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Media Factory

Digital_Fabrication_Studio.06

CNC milling - materials, finishes, process

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<http://www.slideshare.net/openp2pdesign>



11.10.2012



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Today:

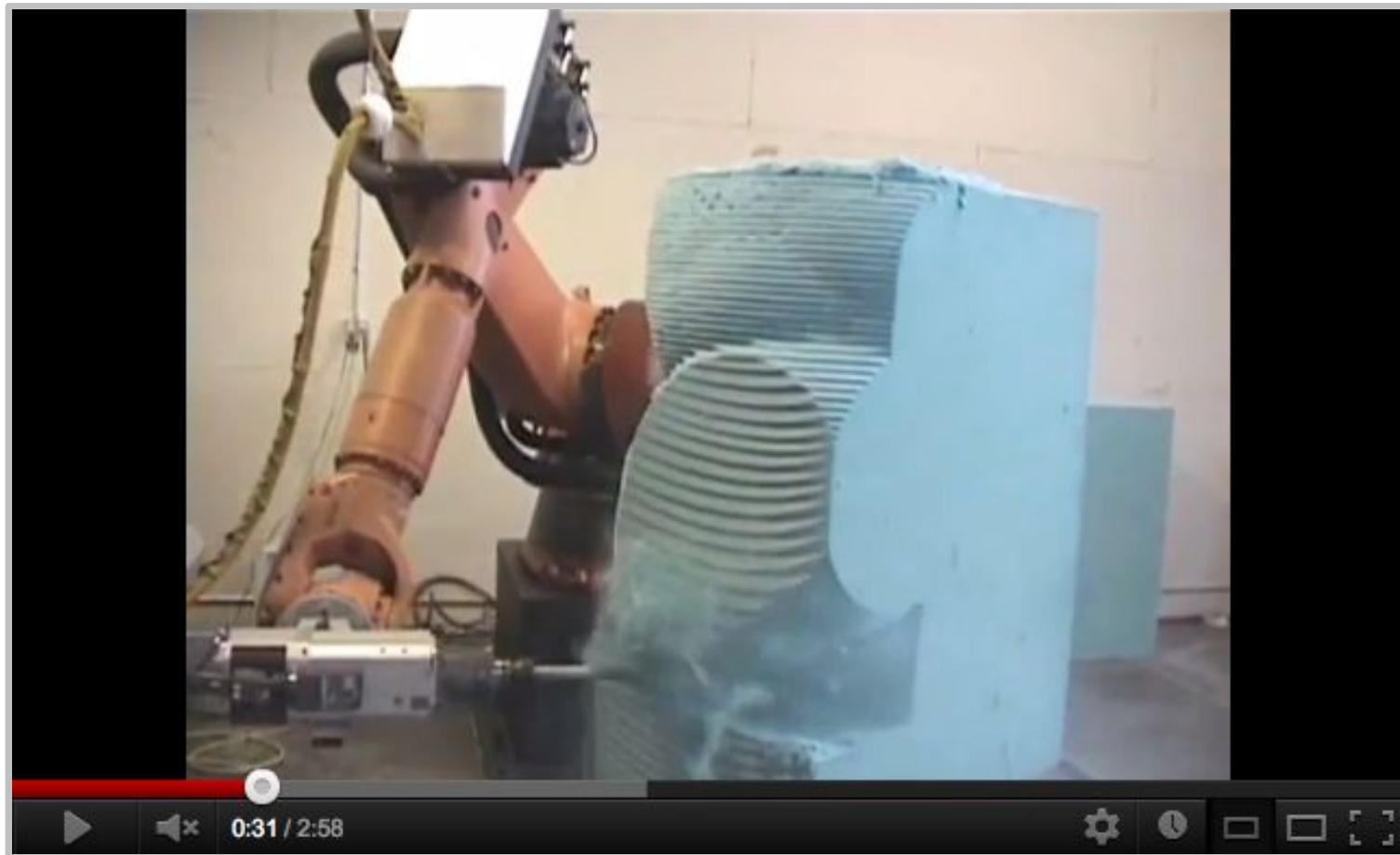
- * CNC Milling
- * CNC, but not only Milling
- * Examples
- * Design techniques



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01. CNC Milling: computer controlled sculptures

CNC milling



Sculpting (subtracting) from a block of
(almost) any material.

Source: <http://youtu.be/j4akxGjTbOs>

CNC routing



Routing = different technology, different speed and resistance (more suitable for wood than metal).

CNC milling: 2D, 2.5D or 3D ?



2D or 2-axis (only X and Y), 2.5D or 2-axis (X,Y, and up/down position), 3D or 3-axis (X,Y,Z).

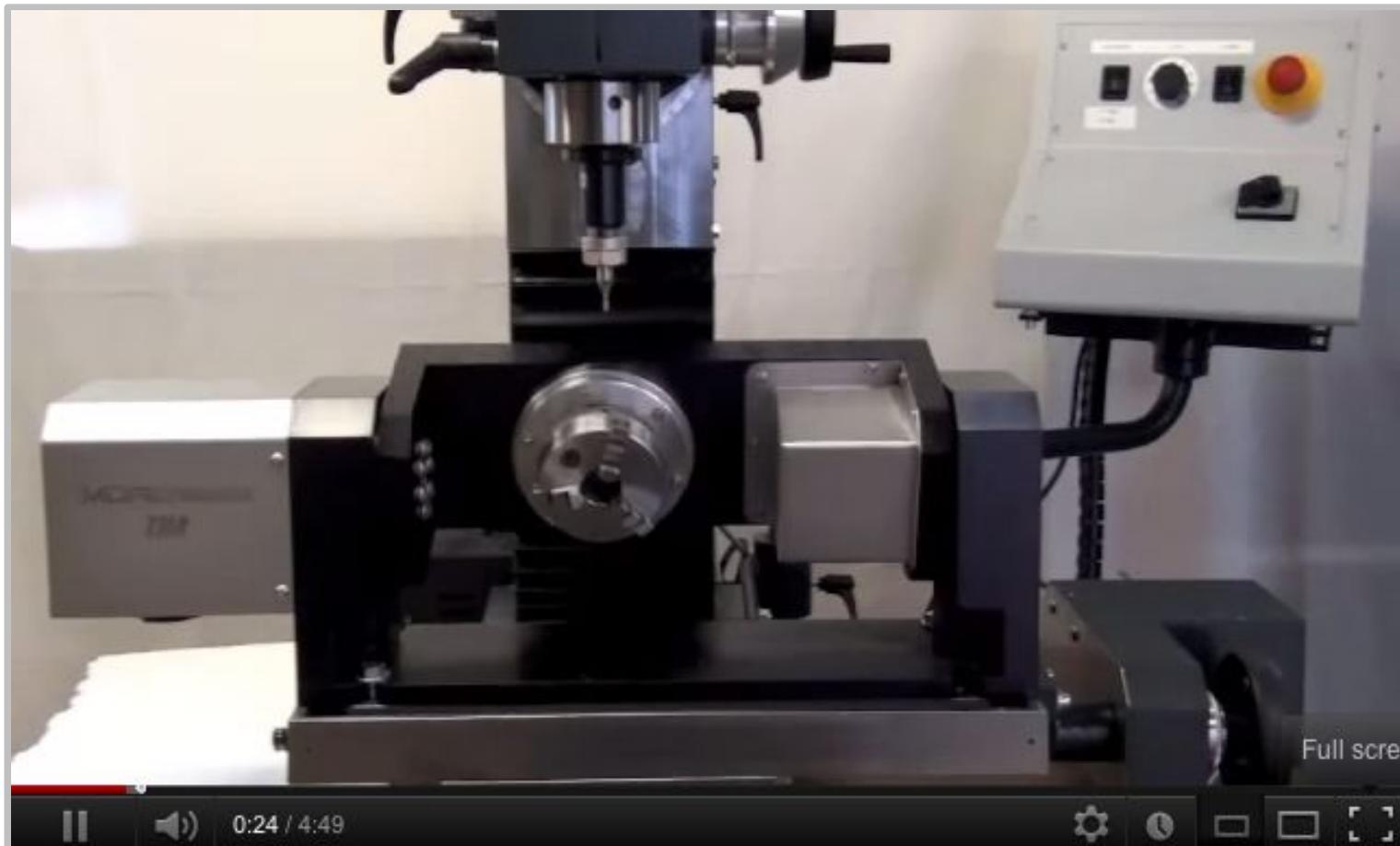
CNC milling: 4-axis



An example: Roland MDX-540 (but there's also a desktop version, the MDX-40A).

Source: http://youtu.be/ZuXF_Y97j2M
<http://www.rolanddga.com/products/milling/mdx540/>

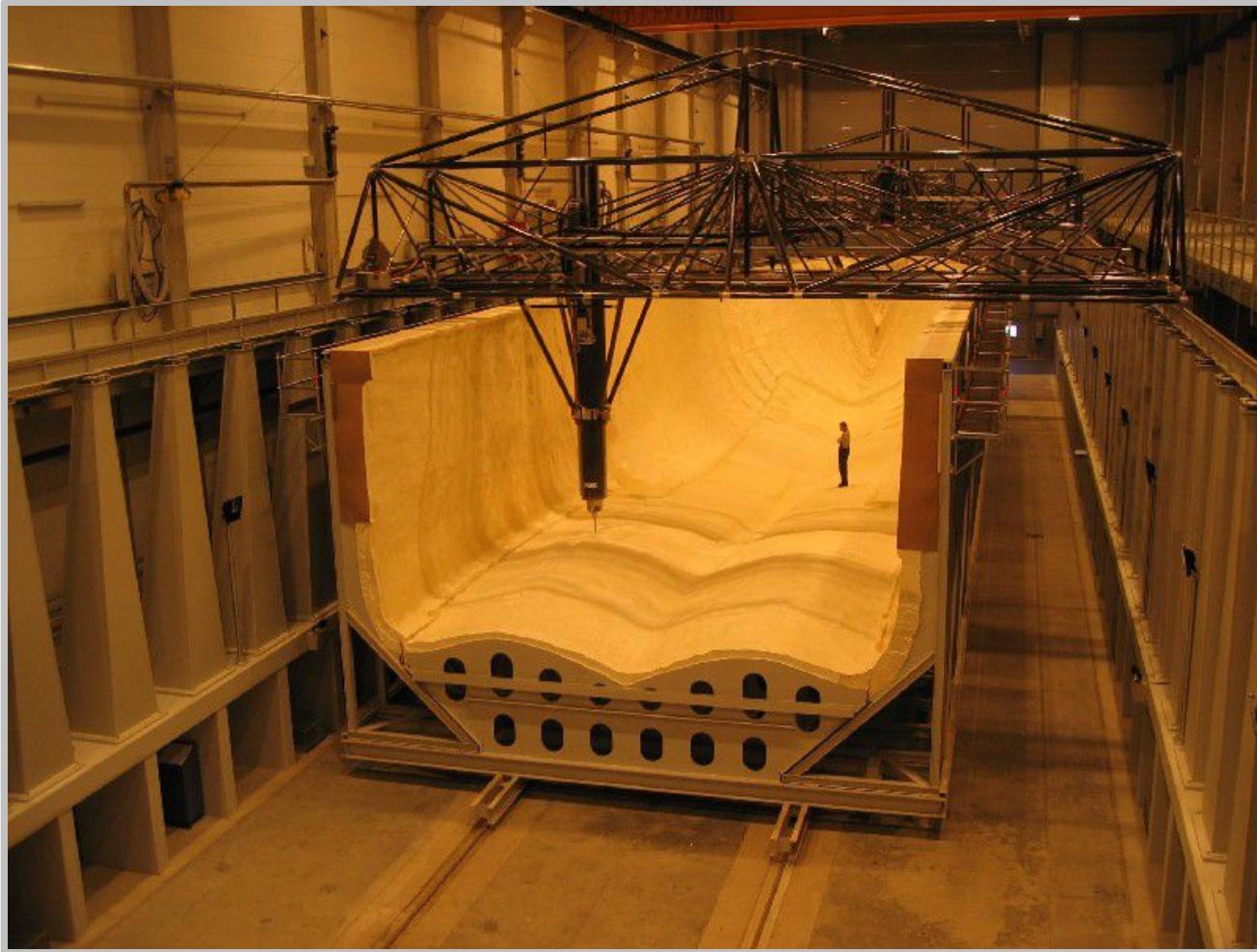
CNC milling: 5-axis



An example: TN5, a 5-Axis Milling Machine.

Source: <http://youtu.be/vark2IBMGr0> <http://www.mdaprecision.com/>
<http://www.fiveaxismachining.com/index.php/why-5-axis/> <http://www.shopbottools.com/mProducts/5axis.htm>

CNC milling: big size!



Meet HSM-Modal. This modular and customizable milling machine can expand into a 12.5m wide, 4m tall, and 150m long giant.

Source: <http://www.wired.com/design/2012/06/cnc-mill-that-will-build-a-house/>

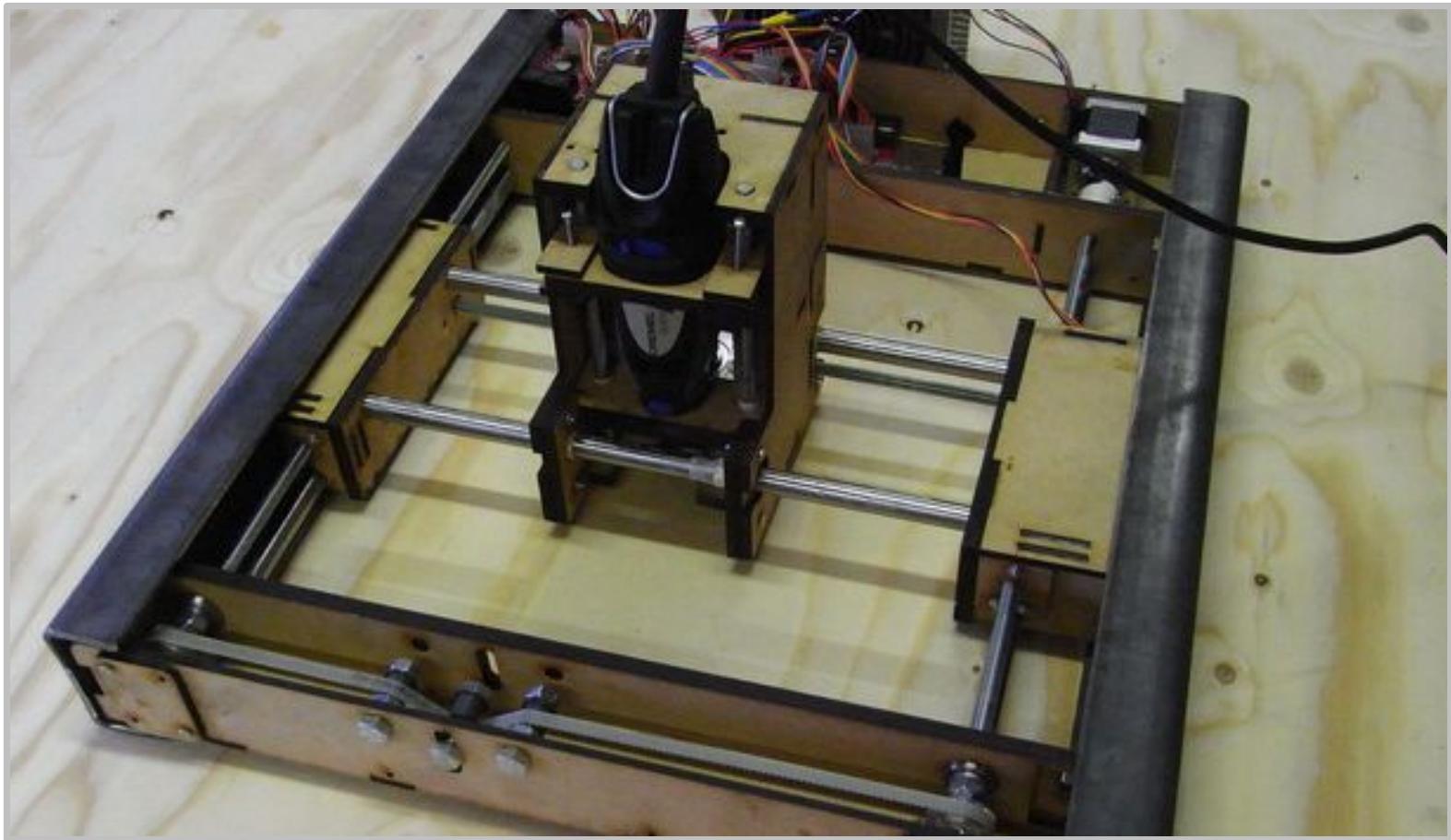
Roland iModela: small, low-cost CNC milling



The iModela is a low-cost, easy-to-use desktop device that mills wax, foam, balsa wood and plastic materials. Max operation area: 86 x 55 x 26 mm

