Paris-rue-Madame database

A 3D mobile laser scanner dataset
for benchmarking urban detection, segmentation and classification methods.

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Outline

- Motivation and State of the Art
- Acquisition system
- Annotation process
  - Automatic method
  - Manual refinement
- Conclusions and Perspectives

Why an annotated 3D dataset?

- In the literature, most available urban data consist in close-range images, aerial images, satellite images but a few laser datasets.
- Few annotated 3D urban point clouds:

Database	Description	Annotated objects	Disadvantage
Oakland (Munoz et al., 2009)	MLS data from the Carnegie Mellon University campus in Oakland, Pittsburgh, USA. 1.6 million (X, Y, Z, class, confidence) points.	5 classes: scatter misc, default wires, utility poles, load bearing and facades.	Few classes. Few points.
Ohio (Golovinskiy et al., 2009)	Combination of ALS and TLS data from Ottawa city (Ohio, USA). 26 tiles 100 × 100 meters each.	20 classes: buildings, trees, cars, lampposts, etc.	Ground truth annotations only consists in a 2D labeled point in the center of each object. Point-by-point evaluation is not possible.
The Enschede (Zhou and Vosselman, 2012)	MLS data from the Enschede (The Netherlands). 1 km long. Ground truth: 2D geo-referenced lines marking curbstones.	1 class: Curbstones.	Only one class.
Paris-rue-Soufflot (Hernandez and Marcotegui, 2009)	MLS data from a street in the 5th Parisian district. 500 m long.	6 classes: facades, ground, cars, lampposts, pedestrians and others.	Few classes. Not available anymore.

Why an annotated 3D dataset?

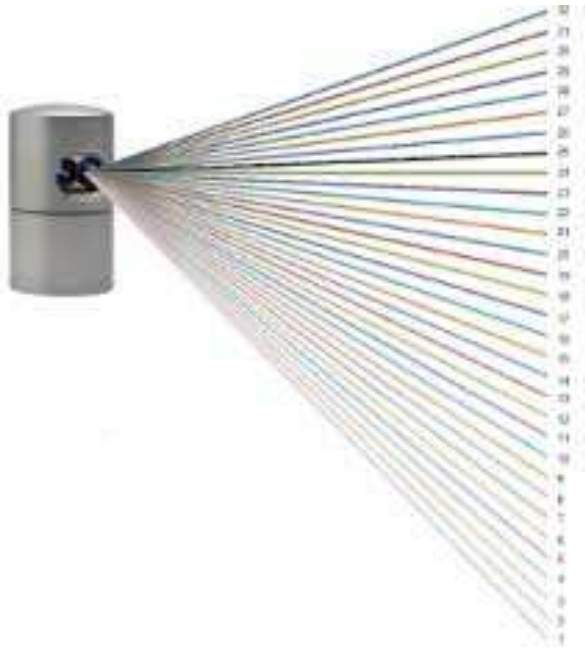
- We present a 3D MLS database for benchmarking detection, segmentation and classification methods.
  - The entire 3D dataset has been segmented and classified. Then each point contains a label and a class, allowing point-wise evaluations.
  - Our annotation includes all available objects in the urban scene.

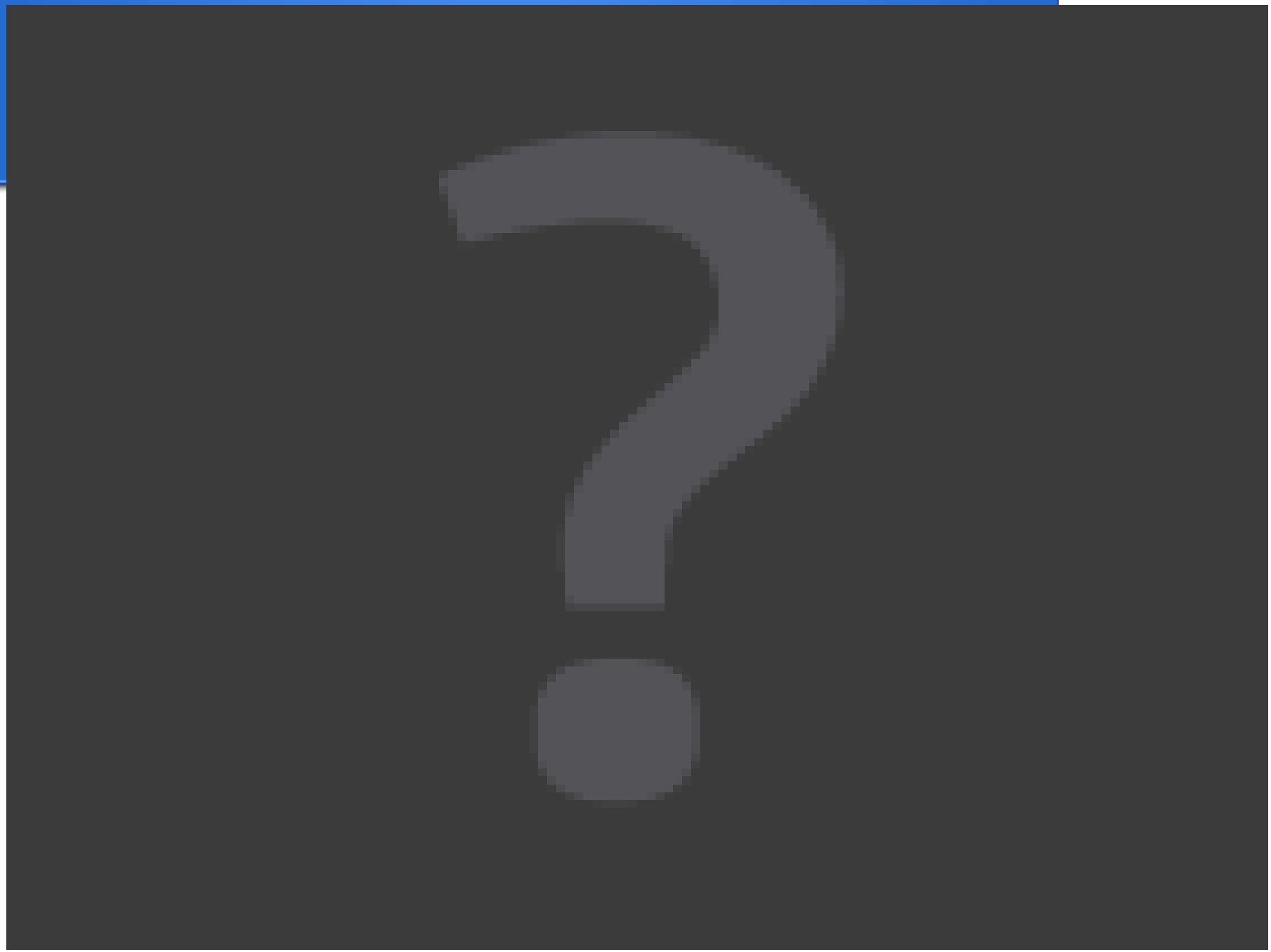
- Data have been acquired and processed in the framework of TerraMobilita project:

