Classifying Tree Species in Sentinel-2 Satellite Imagery Using Convolutional Neural Networks

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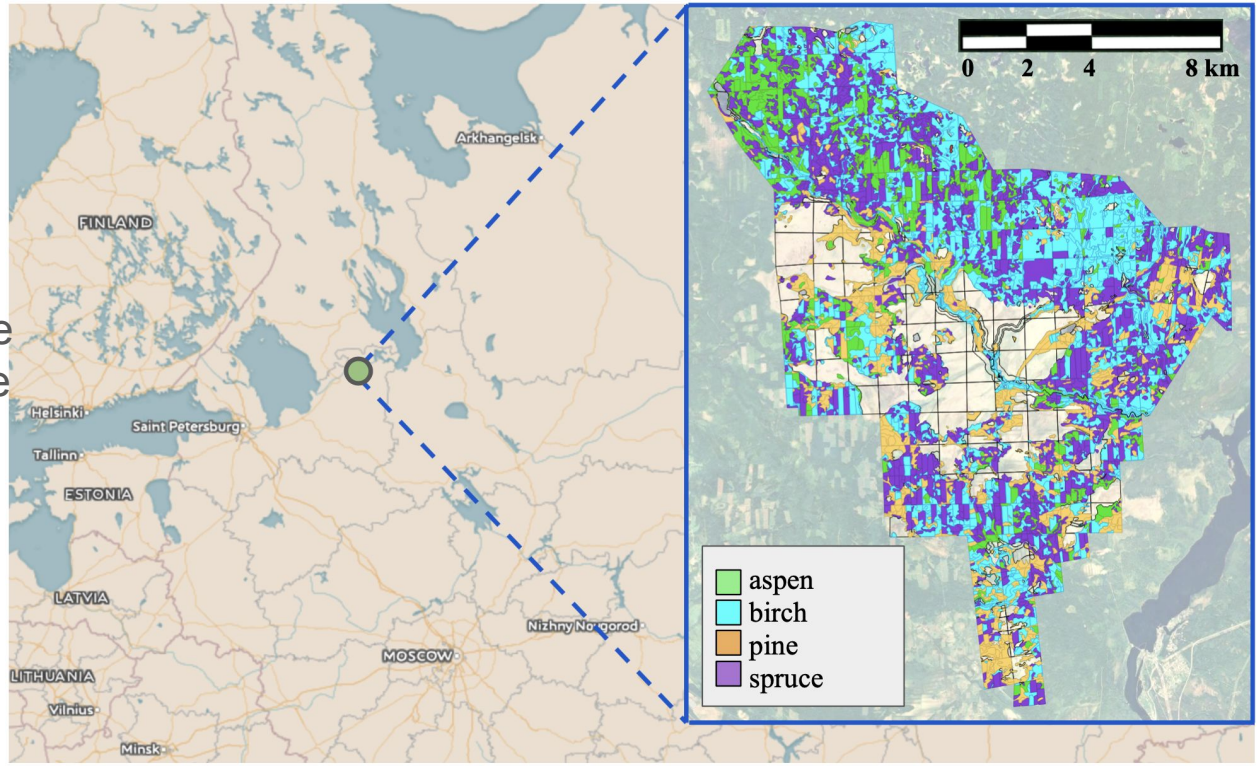
Forest species classification

The problem: forest dominant species classification using weak markup

The objectives:

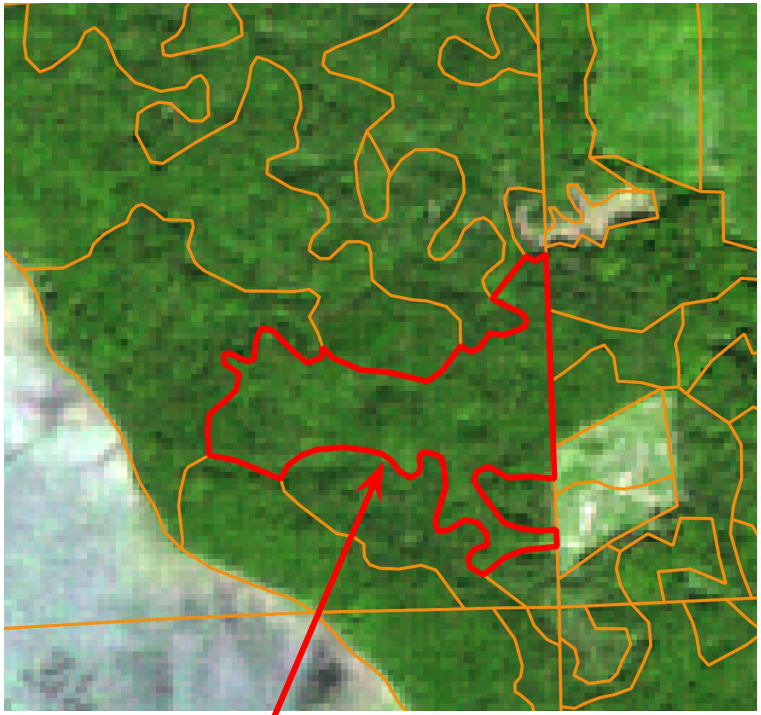
- to provide a more appropriate sampling strategy (alternative approach to pixel-wise and patch-wise)
- to examine markup adjustment approach

