Unconventional LiDAR Mapping from Air, Mobile and Terrestrial

Juha Hyyppä

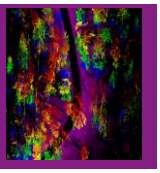
www.fgi.fi/coelasr
juha.hyyppa@fgi.fi
Papers: Google Scholar

GEODEETTINEN LAITOS

Stuttgart, September 11, 2013

CoE-LaSR

Centre of Excellence in Laser Scanning Research



Finnish Geodetic Institute, Juha Hyyppä, Professor, (Remote Sensing and Photogrammetry), Head of Department, D.Sc. (El. Eng.),
University of Oulu, Juha Kostamovaara, Academy Professor (Electronics), Head of Electronics Laboratory
University of Helsinki, Markus Holopainen, Professor, (Geoinformatics), D.Sc. (Surveying), PhD (Forest Inventory),
Aalto University, Hannu Hyyppä, Head of Research Institute of Measuring and Modelling of Built Environment, adjunct. prof., D.Sc. (Civ.Eng)

1.1.2014-31.12.2019

GEODEETTINEN LAITOS

Together "what is otherwise impossible"

GEODEETTINEN LAITOS

International benchmarking studies

Unconventional LiDAR Mapping from the air

Anttoni Jaakkola, Yuwei Chen, Juha Hyyppä, Xiaowei Yu

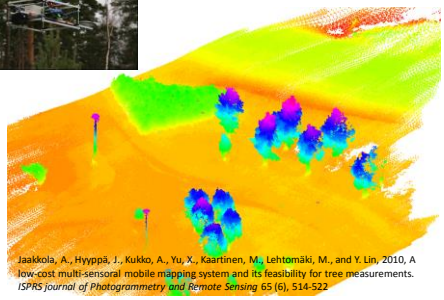
GEODEETTINEN LAITOS

UAV LS – 2nd generation FGI system

GEODEETTINEN LAITOS

5

UAV-based Laser Scanning SENSEI

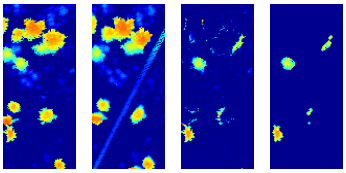


Jaakkola, A., Hyyppä, J., Kukko, A., Yu, X., Kaartinen, M., Lehtomäki, M., and Y. Lin, 2010, A low-cost multi-sensoral mobile mapping system and its feasibility for tree measurements. *ISPRS journal of Photogrammetry and Remote Sensing* 65 (6), 514-522

GEODEETTINEN LAITOS

GEODEETTINEN LAITOS

UAV LS is usable for multitemporal studies

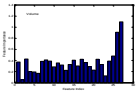


GEODEETTINEN LAITOS

Use of Individual Tree Features in ABA

Accuracy of area-based inventory based on three different feature sets.

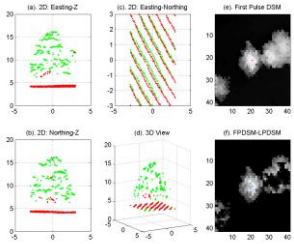
	Bias	RMSE	RMSE (%)	R
With all features				
Mean height (m)	-0.00	1.10	6.15	0.98
Mean DBH (cm)	0.00	2.91	16.07	0.89
Volume (m³/ha)	0.24	30.05	20.32	0.96
With point height metrics				
Mean height (m)	-0.03	1.25	6.99	0.98
Mean DBH (cm)	0.02	3.02	16.65	0.88
Volume (m³/ha)	0.13	**37.56**	**25.41**	0.93
Individual-tree-based features				
Mean height (m)	-0.00	1.24	6.97	0.98
Mean DBH (cm)	-0.06	3. 54	19.54	0.83
Volume (m³/ha)	-1.06	**30.16**	**20.40**	0.96



GEODEETTINEN LAITOS

First-Last Pulse Difference

Deciduous Trees



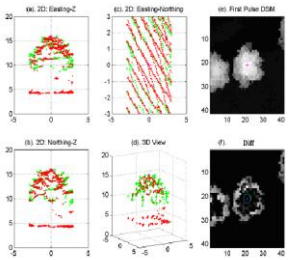
First pulses: in green; Last pulses: in red

