PhD position in Computer Vision and Machine Learning

Learning the geometric signature of CAD models

Context

Geometric modeling has become an indispensable component in the quest towards the 3D digitization of our world. The need for 3D models reconstructed from physical measurements is ubiquitous, from 3D printing to architectural design through reverse engineering and intelligent cities. In many applicative fields, only user-guided Computer-Aided Design (CAD) tools can deliver 3D models whose quality fulfills the requirements of practitioners. Indeed, when a human operator creates a CAD model with an interactive software such as AutoCAD, he leverages expert knowledge, learned from past experiences, on the nature of the object and its structure into geometric parts. However, these tools and their reliance on user interaction do not constitute a viable solution for processing big volumes of data: designing automatic reconstruction algorithms that produce CAD-quality models is a key scientific challenge.

The growing availability of large datasets of CAD models combined with the recent advances on geometric learning [1] suggest this challenge could be tackled by learning and exploiting such expert knowledge. As illustrated in Figure 1, an object can be represented by a large spectrum of CAD models, with different shapes, levels of details, assembling rules or topological properties - in other words, with different *geometric signatures*. To be competitive with user-guided CAD, automated geometric modeling must be able to detect, learn and replicate these variations.

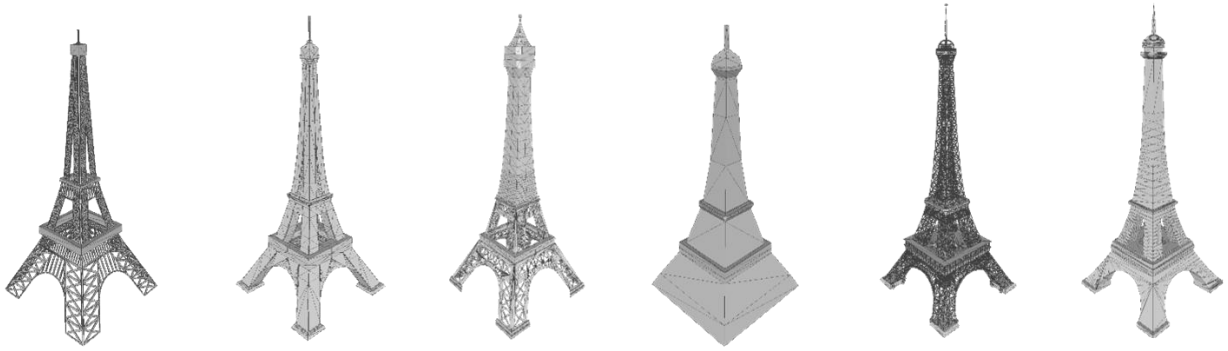

Fig.1 – Different CAD models representing the same object. These models differ in terms of geometric shapes, levels of details, assembling rules or topological properties.

Objectives

The goal of this PhD is to investigate methods that detect, learn and replicate the geometric signature of CAD models. Two main research directions will be investigated during the PhD.

- **Learning geometric signatures.** The candidate will investigate how to represent the geometric signature of a set of CAD models and propose learning strategies that take into consideration the local shapes of objects, the rules to assemble these shapes into objects, the level of details as well as the geometric and topological properties of the underlying mesh data structures. A preliminary work in this direction suggests a basic formalism such as the CityGML Levels of Details can be learned quite effectively from simple planar shapes [3]. The goal here is to be able to characterize any type of formalism or design style, not just an urban-specific formalism based

on basic level of details. One possibility could be to learn a multimodal style distribution similarly to [4], but adapted to CAD models. Another possibility could be also to learn a distribution of geometric differences between two models, such as the approach proposed in [2] for characterizing shapes only. Another issue to address will be to create meaningful training sets from a small amount of CAD models.

- **Designing priors for the 3D reconstruction of objects.** The candidate will also investigate how to utilize this learned knowledge for reconstructing objects from 3D data measurements with a specific CAD style. In particular, the candidate will propose strategies to convert this knowledge into prior functions that will be integrated into existing reconstruction pipelines such as [5]. Such functions must be able to measure the similarity between a 3D model and a given geometric signature. It will be also interesting to extend the approach to generative models to create objects with new geometric signatures, in particular for applications in design.

Keywords

Computer Vision, Geometry Processing, Deep Learning, CAD models, 3D reconstruction

Candidate profile

The ideal candidate should have good knowledge in Computer Vision, Machine Learning and Applied Mathematics, be able to program in C++ and Python, be fluent in English, and be creative and rigorous.

Location

The job will take place at Inria Sophia Antipolis, France. The research will be conducted in the Titane group (https://team.inria.fr/titane/). The group does research on geometric modeling of complex environments from 3D data measurements.

Application deadline: 7th of May, 2021

Contact

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