TOPOLOGY
OF
DUBAI

Credits

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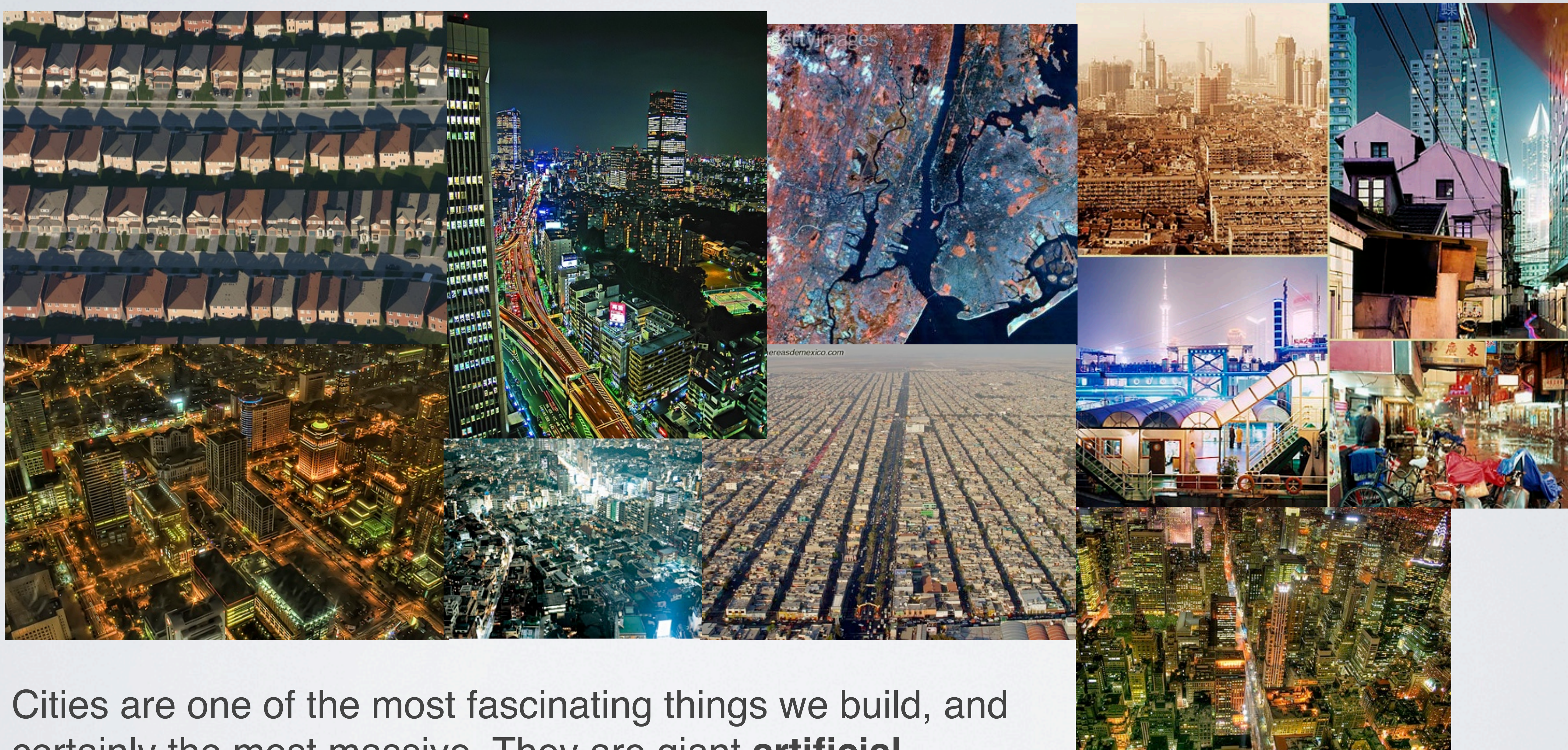
Takashi Mizohata, Japan - Live data collection programming
Andrea Bianchi, Italy - Computer vision and embedded programming.
Will Craig, USA - 3d simulation and printing algorithm design.
Sogang Unviersity Art & Tech Department, Korea - Facilities and Digital Resources.

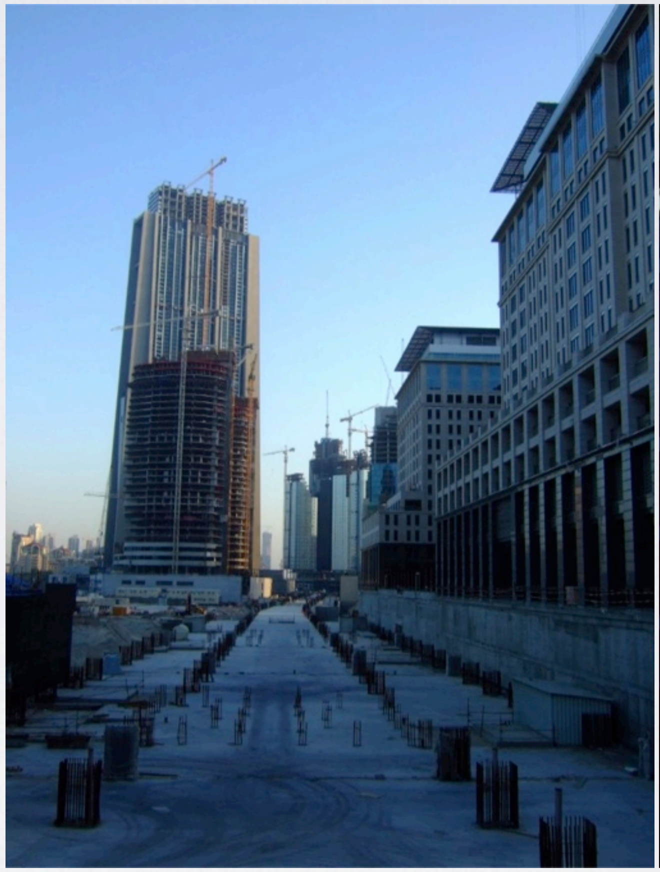
Concept

Cities as Networks



Cities are one of the most fascinating things we build, and certainly the most massive. They are giant **artificial networks** of concrete, steel, glass, and machines, that soar high into the sky, and dig deep under the earth. They sprawl over massive areas, and **evolve like organisms** with the passage of time.

Growth of Cities

The growth of cities is complex **like the growth of a person**. Even though we have city planners, community organizers, organized government, so many factors effect the growth of a city that the results are **largely unpredictable**, and often totally different then anticipated. Just like a person who has parents and teachers, the results of a child's growth is not necessarily what they imagined. **Just like people cities are shaped and reshaped through the time** periods of intellectual fashion, technology, and culture that they live through.

Dubai is Different

- Growth of **buildings first** rather then growth of people first.

-Most cities attract people that live on the edge of the city in **temporary improvised housing** or slums. Gradually this housing **improves** and matures into permanent housing/neighborhoods, and the city expands.

-Dubai however started with a small center, then started to build the **massive infrastructure of a larger city, around its center**. This **building project or growth attracted people** who could then live in its new buildings and towers.

It was growth of the city that attracted people rather then people that demanded growth.

The Construction Crane

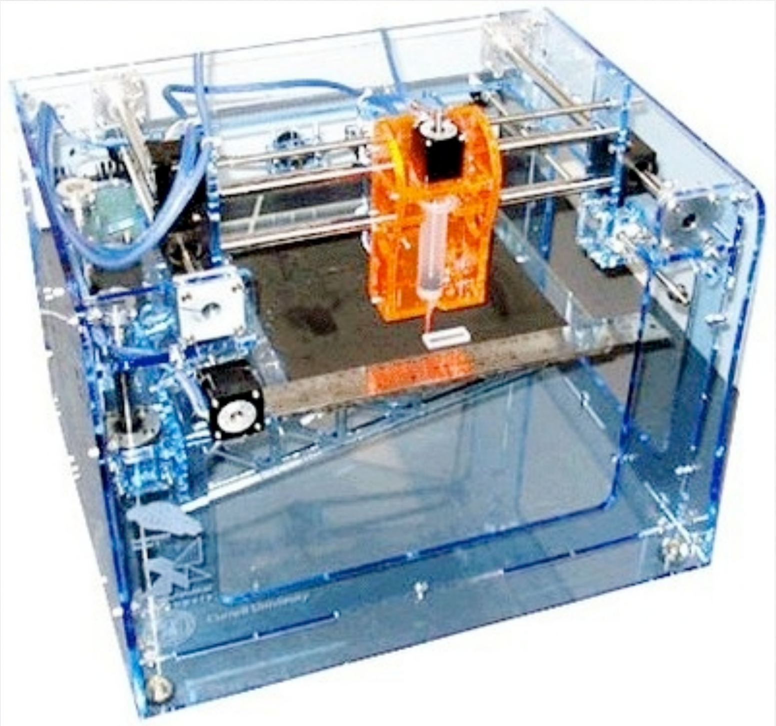
- Thinking about all these ideas, lead me to ask the question, **what then is the symbol of growth in Dubai**? The answer of course is most obvious. Its construction, and more specifically **the construction crane**.

So if the construction crane is the source of live data, what can be the output of the data? Since the data is **of growth**, then of course it **has to grow something**?

Project Concept

"The use of live growth data to grow a physical 3d object"

The 3d Printer

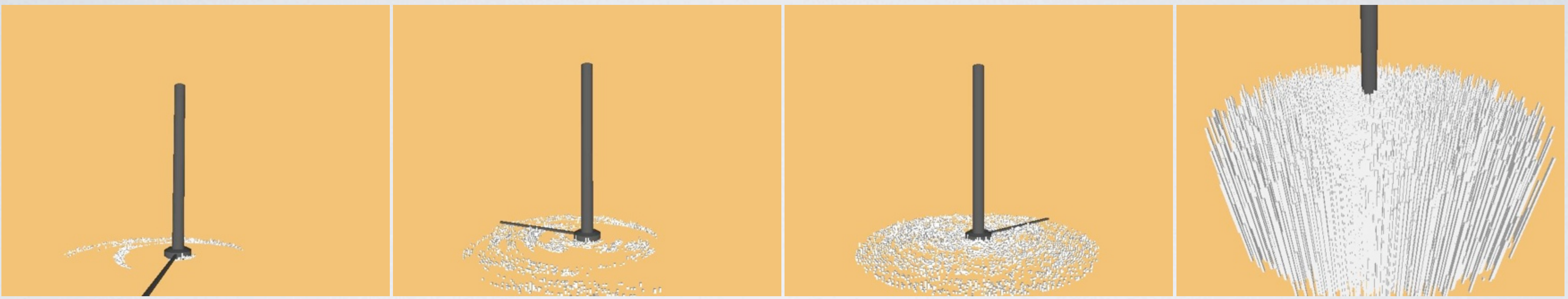


So how can we grow a 3d object with live data?

Through, the use of a **3d printer**, also known as rapid prototyping machine, or desktop fabricator.

