Typical Problems in LiDAR surveying

What should my flight plan look like to achieve sufficient coverage of the study area?

If my data were collected in a different way, would my method still work well?

I cannot obtain any reference data, how should I evaluate my method?

There is not enough labelled data available. My machine learning model does not learn anything. What can I do?

What should my flight plan look like to achieve sufficient coverage of the study area?

I cannot obtain any reference data, how should I evaluate my method?

There is not enough labelled data available. My machine learning model does not learn anything. What can I do?

If my data were collected in a different way, would my method still work well?

How should I plan the flight for the most efficient coverage of the study area?

I cannot obtain any reference data, how should I evaluate my method?

There is a systematic error in the data available and my model is not learning anything. What can I do?

If my data were collected in a different way, would my method still work well?

Simulation Experiments and Synthetic Data

Laser Scanning Simulation with HELIOS++

3DGeo Research Group, Institute of Geography, Heidelberg University, DE

Scientific Software Center (SSC), Interdisciplinary Center of Scientific Computing (IWR), Heidelberg University, DE

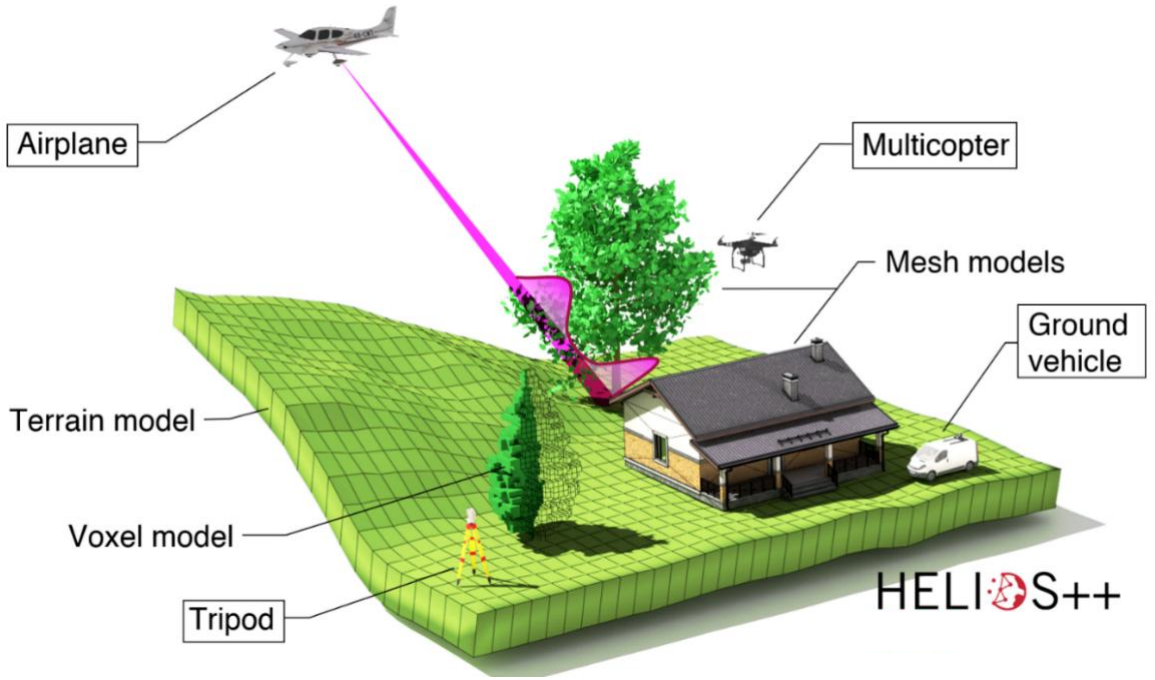
University of Innsbruck, AT

Catallactical S.L., ES

TRAIL Workshop on Archaeological Ground Point Filtering of LiDAR Point Clouds

Virtual Laser Scanning (VLS)

- **Simulation** of laser scanning in a computer environment
- VLS to **complement** costly **real data acquisition**, e.g.,
  - Survey planning
  - Sensitivity analysis
  - Algorithm and sensor development
  - Generation of labelled data
- **Annotations and known reference**
- Creation of different **scenarios** by changing
  - scene composition
  - acquisition platforms
  - acquisition settings



