Individual Tree Species Classification using the Pointwise MLP-Based Point Cloud Deep Learning Method

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1. Introduction

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Tree species is a critical factor in the practice of forest resource field sample surveys.

Light detection and ranging (**LiDAR**) can obtain 3D structural information about forests and trees and is increasingly being used in forest resource surveys.

We used three **pointwise MLP-based deep learning methods** (PointNet, PointNet++, and PointMLP) to identify individual tree point clouds of seven different tree species to explore the effectiveness of point cloud deep learning in classifying individual tree point clouds.

Experiment results have been extremely exciting. 👏👏👏👏👏 **Higher classification accuracy** can be attained.

Keywords:

- Tree Species Classification
- Point Cloud
- Deep Learning
- Pointwise MLP

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2. Materials and Methods

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2.1 Individual Tree Point Cloud Data

GRO.data >

Single tree point clouds from terrestrial laser scanning

Version 2.0

Seidel, Dominik, 2020, "Single tree point clouds from terrestrial laser scanning", https://doi.org/10.25625/FOHUJM, GRO.data, V2

Cite Dataset ▾ Learn about Data Citation Standards.

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Dataset Metrics

0 Views

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Description

Single tree point clouds from terrestrial laser scanning obtained from laserscanning campaigns throughout Germany and an additional dataset from a campaign on the Christy Flats, near Eugene, Oregeon, USA. Files are sorted by species (ash, beech, Doglas-Fir, Oak, Maple, Pine, RedOak, Spruce) and are in the format .pts, .xyz and .txt. (2020)

