Plycutter - laser cutter pattern generator

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Introduction

Laser cutters are a cheap way of cutting e.g. plywood sheets into shapes specified by digital files. For most hobbyists, they are the only accessible form of CNC.

Plycutter is a program that generates laser cutter 2D .dxf files from a 3D model using finger joints between material sheets.

Unlike most such software, plycutter does not slice the 3D model using planes but rather looks for natural sheets in the model and then reasons about how to generate finger joints between the sheets - even for sheets that do not meet at straight angles.

Other software, such as boxes.py that is widely used in the hobbyist community, generates predetermined shapes with finger joints - plycutter, on the other hand, analyzes arbitrary 3D models to add the joints to.

As of 2020-11 the software is in process of being cleaned and open-sourced under an AGPL-3 or later license.

Use cases - why?

The process of

> Quick 3D design → automatic finger joint 2D patterns → laser cut → assemble

Is best suited for

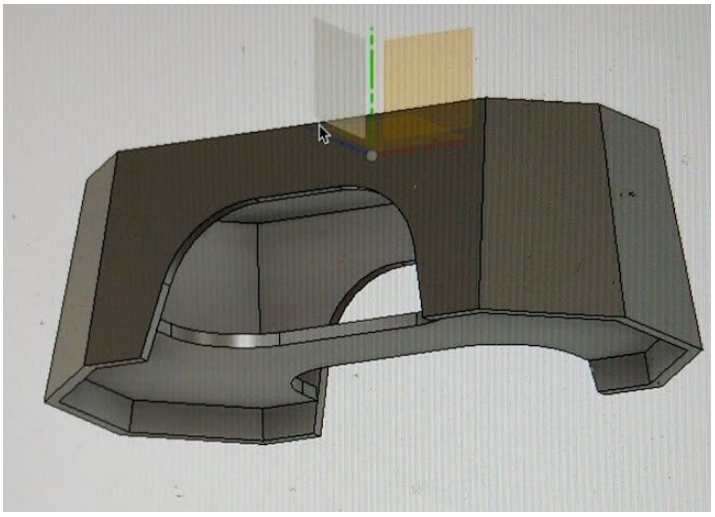
- Single objects
    - e.g. make **one** shoe stand perfectly suited for a particular apartment and family
- Small production runs where economies of scale do not yet apply
- Prototyping where an object needs to be repeatedly made with small tweaks
    - A fast iteration loop idea → create test → analyze is a key component of prototyping
- Generative objects where each object is custom-generated from user input, for example
    - Custom 3D puzzles of user's heads
    - 3D text
    - Custom shelf structures

The following are **not** reasonable use cases for the current generation of this software. Some cases might be enabled by new features later

- Mass production
    - It is economical to use much more designer time to tune mass-produced objects and to optimize the production processes highly
- Safety-critical applications
    - The structure would have to be analyzed for sufficient strength **after** running plycutter and the analysis redone after any changes

Simple example

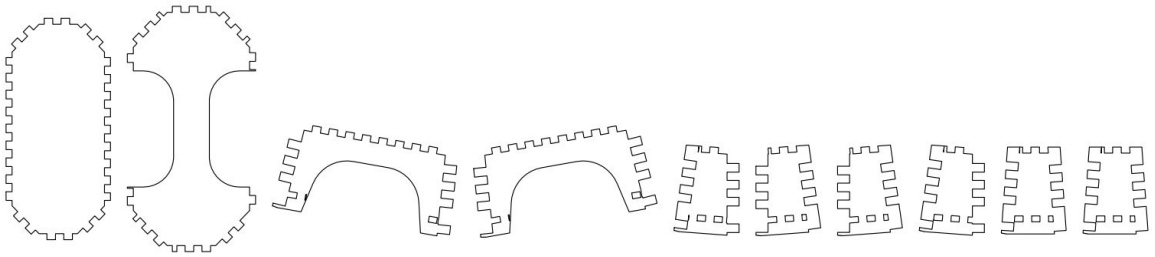
CAD model (made in 5 minutes as a quick test case (thinking of a stool for reaching bathroom sink but this is a small scale model)