Source: <http://icreate.rolanddg.com/iModela/Global/English/about/index.html/>

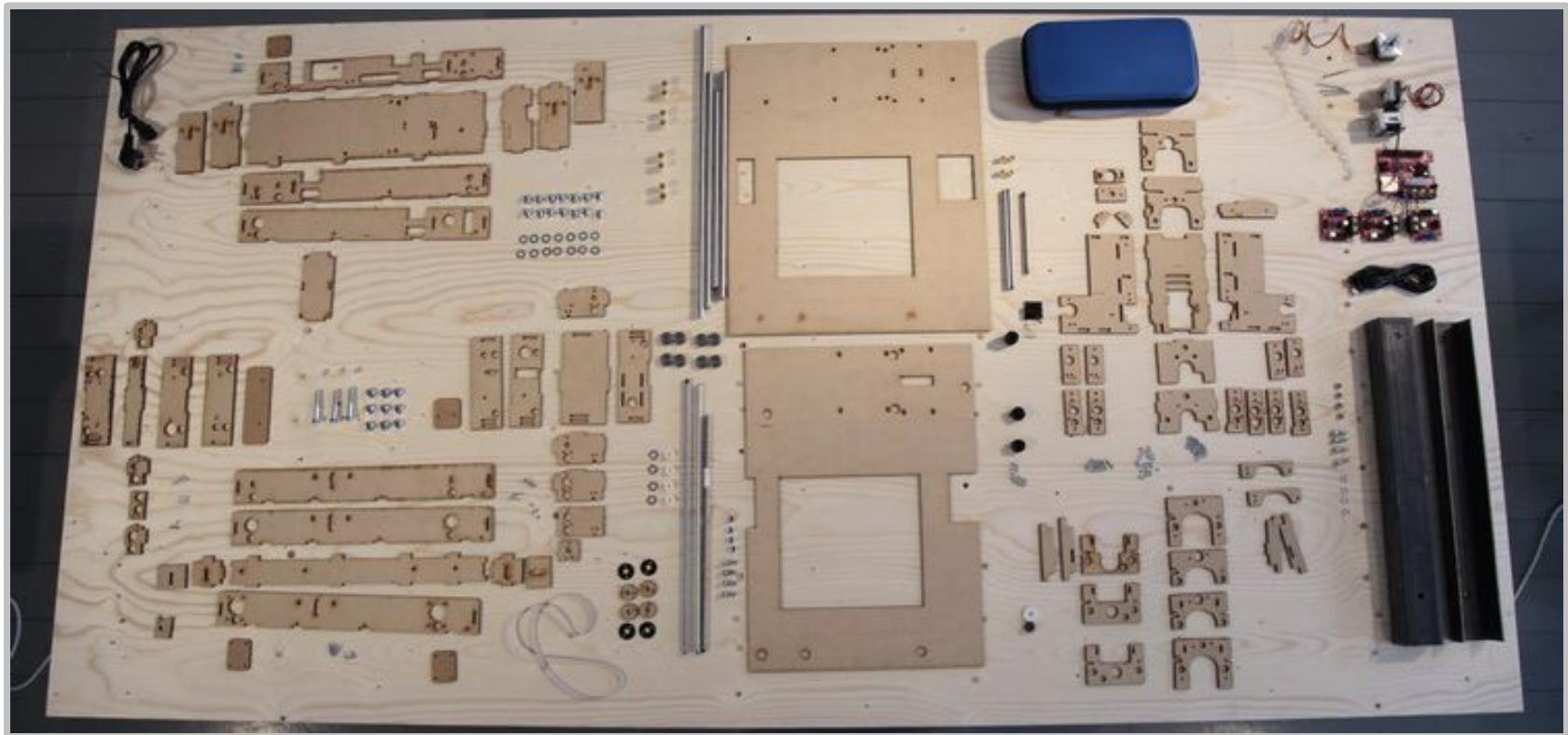
MiniCNC: Open Source CNC milling



A desktop-size, open-source milling machine in kitform, built from lasercut parts: a computer-controlled Dremel with a 20 by 20 cm work surface.

Source: <http://www.repairablemachines.com/>

MiniCNC: Open Source CNC milling



A desktop-size, open-source milling machine in kitform, built from lasercut parts: a computer-controlled Dremel with a 20 by 20 cm work surface.

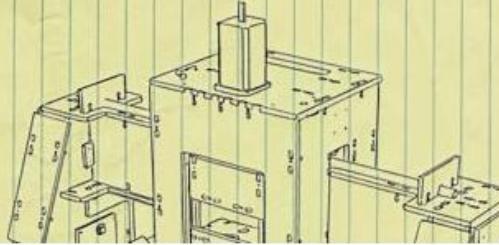
Source: <http://www.repairablemachines.com/>

DIYLILCNC: Open Source CNC

DIYLILCNC

vers. 1.0.2

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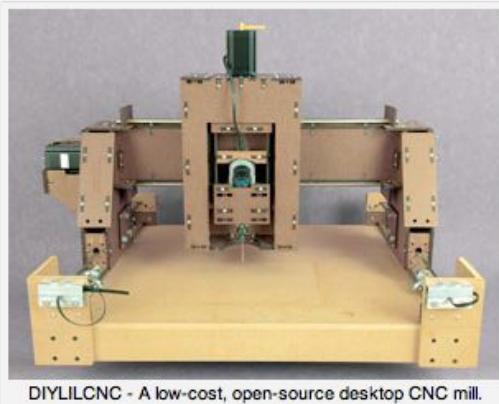


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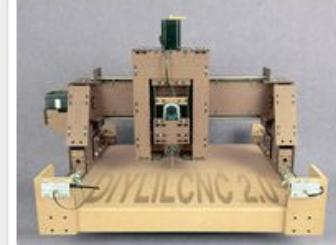
The DIYLILCNC project is a free & open-source set of plans for an inexpensive, fully functional 3-axis CNC mill that can be built by an individual with basic shop skills and tool access.

CNC devices are used to fabricate physical objects with a high degree of precision. Some CNC devices, including the DIYLILCNC, feature a gantry-mounted cutting tool (like a router) that can move in two or more directions. The operation of the tool is controlled by a computer, which is tasked with translating a digital design into actual tool movement.



DIYLILCNC - A low-cost, open-source desktop CNC mill.

Kickstart v2.0!



DIYLILCNC 2.0 - Open-source plans for a low-cost CNC mill.
by DIYLILCNC
We're preparing to release version 2.0 of our free, open-source plans for a robotic cutting machine that you can build yourself.

A free & open-source set of plans for an inexpensive, fully functional 3-axis CNC mill that can be built with basic shop skills and tool access.

Source: <http://diylilcnc.org/>

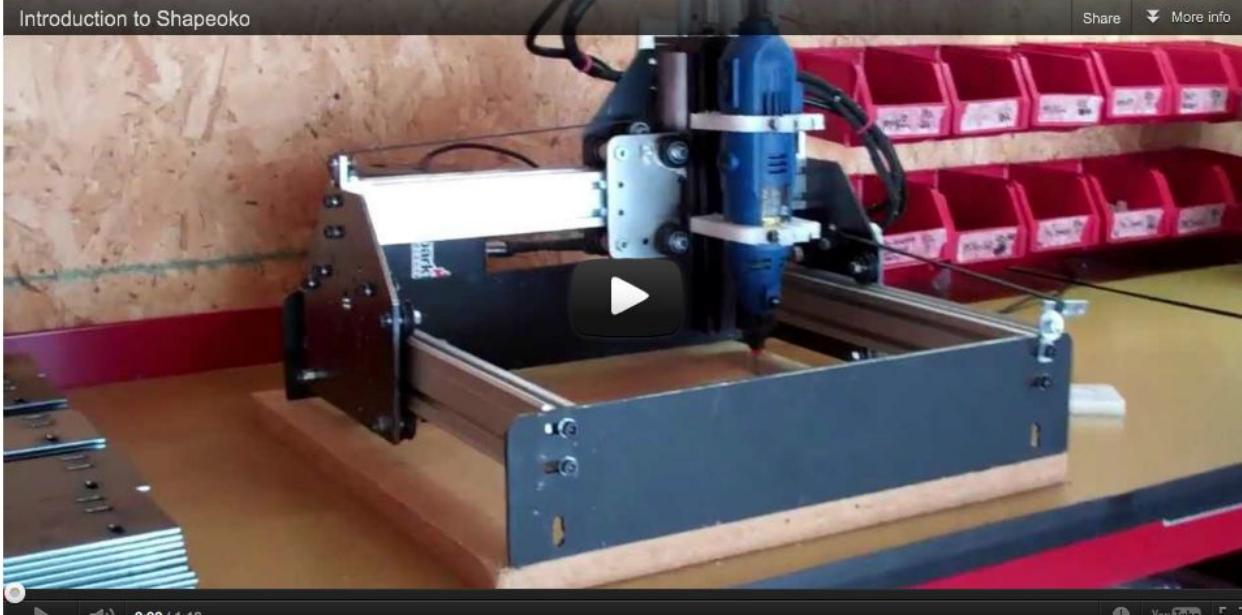
Shapeoko: Open Source CNC

shapeoko

Home Blog Purchase Downloads Wiki Forum About

Shapeoko is now available through [inventables.com!](#)

Introduction to Shapeoko



Share More info

0:00 / 1:16

YouTube

An open source CNC milling machine that was over 700% funded on Kickstarter and that it is now also available on Inventables.com.

Source: <http://www.shapeoko.com/>

3 Axis CNC router built from Lego



Arthur Sacek has created a 3D CNC router built entirely from Lego Mindstorm robotics components.

Source: <http://blog.ponoko.com/2011/08/21/3-axis-cnc-router-built-from-lego/>
<http://youtu.be/pX1c02XhMrg>

Hexapod Robot CNC Router



A walking CNC router built using B.F.Hexapod with an additional floating pen attachment, and a utility to convert DXF files into commands.

Source: <http://youtu.be/quN37YskoaM?t=1m18s>
<http://blog.ponoko.com/2008/11/11/articulated-cnc-robots-are-kind-a-scary/>

And in our lab: Roland Modela MDX-20 (3 axis)

Imagine.

Roland®

Applications Gallery About Accessories Support Store Find a Dealer en Español

Inkjet Printers + Printer/Cutters Vinyl Cutters + Print Trimmers Rotary Engravers + Impact Printers Benchtop Mills + 3D Scanners

COMBO 3D SCANNING & MILLING



MDX-15 & MDX-20 Portable Milling Machine and Scanner

Overview Features Specifications Accessories Brochure Technical Support

These small milling machines, capable of scanning and milling, are ideal for a variety of product design tasks, including reverse modeling, rapid prototyping, jewelry and model making, and small lot production.



Brochure

 Free brochure available in print or download form.

 Choosing The Right RP System. Free brochure available in print or download form.

Download Prototyping White Paper

Max operation area:
203.2 mm (X) x 152.4 mm (Y) x 60.5 mm (Z)

Source: <http://www.rolanddga.com/products/scanners/mdx15/>

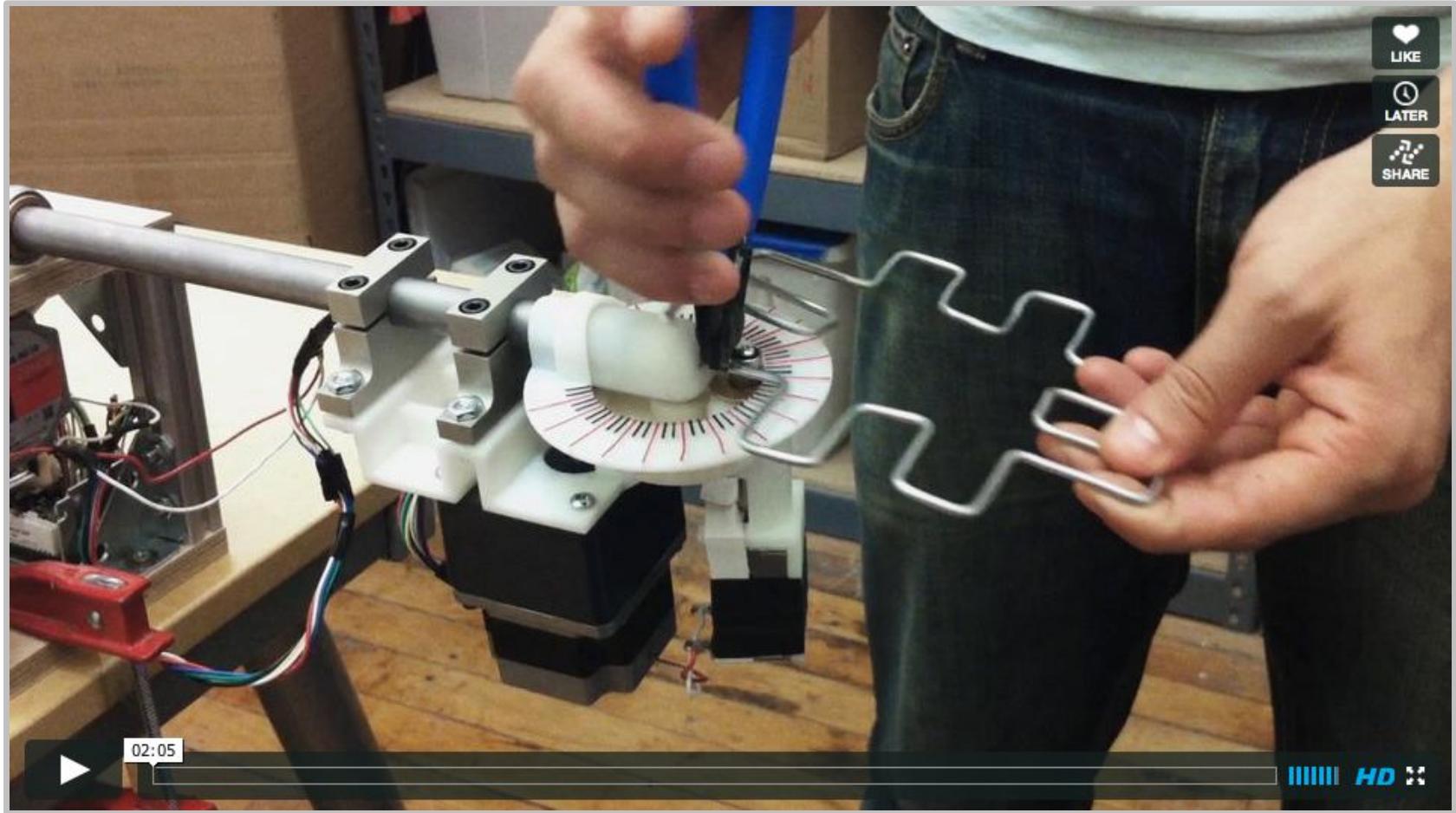


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02.

CNC, but not only Milling: other computer controlled tools

DIWire Bender



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The DIWire Bender is a rapid prototype machine that bends metal wire to produce 2D or 3D shapes.

Source: <http://blog.pensanyc.com/tagged/DIWire>
<https://vimeo.com/41425580>

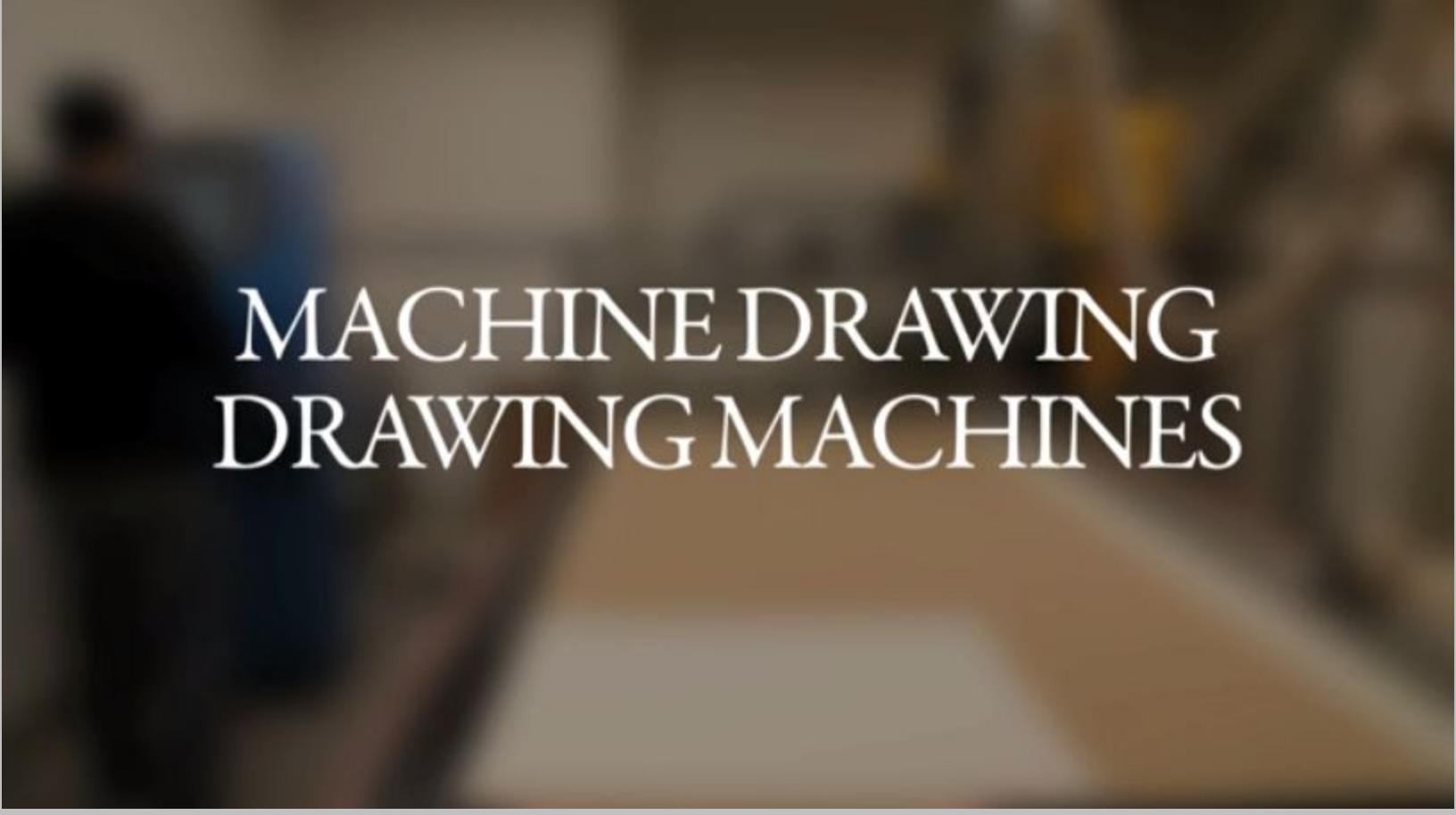
CNC milling the music



Tomorrow we will test
the actual milling of the blanks.

