

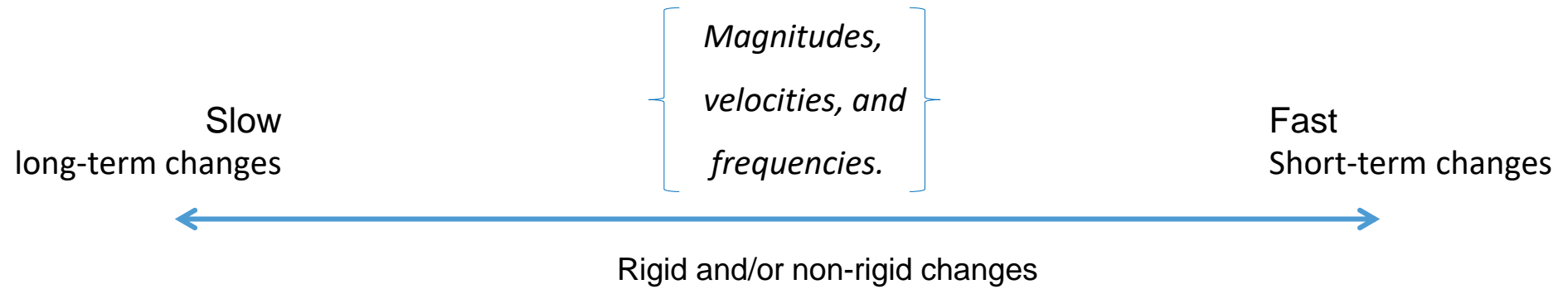
Mapping the change using 3D point clouds

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

3rd May 2022 in Brussels

Dynamics on earth

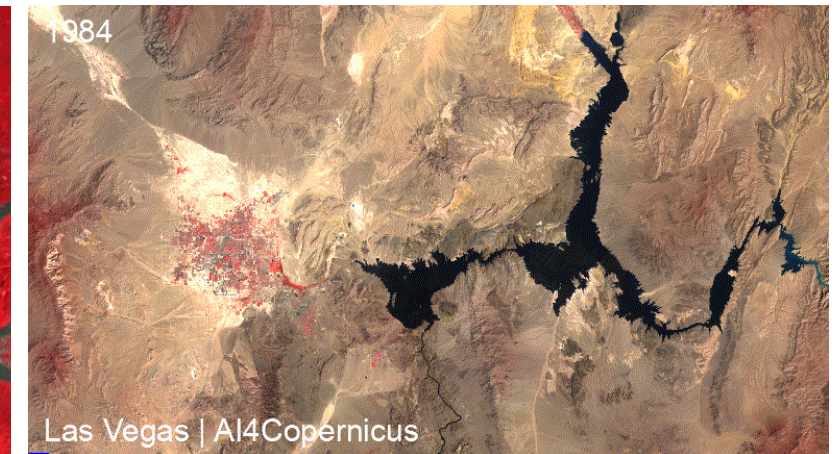
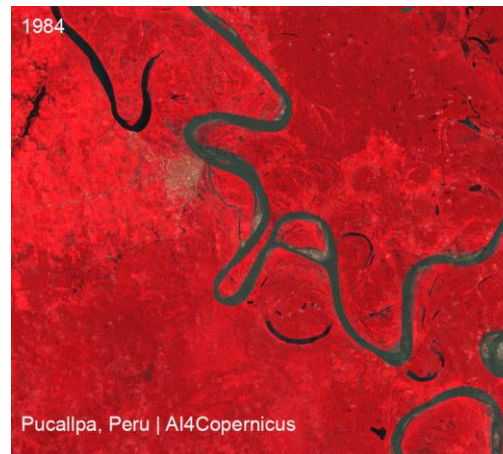
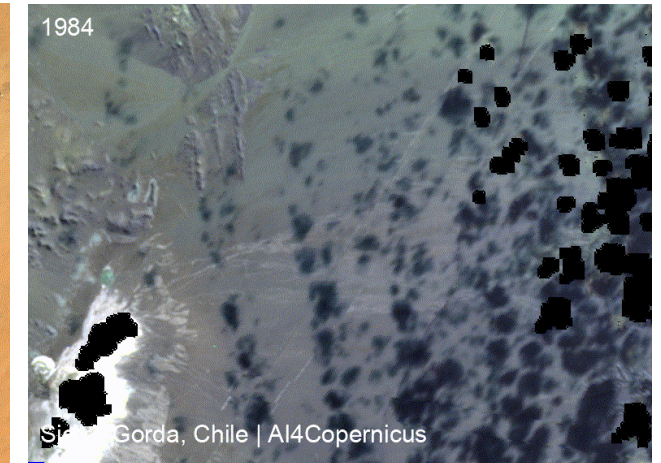


→ Automatic change detection is of general interest for monitoring dynamic process which can show a confusing situation for human observers.

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.