  http://cmm.ensmp.fr/TerraMobilita/

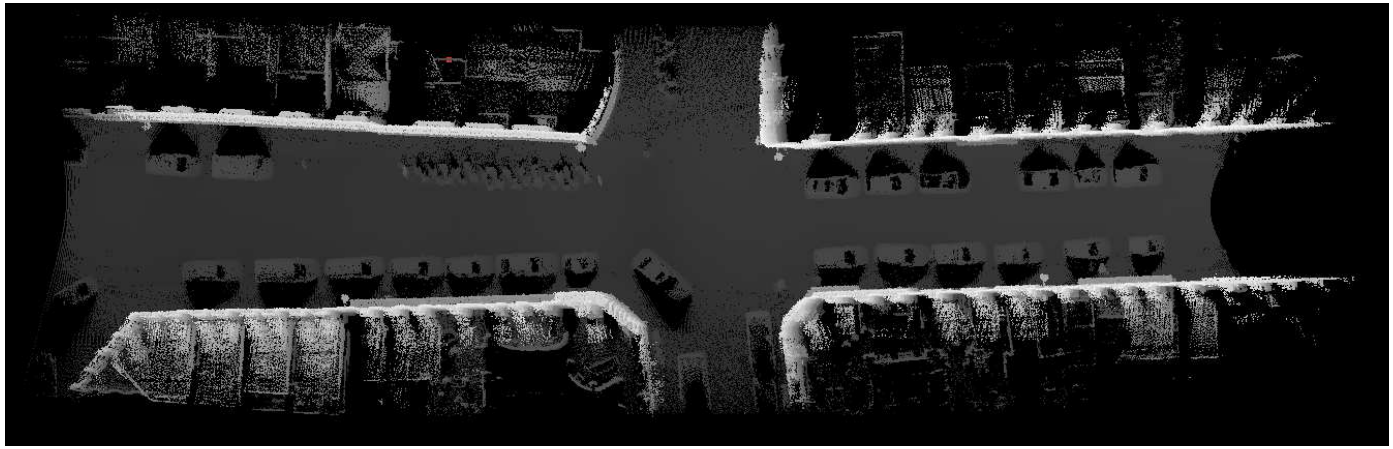
L3D2 MLS System by MINES ParisTech

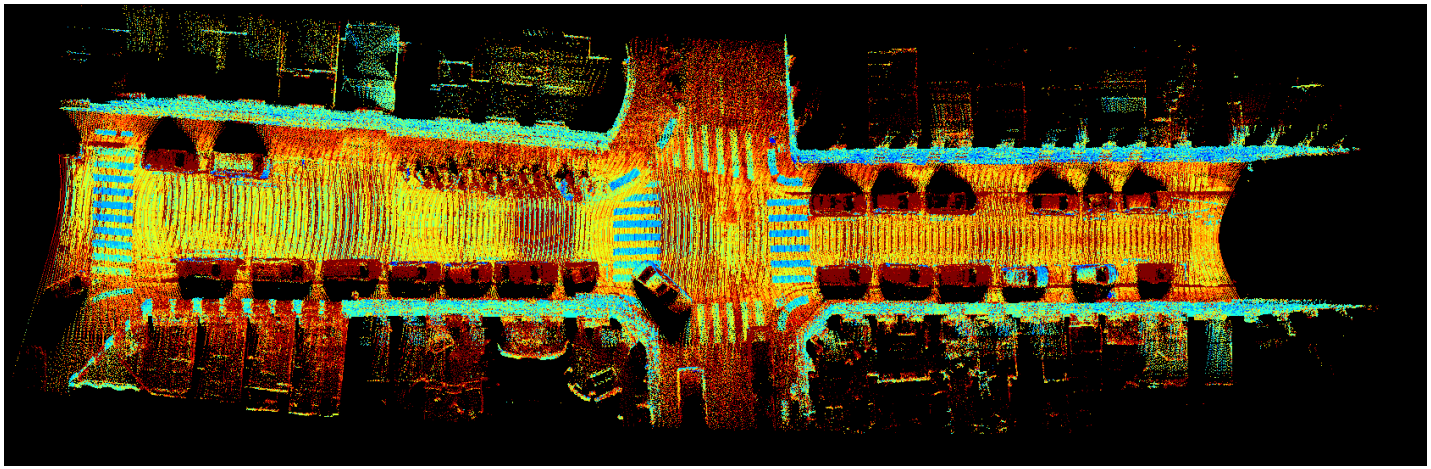
- Velodyne HDL-32E:
  - 32 lasers aligned from +10° to -30°
  - The entire unit spins, providing very dense point clouds.
  - 700,000 points per second. Range of 70 meters.
  - Typical accuracy: +/- 2cm.



