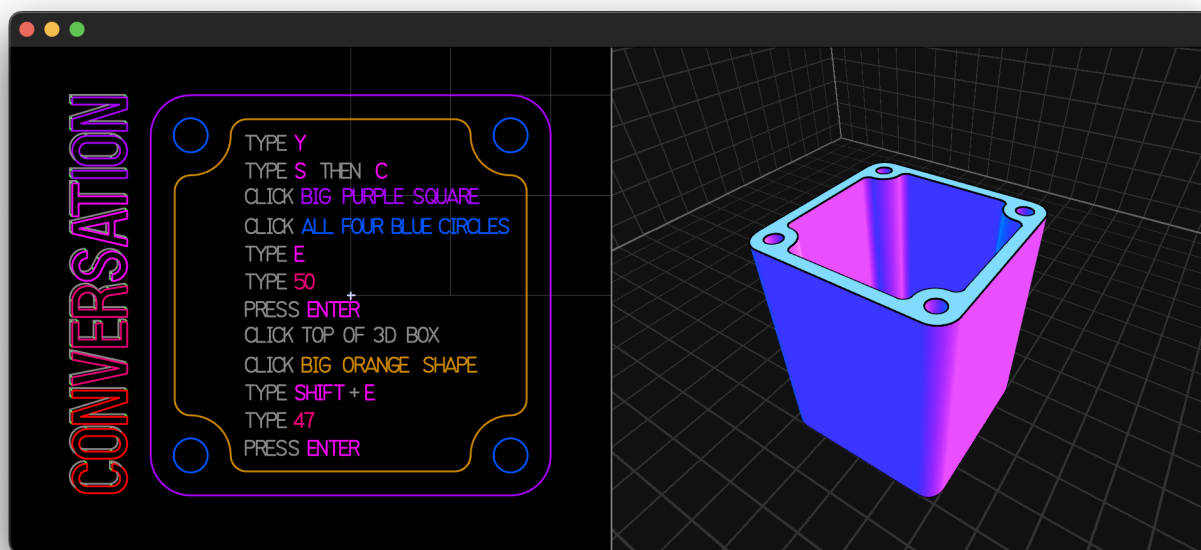


Conversation: An Extremely Fast and Simple CAD Program for 3D-Printed Parts and Robots

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We propose *Conversation*, an experimental CAD program that emphasizes speed and simplicity. *Conversation* enables a user to rapidly transform a 2D DXF drawing of lines and arcs into a 3D STL triangle mesh. *Conversation* is extremely fast to use and easy to learn. Target users of this technology include (i) K-12 students who would like to quickly begin designing and printing their own robots, (ii) programmers who do not want to invest the time required to learn a more fully-featured CAD package like SolidWorks, and (iii) mechanical designers who want to design and print relatively simple parts more quickly. *Conversation*'s simplicity promises to make it highly extensible and scriptable, and we envision it serving as an exciting research platform for robotic co-design.

Motivation: Modern CAD packages like SolidWorks are incredibly featureful and powerful [1]. It is possible to design and assemble entire complex machines (and even factories!) in these programs. However, this power does not come for free. Programs like SolidWorks are complex. Learning them can be a time-consuming challenge. And, even for an expert, creating simple parts can be surprisingly involved.

These facts have serious downstream consequences:

- K-12 students may find programs like SolidWorks inaccessible, and instead attempt to use programs that are poorly suited to designing machines like robots.
- Non-Mechanical Engineering majors may not learn programs like SolidWorks at all, even if they have a personal interest in designing robots. (And their Mechanical Engineering peers learn SolidWorks via a semester long baptism by fire in Mechanical Design I.)

- Expert robotics researchers must “jump through hoops” just to design simple one-off parts.

A simple, fast CAD program would address these problems, and help democratize the design of robots.

Preliminary Results: We propose a CAD system that operates directly on “lowest common denominator” file formats, the DXF for 2D drawings, and the STL for 3D triangle meshes. For our purposes, the DXF is just a list of line segments and arcs, and the STL is a list of triangles. Our key insight is that—for a wide range of robot design problems—this is enough! For example, all of the 3D-printed parts for robot arm in Figure 1 were created using *Conversation*.

The result is a novel, extremely fast 2D → 3D CAD system, with a workflow still reminiscent of SolidWorks. We are using the software to teach CSCI 345: Robotics and Digital Fabrication at Williams this semester, and were excited to observe that students picked it up quickly and were able to use it to design their own custom robots.

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Conversation is written in C/C++ and OpenGL, and draws inspiration from OpenSCAD’s straight-forward boolean workflow [2] and LAYOUT’s rapid 2D picking and drawing [3]. Additionally, we employ the recently developed Manifold [4] library for efficient mesh boolean operations.

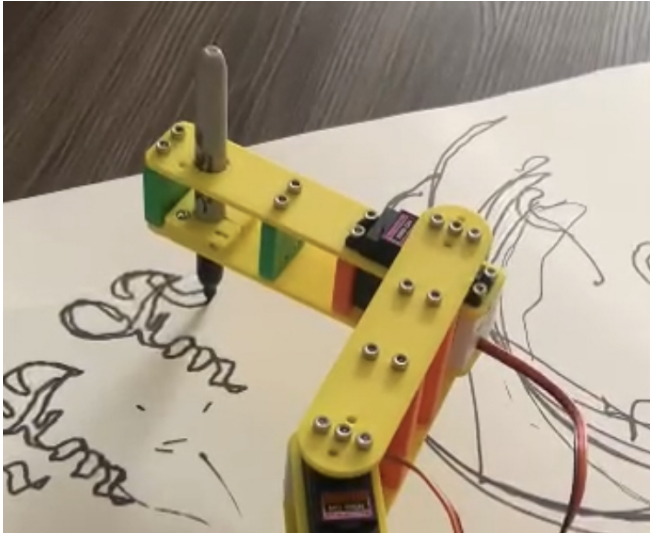


Fig. 1: This simple robot arm is capable of drawing names. Its 3D-printed parts were all modeled using *Conversation*.

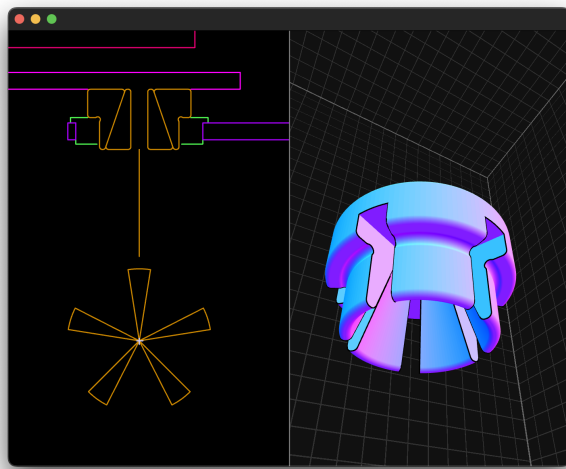


Fig. 2: *Conversation* enables users to rapidly turn 2D drawings into functional 3D robot parts without the difficulties inherent to fully-featured parametric CAD programs. This part supports a bearing of the robot arm shown in Figure 1.

Outlook: An exciting future for *Conversation* is as a test-bed for developing robot co-design algorithms. The software’s balance of simplicity and power makes it ideal for scripting and extending. Additionally, because the software operates directly on simple and ubiquitous file formats—DXF and STL—it can be readily incorporated into existing computational design pipelines.

REFERENCES

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