Laboratory 8: Digital Piano - Introduction to Model Fabrication

Introduction and Objective: In this laboratory, you will learn the principles, processes, and tips to fabricate parts using laser cutter and 3D printer. The case designed for the digital piano with be laser-cut, while a decoration parts will be designed and 3D-printed. The digital piano will be finished with the case and the decoration. You should acquire the basic skills of fabrication by practicing.

1 Introduction

Welcome to our exploration of laser cutting and 3D printing, two versatile and precise technologies that have revolutionized the fields of manufacturing, design, and prototyping. In this lecture, we will delve into the fundamentals of laser cutting and 3D printing, their applications, and the essential steps to operate them safely and effectively. By the end of this session, you will have a solid understanding of how these remarkable tools works and how to harness their capabilities for your projects.

2 What is a Laser Cutter?

A laser cutter is a precise computer-controlled machine that uses a high-powered laser to cut, engrave, or etch materials. The laser is generated by a tube and directed through mirrors to a lens that focuses it onto the material's surface, vaporizing or melting it for clean cuts or engravings. Laser cutters work with materials like wood, acrylic, paper, fabric, leather, and some metals. This technology is widely used across industries for its precision and versatility, aiding in product design, architecture, art, electronics manufacturing, signage, and fashion.

3 Procedures of Laser Cutting

The operation of a laser cutter can be broken down into several key steps:

1. **Design Preparation**: Create a digital design using vector or image software like Adobe Illustrator, CorelDRAW, or AutoCAD, and save it as a PNG, JPG, DXF or SVG file. Also, you can use 3D CAD for modeling and export a drawing for cutting. Consider the laser beam width (kerf) for precise fitting of pieces.

2. **Material Selection**: Select a material compatible with the laser cutter, such as wood, acrylic, paper, fabric and leather, adjusting laser settings for optimal results. Some materials, such as PVC, can release toxic gases when cut.

3. **Setting Parameters**: Enter the laser cutter's software settings, including power, speed, and frequency, based on the material and desired result. Lower power and higher speed yield lighter engravings; higher power and lower speed create deeper cuts. Perform test cuts on the same material to fine-tune settings.

4. **Running the Job**: After configuring settings, upload the design file to the laser cutter. Load the material flat on the bed of the laser cutter. The machine will precisely cut or engrave along the vector paths (for image, the vector paths are generated by the software).
5. **Safety in Running**: Never leave the running laser cutter. Monitor the process for smooth operation and avoiding accident, such as flame and laser overheat. Wear safety glasses and keep a fire extinguisher nearby. Laser cutting is fuming, always use it with an exhaust system.
6. **Post-Processing**: Once cutting is finished, remove the material carefully. Additional steps like edge cleaning, sanding, or assembly may be required, depending on the project.

Answer the questions of the laser cutting in the answer sheet.

3.1 Questions of the laser cutting.

4 What is a 3D Printer?

A 3D printer creates three-dimensional objects by layering material, like plastic, based on a digital model, allowing for intricate designs and rapid prototyping, a process known as additive manufacturing. It has versatile applications ranging from engineers and designers quickly prototype ideas to tailored medical implants and custom-fit footwear. It is also used by artists and fashion designers for intricate sculptures, jewelry, and clothing.

5 Procedures of 3D printing

Using a 3D printer involves multiple steps, from digital model preparation to post-processing. Here's how:

1. **Design a 3D Model**: Obtain a 3D model by creating one with software like Onshape, SolidWorks, or Blender, or download from internet.
2. **Slicing the Model for Printing**: Use slicing software like Creality Slicer to convert the model into thin layers, generating a G-code file with printer instructions. Adjust settings like layer height, infill density, and print speed. Add supports and/or adhesion by requirement.
3. **Load the Filament**: Load the correct filament into the extruder, heat the hot end to the appropriate temperature, and feed the filament until it flows smoothly.
4. **Level the Print Bed**: Ensure the bed is level and correctly distanced from the nozzle for a smooth first layer.
5. **Start the Print**: Load the G-code via SD card or computer, begin the print, and monitor the initial layers. Most printers show the estimated time remaining.
6. **Safety in Running**: Avoid touching the hot end and print bed as they reach high temperatures during and immediately after printing. Be cautious near the moving parts of the printer during operation to avoid injury or print disruption. Ensure you are working in a well-ventilated area.
7. **Post-Processing**: After printing, remove the object and, if needed, remove supports, adhesion, sand edges, or apply finishing techniques like painting or polishing.

