Occlusion mapping tools for point cloud quality assessment in forest laser scanning

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COST Action 3DForEcoTech

WG1: Laser- and Image-based Data Collection

Task: Point cloud quality framework

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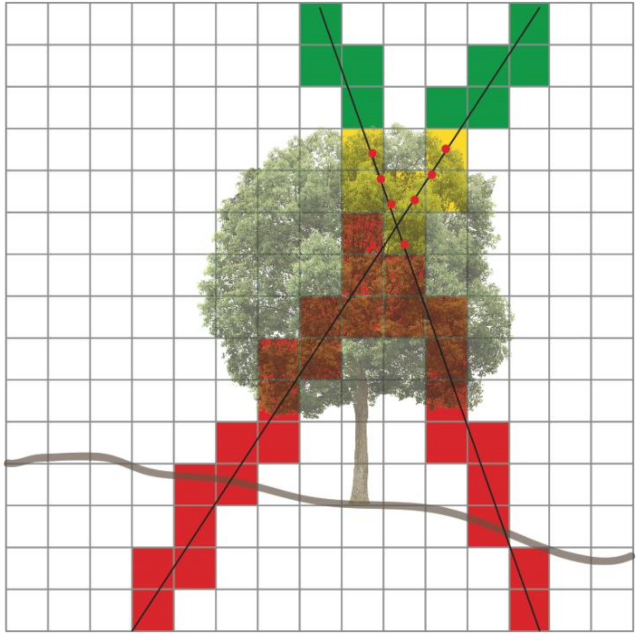
Motivation: Why Occlusion Mapping?

- Occlusion → incomplete point clouds
- Reduced accuracy/ reliability of derived metrics
- Occlusion often identified as a limitation
- Rarely quantified
- No standardized workflow/ tool available (yet)
- Occlusion mapping for quality assessment of data

Ray-tracing

- Required information:
  - Beam origin
  - Reflection points
- Generalization through voxelization
- Occlusion as relative value:

$$Occlusion\,rate = \frac{nOcclusion}{nMiss + nHit + nOcclusion}$$



Kükenbrink et al. (2015), SilviLaser 2015, La Grande Motte, France

Tools

	AMAPVox	OccPy	voxelizeR
Reference/ Developer	Vincent et al. (2017)	Daniel Kükenbrink	Benjamin Brede
Developed for Occlusion Mapping	No	Yes	Yes
Programming Language	R & Java	Python & C++	R
Supported Operating Systems	Linux-based, Mac OS X, Windows	Linux-based, Mac OS X, Windows	Optimized for Linux-based, runs on Windows
Multi-core Processing	Yes	No / Not yet	Yes (Linux)
Graphical User Interface	Yes	No	No
Additional plotting software required	No	Yes (e.g., VisIt)	Yes (e.g., QGIS)
3D Plots	Yes	Yes	No
Output File Format	VoxelSpace (.vox)	Numpy arrays (.npy)	GeoTIFFS (.tif)
Considering Beam Size	Yes	No	No
Height Normalization	Yes	Under development	Yes
LAD relevant Metrics	Yes	Under development	Yes