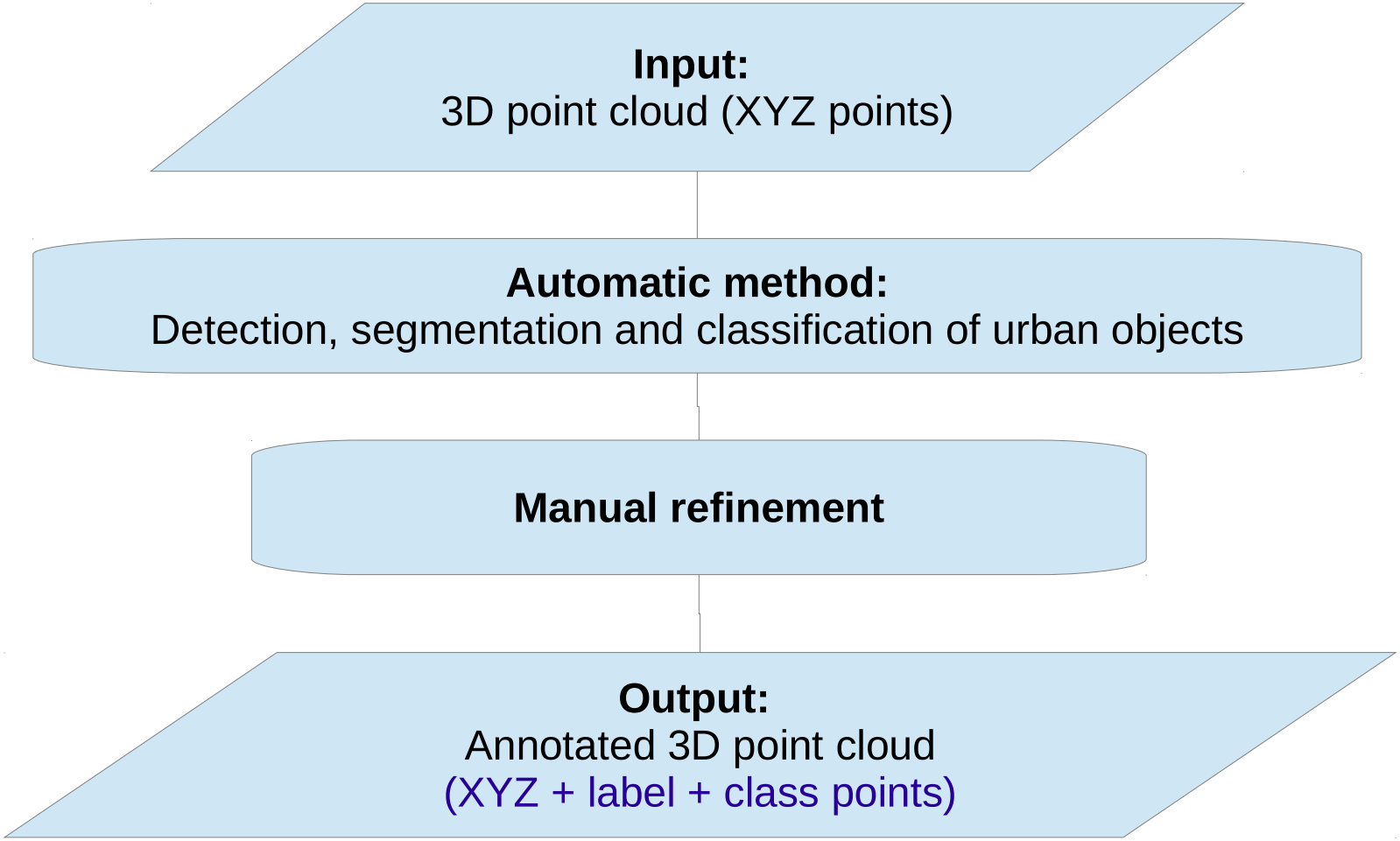


Input: 3D point cloud

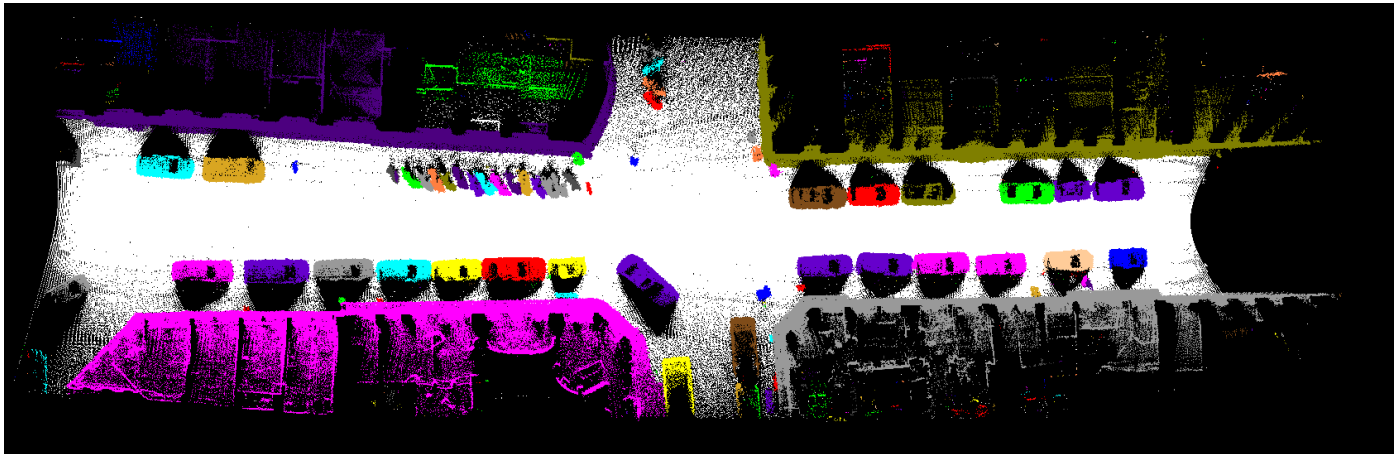




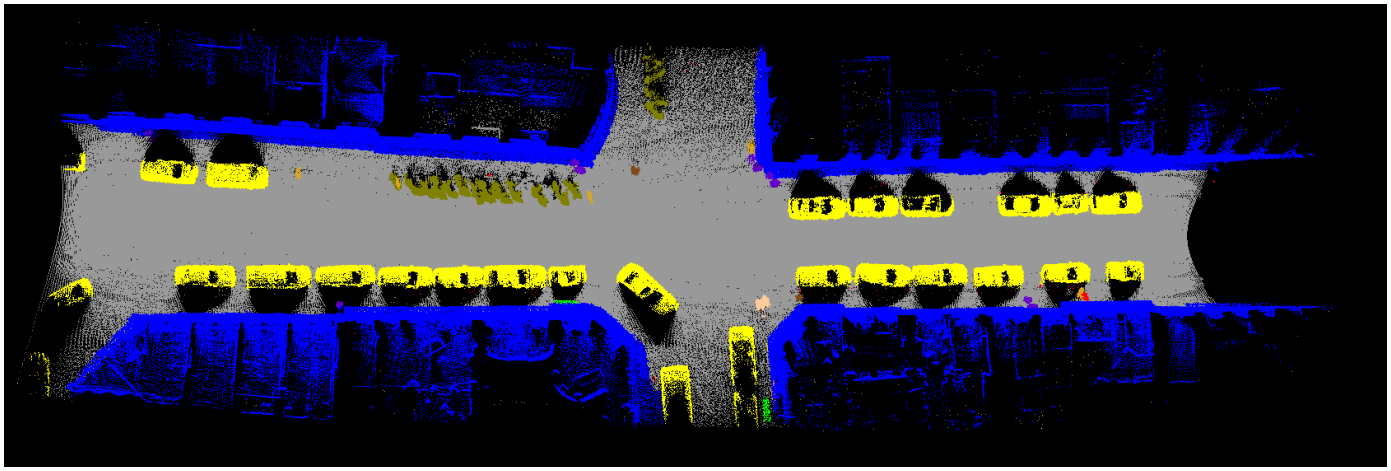
Annotation process



Output: annotated 3D point cloud

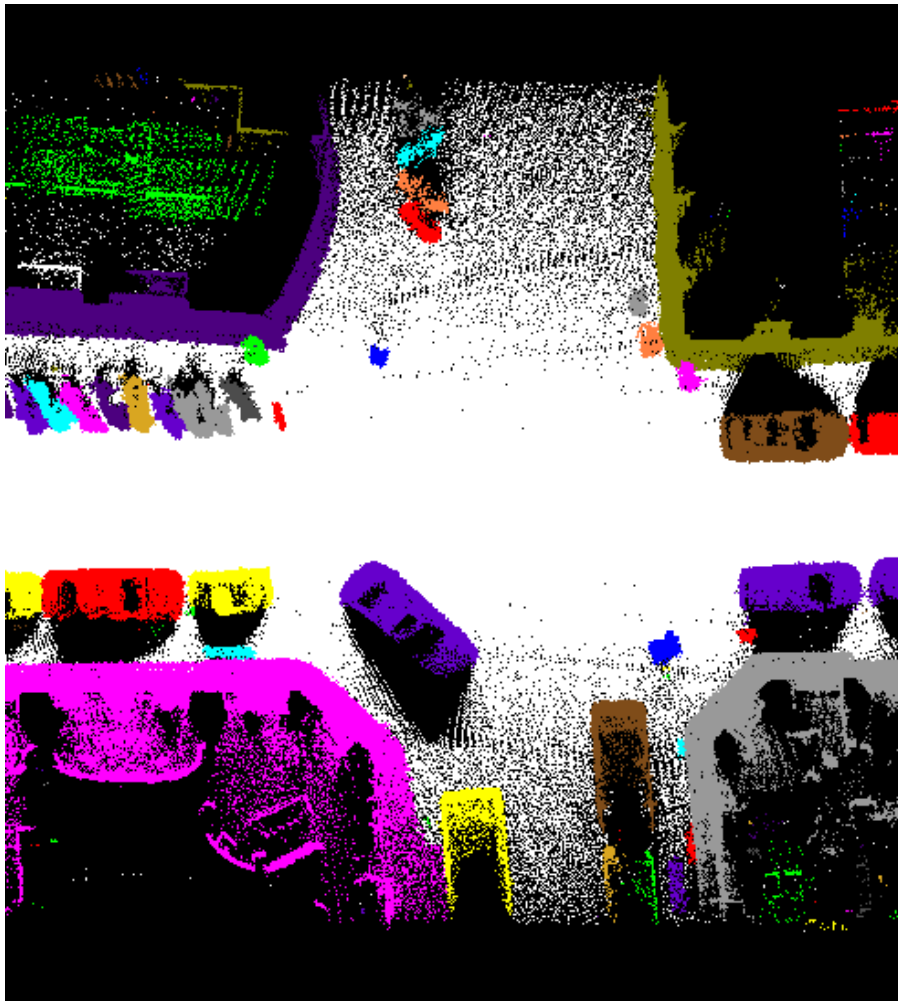


Object labels