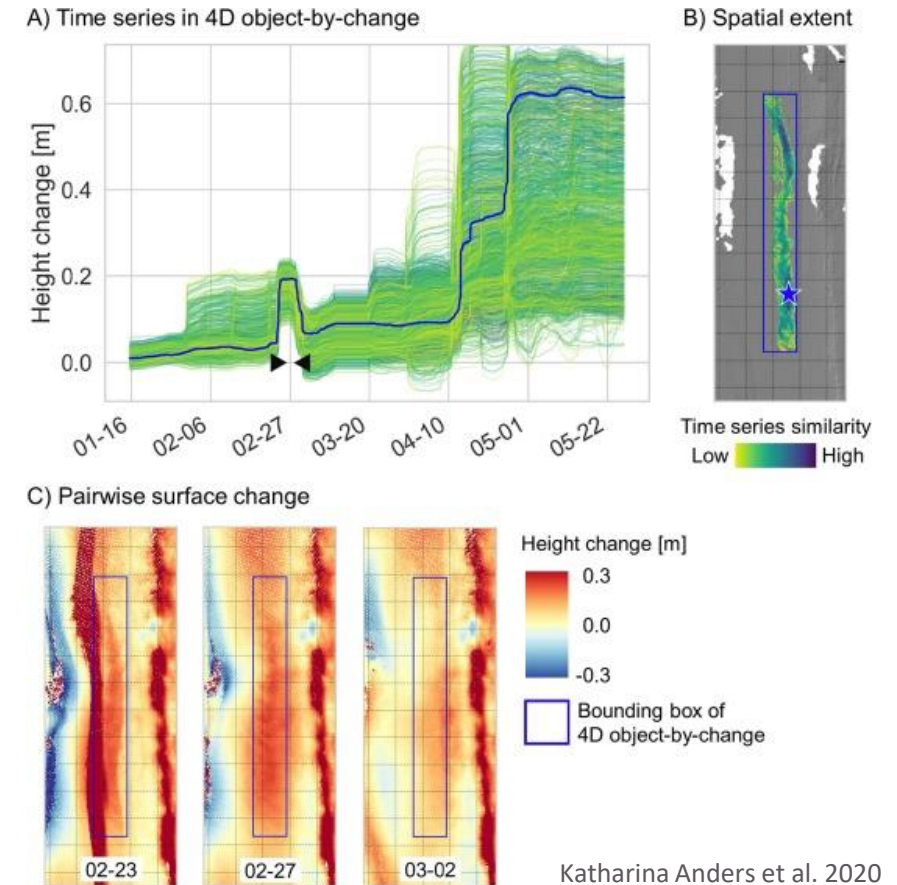
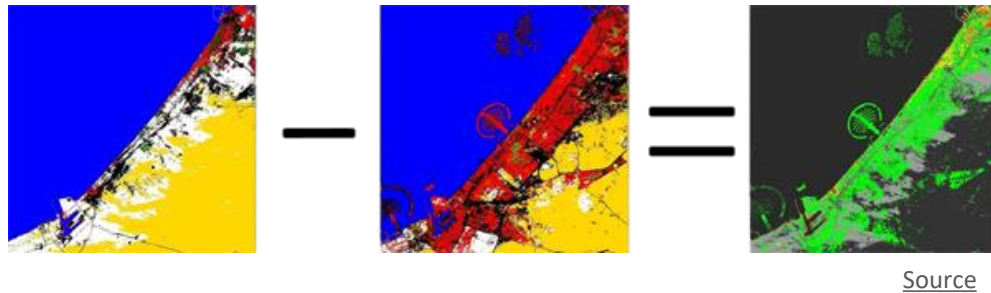


Created with: <https://streamlit.geemap.org/>

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,...



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.

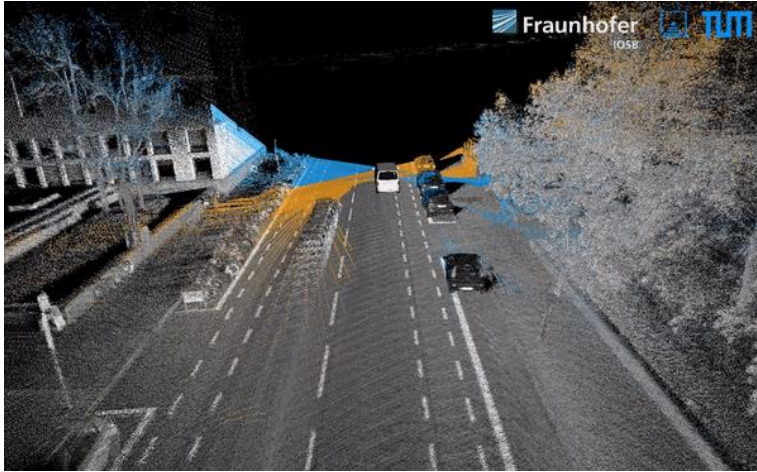
Insensitive to perspective distortions in 2D CD: the comparison of geometry can be performed in a true three-dimensional space, or any projected space.

