PostDoc Position in machine learning and computer vision

Reconstruction of buildings from satellite imagery by detecting and assembling planar shapes

Context

Automatic city modeling has received an increasing interest during the last decade. Aerial acquisitions with Lidar scanning or multi-view imagery constitute the best way so far to automatically create 3D models on large-scale urban scenes [1,2]. Because of high acquisition costs and authorization constraints, aerial acquisitions are, however, restricted to some spotlighted cities in the world. In particular, Geographic Information System (GIS) companies propose catalogs with typically a few hundred cities in the world. Satellite imagery exhibits higher potential with lower costs, a worldwide coverage and a high acquisition frequency.

Satellites have however several technical restrictions that prevent GIS practitioners from producing compact and detailed city models in an automatic way [5]. Recent works [3,4], illustrated on Fig.1, have demonstrated that buildings can be modeled with a Level Of Detail 1 (LOD1) representation with satellite images at 0.5m resolution by recovering geometry and semantics simultaneously, and exploiting geometric atomic regions instead of traditional pixels. An important challenge would now be to reconstruct LOD2 models from the last generation of very high resolution satellite images.

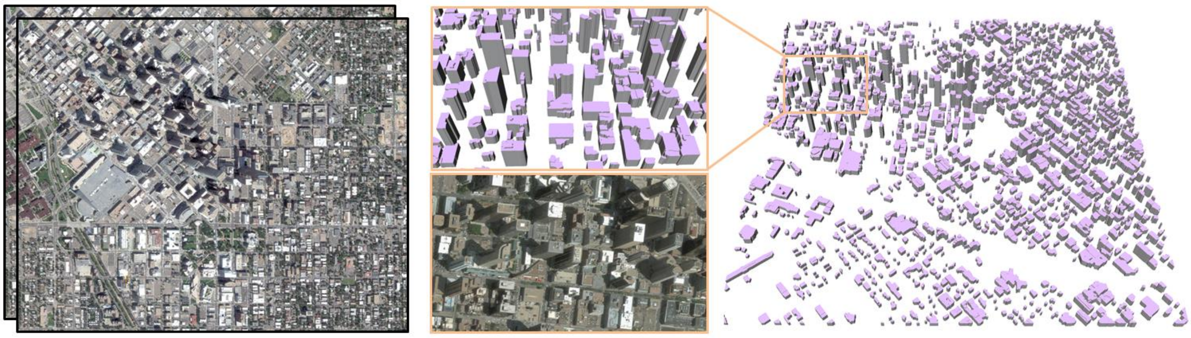

Figure 1 – LOD1 city model of Denvers (right) obtained from 0.5m resolution satellite images.

The reconstruction pipeline is traditionally composed of four steps: i) the identification of buildings via image classification, ii) the extraction of 3D information at the pixel scale with typically the creation of DSM and DTM by stereovision, iii) the extraction of geometric shapes, typically planes

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that describe the piecewise-planar structure of buildings, and iv) the assembling of the geometric shapes to form concise polygonal meshes that conform to the LOD2 CityGML formalism. While the last step has been investigated in previous works [6] and is now mature, the three first steps still require research investigations. In particular, the goal of this study consists in developing robust algorithms for the shape extraction step.

Objectives

The main goal of the PostDoc is to develop efficient, robust and scalable methods for extracting geometric shapes from the last generation of satellite images (at 0.3m resolution). Besides satellite images, input data will also include classification maps that identify the location of buildings and DSMs that bring rough pixel-based estimation of the urban object elevation. The geometric shapes will be first restricted to planes that typically describes well the piecewise planar geometry of buildings. The goal will be then to detect and identify each roof section of façade component of a building by a plane in the 3D space. Existing shape detection algorithms [7,8,9,10] are typically non-optimal iterative mechanisms that bring no guarantee on the quality of the returned configuration of shapes [11]. Moreover, they operate from point clouds with a low level of noise. Our context is more challenging because 3D points returned by DSMs are highly corrupted by noise. Two main research directions will be investigated.

Shape detection by deep learning. To be robust to highly noise data, the postdoc will investigate learning algorithms for detecting shapes and their geometric regularities in a more robust manner than the unsupervised and non-optimal existing approaches. Recent work shows basic 2D geometric shapes could captured objects in images efficiently with deep learning architectures operating on continuous parameter space. With more complex 3D shapes such as planes, an important problem to tackle will be to design architectures with reasonable computational complexity. Another issue to address will be to create efficient and relevant training sets from synthetic models, as underlined by [12]. Last but not least, the proposed architectures will have to consolidate missing data and occlusions by using an efficient multi-scale shape representation.

Shape refinement. Given an initial configuration of planar shapes, the postdoc will explore mechanisms for improving the quality of the configuration. This quality will be measured by an objective function to define that will take into account i) the accuracy of shapes (eg Euclidean distance between inliers and shapes), ii) the completeness (eg ratio of inliers) and the complexity (eg number of shapes). Depending on the form of the objective function, efficient optimization procedures will have to be developed, either in variational or stochastic frameworks.

Keywords: city modeling, remote sensing, satellite images, shape detection, stereovision, large scale.

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