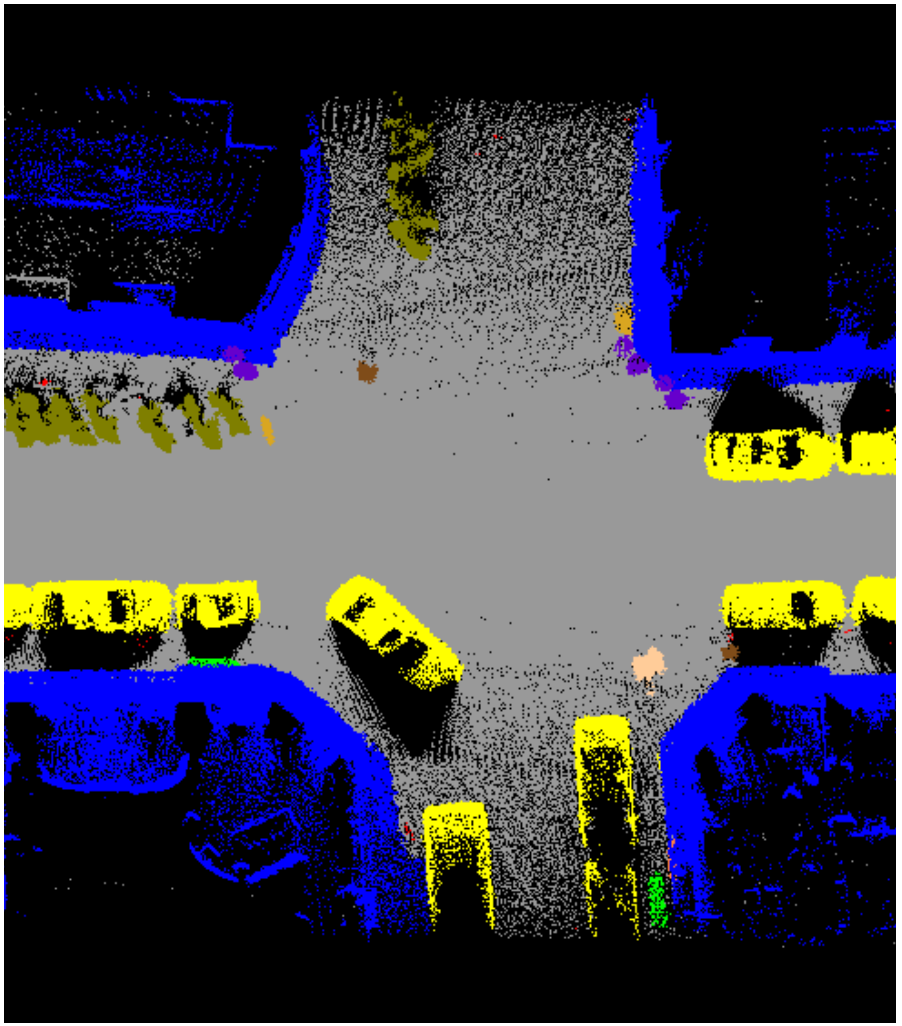
Object classes

Output: annotated 3D point cloud

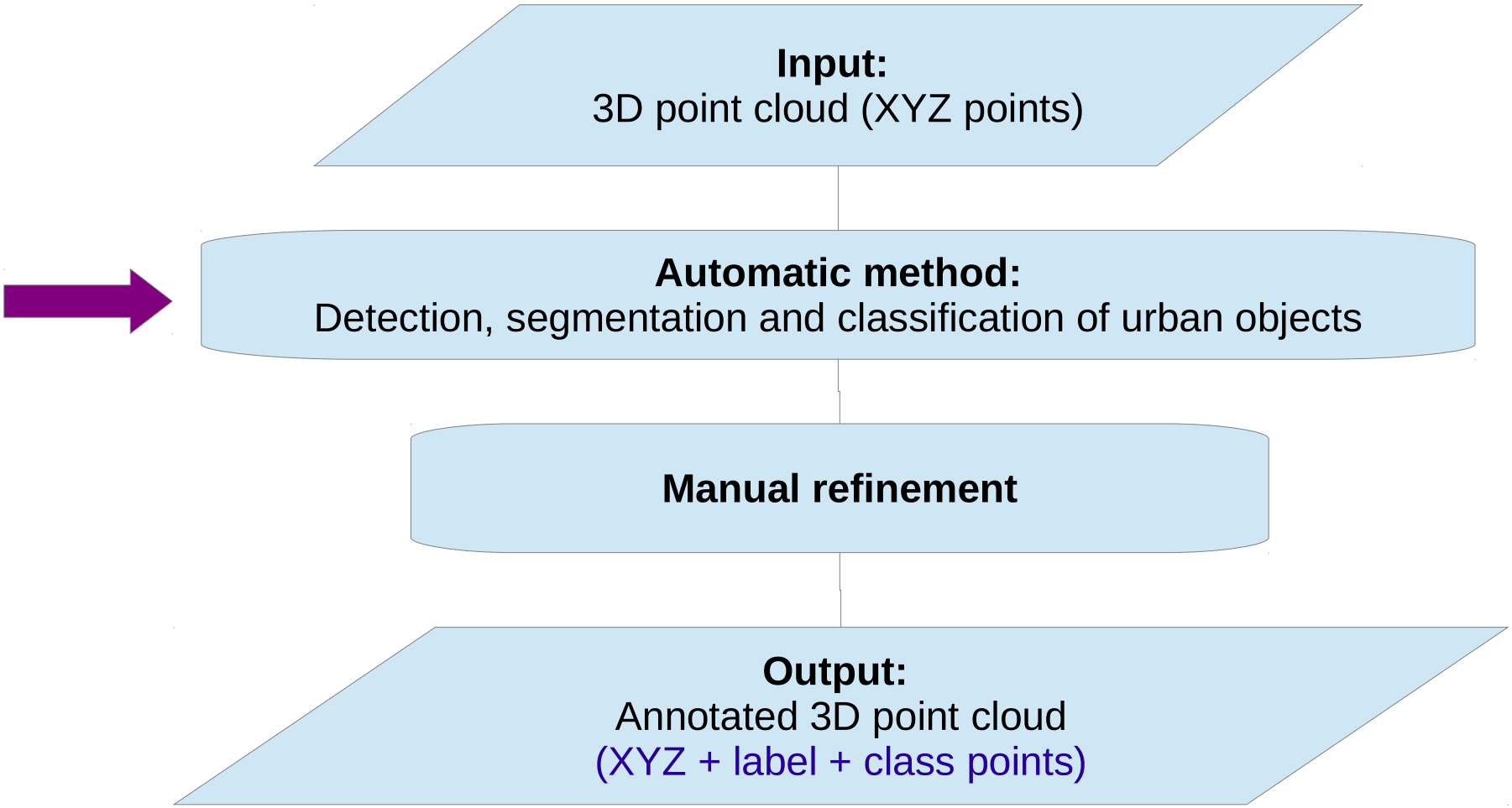


Object labels

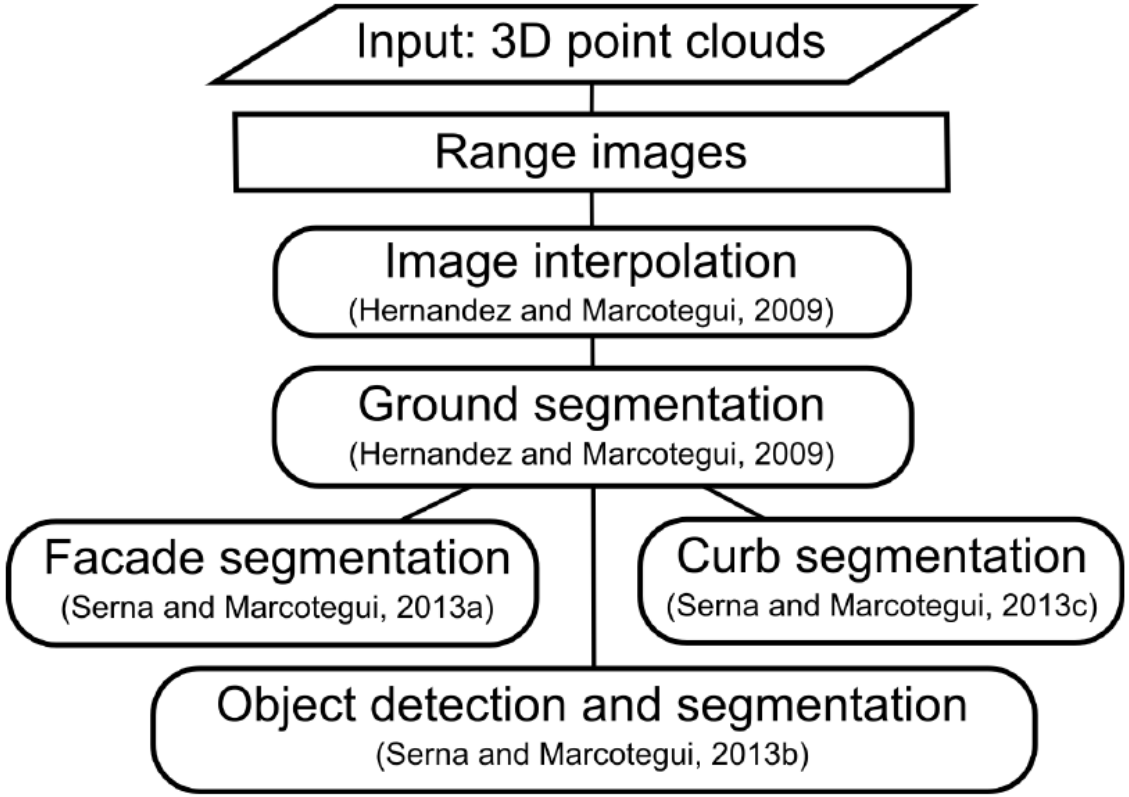
Object classes



Annotation process



Automatic process (1/5)



