Mixed-Integer Optimization for Line Drawing Reconstruction

Advisor
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Context and Research Goal

Designers draw extensively to externalize their ideas and communicate with others. However, drawings are currently not directly interpretable by computers. To test their ideas against physical reality, designers have to create 3D models suitable for simulation and 3D printing. A long term ambition of our research group is to bring the power of 3D engineering tools to the creative phase of design by automatically estimating 3D models from drawings (Figure 1).

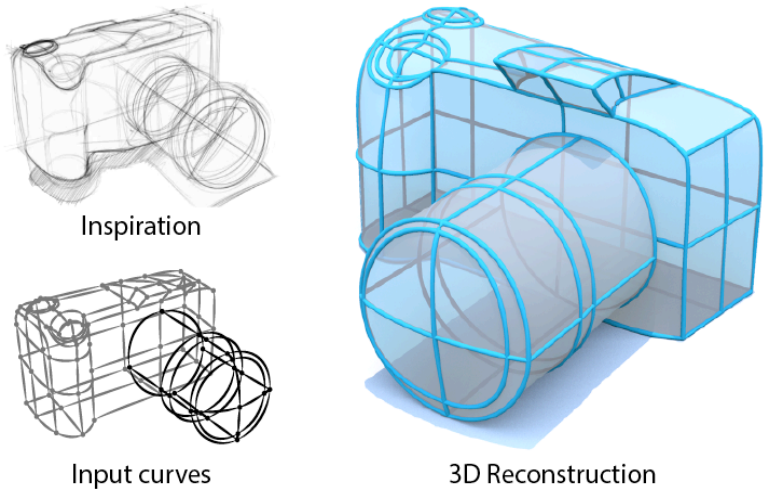

Figure 1: Our ambition is to automatically reconstruct 3D models from design drawings. Our preliminary solution [2] requires the presence of cross-section lines, that are assumed to be mutually orthogonal.

However, reconstructing 3D models from drawings is an ill-posed problem: a point in the drawing can lie anywhere in depth. In addition, line drawings are often drawn quickly and do not represent a perfect projection of a 3D object. We thus need additional constraints on the solution to reduce ambiguity and correct for drawing inaccuracy.

Approach

While line drawing reconstruction remains an open problem, several methods have been proposed for specific shapes (see [1] for polyhedrons) and drawing techniques (see our work [2] that exploits a technique called cross-sections). The main idea behind these approaches is to impose geometric constraints between the lines in the drawing. For instance, two lines that are parallel in the drawing are constrained to be parallel in 3D. However, existing methods often rely on heuristics to detect these constraints, such as thresholds to identify parallel lines. While these heuristics work well on simple examples, they are not sufficiently robust to handle real-world design drawings.

The goal of this internship is to design and implement a novel optimization method capable of *jointly identifying constraints in a drawing and reconstructing the corresponding 3D shape*. To do so, we need to consider a number of candidate constraints in the drawing (parallelism, orthogonality, symmetry) and associate each constraint with a binary variable that indicates if the constraint is active. These additional discrete variables make the problem a so-called Mixed-Integer formulation, which is NP-hard since finding the optimal solution would require testing all potential combinations of constraints. Instead, we need to devise efficient strategies to only evaluate a subset of high-quality configurations. One potential approach will be to use the existing heuristics to compute a probability distribution on the set of binary variables, and then rely on stochastic optimization such as Markov Chain Monte Carlo to evaluate the most probable constraint configurations. Other mixed-integer optimization strategies, such as the "branch-and-bound" algorithm, may also be considered.

This internship may be extended to a PhD.

Location

The internship will take place at Inria Sophia Antipolis, on the beautiful French riviera. The research will be conducted in the GraphDeco group (https://team.inria.fr/graphdeco/). The group does research on image synthesis and computer-aided design.

Inria will provide a monthly stipend of 1100 euros for EU citizen and 400 euros for non-EU.

Requirements

The successful candidate should have taken courses in one or more of the following topics: numerical optimization, computer graphics, computer vision, geometry processing. The candidate must have experience in C++ programming.

References

[1] H. Lipson and M. Shpitalni
Optimization-based reconstruction of a 3d object from a single freehand line drawing
Computer-Aided Design 28, 651–663. 1996
http://dl.acm.org/citation.cfm?id=1281556

[2] Baoxuan Xu, William Chang, Alla Sheffer, Adrien Bousseau, James McCrae, Karan Singh
True2Form: 3D Curve Networks from 2D Sketches via Selective Regularization
ACM Transactions on Graphics (Proc. SIGGRAPH) 2014
http://www.cs.ubc.ca/labs/imager/tr/2014/True2Form/index.htm