Study area: Leningrad Oblast of Russia

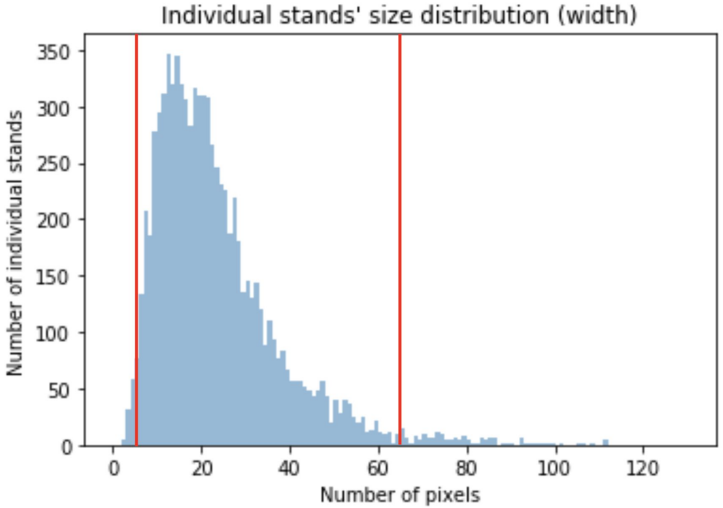


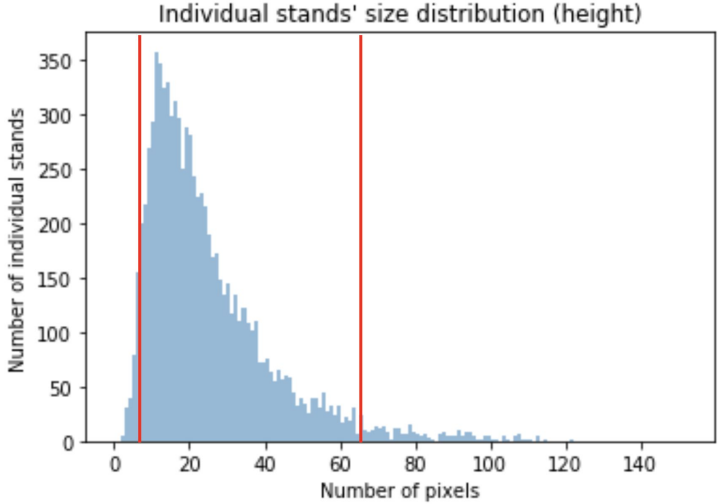
Data representation

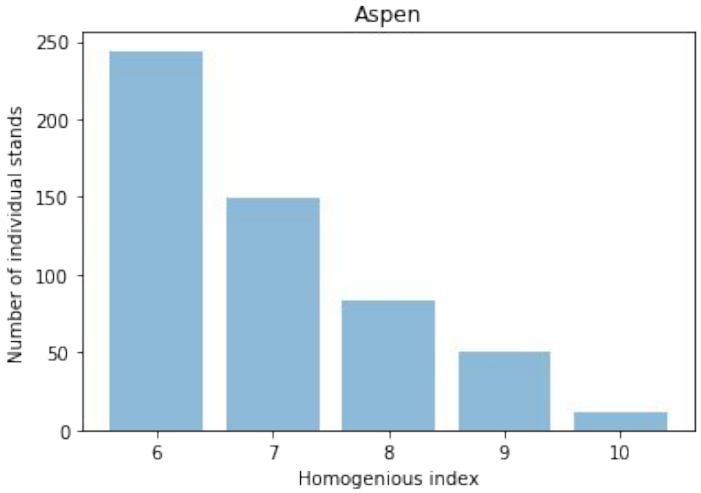
Reference data: inventory field-based measurements