Valse Automatique is a design performance made by translating music to form over the use of a kuka industrial robot.

CNC milling drawing



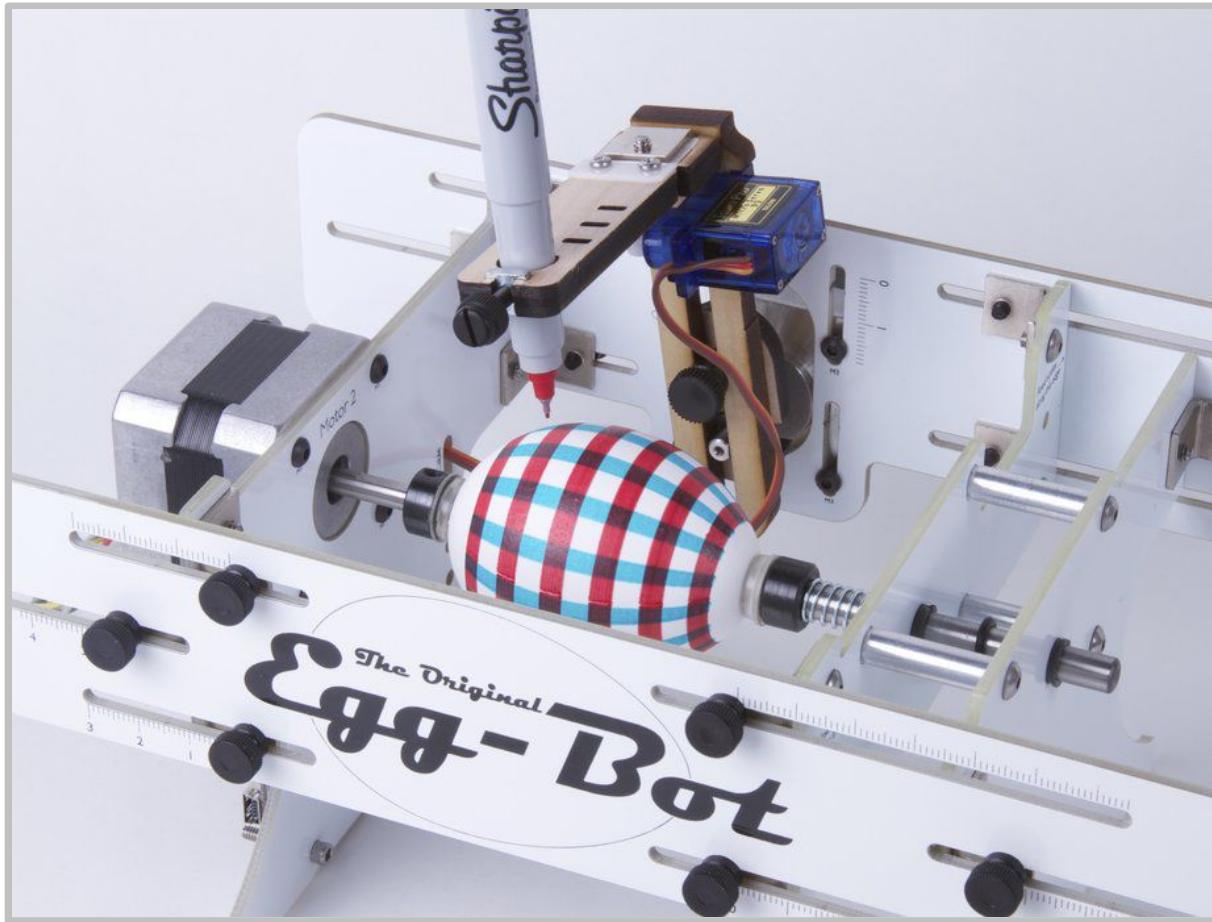
MACHINE DRAWING
DRAWING MACHINES

In which twelve drawings of historical drawing machines are drawn by a computer numerical controlled machine.

Source: <https://vimeo.com/39951217>

<http://www.designboom.com/weblog/cat/10/view/20427/cnc-historical-drawing-machine.html>

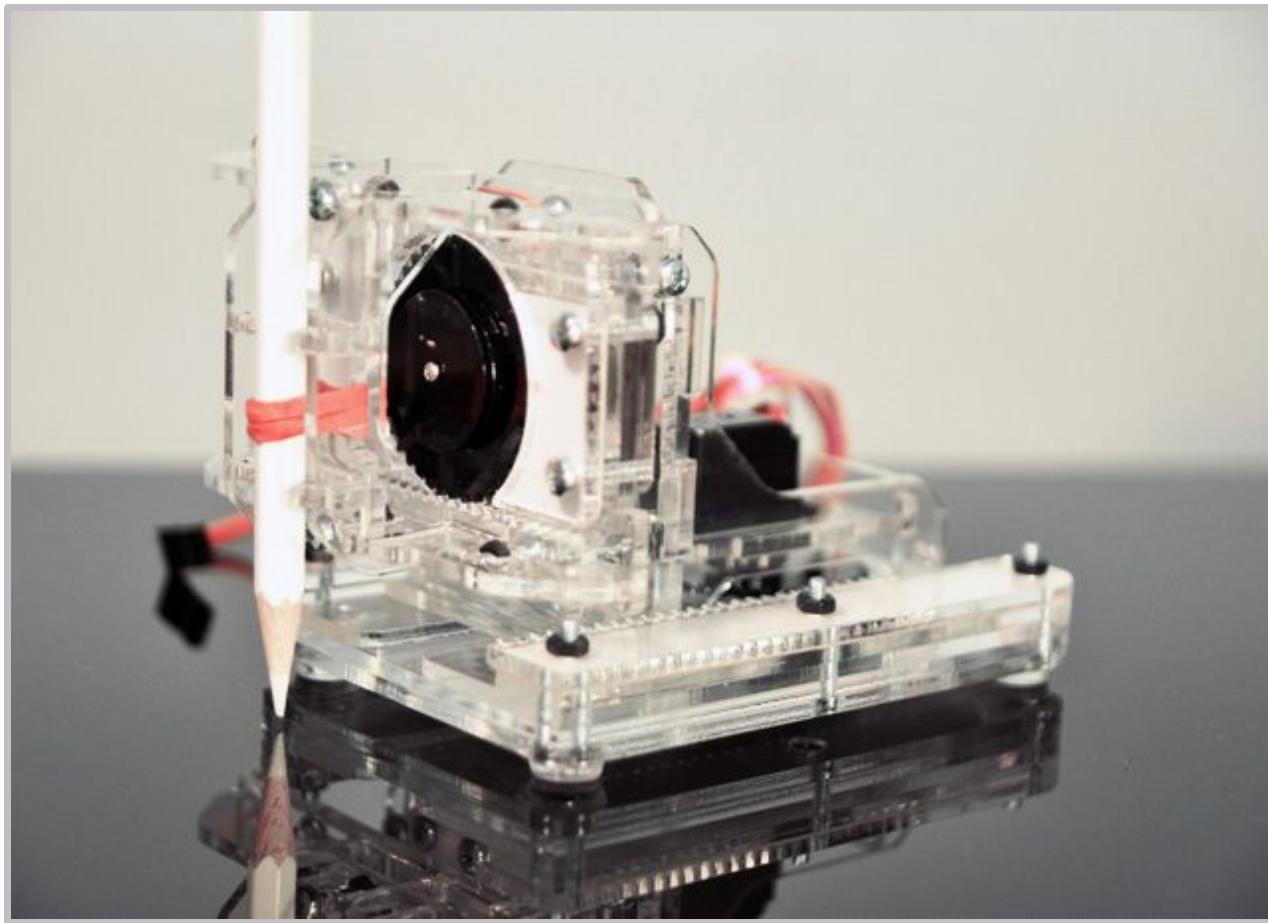
Egg-bot



“My experience, perception and digital information (bits) shape this exact material and its values (atoms)”

Source: <http://evilmadscience.com/productsmenu/tinykitlist/171-egg-bot>
<http://egg-bot.com/>

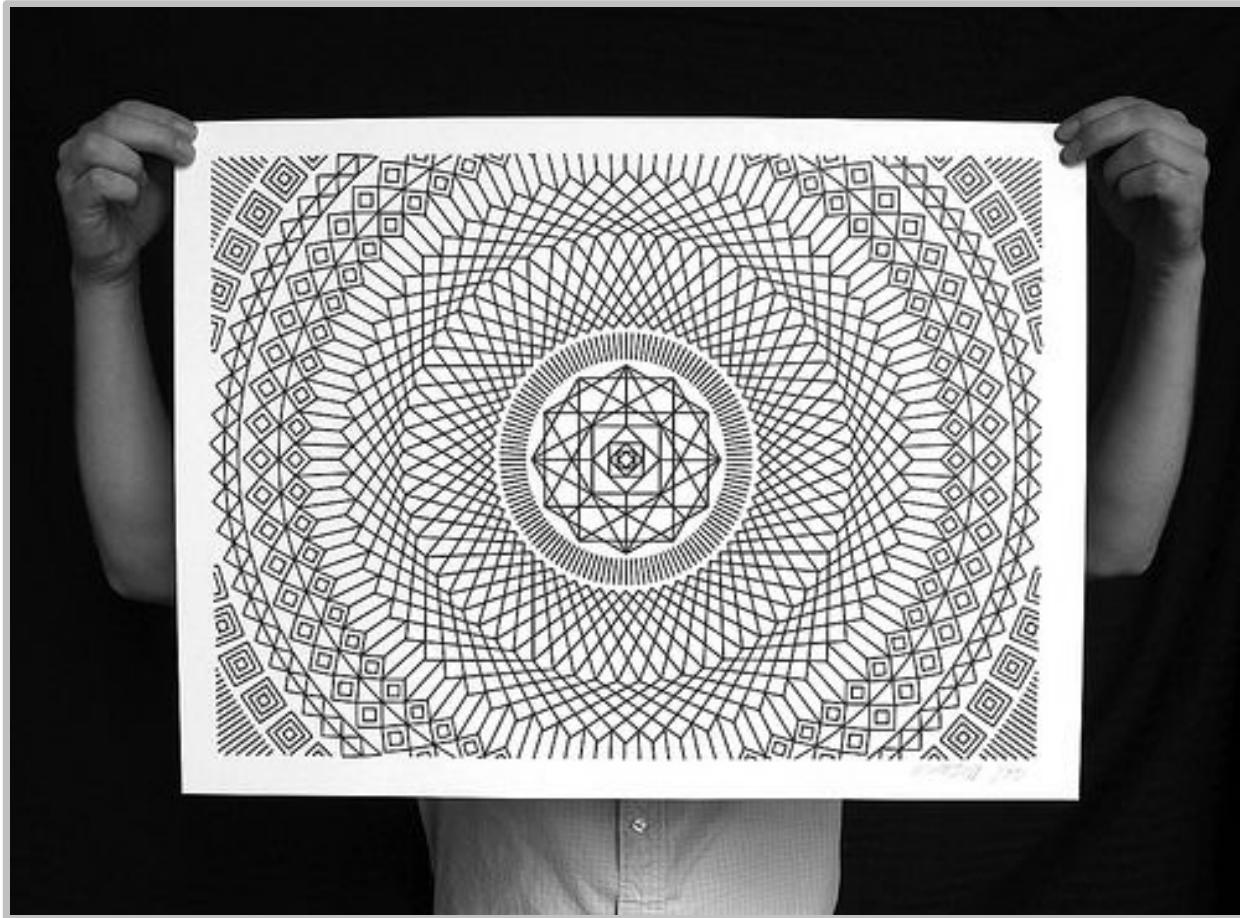
Piccolo



“My experience, perception and digital information
(bits) shape this exact material and its values (atoms)”

Source: <http://diatom.cc/piccolo>
<https://vimeo.com/36869769>

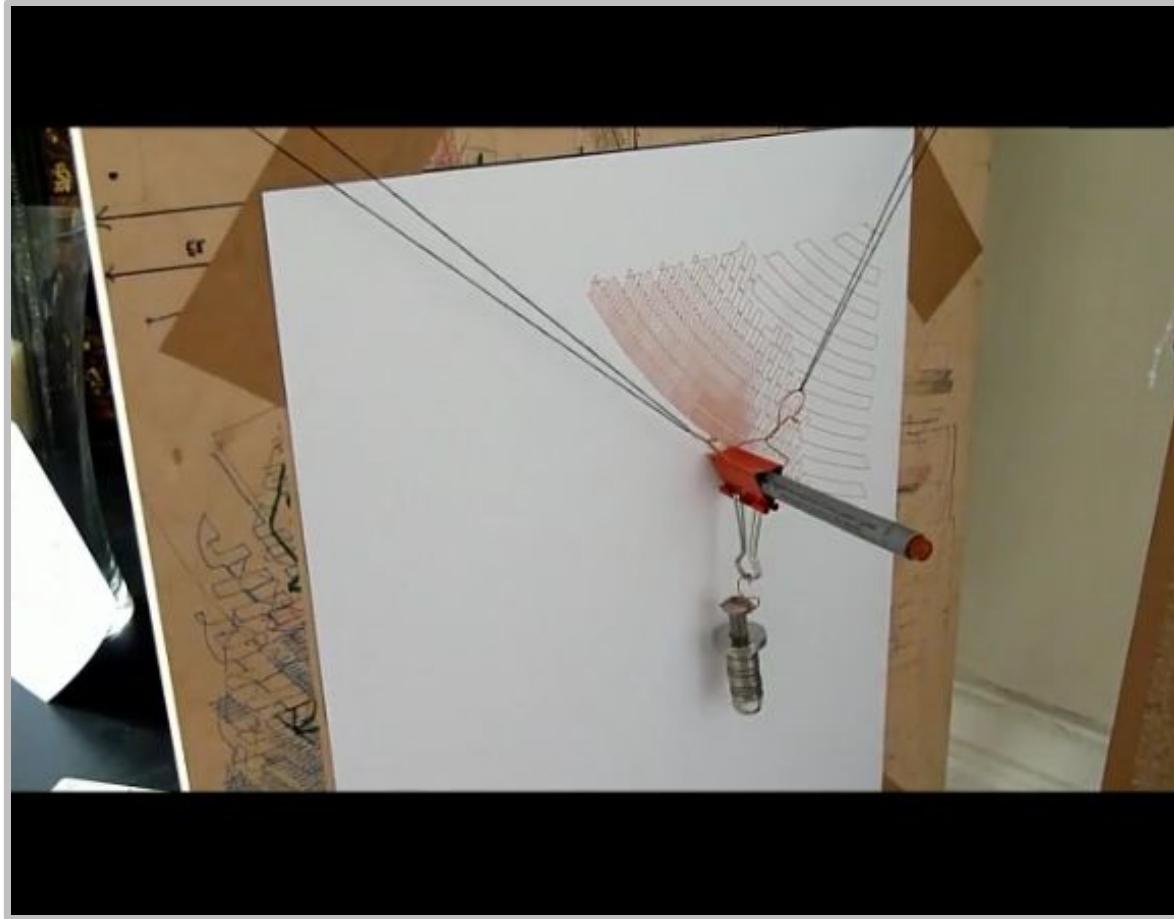
MWM graphics/aarn: CNC drawing series



3-axis CNC machine retrofitted with a special fixture - which holds a marker and mimics typical hand pressure during the act of drawing.

Source: <http://44rn.com/post/7774864814/numericallycontrolledseries>

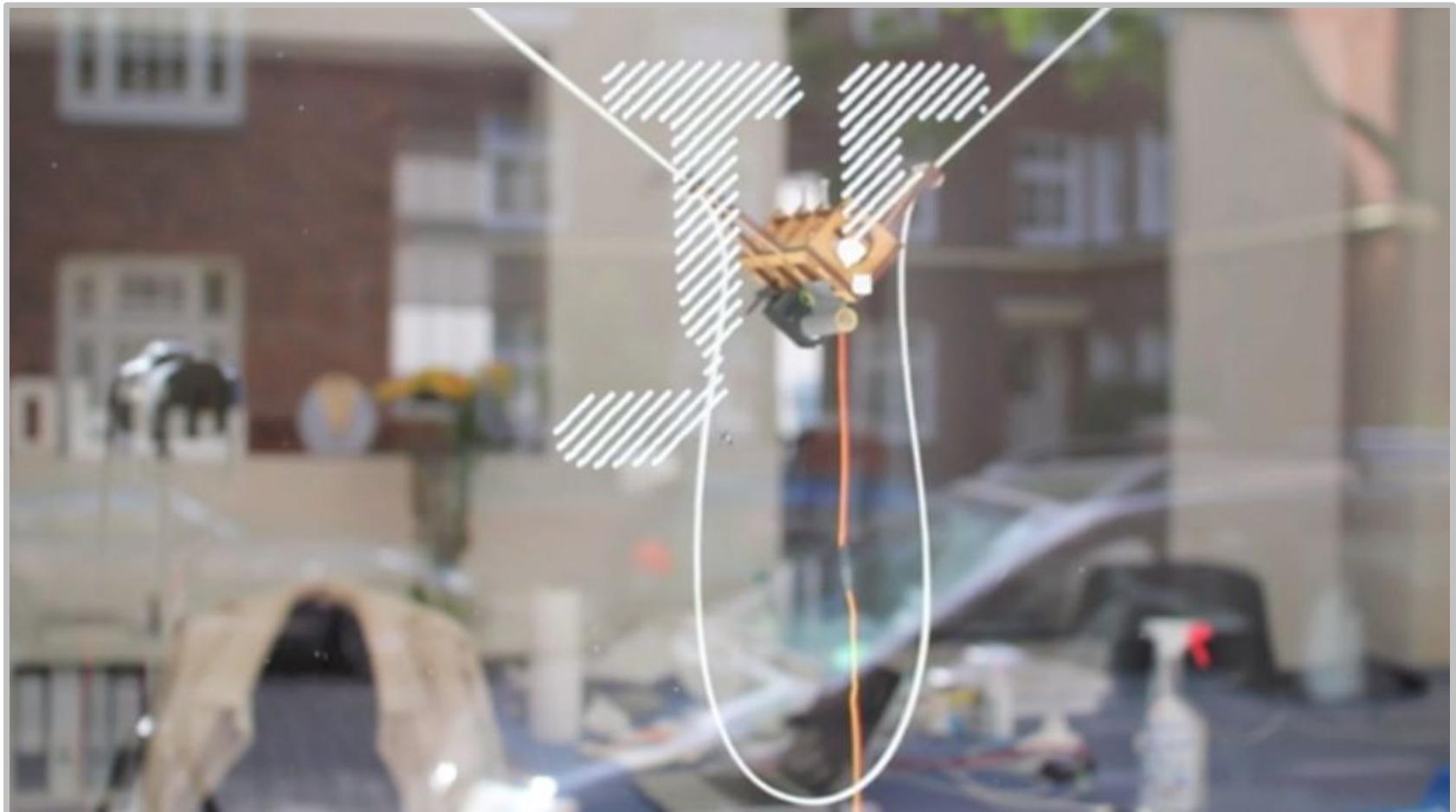
Polargraph Drawing Machine



Sandy Nobel's Polargraph uses a dual-polar coordinate system instead of the standard cartesian.