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

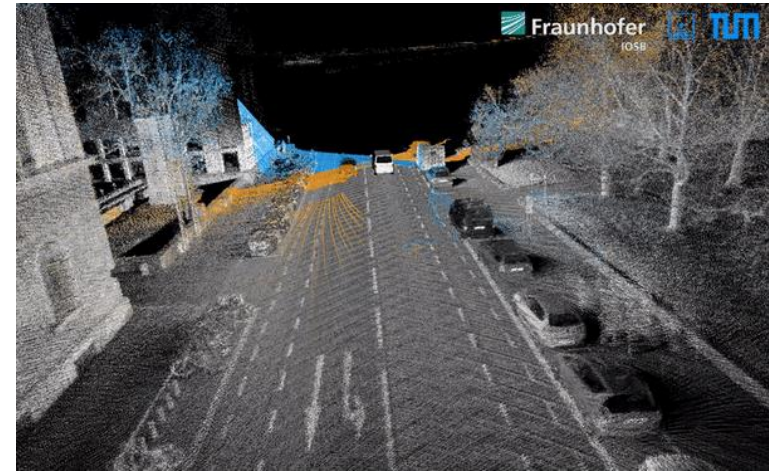
Near-continuous laser scanning (terrestrial and aerial).

3D point clouds for change detection

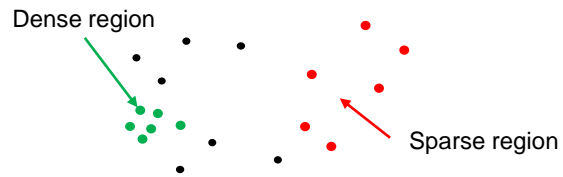
Date 1



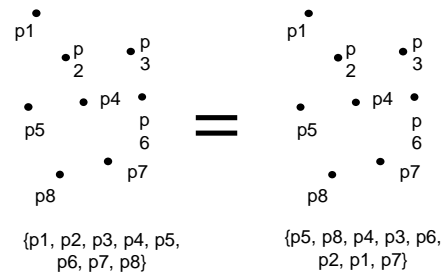
Date 2



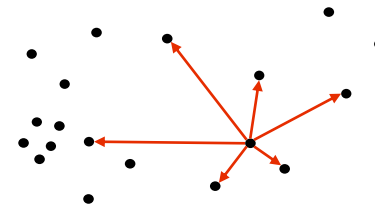
Irregular



Unordered



Unstructured



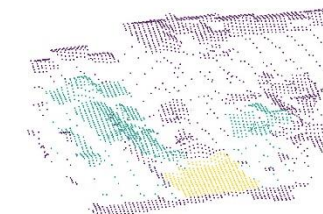
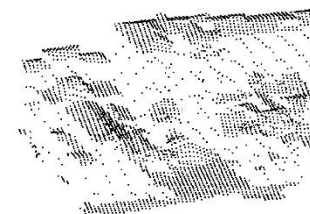
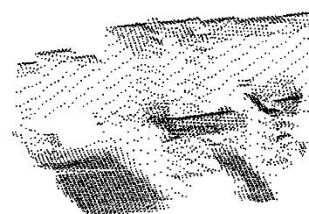
- Hidden part in each point clouds
- No direct comparison (no corresponding points)

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

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

Pre-classification

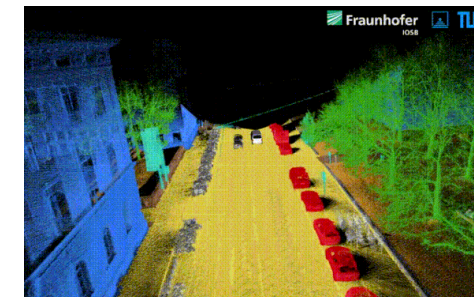
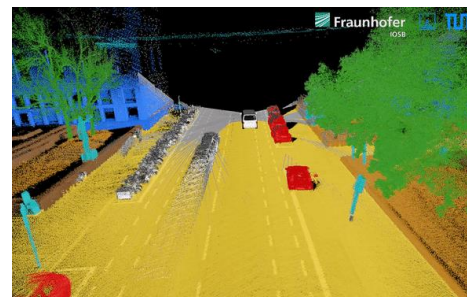
- No semantics
- No change type



Iris de Gélis et al. 2021

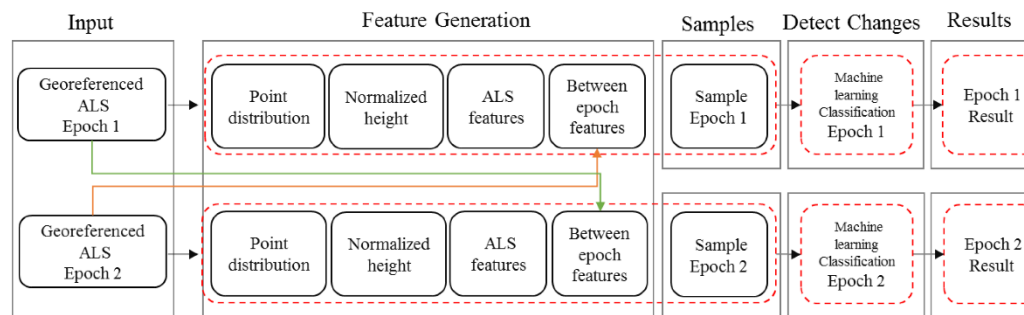
Post-classification

- Results are highly impacted by the classification quality
- Multiplicative errors