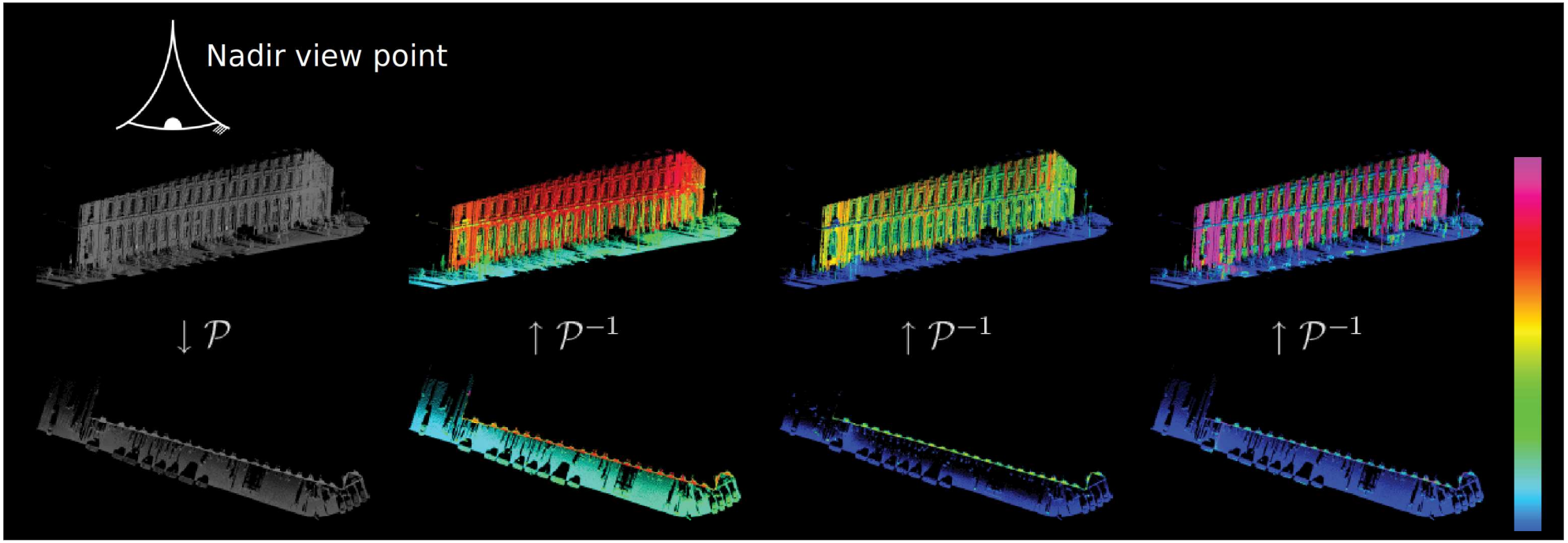
J. Hernandez and B. Marcotegui. « Filtering of artifacts and pavement segmentation from mobile LiDAR data » The ISPRS International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, XXXVIII-3/W8:329–333.

A. Serna and B. Marcotegui. « Urban accessibility diagnosis from mobile laser scanning data » ISPRS Journal of Photogrammetry and Remote Sensing Volume 84, October 2013, Pages 23-32 (2013)

A. Serna and B. Marcotegui. Detection, segmentation and classication of 3D urban objects using morphological and learning techniques. Accepted to ISPRS Journal of Photogrammetry and Remote Sensing (2013)

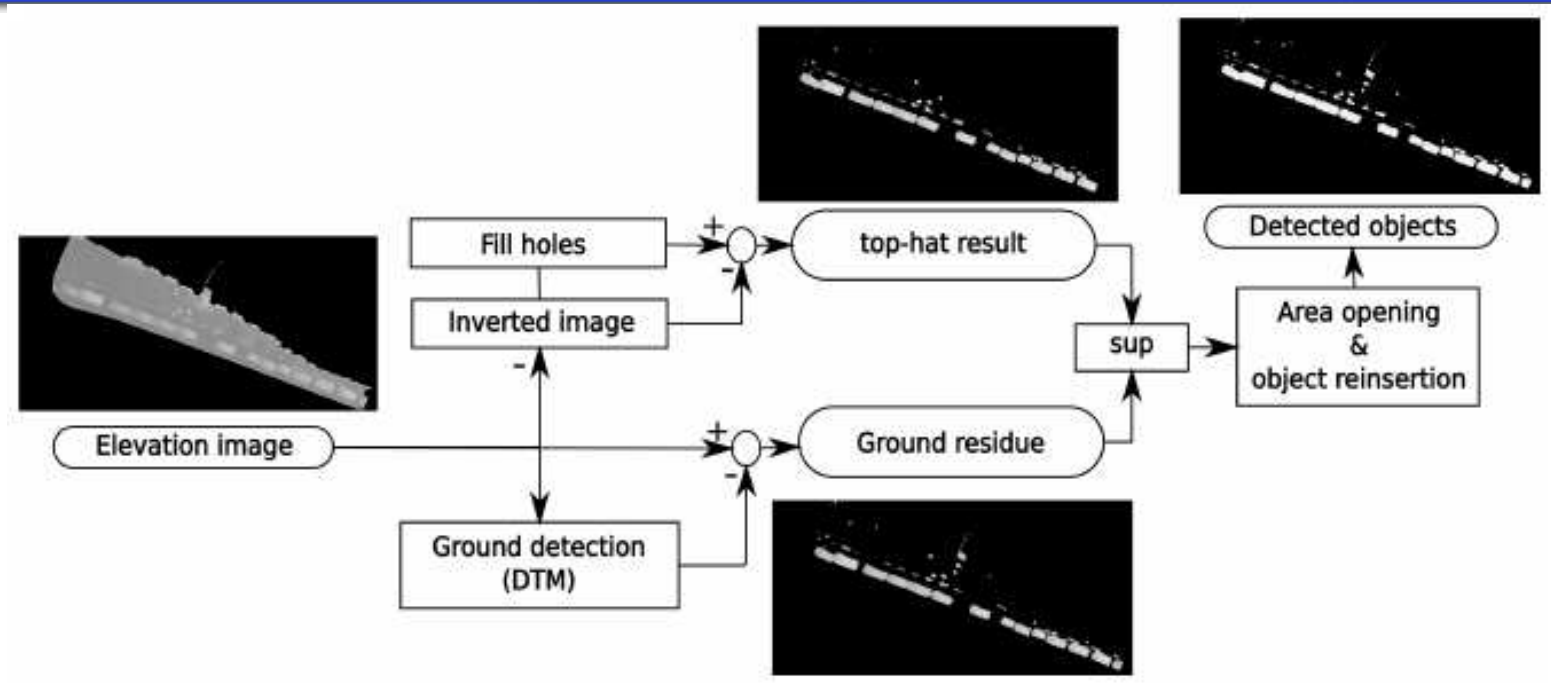
Automatic process (2/5)

- Elevation images are 2.5D structures that contain altitude information at each pixel.
- They are convenient structures to visualize and to process data (using image processing tools).
- They can be processed quickly, implicitly define neighborhood relationships and require less memory than 3D data.