Source: <http://blog.makezine.com/2011/09/27/polargraph-drawing-machine/>
<https://vimeo.com/24647023> <http://www.instructables.com/id/Polargraph-Drawing-Machine/>

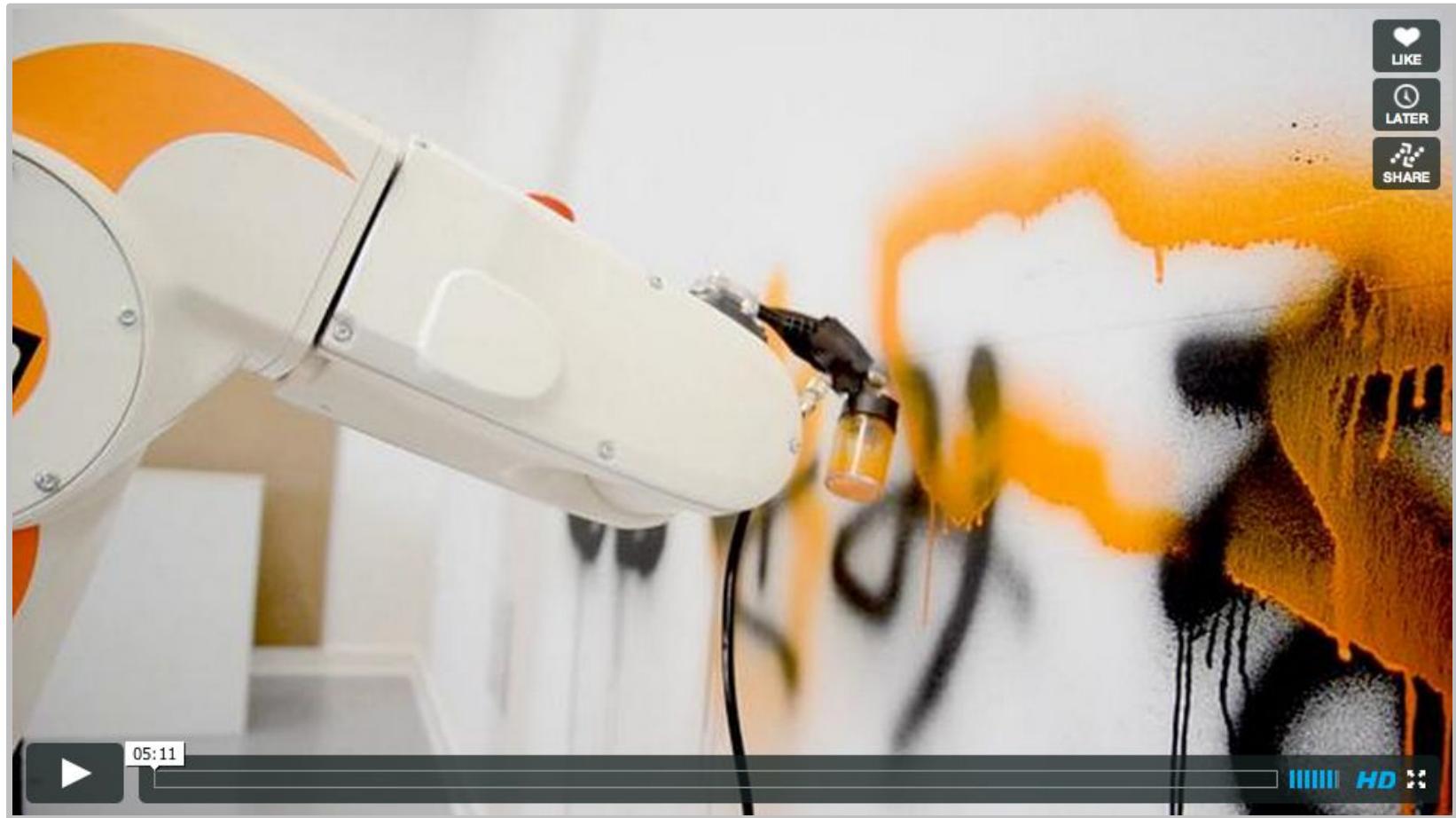
Der Kritzler Drawing Machine



2D scribbling machine, drawing directly on a window.

Source: <http://tinkerlog.com/2011/09/02/der-kritzler/>
<https://vimeo.com/28003302>

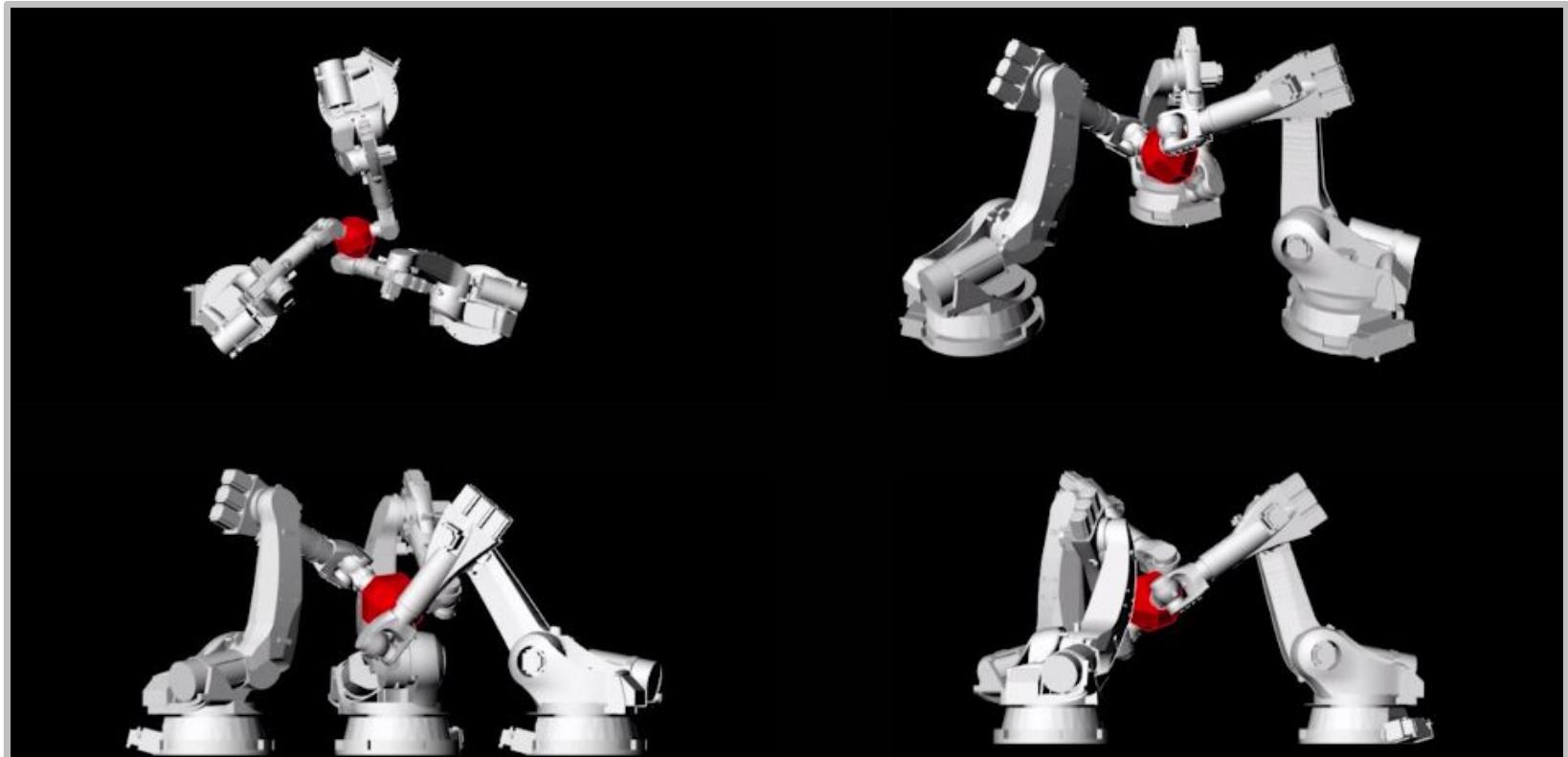
Robot Masterclass



Using an Arduino board, the KUKA robot interfaced with the spraygun, allowing designs that consist of multiple strokes.

Source: <https://vimeo.com/30506602>
<http://www.robotsinarchitecture.org/>

And a plugin for Grasshopper



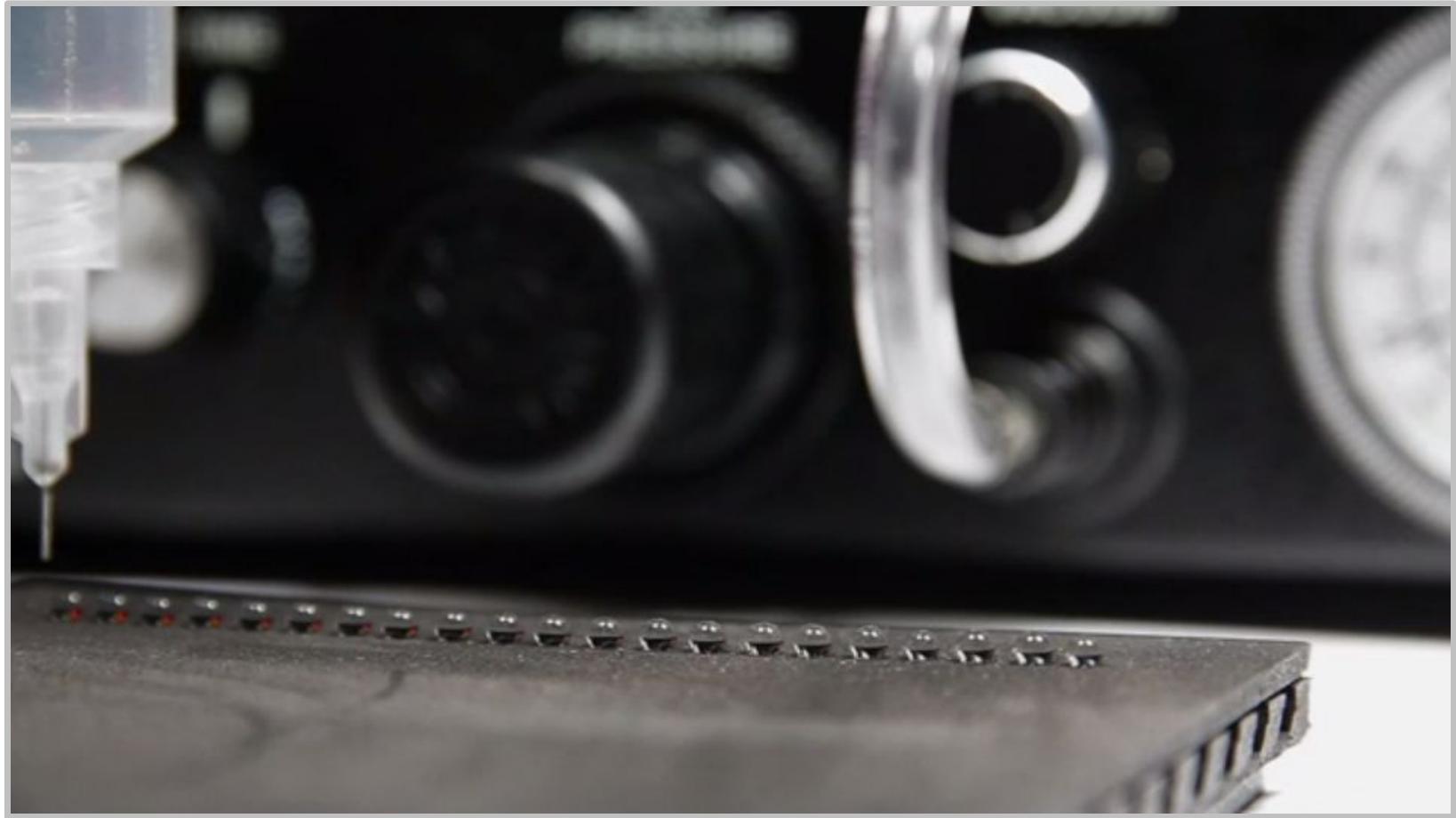
Multiple robot simulation

Simulate multiple robots by locking each kinematic component after setting it up

KUKA|prc enables you to program industrial robots directly out of the parametric modelling environment, including a full kinematic simulation of the robot.

Source: <http://www.robotsinarchitecture.org/kuka-prc>
<https://vimeo.com/37480161>

Positioning systems I - falling objects



A custom made machine that adds drops of water onto a special textured surface. Each drop forms into an almost perfect sphere through the surface tension.

Source: <https://vimeo.com/24491037>



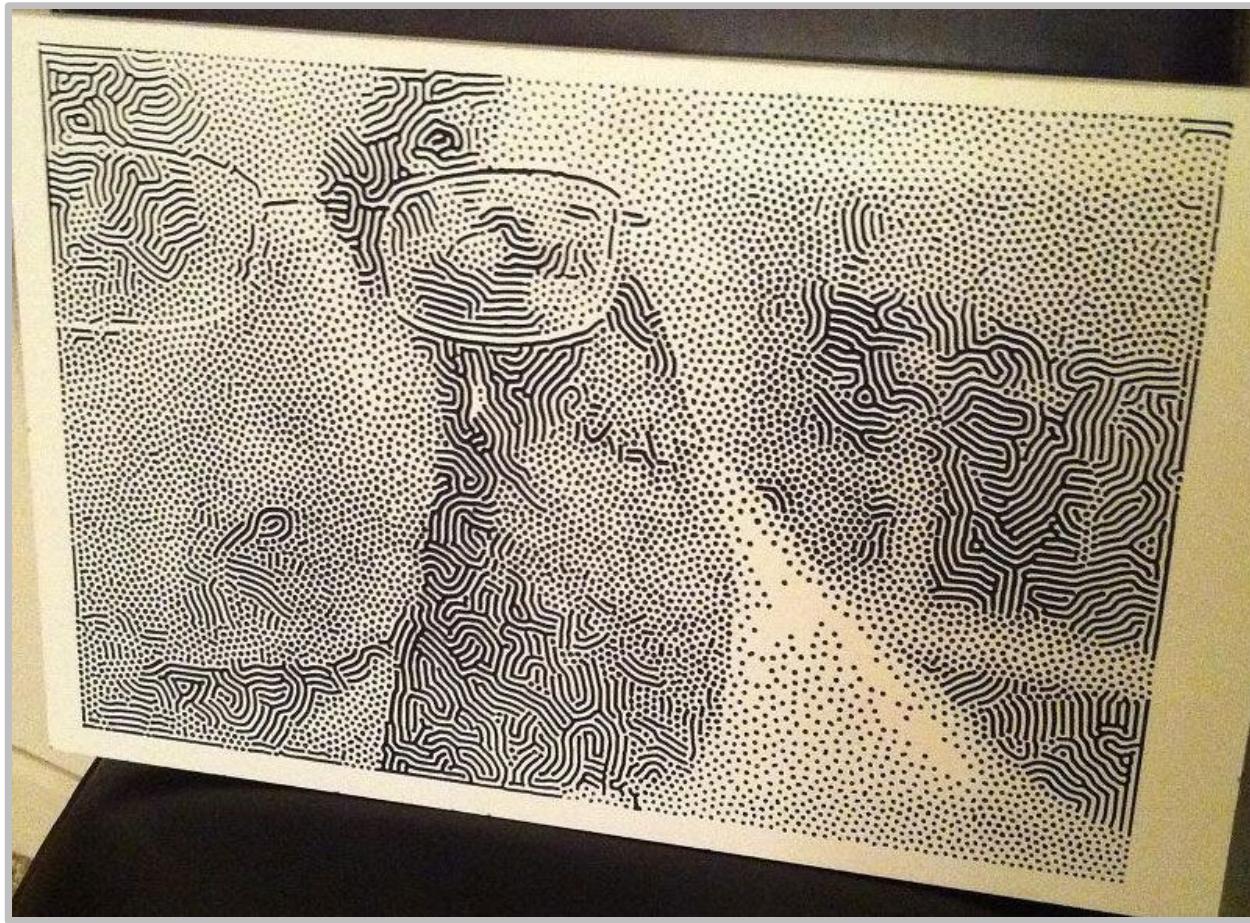
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03.

