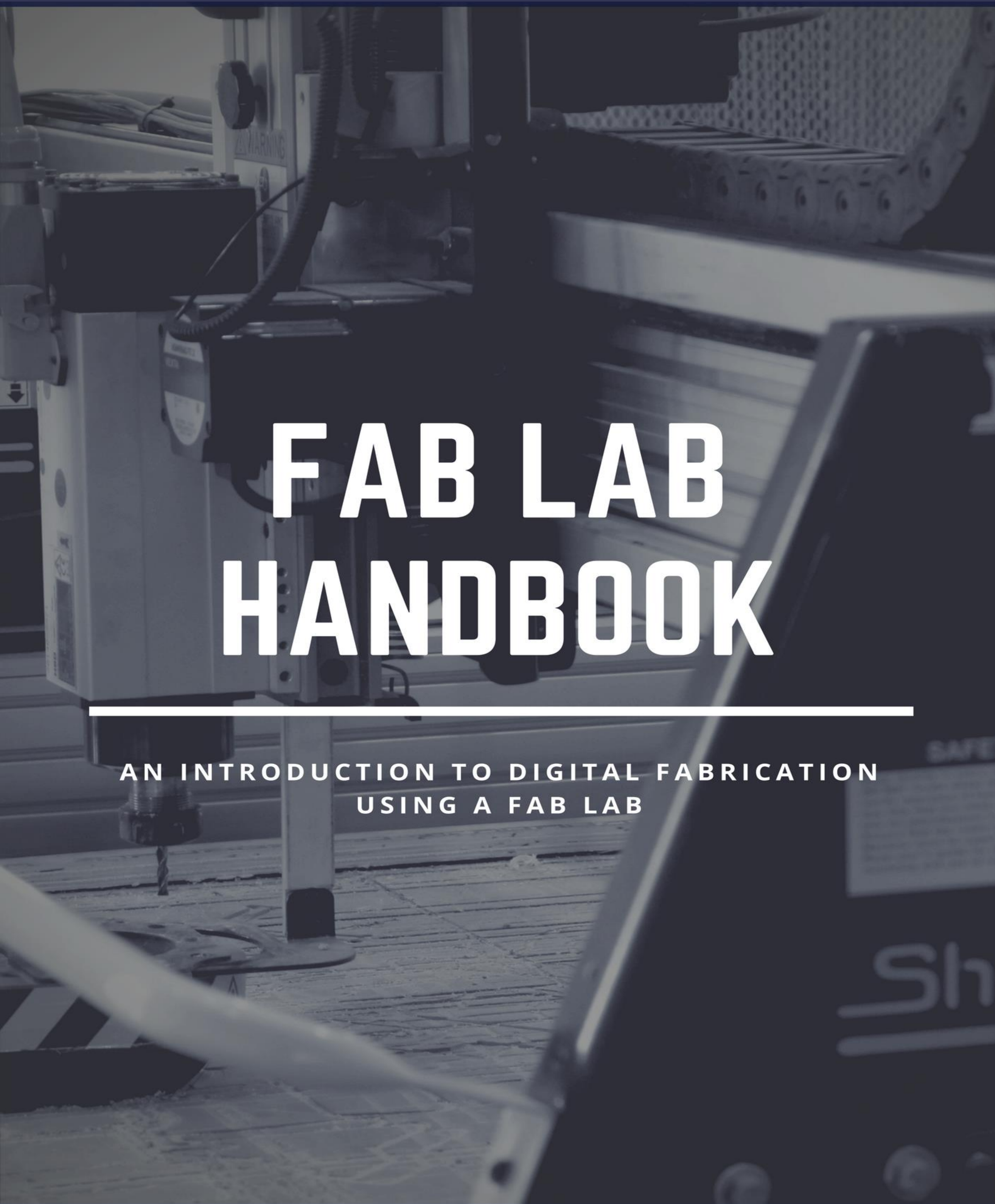
A BEGINNER'S GUIDE TO FAB LAB



FAB LAB HANDBOOK

AN INTRODUCTION TO DIGITAL FABRICATION USING A FAB LAB

RAHUL S RAJAN

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INTRODUCTION

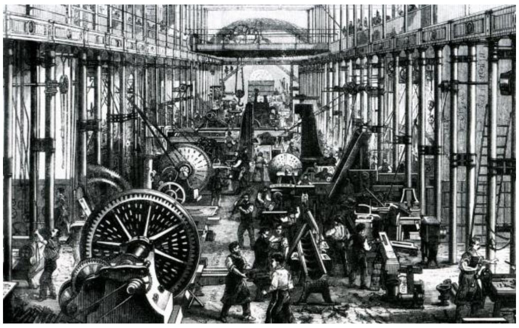
FABRICATION METHODS



Prologue

The word Manufacturing is derived from the Latin words Manus Factum, meaning made by hand. And the people who worked on their crafts for their livelihood were called Artists and Artisans. They served as the source of invention and education during their time.

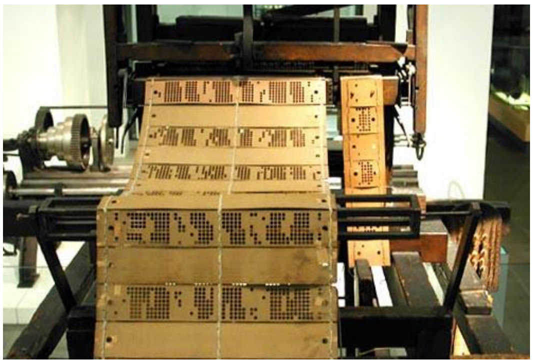
Craftsmen and owners of small shops would organized into guilds and Young men accepted into these guild would train as apprentices, become masters and set up their own shops. Art did not just mean creative expression, it meant on a broader picture the mastery that was developed over each domain. These guilds were effective monopolies, controlling both the supply and standard of workmen.



The industrial revolution started in Britain in 18th century. During this time manufacturing shifted from people’s homes into large factories. What impressed the Scottish economist Adam Smith was that manufacturers could constantly reorganize labor, dividing work into smaller chunks, which could be mastered by single worker or substituted with a machine.

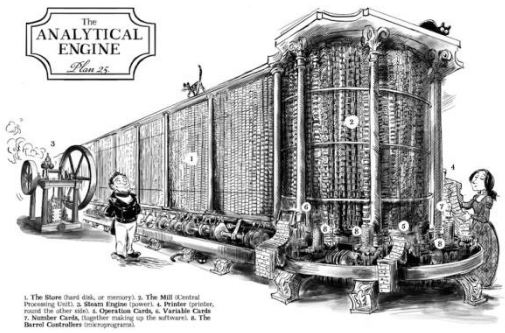
This methodology laid the foundation for the assembly line. With advancement in technology and ever increasing demand, more factories were set up, and industrial production grew exponentially. Artisans couldn’t compete with factory made products, and many left their jobs and moved to the cities to work on the very machines that would replace the jobs of many other artisans.

In 1804 Joseph Marie Jacquard invented an extension for a power loom, which can be programmed to produce patterns on fabric. He used punch cards as a means of inputting instructions into the machine. These punch cards were rectangular cards with rows of holes cut in them, these holes tell the loom where to thread, each row representing one row in the fabric.



The ability to program a machine was an important stepping point in computing history. Information bearing punched cards made machines more flexible in what they can do. When machines could follow instructions, their operators don’t need to anymore. So the job of a weaver was reduced that of an operator, this lead to a decline of the skilled labor during the industrial age.

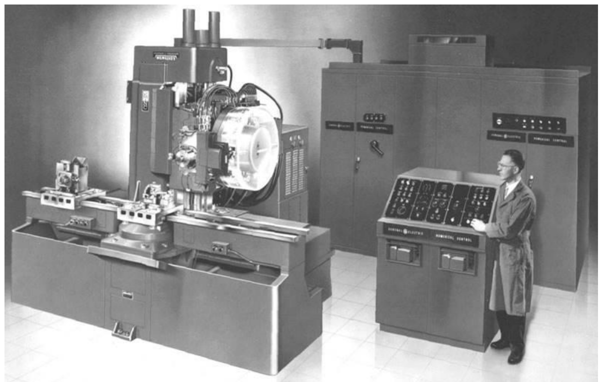
Prologue



Charles Babbage realized that an improved steam powered machine could follow instructions on a punch card to perform arbitrary mathematical operations. In 1837 he proposed the concept for the Analytical Engine, a mechanical general-purpose computer which incorporated an arithmetic logic unit, control flow, and integrated memory.