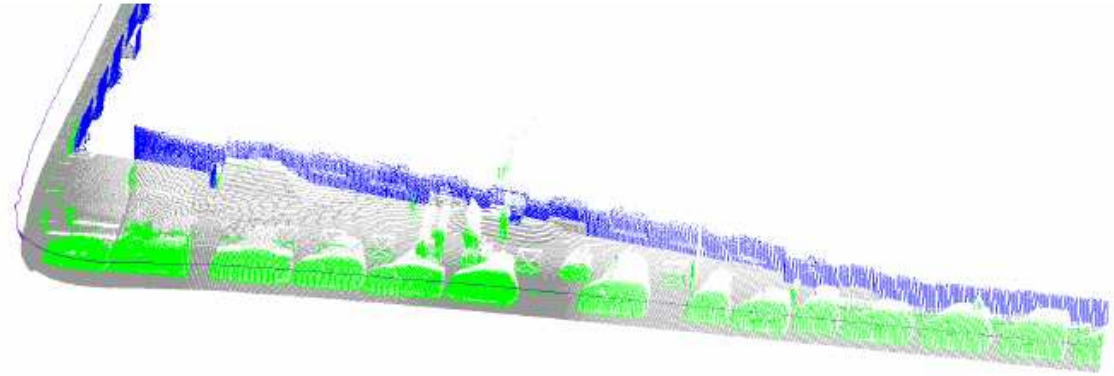


Point Cloud | Elevation = Max(Distance) | Height = Max-Min | Accumulation

Automatic process (3/5)



(a) Detection scheme using elevation images

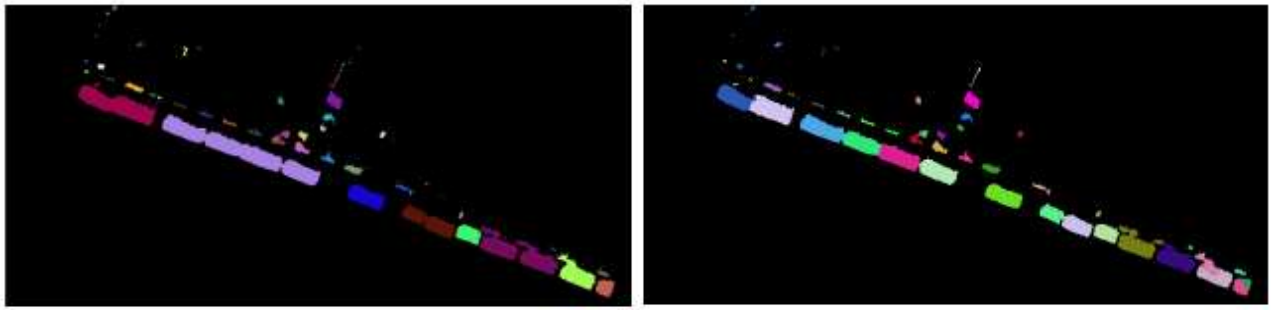


(b) Reprojection to the 3D point cloud: ground (gray), objects (green), facade (blue) and acquisition trajectory (violet).

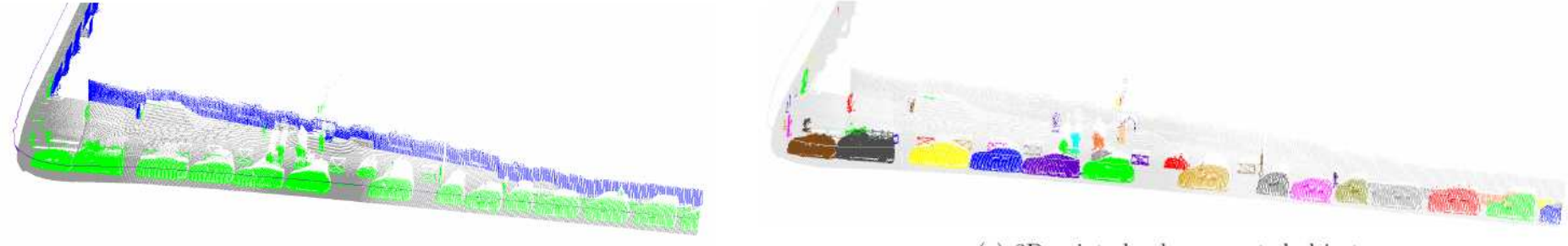
A. Serna and B. Marcotegui. **Detection, segmentation and classication of 3D urban objects using morphological and learning techniques**. Accepted to ISPRS Journal of Photogrammetry and Remote Sensing (2013)

Automatic process (4/5)

- Segmentation of connected objects:
  - “the number of connected objects in the same CC is equal to the number of significant maxima on it”.
  - Filtering to preserve only the most significant maxima (to get rid of maxima due to texture and noise).



(a) Elevation image: connected objects (b) Elevation image: segmented objects

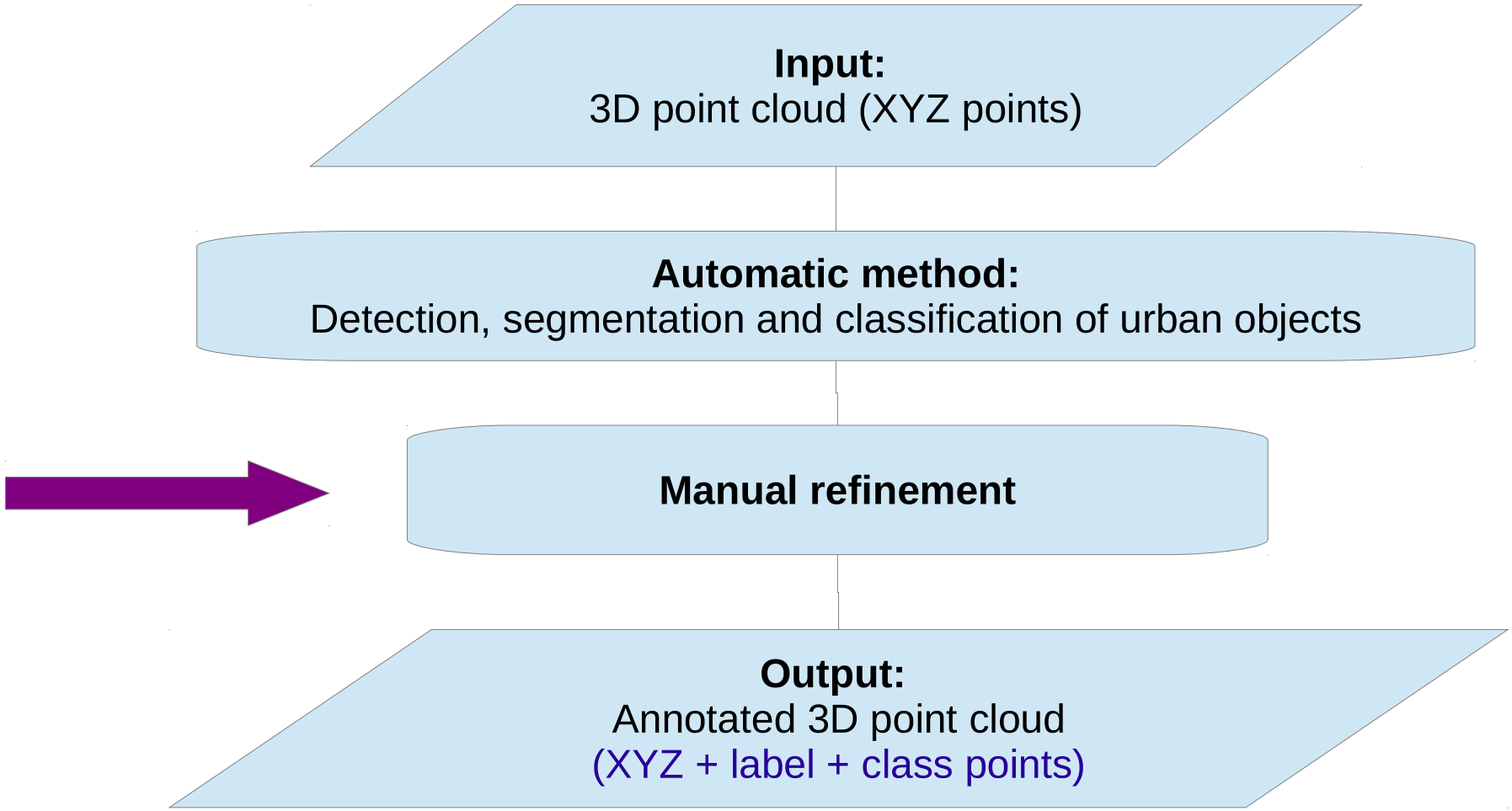


(c) 3D point cloud: segmented objects

Automatic process (5/5)

