# DIY CNC and Blender3D

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## Contents

# 1 General

## 1.1 Introduction

Many years ago, (maybe around the year 2000) I thought it would be fun to build a CNC machine. These writings tell the story of my journey.

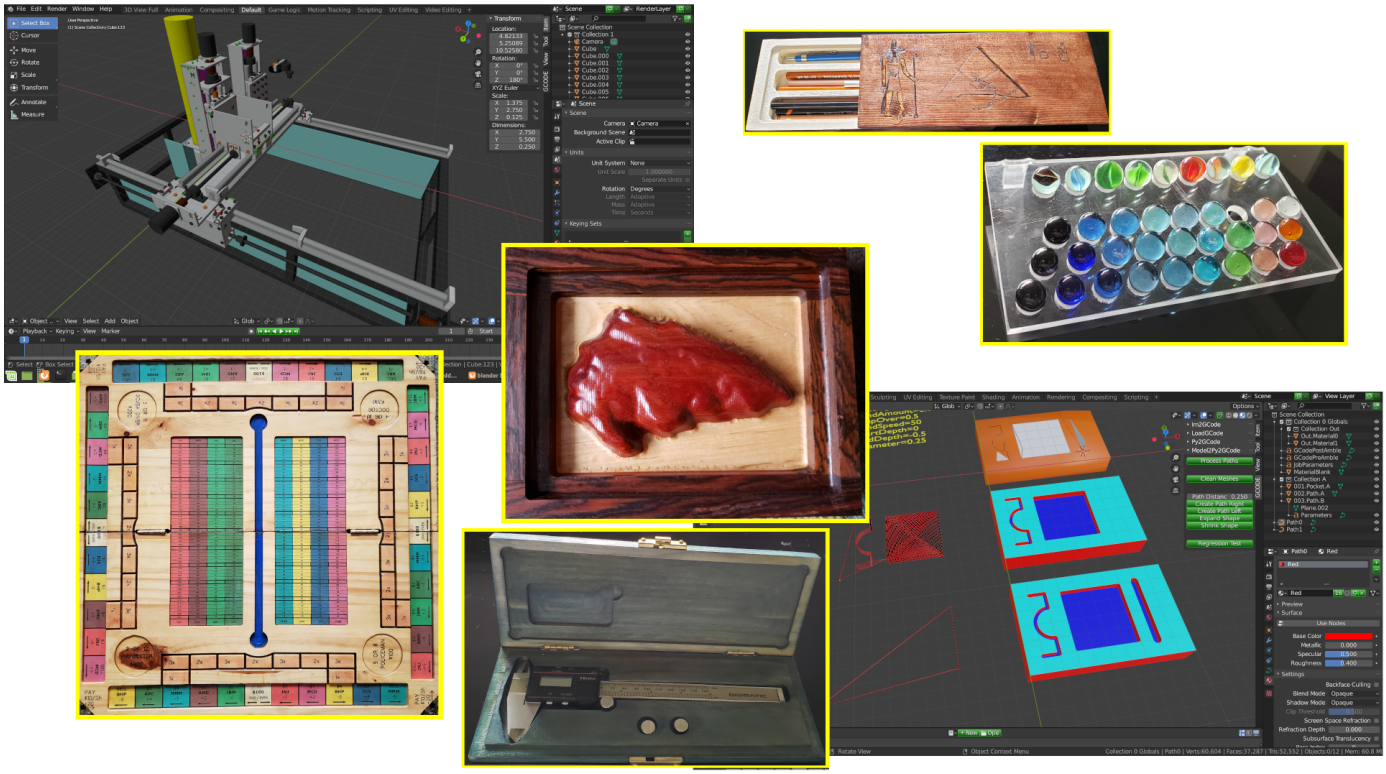

Figure 1: CNC Projects

I am a DIY'er. I enjoy "doing it myself" whatever "it" is. I am a qualified software engineer and electrical engineer. I am mechanically inclined but really never had much education in mechanical things and certainly I have never been a machinist or a CNC operator. Therefore I learned a lot of things the hard way! (And there is still plenty I don't know.)

I thought building a CNC machine was a great idea because it would involve software, electronics and mechanics; and because it dovetailed nicely with other hobbies of mine like wood-working. Back in those days it wasn't easy to find resources on the internet about building your own CNC machine. There definitely were no "kits" to buy and build. So I actually bought a plan from an elderly gentleman who explained how he built one (maybe the price was around $20 for the plan - I don't remember clearly).