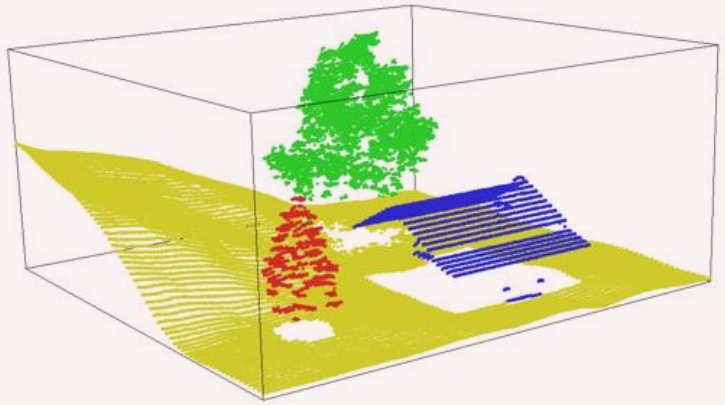
Winiwarter et al. 2022

HELIOS++

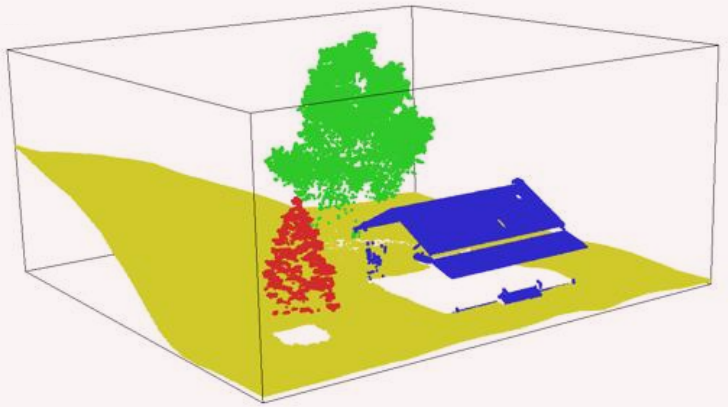
- **Open-source framework** for LiDAR simulation
- Supports multiple platforms, scanners, and scene types
- Full-waveform simulation and reflectance modelling
- Execute via command-line tool or Python API

https://github.com/3dgeo-heidelberg/helios

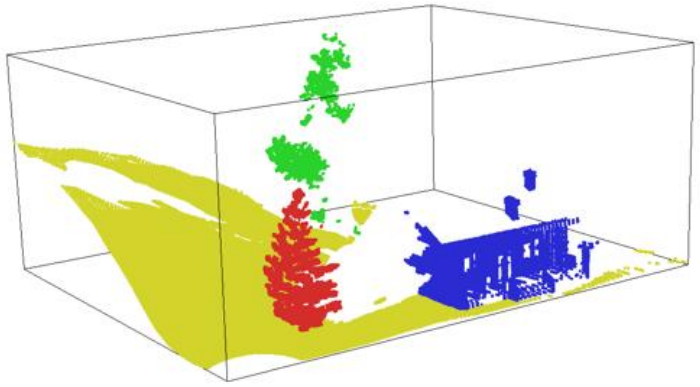
Airborne laser scanning (ALS)

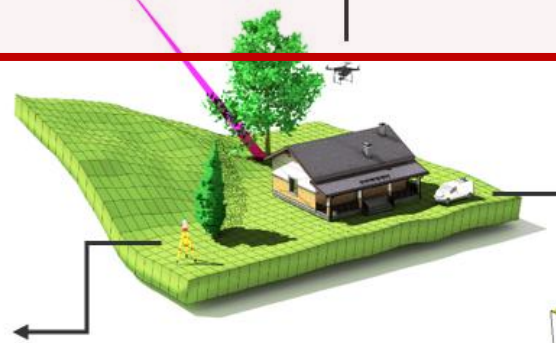


UAV-based laser scanning (ULS)



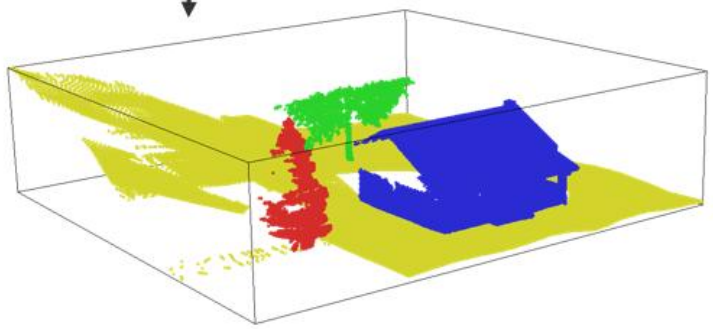
Terrestrial laser scanning (TLS)





3D scene

Mobile laser scanning (MLS)