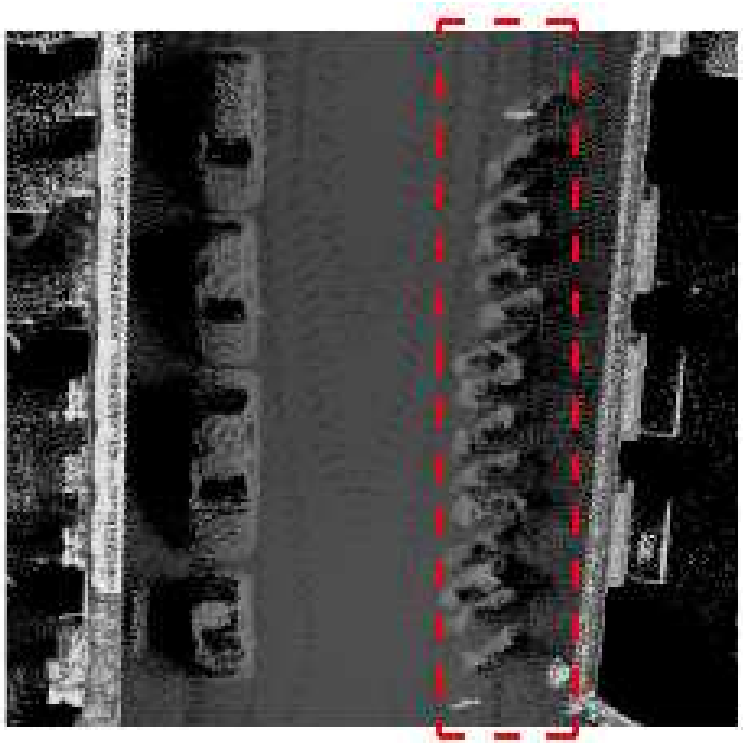
- SVM classification
- Geometrical features:
  - Object area and perimeter
  - Bounding box area
  - Object volume, computed as the integral of the elevation image over each object.
  - Maximum, mean, standard deviation and mode (the most frequent value) of the object height
- Contextual features:
  - Neighboring objects, defined as the number of regions touching the object on the elevation image.
  - Confidence index, which depends on the points density and therefore on the distance between sensor and objects.

Annotation process

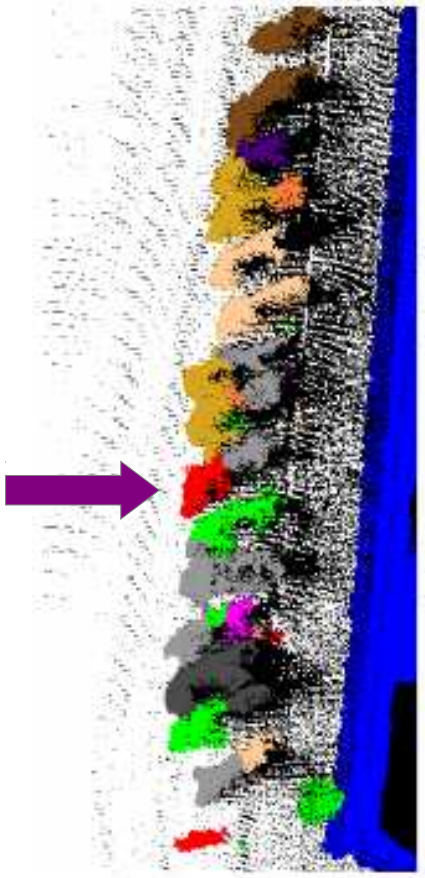


Manual refinement (1/3)

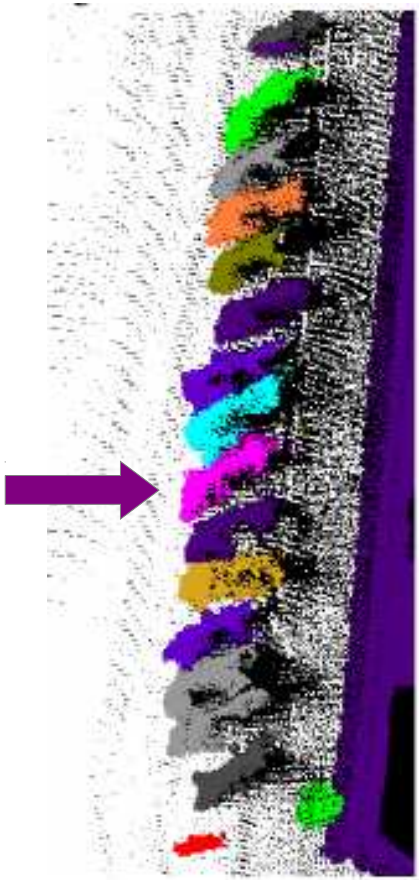
- Over-segmentation (Motorcycles):
  - Connected objects with more than one significant maximum



Input 3D point cloud



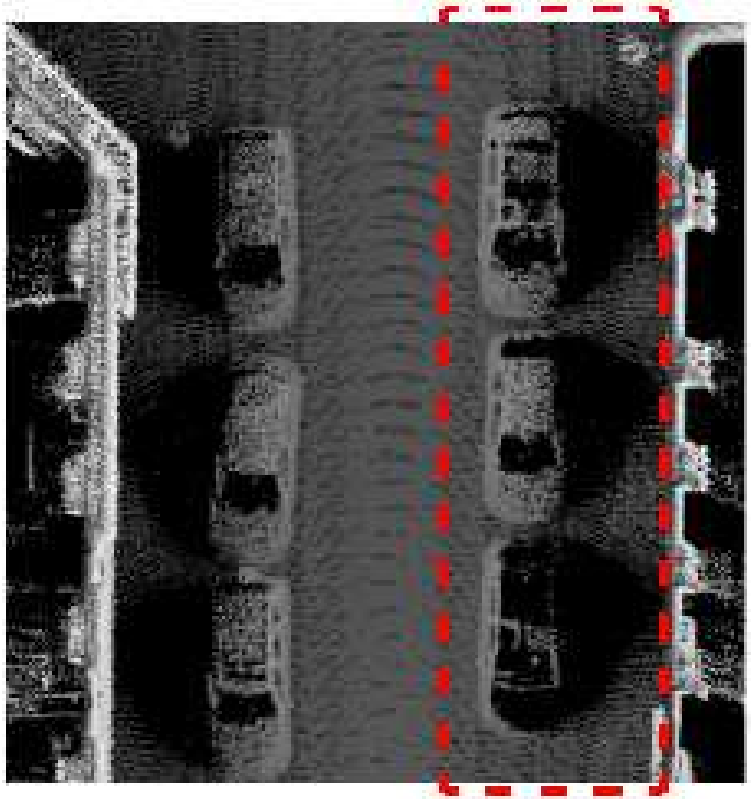
Automatic segmentation



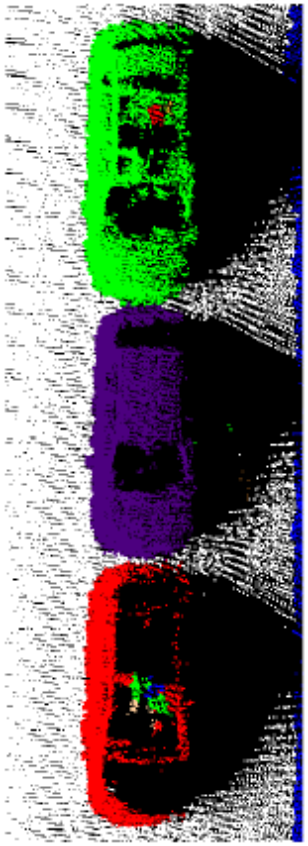
Manual refinement

Manual refinement (2/3)

