https://shorturl.at/ovG27

We will also post the entire video clips on Panopto
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
C02 Laser tube

Mirrors

Laser head

MOTOR
LINEARRAIL
**distance** of sheet to lens is important (focal length of lens)

- **focused**
- **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 or 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

Mizrahi et.al.

The Hebrew University of Jerusalem, Israel, MIT Media Lab, and Bezeq Academy of Arts and Design, Jerusalem, Israel

ABSTRACT

Several recent projects have introduced digital technologies to the kitchen, yet their impact on culinary culture is limited by a lack of a vision of Digital Gastronomy. As digital technologies are increasingly replacing the chef with an autonomous machine, these digital cooking instruments in traditional kitchens may not directly benefit the cooking experience. This project introduces new digital technologies and methods to the kitchen, blending digital techniques with traditional cooking techniques. We present our historic kitchen, a prototype kitchen, and our new cooking methodology, illustrated by digital recipes with degrees of freedom that can be set at any level of precision or accuracy, thus melting the borders between the digital and the analog.

INTRODUCTION

Researchers have long been working on various aspects of digital technologies in the kitchen, from the keyboard to kitchenware. In this paper, we present a new concept of digital kitchenware, which is not only to replace the chef with an autonomous machine, but also to modify the culinary experience. We introduce a new methodology for cooking that is not limited to traditional methods, but combines them with digital techniques.

The kitchen is more than a venue for digital augmentation: it is a place where culture and meaning exist. In this paper, we focus on the intersection between digital technologies and cooking. We present a new concept of digital kitchenware, which combines traditional and digital techniques, and explores the potential of digital technologies to enhance the cooking experience.

Keywords: Food, cooking, digital, kitchenware, design.

ACM Classification Keywords: R.3.2. User interfaces. H.5.2. User-centered design.

Figure 1: A general scheme of hybrid cooking procedures using manual and digital techniques to offer a personalized experience of the dish. Gray: traditional cooking; Orange: interaction with digital procedures. (B) Five examples of dishes made using hybrid cooking techniques.
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: @rahulbat
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:
to speed up design iteration...
segmentation into plates

Platener: Low-Fidelity Fabrication of 3D Objects by Substituting 3D Print with Laser-Cut Plates

Dustin Beyer, Serfatma Gurevich, Stefanis Mueller, Hsiang-Ting Chen, Patrick Baudisch
Hasso Plattner Institute, Potsdam, Germany
firstname.lastname@hpi.uni-potsdam.de

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 approach 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 executed as full-scale 3D prints. Platener connects the parts it has created by automatically inserting joints. To help fasten assembly, it improves instructions by (1) specifying fidelity-speed tradeoffs, (2) choosing whether or not to convert curved surfaces to plates bent using laser, and (3) specifying the connexions of individual plates and joints interactively.

Platener is designed to best preserve the fidelity of free-form objects, such as organic and mechanical parts, of which contain a large percentage of smooth/non-planar elements. Compared to other low-fidelity systems, such as fabrication and 3D printing, Platener better preserves the stability and functionality of such objects, the resulting assembly has fewer parts and the parts have the same size and thickness as in the 3D model.

To validate our system, we converted 2,000 3D models downloaded from a 3D model site (Turbosquid) Platener achieves a speed up of 10x or more for 99.6% of all objects.

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

ACM Classification Keywords: H.5.2 [Information inter
Why laser cutter again?
Kyub: A 3D Editor for Modeling Sturdy Laser-Cut Objects

Patrick Baudisch, Adrian Hille, Tanja Schwarm, Rabea Gross, Isabell Wahl, Kay Krumm, Licia Prinz, Anja Schweitzer, and Ralf Steinmetz

ABSTRACT

Kyub is an interactive editor where the user can easily design 3D objects using sturdy cardboard. The cardboard is cut with a laser cutter, and the cardboard objects can be used as a tangible user interface to control the 3D editor. The cardboard objects are designed to be sturdy enough to withstand vandalism, but also flexible enough to be easily modified. Kyub provides a seamless transition from a digital to a physical world, allowing users to interact with their designs in a tangible way. Kyub is designed to be used in a group setting, allowing multiple users to collaborate and create designs together. Kyub is also designed to be easy to use, with simple controls that make it accessible to users with no previous experience with 3D modeling.

