Secure Tracing With Dendrite Vision: Computer Vision Methods For Matching Dendritic Identifiers Within The Supply Chain

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Abstract

Dendrites are fascinating branching structures that exhibit randomness; yet they are unique, non-repeatable, and identifiable with the right algorithmic innovations. **The question this research aims to answer is how can machine learning and these naturally random structures be brought together to create a highly accurate, secure, and specific identifier?** In order to create a model with high dendrite identification accuracy, a pre-trained model was fine-tuned over an original dataset consisting of unique dendrites from multiple angles. The model's success suggests that dendrites can be implemented on a large scale within the supply chain.

Background

Unlike barcodes, which are fundamentally lines - structures with the element of randomness introduced to them - dendrites are random by their creation. Research on dendrite manufacturing, at scale, is cutting edge, with the vast majority of progress having been made in the past year, almost entirely at ASU. Dr. Kozicki's research on dendrites, including the many patents he holds [1, 2, 3, 4, 5], are currently the only existing works in the field. Understanding these remarkably secure, singular, and unique "thumbprints" have an incredibly high potential for creating a disruptive and innovative future of identifiers.

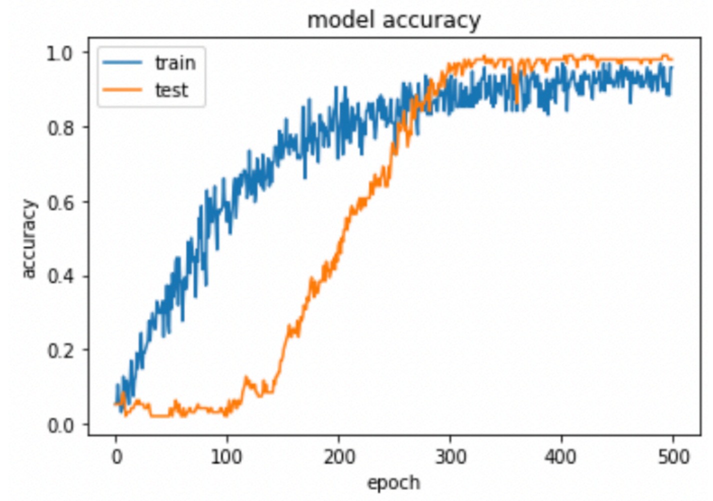
Results

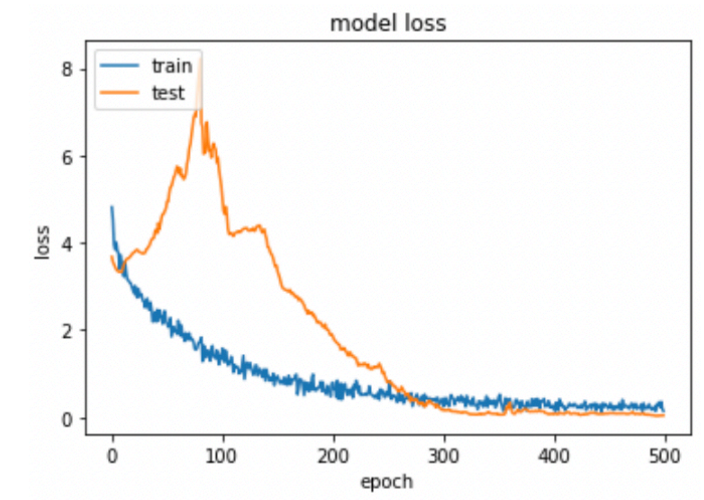
Dataset Creation

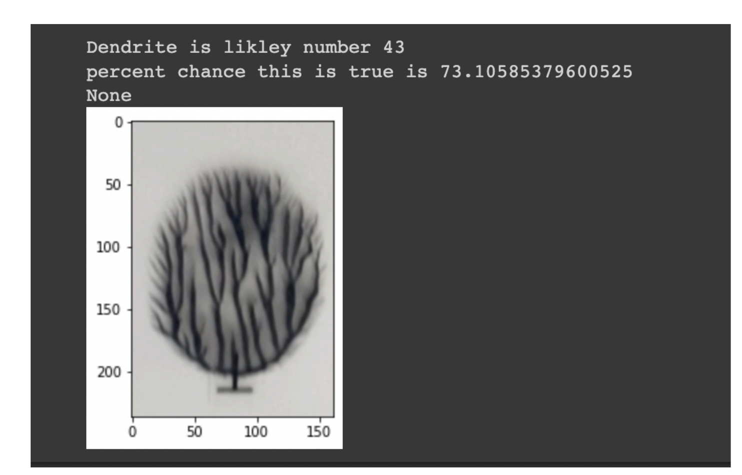
This project necessitated the construction of a dataset of 105 unique dendrites. The dataset is structured into 105 classes (folders), consisting of different angles of each individual dendrite. Data augmentation effects were applied to training data for increased image diversity. Shown below is one class of data-augmented dendrites.

Model Development

In order to maximize training efficiency, the pre-trained model called ResNet50 was utilized for training on the data. The model was fine-tuned and a dense layer was added to match the number of dendrites. Several models with different class sizes were created in order to experiment with model accuracy, including 6, 21, and 105 class size models. Displayed below (in order) are two training graphs from the 21 class model and testing results and the 6 size model.







Conclusion

The model trained on six classes achieved nearly perfect training and validation results, with testing accuracy in the 70's range. Model's with higher classes (105 and 21) achieved relatively high training and validation accuracy and low losses, however, experienced complications during testing. As the model continues to be fine-tuned, these problems are slowly being resolved. Regardless, these findings show that large scale dendrite implementation within the supply chain is possible given the relative success of the models.

References

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