This topic is another interest of mine. The upcoming **revolution of desktop 3d fabrication**. The latest iteration and miniaturization of the on going industrial revolution. Breaking the boundary between the physical object and the virtual object. **The end of mass production and the beginning of unlimited customization.**

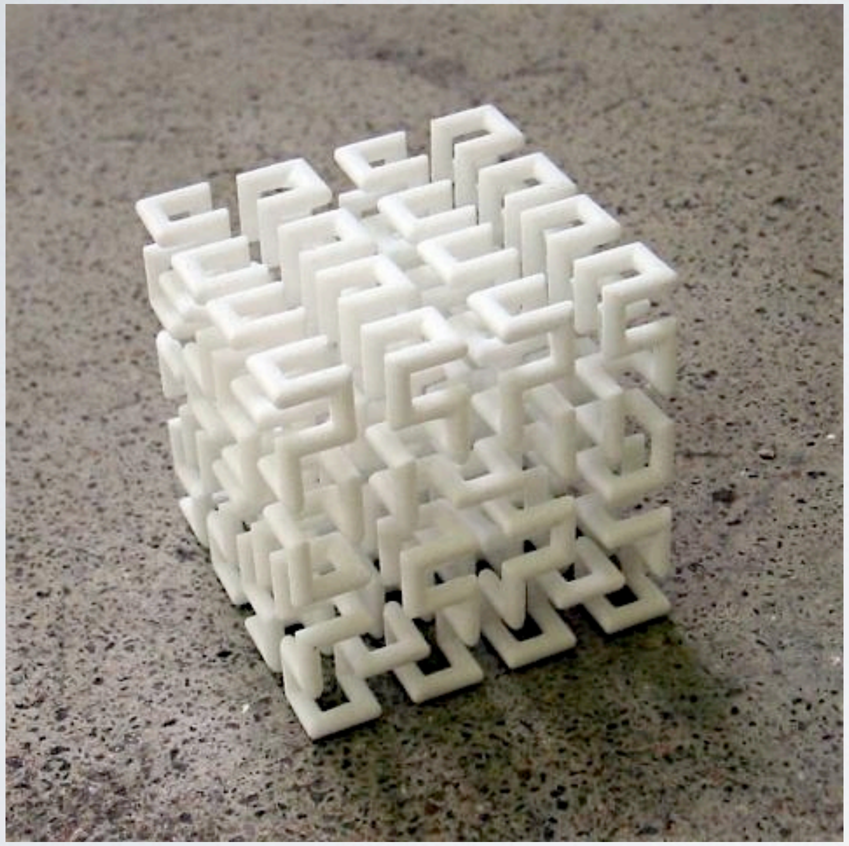
Live data 3d printing



How does this apply to the 3d mapping of growth?

Since the data is live, and **the growth is unpredictable**, then the only way to grow a 3d physical object of an unpredictable shape and size, based on a real time data source, would of course be through this technology of instant fabrication and customization.

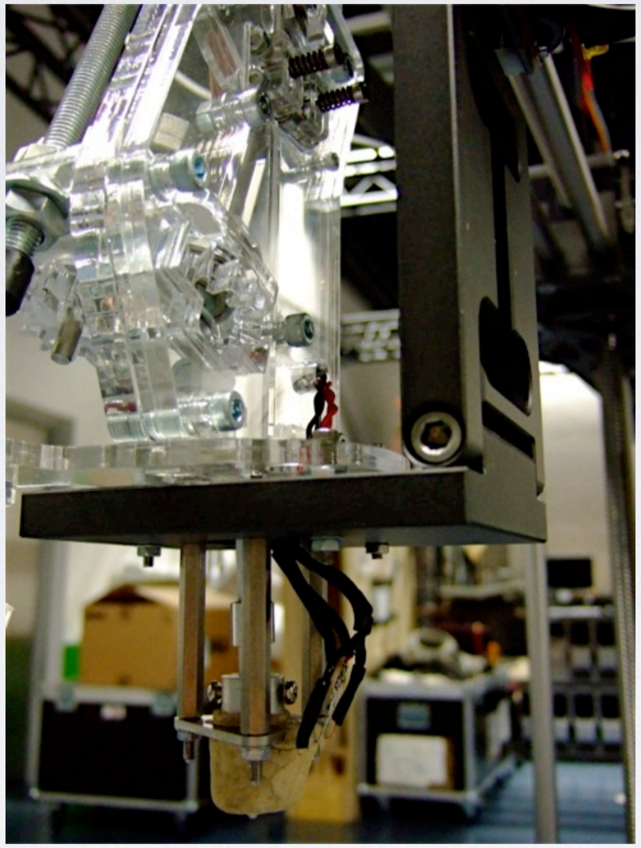
3d printing plastics

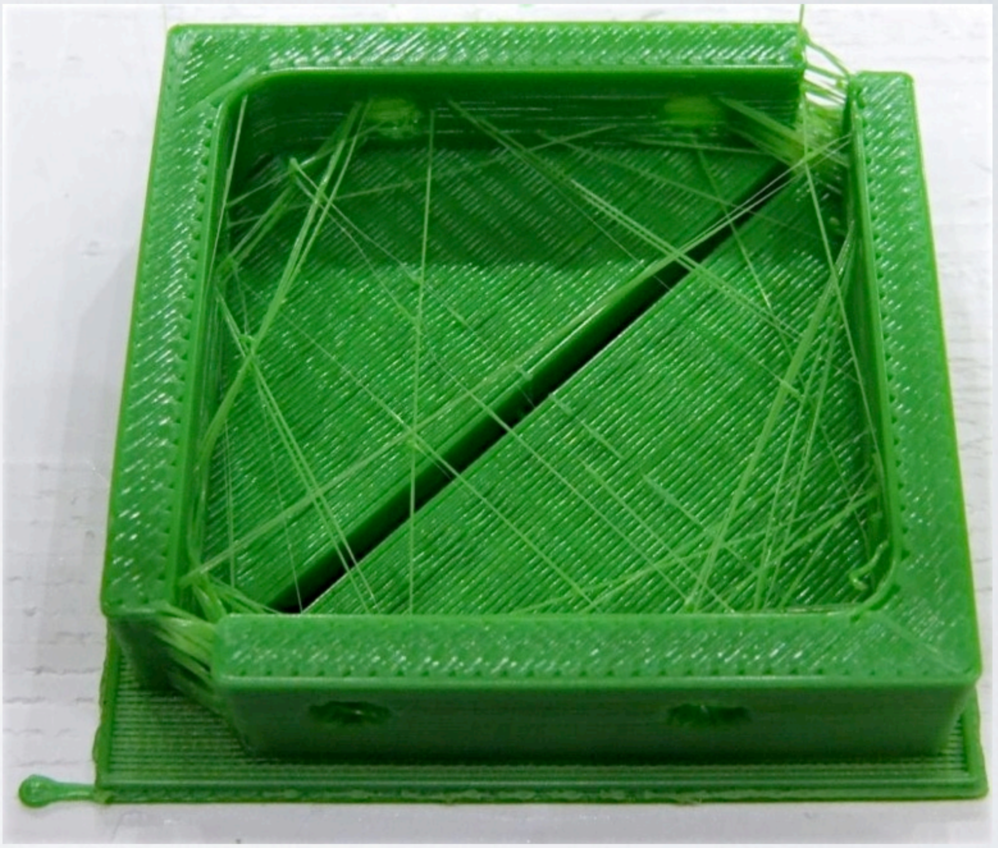


The current technology of **3d printing** is based around the idea of **creating objects out of plastics.**

Many types of plastics can be used, however the most popular are ABS or HDPE. The device works by heating up the plastic, and **pushing it through a small nozzle of 0.5mm** the size of the graphite in a mechanical pencil. **Very similar to a glue gun.**

Automated Glue Gun





However this **glue gun has automated motion**. The rapid placement and motion of the glue gun allow for the machine to **draw the outline and then create the fill** of an object **layer by layer** until a 3d plastic object is complete.

Design Process

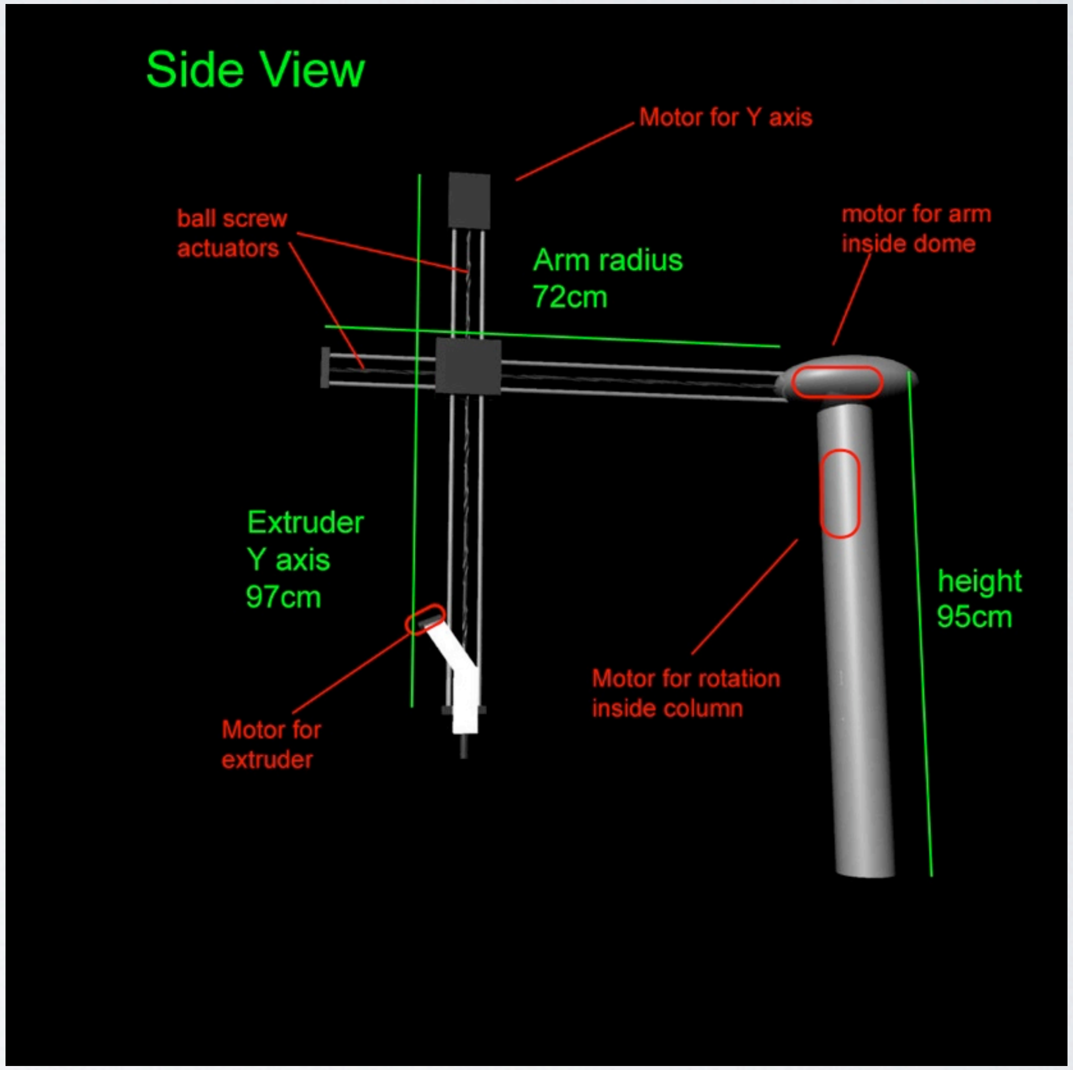
Design Process

- The build process started with the design of the **mechanical system.**

- What **motions** were **necessary**
    - How many axis
- What was the general **shape and size**
    -Dimensions
    - Form and structure
- The **aesthetic and look**
    - shape and style, open or closed system
- **What parts** were necessary to build it.
    - example: ballscrews, motors, bearings