Subject

Earth and Environmental Sciences

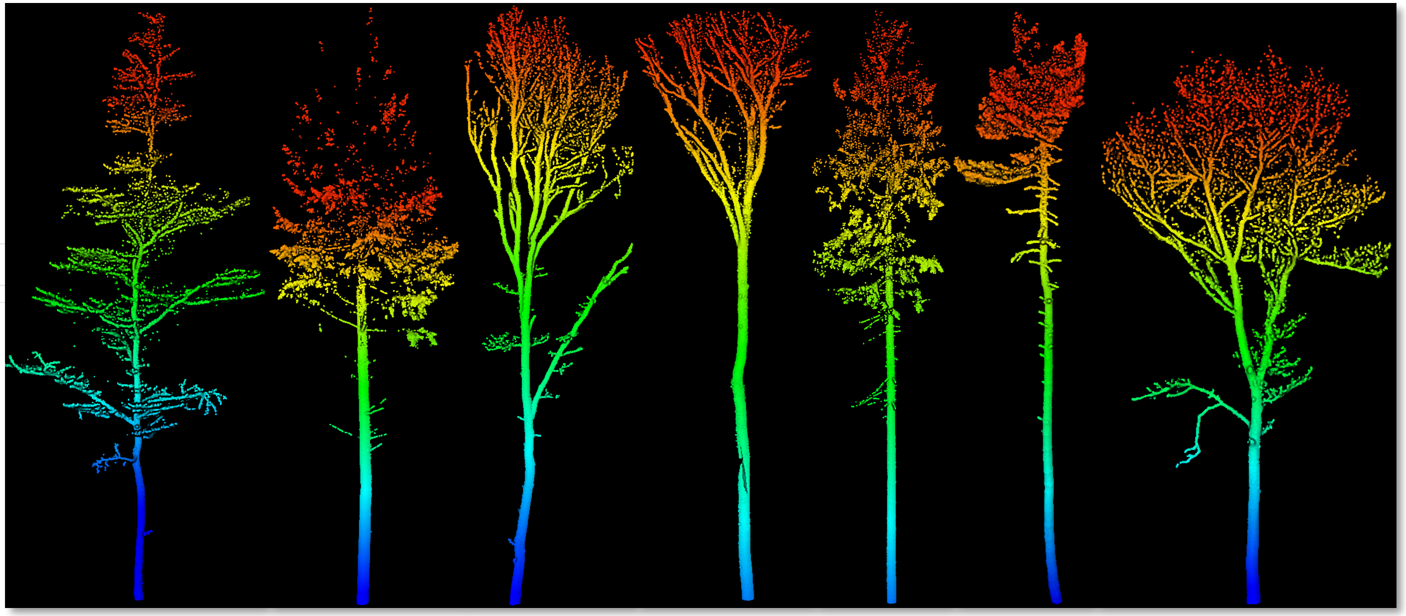
Keyword

LiDAR

License/Data Use Agreement

PUBLIC DOMAIN CC0 1.0

Files Metadata Terms



Buche Douglasie Eiche Esche Fichte Kiefer Roteiche

Table 1. Information on tree species and number of samples.

Species	Number	Species	Number
Buche [1]	104	Eiche	31
Douglasie [1]	116	Esche	27
Fichte [1]	127	Kiefer	21
Roteiche [1]	100		

[1] To balance the sample data, we conducted a comparison experiment using **four** datasets with similar numbers of samples from Buche, Douglasie, Fichte, and Roteiche.

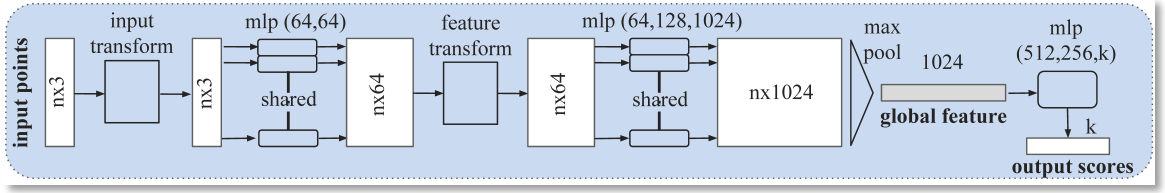
2.2 Data Preprocessing

1. *Manual selection.*
2. *Deleted 30% density at the bottom.*
3. *Downsampling to 1024 and 2048.*
4. *Data Organization.*

2.3 Point Cloud Deep Learning Models

Three pointwise MLP-Based deep learning methods.

PointNet

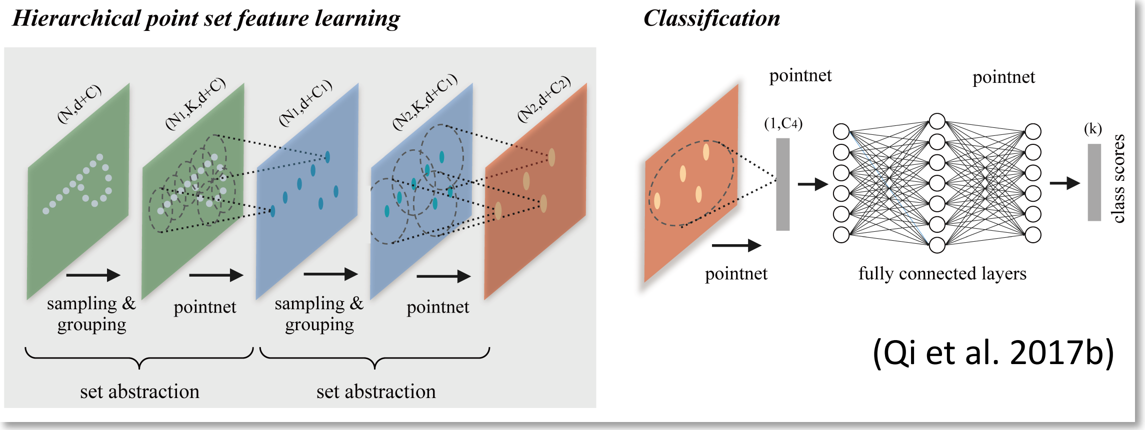


(Qi et al. 2017a)

Table 2. Summary of hyperparameters for deep learning models.