Courtesy to X. Liang, FGI

GEODEETTINEN LAITOS

First-Last Pulse Difference

Coniferous



Courtesy to X. Liang, FGI

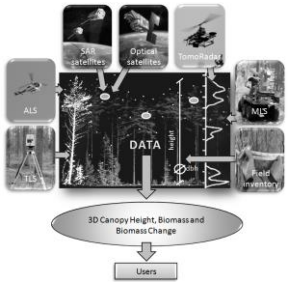
GEODEETTINEN LAITOS

State-of-the-art of Forest Inventory

- Dominant canopy height in large areas with ALS
  - Processing level either microstand or tree level
- Canopy Height of other storeys
  - Point cloud metrics (ABA) or ITD
- Reference
  - MLS
  - TLS
  - field plots
- Tree Species:
  - LS point cloud,
  - aerial image,
  - hyperspectral aerial image,
  - waveform,
  - LS time series
  - **Multispectral ALS in needed (boreal zone, 3-4 tree species needs to be mapped)**

GEODEETTINEN LAITOS

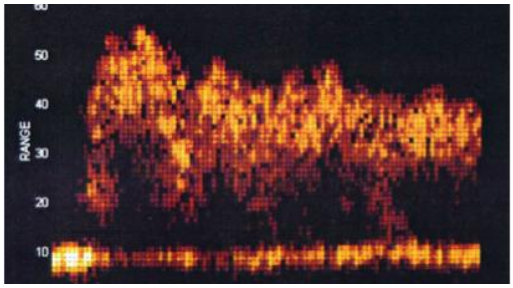
UAV Tomoradar



GEODEETTINEN LAITOS

GEODEETTINEN LAITOS

Output of UAV TomoRadar



GEODEETTINEN LAITOS

Unconventional LiDAR Mapping from mobile

Antero Kukko, Harri Kaartinen, Anttoni Jaakkola, Yuwei Chen, Xinlian Liang, Juha Hyyppä, Hannu Hyyppä (Aalto), Matti Vaaja (Aalto)