Herman Hollerith, a lecturer at MIT realized that holes cut in punch cards represented abstract information that could be recorded electrically. While working for the United States Census Bureau, he invented the Hollerith Tabulating System. In 1896 he launched the Tabulating Machine Company, which later became IBM (International Business Machines Corporation) in 1924.

After the Second World War airplane parts were getting increasingly complicated even for the most skilled of operators to make. In 1949 John Parsons while working on Air Force Research projects developed an experimental Milling machine at MIT's Servomechanisms Laboratory. By using computer controlled machines, manufactured shapes were only limited by the expressive power of the program, rather than the manual dexterity of the operators.



A new challenge came up. How could the designers tell the computer where to go and what to cut? The answer was the development of the a new kind programming language called CAM or Computer Aided Manufacturing. The first of which was the ATP (Automatically programmed tools) in 1955 became available in IBM's704. ATP was machine centric, it describes the steps that the machines needed to make, not what the designer wanted to see.

Advancements in software have made possible many CAD (Computer Aided Design) packages, which provide the ability to design a part completely in software. CAM's have come a long way from steps in ATP to being able to generate complex machine paths for 5-Axis machining.

**Inspired from the book 'FAB' by Neil Gershenfeld.*

Introduction

We want to create products that satisfy our need because nature does not provide them in the form and quantity we want them in. Hence we have to reorder the world, but order is not what the world tends to move on its own.

So to create order, we need information about what that order is, and knowledge about how to get there. Reordering the world needs work, which needs energy. Which is why most of the technological revolutions of our past have been related to mastering energy: From wind and water power, coal powered steam engines, to electric motors and internal combustion engines.

In 1965 Intel co-founder Gordon Moore noticed that the number of transistors per square inch on integrated circuits had doubled every year since their invention. Moore's law predicted an exponential growth of computing power and by extension machines that run on computers all become smaller and faster with time, as transistors on integrated circuits become more efficient.

Mainframe computers were expensive, but as technology progressed and made it accessible to common people, it was an outpouring of new ways to work and play. The adoption of Personal Computers were driven by the killer apps. Apps that were so compelling that they motivated people to buy systems to run them. The classic killer app was 'VisiCalc'—the first spreadsheet computer program for personal computers—which turned Apple 2 from hobby toy to a serious business tool.

Even as PCs became accessible, the machines that make them are still expensive. Like earlier transition from mainframes to PCs, machine tools will become accessible to common people in the form of personal fabricators. The Killer app for personal fabrication is fulfilling individual desires rather than meeting mass-market needs.

Engineering in space and time has become cheap, a cd player can place its laser reed with a resolution of one millionth of a meter, a micron, similarly a one dollar embedded chip can operate faster than a millionth of a second. Its fast enough to run software for many functions like generating communication signals and driving displays.

Introduction

Possession for the means of industrial production is what separates workers from owners, but if those hardware is easily acquired, and the designs freely shared, hardware will have a similar growth as software technology. In Shenzhen—the silicon valley of hardware—there exists a principle called ‘Shanzhai’, commonly understood as counterfeiting, but it shares the same spirit as the ‘maker movement’ —democratizing the access to technology and its means for production and has its roots in people coming out of the factory and building something of their own.

When the market is just one person the prototype is the product. The big machines will continue to mass produce things in large quantities like nuts and bolts which are same, and the little machine tools will custom make the products that depend on differences. Personal, instead of mass manufacturing. A new market will open up, which craters to the needs of individuals. The biggest limitation is not men and machines, it's the lack of knowledge that this is even possible. Digital fabrication will bring about the programmability of the digital worlds we invented into the physical world we inhabit.

**Inspired from the book ‘FAB’ by Neil Gershenfeld.*

Chapter one

What are Fablabs?

Fab labs or Fabrication Laboratories began as an outreach program from MIT's Center for Bits and Atoms (CBA). They are a technical prototyping platform, where people can design and build their own technology.

Fab labs are designed in a way that people with minimal training can come and work on developing their own technology for personal or commercial use. They comprise of roughly fifty thousand dollars in equipment and materials that can be used to make almost anything. They share core capabilities so that people and projects can be shared across them. This currently includes,

- A computer-controlled laser cutter, for press-fit assembly from 2D parts
- A larger (4'x8′) numerically-controlled milling machine, for making furniture, and large parts
- A sign cutter, to produce printing masks, flexible circuits, and antennas
- A precision (micron resolution) milling machine to make three-dimensional molds and surface-mount circuit boards
- Programming tools for low-cost high-speed embedded processors

This inventory is continuously evolving, towards the goal of a fab lab being able to make a fab lab. The Fab Lab comprises of off-the-shelf, industrial-grade fabrication and electronics tools wrapped in open source software and programmes written by researchers at the MIT.

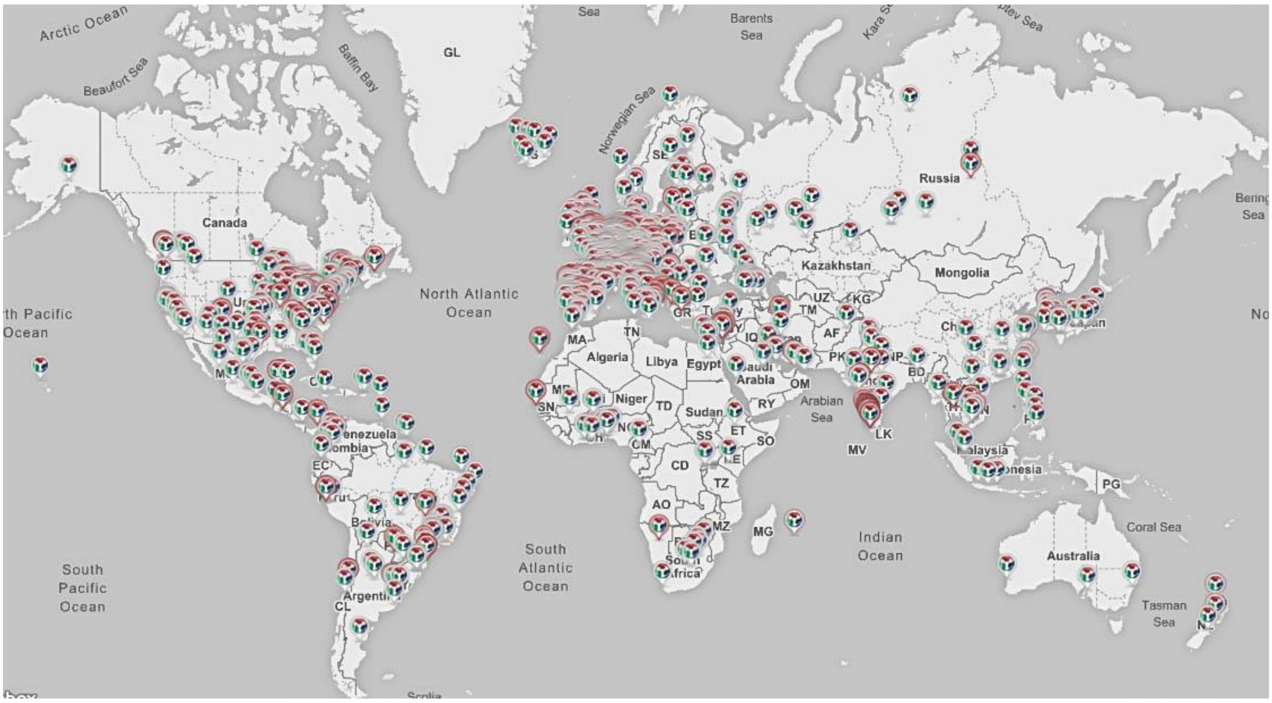
More than just a prototyping platform, a Fab Lab connects to a global community of learners, educators, researchers, makers, and innovators – a knowledge sharing network that spans 30 countries and 24 time zones. And because all Fab Labs share common tools and processes, the program is building a global network, a distributed laboratory for research and innovation

Fab Lab Network

The Fab Lab Network is an open, creative community of fabricators, artists, scientists, engineers, educators, students, amateurs, professionals, of all ages located in more than 78 countries in approximately 1,000 Fab Labs.