Winiwarter et al. 2022: https://doi.org/10.1016/j.rse.2021.112772

HELIOS++

Heidelberg LiDAR Operations Simulator

Inputs

Survey parameters:
scan settings, trajectory (XML)

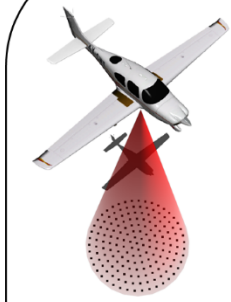
Platform
specifications (XML)

Scanner
specifications (XML)

3D **Scene** parts
(GeoTIFF, OBJ,
XYZ, VOX)

with transformations
(translation, rotation,
scale) and motions
(XML)

Simulation



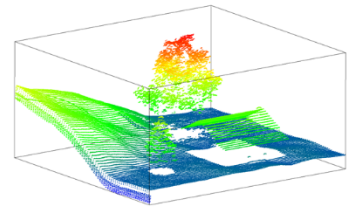
Multi-channel
physical-based
ray tracing

for multiple sub-rays
(**beam divergence**)

Interface
Command line / Python
bindings **`pyhelios`**

High performance
Parallelization
Optimized KDTree

Outputs

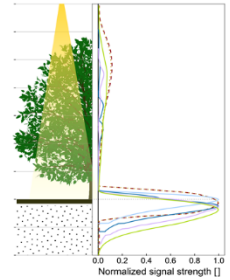


Point clouds
(ASCII / LAS)

Trajectory (ASCII)

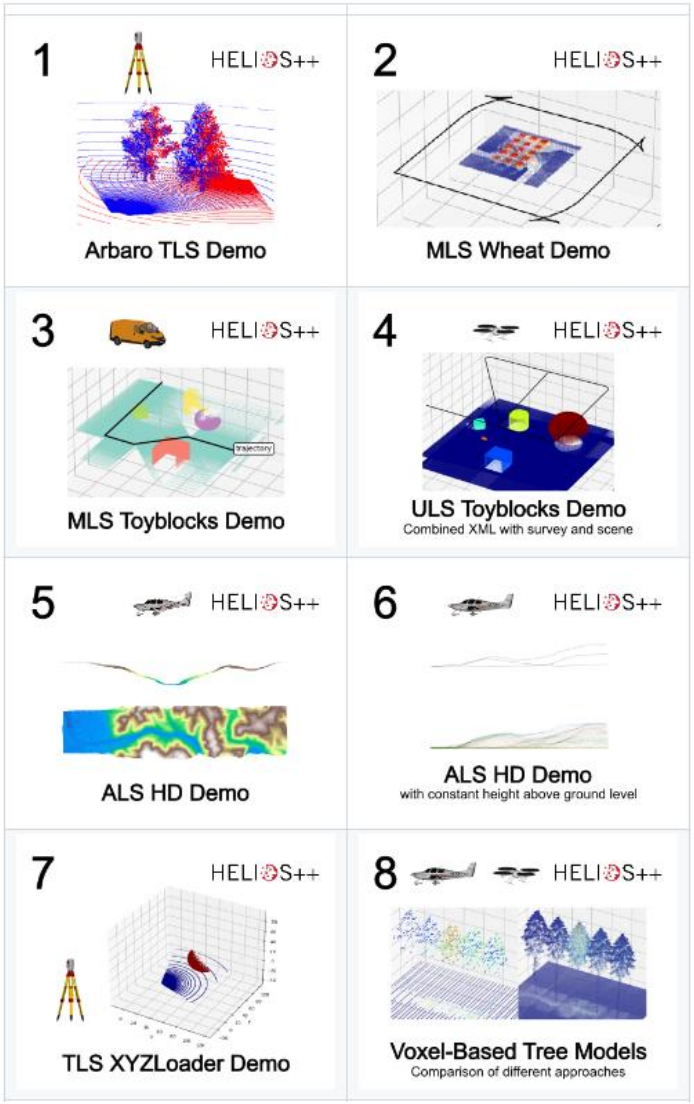
Full waveform
(ASCII)