GEODEETTINEN LAITOS

Backpack MLS – 2nd generation

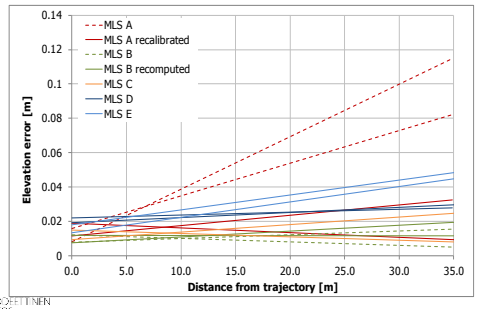
GEODEETTINEN LAITOS

FGI Roamer – 3rd generation

GEODEETTINEN LAITOS

Accuracy of MLS in good GNSS

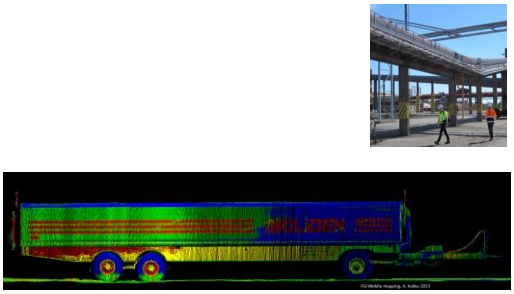
- Elevation error vs. distance



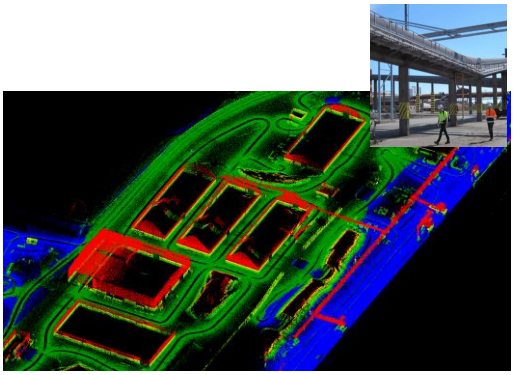
GEODEETTINEN LAITOS

GEODEETTINEN LAITOS

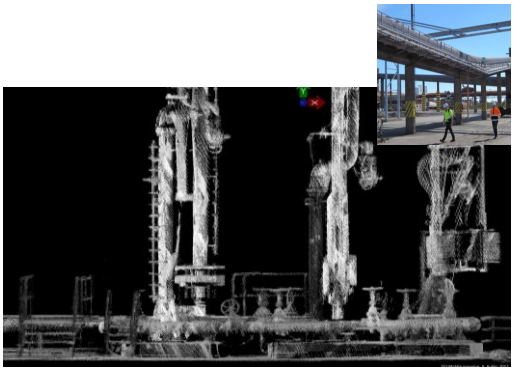
GEODEETTINEN LAITOS



GEODEETTINEN LAITOS 19



GEODEETTINEN LAITOS 20



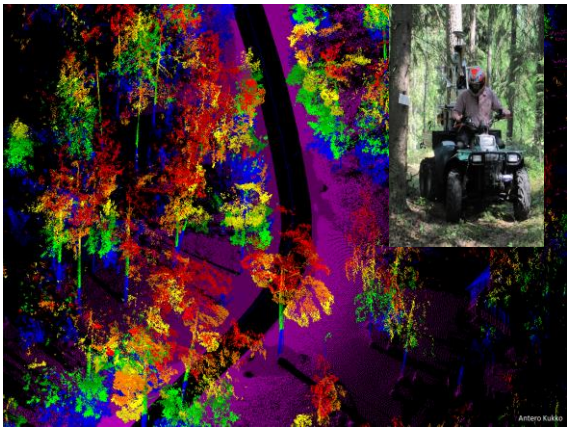
GEODEETTINEN LAITOS 21

GEODEETTINEN LAITOS

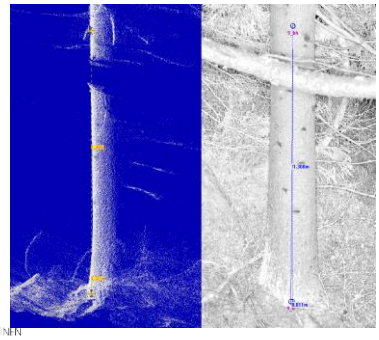
GEODEETTINEN LAITOS

GEODEETTINEN LAITOS

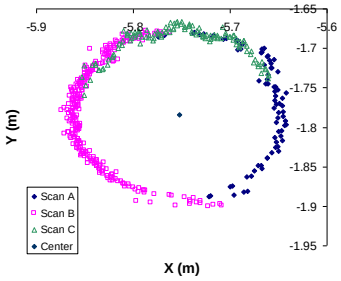
TLS/MLS with harvester



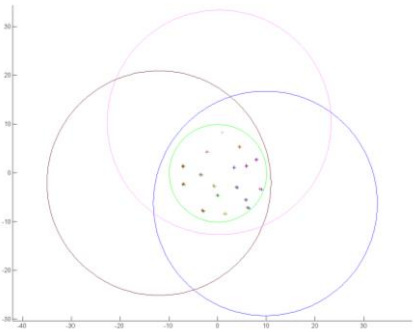
Dbh determination



- SS: only part of the trunk detected, diameter estimation not accurate
- MS: diameter estimated from matched point clouds



Multi-Single-Scan



Multi-Single-Scan

The results of stem mapping using the MSS method

Plot		1	2	3	4	5
Density (stems/ha)		605	732	764	764	1210
Detection	(mapped stem /the total)	18/19	23/23	22/24	24/24	35/38
	(%)	94.7	100	91.7	100	92.1
DBH	Bias (cm)	0.69	0.23	0.70	0.11	0.63
	RMSE (cm)	0.90	1.64	1.90	0.97	1.79
	RMSE (%)	5.16	7.72	9.77	5.26	9.84
Height	Bias (m)	1.16	2.11	1.69	1.95	-0.34
	RMSE (m)	2.04	6.53	3.74	3.16	4.58
	RMSE (%)	12.47	34.11	21.21	22.02	26.34