The plan involved using black gas pipe for rails, a base of MDF and roller-blade bearings mounted to aluminum angles. The parts were chosen to be cheap as possible. I never did complete the design. Figure 2 shows the Z axis where I mounted the smallest most-inadequate stepper motor (removed from a CD player I think). I was learning as I built this design and I could already see that the rails (gas pipes) were very wobbly and the gantry was easily able to bind up as it would skew out of square. Especially, as I left the project for months at a time and came back to it, I could see how the MDF (and other wooden parts) were warping as they expanded and contracted with changes in temperature and humidity. I was already thinking of ways to "improve" the design.

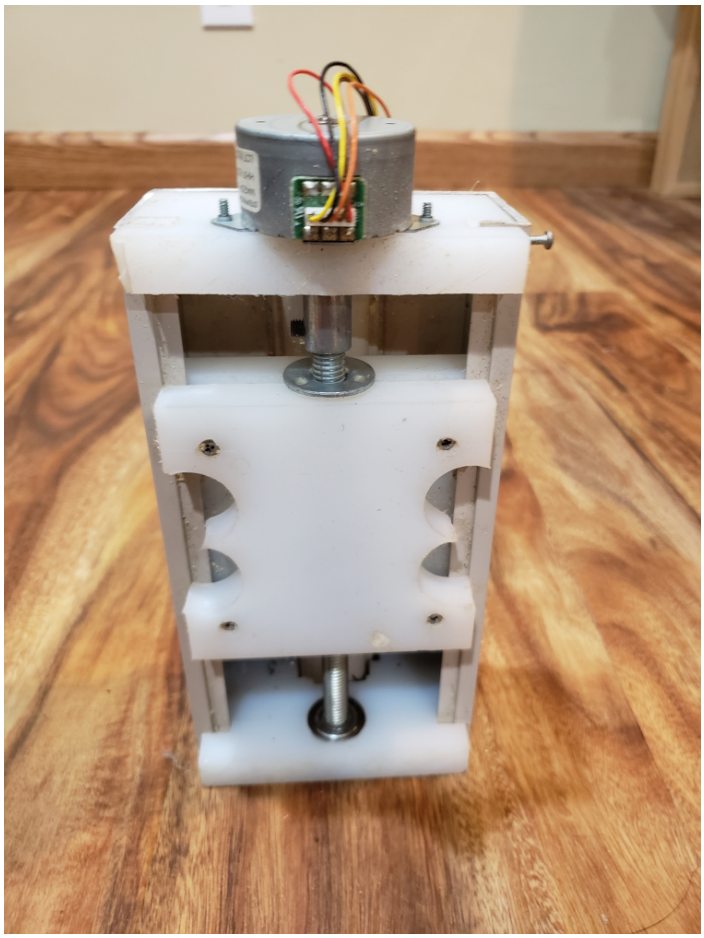

Figure 2: Original (first) Z Axis

There was one part of the plan that I thought was brilliant and it was right at the start. The gentleman stated that his plans did not include a consolidated parts list or prices. The reason he gave was that many people start but do not finish projects and he recommended a person buy what they need for just the next step in the plan at each step. He thought that providing a parts list would encourage people to rush in and buy everything only to learn they wasted money if (most likely when) they lost interest. How True! It was true for me too for although I did build a significant portion, I never finished it because I wanted to start over with new design ideas.

I think people like me (DIY'ers) end up following a similar learning pattern. Without a predesigned kit to build and without any real machining experience with real CNC machines we learn everything the hard way. You begin the project thinking "Can I make a machine that moves in three dimensions?" and "How cheaply can I do it?" Afterall, it's not a challenge if you go out and spend lots of money buying professional components (of course that'll work).

Once you build your first machine and feel excited at seeing it **actually** move, you realize that you've only just begun. You notice the binding and the warping with temperature and humidity and you start to ask yourself "Can I build a machine that can consistently move reliably even if I don't use it for months and then come back to it?" And so you design and build a second machine. (I realize as I'm writing that this sounds suspiciously like the story of the three little pigs - the first little pig built a CNC machine out of wood, the second little pig built a CNC machine out of metal...) Of course I realized that to have any real chance of a reliable CNC machine I must use a metal frame (and buying proper rails with matching trucks and bearings was worth the expense).

So it was time to build my second machine and this one actually worked fairly well. I had plenty of scrap steel tube that I had ripped out of old cubicle walls I had purchased at an auction really cheap - this was going to be my metal frame. But I had been a hobbyist woodworker for many years and knew nothing about building with steel. I knew nothing about welding. With an eye on the budget, I went to Harbor Freight and bought the cheapest welder they sold. I think it was about $40 and it ran off 120v (not 220v like a more professional welder). It was so "weak" it only had a 25% duty cycle. You could only use it for two and a half minutes out of each 10 minutes or it would overheat (I suspect the laminations in the transformer would fail). To my credit, I did not destroy the welder. I would weld for about two minutes and then I would spend the next 10 minutes cutting, grinding or finishing the next pieces to be welded so I stayed relatively, continuously busy.

