constructable: Interactive Construction of Functional Mechanical Devices

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Abstract

constructable is an interactive drafting table based on a laser cutter that produces precise physical output in every editing step. Users interact by drafting directly on the workpiece using a hand-held laser pointer. The system tracks the pointer, beautifies its path, and implements its effect by cutting the workpiece using a fast high-powered laser cutter. constructable achieves precision through tool-specific constraints, user-defined sketch lines, and by using the laser cutter itself for all visual feedback, rather than using a screen or projection.

1 Introduction

The common workflow of personal fabrication tools places computer-aided design software at the front-end. The use of CAD provides three main benefits over traditional woodworking tools, such as saws and wood chisels: (1) interacting in software is faster than operating a mechanical tool, (2) users can undo mistakes, and (3) construction aids allow for high precision. On the flipside, all editing is now done on a computer screen, which removes users from the workpiece and prevents users from refining their design interactively.

Interactive fabrication systems address this by letting users once again work directly with the workpiece [Willis, 2011]. A key element of interactive fabrication systems is that they provide output after every editing step. This allows users to (1) validate their designs earlier and (2) build on the result of earlier steps. However, editing now becomes slower, because users have to repeatedly wait for the fabrication engine to finish. Second, users lose the precision required to create functional devices.

With constructable [Mueller, Lopes, & Baudisch, 2012], we attempt to put these qualities back into interactive fabrication, moving it in the direction of what we call interactive construction.

2 constructable – interactive construction

constructable is a drafting table that produces physical output in every step. As illustrated by Figure 1, all interaction in constructable takes place on the work-piece, mediated through low-power hand-held laser pointers, which we call proxy lasers or simply tools. In the shown example, the user uses the finger joint tool to add finger joints between two pieces by crossing the two involved edges. Proxy lasers are too weak to affect the work piece. Therefore, constructable tracks proxy laser interactions using a camera mounted above, reconstructs the tool's path, transforms it using a constraint set defined by the current tool, and implements the effect using its high-powered cutting laser. Since all elements were constructed using constraints, we obtain functional mechanical devices, such as the gearbox in Figure 1d.

Each proxy laser features three barrel buttons. While held depressed, the middle button activates the beam, allowing the user to determine a starting point with precision. The other two buttons trigger the tool's two modes of operation. The cut button allows cutting a tool-specific shape, such as a circle for the circle tool. The sketch line button creates the same shape, but etches it as a shallow dashed line into the surface of the material. Sketch lines have no direct impact on the mechanics of the workpiece, but instead serve as alignment aids that attract sub-sequent cuts.

constructable users create objects by using a sequence of tools, each of which embodies a different constraint set. Figure 2 shows the sequence for creating a simple booklet.

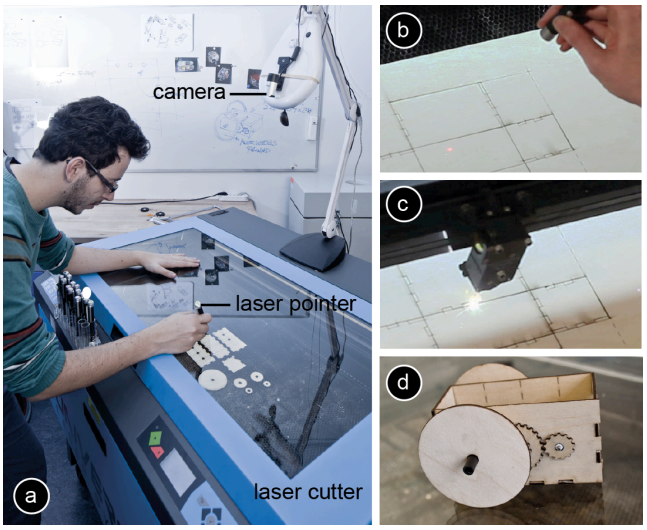

Figure 1: (a) constructable users interact by drafting directly on the workpiece with hand-held lasers. (b) Here the user sketches a finger joint across two objects. (c) The system responds by laser cutting the desired joint. (d) constructable allows creating precise & functional mechanical objects, such as this simple motorized vehicle.

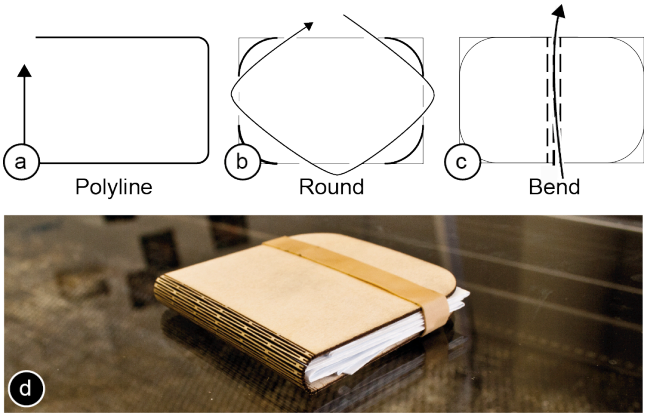

Figure 2: Creating a booklet using the *polyline*, *round* and *bend* tool.

3 Conclusions

constructable is an interactive system that enables users to create functional mechanical devices. The key behind constructable is that it, unlike previous work in interactive fabrication, allows users to create precise output using tools-based constraints, sketch lines for alignment, and the laser cutter itself for precise output.

References

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ACM 978-1-4503-2261-4/13/07