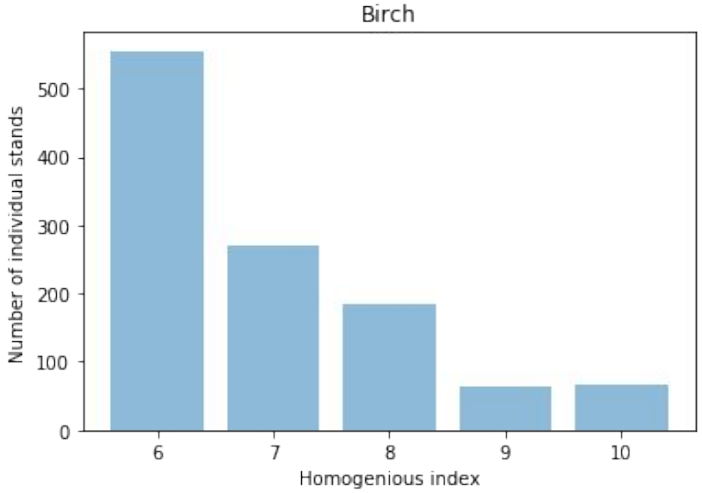


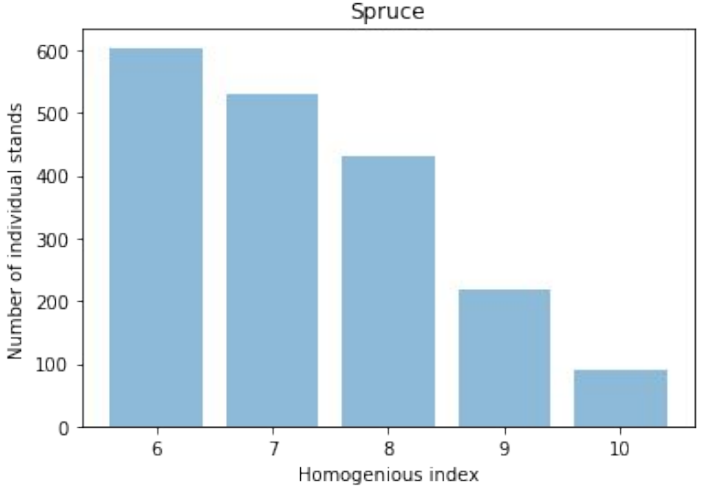
60% birch, 20% aspen, 20% spruce

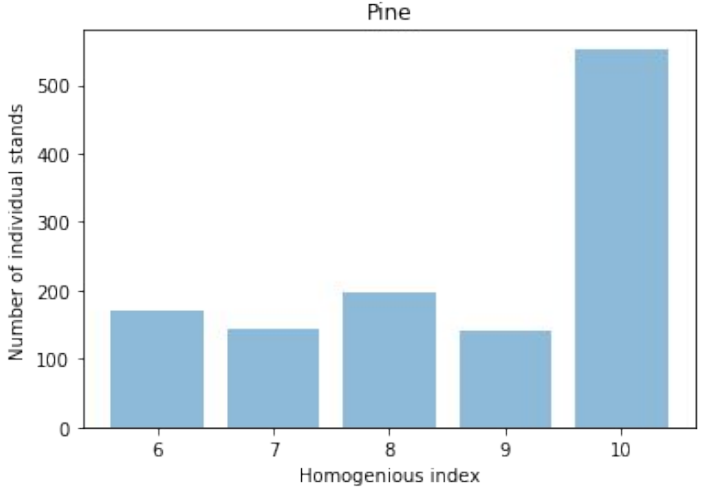




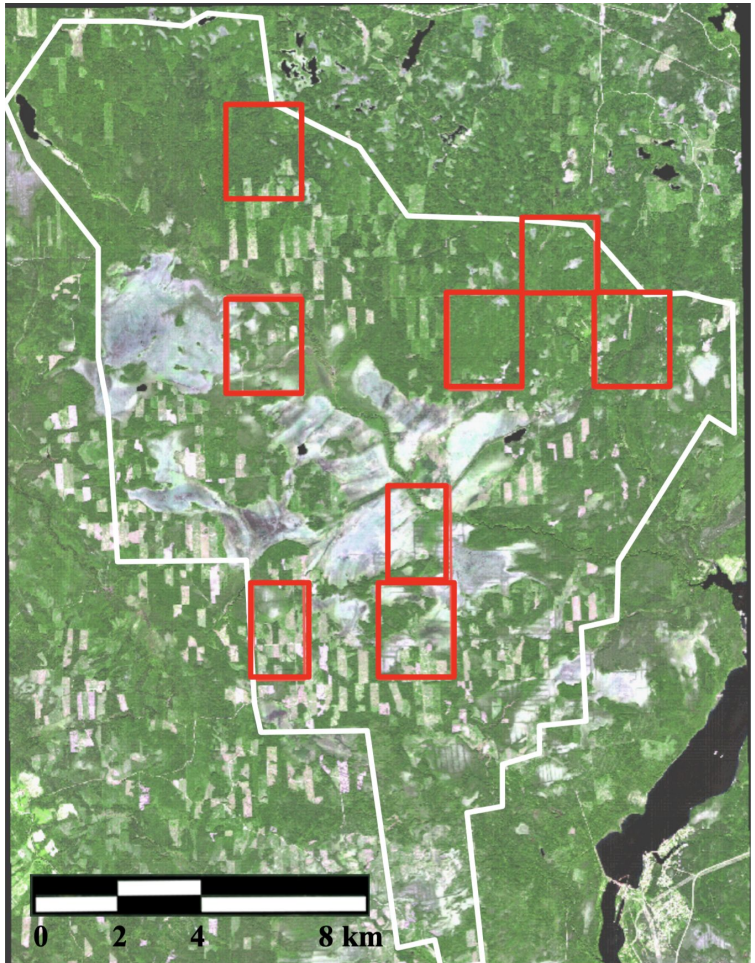

Aspen
Number of individual stands
Homogenious index
0
50
100
150
200
250
6
7
8
9
10


Birch
Number of individual stands
Homogenious index
0
100
200
300
400
500
6
7
8
9
10


Spruce
Number of individual stands
