Rationalization of CAD assemblies

Master-level internship, could be extended to a PhD

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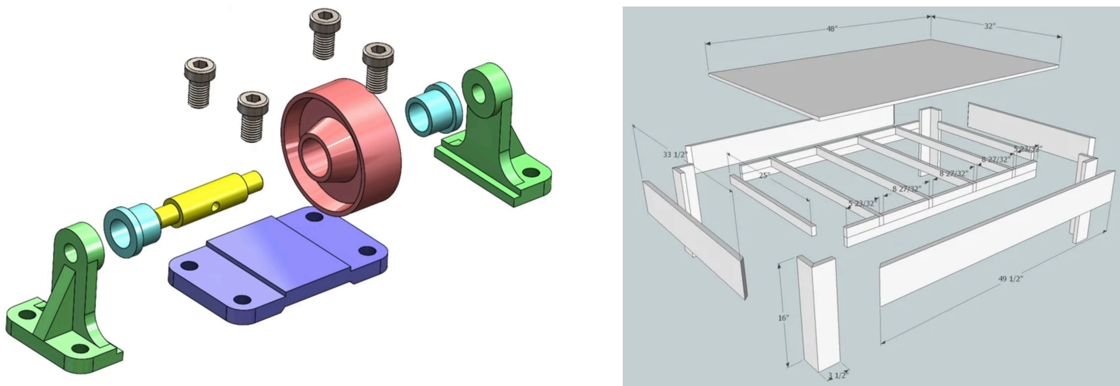

Figure 1: *Manufactured objects are often created by assembling many parts, such as plates, wheels and tubes in mechanical assemblies (left) or planks in furniture assemblies (right). Objects are easier to fabricate and repair if they are made of standard parts also present in other assemblies.*

Context

Many objects that surround us are created by assembling simple parts, and the cost of fabricating and repairing these objects highly depends on the availability of their constituent parts. Creating objects such that they are composed of standard parts is a difficult design task, akin to solving puzzles with pieces taken from a very large catalogue of items. Our goal is to ease this task by assisting designers in creating families of objects composed of the same parts. We call this problem *assembly rationalization*, as the goal is to make a set of assemblies be more efficient by sharing their parts. A similar notion of rationalization has been studied in the related domain of architectural design [1].

Approach

We will formulate this problem as an optimization, where the input is a set of assemblies created using Computer-Aided Design (CAD), and the output is a new set that best satisfies two competing objectives:

- Each assembly should remain as similar as possible to its initial state,
- All assemblies should share as many parts as possible.

Solving this problem requires identifying similar parts across assemblies, and modifying the dimensions of these parts until they are identical. Importantly, these geometric modifications should maintain the functionality of the original assemblies, which induces complex dependencies between parts in each assembly. The resulting optimization is likely to include both discrete variables (which parts can be made the same) and continuous variables (what dimensions should the parts takes to be identical), along with constraints ensuring preservation of functionality (alignments, contacts).

As a first step, we will formalize and develop the optimization procedure by working on furniture assemblies, which we could generate artificially by defining simple parametric furniture models, such as closets and shelves [2,3]. If time permits, we will then consider the extension of the method to more diverse and realistic assemblies from recent CAD datasets [4,5].

Work environment and requirement

The internship will take place at Inria Sophia Antipolis. Inria will provide a monthly stipend of around 1100 euros for EU citizens in their final year of masters, and 400 euros for other candidates. Candidates should have strong programming and mathematical skills as well as knowledge in computer graphics, geometry processing and optimization.

This internship may be extended to a PhD.

References

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[2] Towards Zero-Waste Furniture Design
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http://geometry.cs.ucl.ac.uk/projects/2016/zero-waste_design/

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[4] JoinABLe: Learning Bottom-up Assembly of Parametric CAD Joints
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[5] AutoMate: A Dataset and Learning Approach for the Automatic Mating of CAD Assemblies
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