Fab Labs share the goal of democratizing access to the tools for technical invention. This community is simultaneously a manufacturing network, a distributed technical education campus, and a distributed research laboratory working to digitize fabrication, inventing the next generation of manufacturing and personal fabrication.

> *There has been a digital revolution in communication. Now it is time for a digital revolution in fabrication, where data is turned into products*
>
> *— Neil Gershenfeld*



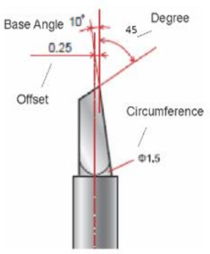
FABRICATION METHODS

THE TECHNOLOGY, PROCESS, AND APPLICATION

Chapter Three

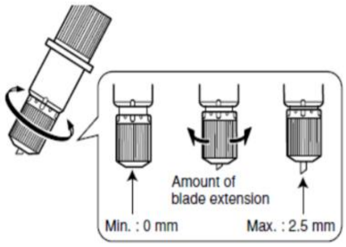
Vinyl Cutting

A vinyl cutter is a computer controlled machine, which can cut out letters and shapes in the vinyl by moving a sharp blade against a thin vinyl sheet. It is used to make logos and decals for cars and laptops. It can also cut thin copper sheets which can be used to make flexible circuits for soft electronics or antennas for radio communication.



45 deg. Bit

Bits



Bit Holder

How it Works

The input for the Vinyl cutter is an image in vector format. The design is fed into the software which traces out the cutline based on the image and creates the machine tool path in the same scale as the image. Once the material is loaded, and the machine path is send, the knife cuts through the material to the desired shape.

Each material is different and requires different cutting parameters. We can vary the cutting force and speed of the blade for each cut. Test the machine parameters by making a small test cut on the material. The cutting knife will cut through the top layer of the vinyl leaving the substrate material intact. The depth of the knife can be varied by adjusting the bit holder.

Once the desired shape is cut, the design needs to be transferred into the actual material. A common method is to use a transfer tape. The procedure for transferring the vinyl onto the work piece is to first cover the entire cut out with a layer of transfer tape and slowly lift the design off the substrate, making sure to remove all the unwanted portions. And transfer it to the workpiece.

Chapter Three

Roland GX-24

The vinyl cutter is a versatile machine that can cut thin sheets of vinyl, paper, or even copper sheets. It can be used to make anything from decals for laptops and cars to printed circuit boards and antennas.

The Roland GX-20 consists of a computer controlled knife on a linear axis. The sheet is held in place by rollers and fed in a direction perpendicular to the motion of the knife. We can set the cutting velocity and force depending on the material of the sheet we are cutting.

Workflow of Vinyl Cutting

Input file : A Vector Image in **.PNG** Format.
Materials : Vinyl Sheet, Copper sheet

1. Design your graphics in any vector graphics software.
2. Load the Vinyl sheet into the machine.
3. Turn on the machine, and set the origin.
4. Set the cutting parameters and start cutting.
5. Use transfer tape to transfer the Vinyl logo onto the object.

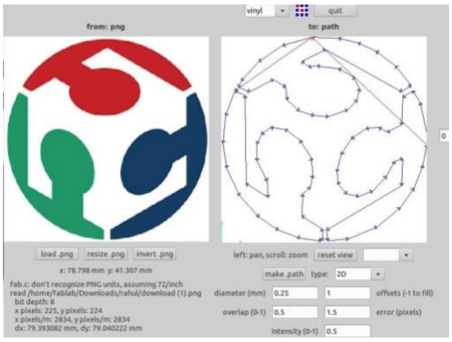
Chapter Three

DIY Example

Make your own Vinyl Logo

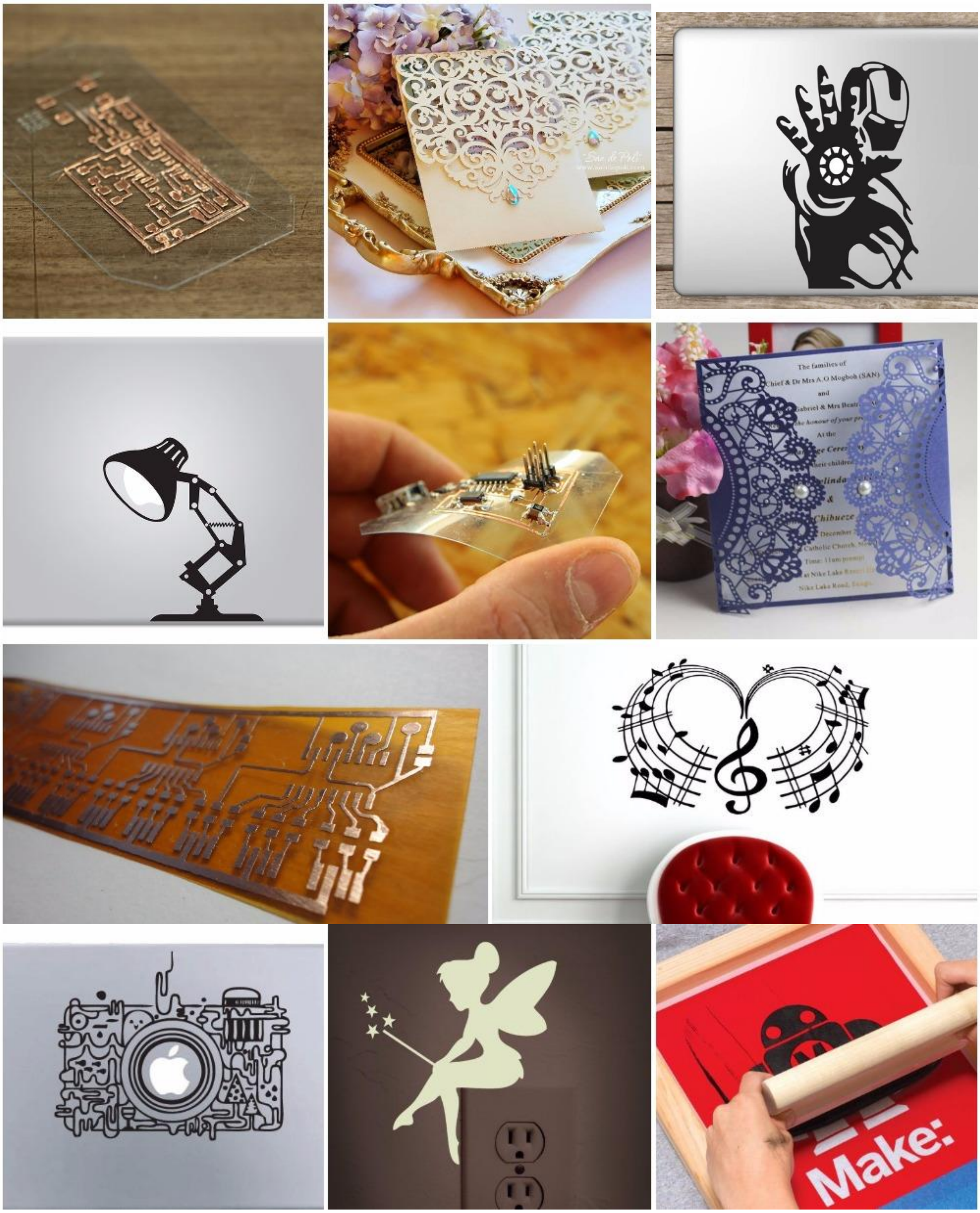
Vinyl logos are quite easy to make. The process starts with a vector image of the logo, which is imported into the CAM software, which converts the image into machine too paths. The material is prepped in the machine and the design is cut out by the computer controlled knife.

1. Design your Logo in a Vector graphics software like Inkscape, Photoshop, Illustrator and export as PNG image.
2. Open Fab modules in the PC and select input as PNG image and output process as Roland Vinyl Cutter (.camm)
3. Set the cutting parameters like force and speed—depends on each material—and test it.
4. load the vinyl sheet from the back set the origin.
5. Once all the parameters are set, click **Send** to start cutting.
6. Once the cut is finished, use a transfer tape to transfer the logo onto the surface. Making sure to remove all the unwanted portions before applying the logo.