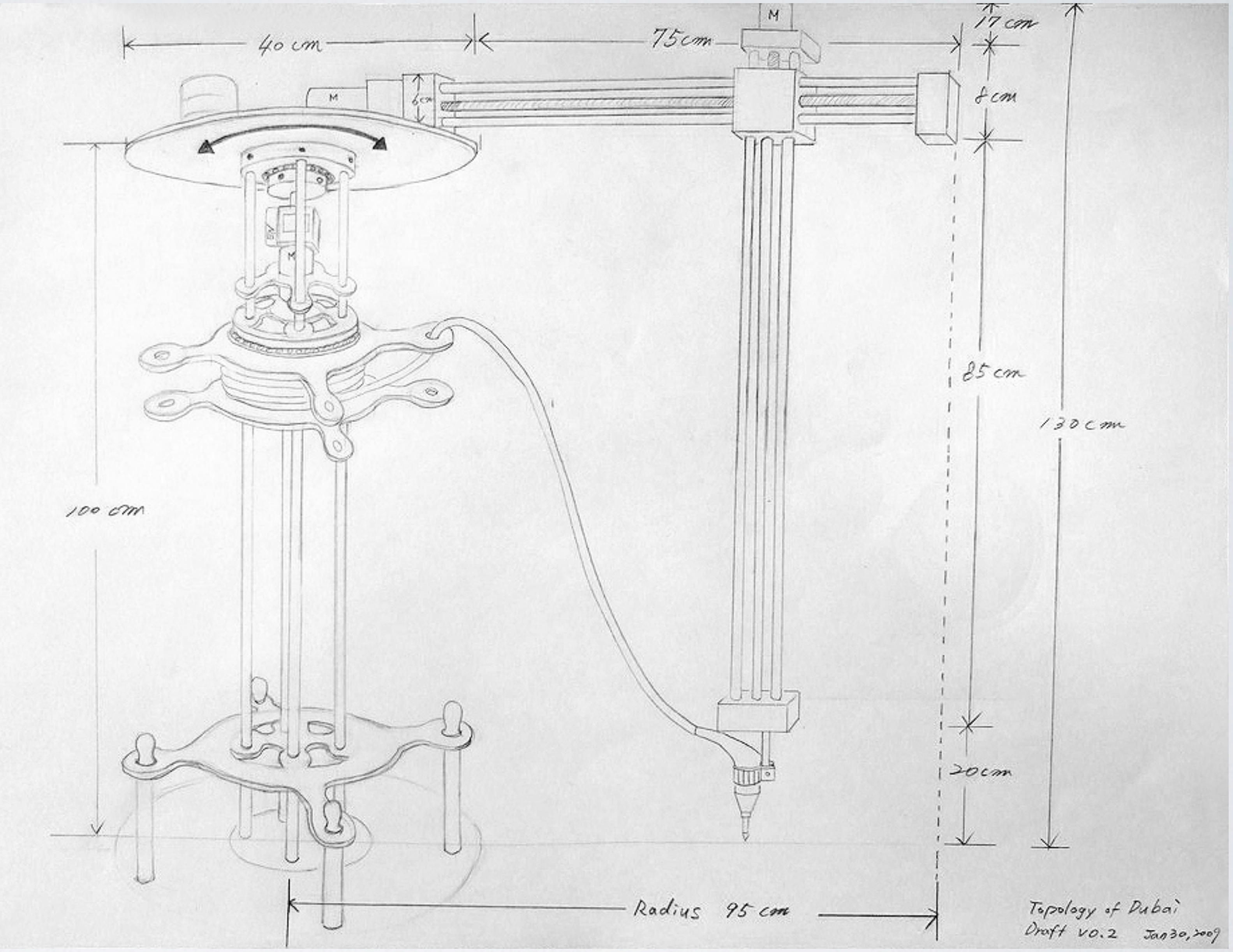
Design Process

- The process first started with a **very basic 3d model**, that explained the general shape size and motion.



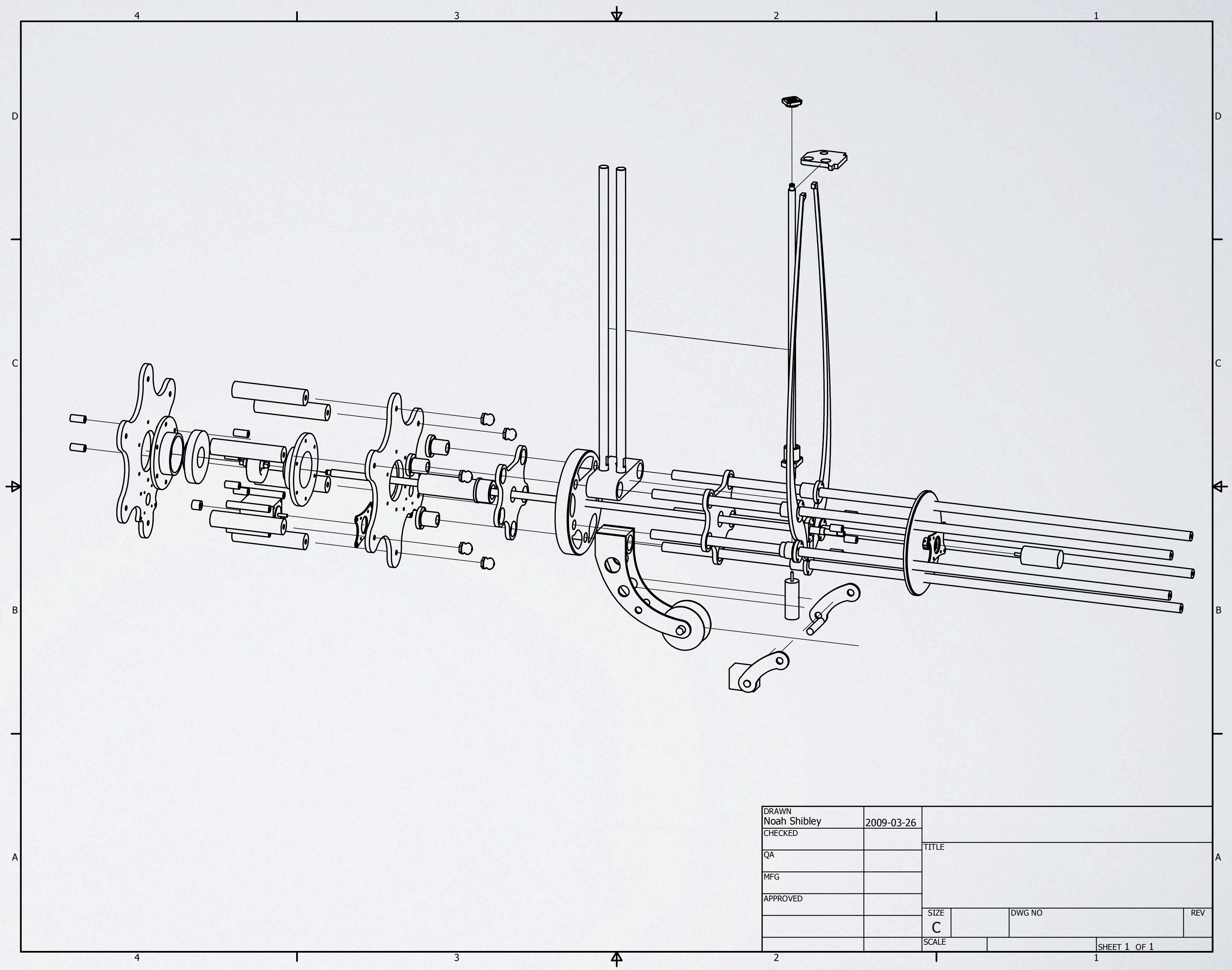
Design Process

- Next there were **pencil drawings** that created the general **style and form** with more detail.