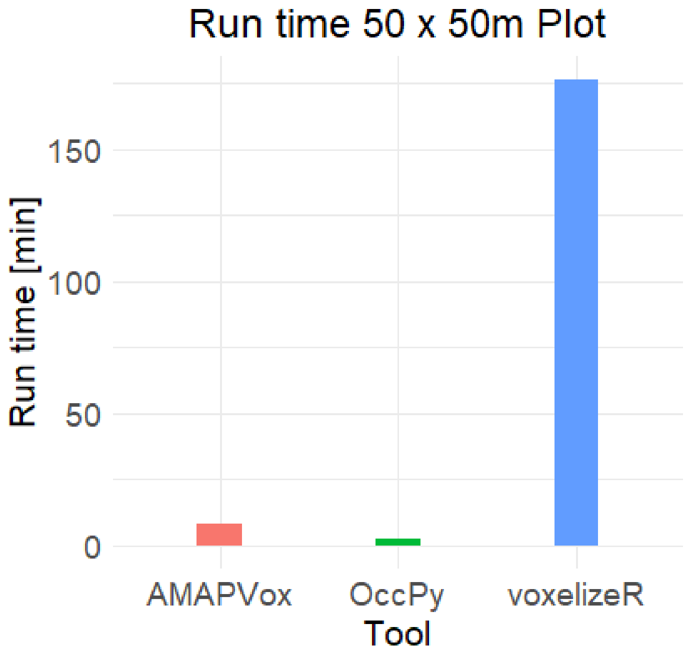
Benchmarking: Data

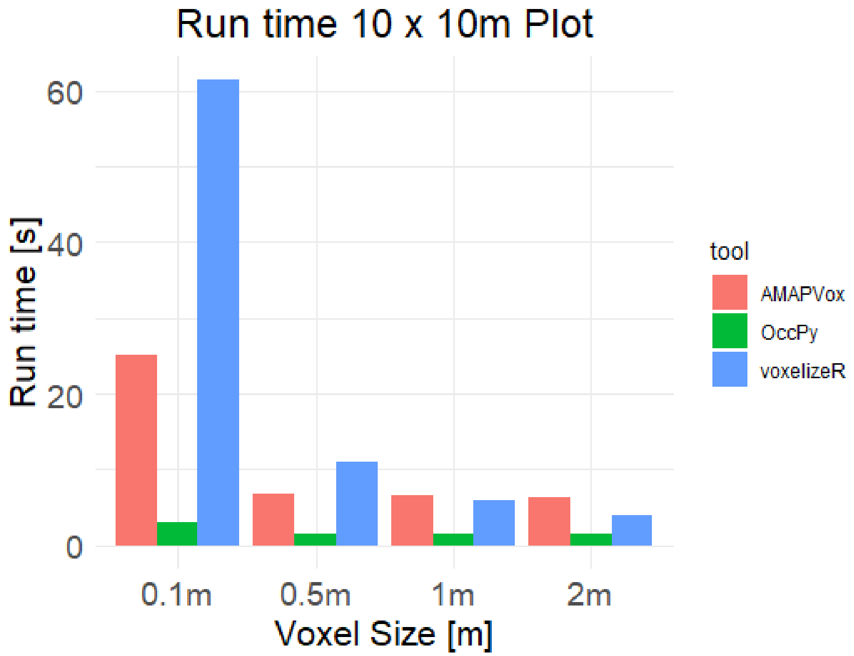
- TLS data
  - Faro Focus S120
  - Leica BLK 360
- MLS data
  - GeoSLAM ZebRevo
  - GeoSLAM ZebHorizon
- UAVLS data
  - RIEGL miniVUX2
  - RIEGL miniVUX3
- Voxel sizes: 2m, 1m, 0.5m, 0.1m

- Analysed area sizes:
  - 50 x 50 m²
  - 10 × 10 m²
- Point densities (UAVLS):
  - 1717.37 points per m²
  - Reduced by factor 1000
- Forest type: Beech forest
  - Kükenbrink et al. (2022) (https://doi.org/10.1016/j.jag.2022.102999)
  - Dataset freely available Kükenbrink & Marty (2023) (https://www.doi.org/10.16904/envidat.383)