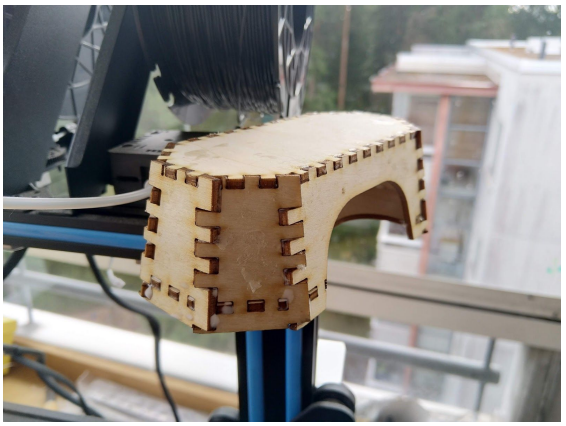
(i.e. the model is already made thinning about sheets, e.g. using the CAD "shell" command but the joints between sheets are not modeled by the user, saving an enormous amount of time)

→ PlyCutter script runs fully automatically after sheet thickness and some parameters specified

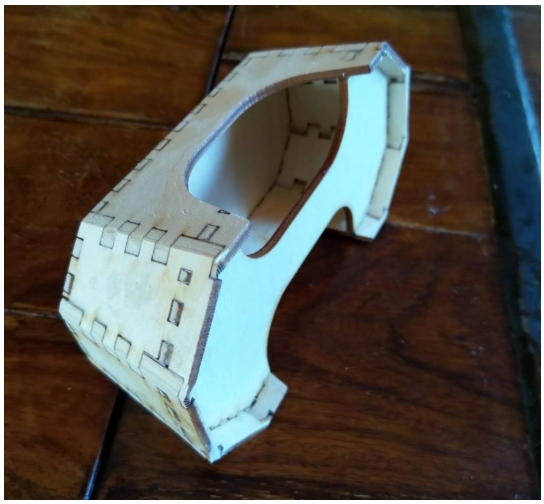
→ DXF file for laser cutter



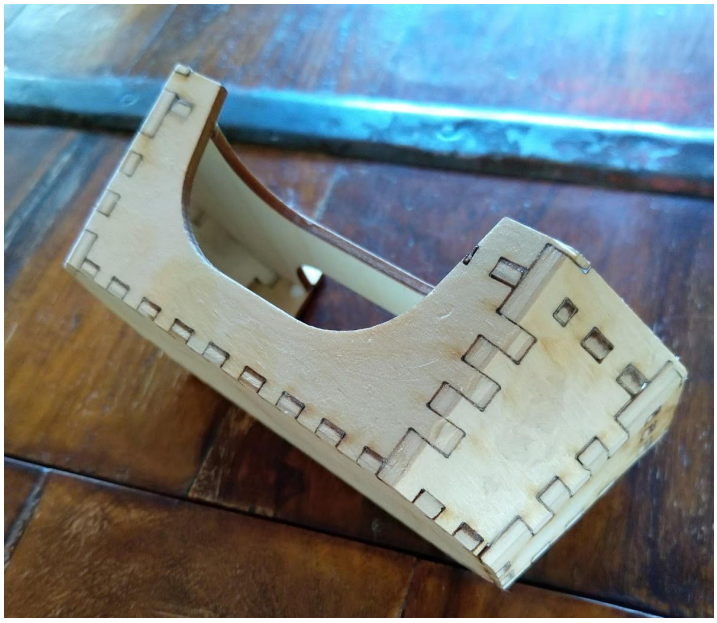
→ Cut with laser cutter and assemble the “puzzle pieces” manually



→ Use a multitool or equivalent to cut the overhanging bits and sand it a bit



Different angle:



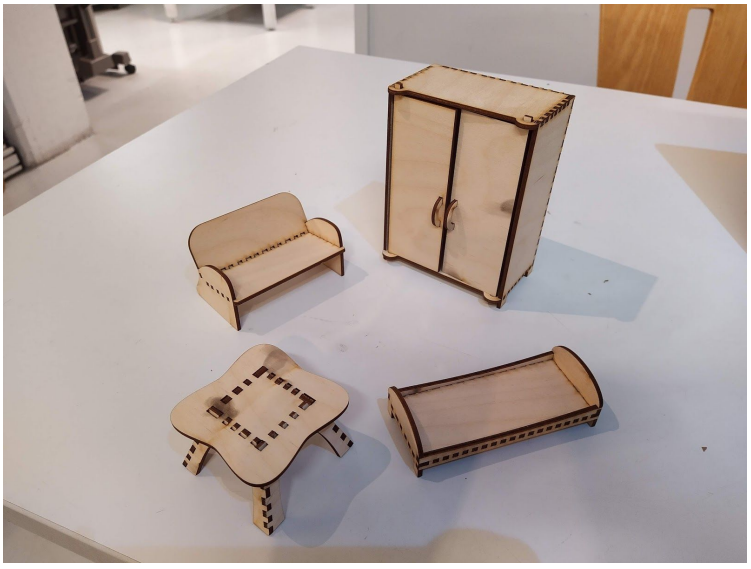
More examples

The examples are shown unpainted to most clearly demonstrate the structure the software creates.

Dollhouse furniture

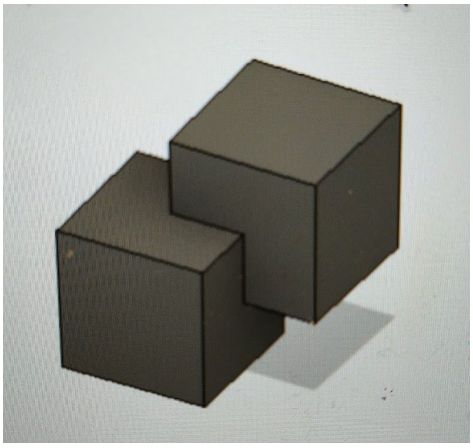
CAD:

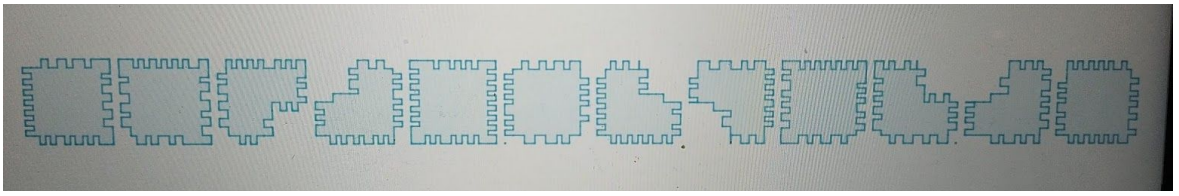
After plycutter + laser cutting + assembly (quick processes, much faster than 3D printing would have been):