Chapter Three

Fabrication Possibilities



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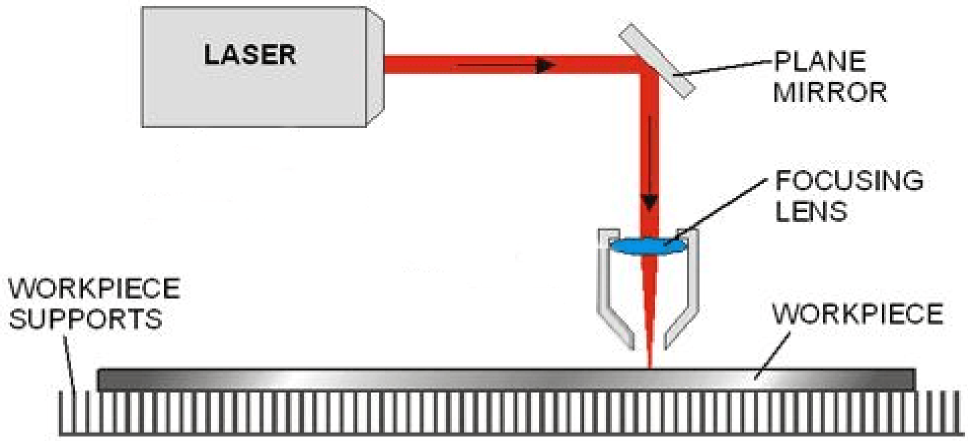
Chapter Four

Laser Cutting

Laser cutting is a form of subtractive machining which uses a high energy beam of light to vaporize the material. Unlike conventional machining there is no physical contact between tool and work piece. Lasers are very efficient in cutting small and intricate parts and there is no tool wear with prolonged use, but care must be taken to avoid chances of fire.



How it Works

A laser is generated in a simulated environment and directed at the workpiece through a system of prisms and lenses. The optics are held in a CNC arrangement , capable of positioning the laser beam with very fine resolution. The beam vaporizes the material and cuts through it.

There are many type of lasers, Carbon dioxide lasers are most commonly found in small format machines, they can cut through wood, paper, and acrylics. In order to cut metal, a high power fiber laser of is required,

Warning!

- **Laser cutting is a dangerous operation. Never look directly at the cutting beam. Invisible radiations may cause blindness.**
- **Never cut reflective material in a carbon dioxide laser.**
- **Never cut PVC or other plastics you don't know the compositions of.**
- **Always test out machine parameter before cutting on a new material.**
- **Never leave the machine running unattended.**

Chapter Four

Trotec Speedy 100

In Laser cutting, a focused beam of light is used to cut through the material. The Speedy 100 has a 40W carbon dioxide laser, capable of cutting through wood, paper and acrylic. The high energy beam generated in the chamber is directed at the work piece through a system of prisms moving in a CNC arrangement.

Since material removal takes place by vaporization, care should be taken when cutting flammable materials like paper and wood.

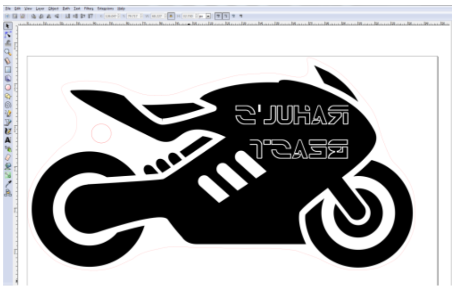
Workflow of Laser Cutting

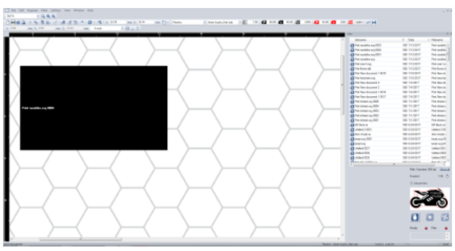
Input file : Images(PNG,JPG,SVG)
Engineering drawings(DXF,SVG,3DM)
Materials : Craft Wood, Acrylic, Paper

1. Design your graphics in any vector graphics software and set the document properties so that it matched with the size of the image.
2. Turn on the machine, and let it run calibration and load the sheet on the bed, ensure that it is level.
3. Focus the laser beam, move it to a suitable position and set the origin.
4. Turn on the Air Filter and Start Cutting.

Chapter Four

DIY Example





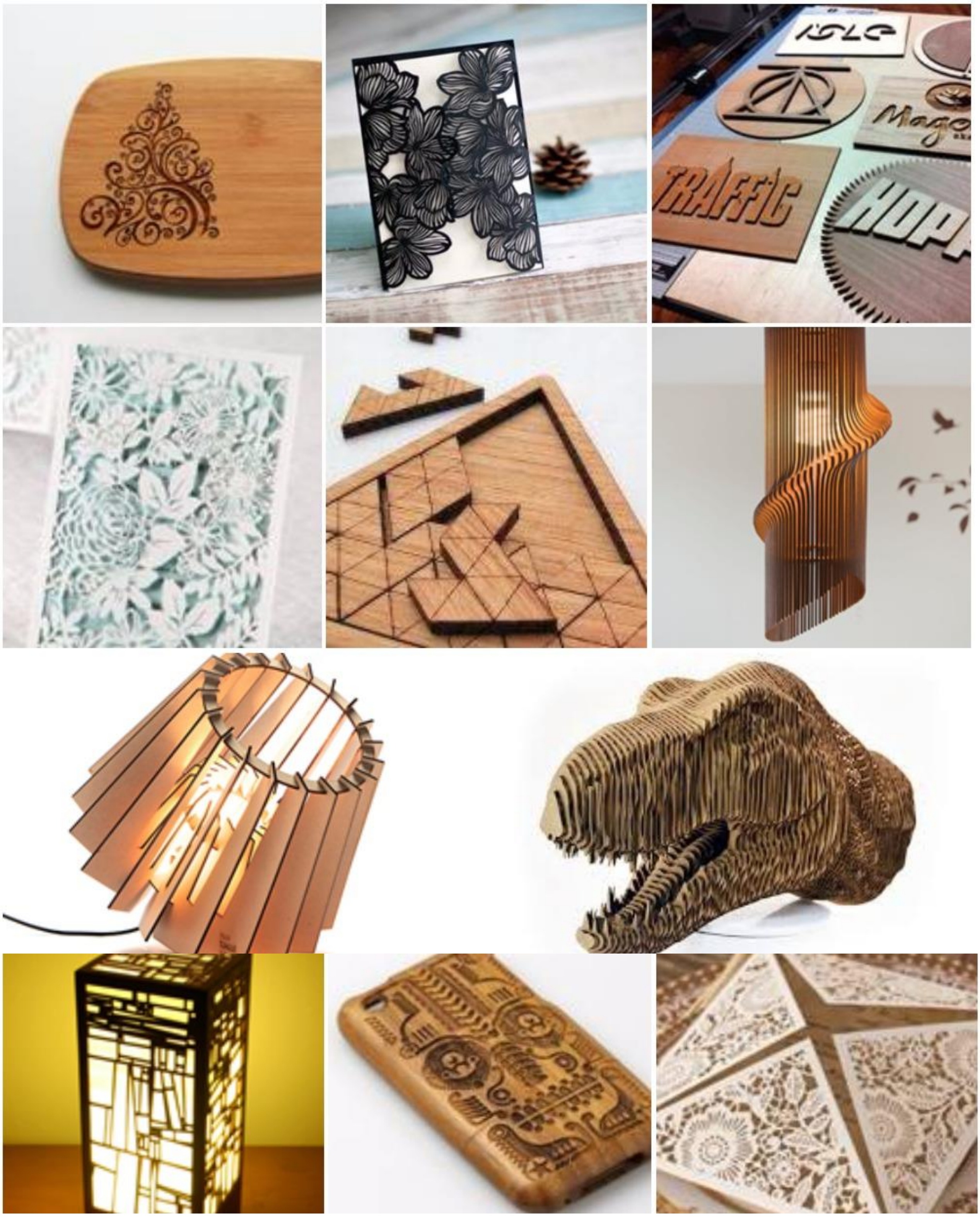
Make a Racer Bike keychain

A variety of materials can be cut in a laser, including wood and acrylics. For this example we'll be making a simple keychain out of Acrylic. First we will engrave our design and then cut it out. The laser works on the basis of colour, Black for engrave and Red for cut. When engraving images, convert to grayscale for getting depth.