Single step

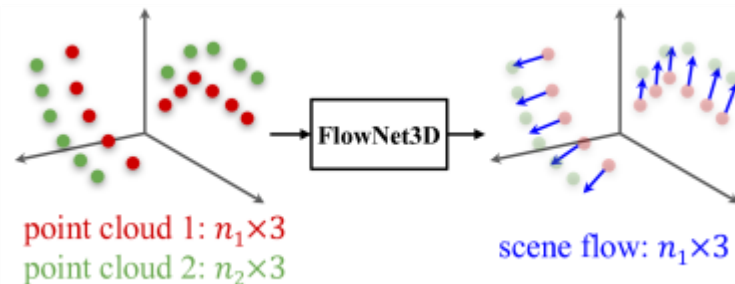
- Interaction and refinement of classification process



Tran, Thi et al. 2018

Approaches + Datasets + Metrics

- Image differencing methods
- C2C (Cloud to cloud)
- M3C2 (Multiscale Model to Model Cloud Comparison)
- Machine learning with handcrafted features
(Random forest)
- Deep learning (SiamGCN, SiamPointNet++, Siamese KPConv...ect)
- Scene flow in 3D point clouds



Authors	Year	Data type			CD Approach	CD Classes
		LIDAR	Image	Maps		
Matikainen et al. [22]	2004	X	X	X	Post-classification	Building
Matikainen et al. [23]	2010	X	X	X	Post-classification	Building
Stal et al.[24]	2013	X	X		Post-classification	Building
Malpica et al. [25]	2013	X	X		Post-classification	Building
Matikainen et al. [26]	2016	X	X	X	Post-classification	Building
Matikainen et al. [27]	2017	X	X	X	Post-classification	Building, roads
Vosselman et al.[28]	2004	X		X	Post-classification	Building
Tang et al.[29]	2015	X		X	Post-classification	Building
Awrangjeb et al. [30]	2015	X		X	Post-classification	Building
Choi et al. [31]	2009	X			Post-classification	Ground, vegetation, building
Xu et al. [32,33]	2013, 2015	X			Post-classification	Building
Huang et al. [34]	2021		X		Post-classification	Building
Teo et al. [35]	2013	X			Post-classification/DSM-based	Building
Murakami et al. [36]	1999	X			Pre-classification/DSM-based	Building
Pang et al. [37]	2014	X			Pre-classification/DSM-based	Building
Vu et al. [38]	2004	X			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	X	X		Pre-classification	Building
Zhang et al. [42]	2019	X	X		Integrated	Building
Ku et al. [43]	2021	X			Integrated	Building, street, tree
Iris et al. [44]	2021	X			Integrated	Building
Tran et al. [45]	2021	X			Integrated	Ground, vegetation, building
Zhang [46]	2022	X			Integrated	Building

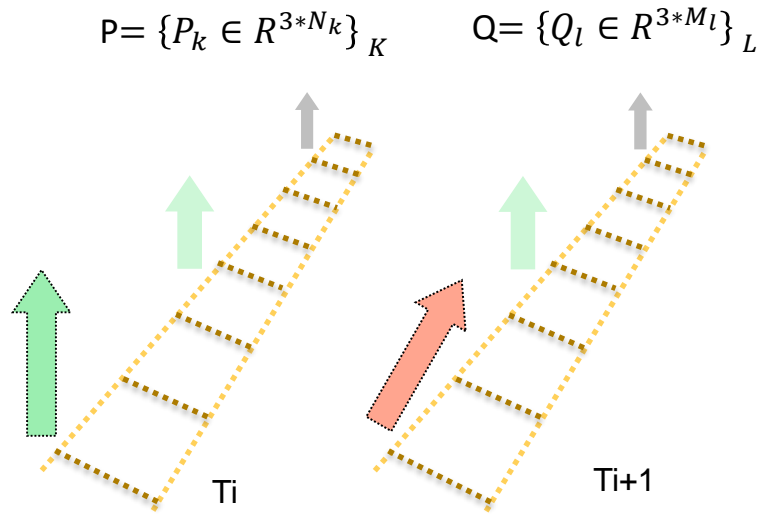
Changes that matter !

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 !

