Self & team survey

Link: https://forms.gle/WAh39vh3DRF5hriH9

Nov 28th, EOD
Laser Cutting
Formative manufacturing

Subtractive manufacturing

Additive manufacturing
We already talked about 3D printing, why laser cutting?

- **Fast** (Good for iteration)
- **Durable** (because there is no layer bonding)
- **Simple** (Similar to 2D paper printing)
How does a CO2 laser cutter work
What we can do with it
distance of sheet to lens is important (focal length of lens)

defocused: too little power for cutting
how can I laser cut something?
laser features #1

Raster engraving
Engraving takes about half an hour at this size.
Raster engraving

This process is the same as used by inkjet printers. A file is printed line by line.

Instead of ink being applied, material is removed pixel by pixel by the laser.
When to use raster engraving?
Want to leave “trace” on the material, but doesn’t want to “cut through”

Pros/Cons?
Detailed engraving images
Slow in speed
laser features #2

Vector engraving/cutting
Vector engraving/cutting

The file to be printed is a graphic file consisting of **vectors**, marked as hairlines in the graphics.

**Vector by vector is traced by the laser** and then engraved.

In vector engraving, the axles move simultaneously, and more slowly than in raster engraving.
We can also score lines without cut-through. (folding lines)

We will assign different lines with different power and speed
relationship between power and speed?
if we increase speed, do we get more of less power?
if we go faster
the laser spends less time on a single spot
-> less power
What materials can we cut?
most common materials

Paper
Cardboard
Acrylic
Solid wood
MDF
Leather
what *other* materials can we laser cut?
unconventional materials
Digital Gastronomy: Methods & Recipes for Hybrid Cooking

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ABSTRACT
Several recent projects have introduced digital machines to the kitchen, yet their impact on culinary culture is limited. We envision a future where digital technologies and robotics technologies are embedded in the kitchen, thus allowing for new culinary experiences. We present our work towards replacing the chef with an autonomous robotic system that could create, monitor, and manage the cooking process.

INTRODUCTION
Recently, we have witnessed a growing number of projects incorporating digital technologies into the kitchen, in the form of food printers [11, 12, 13, etc.], an automated cooking robot [14], and the use of robotics to assist in the cooking process [15]. Despite these advances, the potential of digital technologies to transform the culinary experience remains largely unexplored, and we often think of these technologies in terms of time-savers or convenience. This project suggests that cooking can be expressed as a form of art, something that is not only aesthetically pleasing but also intellectually stimulating.

The kitchen is more than a “space” for food preparation; it is a place where culture and meaning are created and consumed [1]. In this sense, the digital kitchen can be seen as a new way of understanding and experiencing food, where the digital elements blend seamlessly with the physical environment to create a new form of culinary expression.

In this paper, we present our work on the development of a kitchen environment that incorporates digital technologies into the cooking process, allowing for new culinary experiences. We describe our approach, the technologies we used, and the results we achieved.

Author Keywords:
Food, kitchen, cooking, design, 3D printing, fabrication.

ACM Classification Keywords:
H.5.2 User Interfaces: User-centered design.

Figure 1: A general scheme of a hybrid cooking procedure using manual and digital techniques to alter presentation of a dish: 1) Traditional cooking 2) Change in interactions with digital processes 3) Live examples of dishes made using hybrid cooking techniques.

Mizrahi et al.

UIST 2016
never cut materials that are flammable
create toxic fumes

Ask the lab manager (or me) before you try novel materials
can we laser cut metal and glass?

No we can’t, at least not with CO2 laser cutter.

We may engrave glass, coated metal, marble, anodized aluminum, titanium, some phones, tablets, and laptops.
can we laser cut metal and glass?

However, IRB0102 has a fiber laser that allows engraving and cutting on metals.
laser features #3

Joints - creating 3D objects
finger joints (box joints)
will this fit?
no, it will not fit.
it will be very loose

material evaporates during cutting.
you need to make the joint larger than the gap
Box Designer

Give us dimensions and we'll generate a PDF you can use to cut a notched box on a laser-cutter. Check out this example box design. People have used this website to design more than 150,000 boxes!