Examples:

what you can do with a CNC milling machine

Create halftones images with CNC Milling



Jason Dorie has created a couple of Windows applications that allow people to create halftones images for CNC routing from ordinary image files.

Source: http://jasondorie.com/page_cnc.html

Create halftones images with CNC Milling



Jason Dorie has created a couple of Windows applications that allow people to create halftones images for CNC routing from ordinary image files.

Source: <http://youtu.be/xoJDTPRqI6o>

Create halftones images with CNC Milling



A similar example, from Finland...

Source: <http://blog.ponoko.com/2011/08/07/halftone-pictures-drawn-by-cnc/>
<http://youtu.be/REu3MBDsNWo>

CNC Milled furniture: flat plack



PANELS.02&03 - Chair & table by Sebastien Wierinck.

Source: http://sebastienwierinck.com/html/SW_WORK_DF.html

CNC Milled bike: flat plack



Winning second prize from the L'Argus Design Competition for his Roll Bike Concept design, Nicolas Belly has taken the children's balance bike to another level.

Source: <http://blog.ponoko.com/2010/01/28/flat-pack-bike/>

CNC Milled and stitched furniture



Stitched collection by Tord Boontje

Source: <http://blog.ponoko.com/2011/08/06/tord-boontje-stitched-collection/>
<http://tordboontje.com/>

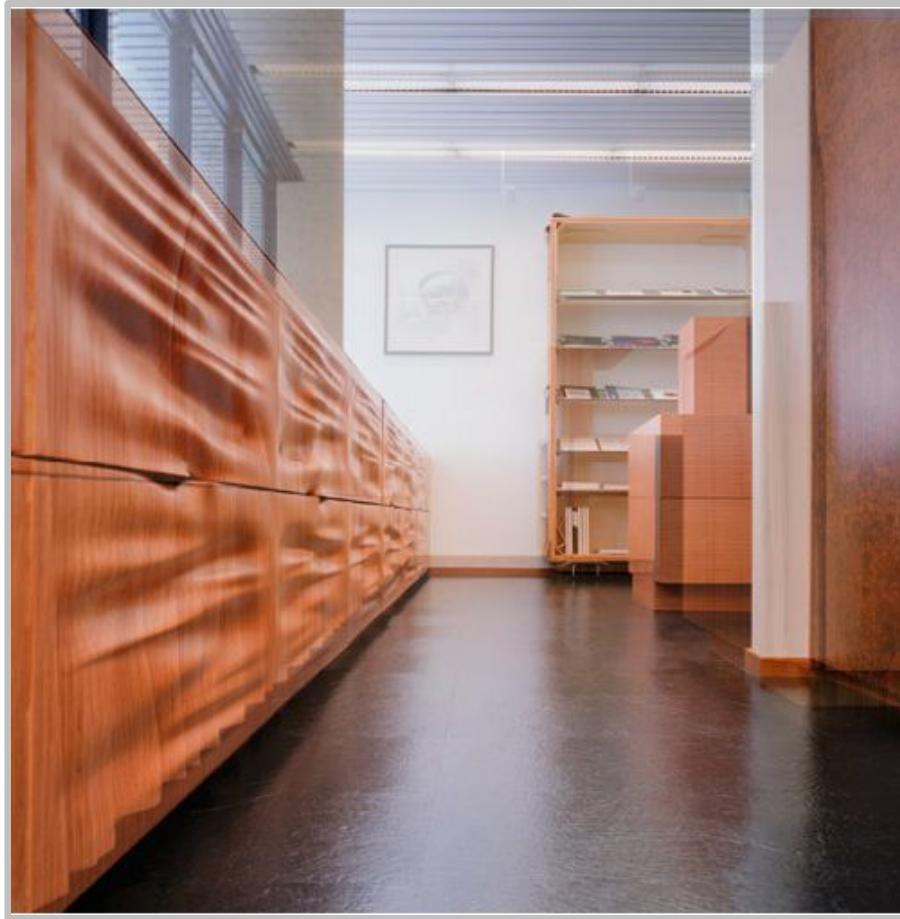
CNC Milled furniture



Gareth Neal has produced a few exceptional pieces that straddle the divide between art and design, furniture and sculpture.

Source: <http://blog.ponoko.com/2010/02/21/classic-cuts-and-cnc-craftsmanship/>

CNC Milled furniture



The design of the Laszlo Files are based on new possibilities afforded by the use of computer numerically controlled (CNC) technology.

Source: <http://blog.ponoko.com/2009/06/03/office-da-pump-serious-cnc-assisted-design/>

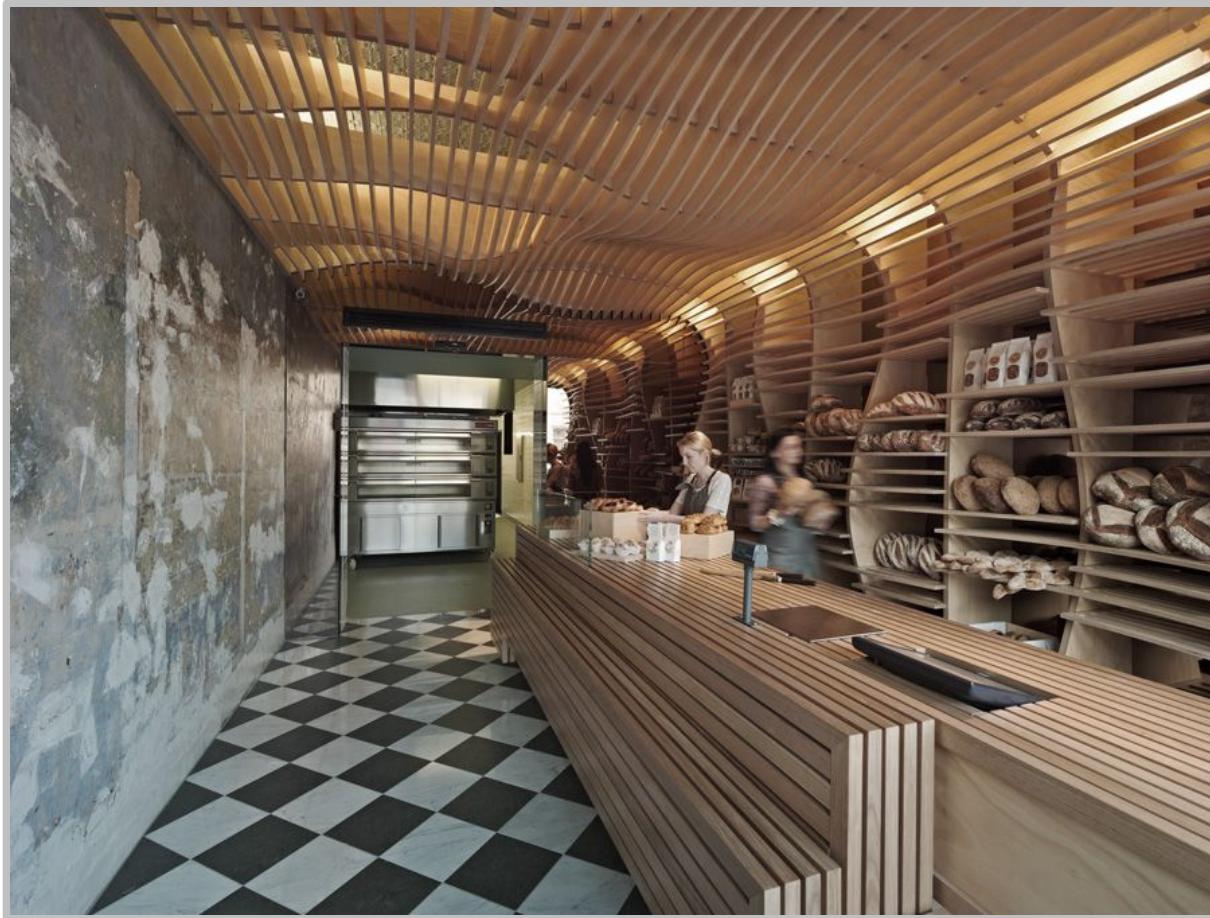
Textures: experiment with density and porosity



“Albeflex BL Special” is designed to be lightweight, self-supporting and capable of taking advantage of CNC driven digital fabrication techniques.

Source: <http://blog.ponoko.com/2009/12/13/experiments-in-porosity/>
<http://dudye.com/experimenting-with-porosity>

CNC Milled interior design



Working with natural materials, March Studio has formed a sculptural retail space for an artisan bakery in Melbourne, Australia.

Source: <http://www.frameweb.com/news/d-chirico-bakery>

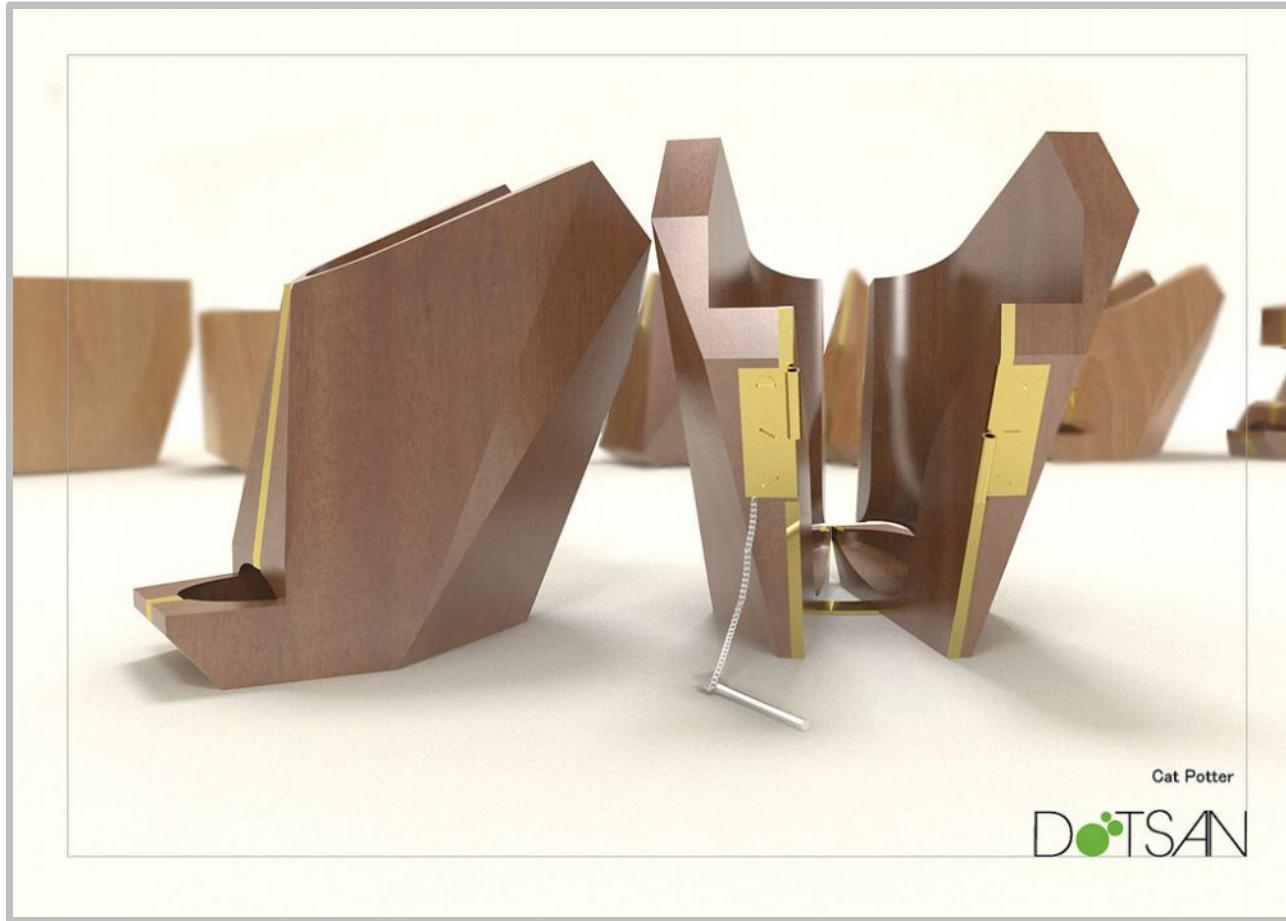
CNC Milled interior design



The piece is essentially a storage cabinet lifted 12" above the floor. The architect studied the form of water ripples from several photographs of the lake.

Source: <http://blog.ponoko.com/2009/05/25/lake-cabinet-further-cnc-wall-madness/>
<http://blog.ponoko.com/2012/03/12/cnc-milling-waves/>

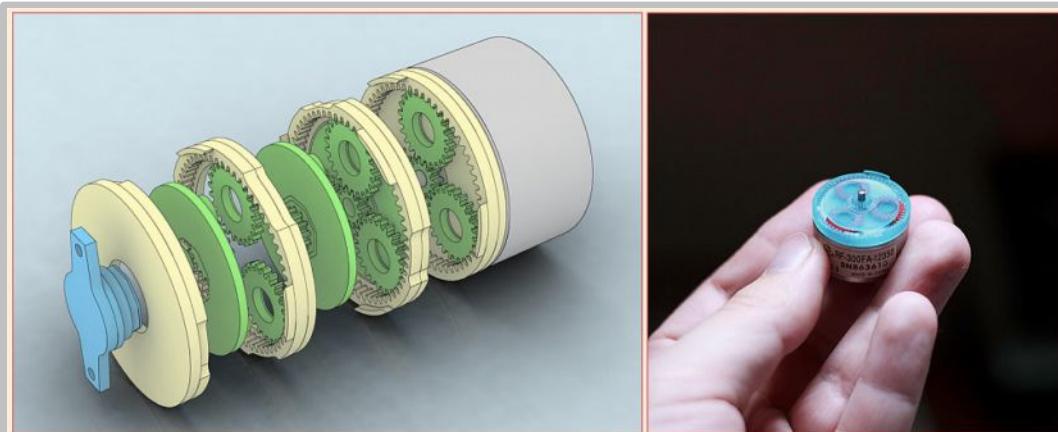
CNC Milled shoes



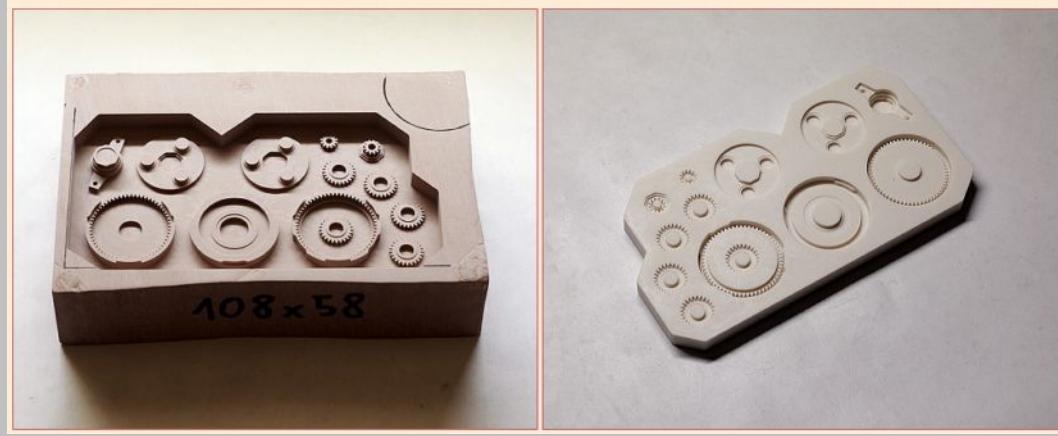
Experimental shoes by designer Cat Potter were shaped from solid blocks of wood with a 3-axis CNC milling machine.

Source: <http://www.flickr.com/photos/42746980@N02/6673839607/in/pool-375602@N23/lightbox/>
<http://blog.ponoko.com/2012/01/11/cnc-milled-wooden-shoes/>

CNC Milled molds for mechanical parts



Well, this time around, it worked out [pretty much flawlessly](#):



XXX

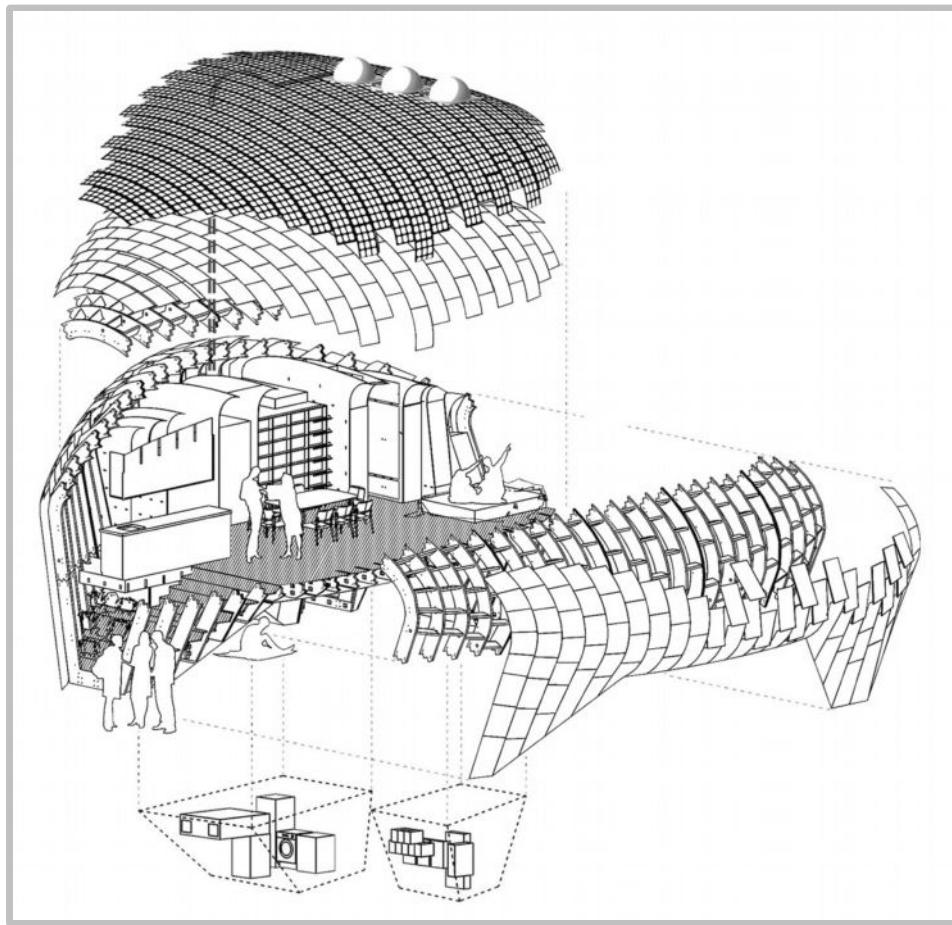
CNC milled products



Blocks of solid maple are milled in two separate halves and joined together with an accentuated “parting line”, articulating the profile of the shapes.