As you work with the second CNC machine you've built, you start to notice imperfections. Things are not perfectly square and you spend a lot of time loosening bolts, "tapping" parts slightly to align them and re-tightening the bolts only to learn that now everything is slightly not square in the OTHER direction! And who would have thought that the weight of the Z axis and router was enough to **bend**

two 20mm thick steel rails on the gantry? (Well, obviously people with real experience would know that - but I didn't, because I wasn't a mechanical engineer or a machinist.) So you start to ask yourself, "I wonder if I can design and build a CNC machine that is **precise** and **accurate**?"

So it was time to design and build my third CNC machine. (Said the 3rd little pig.)

This time I used a 3D modelling package called Blender (not really intended for technical drawings as it is intended for developing movie and game assets, but I have experience with it and I like to use it for just about anything I can because I really think it's a great, free application!). I used Blender to design a model of my CNC machine. Knowing I couldn't build it perfectly square, I designed it for easy adjustments to square and tram the machine. Then, I decided to spend a little money having a professional company cut out numerous aluminum parts so I went to www.emachineshop.com and used their software to design the parts and sent them the job. Mostly the parts fit together quite well and I had a new gantry and Z axis riding on the steel frame and rails from the second machine.

The third CNC machine was complete! It was much easier to adjust for squareness and to tram it. Upon testing and measuring, it was accurate and precise (to at least 0.01" which was just fine for routing wood).

These days, there is a lot more information on the web about building CNC machines. There are a few, very helpful kits that can be purchased. There is quite a helpful community of people who can give advice on designs, kits, motors, controllers, software etc. There are numerous groups on facebook for people to discuss ideas and their latest projects. It is in these groups where you see many "new" people asking for advice and researching ideas for how they can get started and what they should buy or build. These people are quite smart to do their homework and learn from others to minimize any mistakes. If only such groups had been more common when I started. (Even if I could have had access to such advice I was always destined to learn a lot of things the hard way - that's just the way I am.)

I was also interested in writing my own software to control the CNC machine. However, I realized this was another whole level of work on top of all the work of learning how to design and build one. So when I was running the second CNC machine, I bought Mach3 (software for controlling a CNC machine) and ran it on a Windows laptop. This worked well enough. However, I am also a fan of the Linux operating system and when I finished the third CNC machine, I switched to using LinuxCNC (also on a laptop). LinuxCNC has been rock-solid and I have been extremely happy using an open-source project to control my CNC machine.

I was very interested in writing my own G-Code and most of the projects I did on Mach3 were with my own hand-coded G-Code. I was always experimenting with ways to write little bits of code to help me manage the mundane parts of producing a G-Code program. This led me into the idea of writing my own open source software for designing projects for a CNC machine and outputting G-Code.

As I mentioned above, I'm a fan of the open source project Blender. Every now and then I would notice people on the internet asking questions about whether Blender can produce G-Code or whether it is suitable to use for CAD work. You also see people asking if there is any open source software for V-carving etc. and designing CNC projects. Well, I too have asked those same questions and a couple of times each year I would do a search to see what was available. I already make some compromises and use Blender as my "CAD" software and so I took it upon myself to write a plugin for Blender that would allow a person to create routing operations, visualize the results, and output G-Code. Ultimately, this became the plugin called Blender4CNC.

## 1.2 Finished Projects - Examples

Here are some pictures of the projects I have completed on my CNC machine.

### 1.2.1 Pre 2019

Figure 3: Cribbage board – pine (1"x3") with cherry stain and tung oil finish. Compartment holds 6 pegs. The sliding lid on the compartment is a snug dovetail.

Figure 4: Pencil case – 2 pine boards (1"x4") with tung oil finish. Lid attaches with snug dovetail.

Figure 5: Shelf – pine (1"x10") to hold/display specific tools.