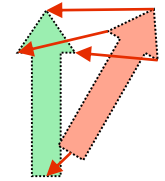
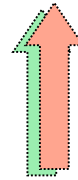
Automatic Point Cloud 3D Change Detection Using a Priori
Semantic Information

Make sense of the captured data !



$$T(p) = R \cdot p + t$$

where $t \in R^3$ is the translation and $R \in SO(3)$ is the rotation

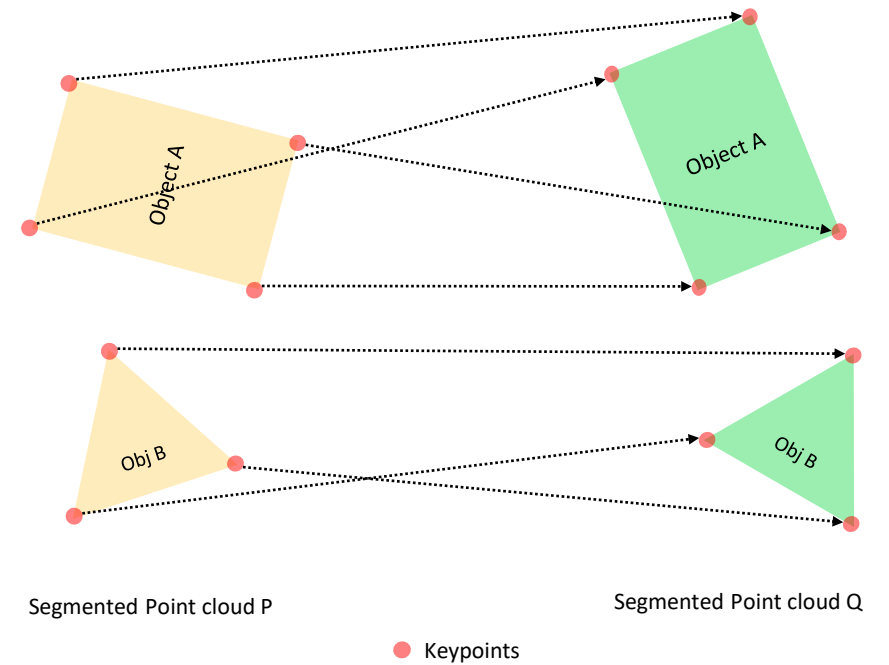
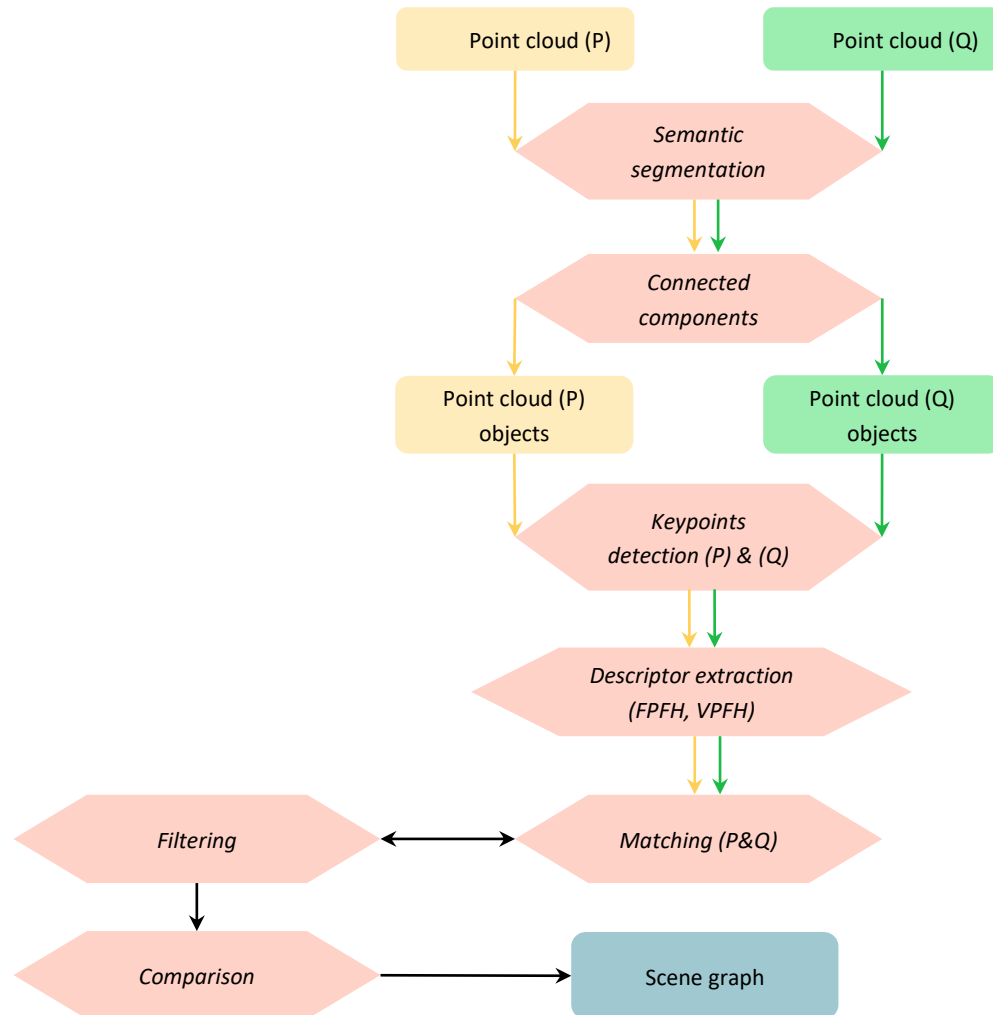