Source: <http://blog.ponoko.com/2009/05/07/cnc-vases-by-paul-loebach/>

FabLab House



The Fab Lab House is developed on a network of fablabs using CNC machines to design and produce houses than can be customizable.

Source: <http://www.fablabhouse.com/en/la-forma-sigue-la-energia/>



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04.

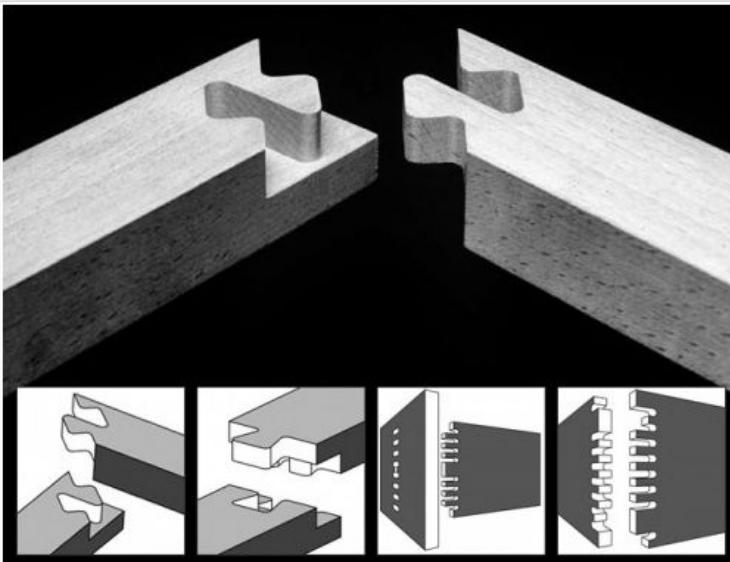
Design techniques: how to design for CNC milling machines

Digital wood joints ready to use

Flexible Stream
OPEN DESIGN SOURCE

Free Design What for Submit Help

50 DIGITAL WOOD JOINTS
Jochen Gros



Download this Design

- Digital Wood Joints (4 examples)
- Instructions 4 Examples

[Download all Woodjoints](#)

Some rights reserved:
[CC BY-NC-SA 3.0](#)

Parts
No parts available

Contact Designer

Jochen Gros
www.movicons.com

A library of 50 wood joints in digital format available for download and use in your project.

Source: <http://www.flexiblestream.org/Digital-Wood-Joints-001.php>

Digital wood joints ready to use

Make: Blog Magazine Projects Reviews Shop

Hot Topics: Kids Arduino 3D Printing Computers & Mobile Craft Raspberry Pi

Home / Desktop Manufacturing / CNC / CNC Panel Joinery Notebook

CNC Panel Joinery Notebook

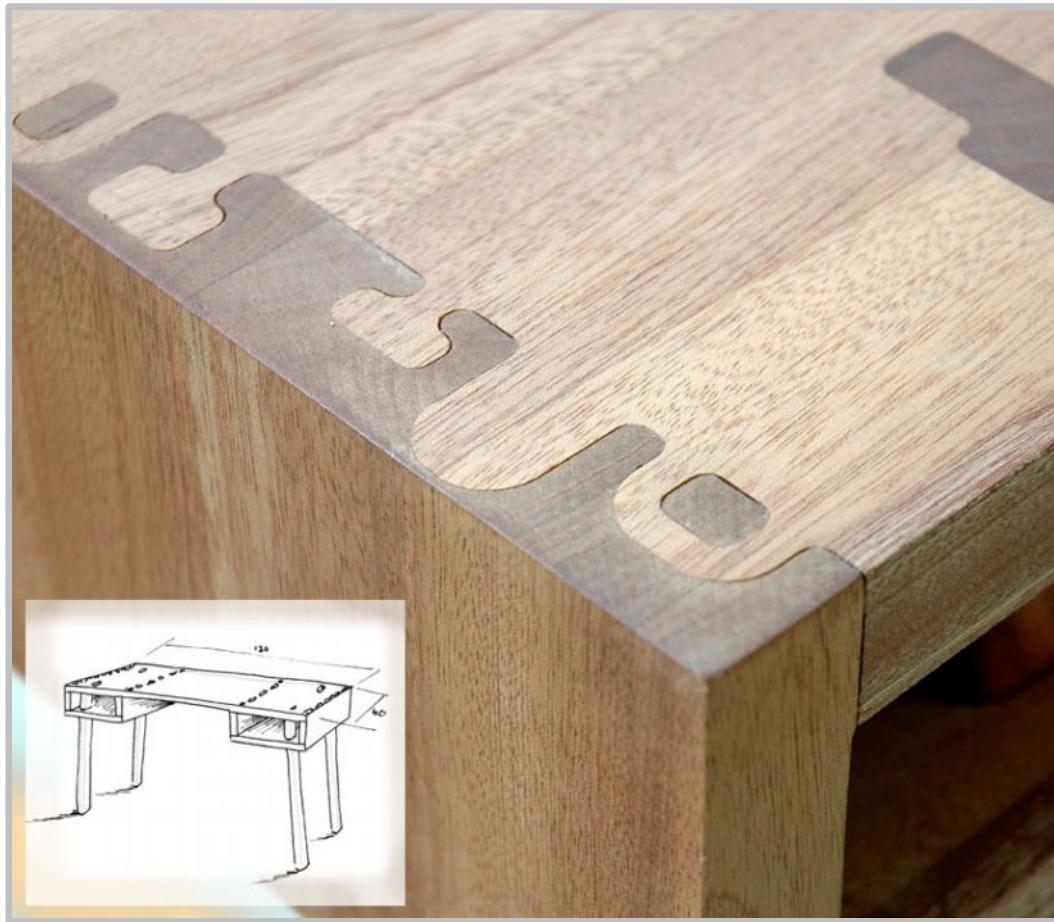
By Sean Ragan, 2012/04/13 @ 9:00 am



More information and tutorials..

Source: <http://blog.makezine.com/2012/04/13/cnc-panel-joinery-notebook/>

Wood joints: they don't have to be boring



Joints by Tineke Beunders and Nathan Wierink (ontwerpduo) takes advantage of the precision in digital fabrication for an entire mahogany desk.

Source: <http://blog.ponoko.com/2009/05/31/ontwerpduo%20%94fun-studio/>

CNC Simulator



The idea of the new CncSimulator Pro is to provide the machining industry with a contemporary competent Fanuc inspired CNC ISO simulator.

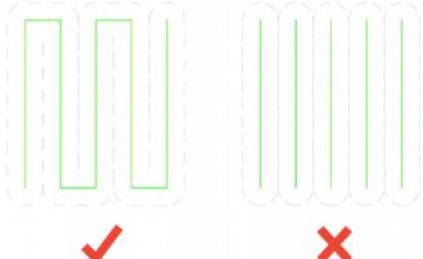
Source: <http://www.cnccsimulator.com/>

Some suggestions for CNC Routing

Pocketing lines should be joined where possible.

A continuous line (red, green, magenta) is better than a series of disconnected shorter lines. Every time the machine starts a new path/line it has to move to the start of the line, plunge into the material and then move along the line. Repeating this process over and over is not ideal. The edge of your pocket will not be as clean as it will be if you use a continuous line.

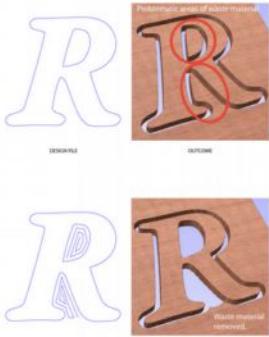
Also you can't guarantee which order the router will cut a lot of short disconnected lines. It is possible that it will leave a middle line until last leaving a thin, unstable piece of material that has the potential to break off and damage your job.



Find out more about pocketing and how to remove areas of material.

Small areas of waste need extra cut lines to remove them.

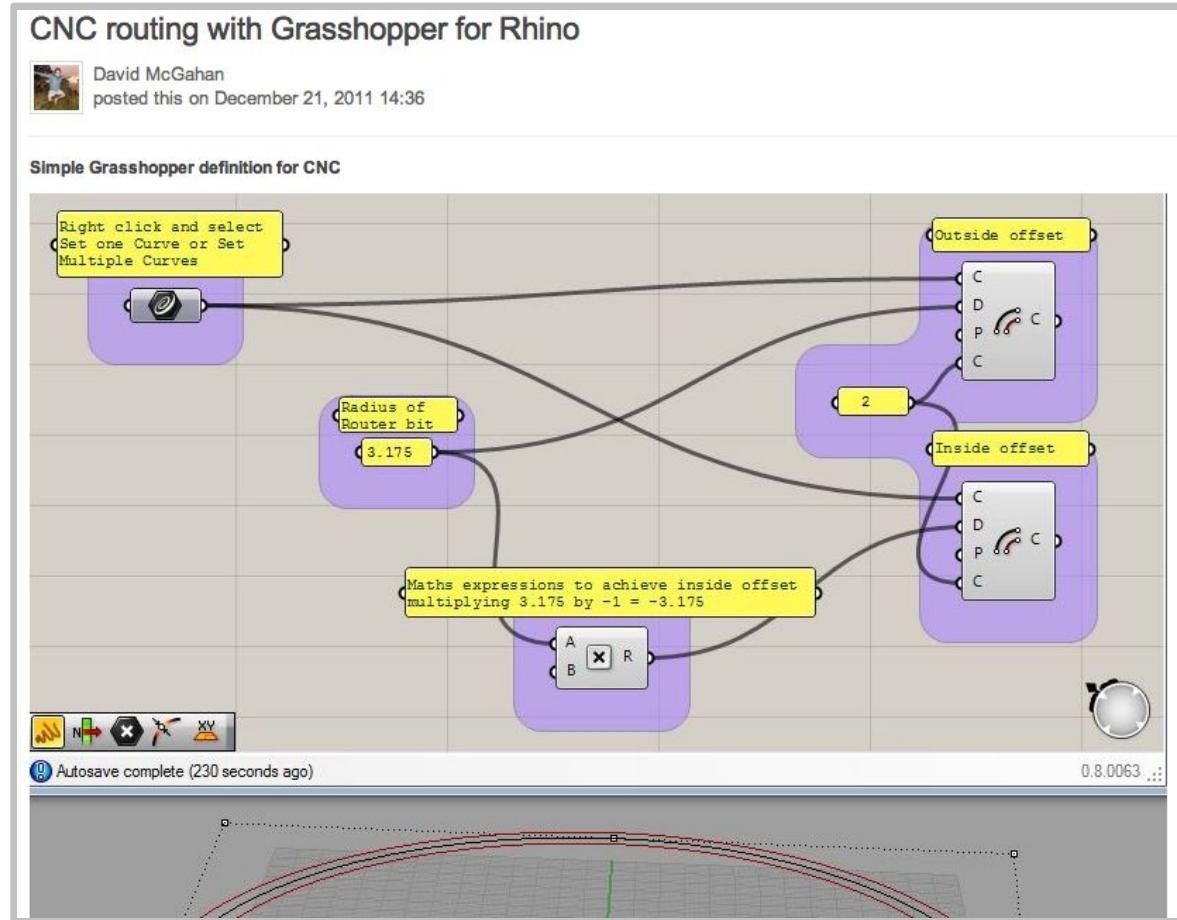
As the router cut out your design there can be small areas of waste can be left in the middle which are not beefy enough to support themselves. These usually break off leaving a rough edge and cause the machine to jam damaging it and your work. If you have a narrow/small strip of waste, it's best to add extra lines so the area is left clear. These extras cutting paths should be open paths so the router knows to cut them before the cutting lines for your design.



You cannot avoid the size of the tool this time, so your design has to be drafted according to that.

Source: <http://support.ponoko.com/entries/20735156-things-you-must-know-for-cnc-routing>

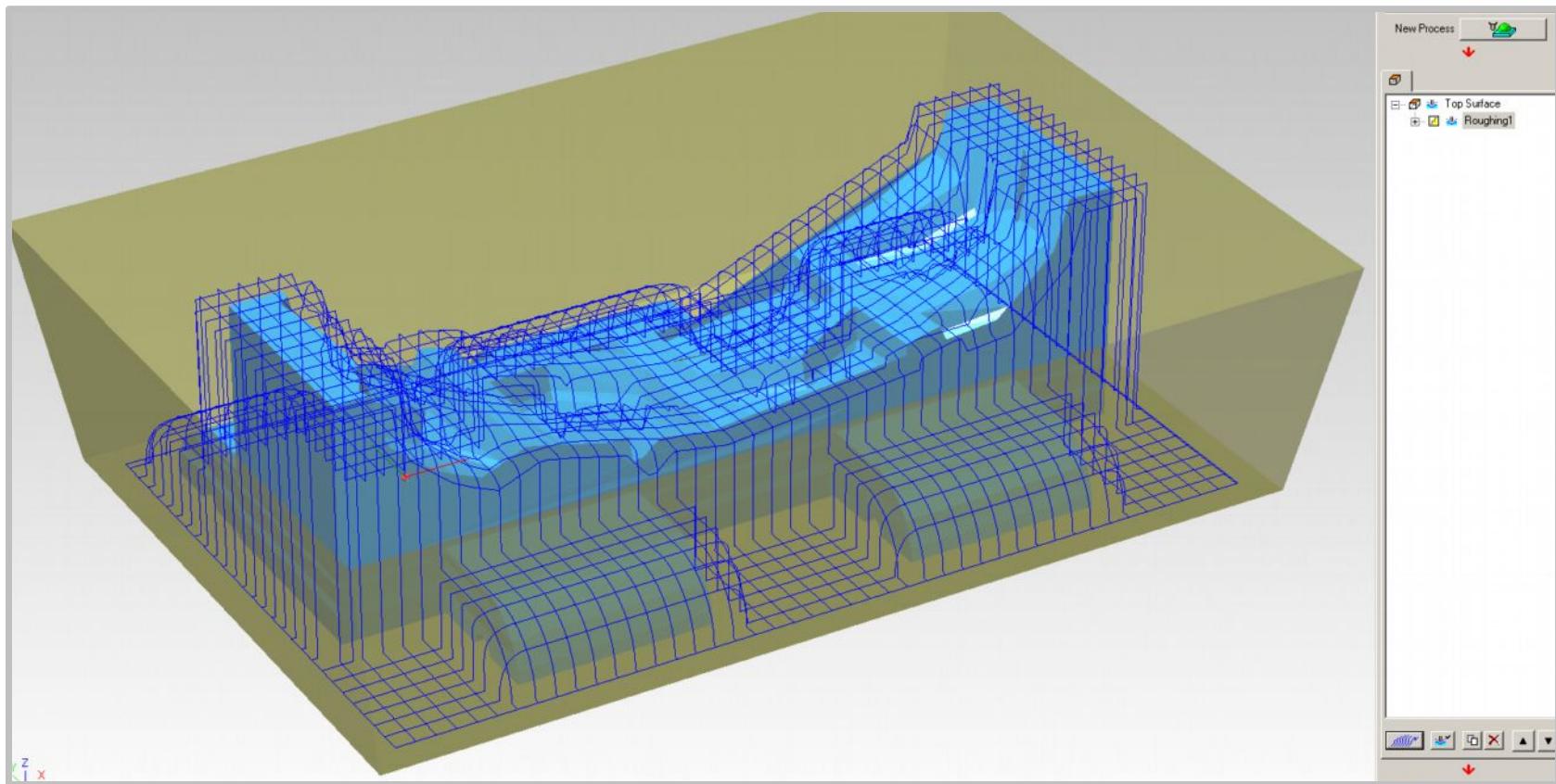
CNC routing with Grasshopper for Rhino



The Grasshopper plugin for Rhino is also useful for much simpler tasks such as offsetting lines as you might do manually for CNC routing.