Homogenious index
0
100
200
300
400
500
600
6
7
8
9
10


Pine
Number of individual stands
Homogenious index
0
100
200
300
400
500
6
7
8
9
10

Dataset properties



	Individual stands	Area (ha)
aspen	725	2298
birch	1644	4165
pine	2295	3620
spruce	1537	6315

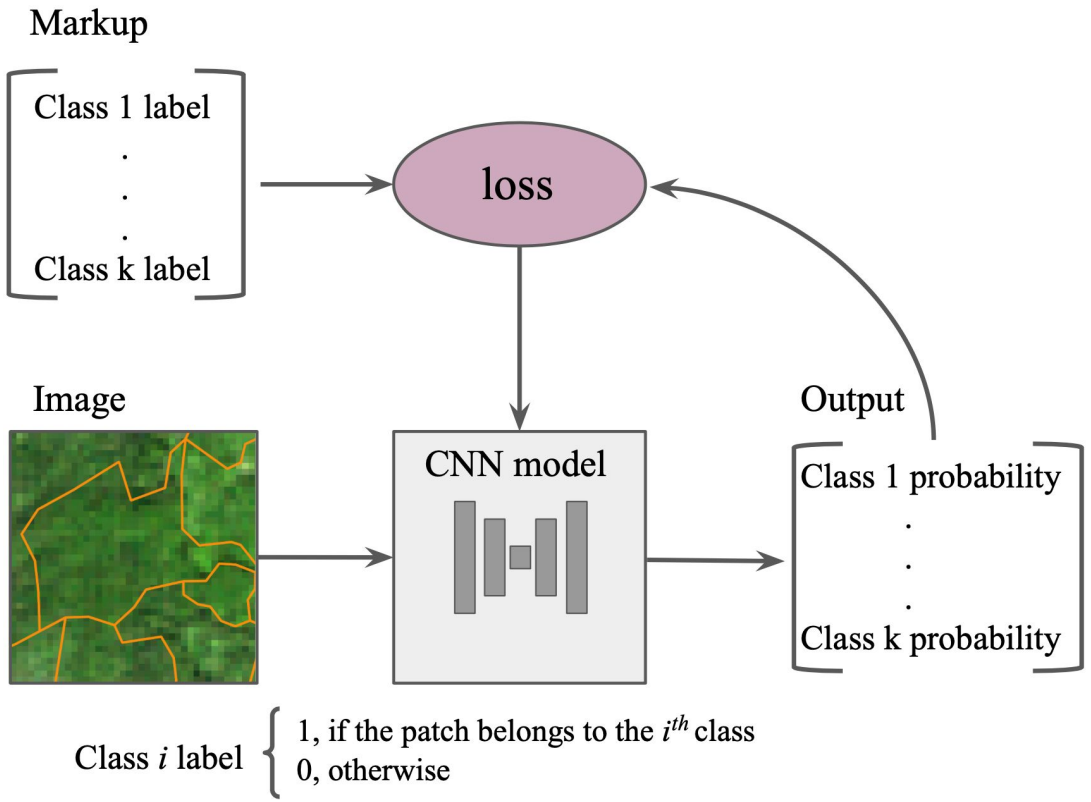
Test:

- *sampling adjustment:* 8 test regions (about 450 ha each)
- *markup adjustment:* 30% of individual stands are in test