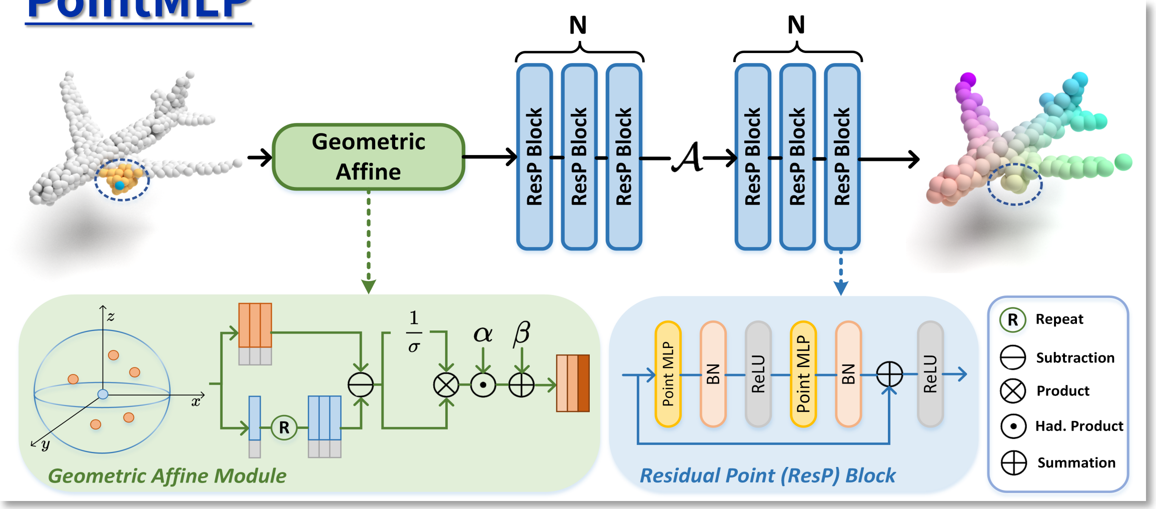
Model	PointNet	PointNet++	PointMLP
Batch Size	12	12	12
Number of Points	1024/2048	1024/2048	1024/2048
Categories	4/7	4/7	4/7
Epochs	200	200	300
Optimizer	Adam	Adam	SGD
Learning Rate	0.001	0.001	0.1
Weight Decay	0.0001	0.0001	0.0002
Momentum	—	—	0.9

PointNet++



(Qi et al. 2017b)

PointMLP



(Ma et al. 2022)

3. Results & Discussion

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Table 3. Accuracy of tree species classification results for three deep learning models.

Model	Number of Categories	Points	Train		Test	
			BAcc	*kappa*	BAcc	*kappa*
PointNet	4	1024	0.4865	0.3246	**0.5205**	0.3663
		2048	**0.5135**	0.3598	0.4954	0.3412
	7	1024	0.2672	0.2473	0.2923	0.2879
		2048	0.2638	0.2309	0.2776	0.2598
PointNet++	4	1024	0.7663	0.6910	0.8787	0.8298
		2048	**0.8109**	0.7430	**0.9483**	0.9297
	7	1024	0.6630	0.6686	0.7263	0.7927
		2048	0.7791	0.7762	0.8849	0.9205
PointMLP	4	1024	0.9176	0.8885	0.9074	0.8694
		2048	**0.9782**	0.9700	**0.9474**	0.9296
	7	1024	0.7654	0.8444	0.7061	0.7839
		2048	0.7852	0.8073	0.8460	0.8803

four tree species achieved high accuracy.

a larger number of samples & balanced sample data .

2048 sampling points achieved higher classification accuracy.

(consistent with the findings of Liu et al.)

This indicates that 1024 points are not a good representation of the accurate 3D structural information of individual trees.

PointNet classification acc is low, similar to Seidel et al.

PointNet cannot capture local features of 3D objects, which limits its ability to classify and recognize similar objects.

PointNet++ & PointMLP high classification accuracy.

introduce local feature extraction module, which can extract the fine-grained local features of 3D objects well.

