A **BRIEF REVIEW** ON METHODOLOGIES FOR **3D RECONSTRUCTION** OF **URBAN ENVIRONMENTS** USING **POINT CLOUDS**

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INTRODUCTION

Urban environments are densely populated areas composed mostly by residential, commercial, and industrial sectors. From airborne or satellite images is clear to notice its linear patterns due to predominance of artificial structures. Accurate mapping expresses the idea of organization and the possibility of future planning, e.g., for drawing up plans for greater comfort of the population. Besides, enables computational simulations of natural disasters and their potential impacts.

Considering **geometry (trideminsional) mapping**, two **major data sources** emerges: **laser** sensors, so called LiDAR (Light Detection And Ranging) and **optical**, but other sensors, such as radar, could also provide data through Persistence Scatterer Interpherometry (PSI) technique. Among the methods using those sources, many of them have adopted the workflow: **detection** and **reconstruction**, wherein the first, the buildings edges are delineated, second, geometric modeling procedures are applied to reach the 3D representation.

Briefly present the most widely used methods for 3D reconstruction, separated in methods for detection and reconstruct buildings

3D URBAN MAPPING

DATA ACQUISITION

point cloud

METHOD

Detection, accuatly, consists in the classification of each point according to its disposition, which later gives an idea of "detection" of a certain object

DETECTION

Regularities rules
Classsify based in the spatial distribution of the points, such as proximity, angle, similarity, homogeneity, so on (VOSSELMAN, 2000)

Morphology
Non-linear transform which process the dataset based in its shape, texture, size, and uniformity. Also, could provide a more accurate DSTs (ROTTENSTEINER et al., 2005)

Markov Random Fields
A Graph-based approach, which unify statistics operators to classify points based on distance, shape, elevation, and other (ANGUELOV et al., 2005). Fail in classify small objects

Non-parametric approach
Support Vector Machine (VAPNIK; CORTES, 1995) and Self-Organized Maps (KOHONEN, 1982) are common methos in this scope, which allow the classification based on patterns recognition

Random Forest
Extends the Decision Tree classification method to a "Forest" Decision Tree. A more sofisticated, and less time consuming approach in terms of classification (BREIMAN, 2001)

Object-oriented
Takes a real world constraits to classify specifics objects, where each spectral behavior, texture and semantic of objects in a scene are take in account (BLASCKE, 2010)

RECONSTRUCTION

Considers only classes that satisfy a certain purpose. Once defined, planar surfaces, vegetation, or any other object could be "reconstruct" according to its physical characteristics

Hough Transform
Used to identify objects based on its geometry, maily, linear features. Thus, the technique is spreadly used in the delineation of roof-tops (HOUGH, 1962)

RANSAC
RANdom SAmple Consensus (FISCHLER; BOLLES, 1981) is a well known approach due its hability in detect planar surfaces, taking in accound only few points

Region growing
Since the point set is already defined in the previous step, the region growing could be apply to eliminate possibles outliers (BRENNER, 2005)

Normal Vector Analysis
Also explored in the previous step (regularities rules), the normals could be also analyzed in the facet TIN scope (VERDIE, 2015). In this case, the object may be reconstruct considering its characterists and vicinity

Regularization
Remove outliers that could not obey the shape of a specific object. Besides, apply smoothing and alignment procedures to reach a better represented models (DORNINGER et al., 2008)

Stardardization
Not a reconstruction technique, but equally important in this step. It takes a common data model, such as CityGML (OGC, 2015), to stardardize the digital model

3D MODEL

CONCLUSIONS

- Urban environments consists in a **complex** and **dinamic system**, which often **demands differents data sources**
- Recent techniques have been providing new ways to reach a **more accurate 3D urban representations**
- The literature has been increased with papers on this topic, additionaly, new ways **to analyse the urban space** has been presented
- The **point cloud technology** has been **decisive** to explore urban features in a **systematic terms**
- The **human interference** is still needed in the points **classification procedures**
- In **irregular topografy** and **complex environments**, the results in the literature are still **unsatisfactory**

ACKNOWLEDGMENT

We are grateful for the financial support of the **Coordination for the Improvement of Higher Education Personnel (CAPES)**. A special thanks to my advisors **Dr. Luiz E. O. C. Aragão** and **Dr. Yosio E. Shimabukuro**.


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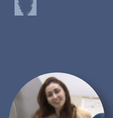
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