Training strategies

- pixel-wise
- object-wise
- patch-wise

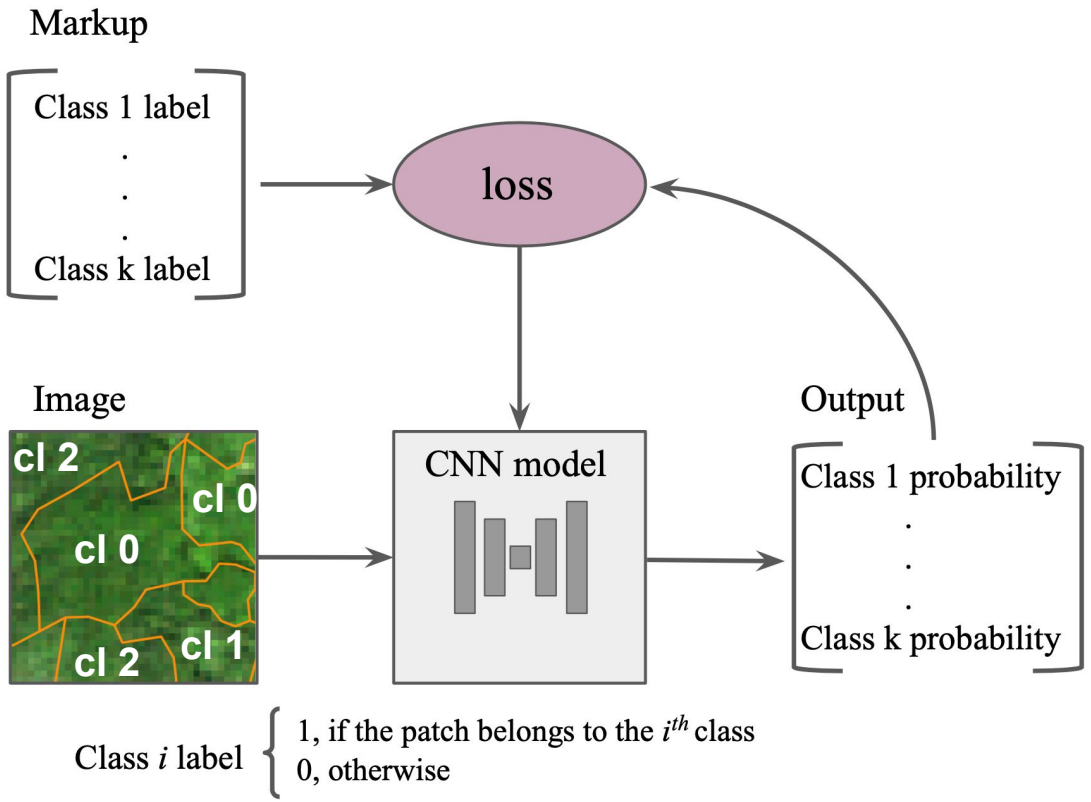
Example of patch-wise approach



Training strategies

- pixel-wise
- object-wise
- patch-wise

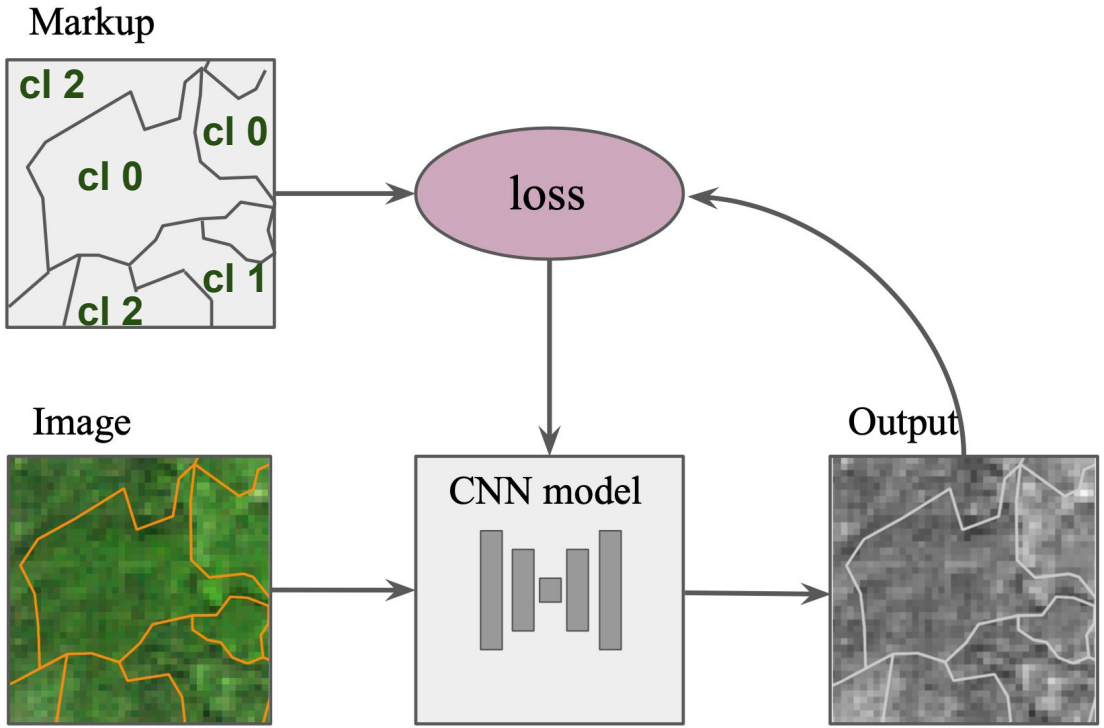
Example of patch-wise approach



Training strategies

- pixel-wise (baseline)
- object-wise
- patch-wise