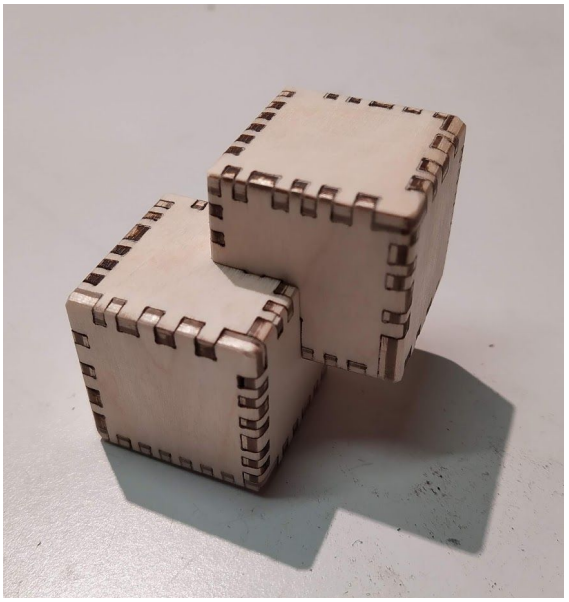


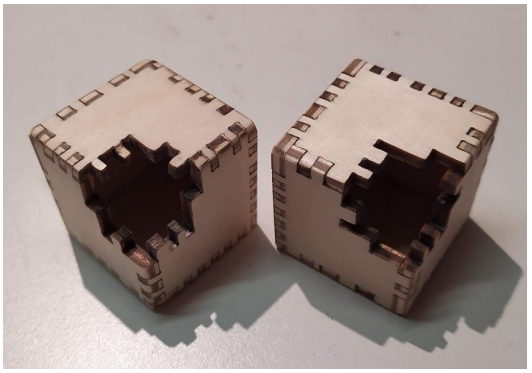
Decorative geometrical objects

Interlocking cubes



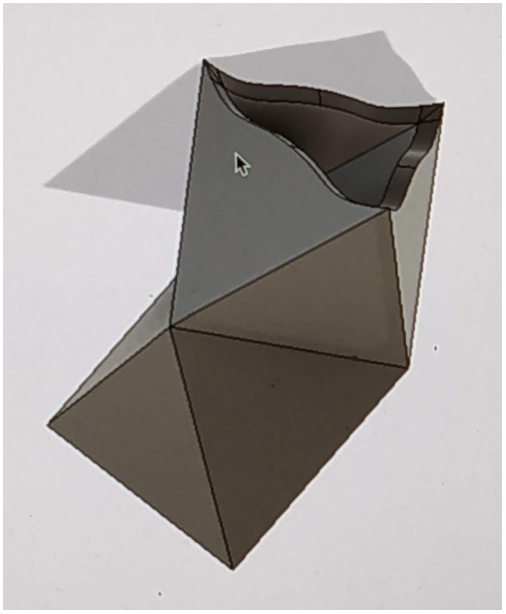






Pen holder from two stacked tetrahedra (scale model)

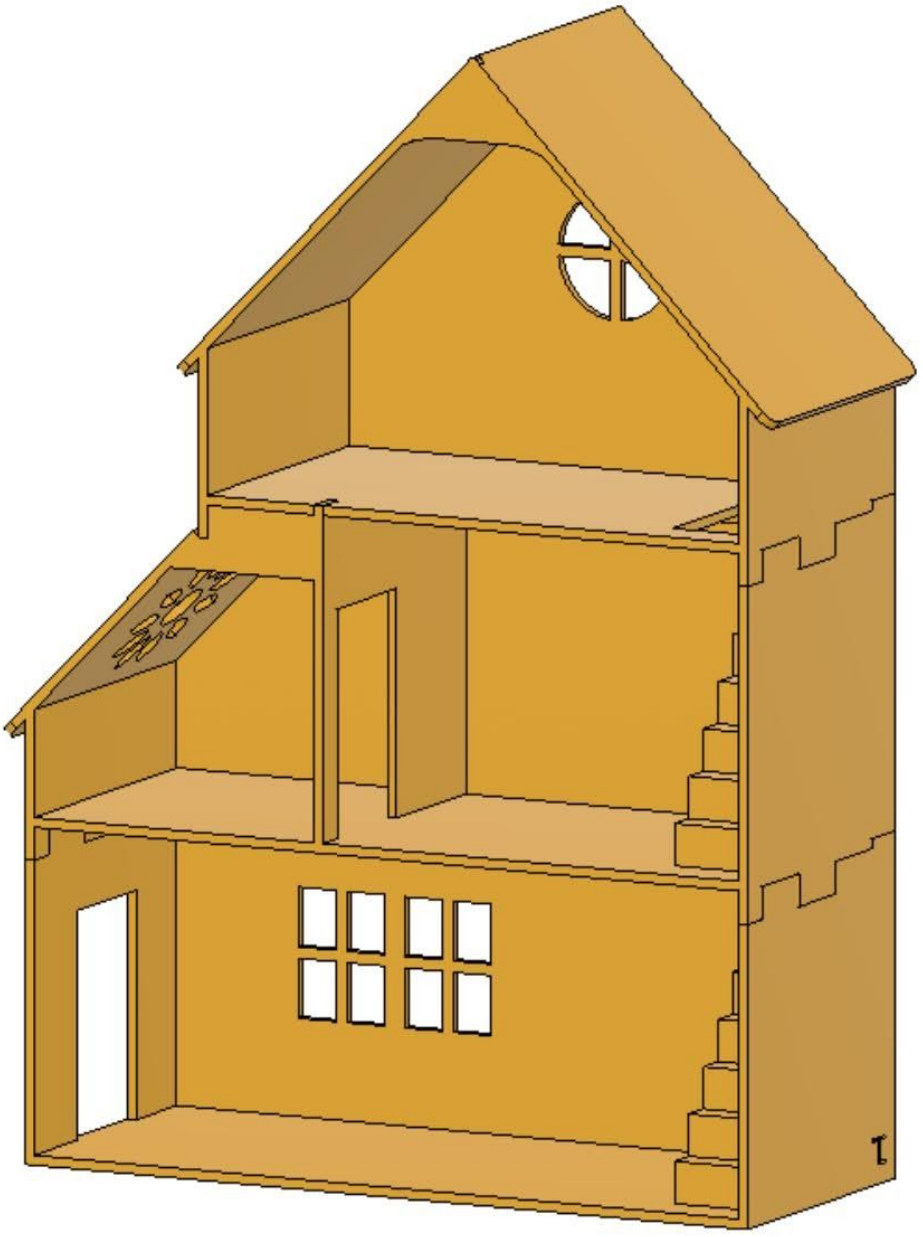
A study in non-90 degree joint. Because the laser cutter makes only 2D cuts, the corners would still need to be sanded to shape.