Use this box designer a lot? Consider chipping in some money to support our hosting and bug fixes!

Donate

email: rahul [ at ] connectionlab [ dot ] org
a Connection Lab project
twitter: @rahulbot
version 2.1.0

Add your picture to the flickr pool!

http://boxdesigner.connectionlab.org/
other connection joints
Designs are transferred in and out of the system as SVG files.

https://clementzheng.github.io/joinery/
We already talked about 3D printing, why laser cutting?

- **Fast** (Good for iteration)
- **Durable** (because there is no layer bonding)
- **Simple** (Similar to 2D paper printing)
replace 3D print with laser cut 2D plates:

- 30 min
- 60 min
- 20 min
- 870 min
- 290 min
to speed up design iteration...
Platener: Low-Fidelity Fabrication of 3D Objects by Substituting 3D Print with Laser-Cut Plates

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ABSTRACT
This paper presents Platener, a system that allows quickly fabricating intermediate design iterations of 3D models, a process also known as low-fidelity fabrication. Platener achieves its speed-up by extracting straight and curved plates from the 3D model and substituting them with laser-cut parts of the same size and thickness. Only the regions that are of relevance to the current design iteration are converted to full-fledged 3D prints. Platener connects the parts it has created by automatically inserting joints. To help fast assembly, a user interface allows specifying (1) fabrication speedup ratios, (2) positioning whether or not to connect curved surfaces to plates bent using lasers, and (3) specifying the conformance of individual plates and joints interactively.

Platener is designed to best preserve the fidelity of featureless objects, such as costumes and mechanical parts, all of which contain a large percentage of straight/non-curved elements. Compared to other low-fidelity systems, such as fabrication and WordPress, Platener better preserves the stability and functionality of such objects; the resulting assemblies have fewer parts and the parts have the same size and thickness as in the 3D model.

To validate our system, we converted 2,159 3D models downloaded from a 3D model site (Thingiverse). Platener achieves a speed-up of 70x or more for 94.9% of all objects.

Author Keywords: rapid prototyping; 3D printing; building blocks; physical prototyping.

ACM Classification Keywords: H.5.2 [Information inter-

Figure 1: Platener speeds up the fabrication process by:

segmentation into plates

UIST 2015
Beyer et.al.
Why *laser cutter* again?
Kyub: A 3D Editor for Modeling Sturdy Laser-Cut Objects

Patrick Baudisch, Adrian Giele, Yvonne Esmann, Iuliana Crisan, Ludger Wall, Kevin Kozák, Lukas Hagedorn, Wouter van Beek, and Filip Blasko

ABSTRACT

Kyub is a 3D modeling tool that simplifies the process of creating models for laser-cut objects. It is designed to support the creation of robust and sturdy structures, allowing users to design objects that can be physically cut and assembled. Kyub integrates features such as automatic support structures and constraints to ensure the stability of the final model. The tool is also designed to be intuitive and accessible, with a focus on providing a seamless experience from design to physical creation.

KEYWORDS

modelling, 3D, laser cutting, interaction design
laser features #4

bending
living hinges
living hinges

Repeated patterns with **continuous** connections
Stiff material becomes bendable (with lightweight force applied)
Only work for certain materials (i.e. **acrylics will not work**)

![Images of living hinges](image-url)
bend acrylic

to bend acrylic use a heat gun or strip heater
other ways to make 3D
stacking
intersecting
surface folding
Fusion 360 slicer
laser features #5:

moving parts
gears & linkages::
CO2 laser cutter types
industrial laser cutter
$20k - 50k
(we have 2 in the makerspace)
consumer laser cutters
$3,000 (e.g., Glowforge)
hacker laser cutters < $1,000
water pump under the desk
MicroSlice ca. $200
Arduino, super low-power laser
(cuts paper and makes light engravings)
Customize control for laser cutters
LAOS board
(open source controller board)

gcode:
most widely used **programming language** for controlling industrial machines such as mills, lathes and cutters as well as 3D-printers

