Procedural Tree Generation : Efficiently predict branching structures from foliage

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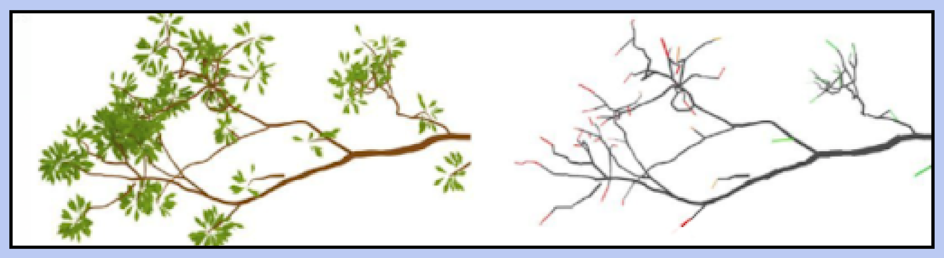
Abstract

Our project focuses on training a model using machine learning, specifically Generative Adversarial Networks (GANs), to **transform tree images with foliage into structures with only branches**. This involves creating a predictive model that minimizes its own error by comparing input images (trees with leaves) to ground-truth images (trees without leaves). The utilization of GANs yielded promising results, evident both visually and through metrics.



Introduction/Background

This research centers on the crucial task of **accurately identifying tree branches by separating them from foliage**, leveraging image-to-image translation algorithms.

Trees, play vital roles in **ecological studies**, **urban planning**, and **biodiversity assessment**. Pix2Pix, a conditional Generative Adversarial Network (cGAN), emerged as a fitting solution, succeeding in crafting lifelike images and aligning well with the goal of transforming **trees** from one domain (**with leaves**) to another (**without**).

Expanding our exploration, we considered alternative methods like **Liu et al** emphasis on unsupervised translation and **Zhu et al** approach for scenarios without paired training data. **Pix2Pix** was ultimately chosen for its proficiency, especially when paired training data is available, making it a robust choice for our specific image translation objectives.

Method and Evaluation

The standard Pix2Pix framework was found to accurately predict branching structure from foliage.

In order to improve the predictions, we used different types of loss functions namely BCE (the original choice), BFCE and MAE.

In order to utilise BFCE we provided a weighted map to create a binary mask for foreground and background and we obtained the best results out of all three.

To evaluate the similarity between predicted images and the ground truth we worked with 3 measurement functions namely **Housedorf Distance**, **Mean Square Error and Structural Similarity Index Measure (SSIM)**, but due to inaccuracy of SSIM we used only HD and MSE.

As it can be observed the predicted images look reasonable but in the table provided it can be seen how using different loss functions change the results.