Dollhouse - the idea that started it all

The original inspiration for the plycutter project was having access to the laser cutter at Helsinki Hacklab and needing a dollhouse for my daughter.

CAD design (made modular in three floors to enable upgrading one floor at a time)

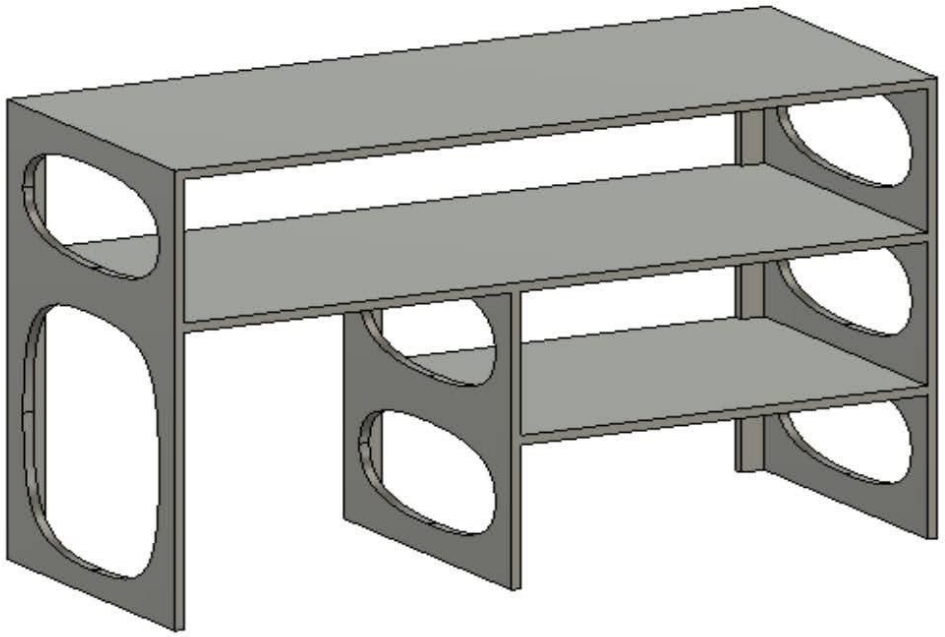


Printed and assembled, with oblique joint ends not yet cut and not sanded / painted.