That’s also how we control 3D printers

draw on the workpiece with a laser pointer
Interactive Construction: Interactive Fabrication of Functional Mechanical Devices
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ABSTRACT
Furniture fabrication tools, such as laser cutters and 3D printers allow users to create personal objects quickly. However, working through a CDR process remains more challenging, as many users are not familiar with the underlying data structures, let alone the command line.
In this paper, we introduce Constructions, an interactive software that enables users to conceptually design furniture parts and machines. It allows users to quickly create models and make changes, and explores the possibilities for creating tools on the fly using the software.
Concrete fabrication machines through non-specific constraints, non-squared object forms, and using the new curse (for all new objects, either using a scripting engine or programming). By doing so, we obtain a fully automated, interactive, and interactive process that can be integrated with traditional fabrication techniques.

Author Keywords: interactive fabrication, laser cutting, rapid prototyping, additive, construction, machines.
ACM Classification Keywords: H.5.2. Information interfaces and presentation (User interfaces); I.6.4. Computer user interfaces.

INTRODUCTION
Furniture fabrication tools, such as 3D printers and computer-aided design (CAD) software, allow users to create objects quickly. However, working through a CDR process remains more challenging, as many users are not familiar with the underlying data structures, let alone the command line.
In this paper, we introduce Constructions, an interactive software that enables users to conceptually design furniture parts and machines. It allows users to quickly create models and make changes, and explores the possibilities for creating tools on the fly using the software.
Concrete fabrication machines through non-specific constraints, non-squared object forms, and using the new curse (for all new objects, either using a scripting engine or programming). By doing so, we obtain a fully automated, interactive, and interactive process that can be integrated with traditional fabrication techniques.

On the flipside, the transition from traditional tools to computer-aided design (CAD) software is not always a smooth process. Users often struggle with the new tools and interfaces, and may find it challenging to translate their traditional design concepts into digital models.

Figure 1: (a) Constructions is a tool that allows users to conceptually design furniture parts and machines. (b) The software allows users to quickly create models and make changes. (c) The software supports the creation of parametric models, which can be used to create detailed models for manufacturing.

UIST 2012
Mueller et.al.
advanced tricks with defocused laser
To cut-through we need to have the laser focused to the top surface of the material.

Any benefit of defocusing a laser?
laser cutting  ->  laser bending
LaserOrigami: Laser-Cutting 3D Objects

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Abstract

LaserOrigami is a rapid prototyping system that uses an industrial CO2 laser to cut 3D objects from paper sheets. LaserOrigami is extremely flexible, allowing for digital fabrication of complex objects. To achieve this, LaserOrigami combines laser cutting with origami techniques. LaserOrigami allows the user to design and cut objects directly with a digital interface, providing a seamless interaction between design and cutting. LaserOrigami enables the creation of intricate, three-dimensional objects that can be folded and assembled into a final product.

Author Keywords:
rapid prototyping, laser cutting, paper, laser cutting, origami

Session:
Fabrication

CHI 2013: Changing Perspectives, Paris, France
Using defocused laser to bond layers of acrylics for prototyping

**Auto-stacking**
LaserStacker: Fabricating 3D Objects by Laser Cutting and Welding
Umapathi Somandi, Hong-Ting Chen, Veronika Moritz, Ludwig Wall, Anna Frieder, Patrick Beirach
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Abstract
Laser cutters are useful for most prototyping because they are fast. However, when prototyping older designs, the generated laser cut is usually more than necessary. LaserStacker generates 3D objects from laser cut pieces and adds them to the object to form a dynamic stack to stack and glue them. This approach, however, requires careful effort for the necessary manufacturing and assembly steps. The next section describes how to use the LaserStacker process to create 3D objects in metal, defining the purpose of using a laser cutter for prototyping.