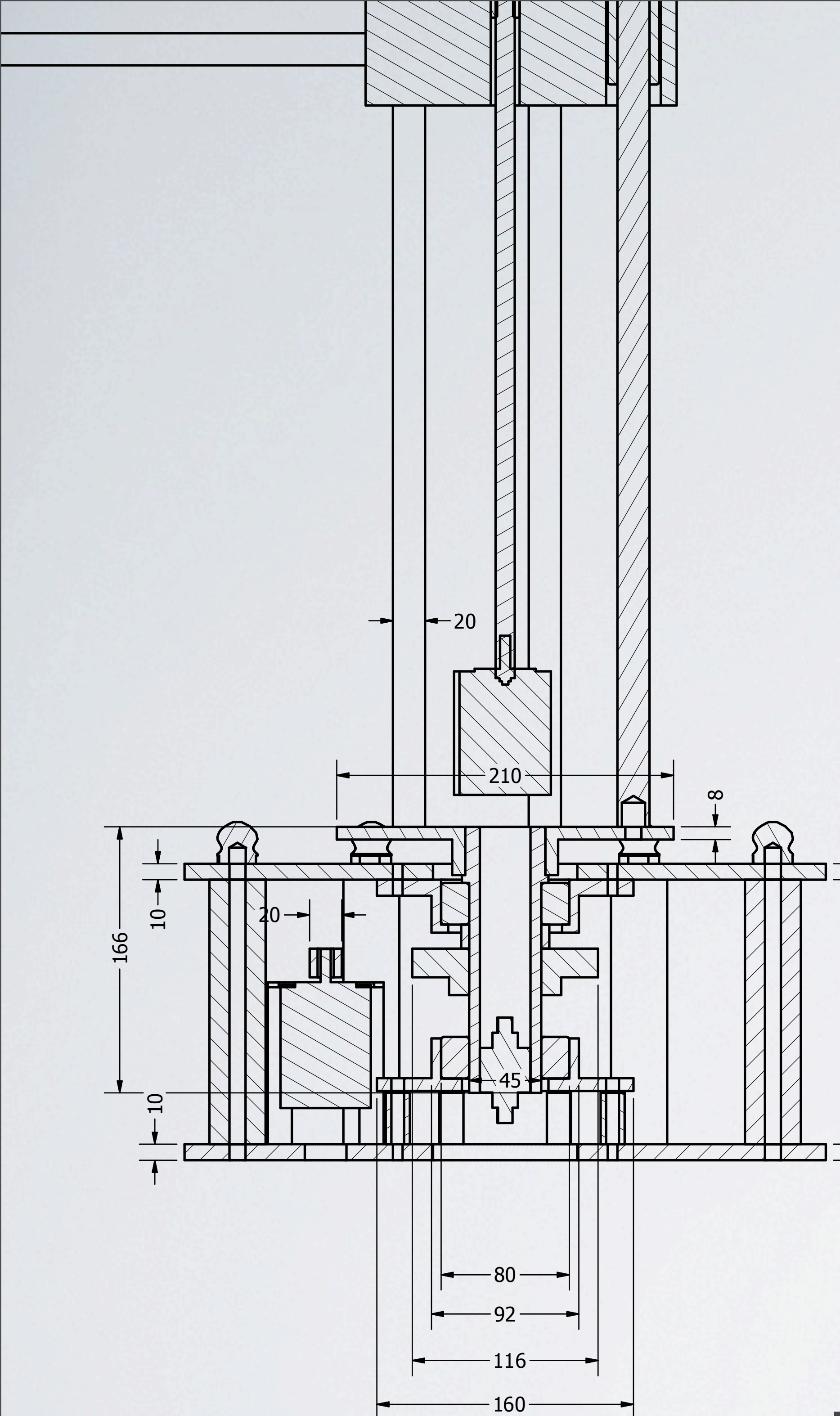


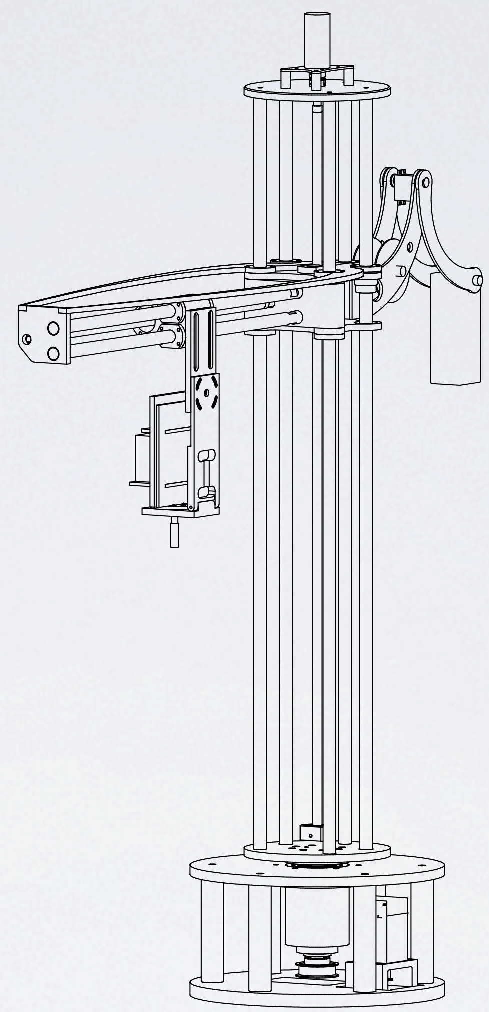
Design Process

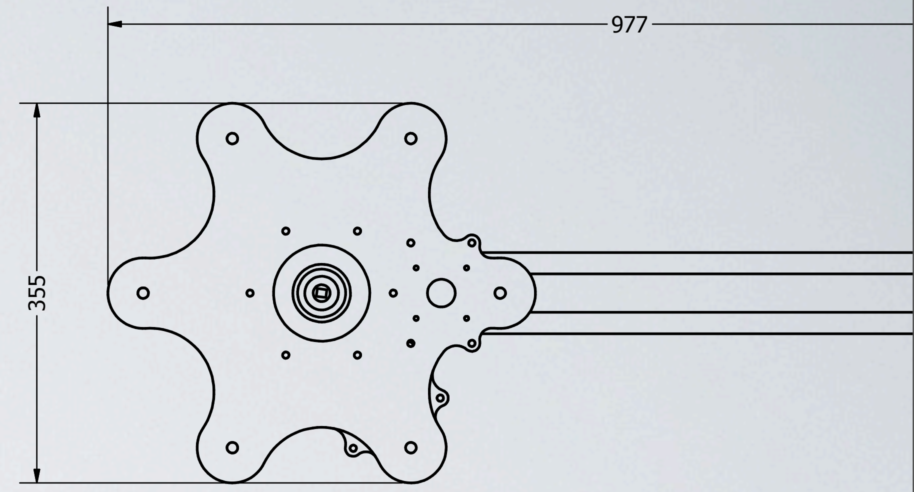
- The next step involved the creating **3d CAD** models from the pencil drawings, to the dimensions of the basic 3d model.

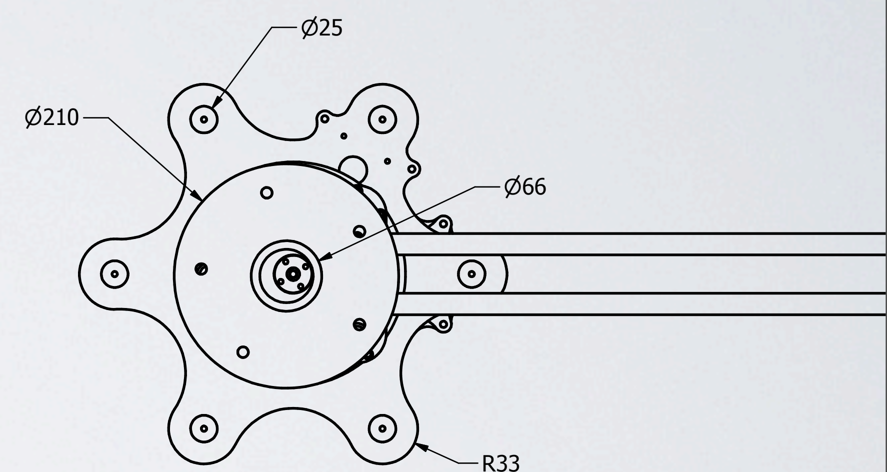


Design Process





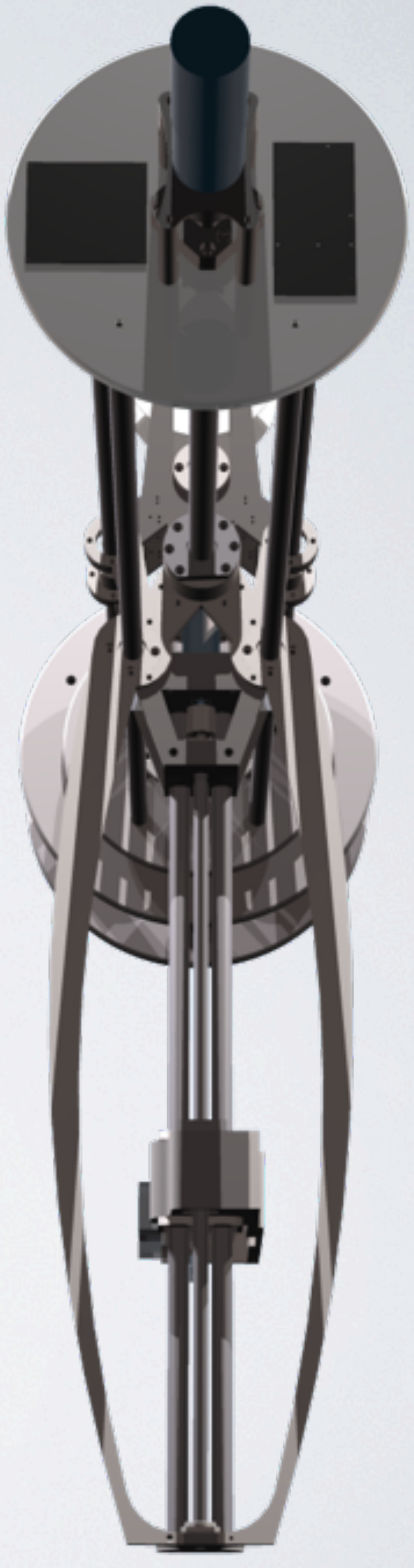




- Numerous **iterations** of the design made the machine more and **more detailed** and realistic, matching together the dimensions of purchased components like bearings and motors with custom components, in the CAD model.

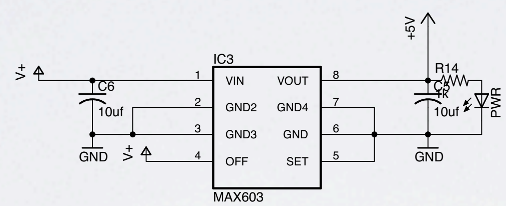
Design Process

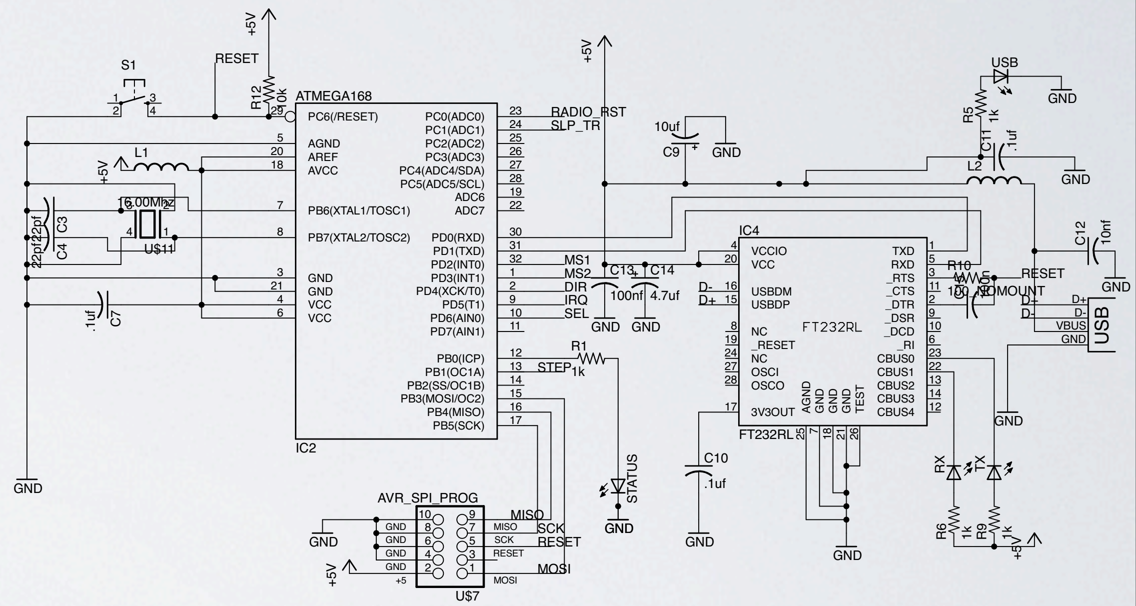
Eventually a final form was reached. All the parts were decided upon and purchased. The only thing left to do was to cut the metal and assemble.