Benchmarking: Run Time

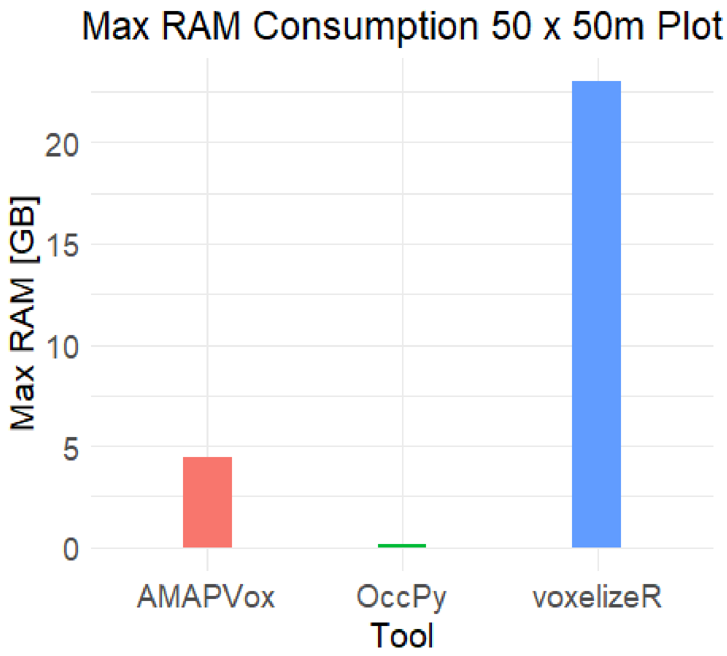
UAVLS Data

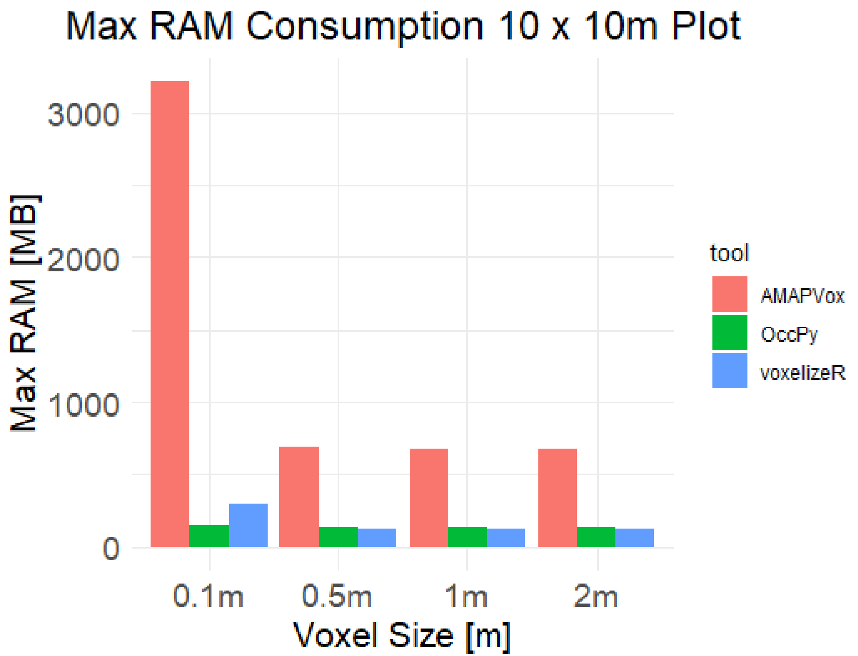




Benchmarking: RAM Consumption

UAVLS Data





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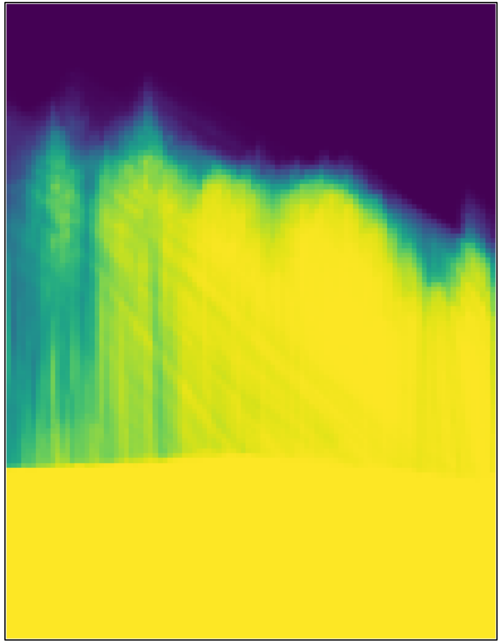
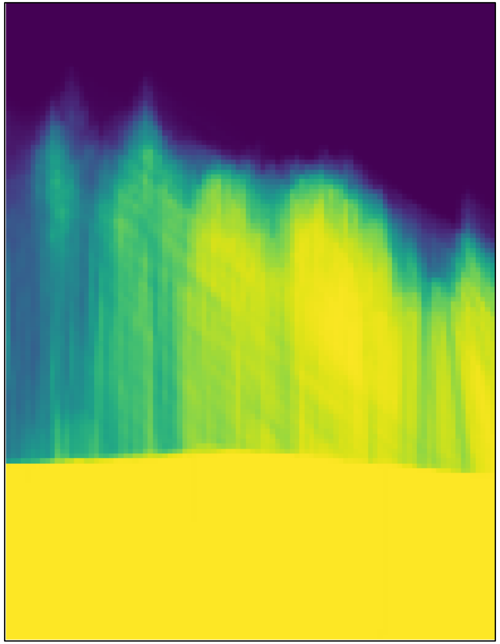
Benchmarking: User-friendliness

