.10%**	**50**
Resnet-50	Original Lab + Field + Non Leaf	**88.29%**	**98.32%**	**50**

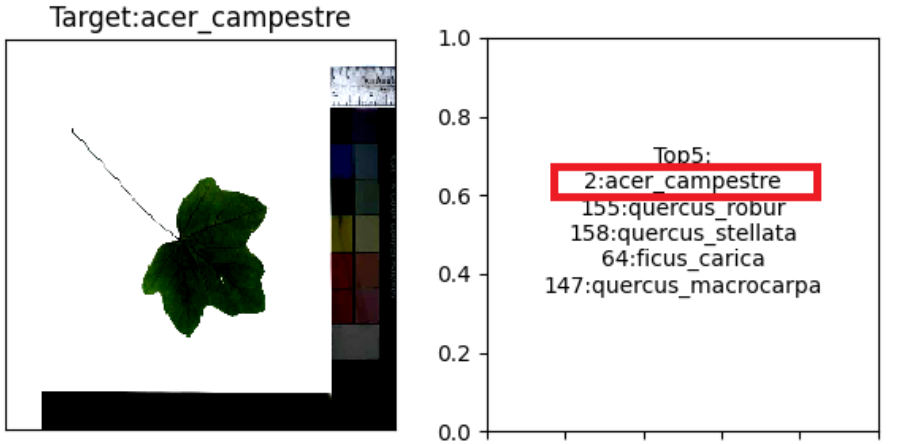
Average prediction time for Resnet-50 model = 0.03s

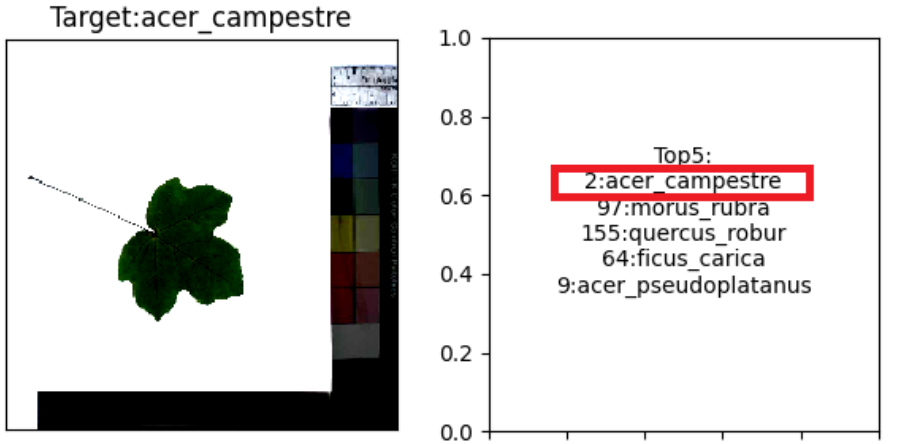
Resnet50: Losses curve & accuracies graph

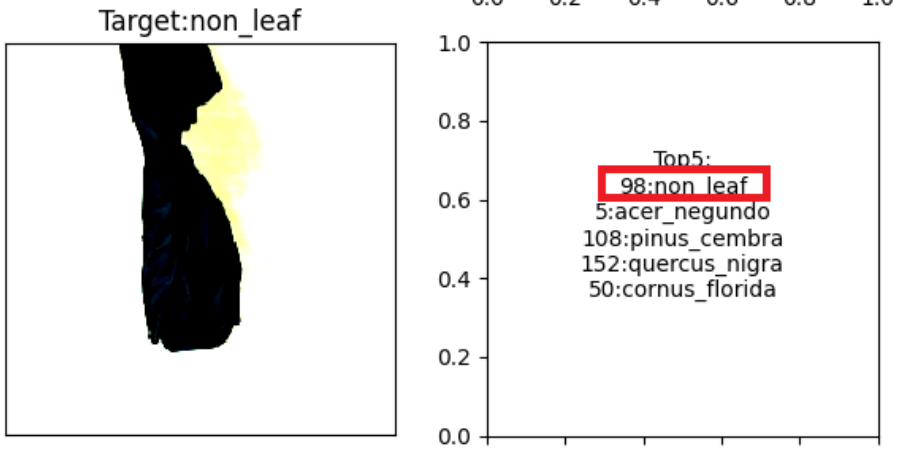


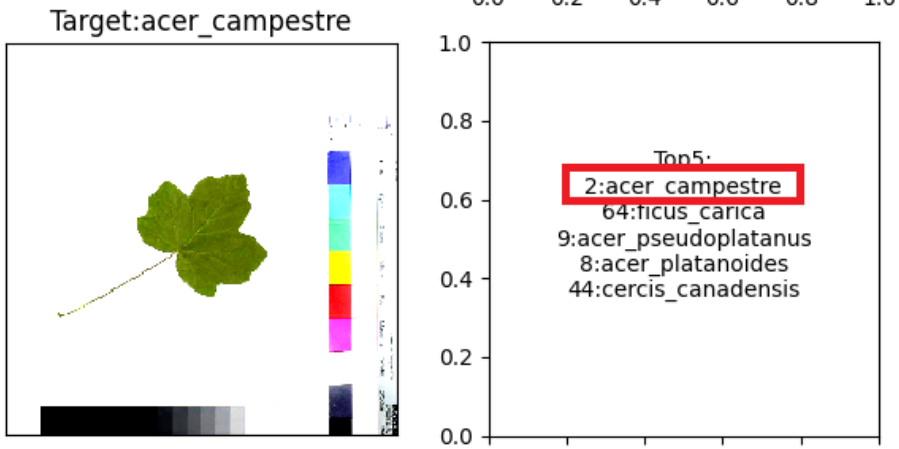


Testing Results









Conclusion & Next Step

- Machine Learning Model based on Resnet50 is
  - **Simpler** – combining four steps process of Leafsnap into one and let the model learned itself how to validate for leaves and segmented the images
  - **More accurate** – top5 accuracy score achieved is 98.32% (Leafsnap – 96.8%) with potential to get better with more training epochs
  - **Potentially faster** – average evaluation time on cuda is 0.03s per image (Leafsnap – about 5s on cpu)
- Next Step:
  - Build a backend to enable query based on the images and return the top 5 results with example image
  - Build a mobile app to test it out on the field