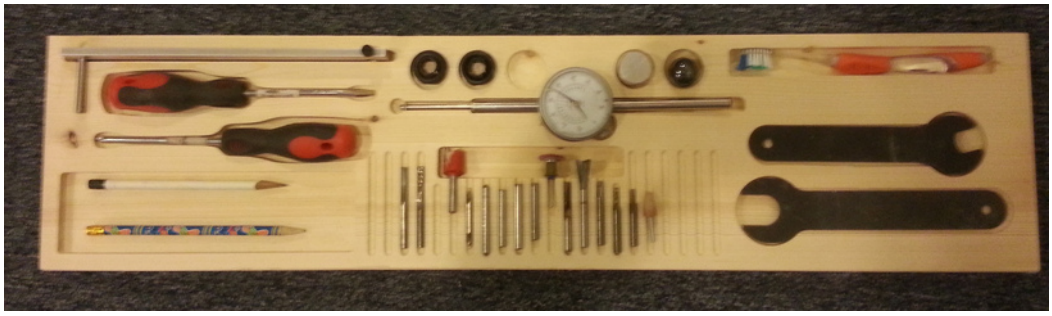

Figure 6: Shelf with Tools

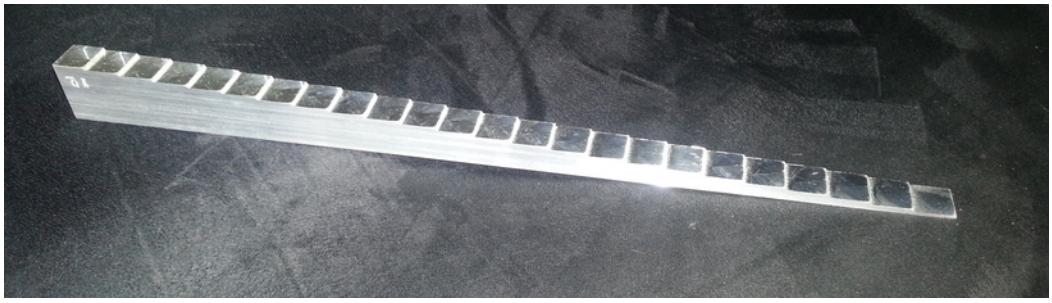

Figure 7: Aluminum Stepped Measuring Tool – 1/2" thick, each step is 1mm. CNC machine not designed for working with anything other than wood but achieved this by moving slowly and shaving down 0.001" at a time.

Figure 8: Box to store/protect stepped measuring tool.

Figure 9: 3D Carving of Uluru – pine 1"x10", painted with water colors.

Figure 10: 3D Carving of Uluru – pine 1"x10", painted with water colors.

Figure 11: 3D Carving of Uluru – oak (1x8).

Figure 12: 3D Carving of Uluru – oak (1"x8").

