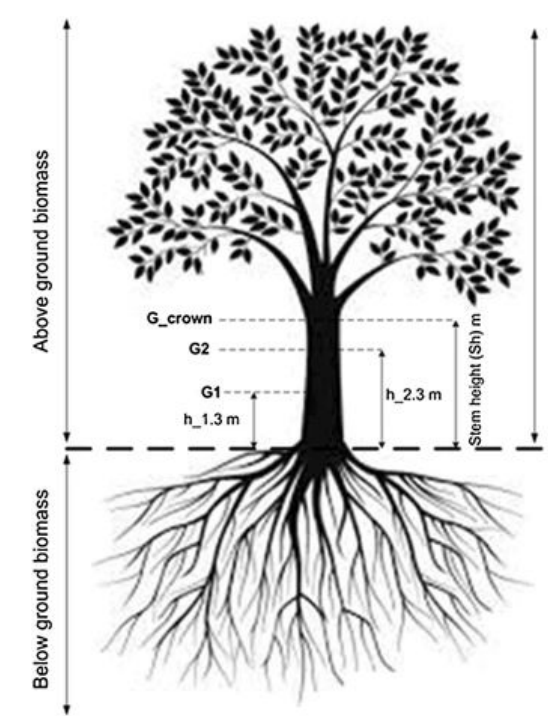


Transfer learning models for tree species detection in agroforestry

Erich Trieschman | CS231N 2022Q2

Background, motivation, and outline

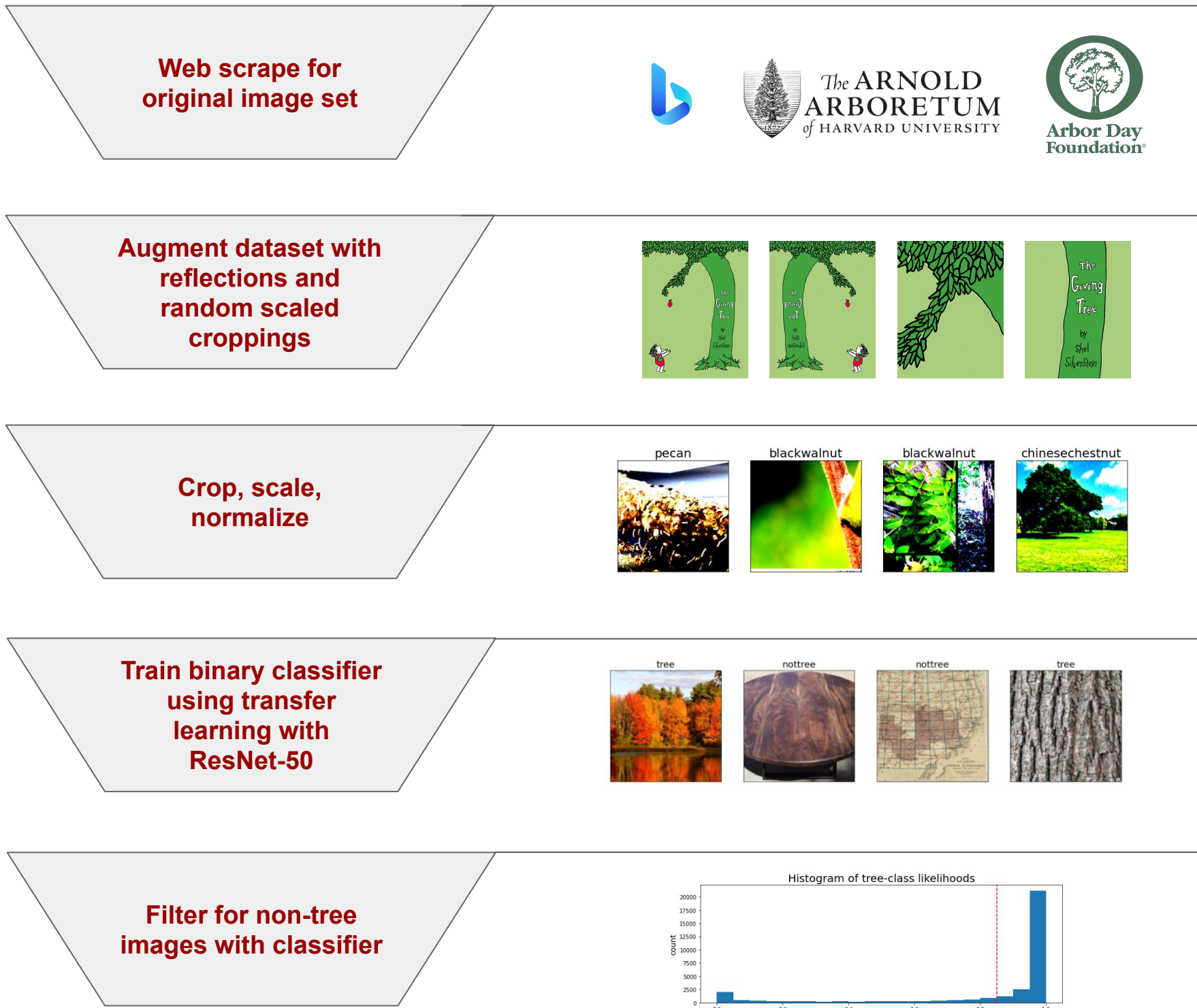


- Trees play a vital role in offsetting anthropogenic carbon emissions and attenuating the effects of climate change. We can grow this pool through **afforestation** and deferred deforestation, increasingly supported by carbon offset payments to forest landowners
- One high-potential opportunity for afforestation is through the addition of trees to pastureland operations, a process called **silvopasture**. We can use allometric equations to estimate tree biomass on these operations; allometric equations relate tree biomass (carbon) to tree height, tree diameter, local climate and **tree species**