Source: <http://support.ponoko.com/entries/20786136-cnc-routing-with-grasshopper-for-rhino>

Roland Modela Player 4



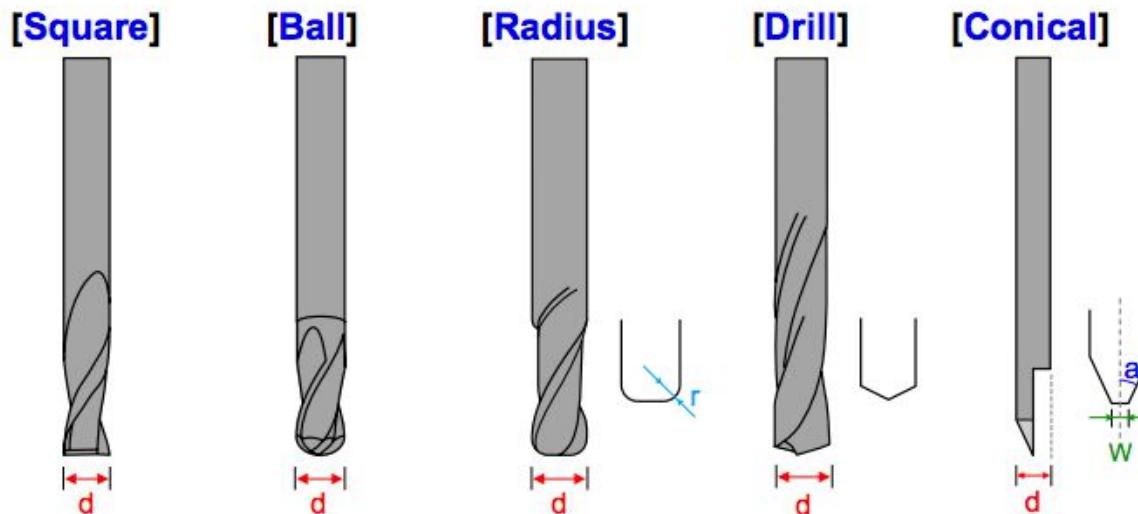
MODEL A Player is a CAM software that allows importing of 3D files for milling it. Virtual MODEL A provides a quick preview of the entire milling operation.

Source: http://academy.cba.mit.edu/content/tutorials/General_Machine_Tutorials/Milling/ModelaPlayer4_tutorial_v2.html
http://www.intellecta.net/mdx-15_20.html http://www.rolanddg.com/product/3d/3d/mdx-20_15/application.html

Roland Modela Player 4: adding milling bits

It is possible to register new tools. Roland original tools are originally registered.

Tool Type, Tool Material, Flute Diameter(**d**), Corner Radius(**r**), Blade Width(**w**) and Blade Angle(**a**) are necessary to be set to register a new tool.



MODELAPlayer is a CAM software that allows importing of 3D files for milling it. Virtual MODELAPlayer provides a quick preview of the entire milling operation.

Source: <http://www.elecprint.ch/downloads/modelaplayer4e.pdf>

Many different milling bits ...



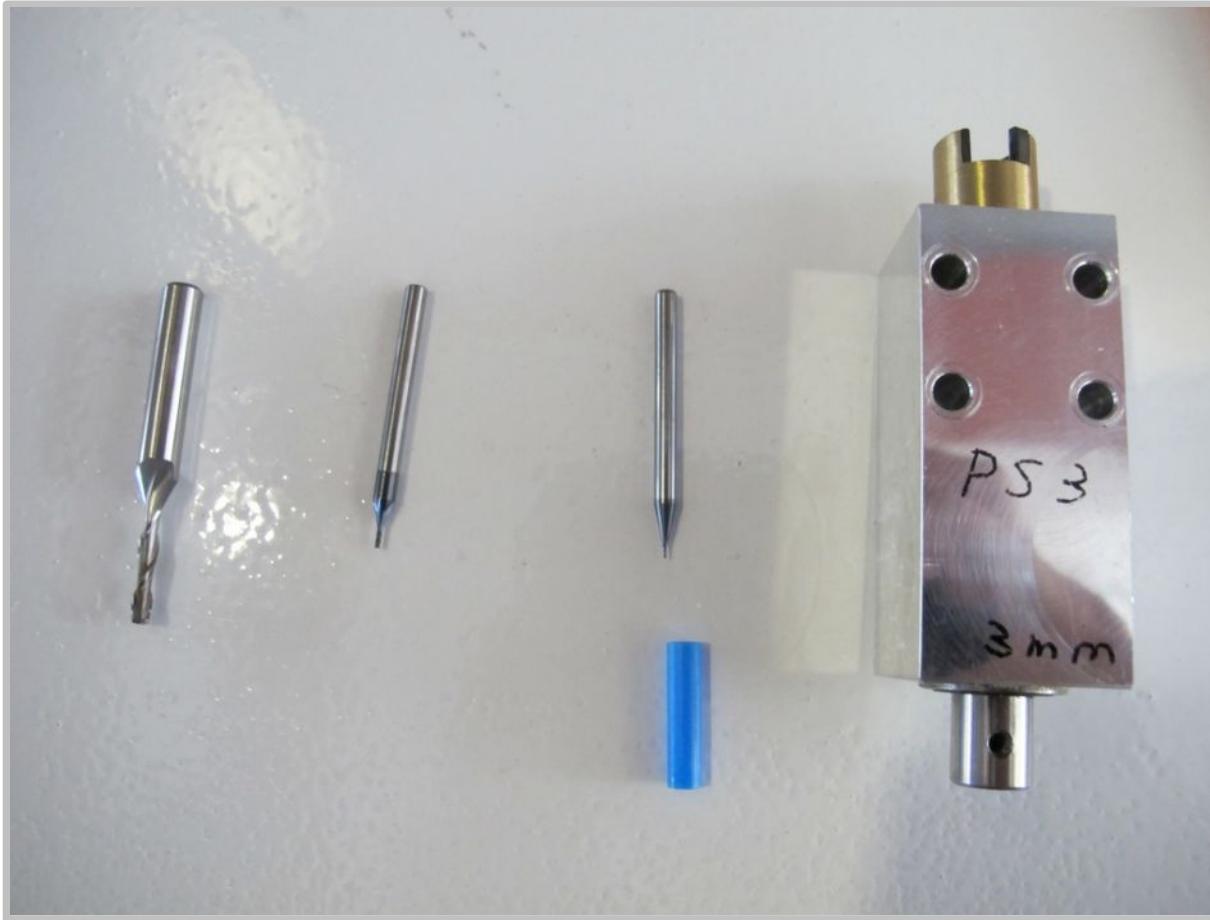
You may encounter also bigger and very different milling bits...

Our milling bits



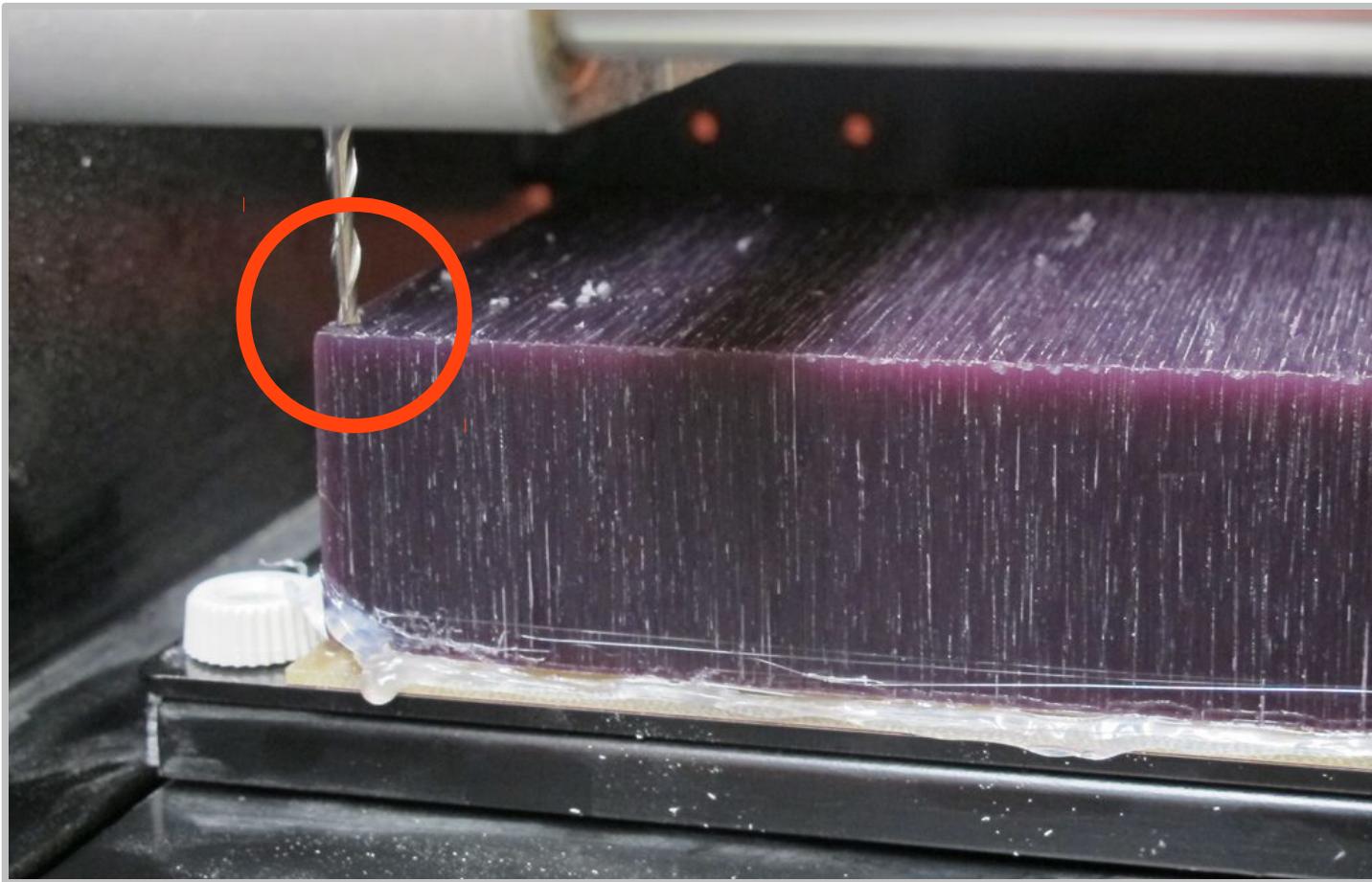
Diameters = 3 mm, 1/32 inch (0.79375 mm), 1/64 inch (0.396875 mm).

Our milling bits



Diameters = 3 mm, 1/32 inch (0.79375 mm), 1/64 inch (0.396875 mm).

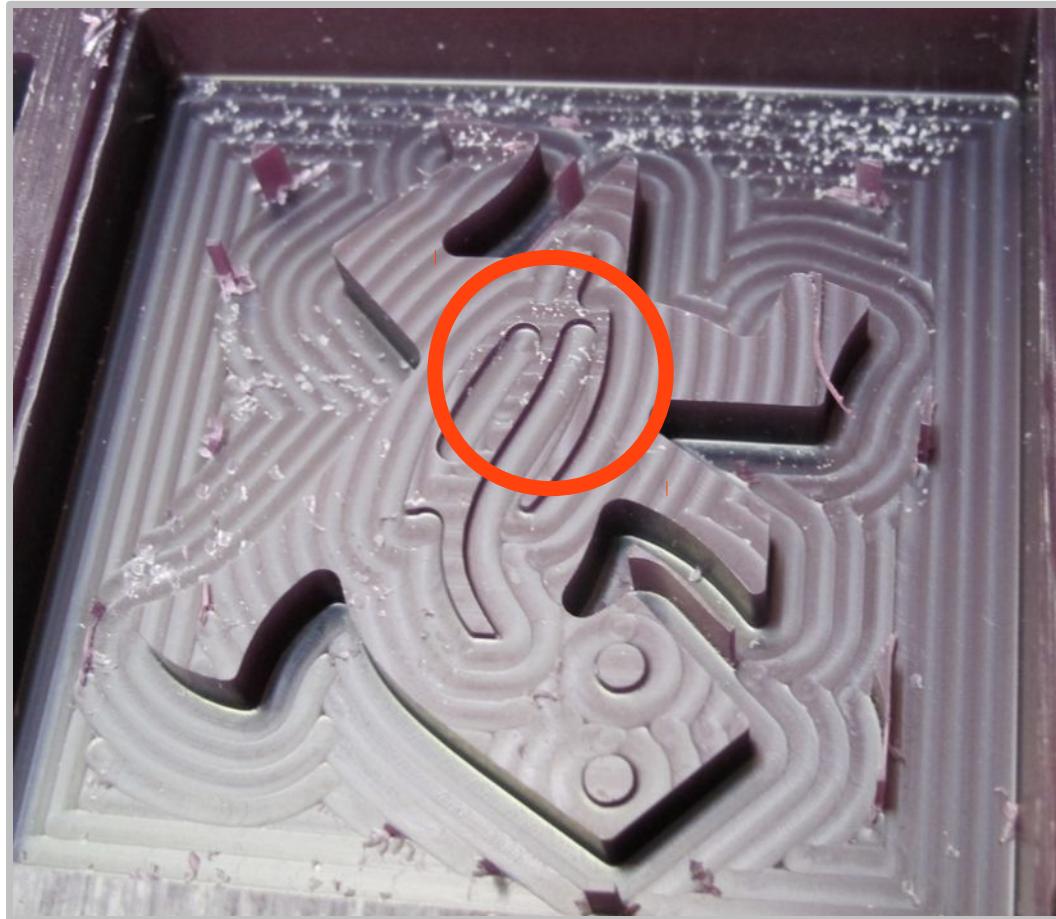
Always, set the Zero: X, Y, Z



And write down the X and Y coordinates! Furthermore, don't mill around it, so you can preserve it for future passes.

Source: <http://www.flickr.com/photos/aaltofablab/6924563776/in/photostream>

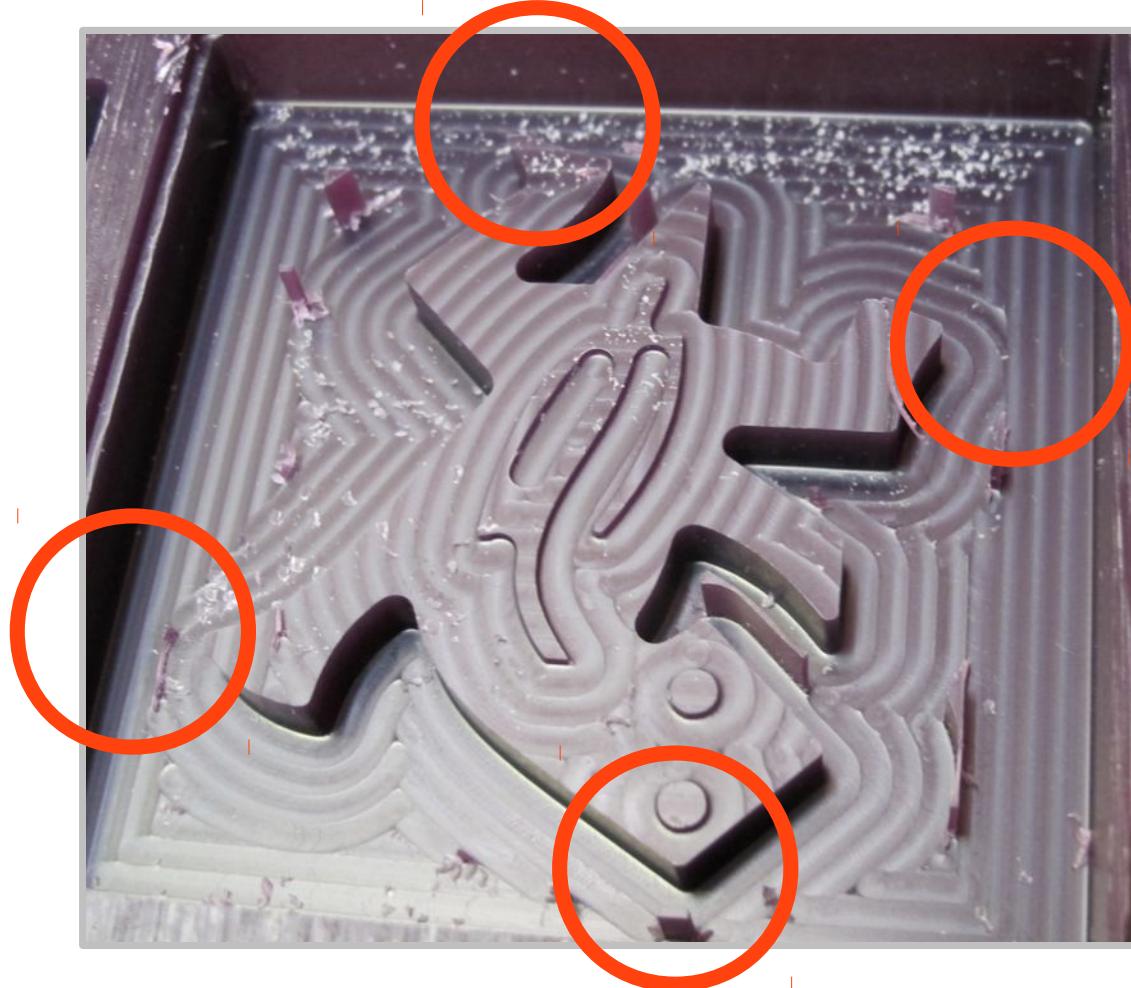
When designing, think about the milling bit



Leave enough space for the milling bit to pass, or it will erase part of your details. Rough finish should leave a 1.4 mm offset.