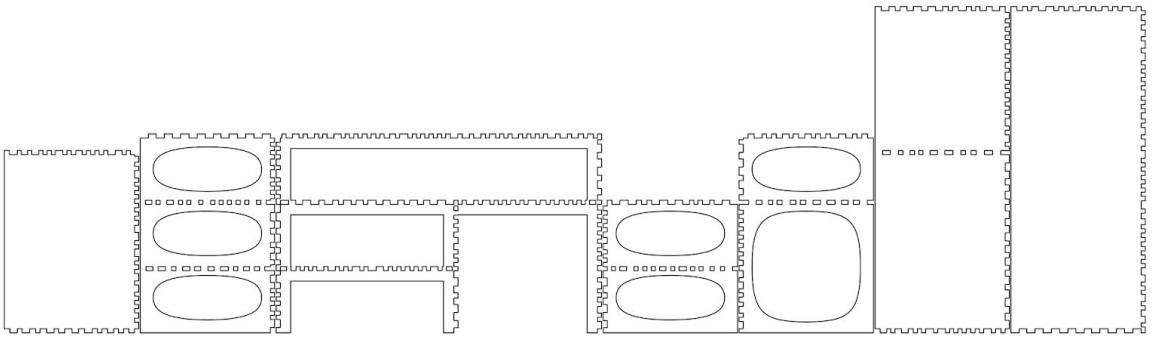
Shoe stand

As a simple project from a practical need. The CAD design took ca. 30min, running plycutter about 20min and lasering some hours. In retrospect, using larger teeth would have significantly reduced the cutting time.

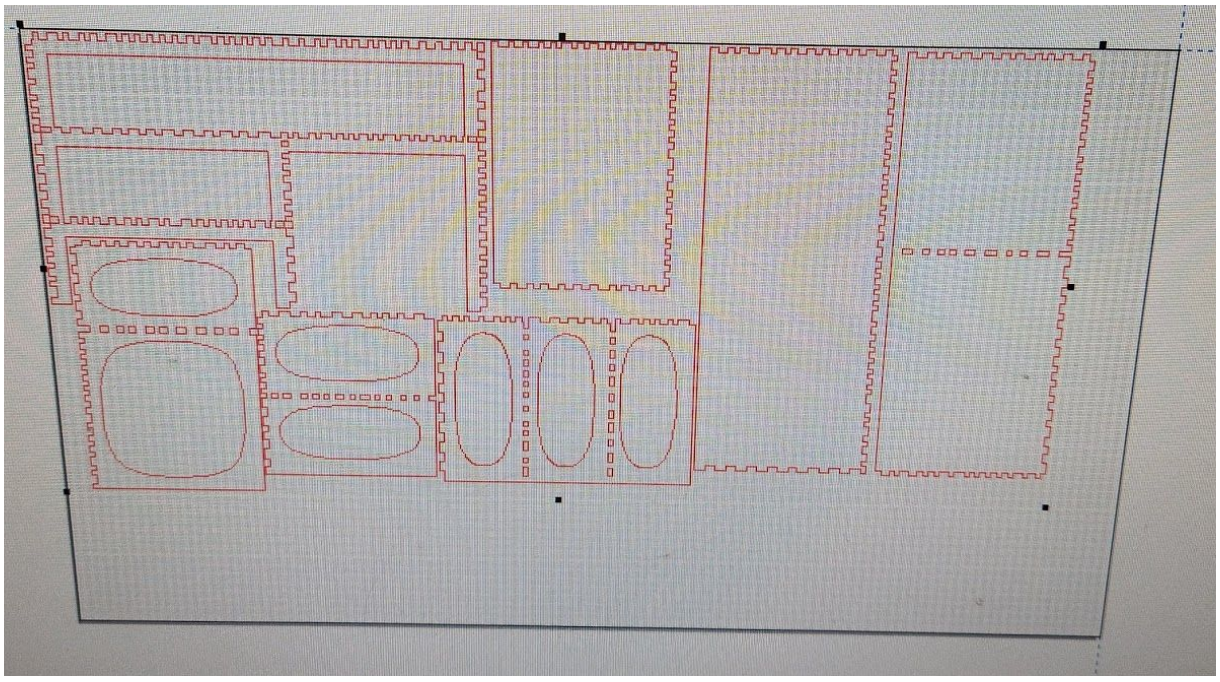
CAD model:



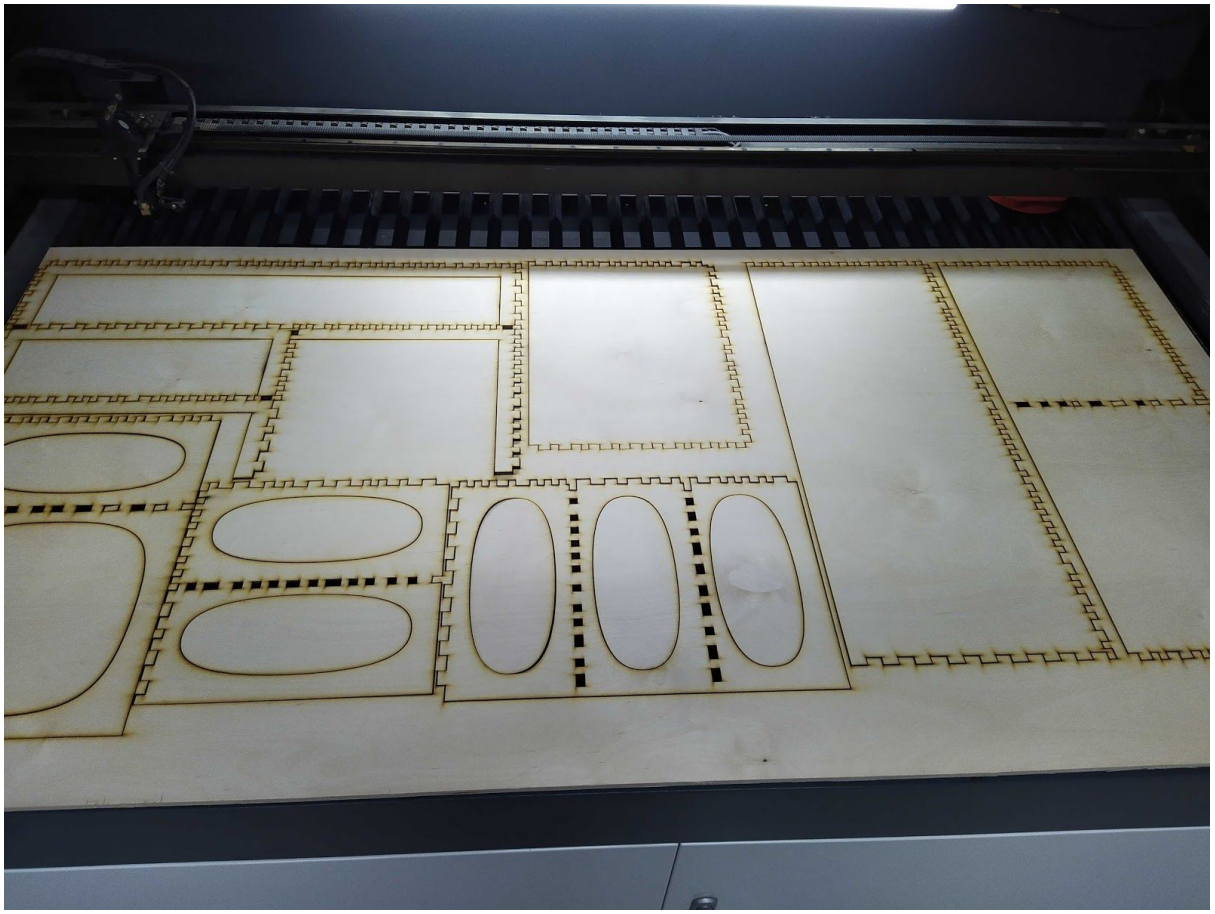
Plycutter output:



After manual nesting (moving the pieces to minimize used sheet material area):



After cutting:



Assembled

Future extensions (in order of easy to hard)

- Laser marking of the surfaces directly from the 3D cad file
- Also create patterns for a final thin veneer layer to cover up the jointsUse 5-axis laser or water cutter or router to improve joint structures
- Mark all joints with numbers to help assembly of large objects
- Curved sheets (e.g. KoskiFlex)
- Incorporate this code into a CAD plugin
- On a 2-axis laser, non-90 degree joints will have small pockets within them that need to be filled with wood filler later.
- Robotic assembly of objects