1. Create your design in any Vector graphics software, if its an image, convert it to grayscale.
2. Draw a cutline (red R255) around the design using the **Bezier curve** tool.
3. Set the Document properties to match that of the design and Print.
4. In printing properties, choose the material, set the machine parameters.
5. Turn on the machine, load the material and focus the laser beam.
6. Move the beam and set the **origin** by using the four arrow key on the side console.
7. Click **Ready** in the bottom right menu to connect to the engraver.
8. Drag the document into the bed and bring it close to the pointer, it will snap on and the job location on the bed will be set.
9. Turn on the **Air Filter** and then click **Run** to start cutting.

Chapter Four

Fabrication Possibilities



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Chapter Five

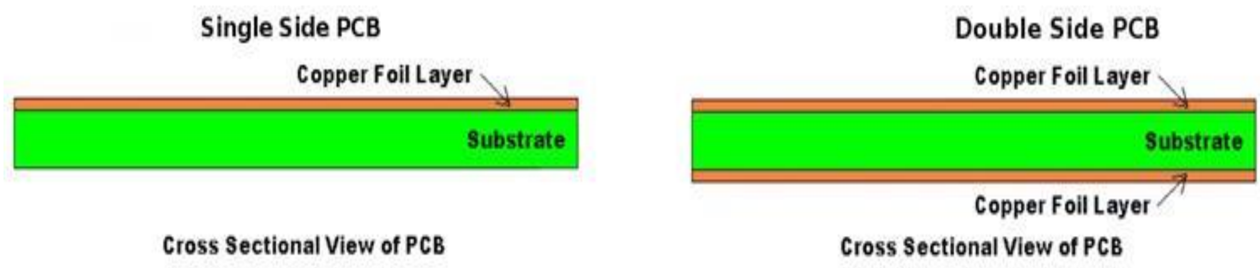
PCB Milling

A Printed Circuit Board forms the heart of almost all electronic devices. They simplified the production of large circuits in a small space. A PCB starts from a schematic, drawn by a designer in a CAD program. This design is later converted into a mask and transferred onto a copper clad board. The unmasked portions are generally removed by subtractive methods. Once done ,will leave behind tracks of copper which complete the circuit

How it Works

A PCB mechanically hold and electronically connects the components using conductive copper tracks. A PCB generally start out as copper clad boards. PCB substrates are specialized materials that do not conduct electric currents. For example FR-1 is a hard, flat material that consists of a thin layer of copper over a non-conductive phenolic paper. PCBs are made by selectively removing this copper layer from the substrate., thereby isolating the traces and forming electrical connections. Components are generally soldered on the board.

The various fabrication methods for making a PCBs are
1. **Silkscreen Printing** — Large volume, and used for PCBs with bigger features
2. **Photoengraving** — Large volume, and PCBs with finer features.
3. **PCB Milling** — Low volume with larger features.



PCBs can be single sided , double sided, or multi layer depending on complexity, and the different layers are connected by vias. The more layers a PCB has the higher the component density, thereby reducing the size of the board.

Chapter Five

Modela MDX 20

Modela MDX 20 is a Desktop milling machine that is capable of milling wood, wax and circuit board blanks. It has a small work bed which moves in the Y-axis, a Tool head which moves in the X-axis and the end effector which moves in the Z-axis. It is a versatile machine which supports many milling end mills.

It can be used for making 3D scans of small parts by changing the end effector. The machine has a tiny footprint and can be used in a desktop setting.

Workflow of PCB Milling

Input file : PNG

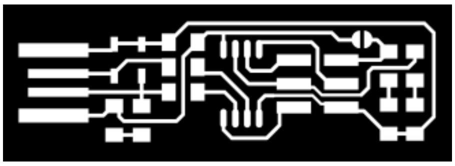
Materials : FR1 Copper Blank.

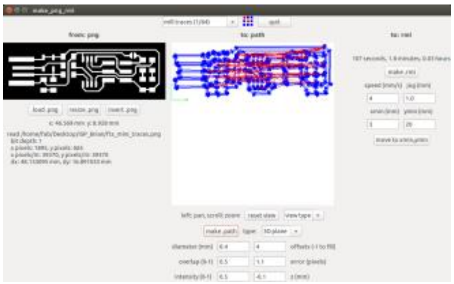
1. Design your circuit board in any PCB layout software and export as PNG image.
2. Fix the PCB on the bed using double sided tape.
3. Open PNG image of traces in fab modules and set machine parameters.
4. Mill traces first using 1/64 inch end mill.
5. Load the Cut out image in Fab modules and set the machine parameters.
6. Cut out the board using 1/32 inch end mill.

