Towards an automatic segmentation and classification of multi-source point clouds for Arctic to boreal permafrost ecosystem analysis

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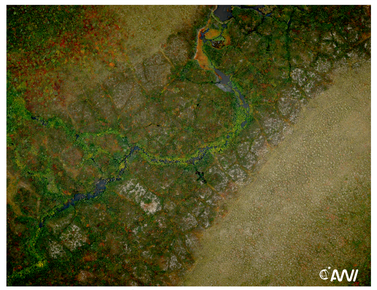


Ice Wedge Polygons in NWT, Canada

Drunken Forest along thermokarst lake NWT, Canada

Data acquisition in dense boreal forest NWT, Canada

Background

Point clouds provide valuable insights into the change of Arctic and boreal ecosystems, resulting in a surge of point cloud acquisition in high latitude regions using various sensors and methods (e.g. LiDAR and SfM). This in turn leads to point clouds with a variety of characteristics. However, analyzing these point clouds requires time-consuming segmentation and classification, often involving manual correction. With the large amount of data sets, automated segmentation and classification become necessary.

Aim | Research questions

Our goal is to develop an automated segmentation process that is efficient and accurate, and most importantly applies to point clouds of high variety of characteristics. Thereby we want to answer the following research questions:

1) How can we speed up the time consuming labeling process?

2) Can transfer learning lead to accurate results?

3) To what level of detail can we segment and classify our data?

Sensors

	resolution [Mpx | Kpx]	FOV °	wavelength [nm]
MACS	50 1.024 x 0.768	58 x 43 60 x 47	RGB, NIR, TIR
Sony E - Exmor CMOS	19.8	83	RGB
Micasense Altum	3.2 1	48x36.8 57x44.3	475-560-668 717-842-0.011
Phantom 4 multi	2.08	62.7	RGB-450-560, 650-730-840

	Point rate [pt/s]	precision [cm]	accuracy [cm]	wavelength [nm]
Riegl LMS-Q680i	266 k	2	2	NIR
Livox AVIA	240 k	2.5	3	905
Riegl 400	122k	0.3	0.5	NIR
VPL 16	600k	3	5	903

Software

Raw data Processing

RiANALYZE, DLR, opals, CloudStation, POSPac™ UAV, LiPowerline, Metashape

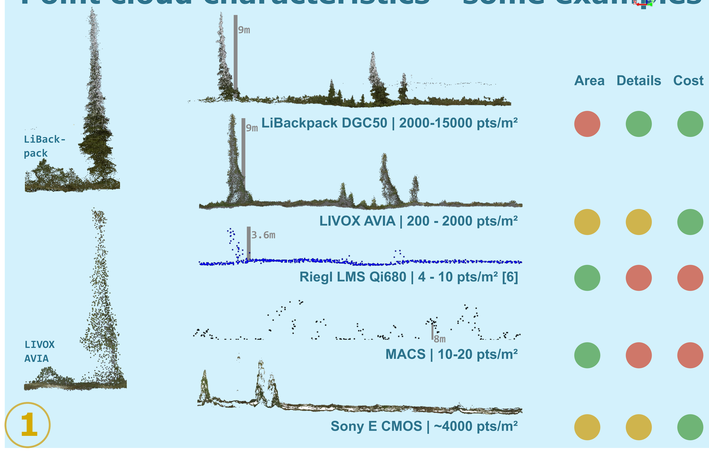
Labelling and Segmentation :

PyTorch, KPConv, Points 3D, lidR

Visualization:

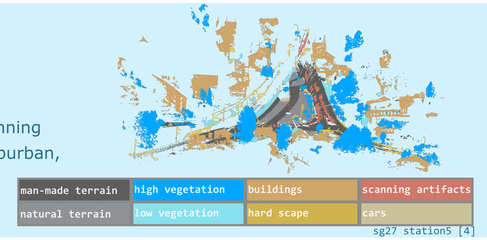
CC, LIDAR360

Point cloud characteristics - some examples



Semantic3D

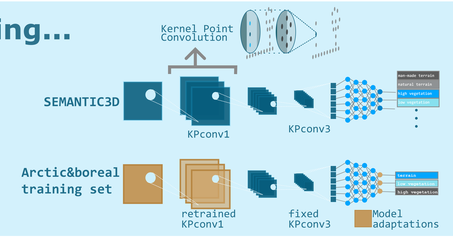
- number of sets: 30
- number of points: 4B
- Terrestrial LiDAR Scanning
- landscape: urban, suburban, rural