Answer the questions of the 3D printer in the answer sheet.

5.1 Questions of the 3D printer.

6 Comparison of Laser Cutters and 3D Printers

Feature	Laser Cutter	3D Printer
Process	Subtractive (cuts material)	Additive (builds material layer by layer)
Materials	Wood, acrylic, paper, fabric, metals	Thermoplastics (PLA, ABS), resins, metals (in advanced printers)
Precision	High (for 2D cuts and engravings)	Moderate to high (depends on layer height)
Speed	Fast (for 2D cuts)	Slower (depends on object size and complexity)
Applications	Cutting, engraving	Prototyping, custom parts, complex geometries

7 Fabricate the Piano Case

The drawing of the parts of the piano case should have be prepared in the last laboratory. Check the drawing to be restricted in a 200 × 100 mm left upper region in a A4 paper. Export the drawing to a PNG image file for cutting. Read the video guidelines (https://youtu.be/bk7Kf226Xt8) of the laser cutter in ITC-52. Laser-cut the parts of the case from the acrylic sheet (200 × 100 × 2 mm) following the guidelines. Take photo of the parts and post them to the answer sheet.

7.1 Photos of the parts of the piano case.

8 Fabricate the decoration

Design a 3D model of a decoration part for the digital piano using Onshape. An example is shown in Fig 1. The size of the decoration should be limited to be (40 × 40 × 10 mm). There should be a M3 through hole with 6 mm length for installing to the case. You would design the decoration whatever you want. Export the drawing to a STL 3D model file for printing and upload it to Moodle.

8.1 Export the drawing to a STL 3D model file and upload it to Moodle with file name "lab8_m81".

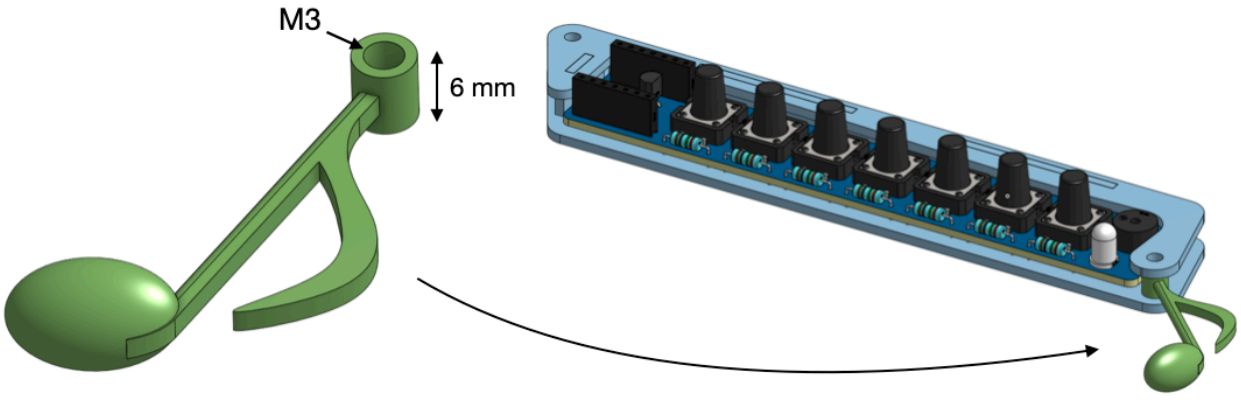

Figure 1: An 3D model example of the decoration.

Read the video guidelines (https://youtu.be/JHbj7Ge_WVA) of the 3D printer (Creality CR10 smart Pro) in ITC-52. Print the decoration following the guidelines. You might download Creality Slicer from https://www.crealitycloud.com/downloads/software/creality-slicer. Take photo of the decoration and post them to the answer sheet.

8.2 Photos of the decoration of the piano case.

9 Assembling the Digital Piano

Assemble the soldered PCB board with electric components, the parts of the cases and the decoration using the M2 screws and M3 standoffs. Take photo of the digital piano and post it to the answer sheet.

9.1 Photo of the digital piano.

Demonstrate the function of the digital piano and take video of it.

Take a video to demonstrate the button LED flowing and upload it to Moodle with the file name" lab5_v42"

10 Conclusion

In this laboratory, you gained hands-on experience in prototype fabrication using laser cutter and 3D printer. Your have made the prototype of the digital piano. The four laboratories provide a solid foundation for future project design and prototype making. We will start your own project for creative mechantronic devices.