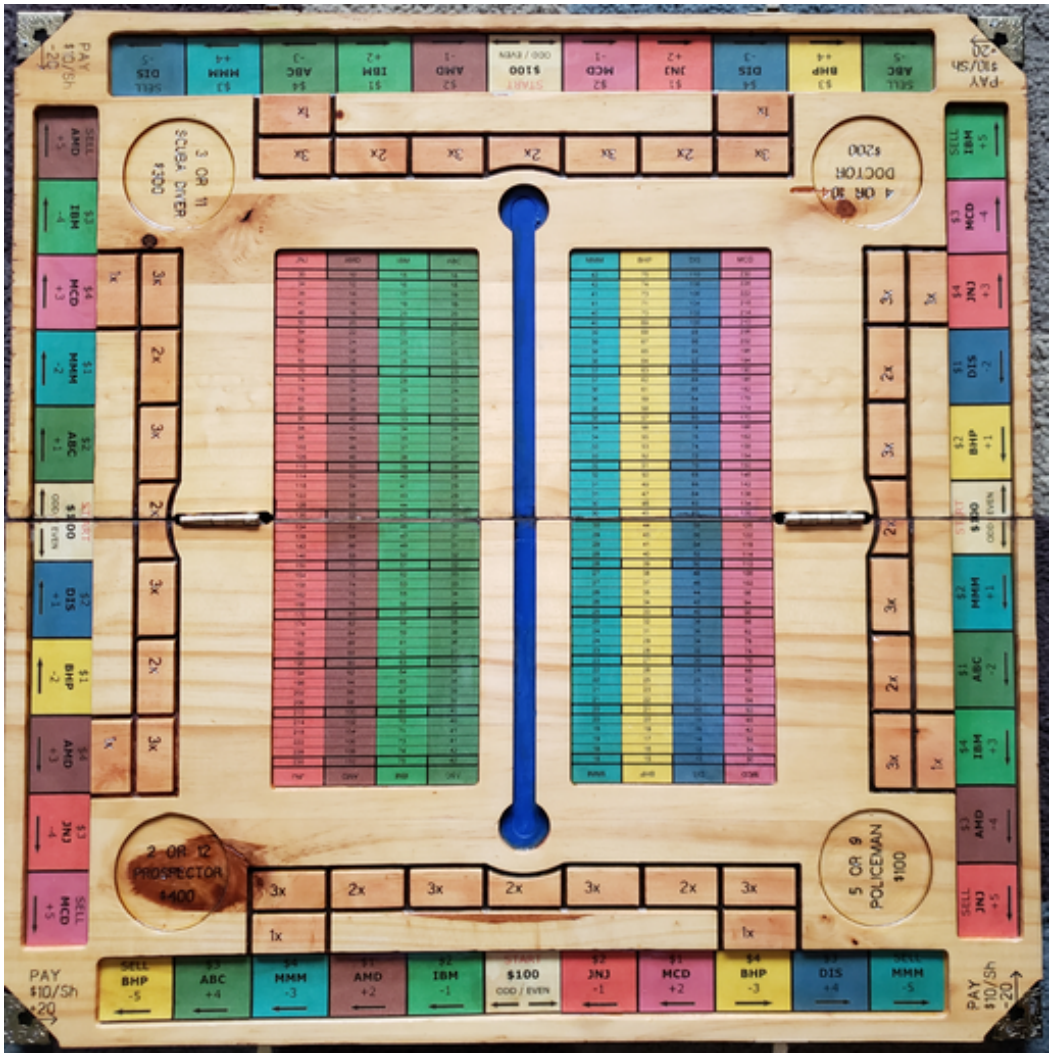


Figure 13: Stock Market Game Board

Figure 14: Stock Market Board folded up

Figure 15: Part for older CNC machine vaccuum shroud part.

Figure 16: A multi-layer uluru

Figure 17: Uluru from 3 exotic woods.

Figure 18: Uluru from 3 exotic woods (side view).