1. Enriched point clouds
(object level)

2. Object registration

3. Correspondence

Change detection and delineation



Do not hesitate to contact



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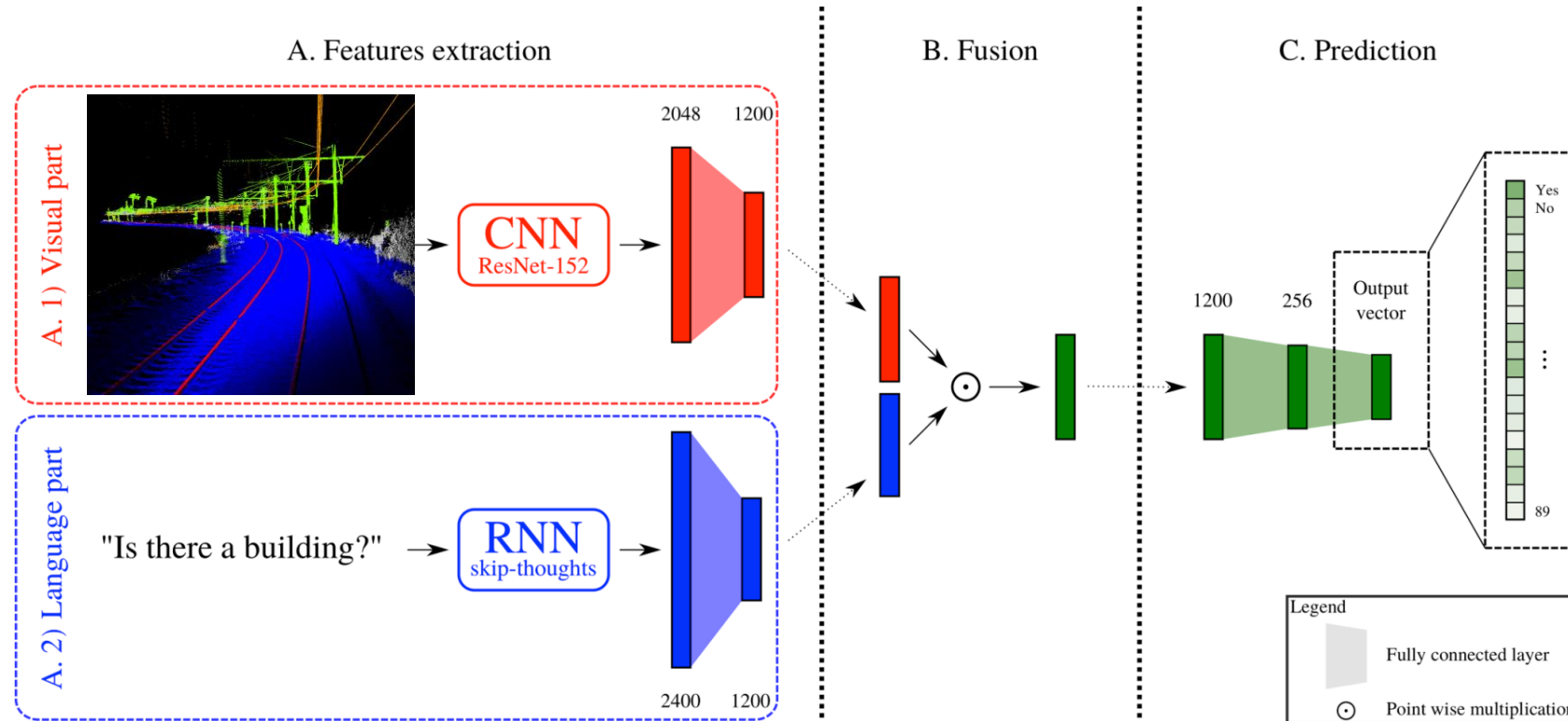
akharroubi@uliege.be

My Publications

1. [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).