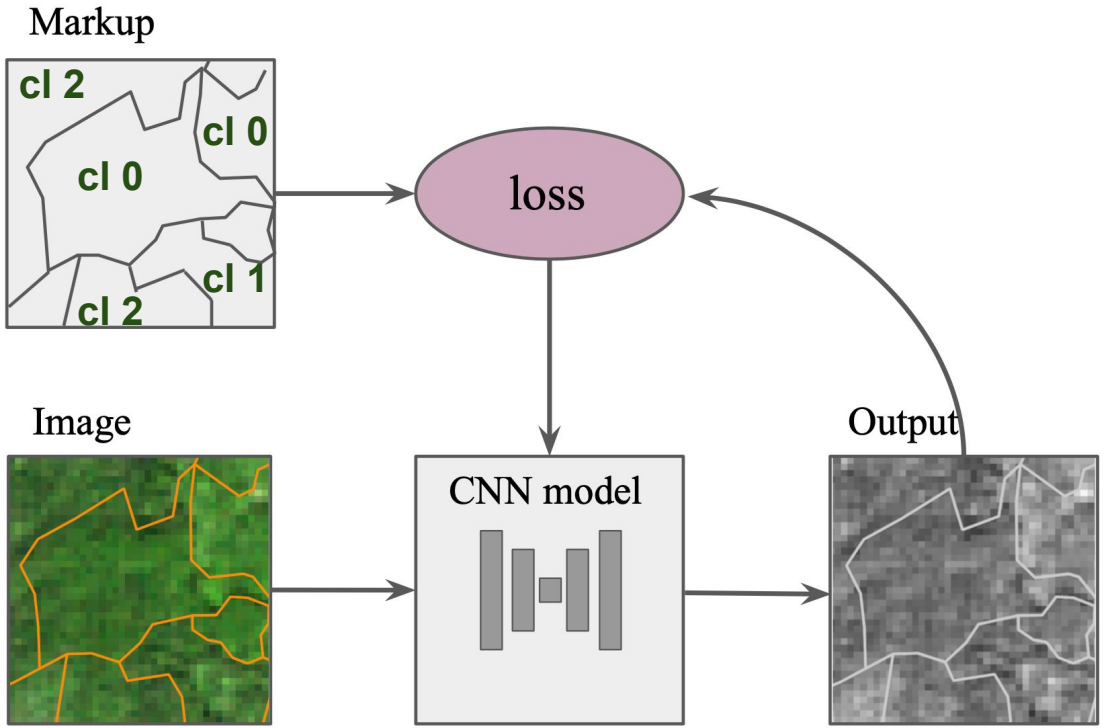
Example of pixel-wise approach



Training strategies

- pixel-wise (baseline)
- object-wise
- patch-wise

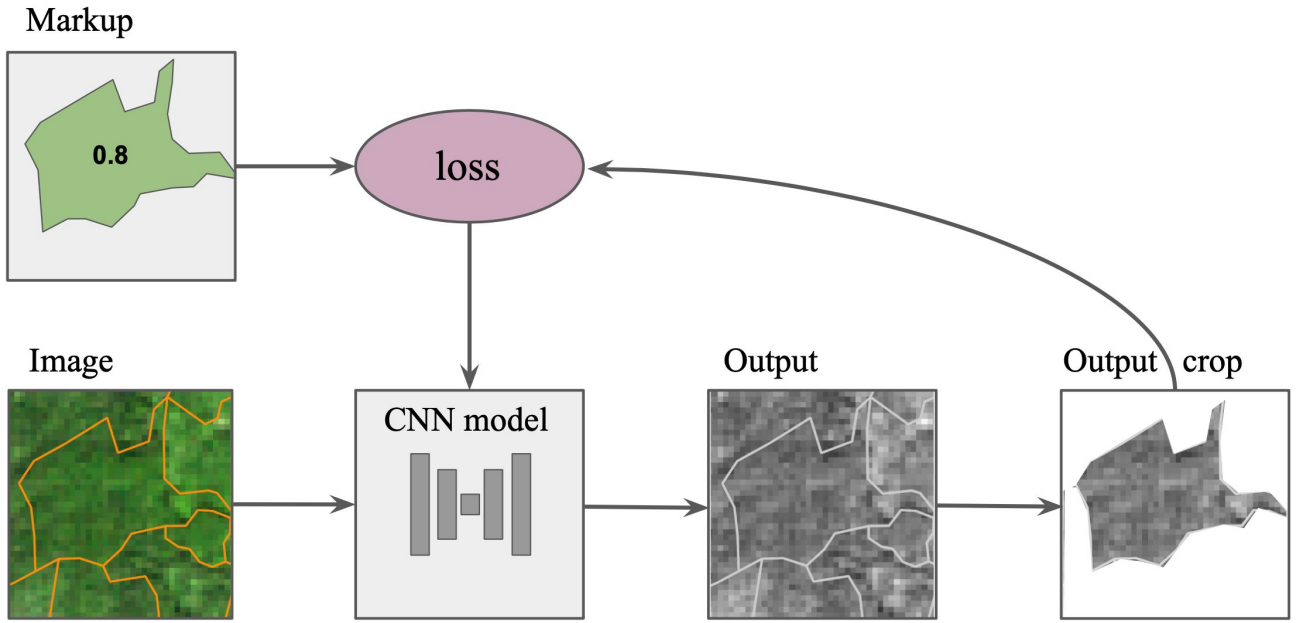
Example of pixel-wise approach



Drawbacks: the case of imbalanced and not evenly distributed classes

Our sampling strategy