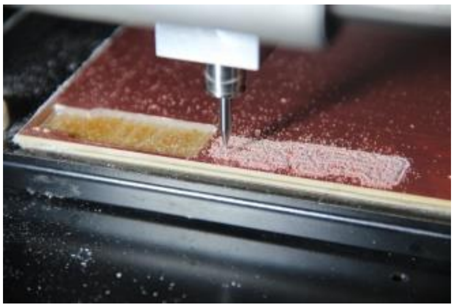
Chapter Five

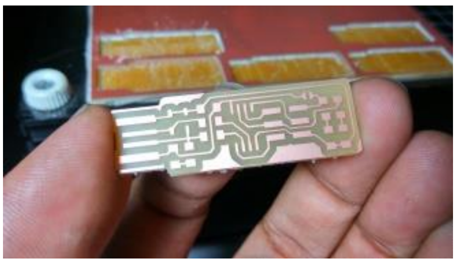
DIY Example

Making a Fab ISP Programmer







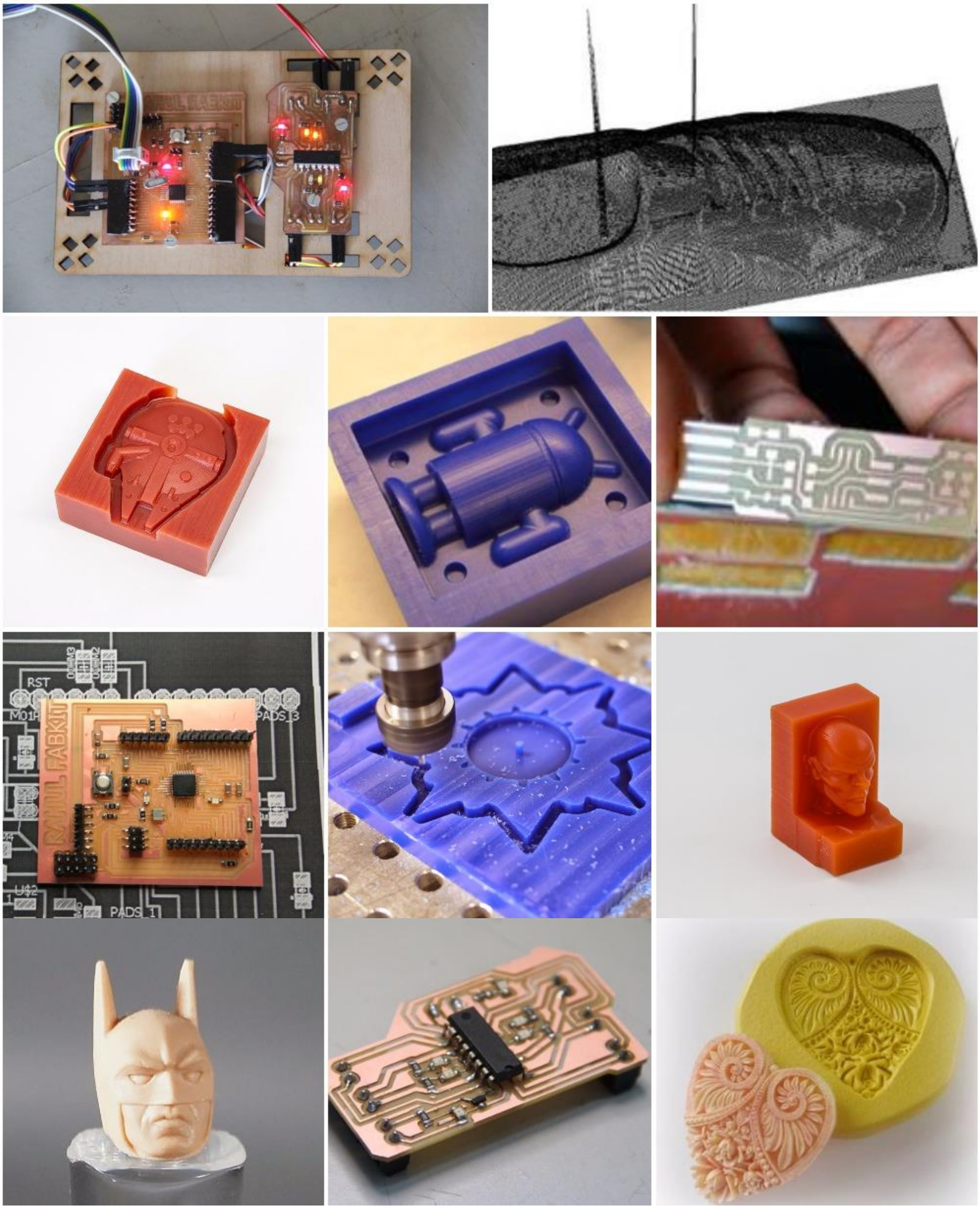


An ISP programmer is a device used to program a Microcontroller unit. It is a crucial device in electronics prototyping. The C program that is fed into the MCU, is first converted into a HEX file by running the make operation in PC. This HEX file is burned into the MCU in a process called flashing. The programmer receives the data from the PC and writes it onto the MCU.

1. Design your board using any software like EAGLE, KiCad and export the file as a **.PNG** image.
2. Setup the machine and put the 1/16th end mill and set the Z origin(height)
3. Import the design into fab modules
4. Give the required machine parameters, move the spindle to required position and start milling.
5. Similarly change the end mill to 1/32”, load the cut out file and machine the sides of the board.
6. Once the machining is done, remove the board from the bed.
7. Now you can proceed to solder and stuff your board.

Chapter Five

Fabrication Possibilities



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Chapter Six

3D Scanning

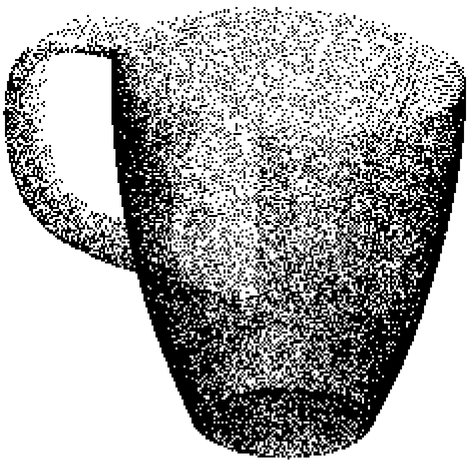
3D scanning is a method of capturing real world data in 3 dimensions. A 3D scanner is a device that analyses a real-world object or environment to collect data on its shape and possibly its appearance . The collected data can then be used to construct a digital three-dimensional models.

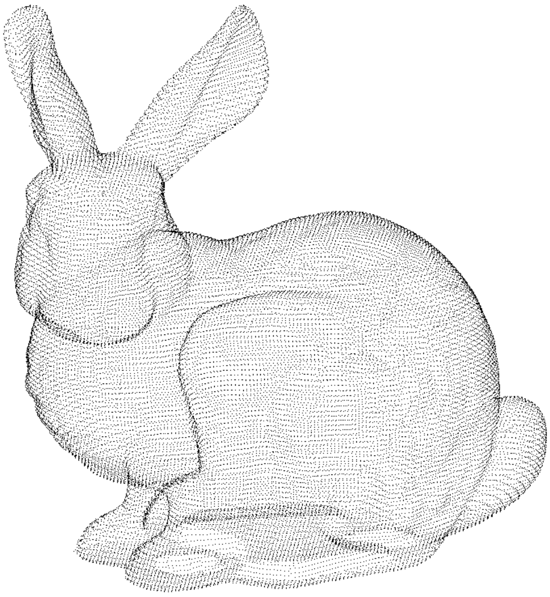
How it Works

A 3D scanner works by generating a point cloud of geometric samples on the surface of the subject. These points can then be used to extrapolate the shape of the subject in a process called reconstruction. If colour information is collected at each point, then the colours on the surface of the subject can also be determined.

3D scanners share several traits with cameras. While a camera collects colour information about surfaces within its field of view, a 3D scanner collects distance information about surfaces within its field of view. The "picture" produced by a 3D scanner describes the distance to a surface at each point in the picture. This allows the three dimensional position of each point in the picture to be identified.

A single scan may not produce a complete model of the subject. Multiple scans are required, from many different directions to obtain information about all sides of the subject. These scans have to be brought into a common reference system, a process called alignment or registration, and then merged to create a complete model. The whole process of going from a single range map to the whole model is known as the 3D scanning pipeline.





Chapter Six

Xbox Kinect

Kinect is a line motion sensing input device developed by Microsoft for the Xbox 360. It uses a system consisting of an infrared projector and camera and a special microchip that generates a grid from which the location of a nearby object in 3 dimensions can be ascertained.

The device features an RGB camera, depth sensor and multi-array microphone running proprietary software, which provide full-body 3D motion capture, facial recognition and voice recognition capabilities.

Workflow of 3D Scanning

1. Install appropriate drivers from Microsoft website.
2. Install a 3D scanning software like Skanet, Kscan3d, Reconstructme.
3. Keep the object stationary and move the sensor or vice versa while scanning.
4. Scan from all angles to increase level of detail.
5. As minimum resolution distance is large maintain some distance to get good results.

Chapter Seven

3D Printing

3D printing is a process of creating a 3-Dimensional object from a 3D CAD model, the process comes under Additive Manufacturing. To get the product, instead of removing material from the bulk, the 3D printer adds material and builds it from the bottom up. The model is built as a series of layers, each deposited on top of the previous one.

The main advantage of 3D printing is that it can handle any complicated shape without any extra machining effort. But the disadvantage being time consumed, with the current technology, 3D printing has not yet reached the speed required for mass production. Hence best suited for rapid prototyping of complicated prototypes in small numbers.

3D Printing Technologies

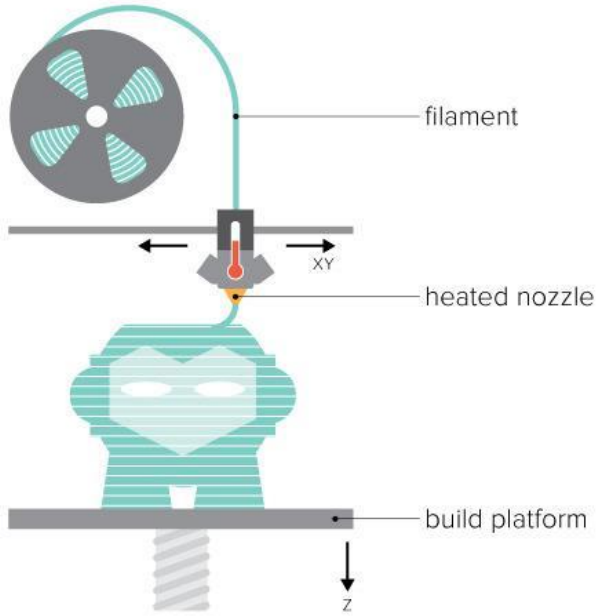
- Fused Deposition Modeling (FDM)
- Stereo lithography and Digital Light Processing (SLA & DLP)
- Selective Laser Sintering (SLS)
- Material Jetting (PolyJet and MultiJet Modeling)
- Binder Jetting
- Metal Printing (Selective Laser Melting and Electron Beam Melting)

How it Works

The model, designed in a CAD program is exported as STL (Stereolithography) and loaded into a slicing software. Slicing is a process of dividing our designs into multiples of horizontal layers. The software slices the 3D model into a series of layers. One common example for slicing software is ‘Cura’, made for the ‘Ultimaker’ 3D printer.