Electronic Design

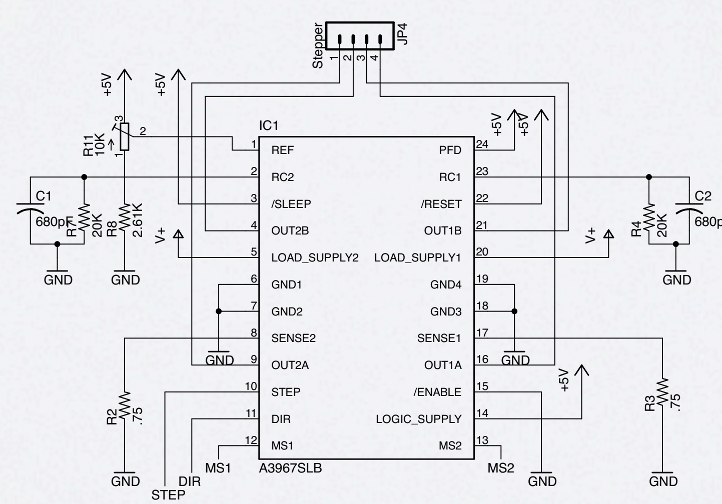
While the metal was being cut, and the machine assembled. The design of the electronic control systems began.

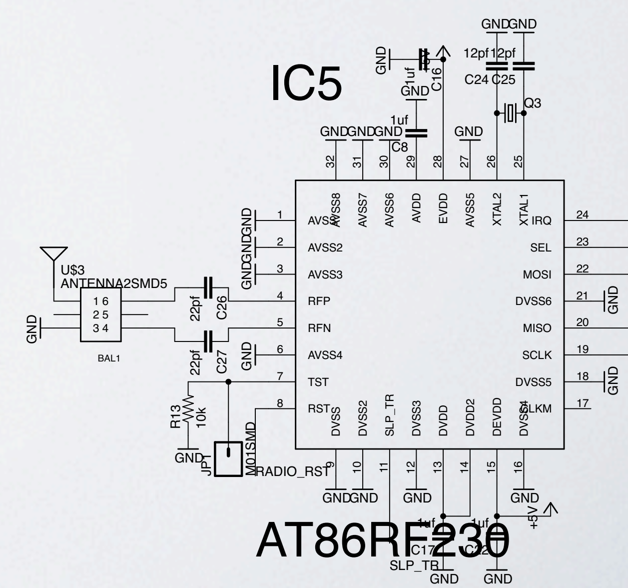




Considerations

1. How do we control movement of the printer
2. How does it get power
3. How does it connect to the internet





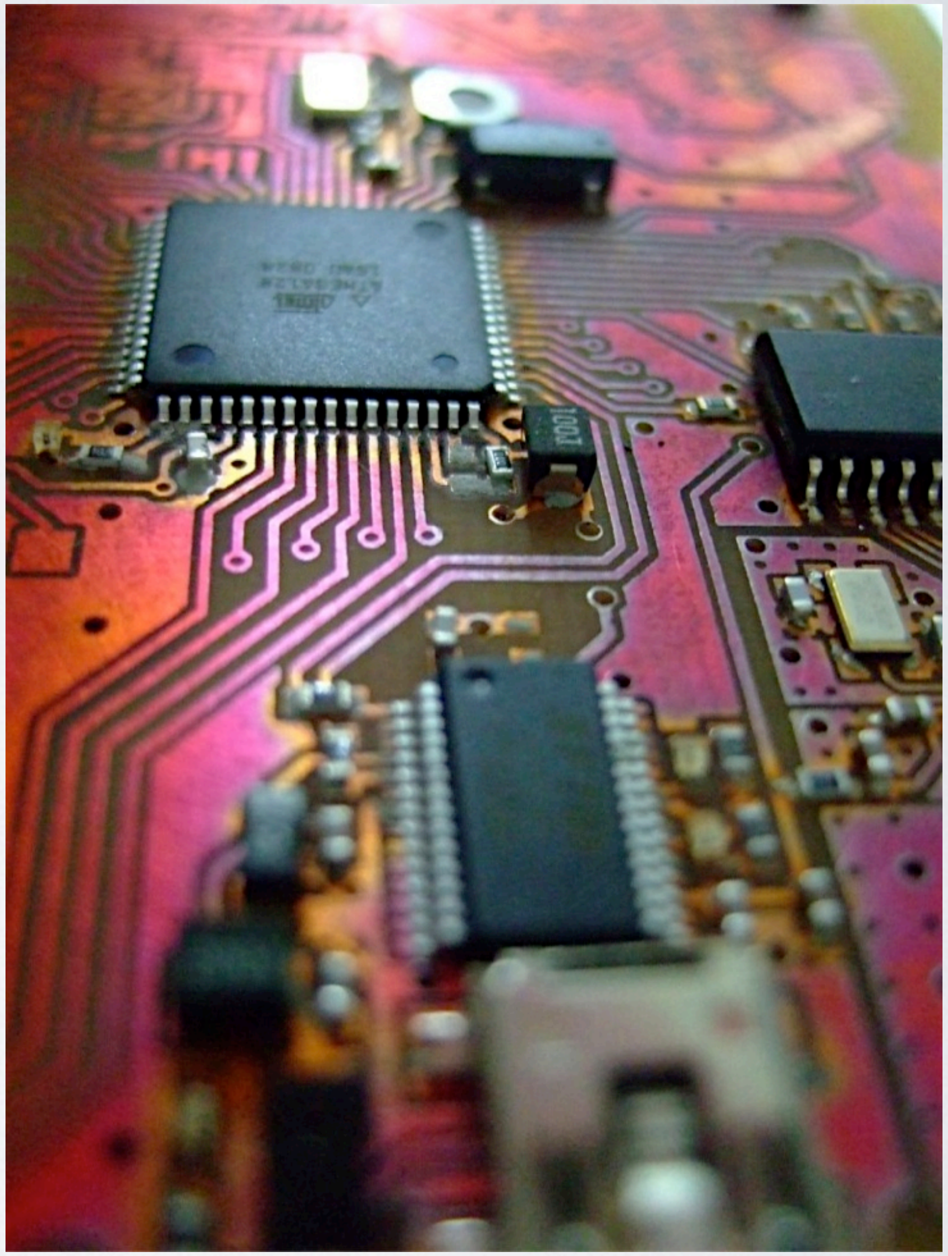
Electronic Design

Goals / Obstacles

A positioning precision of 0.01mm for three axis using servo motors and encoders.

The mechanical design calls for 360 degree rotational motion. That means, any wires, sending power or communication will get twisted and eventually break as the arm rotates.

Also, motion of the other two axis could cause the wires to tangle.



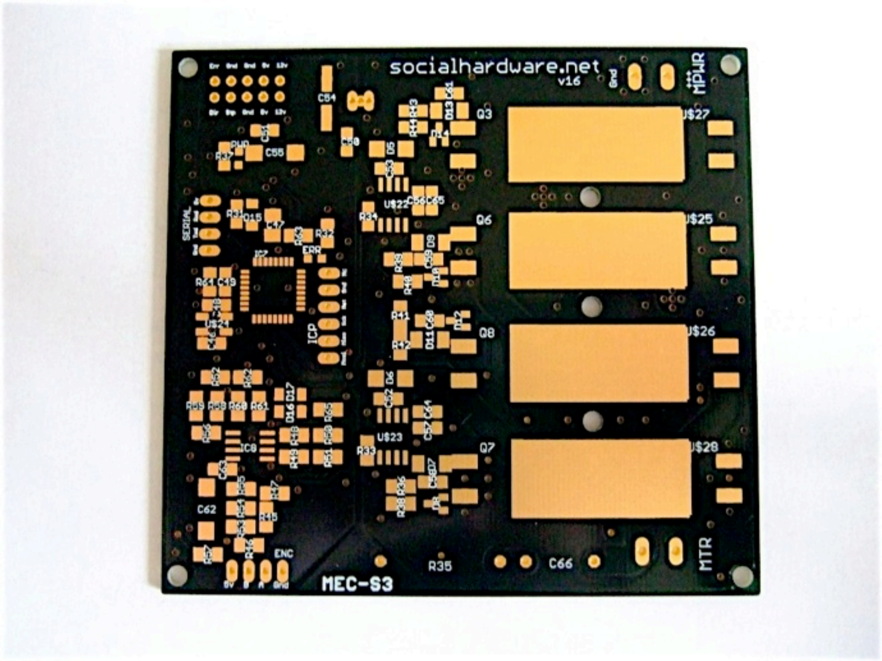
Electronic Design

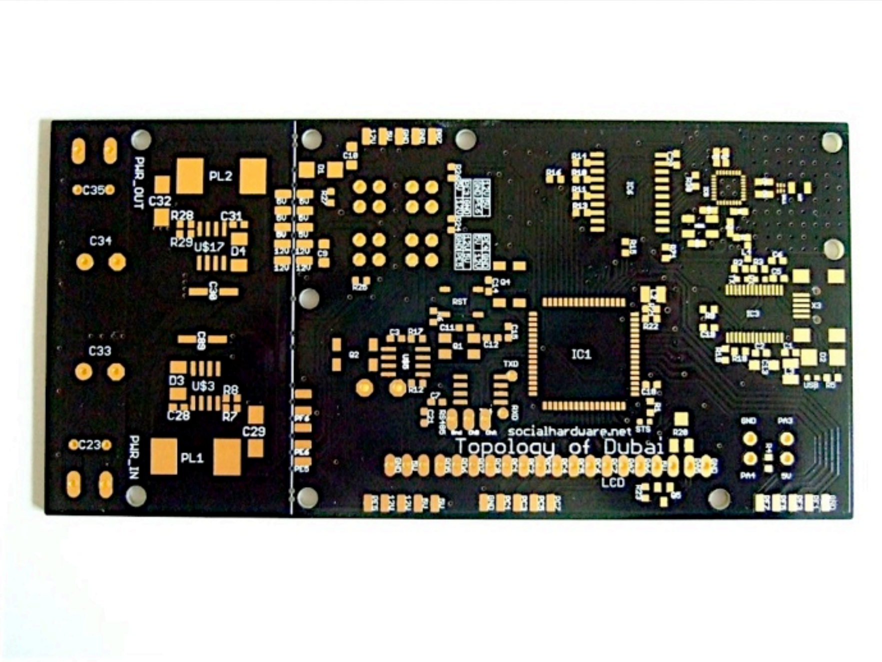
Solution

The final design called for the creation of a two control boards per axis.

1. One board was for reading the encoder position values and step and direction control of the servo motors using 30volt power.