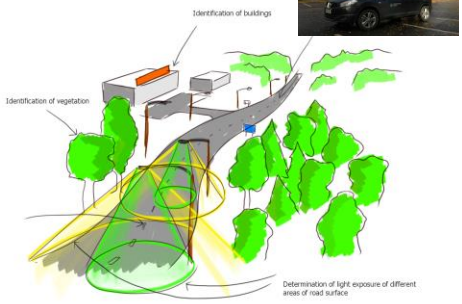
GEODEETTINEN LAITOS

The volume estimation using automatic TLS measurements and Laasasenaho volume models

Volume	Species	Bias (dm^3)	RMSE (dm^3)	RMSE (%)	R
TLS	Pine	-0.91	24.24	8.88	0.98
	Spruce	-12.49	34.90	9.75	0.99
	All	-5.87	29.29	9.47	0.99
f(d,d6,h)	Pine	-5.37	21.97	8.04	0.99
	Spruce	-12.66	36.17	10.11	1.00
	All	-8.50	28.92	9.35	0.99
f(d,h)	Pine	-6.85	29.41	10.77	0.98
	Spruce	-0.53	36.68	10.25	0.99
	All	-4.14	32.72	10.57	0.99

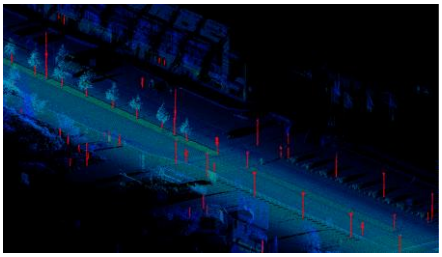
GEODEETTINEN LAITOS

MLS in road lightning mapping



GEODEETTINEN LAITOS

Traffic pole recognition



Pole-type object derived from mobile mapping point clouds by an automatic process. In the project, we further develop object extraction methods for documenting of the road environment.

GEODEETTINEN LAITOS

Cultural heritage mapping

GEODEETTINEN LAITOS

A Step Forward

GEODEETTINEN LAITOS

Unconventional LiDAR Mapping from terrestrial

Yuwei Chen, Teemu Hakala, Anttoni Jaakkola, Xinlian Liang, Sanna Kaasalainen, Juha Hyyppä

GEODEETTINEN LAITOS

Defoaliation

- TLS measurement (number of points very high, ab. 1 M hits from one tree)
- Pine tree selected, simulation of the needle loss caused by Large pine sawfly (*Diprion pini*)
- Manual destructive removal of needles in six consecutive steps, weight of removed needles measured with accuracy of 2g. The original weight of the tree measured. TLS was recording the pine tree after each step
- Voxel model created
- Additionally, features calculated such as
  - Number of hits coming from the tree (above a threshold)
  - Relation of tree hits (tree hits divided by the total number of hits)
  - Number of ground hits

GEODEETTINEN LAITOS

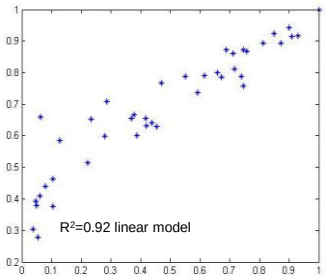
Use of TLS

- Single scan/Multi Scan
- Trunk location
- Trunk diameters and trunk curves
- Tree Species
- ALS + TLS integration

