Example-Based Print Preview for Laser Cutting

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Abstract
Laser cutting is a powerful fabrication tool in which a user can specify vector drawings to be engraved or cut into a material by a laser. This tool is widely used in manufacturing due to its precision and versatility in cutting and engraving small details into a variety of materials. However, the current process of laser cutting from design to fabrication involves guess work and can end up wasting time and material. We propose a design and visualization tool to create vector drawings that look accurate to what they would be as a laser-cut product. Based on the user’s chosen material and their desired properties of a laser cut, we generate a real-time realistic preview of the finished product as the user edits.

Index Terms: Applied computing—Computer-aided design; Computing methodologies—Image manipulation; Human-centered computing—Visualization systems and tools

1 Introduction
Laser cutting is becoming a more popular form of fabrication recently. Because there aren’t more standardized tools for it like there are for 3D printing, people must use the laser cutter creatively in order to make what they envision. By working around a laser cutter’s limitations, such as in [5], Mueller et al. bend materials by defocusing the laser and heating them up to make 3D objects. Beyer et al., in [1], make an interactive tool that takes 3D models and separates flat parts of the design into laser-cut plates for fast prototyping. In [4], McCrae et al. slice 3D models into orthogonal planar pieces that can be laser cut and assembled. [3] shows that existing furniture designs can be optimized to use less material while still fitting certain criteria to leave the designs fabricable.

The current process of laser cutting starts with the digital design phase. Programs like Adobe Illustrator and Rhino are used to create vector graphics in such a way that the file can be correctly interpreted by the laser cutter’s driver, such as in Figure 1. The user must draw in very specific colors – only those that come programmed into the driver. These are usually bright, pure colors in RGB format, like red = (255, 0, 0) for example. After the user is satisfied with their drawing or design, the user sets the stroke width to be extremely thin to the point where the curves are barely visible. This is also a requirement for the driver. But this visual representation, though logical to the driver, is confusing because it does not give any indication to what it will look like in reality.

Next, the user must choose the material they wish to cut or engrave. In our case, this is normally baltic birch plywood. Most laser cutters come with a limited database that holds other types of wood and even different materials like cardboard, paper, and metal. The database has presets for the laser cutter that tells each color to represent a different combination of settings. Alternatively, the user can add to the database and pick their own settings. However, this is not so straightforward. The settings include: power, speed, frequency, and number of passes. These settings are non-intuitive, as the ordinary user may not know what each of them do, much less the relationship between all of them. In our experience, using either the manufacturer-made settings or the user-made settings, it rarely turns out right the first time. Most of the time, adjustments to the settings must be made and the user tries again.

2 Methods
We propose a system which has the following features to improve the laser cutting process.

![Figure 1: Vectorized shapes with different stroke colors in Illustrator. The colors of these shapes correspond to the settings in Figure 2.](image1)

![Figure 2: Settings in the Trotec laser cutter driver. There are 16 recognized colors that can each be assigned different settings. Each color in the drawing will be cut or engraved according to its settings.](image2)
2.1 Calibration

The first step which will allow for a print preview to be generated is a calibration of the laser cutter. Every laser cutter is different depending on the brand, the wattage of the laser, the type of laser, the environment in which the laser cutter is used, among many other factors. The material also greatly affects the outcome of the laser-cut product. The same laser cutter with the same settings can cut the same design on two materials, but the results will be distinct. The design will come out differently on metal than it does plastic or leather, for instance.

In order to generalize to a wide range of materials and laser cutters, we use image analogies introduced in [2]. Hertzmann et al. presented a framework for applying a "filter" to images based on an analogy between a set of images.

\[
A : A' :: B : B' \tag{1}
\]

If \(A\) is to \(A'\), and \(A\) is a calibration vector graphic and \(A'\) is a photo of this laser-cut piece of material, then given a new vector graphic \(B\), we can create a preview of the design as it would look laser-cut. This will be our \(B'\).

![Figure 3: Calibrating the system to the laser cutter involves cutting a standard pattern with specific settings. In terms of image analogies, this is our \(A\) and \(A'\).](image)

When the user draws a new design, it will become \(B\). Using image analogies, we can generate the \(B'\) which looks like the design laser-cut on wood (or on whichever material the user cut the calibration image). This \(B'\) is updated whenever the user changes the design. This is the basic preview that the user sees.

Our goal in making the calibration design is to cover the largest set of parameters in the fewest amount of cuts and engravings. We need to balance the combinations of settings to represent both a wide range of laser cut appearances and the extreme edge cases. We vary the parameters speed, frequency, and power so that we know how much laser intensity it requires to make marks of different width and color. We can interpolate between to cover the full space. We also make sure the design includes straight lines, curves, and cuts which are placed very close to each other.

2.2 Preview

We take basic features from Illustrator like vector curve drawing, selection, and the fundamental transformations add to the drawing space so that the user can have a more intuitive laser cutting experience. To make this more accessible, we chose to implement it in a web application using JavaScript and its many useful libraries.

To enhance this, we add features which make it a more immersive 3D experience. We generate normal maps of the design and the surrounding wood texture to give the preview depth.

2.3 Explode View

One of the most common mistakes that people make when creating designs to be laser cut comes when the designs are more complication. A design with many pieces often confuses the user and sometimes leads to unwanted pieces missing after they are cut. Sometimes, like stencils, there are “islands” in the design – pieces which are neither connected to the background or the main part of the design. They will fall out after they are cut out of the material. So using connected components, we generate an exploded layer view to show the user.

3 Conclusion

In this extended abstract we proposed an interface to draw and visualize laser cut designs using a variety of techniques. This type of tool does not yet exist for laser cutting and will be a useful improvement to this form of fabrication.

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References