- use percentage of the species during loss computation
- consider pixels just within one polygon during loss computation
- form the training batch based on individual stands instead of a random patch selection



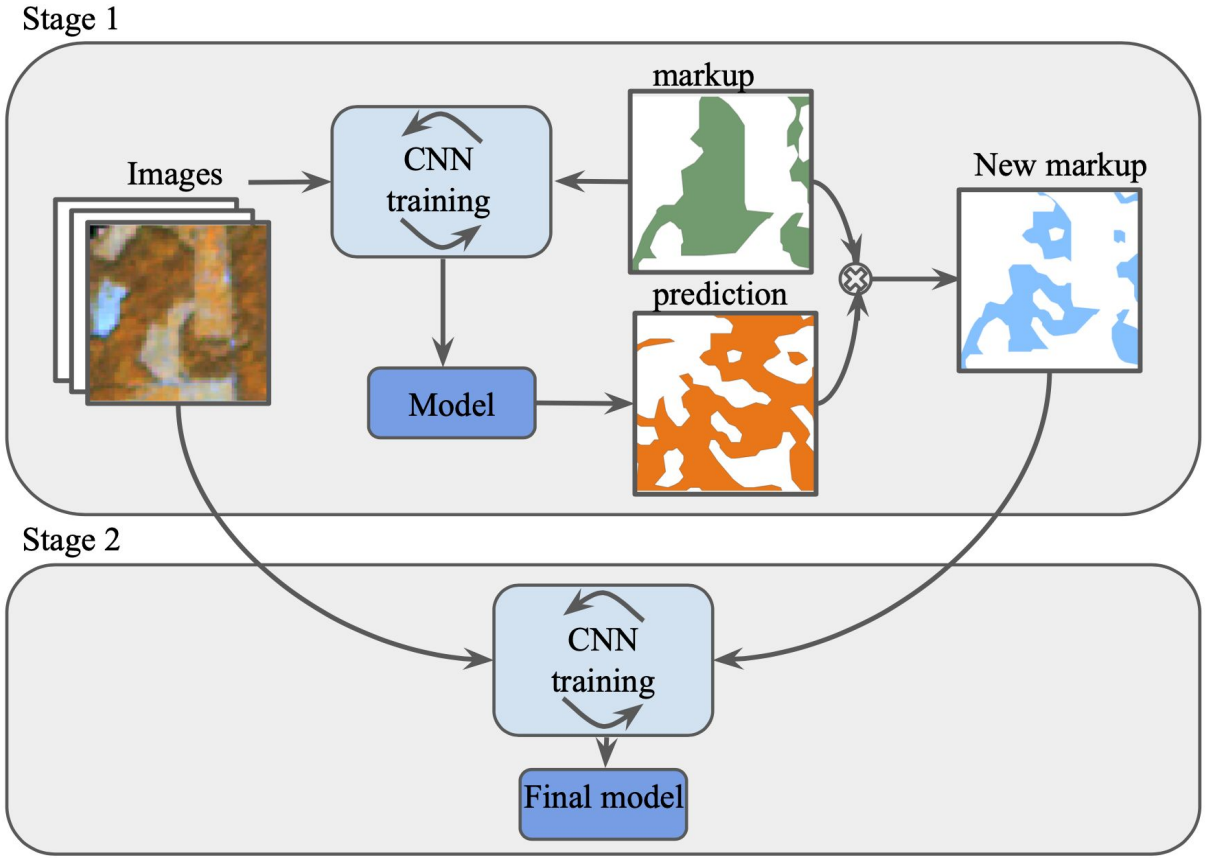
$$\text{Loss} = -\frac{\sum_{i=1}^{N}\sum_{k=1}^{C}(y_{ik} * \log \hat{y_{ik}}) * weights(y_{ik})}{N}$$