3. Results & Discussion

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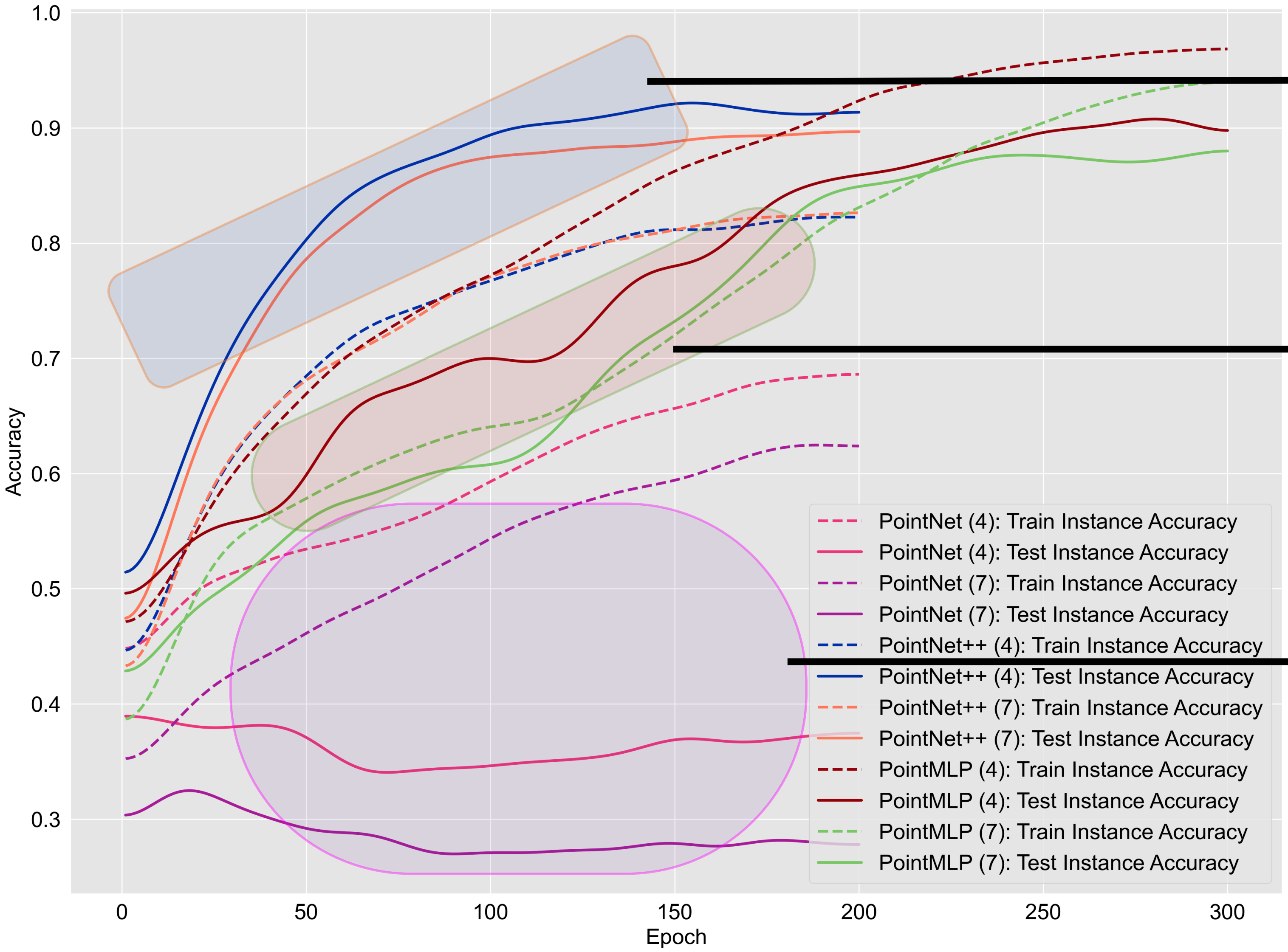

Figure 1. Instance accuracy during training of deep learning models. (The curves were Gaussian smoothed, and the smoothing parameter was set to 10.)