### 1.2.2 2019

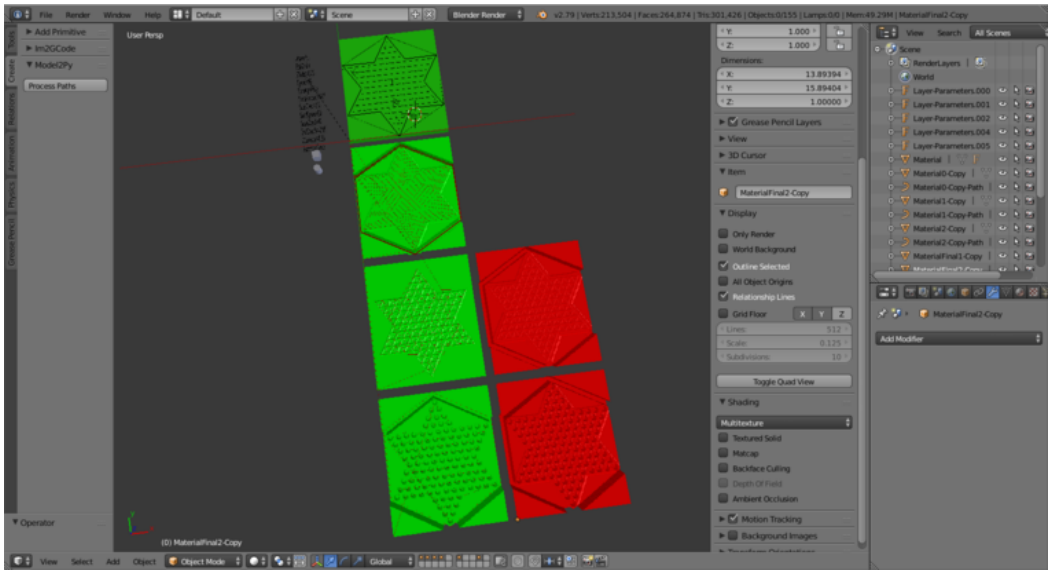

Figure 19: Chinese Checkers Board Design

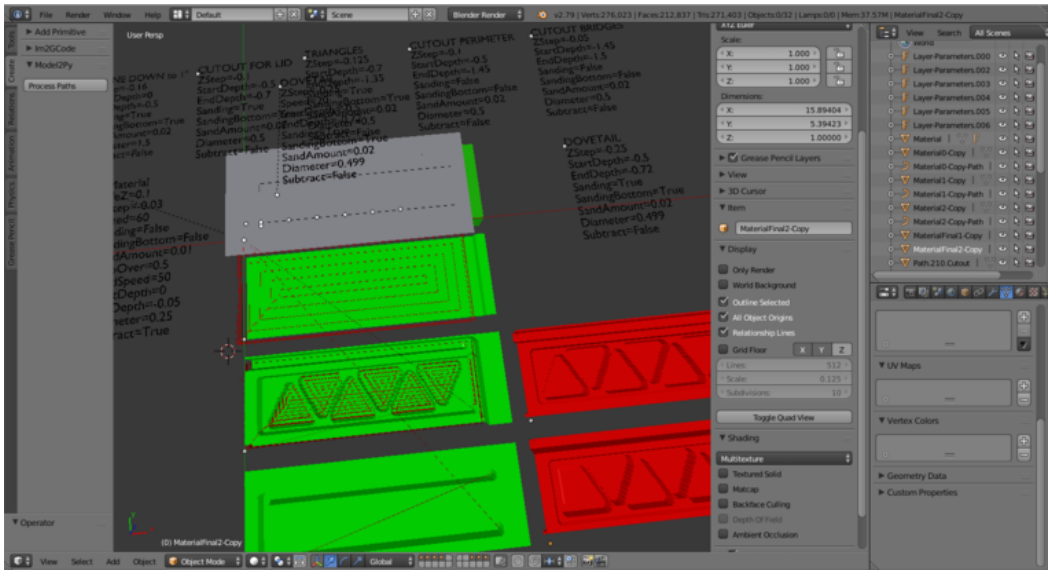

Figure 20: Chinese Checkers Box Design

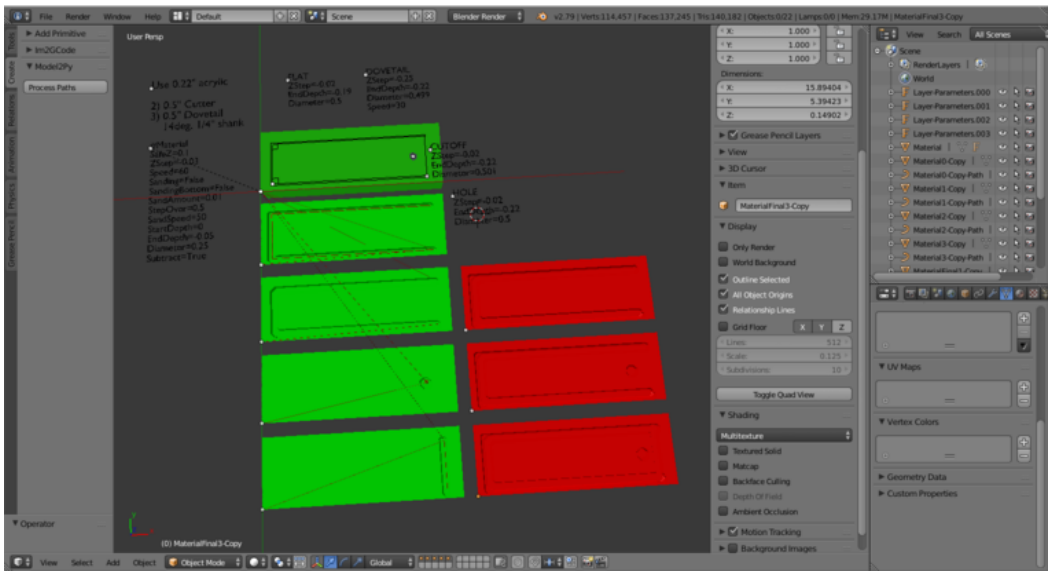

Figure 21: Chinese Checkers Clear Lid Design

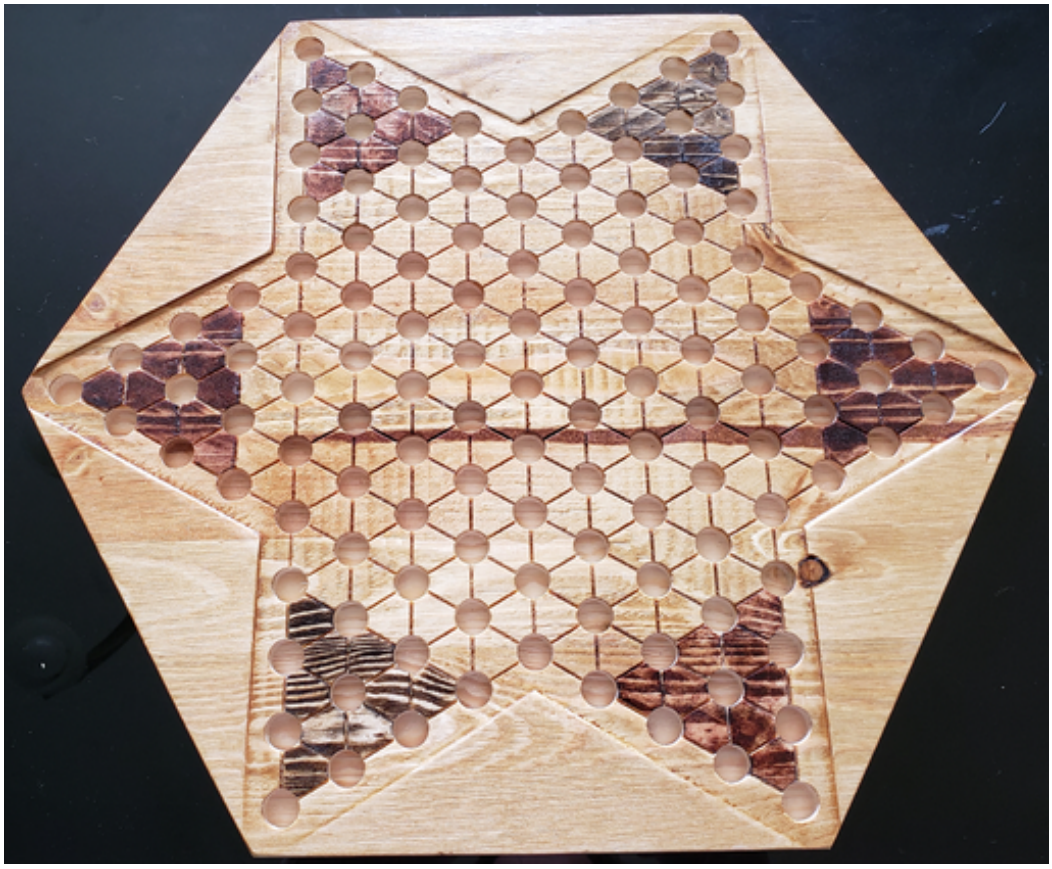