- This research develops a **novel dataset of tree photographs** and trains a deep learning model to **identify tree species** from images in the silvopasture setting. This deep learning model is part of ongoing work, which develops a **mobile-based application for tree carbon estimation**

Image source: Chabi et al., 2016, available at <https://cbmjournal.biomedcentral.com/articles/10.1186/s13021-016-0058-5>

Dataset

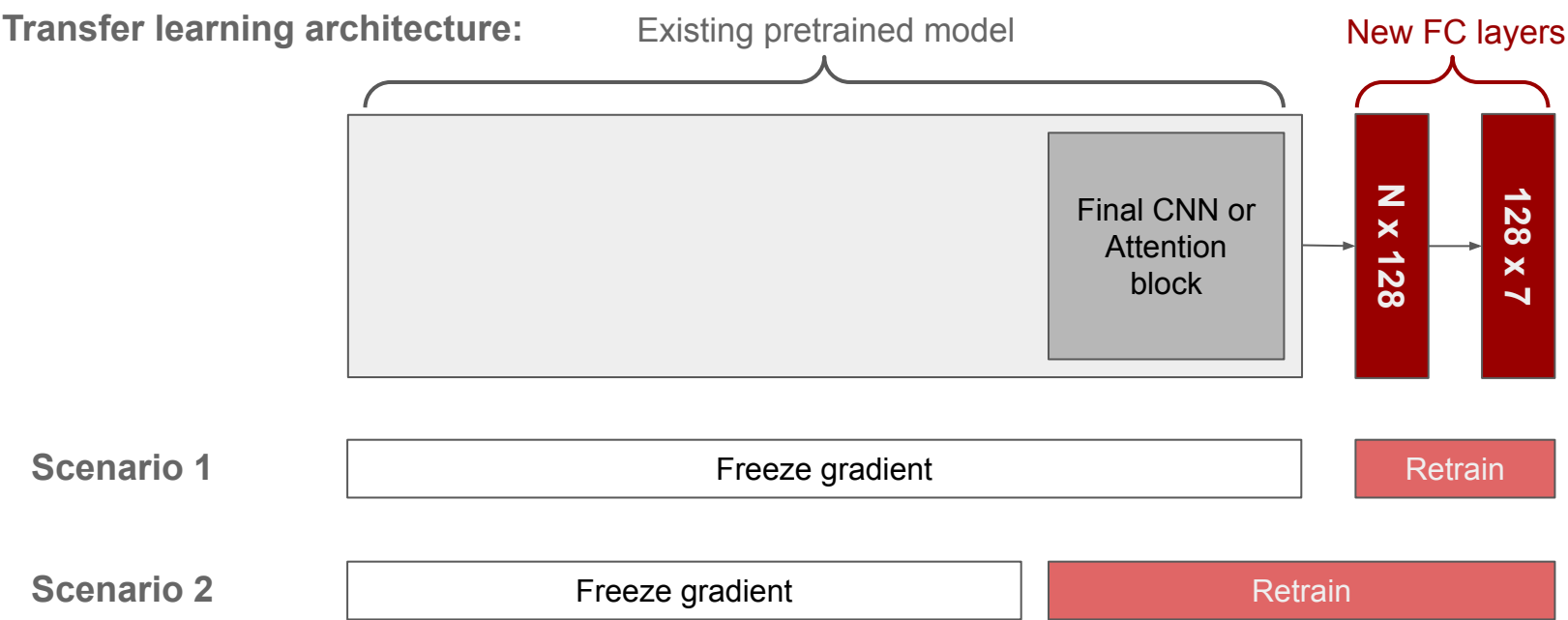
This paper develops a novel dataset of high-fidelity tree photographs, taken in profile perspective, labeled with the tree species. The species included are the seven most common species of tree used in silvopasture in the southeastern US: Black Locust, Black Walnut, Honey Locust, Loblolly Pine, Northern Red Oak, Pecan, Chinese Chestnut.