KEYWORDS

3D modeling, cardboard, tangible user interfaces, interaction design, 3D printing

ACKNOWLEDGMENTS

The authors would like to thank the Kyub team for their support and expertise. The authors would also like to thank the CHI 2019 organizers for their support and encouragement.
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)
bend acrylic

to bend acrylic use a **heat gun** or **strip heater**
other ways to make 3D
stacking
intersecting

woode
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
A Layered Fabric 3D Printer for Soft Interactive Objects

Huaishu Peng | Jen Mankoff | Scott Hudson | James McCann
**40W CO2 Laser Tube Machines 700mm x 50mm for Laser Engraving & Cutting**

<table>
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**Buyer's review:**

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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

Stefano Mueller, Pedro Lopez, and Patrick Headich
Hasso Plattner Institute, Potsdam, Germany

ABSTRACT

Polyline fabrication tools, such as laser cutters and 3D printers driven by digital documents, allow the user to create precise objects quickly. However, finding the right digital document for an object remains a challenge. This paper presents a tabletop fabrication system that allows users to design and fabricate objects on the fly using a simple interface.

INTRODUCTION

Current fabrication tools, such as 3D printers, lack the flexibility to interactively design and build complex objects. This paper presents a tabletop fabrication system that allows users to design and fabricate objects on the fly using a simple interface.

Demo Poster: HPI Interactive Fabrication Table

Interactive Fabrication Table

YouTube video

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?
focused laser lens -> defocused laser bending

laser cutting  - >  laser bending
LaserOrigami: Laser-Cutting 3D Objects

Natascha Mueller, Ruanan Kanai, and Patrick Baudisch

Laser Printing Institute, Potsdam, Germany

(natascha.mueller, ruanan.kanai, patrick.baudisch)@informatik.hu-berlin.de

ABSTRACT

A recent trend in origami is the rapid prototyping of paper models using a laser cutter. LaserOrigami is a technique to rapidly laser-cut traditional origami models, allowing the creation of simple and complex 3D origami, using traditional paper or other materials. LaserOrigami is able to achieve this with a precision of ±0.1 mm and a speed of up to 10 cm/s. LaserOrigami achieves this by accurately cutting along marked lines on the paper. The laser can be adjusted to cut through different layers of paper, allowing for the creation of multi-layered origami. LaserOrigami produces accurate and precise cuts, allowing for the creation of complex designs. The technique is particularly useful for the creation of origami models that require precise and accurate cuts, such as those used in architecture, engineering, and design. LaserOrigami can also be used to create 3D origami, which can be assembled into complex structures, such as those used in robotics and engineering.

Author Keywords: laser cutting, origami, rapid prototyping, 3D printing, robotics, design, engineering

General Terms: Design, Human Factors

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 Umapathi, Haipeng Ting Chen, Helge Huth, Ludwig Wall, Anna Orndorf, Patrick Reindl
FhG Polytech Institut, Fraunhofer, Germany
(uumathis@institut.fhg.de)

ABSTRACT
Laser stacks are useful for rapid prototyping because they are fast. However, their best value comes from 3D printing, where a stack is used to build objects. In this paper, we describe a new process for building 3D objects with a single laser stacker. The idea is to build objects from a stack of pre-processed sheets, where each sheet contains a single layer of material that is fused layer-by-layer to build the desired object.

LaserStacker has been shown to be a viable alternative to traditional 3D printing technologies. However, it has some limitations, such as slow fabrication times and the need for post-processing. To address these issues, we present a new approach that uses laser cutting and welding to fabricate 3D objects more efficiently. The process involves cutting the sheets with a laser to create a pattern that defines the shape of the object, and then welding the edges together to form the final object.

LaserStacker is particularly useful for applications that require high accuracy and precision, such as medical devices, industrial parts, or art objects. The process is also more environmentally friendly than traditional 3D printing, as it uses less material and produces less waste.

LaserStacker is an open-source software that is available for free download. We hope that other researchers will find it useful and contribute to its development.

Keywords: Laser, cutting, welding, 3D printing, prototyping.

UIST 2015
Other methods to create 3(2.5)D shape with laser cutter?
BlowFab: Rapid Prototyping for Rigid and Reusable Objects using Inflation of Laser-cut Surfaces

Yamaoka et.al.