To prototype using the assembly step with our system LaserStacker, the next step is to see the laser cutter as an entity that can be used. LaserStacker is like a piece of metal, but a stack of pieces glued into their shape. In a single process step, LaserStacker can weld and glue the pieces together. The results are strong and stable, and the process can be repeated. The assembly step in this process is called the hourglass, and laser cutting can be higher-quality. When using laser cut objects from the laser cutter.

To allow users to create complex objects efficiently, we have implemented a laser cutter for laser cutting that provides tools for designing which parts should be removed and which should remain. When using the laser cutter, LaserStacker converts the 3D models into cutting, welding, and gluing instructions for the laser cutter.

Figure 1 LaserStacker produces laser cut objects that can be assembled using a stack and glue process. The process consists of welding, cutting, and gluing.

Keywords: laser prototyping, laser cutting

ACM Classification Keywords: H.5.2 [Information interfaces and presentation]: User Interface
Other methods to create 3(2.5)D shape with laser cutter?
ABSTRACT

This study presents BlowFab, a prototyping method used to create 3D pounding structures in a short time by combining laser cutting and blow molding techniques. The use of a laser cutter to cut multilayered plastic sheets and a laser cutter to create 3D pounding structures enables the creation of lightweight, strong, and deformable objects. These objects are then formed using blow molding techniques. Blow molding is a method that can be used to create prototypes of complex shapes. The laser cutting technique is used to create 3D pounding structures, while the blow molding technique is used to form the objects. This method is particularly useful for creating prototypes of objects that are difficult to create using traditional methods. The authors present the results of their experiments, which demonstrate the feasibility of using this method to create prototypes of complex shapes. The results show that this method is effective in creating lightweight, strong, and deformable objects that can be used in a variety of applications.

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Keywords: Blow molding, Laser cutting, Prototyping, Lightweight, Strong, Deformable objects.

INSTRUCTIONS

Inflatable membrane structures such as inflatable buildings and portable buildings are widely used in their high weight and portability. These structures differ from the inflatable bags currently available, which are often made of lightweight but stiff materials. The authors propose a new method for creating lightweight, strong, and deformable objects using inflatable membrane structures. This method consists of creating inflatable objects that can be easily assembled and disassembled, allowing for quick and efficient deployment. The inflatable objects can be used in a variety of applications, including emergency shelters, disaster relief efforts, and temporary housing. The authors demonstrate the feasibility of this method through experiments and provide insights into the potential applications of inflatable membrane structures.

Keywords: Inflatable membranes, Lightweight, Strong, Deformable objects.

Additional Information

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Blow Fab: Rapid Prototyping for Rigid and Reusable Objects using Inflation of Laser-cut Surfaces

Yamaoka et.al.

UIST 2018
Remember the fiber laser I mentioned earlier?
Fibercuit: Prototyping High-Resolution Flexible and Kirigami Circuits with a Fiber Laser Engraver

Zeyu Ye, Ang Safoy, and Ehsan Hashemi

Abstract

Prototyping compact devices with unique form factors often requires the use of DFM manufacturing processes to be outsourced, which can be expensive and time-consuming. In this paper, we present Fibercuit, a set of rapid prototyping techniques for fiber-based circuits with unique form factors. Fibercuit takes a lightweight approach by using custom-built flexible circuit boards that can be fabricated in-house, and laser-cut paper-based kirigami components to realize the desired form factor, assembly, and connection of the final circuitry. The kirigami components are pre-cut and pre-oriented with existing circuits. This approach reduces the need for highly complex manufacturing processes, such as photolithography and embossing, thereby improving the speed, cost, and flexibility of circuit boards.