PointNet++ - **Test acc > Train acc**,

finally obtaining a high classification accuracy.

PointMLP - The test accuracy of the increases with the training accuracy;

finally achieves a classification **accuracy similar to that of the PointNet++**.

PointNet - classification **accuracy of the test dataset does not increase** with the increasing training accuracy of the model.

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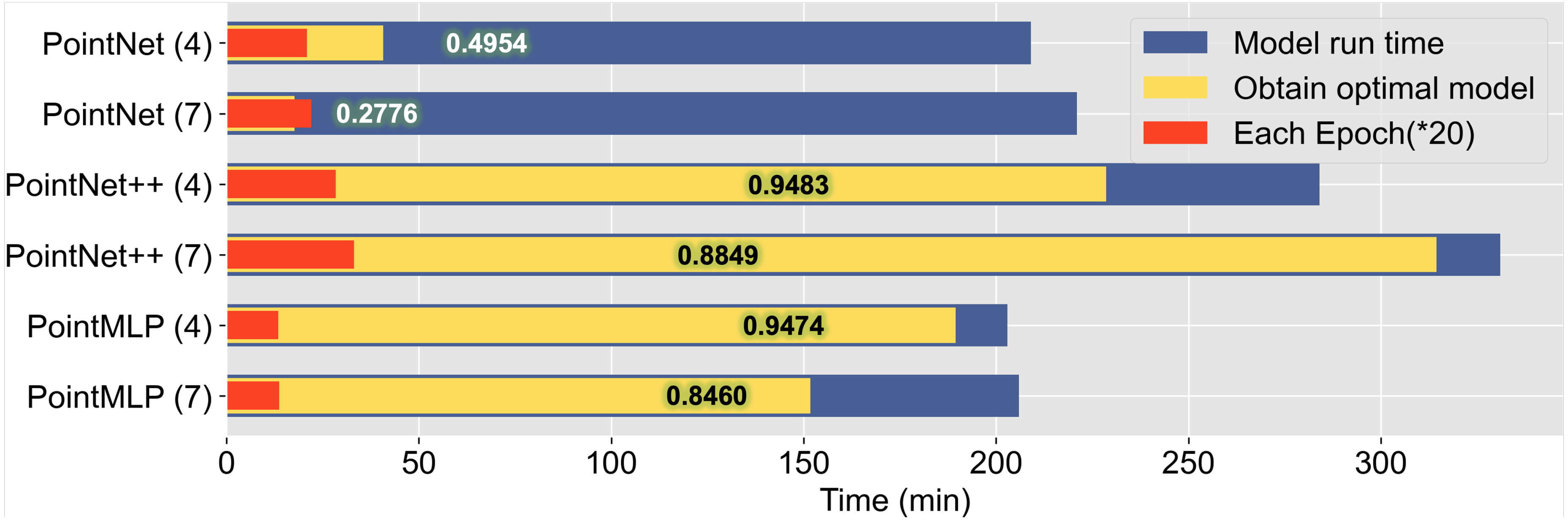
Figure 2. The time used to train the point cloud deep learning model. (The numbers labeled in the figure indicate the highest classification accuracy obtained by the corresponding experiment on the test set.)