ABSTRACT
This study proposes BlowFab, a prototyping method used to create a 3.5 cm-thick prototype in a short time by combining laser cutting and blow-molding techniques. The use of laser cutting to cut and shape stiff sheets of material allows for the creation of curved and complex objects. The object is then topped with a flexible film, which is inflated with helium gas to inflate the object. Inflation of the flexible film creates an air cushion between the two sheets, and the air pressure inside the film is used to inflate the object. This method is suitable for creating various rigid and reusable objects, such as chairs, tables, and lamps. The proposed method is effective in creating objects that are more durable and durable than traditional methods. The object can also be used to create various applications, such as inflatable furniture, inflatable art installations, and inflatable architectural structures. The method is also cost-effective and environmentally friendly, as it reduces the use of raw materials and reduces waste.
Remember the fiber laser I mentioned earlier?
Fibercuit: Prototyping High-Resolution Flexible and Kirigami Circuits with a Fiber Laser Engraver

Zeyu Ye, Ang Su, Abbas Yasa
Department of Computer Science, University of Maryland, College Park, MD, USA

ABSTRACT

Prototyping compact devices with unique form-factors often requires the use of 3D manufacturing means to be achieved, which can be expensive and time consuming. In this paper, we present Fibercuit, a set of rapid prototyping techniques to fabricate high-resolution circuits on flexible substrates using a fiber laser engraver. The technique enables the creation of intricate, functional circuits with controlled cuts and folds. We demonstrate how our approach can be used to create realistic Kirigami circuits that can fold along a cut, and functional circuits that can fold in two dimensions, such as a foldable sector, flexo circuits, and thin-film transistors, demonstrating how to cut around the fold line. Our approach enables previously infeasible devices and opens new possibilities for flexible electronics.

CCS CONCEPTS

• Hardware • Computer hardware and systems • Flexible electronics

KEYWORDS

Laser engraving, flexible electronics, kirigami, fiber laser, circuits, design, fabrication, manufacturing, prototyping.

1 INTRODUCTION

In the ongoing effort to create compact devices for tiny form factors, designing smart structures has assumed a central role in recent research. In the world of self-driving cars, we are already seeing the incorporation of advanced technology, such as sensors, cameras, and processing units, all packed into the smallest possible form factor. This trend is not limited to the automotive industry, with similar advancements being made in the fields of robotics, wearables, and consumer electronics. However, the process of creating such devices is often time-consuming and expensive, especially when it comes to prototyping complex circuits.

Fibercuit is a novel approach that addresses this issue by utilizing a fiber laser engraver to create high-resolution circuits on flexible substrates. This method allows for the creation of intricate, functional circuits with controlled cuts and folds, enabling the realization of previously infeasible designs. Our approach demonstrates the potential for creating realistic Kirigami circuits that can fold along a cut, and functional circuits that can fold in two dimensions, such as a foldable sector, flexo circuits, and thin-film transistors. By cutting around the fold line, our approach enables previously unattainable designs, opening new possibilities for flexible electronics.
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

Ziye Yan
Department of Materials Science and Engineering, University of Maryland, College Park, MD USA

Minghong Wang
Department of Electrical and Computer Engineering, University of Maryland, College Park, MD USA

Jiaxing Li
Department of Materials Science and Engineering, University of Maryland, College Park, MD USA

UIST 2022

ABSTRACT

Prototyping compact devices with unique form factors often requires the PCB manufacturing process to be reengineered, which can be expensive and time-consuming. In this paper, we present FiberCut, a fiber laser engraving system that can fabricate interconnects and functional circuits using flexible substrates. We demonstrate that these fiber-cut circuits can be used to create compact, self-contained systems.

KEYWORDS

- fiber laser engraving
- flexible electronics
- kirigami circuits
- rapid prototyping

CCS CONCEPTS

- Human-centered computing — Interactive systems and tools simplification

CHI 2021

ABSTRACT

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

Martian Nisser
MIT CSAIL, Cambridge, Massachusetts, USA

Christina Liao
MIT CSAIL, Cambridge, Massachusetts, USA

Yu Chen Chai
MIT CSAIL, Cambridge, Massachusetts, USA

Nisser et.al.

ACM Transactions on Computer-Human Interaction, Article Number 42

ACM Transactions on Computer-Human Interaction, Article Number 46

This paper describes LaserFactory, an electromechanical fabrication platform that leverages laser cutting to create fully functional devices. LaserFactory uses a laser cutter to cut and shape mechanical components, which are then assembled using a robot arm. This approach allows for rapid prototyping of complex devices, making it ideal for research and education. LaserFactory is open-source and can be used by students, researchers, and industry professionals to create innovative devices.

KEYWORDS

Human-computer interaction, rapid prototyping, personal fabrication, printed electronics, robotics

UIST 2022

Nisser et.al.

Figure 1: LaserFactory is an integrated fabrication process that creates fully functional devices. (a) Hardware add-on to an existing laser cutter consists of a laser diode and pitch and place mechanism and allows the machine to cut fully functional parts, but also create custom tooling and assembly components. The electromechanical board motion controller enables the laser cutter to move in 6-axis space, allowing it to cut and shape components. (b) After laser cutting, the fabricated device is fully functional.