The software converts the model into machine code and sends it to the printer. The printer then heats up the extruder and moves according to the program, depositing material on the work bed and thereby creating the model. This process is repeated until all the layers are printed and the finished model is obtained.

Fused Deposition Modeling (FDM)



In FDM a plastic filament in the form of a coil is fed to the head of the printer, which contain an extruder. The material is heated in the extruder and the deposited on the bed in layers. The head is placed in a CNC arrangement which moves it in the X and Y directions. The bed will move up and down based on the height of the model and acts as the Z axis.

This technology is most widely used with two types of materials: ABS (Acrylonitrile Butadiene Styrene) and PLA (Polylactic acid). FDM is a great choice for quick and low-cost prototyping and can be used for a wide variety of applications.

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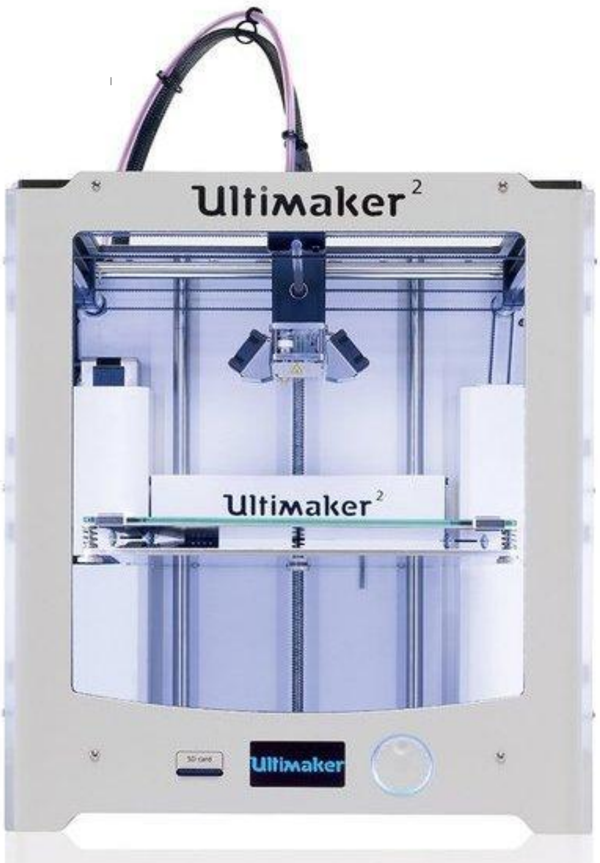
Chapter Seven

Ultimaker 2



Ultimaker 2 is a FDM based 3D printer by Ultimaker. It comes equipped with a heated build platform and can print at a resolution of up to 20 microns. It supports both PLA and ABS and can print at a speed of 300 mm/s. It is having a build volume of 223 mm X 223 mm X 205 mm.

Cura is an open source slicing software developed by Ultimaker along with the community.

Workflow of 3D Printing

Input File : 3D STL model
Material : PLA, ABS

1. Design the 3D model in any CAD software like Solidworks, Rhino, AutoCAD etc.
2. Export the model in .STL (Stereolithography) format.
3. Import the model into CURA, a Slicing software for Ultimaker.
4. Set the printing parameters like layer height, Fill density, Support type etc.
5. Save the file into a removable drive and load it into the printer,.
6. Click Print and choose your file.
7. The printer will warm up and start printing the model.

Chapter Seven

Dimension SST1200es

Dimension is an Industrial grade 3D printer made by the Stratasys which works on the FDM method. It is a ABS plastic based printer. Unlike the Ultimaker this printer can print two types of material at the same time. A model material and a support material.

This is a soluble support type printer that means, the support material after printing can be dissolved away using chemical treatment. Support structures are rigid structures erected in a lattice to act as scaffolding for the actual model.

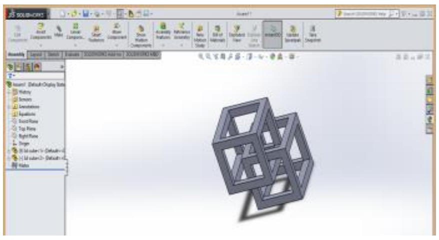
Workflow of 3D Printing

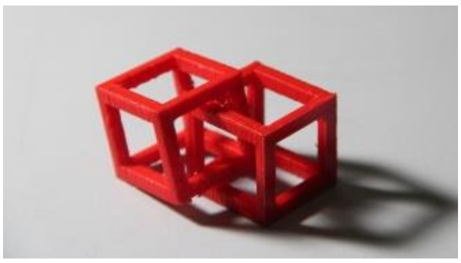
Input File : 3D STL model
Material : ABS

1. Design the 3D model in any CAD software like Solidworks, Rhino, AutoCAD etc.
2. Export the model in .STL(StereoLithography) format.
3. Turn on the printer and let it warm up and calibrate.
4. Import the model into CatalystEX, a slicing software for Dimension.
5. Set the printing parameters like layer height, Fill density, Support type etc.
6. Orient and add models to pack .
7. Click Print and send files to the printer.

Chapter Seven

DIY Example





Making Impossible Cubes

The main advantage of 3D printing is that it can handle any complicated shape without any extra machining effort, This lets us create impossible geometries that are difficult to make using conventional methods. For this example we will make a cube inside a cube.

1. Design the cubes in any CAD software like Solidworks, Rhino, AutoCAD.
2. Export the design as a Stereolithography (**.STL**)
3. Import the file into CURA, and give the Printing parameters like **Layer Height**, **Fill Density**, **Support Type** etc.
4. Save the G-code in a removable drive and load it into the printer.
5. Load the material and clean the bed .
6. Select Print, choose the file.
7. The printer will warm up and start printing once the nozzle and the bed reaches the required temperature.
8. Once the print is done, wait to let the material cool down. And gently remove it from the bed.
9. Gently remove the support material from the model using some nose pliers.
10. Post processing can also be done with chemical treatment (acetone).

Chapter Seven

Fabrication Possibilities

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Chapter Eight

CNC Milling

CNC stands for Computer Numeric Control, it is a process used in the manufacturing sector that involves the use of computers to control machine tools. Here, instead of the operator controlling the machine, the machine follows a set of instructions to move the gantry and make the desired shape. A popular way of giving instructions to the machine is by using G-code. The various movements of the machine for creating a part are programmed in code and fed into the controller, which moves the machine. Some common CNC machines include lathes, mills, routers and grinders.

The process involves creating a CAD (Computer Aided Design) file of the desired object. Then a specialized CAM (computer aided Manufacturing) software is required to convert the 3D CAD file into a set of codes which the machines can understand. this G-code controls all machine parameters like feed rate, depth, location and speeds. With CNC machining, the computer can control exact positioning and velocity.

How it Works

The 2D sketch after designing, needs to be exported in DXF format. The file is then imported into a CAM software (Vcarve Pro) which provides all the necessary features for converting the sketches into machine paths. While giving the machine parameters care must be taken to account for the type of material, the end mill chosen and the condition of the machine.

The CAM software generates the G-code, which will be fed to the shopbot control software for milling the design. Once the material is prepped and the endmill secured, set the origins for all 3- Axes, and begin milling.

Warning!

- **CNC milling is hazardous, never stand close to the machine while its operational.**
- **End mill spinning at such high velocity has possibility of ejecting wooden shards and hot debris.**
- **Always wear eye protection.**
- **Never reach into the machine while operating.**
- **Always secure the work piece and tool properly to avoid damage.**
- **Never leave the machine running unattended.**

Chapter Eight

Shopbot PRSalpha

ShopBot PRSalpha are the toughest, most sophisticated, gantry-based CNC routers. Using advanced technology for CNC cutting, drilling, carving and machining, the PRSalpha series tools deliver rapid transit speeds of 1800 inches per minute and cutting speeds of up to 600 inches per minute. Its easy to configure and use.

The PRSalpha CNC delivers full production performance in digital fabrication of wood, plastic, aluminum, and other materials. The PRSalpha has a bed size of 8x4 feet.

