

PhD Position in Computer Vision, Computer Graphics and Machine Learning

Shape Detection from 3D Point Clouds

Context

Shape detection from raw 3D data is a long-standing problem whose goal consists in turning a large amount of geometric data such as 3D point clouds into a higher level representation based on simple geometric shapes (see Figure 1). Instead of reasoning at the scale of 3D atomic elements such as points, triangular facets or voxels, it is often more appealing to directly handle larger geometric shapes in order to both reduce the algorithmic complexity and analyze objects with a higher representation level. Most common geometric shapes include lines, planes and quadrics. Shape detection is typically used as a prior step in a large variety of vision-related tasks ranging from surface reconstruction to object recognition and data registration.

Existing shape detection algorithms [1,2,3,4] are typically non-optimal iterative processes that bring no guarantee on the quality of the returned configuration of shapes [5]. At best, they are able to recover some geometric interactions such as parallelism, orthogonality or symmetry between shapes. In addition, obtaining a representation that adequately describes the input data often requires time-intensive parameter tuning.

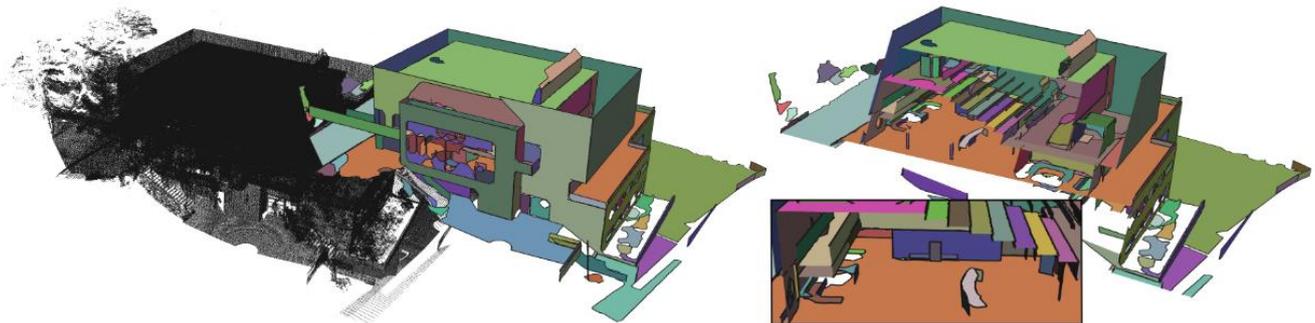


Fig.1 – Example of a configuration of 200 planar shapes detected by [3]. The input point cloud (5.2M points) has been acquired via a LIDAR scanner, from the inside and outside of a physical building.

Objectives. The goal of this PhD thesis is to investigate new shape detection methods that are more controllable, more efficient and more optimal than existing algorithms. Three main research directions will be investigated during the PhD:

Shape refinement. Given an initial configuration of shapes, the candidate will explore novel approaches 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.

Shape detection by deep learning. The candidate 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 that basic 2D geometric shapes can capture objects in images efficiently with deep learning architectures operating on continuous parameter space. With more complex 3D shapes, 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 [6]. Last but not least, the proposed architectures will have to consolidate missing data and occlusions by using an efficient multi-scale shape representation.

General shapes. Existing shape detection methods mostly focus on planar shapes. The later are however not suited to analyze the geometry of freeform objects. The candidate will investigate how to generalize the fitting algorithms to more complex parametric shapes, such as quadric, Bézier or NURBS surface patches. The experiments will be conducted from defect-laden 3D data highly corrupted by noise, outliers and occlusions.

Keywords: geometry processing, computer vision, deep learning, shape detection, model fitting.

Candidate profile. The ideal candidate should have good knowledge in 3D geometry and applied mathematics, be able to program in C/C++, be fluent in English, and be creative and rigorous.

Location. The thesis will take place at Inria Sophia Antipolis - Méditerranée, France. The research will be conducted in the Titane project-team (<https://team.inria.fr/titane/>). Our team carries on research on geometric modeling of complex environments.

Application deadline: April 25th, 2019.

Contact: Florent Lafarge (Florent.Lafarge@inria.fr) and Pierre Alliez (Pierre.Alliez@inria.fr)

References

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