Figure 22: Chinese Checkers Board (Pine - various stains)

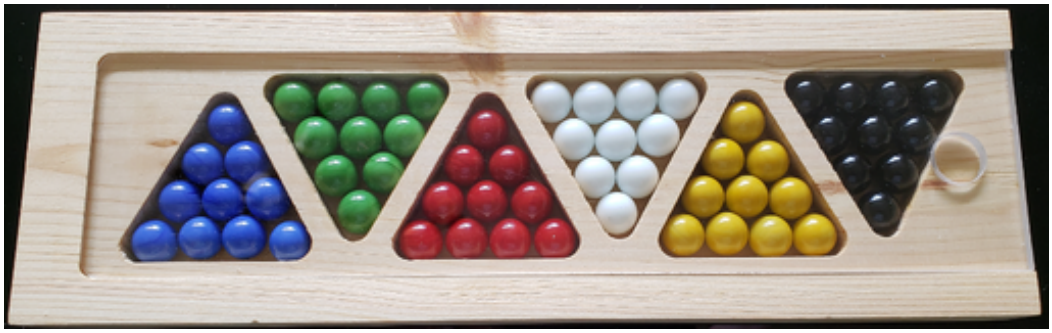

Figure 23: Chinese Checkers Box with Marbles (Pine - Tung oil + 6mm Plexiglass)

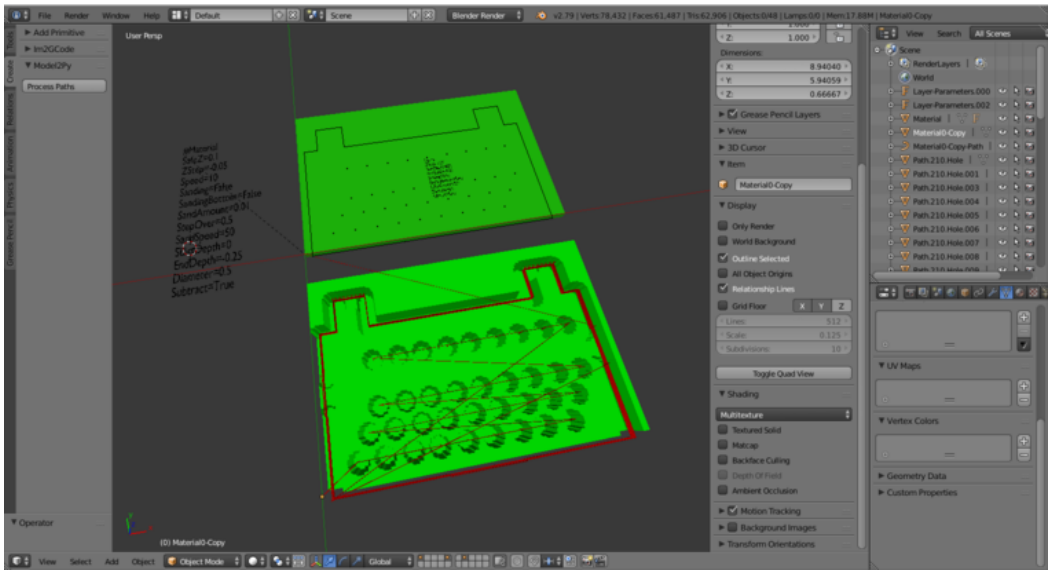

Figure 24: Marble Stand Design (for plexiglass)