	AMAPVox	OccPy	voxelizeR
Pros	• Easy installation • GUI • No additional software required	• Good documentation • Easy to use control script	• Easy installation • Good documentation of functions • Variety of functions
Cons	• Not developed for occlusion mapping • Processing in multiple steps • Partly black box	• More complicated installation • Setting input parameters in script	• Setting input parameters in script

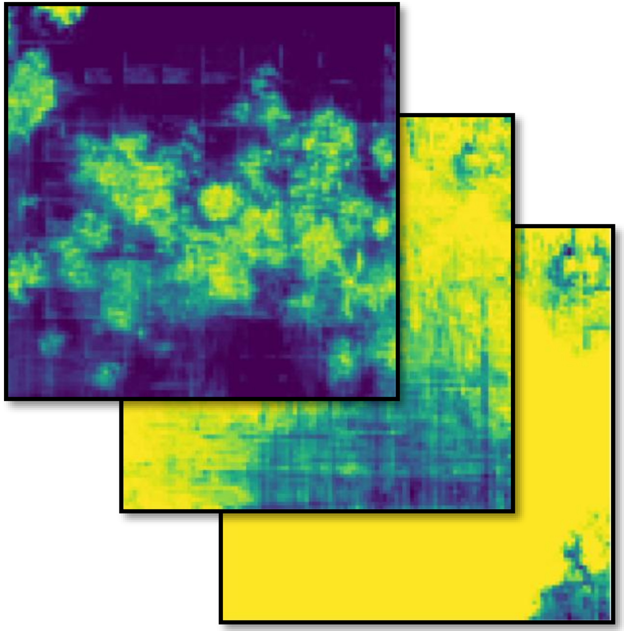
Example Outputs



AMAPVox



OccPy



voxelizeR

Considerations and Outlook

- Saving trajectory files or scan positions
- Choosing the appropriate voxel size
- Considering available processing capacities
- Testing scalability with bigger extents
- Writing a perspective paper
- Finetuning OccPy and voxelizeR

References

Brede, B., Bartholomeus, H. M., Barbier, N., Pimont, F., Vincent, G., & Herold, M. (2022). Peering through the thicket: Effects of UAV LiDAR scanner settings and flight planning on canopy volume discovery. *International Journal of Applied Earth Observation and Geoinformation, 114*, 103056.

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Vincent, G., Antin, C., Laurans, M., Heurtebize, J., Durrieu, S., Lavalley, C., & Dauzat, J. (2017). Mapping plant area index of tropical evergreen forest by airborne laser scanning. A cross-validation study using LAI2200 optical sensor. *Remote Sensing of Environment*, *198*, 254-266.

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Difference in Occlusion Calculation

AMAPVox	OccPy / voxelizeR
Considering beam size (bs)	NOT considering beam size → Rays assumed to be infinitely small
$Occlusion\ rate = \frac{bsOcclusion}{bsMiss + bsHit + bsOcclusion}$ → Using beam size of pulses	$Occlusion\ rate = \frac{nOcclusion}{nMiss + nHit + nOcclusion}$ → Using number of pulses
Increasing distance to scanner → increasing beam size → Increasing impact on occlusion rate value	Same impact of all pulses regardless of distance to the scanner