- Over-segmentation (Cars):
  - Artifacts may create regional maxima



Input 3D point cloud

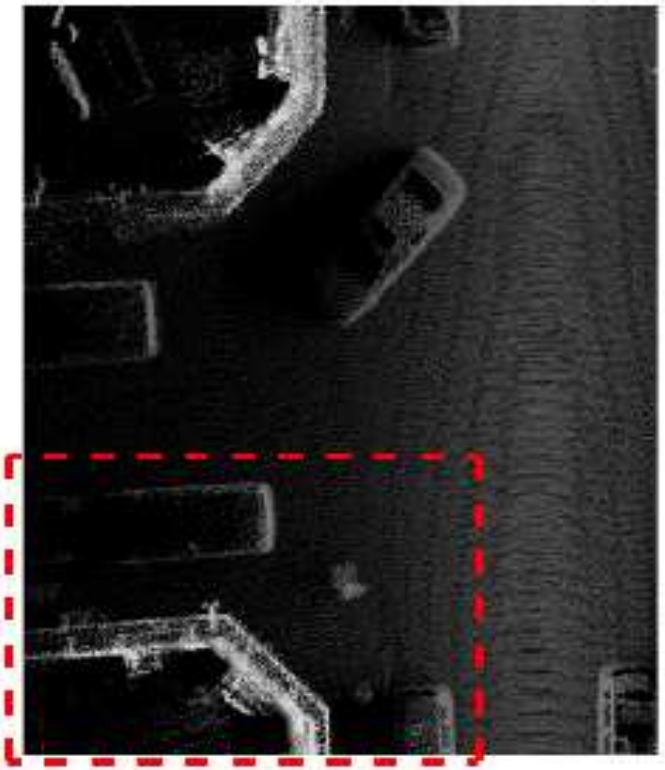


Automatic segmentation

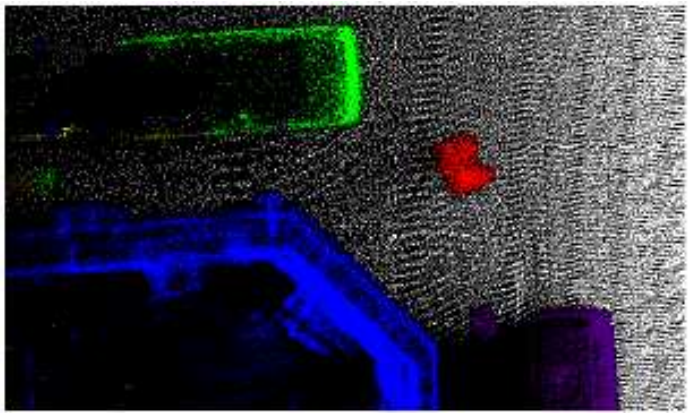
Manual refinement

Manual refinement (3/3)

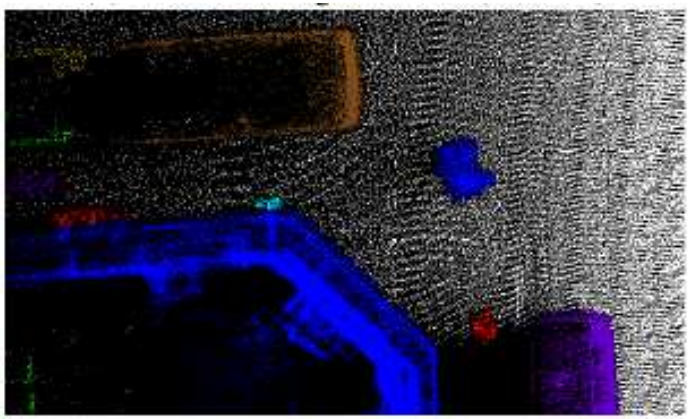
- Under-segmentation (Facades):
  - Some objects touching the facade



Input 3D point cloud



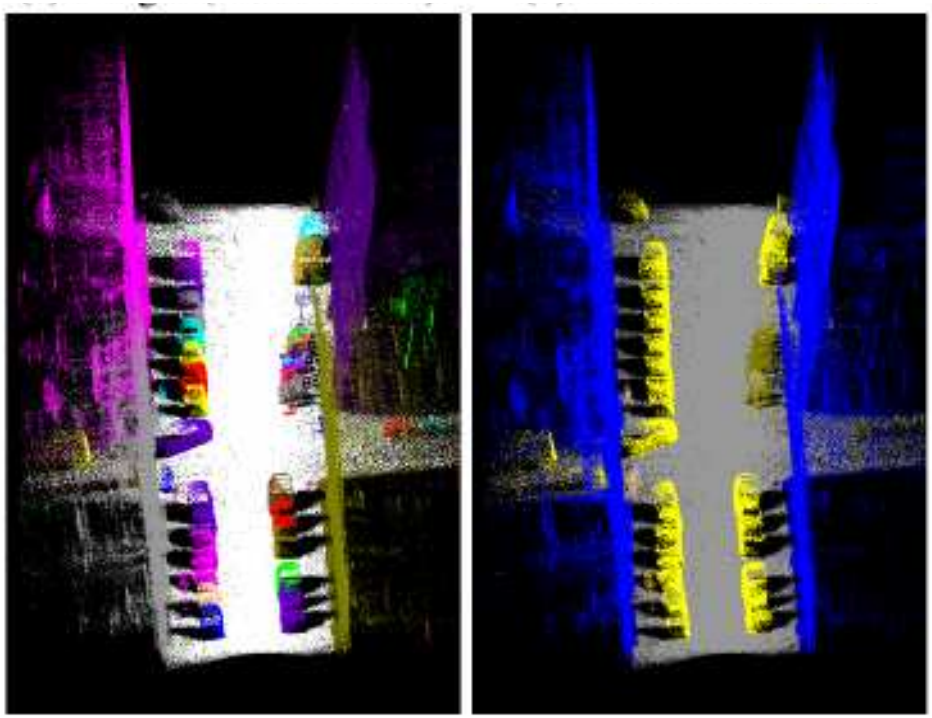
Automatic segmentation



Manual refinement

Paris-rue-Madame database (1/2)

- 3D MLS data from rue Madame, a street in the 6th Parisian district (France).
- It contains a 160 m long street section = 20 million points.
- The acquisition was made on February 8, 2013 at 13:30 (UT).



(c) Object label. (d) Object class.

		Number of objects	
Class	**Class name**	**file 1_2**	**file 1_3**
4	Cars	39	31
7	Light poles	0	1
9	Pedestrians	3	7
10	Motorcycles	23	9
14	Traffic signs	5	1
15	Trash can	2	1
19	Wall Light	6	1
20	Balcony Plant	3	2
21	Parking meter	1	1
22	Fast pedestrian	2	2
23	Wall Sign	1	3
24	Pedestrian + something	1	0
25	Noise	46	80
26	Pot plant	0	4
	Total	**132**	**143**

Paris-rue-Madame database (2/2)

- Paris-rue-Madame database is available at:

  http://cmm.ensmp.fr/~serna/rueMadameDataset.html

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Conclusions

- We have presented a 3D MLS database from rue Madame, Paris.
- Annotation has been carried out in a manually assisted way:
  - First, an automatic method has been applied.
  - Then, manual refinement has been carried out.
- This approach is faster than a completely manual approach and it provides accurate results.
- The entire 3D point cloud has been segmented and classified, resulting in a list of (X, Y, Z, label, class) points.
- This dataset is different from others available in the state of the art since each point has been segmented and classified, allowing point-wise benchmarking.

Perspectives

- To increase the size of the database.
- Other TerraMobilita datasets will be annotated and made available to the scientific community.
- To develop an “official” evaluation method.
- Quantitative results of our algorithms will be available on this database.

References

- J. Hernandez and B. Marcotegui. « Filtering of artifacts and pavement segmentation from mobile LiDAR data » The ISPRS International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, XXXVIII-3/W8:329–333.
- A. Serna and B. Marcotegui. « Urban accessibility diagnosis from mobile laser scanning data » ISPRS Journal of Photogrammetry and Remote Sensing Volume 84, October 2013, Pages 23-32 (2013).
- A. Serna and B. Marcotegui. Detection, segmentation and classification of 3D urban objects using morphological and learning techniques. Accepted with minor corrections to ISPRS Journal of Photogrammetry and Remote Sensing (2013).
- A. Serna, B. Marcotegui, M. Faessel. Towards real-time segmentation of 3D mobile laser scanning data for large scale urban analysis. **Under revision.** Special Issue: Real-Time Computer Vision in Smart Cities (2014).

Thank you for your attention!

http://cmm.ensmp.fr/~serna/rueMadameDataset.html

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