2. The other board would have a wireless radio to receive vector positioning commands from the PC. It would also have a power supply for creating 5volt power for the electronics of both boards.





Build Process

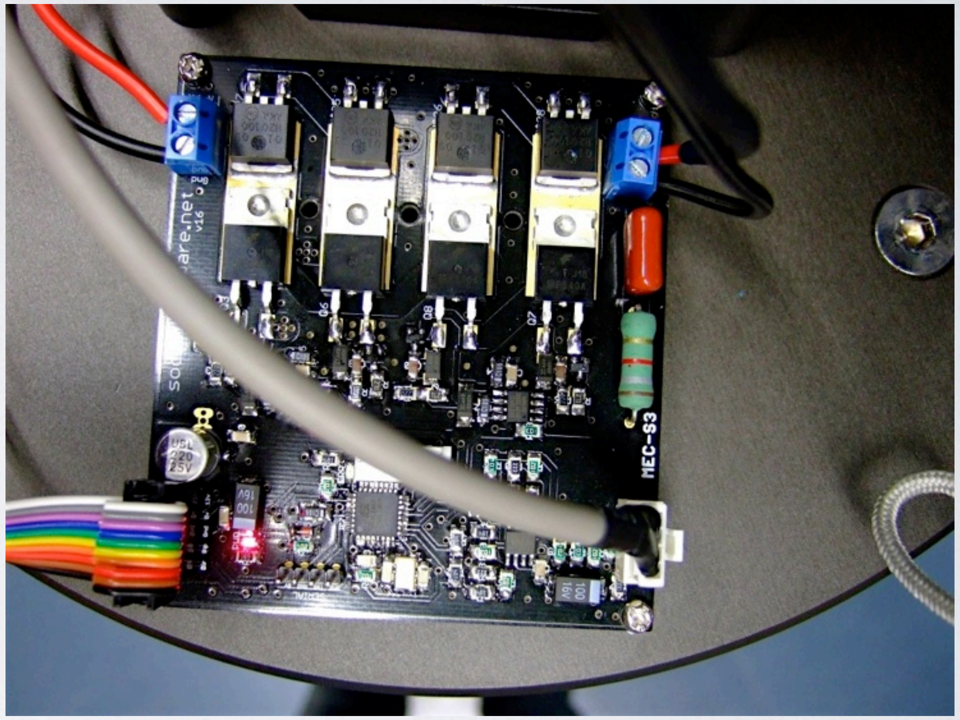
Electronic Design

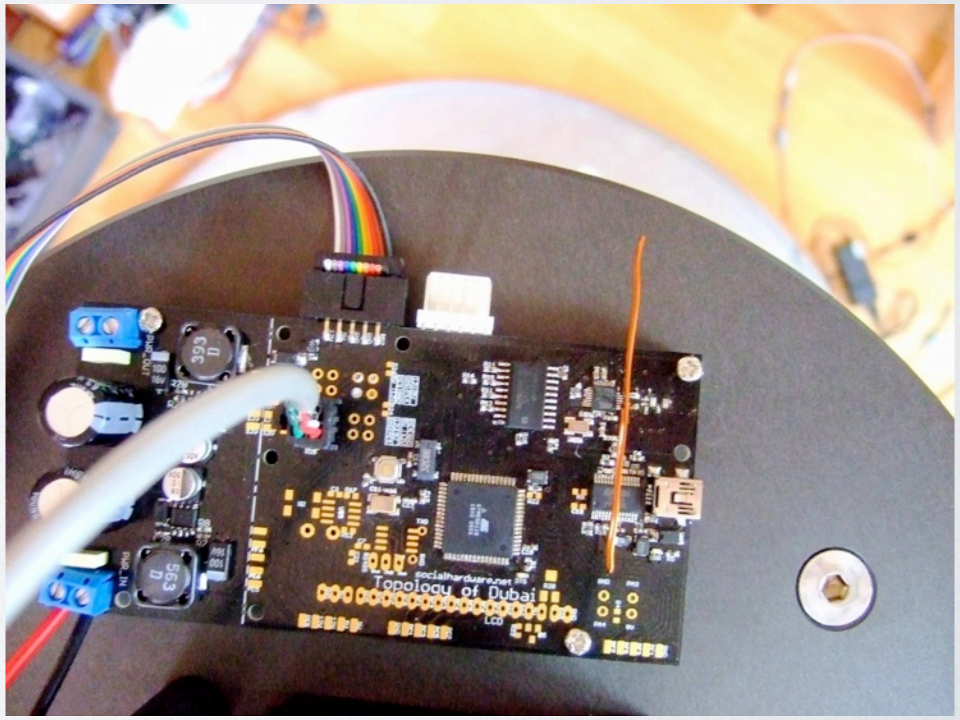
Problems solved

By using wireless communication with the PC, the only wires required were the power wires.

To eliminate the twisting of the wires during rotation we used a mercury slip ring. This device sends the power through a rotating cylinder of liquid mercury. Allowing for 360 degree rotation.

The other way we reduced wires, is to use two of the poles that the up and down axis travels on as substitutes for power and ground wires. Just like an electric train the up and down axis picks up powers from the poles as it slides along them.



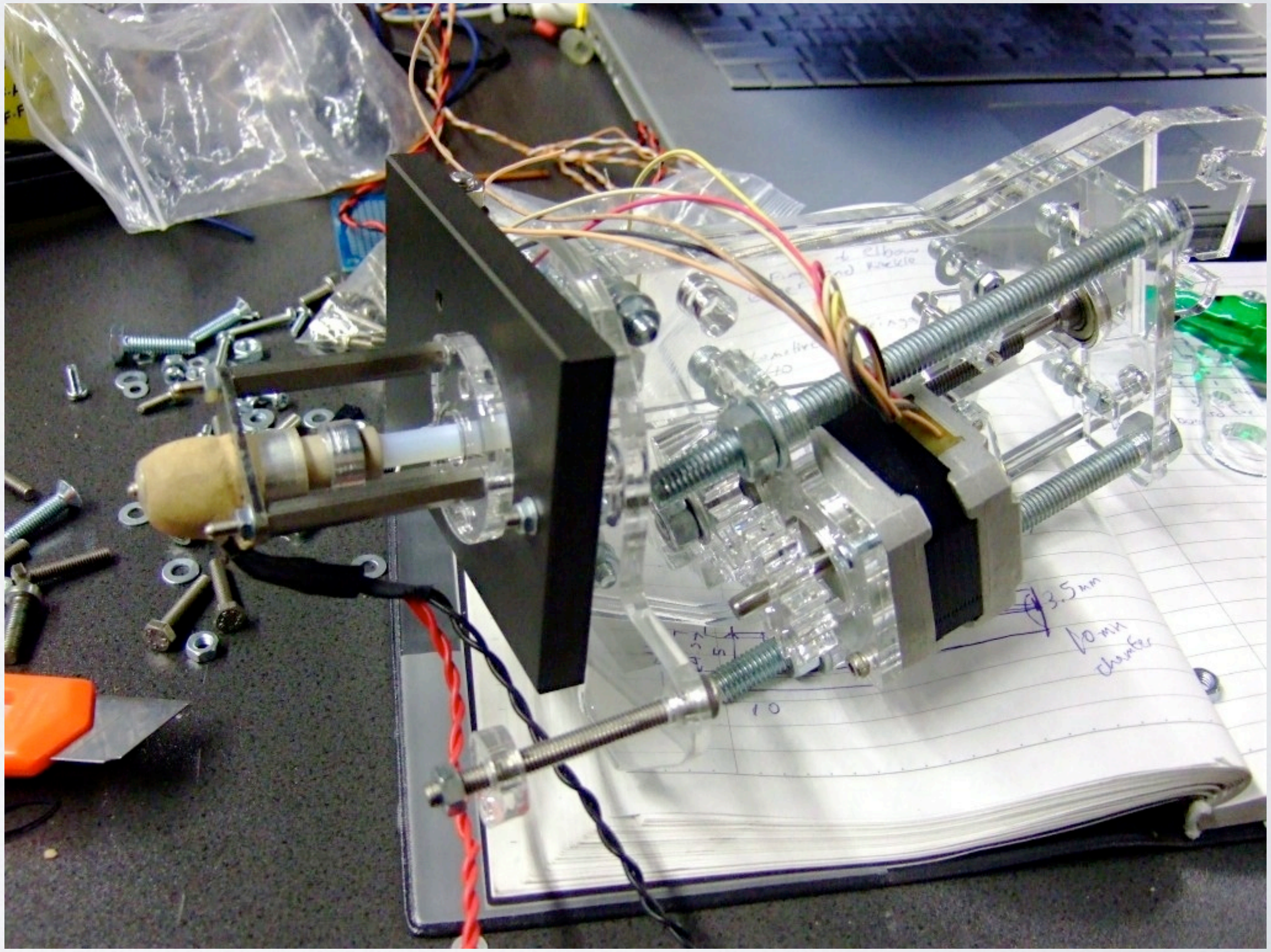


Extruder

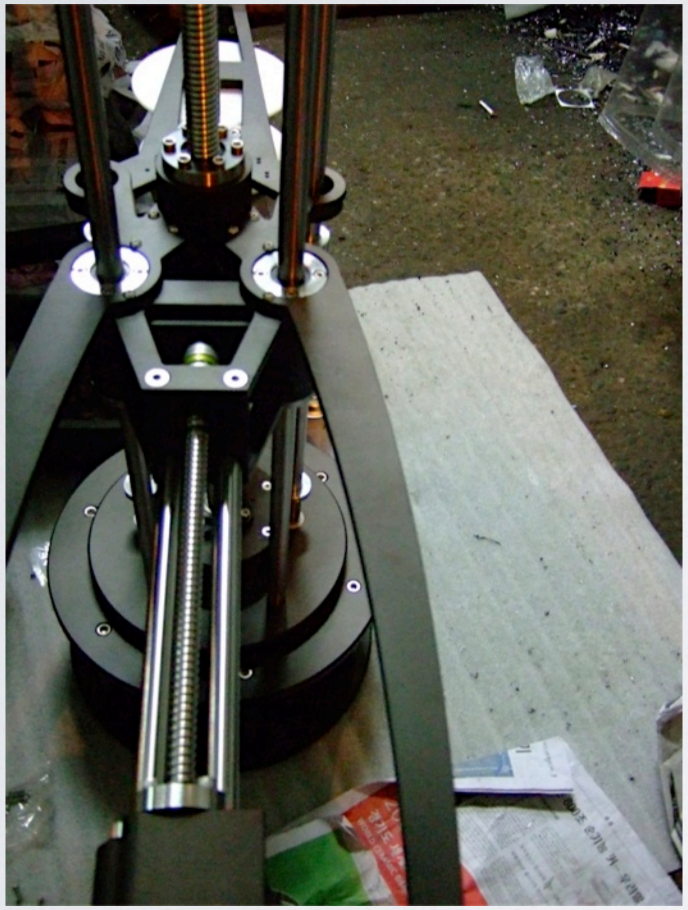
The plastic extruder or glue gun like device, is a complex machine in and of it self.

