

Mapping the change using 3D

point clouds

Abderrazzaq Kharroubi

Engineer in geomatics and surveying PhD candidate at ULiège-Geomatics 10)

Promoter : Prof. Roland Billen Co-promoter : Prof. Adj. Florent Poux



Dynamics on earth



 \rightarrow Automatic change detection is of general interest for monitoring dynamic process which can show a confusing

situation for human observers.

Change detection in remote sensing

- Optical satellite images
- □ InSAR (Interferometric SAR)
- **RADAR**
- □ Laser scanning point clouds
- Automatic change detection is of general interest for monitoring dynamic process.



Created with: https://streamlit.geemap.org/

Predicting the Future by Mapping the Past !

From a time-serie, we aim to detect locations where changes occurred over time, e.g:

- □ Man-made changes: appearance/disappearance of building,...
- □ Natural changes: vegetation growth, deforestation, flooding, fires,...
- □ Variations of terrain: glacier displacements, land subsidence,...



Source



Why 3D Point clouds?

The major advantages of using 3D data over 2D for change detection:

Insensitive to illumination differences: comparison of geometry of bi-temporal data is irrespective of illumination conditions.

Insensitive to perspective distortions in 2D CD: the comparison of geometry can be performed in a true three-dimensional space, or any projected space.

Volume information: 3D CD provides volumetric changes, so more application.

Near-continuous laser scanning (terrestrial and aerial).

3D point clouds for change detection



Date 1



Date 2





Hidden part in each point clouds

No direct comparison (no corresponding points)

Sensitive to: Clutter Noise, Occlusion, Co-Registration error Specifities: Multi-direction and multi-view

Pre-, during-, and post-classification change detection

Pre-classification	•No semantics
	No change type





Iris de Gélis et al. 2021

(c) Labeled changes on PC 2

Post-classification	•Results are highly impacted by the classification quality	~
1 031-01033110411011	Multiplicative errors	$\sum_{i=1}^{n}$







Single step
•Interaction and refinement of classification process

Approaches + Datasets + Metrics

nethods	Image differencir					
	• C2C (Cloud to cloud)					
M3C2 (Multiscale Model to Model Cloud Comparison)						
ith handcrafted features	Machine learning (<u>Random forest</u>)					
iCN, SiamPointNet++, Siamese	• Deep learning (<u>Sia</u> <u>KPConv</u> ect)					
int clouds	• Scene flow in 3D					
et3D \rightarrow scene flow: $n_1 \times 3$	point cloud 1: $n_1 \times 3$					
Signature flow: $n_1 \times 3$	• Deep learning (Size <u>KPConvect</u>) • Scene flow in 3D • Scene flow in 3D • point cloud 1: $n_1 \times 3$ point cloud 2: $n_2 \times 3$					

		Veer	Data type			CD Approach	
	Authors	Year	Lidar	Image	Maps	CD Approach	CD Classes
	Matikainen et al. [22]	2004	х	х	х	Post-classification	Building
	Matikainen et al. [23]	2010	х	х	х	Post-classification	Building
	Stal et al.[24]	2013	х	х		Post-classification	Building
	Malpica et al. [25]	2013	х	х		Post-classification	Building
	Matikainen et al. [26]	2016	х	х	х	Post-classification	Building
	Matikainen et al. [27]	2017	х	х	х	Post-classification	Building, roads
	Vosselman et al.[28]	2004	х		х	Post-classification	Building
	Tang et al.[29]	2015	х		х	Post-classification	Building
	Awrangjeb et al. [30]	2015	х		х	Post-classification	Building
	Choi et al [31]	2009	x			Post-classification	Ground, vegetation,
		2005					building
	Xu et al. [32,33]	2013,	x			Post-classification	Building
	Huang at al [24]	2015		v		Post classification	Puilding
	nualig et al. [54]	2021		^		Post-classification	bullullig
	Teo et al. [35]	2013	х			Post-classification/DSM-based	Building
	Murakami et al. [36]	1999	x			Pre-classification/DSM-based	Building
	0	2014	X				
	Pang et al. [37]	2014	X			Pre-classification/DSM-based	Building
	Vu et al. [38]	2004	х			Pre-classification/DSM-based	Building
	Zhang et al. [39]	2014	x			Pre-classification	Ground
	Xu et al. [33,40]	2015	x			Pre-classification	Building, tree
	Du et al. [41]	2016	х	х		Pre-classification	Building
	Zhang et al. [42]	2019	х	х		Integrated	Building
	Ku et al. [43]	2021	х			Integrated	Building, street, tree
	Iris et al. [44]	2021	х			Integrated	Building
	Tran et al. [45]	2021	x			Integrated	Ground, vegetation,
							building
	Zhang [46]	2022	x			Integrated	Building

Changes that matter !

Essentially we search to MINIMIZE changes due to characteristics we are NOT interested in, in order to IDENTIFY changes we ARE interested in. Changes that matter !

Automatic Point Cloud 3D Change Detection Using a Priori

Semantic Information

Make sense of the captured data !



Change detection and delineation



Do not hesitate to contact



Geomatics Unit | geomatics.ulg.ac.be Allée du Six Août 19 (B5A) | 4000 Liège



This research was funded by the National Belgian Funds for Scientific Research FNRS-FRS, through an Aspirant FRNS grant for Abderrazzaq KHARROUBI (Oct. 2021).



akharroubi@uliege.be

My Publications

- Abderrazzaq Kharroubi, Rafika Hajji, Roland Billen, Florent Poux. Classification and integration of massive 3d points clouds in a virtual reality VR environment. ISPRS - International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences. (2019).
- 2. Abderrazzaq Kharroubi, Roland Billen, Florent Poux. Marker-less mobile augmented reality application for massive 3d point clouds and semantics. ISPRS International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences. (2020).
- 3. Abderrazzaq Kharroubi, Line Van wersh, Roland Billen, Florent Poux. Tesserae3d: a benchmark for tesserae semantic segmentation in 3D point clouds. ISPRS International Annals of the Photogrammetry, Remote Sensing and Spatial Information Sciences. (2021).
- 4. Gilles-Antoine Nys, Abderrazzaq Kharroubi, Florent Poux, Roland Billen. An extension of CityJSON for the support of 3D point clouds. ISPRS - International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences. (2021).
- 5. Rafika Hajji, Abderrazzaq Kharroubi, Youssef Benbrahim, Zidane Bahhane and Adil El Ghazouani. Integration of BIM and Mobile Augmented Reality in the AECO Domain. ISPRS - International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences. (2021).



Future: Point clouds visual question answering (PCVQA)



[Lobry, Marcos, Murray, Tuia, IGARSS 2019]

An advanced form of the SPC !

Standard approach



- Co-registration
- Resampling
- Errors estimation

- Reducing noise
- Handling missed data

- Reference scene
- Moving scene

Point to point differencing

3D Change detection type



3D data representation



Point clouds segmentation