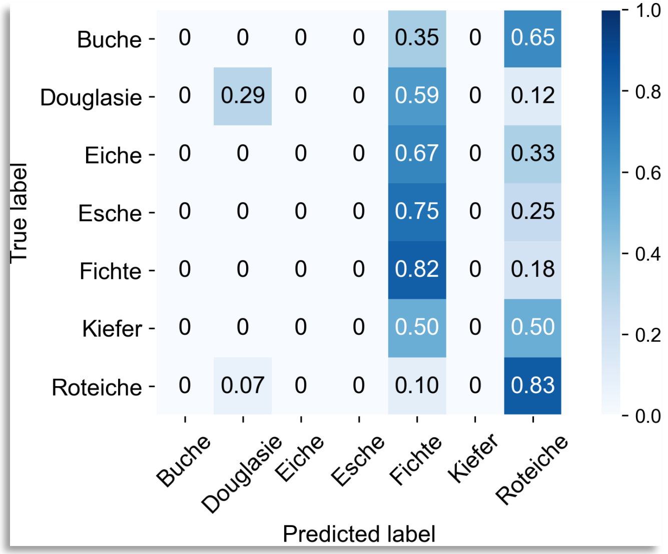


- **PointNet++ model is more time-consuming;**
- **a longer time to train to obtain the optimal model parameters.**

- **PointMLP – acc ≈ PointNet++, a brief period.**
- **a simpler and deeper network architecture**
- **a simple feed-forward residual MLP network.**

- **PointNet model saturates beginning;**
- **classification accuracy is very low.**

4. Conclusions



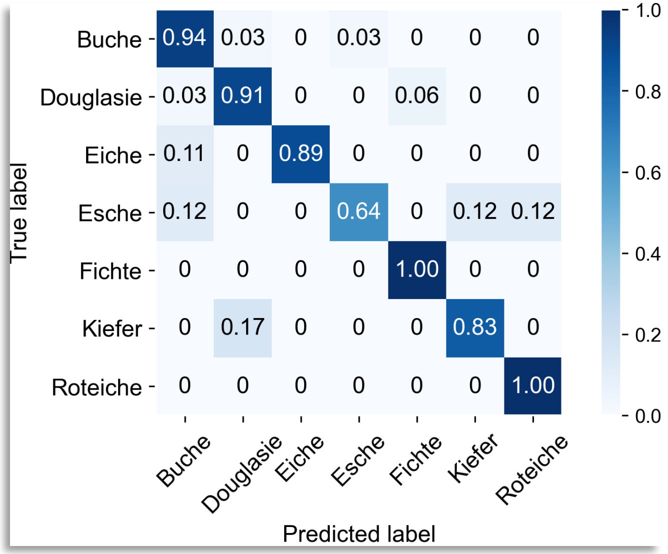
PointNet (2048)
Consistent with Seidel et al.

The tree species classification obtained by the PointNet model in our study was exceptionally low. ①

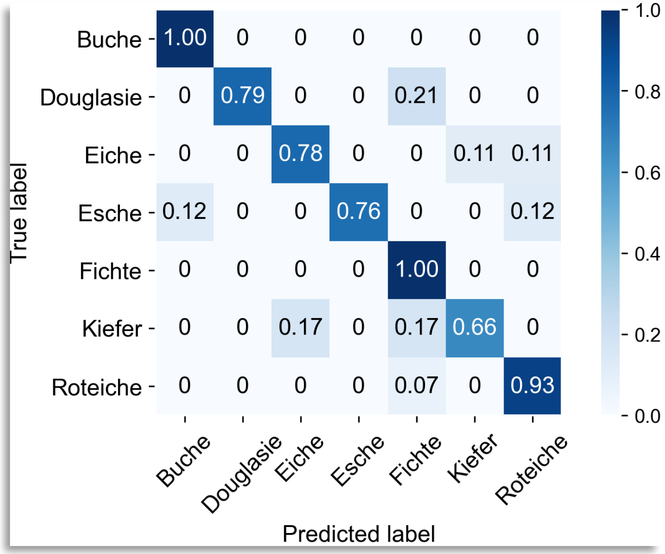
The classification accuracy is higher when the number of sampling points of an individual tree is 2048. ②

Point cloud deep learning models of the MLP type with local feature extraction are proven to be accurate for tree species classification of individual tree point clouds. ③

Choose a substantial number of samples and keep the distribution of the number of samples consistent. ④



PointNet++ (2048)



PointMLP (2048)

☆ **PointMLP**, as the current SOTA MLP-based point cloud deep learning method, has good potential for tree species classification applications. ⑤

5. References

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Acknowledgements

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Thank you for your attention.

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