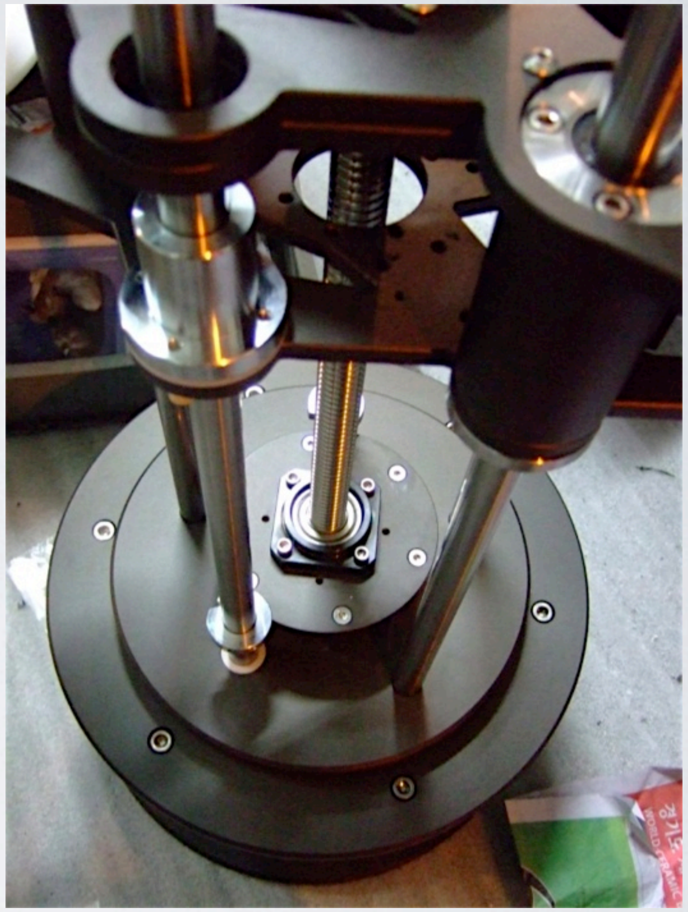
The extruder works by using a stepper motor to turn a screw that in turn grips a 3mm diameter rod of plastic. As the screw turns the plastic is slowly pulled to the end of the extruder.

At the end of the extruder is a heater element that is precisely controlled in temperature by the microchip computer.



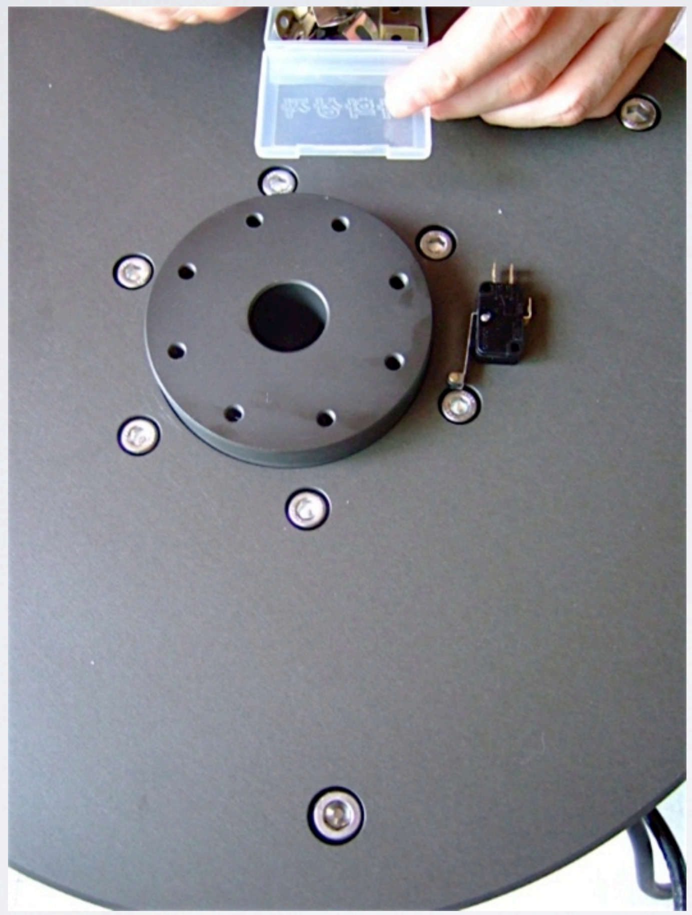
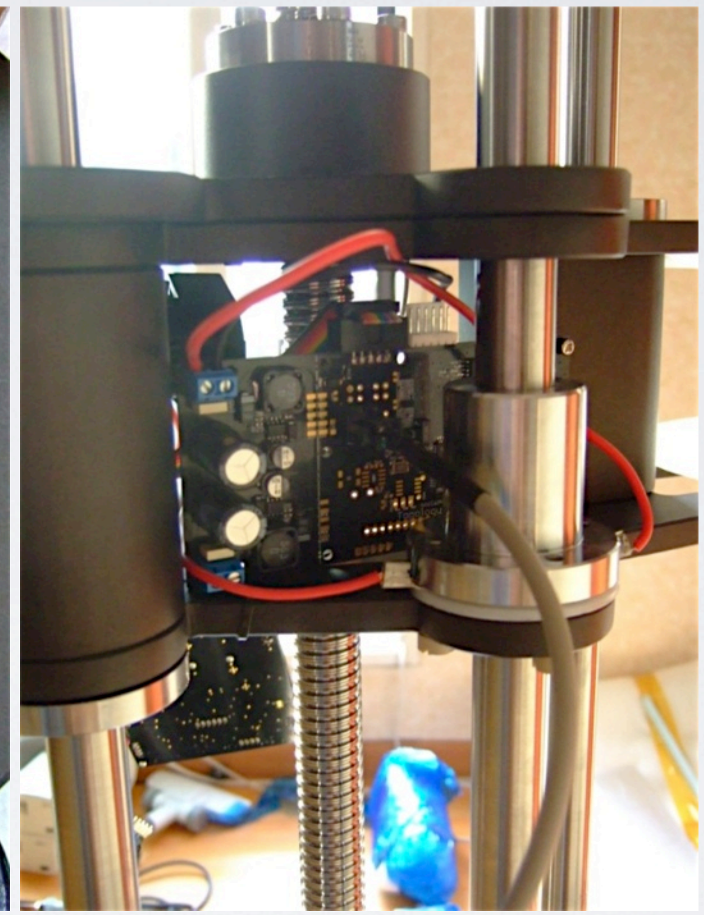
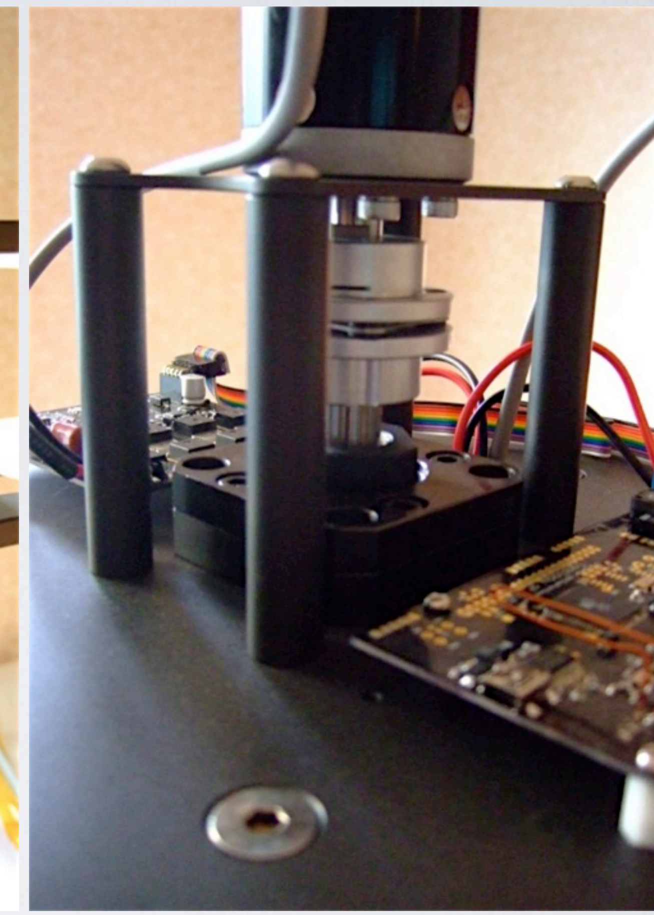
Cutting and Assembly





The results of the metal work were perfect. Exactly duplicating the 3d design

Electrical Assembly

The next step is the electrical wiring of the system. Followed by the testing and tuning of each motor.