Back up

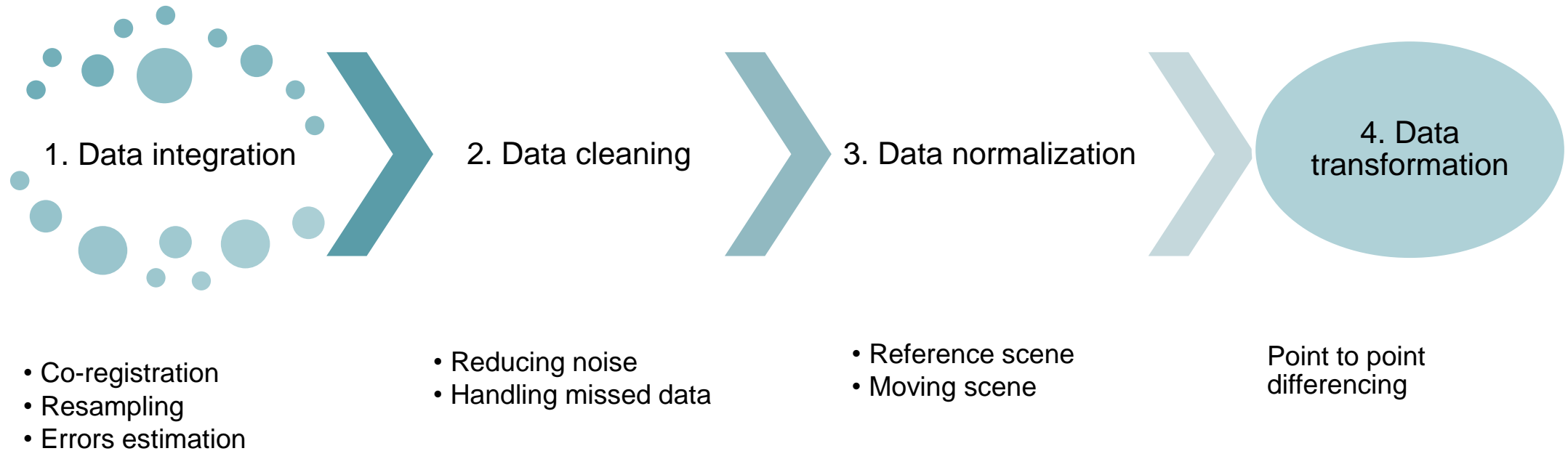
Future: Point clouds visual question answering (PCVQA)



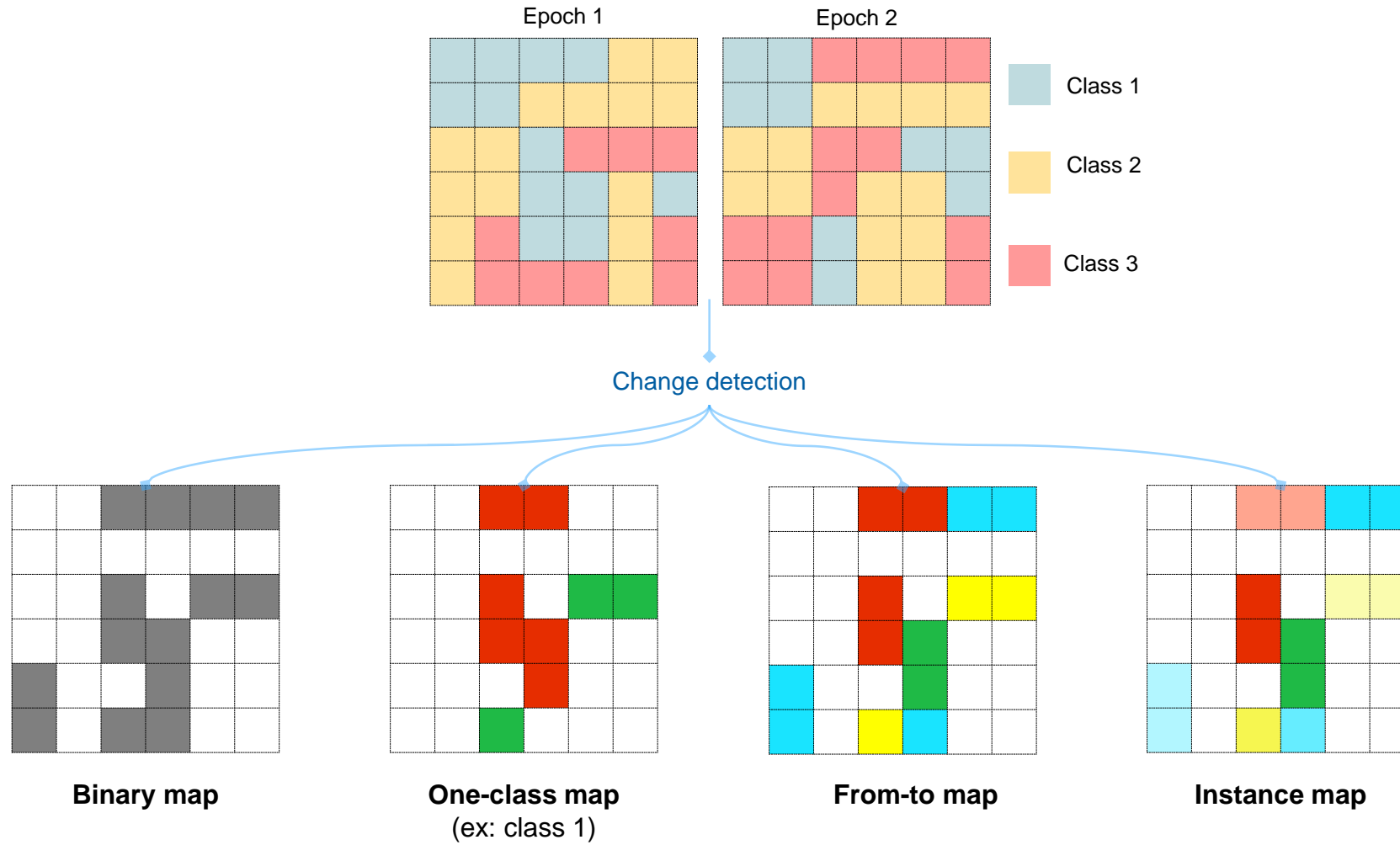
[Lobry, Marcos, Murray, Tuia, IGARSS 2019]