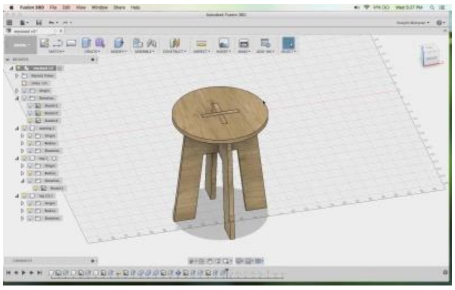
Workflow of CNC Milling

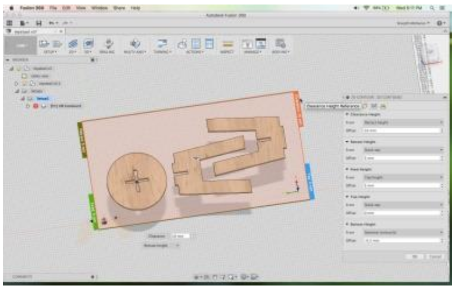
Input File : 2D DXF sketch, 3D STL model
Material : Wood, Plastics

1. Design the 2D, 3D model in any CAD software like Solidworks, AutoCAD etc.
2. Export the 2D model in DXF and 3D model in STL format.
3. Import the design into Vcarve pro, set the machine parameters and export as SBP file.
4. Prep the material by securely attaching it to the bed using screws and clamps.
5. Securely attach the end mill to the spindle.
6. Set the Z-origin by using the contact plate. Set the X,Y origin to a suitable place on the material.
7. Load the SBP file into Shopbot software interface.
8. Turn on the spindle and start cutting.

Chapter Eight

DIY Example





Making a simple Chair

For this example, we’ll be making a simple chair. The designs are created in such a way that the parts press-fit together. Press-fit assemblies can be created by making the hole smaller than the part, thereby the parts will be held tight. This type of construction is also easy to dismantle and transport.

1. Design the chair in any CAD software like Solidworks, Rhino, AutoCAD. The chair is designed as a 2D press-fit model.
2. Export the 2D design in DXF format.
3. Import the design into Vcarvepro or any CAM software.
4. Select the tool paths and give the machine parameters. Pay close attention to Feed, Speed, and Depth of cut. These are the main parameters which influence the cut.
5. When giving machine parameters always work from inside out, and smaller to larger.
6. Select all toolpaths and save them as a .SBP format.
7. Prep the machine, by attaching the proper end mill, and fix the material firmly onto the bed with screws.
8. Move the shopbot spindle using the control panel and set the origin on 3-Axes.
9. Load the SBP file, and start cutting.

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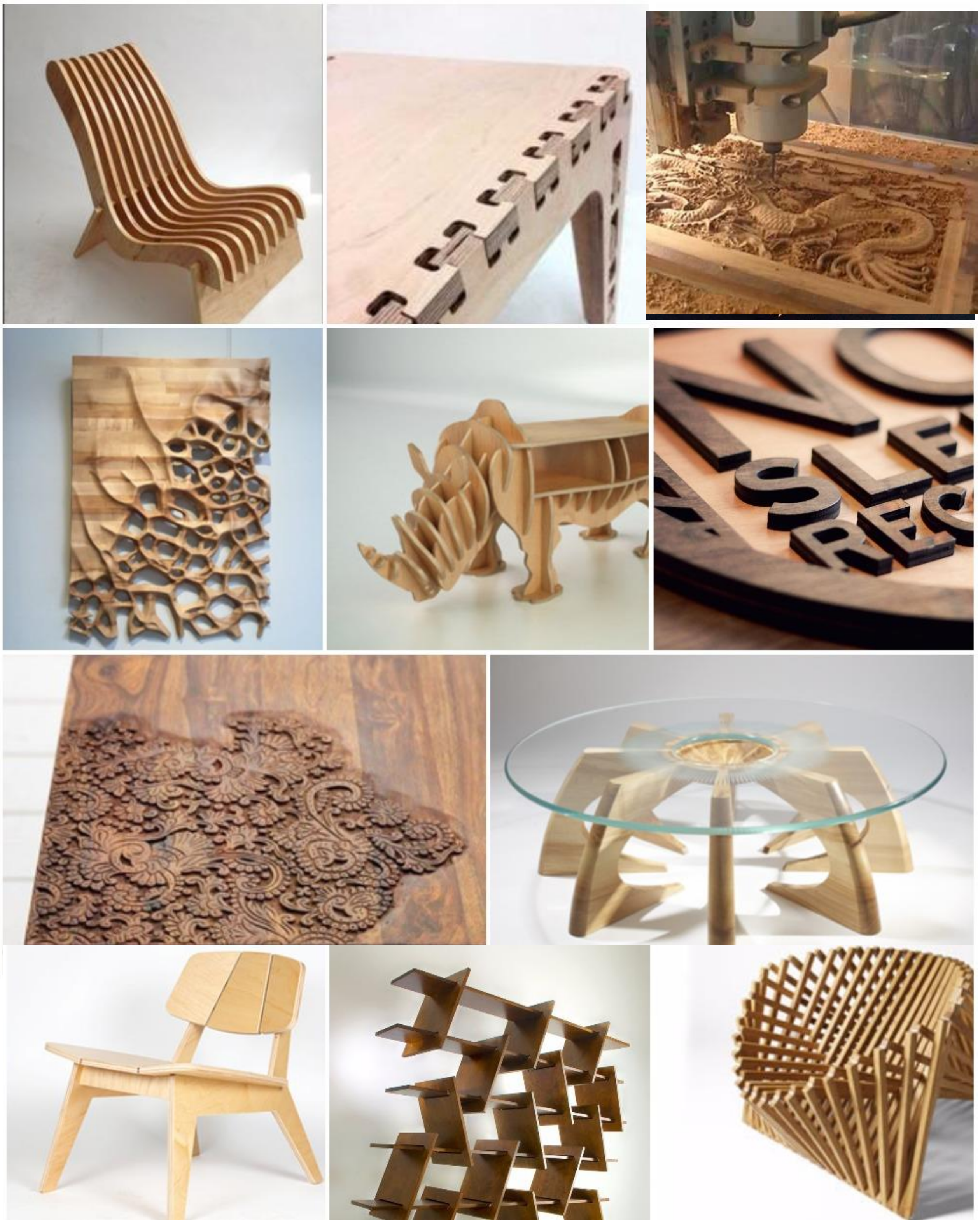
Fabrication Possibilities



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Epilogue

Thinking back, fab academy has been an awesome adventure, I got to learn a lot about many things, but more than that, the fundamental change that happened to me was my change in perspective.

I shifted from a consumer of technology to a maker of some. I no longer look at things as they are, but as what they can be, constantly thinking of ways to improve the ordinary things I use everyday. This is my life lesson from Fab Academy.

There have been many awesome moments during the course of my Fab Journey. But the one thing that always gets me is the feeling I get when I make something new. All the effort of designing, fabricating, and troubleshooting is worth it when you see the final result of your hard work.

The moment of creation, when everything works and you sit back in your chair and enjoy what you made. A truly unrivaled feeling.

It’s not the result that matters, but the journey you took to get there. I faced a lot of problems and have spent more time troubleshooting than fabricating. But through it all, I have gotten a deeper understanding of the problem I'm working on. As they say, smooth seas never made a skillful sailor.

I owe a lot to my friends who helped me through the difficult times, it is because of them that I was able to work through all the difficulties. This is one of things I like about the Fab Network, we are a collection of like minded people, working together to bring a change to the world.

See my journey at **bit.ly/rahulsarchive**

RAHUL S RAJAN

PROFILE

Rahul has completed his Fabacademy in 2017. A course which he credits to giving him the skills to make almost anything. He believes in the power of personal fabrication and the revolution it will bring.

A mechanical engineer by trade and a maker by heart. He is curious about technology and is ready to lead the resistance when the machines rise up.

Photography, Psychology, Astronomy, and Aviation are among his interests and longs for the day men can take to the skies at their own will.

An avid reader and star gazer he is fascinated by the cosmos, and hates writing in third person. Find more about him at www.rahulsrajan.com

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A BEGINNER'S GUIDE TO FAB LAB

RAHUL S RAJAN