Markup adjustment strategy

The goal:

- to eliminate pixels of minor classes within mixed individual stands
- train a new model using purer data

Use two different loss functions for each stage



Results. Training strategy adjustment

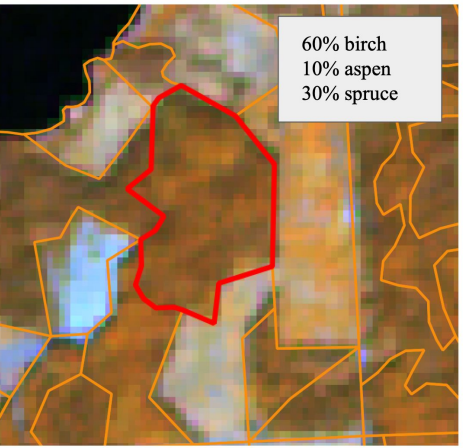
- More accurate predictions
- Address imbalanced classes problem

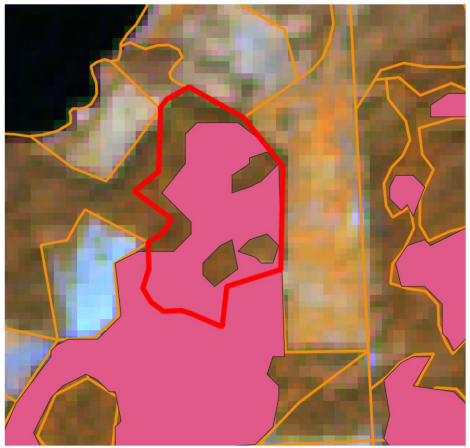
Comparison of two approaches (F1-metric)

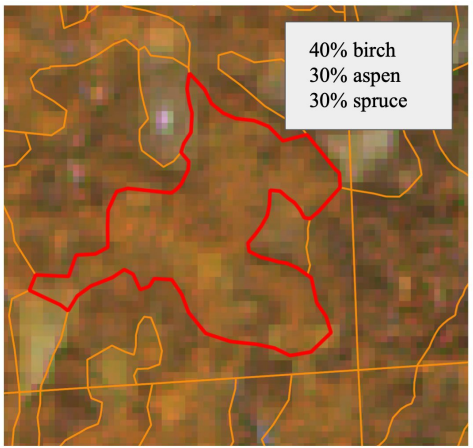
	aspen / birch	pine / spruce	conifer / deciduous
Base approach	0.48 / 0.88	0.91 / 0.88	0.81 / 0.85
Modified approach	0.63 / 0.91	0.94 / 0.87	0.85 / 0.87

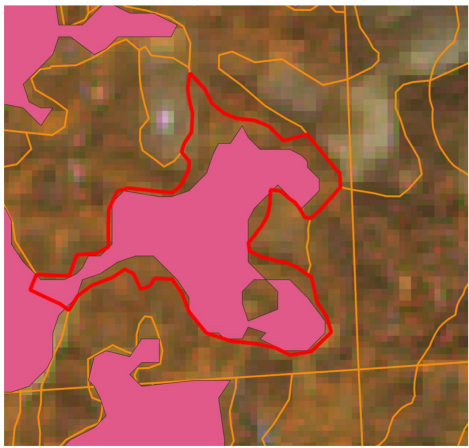
Results. Markup adjustment

Example of models deciduous prediction intersected with initial deciduous dominant areas (species percentages for red polygons are provided)









Species classification (F1-metric)

	aspen / birch	pine / spruce
Source markup	0.77 / 0.9	0.94 / 0.88
Updated markup	0.79 / 0.9	0.95 / 0.9

Conclusion

- we developed a software toolchain for species classification using convolutional neural networks combining pixel- and object-wise approaches during the training procedure, and compared it with a typically used approach for semantic segmentation;

- we provided a strategy for weak markup improvements and examine forest type classification both as a problem of (a) dominant class estimation for mixed individual stands and (b) more precise classification.

Thank you for attention!