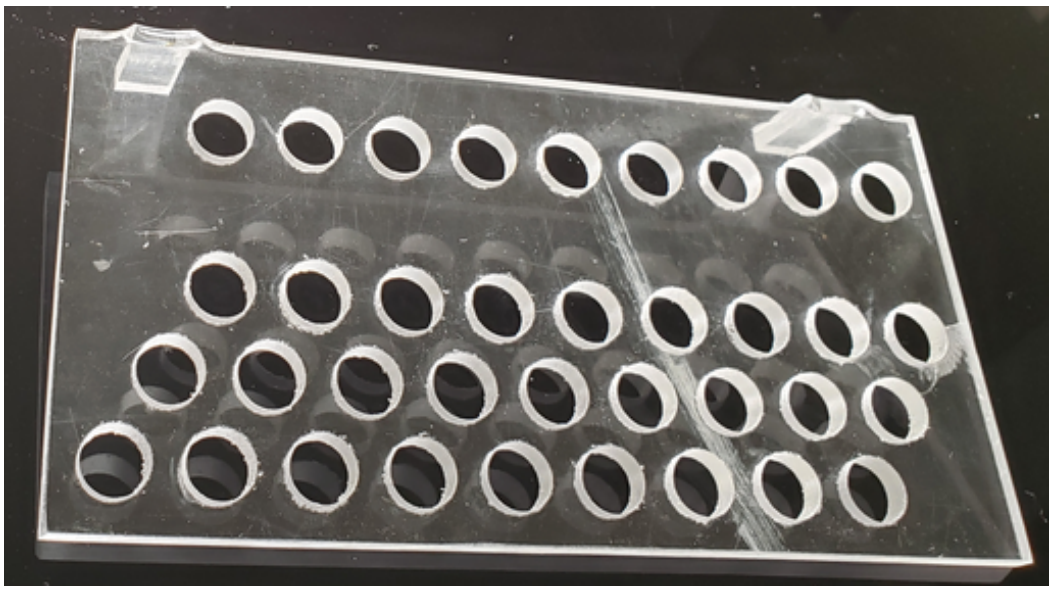

Figure 25: Finished Marble Stand (6mm Plexiglass)

Figure 26: Marble Stand with Marbles

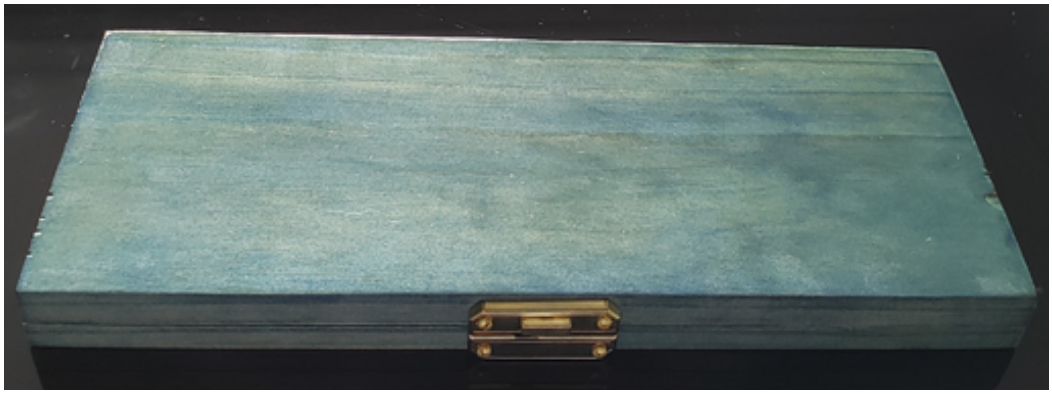

Figure 27: Caliper Case (experimenting with blue stain) (Pine)


Figure 28: Open Caliper Case

Figure 29: Pencil Case (Pine - Mahogany stain - wood burning by hand)

Figure 30: Pencil Case partially opened (dovetail lid)