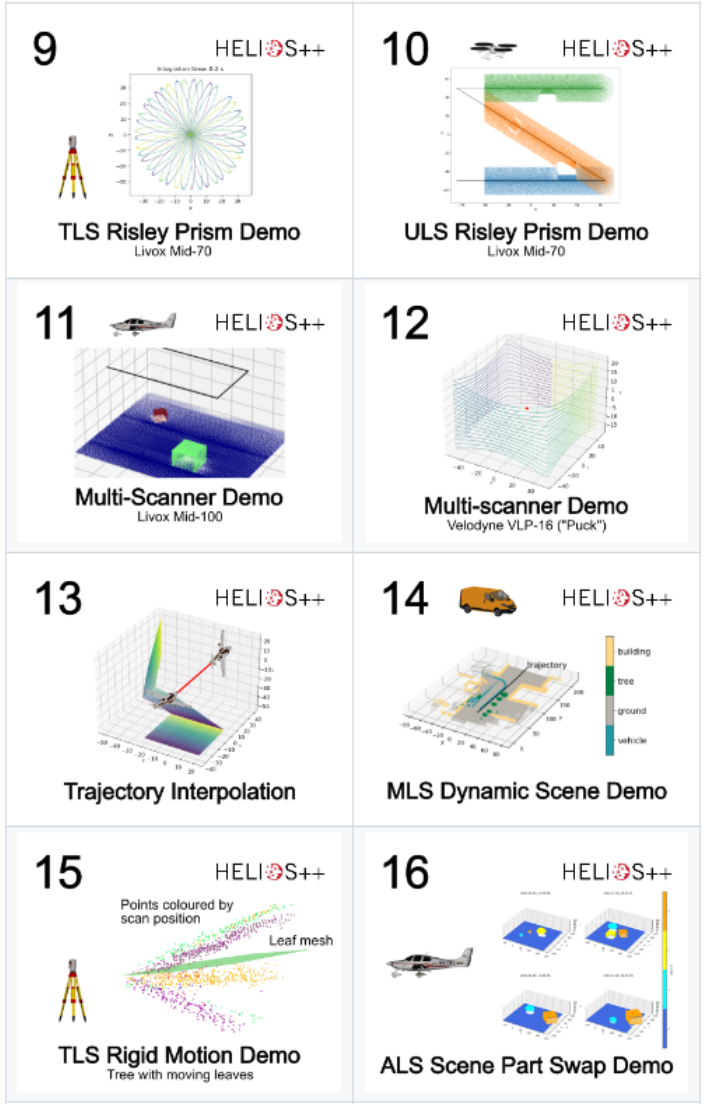
Log
(ASCII)

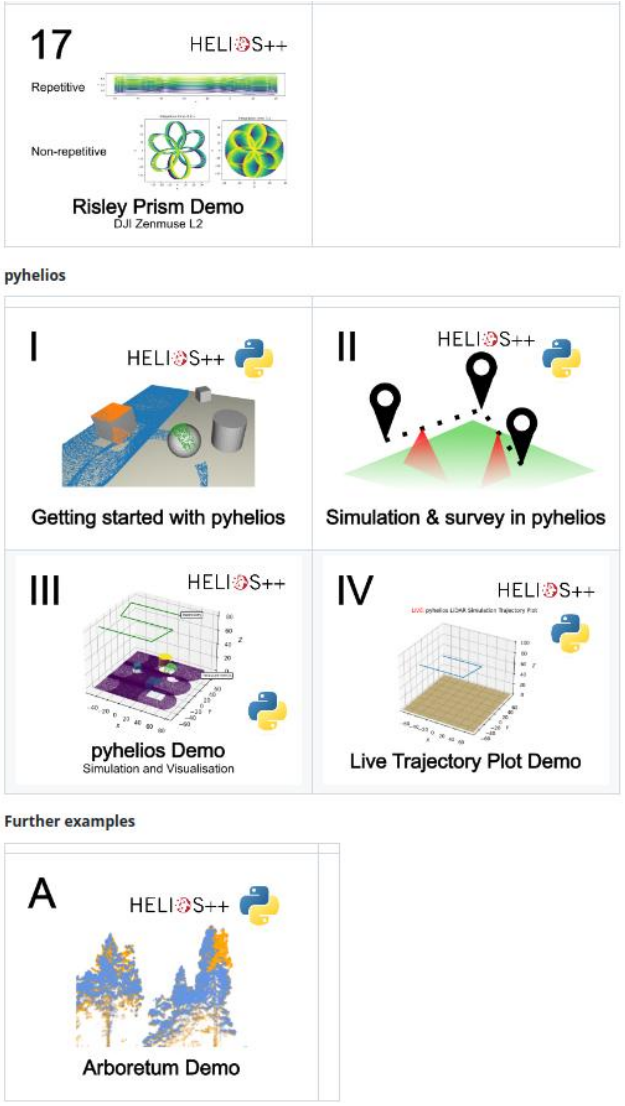


Gallery of Examples

https://github.com/3dgeo-heidelberg/helios?tab=readme-ov-file#-examples







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