Species (N)	Total	Bing Search	Arboday Foundation	Harvard Arboretum
Black Locust	3587	3325	0	262
Black Walnut	3845	3327	23	495
Honey Locust	2925	2925	0	0
Loblolly Pine	3106	3059	47	0
Northern Red Oak	3535	3236	42	257
Pecan	5875	3754	42	79
Chinese Chestnut	4071	2905	17	149
Total	24944	22531	171	2242

Methods

- Optimal model trained using transfer learning, replacing final FC layer with a 2-layer FC NN
- Evaluate ResNet-50, ConvNeXt-tiny, and ViT-12-16
- Evaluate model training in two scenarios:
 - Relearning only the new FC NN
 - Relearning the new FC NN and the final CNN or attention block



Experiments and analysis

ResNet-50 Scenario 2 transfer learning performs best with 82.5% accuracy on validation data. This model achieves Top-1 accuracy of 80.0% and Top-2 accuracy of 92.7% on held-out training data

Train & Validation data

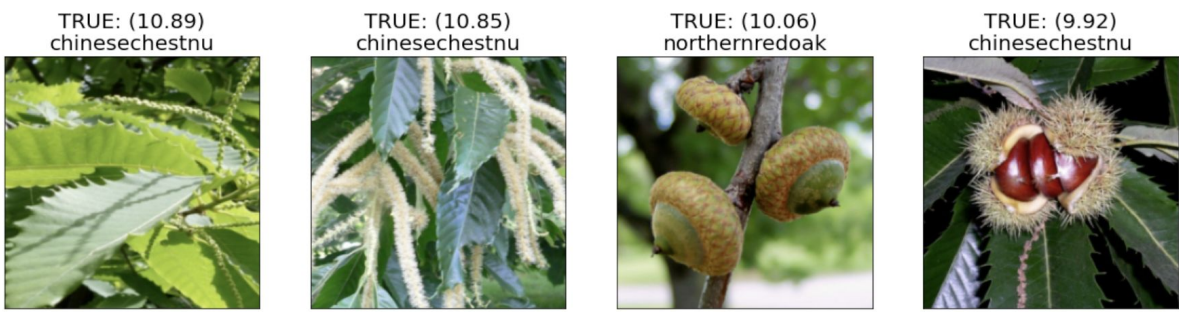
Model	Train acc.	Val acc.	N params
ResNetFC	0.571	0.561	25,557,032
ResNet	0.841	0.825	25,557,032
ConvNextFC	0.612	0.608	28,589,128
ConvNext	0.657	0.649	28,589,128
ViTFC	0.634	0.615	86,567,656

ResNet-50 selected as final model

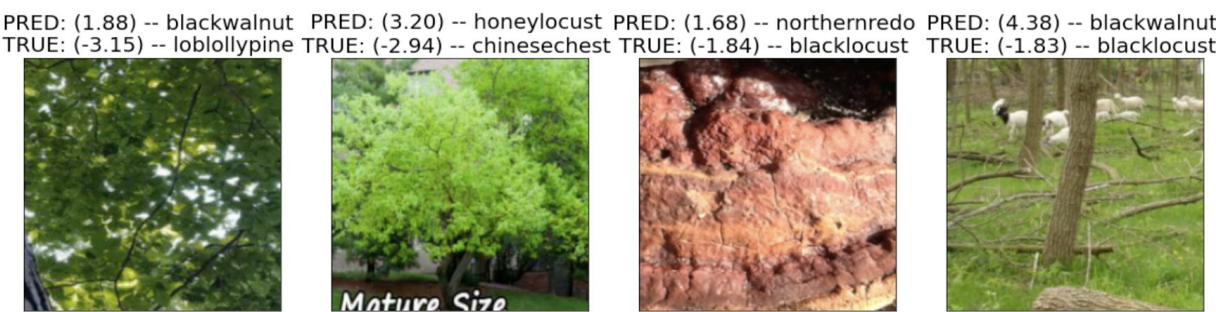
Species	precision	recall	f1-score	support
Black Locust	0.748	0.764	0.756	377
Black Walnut	0.768	0.751	0.759	401
Chinese Chestnut	0.854	0.867	0.860	398
Honey Locust	0.782	0.714	0.747	301
Loblolly Pine	0.911	0.941	0.926	357
Northern Red Oak	0.770	0.84	0.804	307
Pecan	0.758	0.718	0.737	354
Weighted Avg.	0.800	0.008	0.799	2495