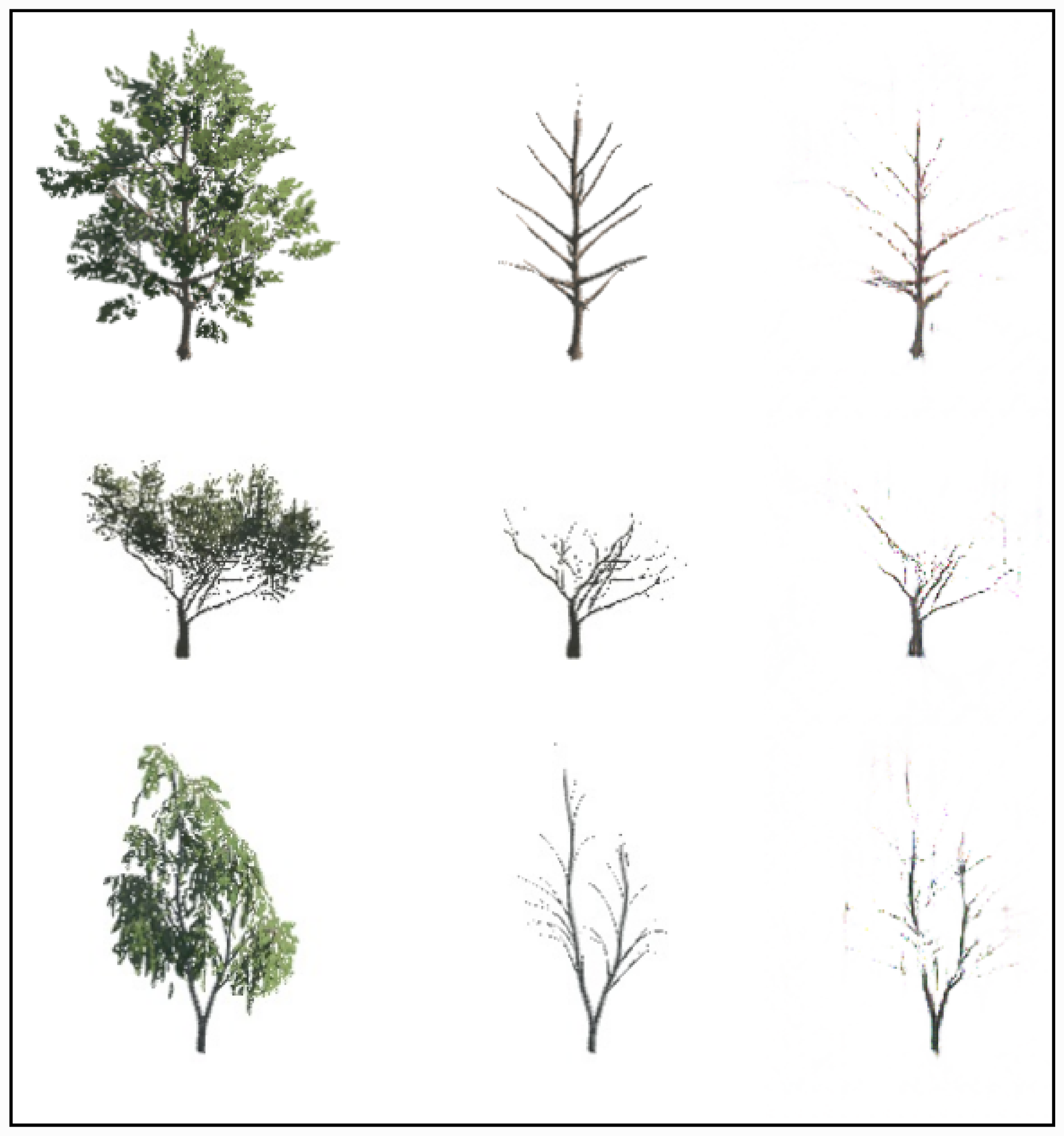
Conclusion

- The domain independent pix2pix algorithm **proved to** be a promising method for **isolating branch structure** from tree foliage **out of the box**.
- Our variation of the Pix2Pix algorithm using Binary Focal Cross Entropy **improved efficiency** in predicting branches from foliage in the generated dataset.

Results

The results of standard Pix2Pix with BCE as the loss function and deploying the BFCE and MAE on the same datasets for comparison.

BinaryCrossEntropy		
MSE	HD	Tree
2.188	882.393	Acacia
2.720	788.440	Birch
3.206	773.173311	Maple
BinaryFocalCrossEntropy		
1.405	**794.134**	Acacia
1.677	**769.324**	Birch
1.786	**774.437**	Maple
MeanAbsoluteError		
1.814	818.385	Acacia
2.225	782.424	Birch
2.478	742.211	Maple



Our variation, which involves using BFCE and applying the weighted map.

The average **Housedorf Distance** on test set:

804.3

As we can see in the table above and below, the results get better when we apply the weighted map to our loss function.

BinaryFocalCrossEntropy		
0.844	**730.499**	Acacia
1.486	**731.255**	Birch
1.230	**746.859**	Maple

9. References

[1] P. Isola, J.-Y. Zhu, T. Zhou, and A. A. Efros, “Image-to-image translation with conditional adversarial networks,” 2016.
[2] Ming-Yu Liu, Thomas Breuel, and Jan Kautz. Unsupervised image-to-image translation networks. 2017.
[3] Jun-Yan Zhu, Taesung Park, Phillip Isola, and Alexei A Efros. Unpaired image-to-image translation using cycle-consistent adversarial networks. 2017.