Key concepts

- Laser-based circuit prototyping
- Flexible circuit boards
- Kirigami components

Keywords

- Laser-based circuit prototyping
- Flexible circuit boards
- Kirigami components

1 Introduction

In recent years, as more computing occurs on flexible devices, designing smart interfaces has become an area of focus in R&D. In this paper, we study the feasibility of in-house fabrication processes to create compact devices using fiber laser engraving and kirigami component assembly. Building and prototyping such devices requires multiple manufacturing stages, which can be expensive and time-consuming. However, with the rise of fiber laser engraving, kirigami, and other advanced techniques, it is possible to create compact devices at lower costs and in a more efficient manner. This paper introduces a new method for creating high-resolution, flexible, and kirigami-based circuits using a fiber laser engraver.
CO₂ laser
10600 nm

fiber laser
1064 nm
Cutting the Outline of the Traces and the Isolating Area.
create outline
Examples
laser features #1
Raster engraving

laser features #2
Vector engraving/cutting

laser features #3
Joints - creating 3D objects

laser features #4
bending

laser features #5
moving parts

Based on Stefanie Mueller’s slides
Optional readings

Fibercut: Prototyping High-Resolution Flexible and Kirigami Circuits with a Fiber Laser Engraver

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Figure 1: Fiber laser engraver setup with a custom rotary table for cutting the conductive layer on an otherwise-transparent fiber laser-cut sample. (A) An example kirigami sample. (B) A kirigami piece with a battery holder and 2 LEDs.

ABSTRACT

Reducing the footprint of electronic devices allows for improved compactness and better integration with other systems. However, the compactness comes at the cost of reduced current-carrying capacity, which is a constraint for devices that require high power. To address this challenge, we introduce a new technology that combines fiber laser-cutting with kirigami to create conductive patterns on transparent substrates. The kirigami patterns are designed to allow for the transfer of current between different parts of the device, while the fiber laser-cutting process provides a means to precisely cut and shape the conductive patterns. This technology allows for the creation of highly compact and efficient electronic devices that can be integrated into a variety of applications. We demonstrate the feasibility of our technology through experiments on transparent substrates, and show that it is capable of handling currents in excess of 100 A.

KEYWORDS

Kirigami, Fiber laser cutting, Transparent electronics, Conductive patterns

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Figure 2: Schematic of the Fiber laser cutting process. (A) The kirigami pattern is designed using a custom software tool. (B) The laser is then used to cut along the kirigami lines, creating conductive paths on the transparent substrate. (C) The finished product is shown in the inset.

UIST 2022

Yan et.al.

LaserFactory: A Laser Cutter-based Electromechanical Assembly and Fabrication Platform to Make Functional Devices & Robots

Martin Nisser, Nisser Guenter
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Figure 3: LaserFactory is an integrated fabrication process that creates fully functional devices. (A) A laser cutter is used to cut laser-cut molds of a driver pinch and guide plate mechanism and allows the machine to cut only one geometry, but also creates several times and assembly components. (B) The component-based motion controller allows for flexibility, but also reduces assembly time and improves assembly quality. (C) The wireless power transfer system allows for wireless power transfer and can be used to power the device during operation.

ABSTRACT

LaserFactory is an integrated fabrication platform that enables the creation of fully functional devices. By using a laser cutter to cut molds of a driver pinch and guide plate mechanism and allowing the machine to cut only one geometry, LaserFactory can create multiple times and assembly components. This approach results in a highly compact and efficient fabrication process, allowing for the creation of fully functional devices that can be used in a variety of applications. The component-based motion controller allows for flexibility, but also reduces assembly time and improves assembly quality. The wireless power transfer system allows for wireless power transfer and can be used to power the device during operation.

KEYWORDS

Laser cutting, Electromechanical assembly, Wireless power transfer, Compact devices

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Figure 4: Schematic of the LaserFactory process. (A) The laser cutter is used to cut the molds of the driver pinch and guide plate mechanism. (B) The fully functional device is shown in the inset.

CHI 2021

Nisser et.al.