	BL	BW	CC	HL	LP	NRO	P
BL	0.76	0.04	0.02	0.09	0.02	0.04	0.02
BW	0.04	0.75	0.05	0.03	0.01	0.04	0.07
CC	0.03	0.03	0.87	0.01	0.01	0.02	0.04
HL	0.14	0.03	0.01	0.71	0.01	0.06	0.04
LP	0.01	0.01	0.01	0.00	0.94	0.01	0.01
NRO	0.03	0.05	0.01	0.01	0.02	0.84	0.04
P	0.03	0.10	0.06	0.02	0.02	0.04	0.72

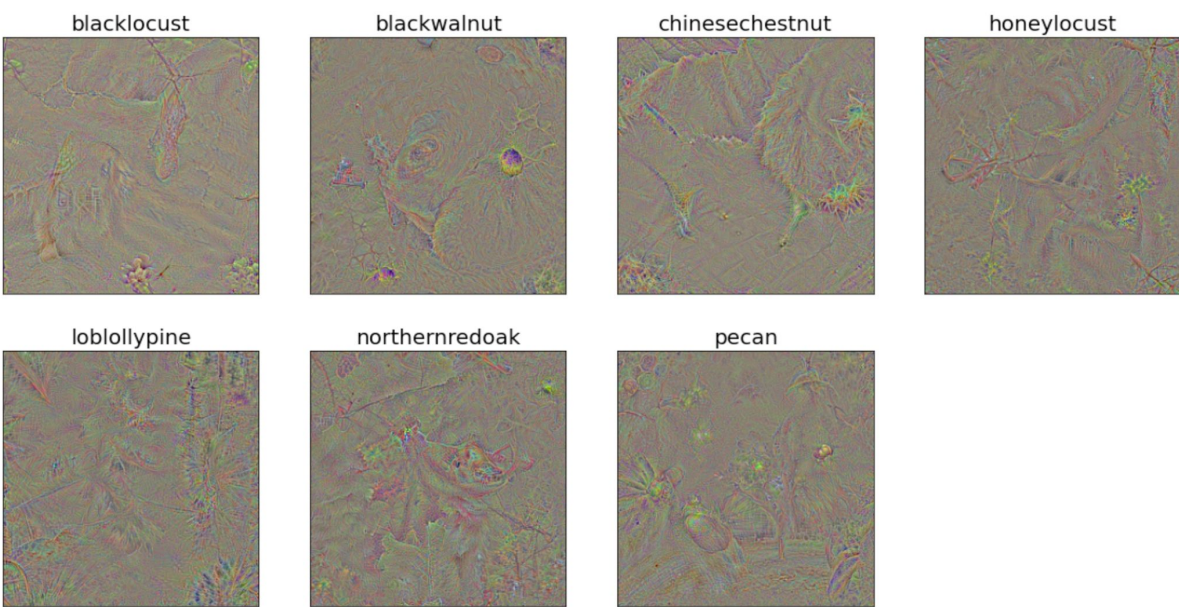
Images with highest scores for the correct class:



Images with lowest scores for the correct class:



Synthetic visualizations for each class



Conclusion and future work



Takeaways and impact

- Novel approach developed to generate datasets for specific classification problems
- High accuracy can be achieved within the tree species classification setting
- Result is a deployable model for mobile-based applications for ree carbon quantification

Next steps

- Incorporate more species through my established dataset-generation approach
- Supplement dataset with high-fidelity images coming from mobile application
- Train larger ResNet pretrained network (e.g., ResNet-152)
- Retrain more of the final CNN blocks in pretrained network

Image source: National Association of Conservation Districts, available at <https://www.nacdnet.org/2016/08/31/silvopasture-getting-closer-look-southeast/>