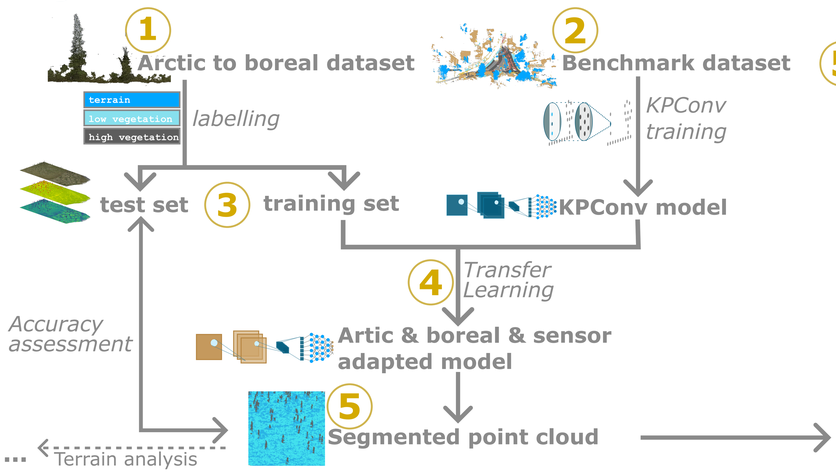
Transfer learning...

...uses the knowledge of a powerful pretrained model on a new but similar task

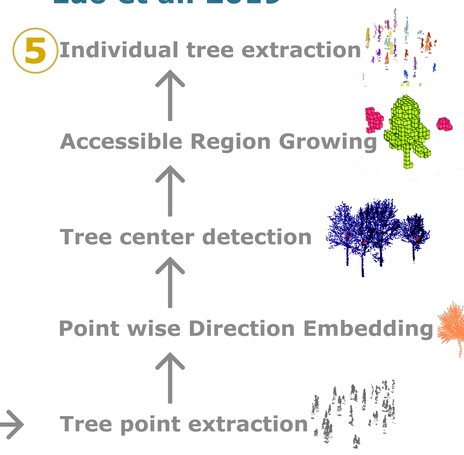
Why?
- Less sample data
- Faster learning curve
- More accurate results



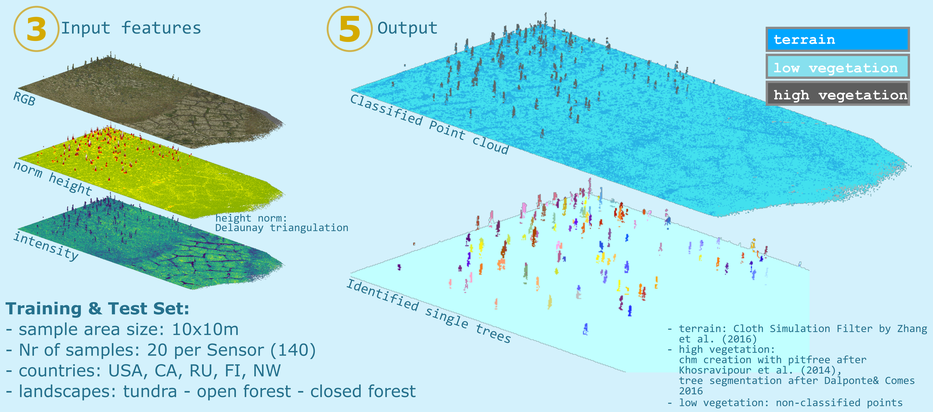
Segmentation and classification



Tree identification after Luo et al. 2019



Exemplary dataflow



Training & Test Set:
- sample area size: 10x10m
- Nr of samples: 20 per Sensor (140)
- countries: USA, CA, RU, FI, NW
- landscapes: tundra - open forest - closed forest

- terrain: Cloth Simulation Filter by Zhang et al. (2016)
- high vegetation: chm creation with pitfree after Khosravipour et al. (2014), tree segmentation after Dalponte& Comes 2016
- low vegetation: non-classified points

Potentials of the processed dataset

- Input for forest structure modelling (LAVESI)
- Biomass derivation
- Species detection
- Subsidence tracking
- Permafrost thaw feature detection
- Erosion quantification
- Hydrological modelling
- Drunken forest analysis

References
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Sharing is encouraged