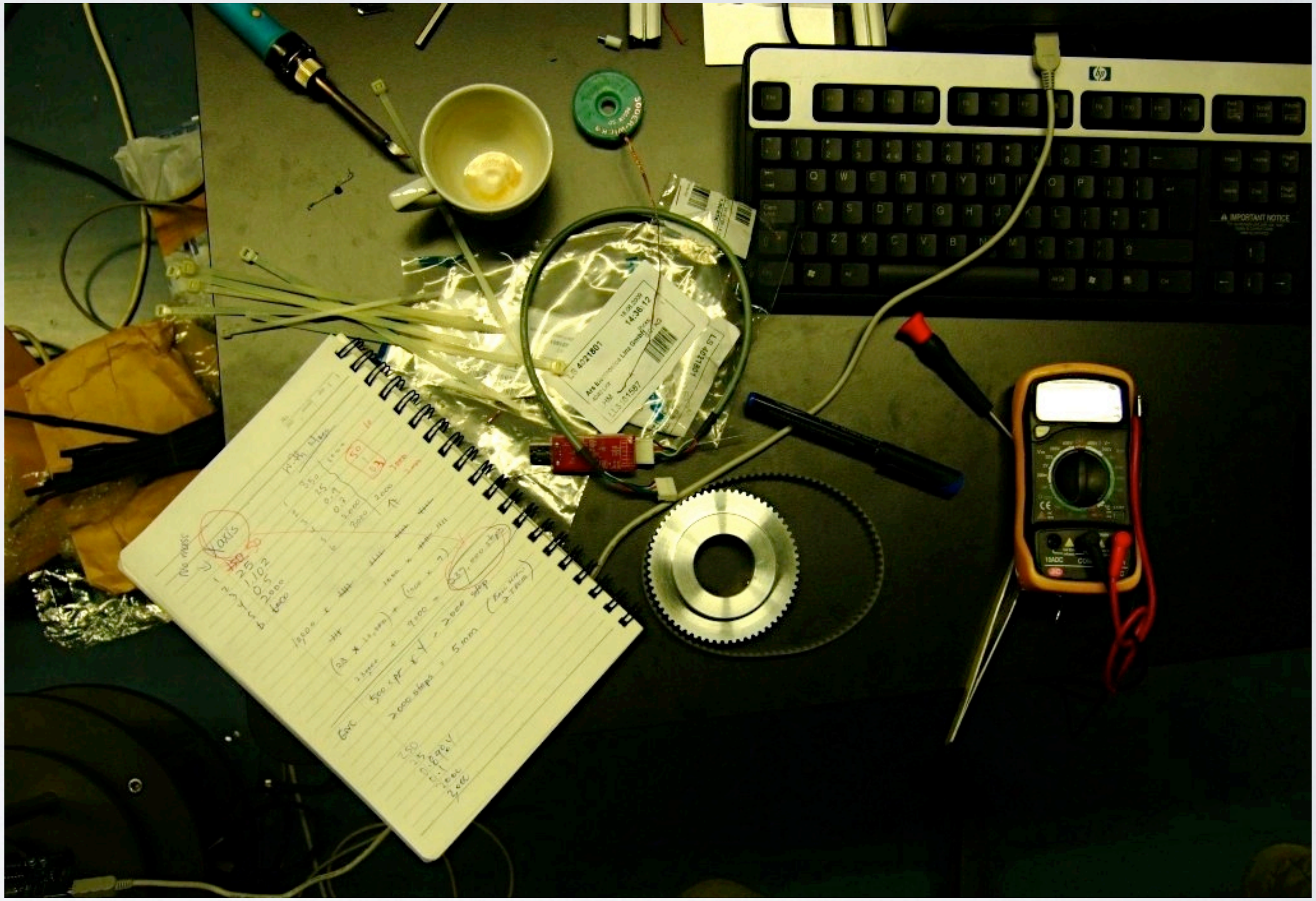
Shipping




After just 48 hours of assembly and testing. The project was packed shipped to Linz Austria. Unfortunately the packing was not so good, and rust damage occurred.

Testing, retesting

For one month in Linz, the project needed to be tested, tuned, modified, and programmed.



Bugs encountered

1. Wrong type of belt drive

2. Electrical noise, on cables

3. Extruder heater short circuit

Programming

The programming of the AVRs was the most time consuming aspect of the project. With over 1500 lines of AVR C code.

Some features:

-heater control
-wireless send/recieve
-usb input
-stepper control
-vector to motor pulse translation.
-motor control
-limit switch interrupts

```c
//dest:s //e-stop

   char temp_buffer[4];
   char *endptr;

   //get the destination address 16bit
    int i;
    for (i=0; i<4;i++)      { temp_buffer[i] = inbuf[i]; }
    //PRINTF("tempbuf %c tempbuf %c temp_buf %c temp_buf %c \n",temp_buffer[0],temp_buffer[1],temp_buffer[2],temp_buffer[3]);
    dest_addr = strtol(temp_buffer, &endptr, 16);
    PRINTF("dest_addr %x \n",dest_addr);

    char cmd = inbuf[5]; //dest:h:1 the 6th char
    PRINTF("cmd %c\n",cmd);

    //get the command value. such as position value or heater value
    uint32_t value=0;
    char value_buffer[6];
    char *endvalueptr;
    for (i=7; i<13;i++)      { value_buffer[i-7] = inbuf[i]; } // convert to char variable
    value  = strtol(value_buffer, &endvalueptr, 10);
    PRINTF("value %d\n",value);


   if(value ==  0)  //if you return a zero figure out if its an error or a number
   {
       if (endptr == inbuf)
           PRINT("Invalid input; no conversion took place \n");
       else if (*endptr == '\0')
           PRINTF("Input is complete; successful conversion of a real %d \n",value);
       else
           PRINTF("Successful conversion with possible garbage at end of input: >>%s<< \n", endptr);

   }
```

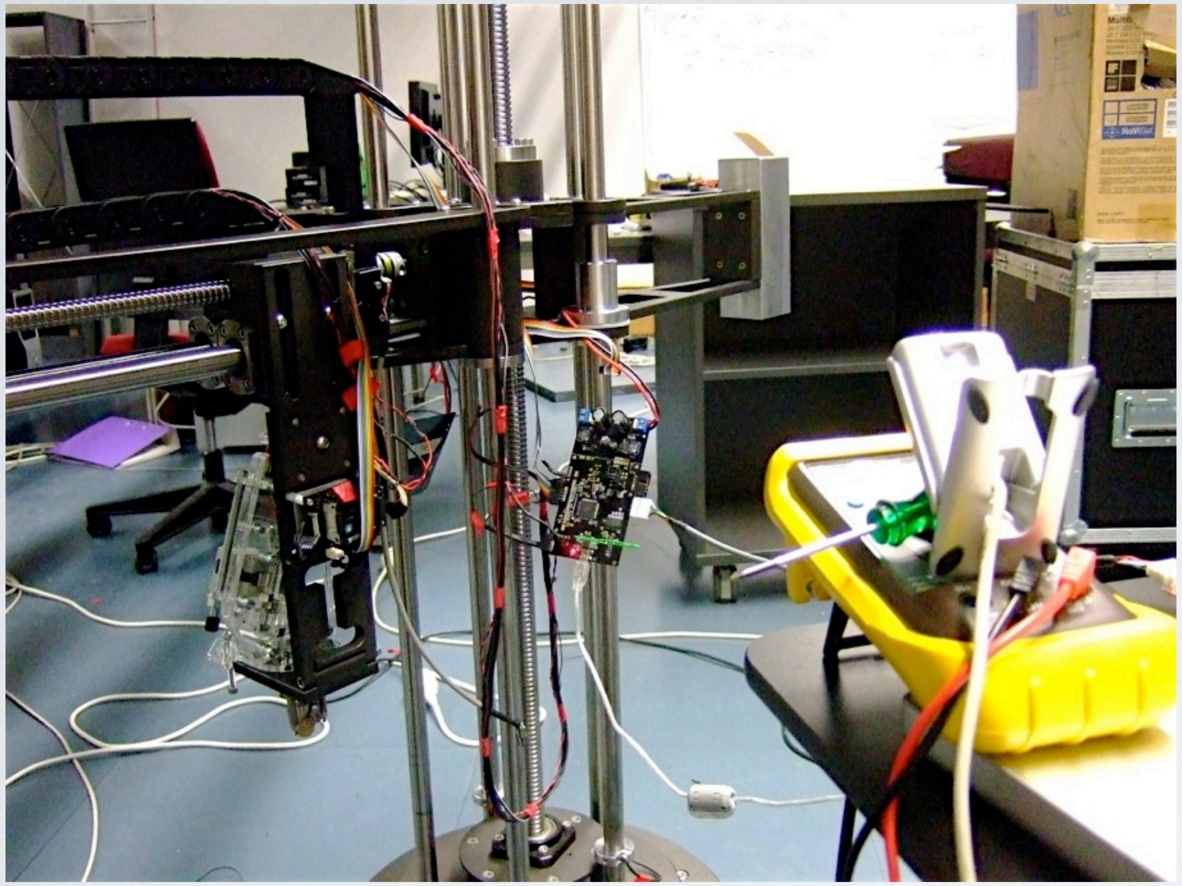
Motion Control Programming

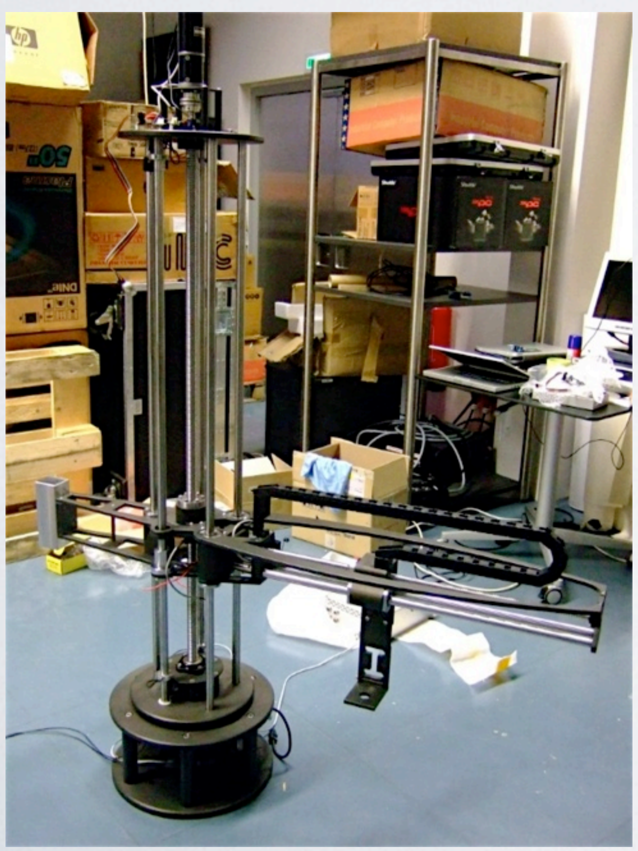
The PC control code consisted of about 5000 lines of C++ code.

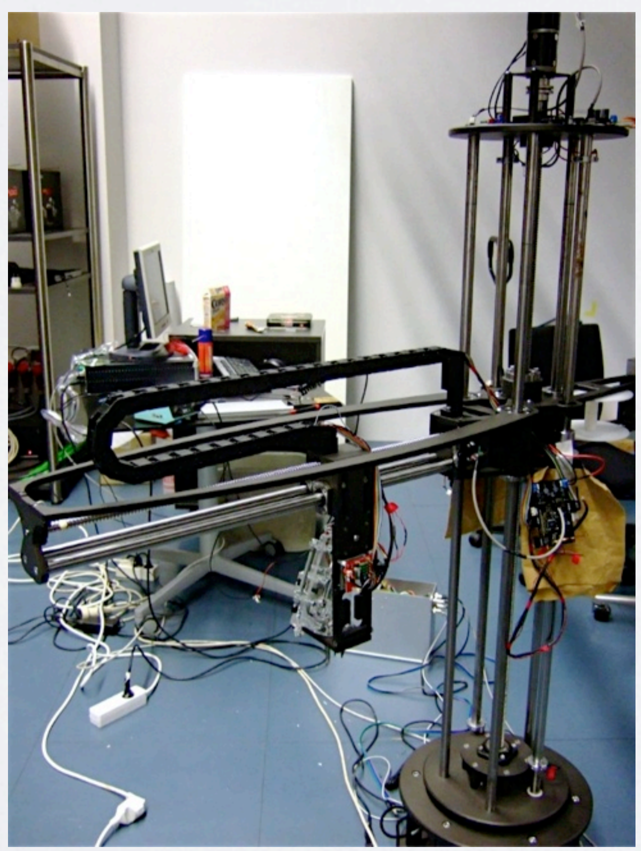
Features:

-Receive live data
-translate data to printing vector points
-store in DB
-when ready to print, get vector points
-generate actions for each sequence of points
-send to an action queue
-send each command through wireless to machine

Photos







Conclusion

Questions?

Thank you