Courtesy to H. Kaartinen, FGI

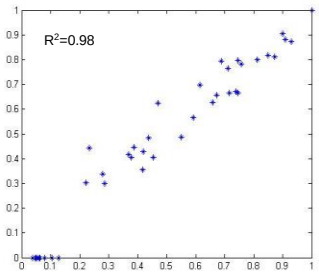
GEODEETTINEN LAITOS

Total biomass



GEODEETTINEN LAITOS

Branch and needle biomass

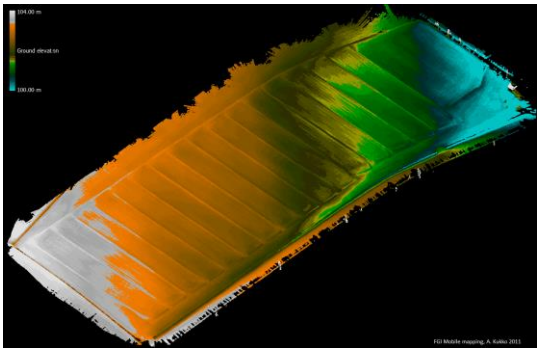


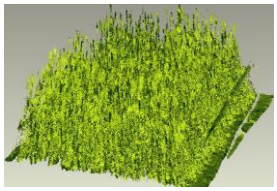
GEODEETTINEN LAITOS

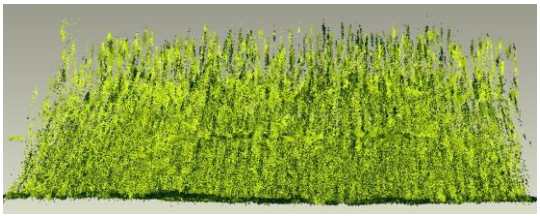
Crop Inventory

Kemira's test site in Vih

GEODEETTINEN LAITOS

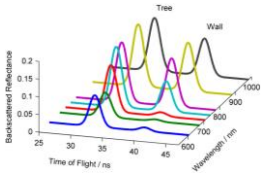






Hyperspectral Lidar

- Supercontinuum laser & laser scanning
- Hyperspectral LiDAR prototype
- Data example & processing
- Environmental applications

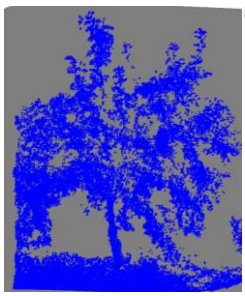


Teemu Hakala, Sanna Kaasalainen, Juha Suomalainen

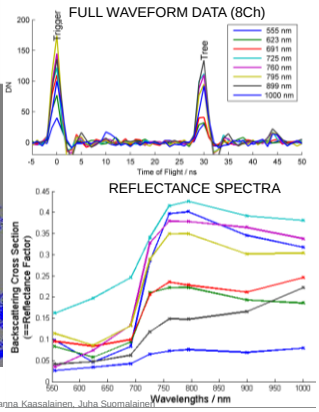
Example of Measurement Data

- Apple tree
- 3.5m high
- 4.5m distance
- 375 000 points with spectra
- 15 minutes scan time

Data

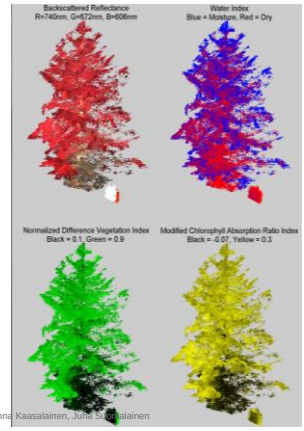


3D POINT CLOUD



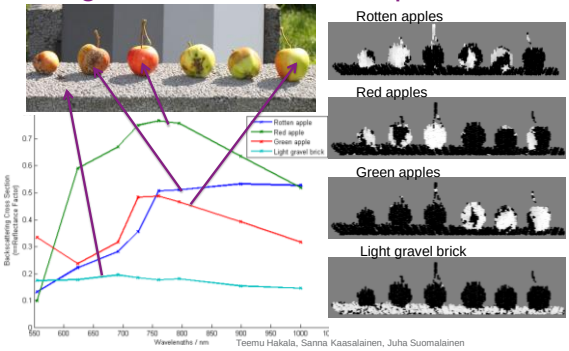
Teemu Hakala, Sanna Kaasalainen, Juha Suomalainen

Applications



Teemu Hakala, Sanna Kaasalainen, Juha Suomalainen

Target classification example



Teemu Hakala, Sanna Kaasalainen, Juha Suomalainen

Technology and applications of virtual 3D models using mobile mapping and 3D games engines

Juha Hyyppä, Anttoni Jaakkola and Lingli Zhu

GEODEETTINEN LAITOS

Automatic generation of virtual reality

GEODEETTINEN LAITOS

Summary

- Unconventional usage of LS actually means that you can use laser scanning/LiDAR in a wide range of problems, applications and phenomena.