An advanced form of the SPC !

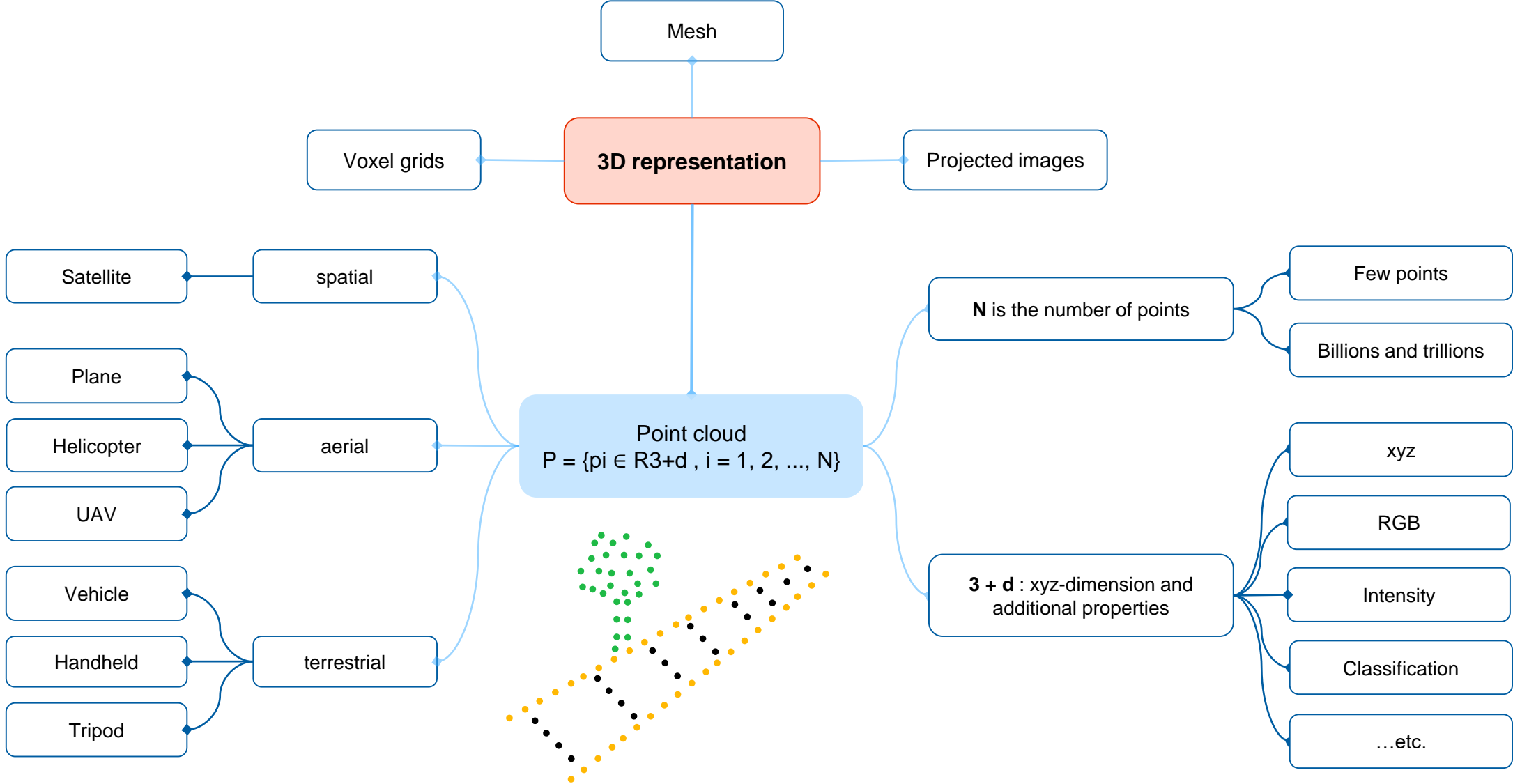
Standard approach



3D Change detection type



3D data representation



Point clouds segmentation