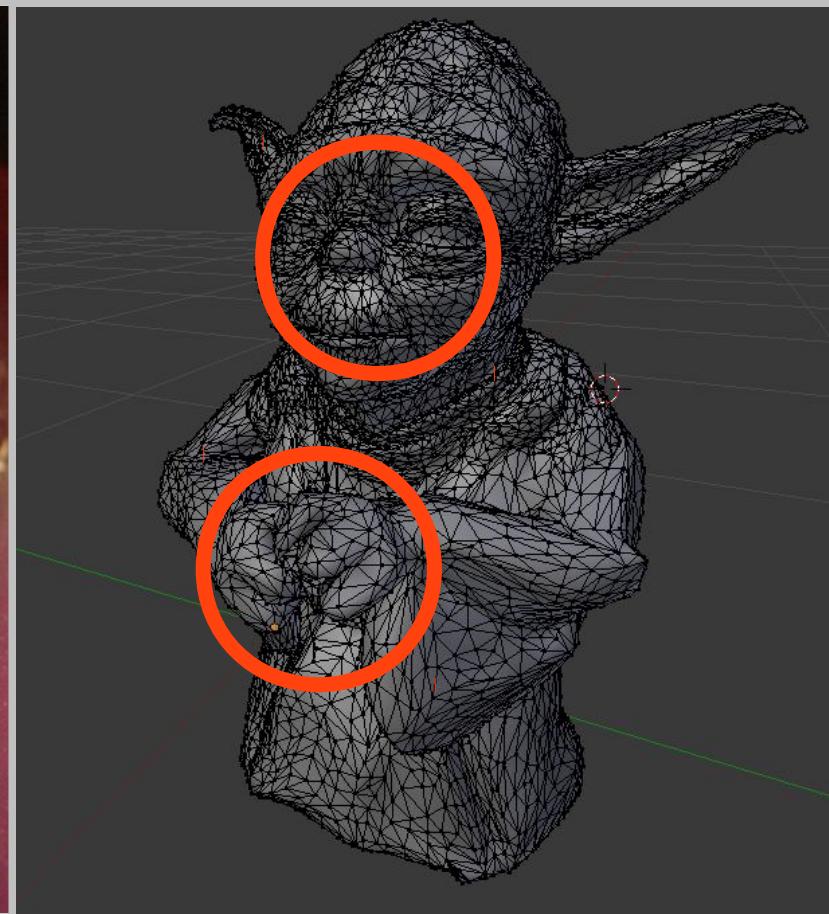
Source: <http://www.flickr.com/photos/aaltofablab/7070645517/in/photostream>

When designing, think about the milling bit



Leave enough space **also** around your object!

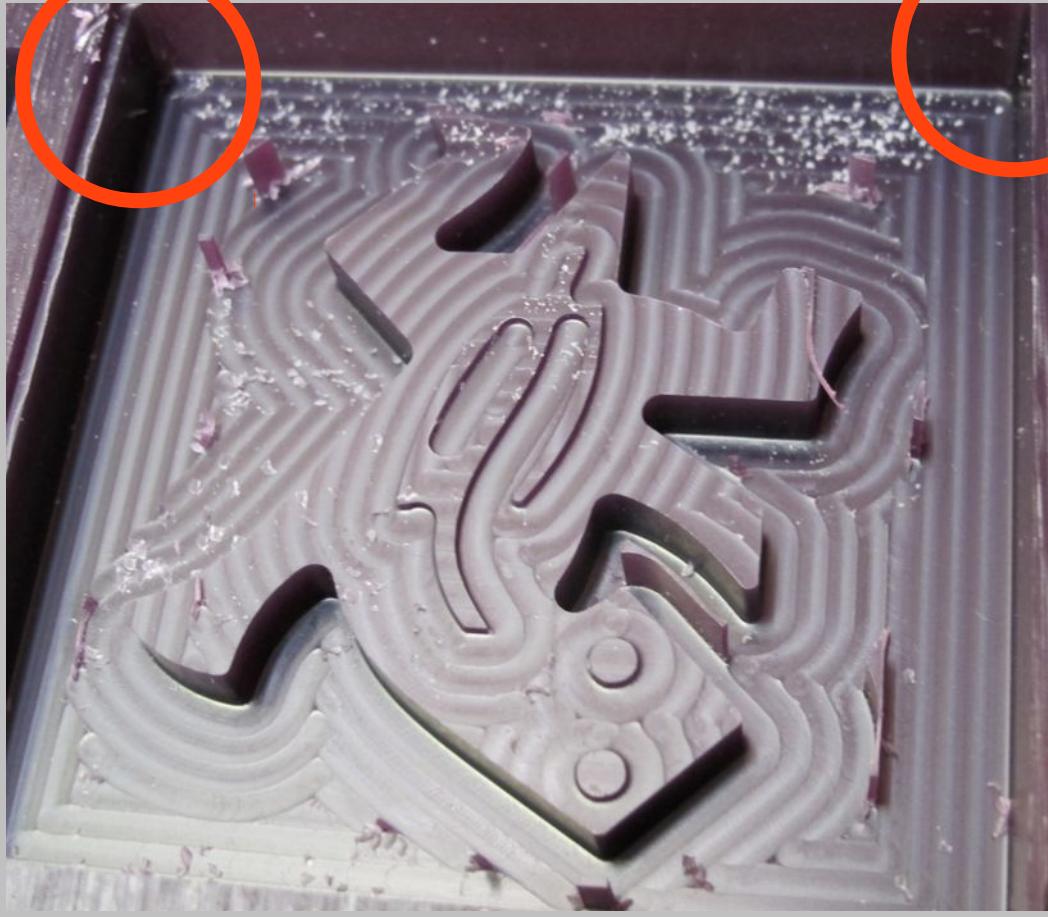
When designing, think about the milling bit



Your tiniest detail will be the size of your smallest milling bit, not the resolution of your mesh, think about it!

Source: http://www.flickr.com/photos/massimo_menichinelli/6765894657/in/photostream

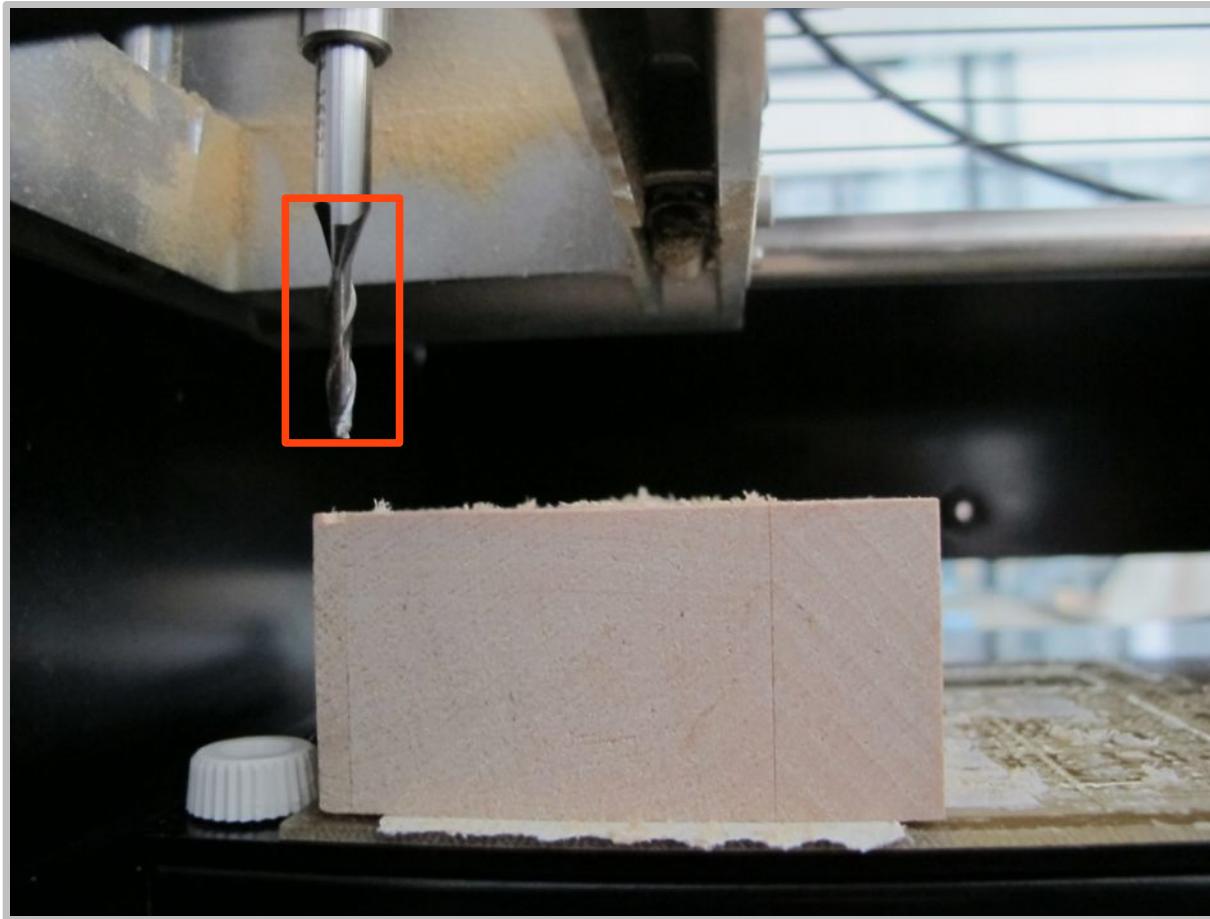
Rounded milling bits: rounded corners



The milling bit is rounded and rotates, so your corners will be rounded, and the radius is the same of your biggest milling bit.

Source: <http://www.flickr.com/photos/aaltofablab/7070645517/in/photostream>

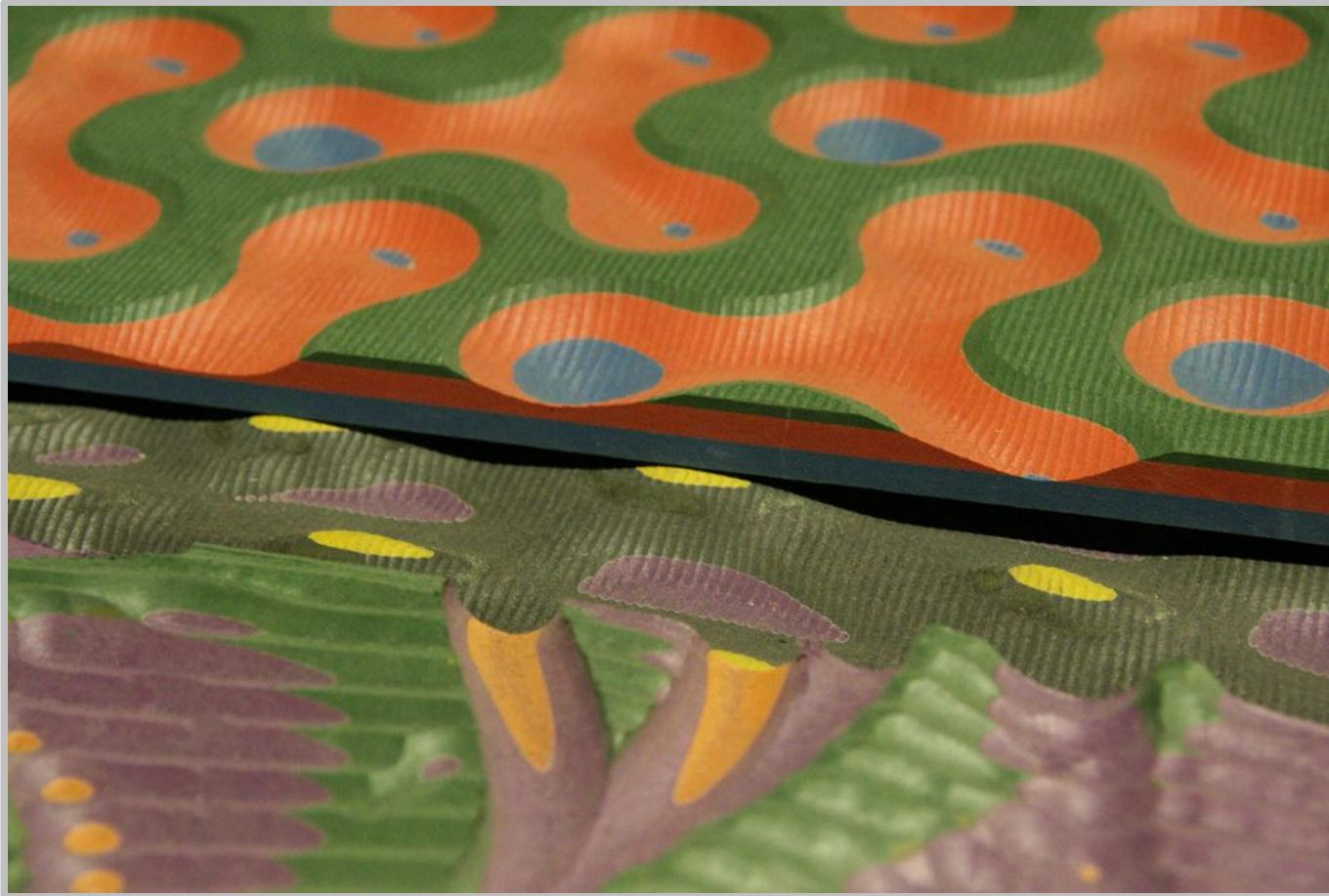
The milling bits also determines the depth



Even if your modelling block is higher than the milling bit, it is the last one that determines how deep you can mill.

Source: <http://www.flickr.com/photos/aaltofablab/7194259202/in/photostream>

Depth: the layers of the material



If your material has many different layers, you can play with its structure to achieve different effects.

Source: http://www.flickr.com/photos/massimo_menichinelli/6680470207/in/photostream

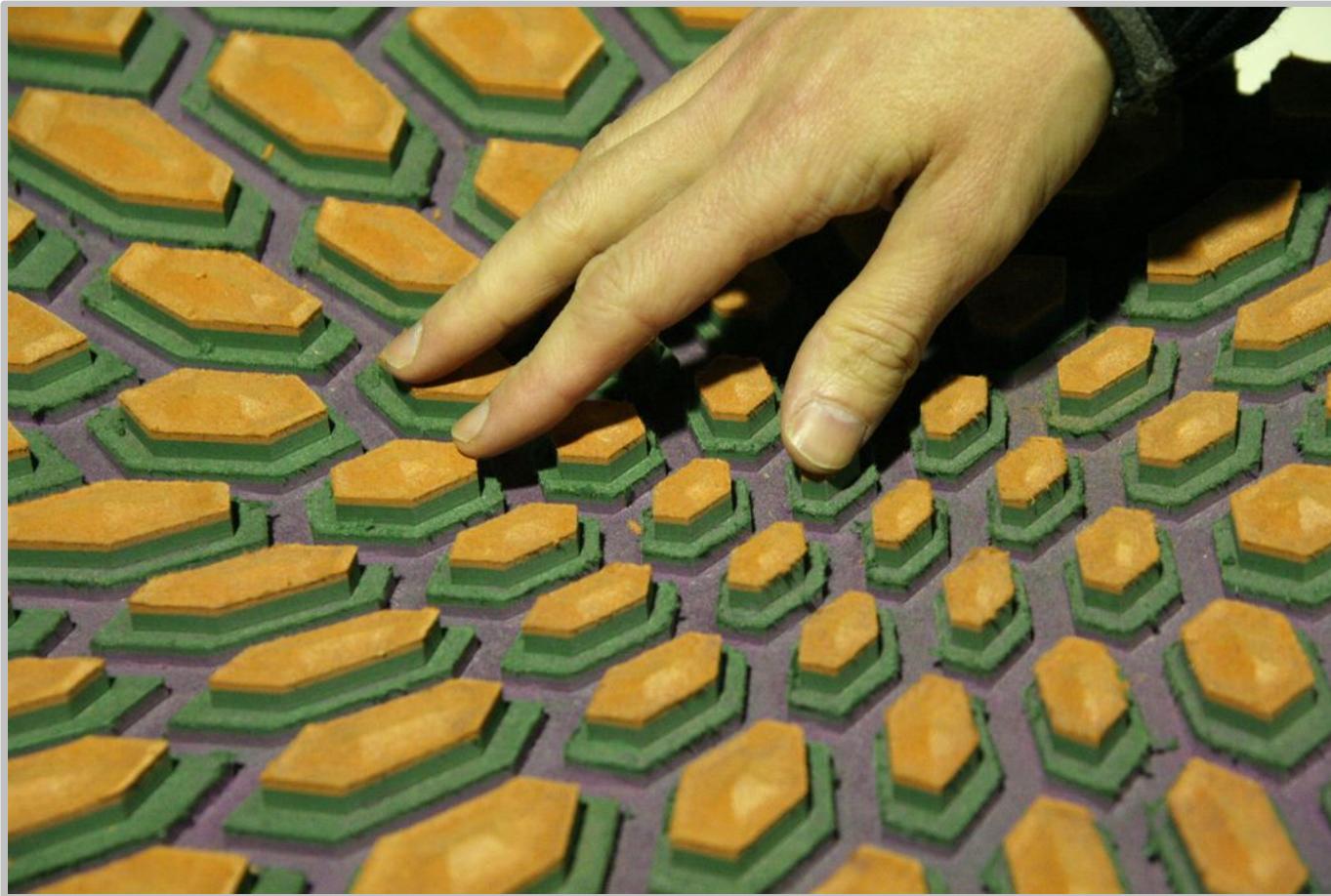
Depth: the layers of the material



If your material has many different layers, you can play with its structure to achieve different effects.

Source: http://www.flickr.com/photos/massimo_menichinelli/6680488643/in/photostream/

Depth: the layers of the material



If your material has many different layers, you can play with its structure to achieve different effects.

Source: http://www.flickr.com/photos/massimo_menichinelli/6680483663/in/photostream

Layers: Ripples, by Toyo Ito



Ripples, winner of the 2004 Compasso d'Oro, is made of a laminated composite of five different solid woods.

Source: http://www.horm.it/eng/prodotti_di_design/toyo-ito/collezione-toyo-ito-foto.php?id=99
http://www.bonluxat.com/a/Toyo_Ito_Ripples_Bench.html

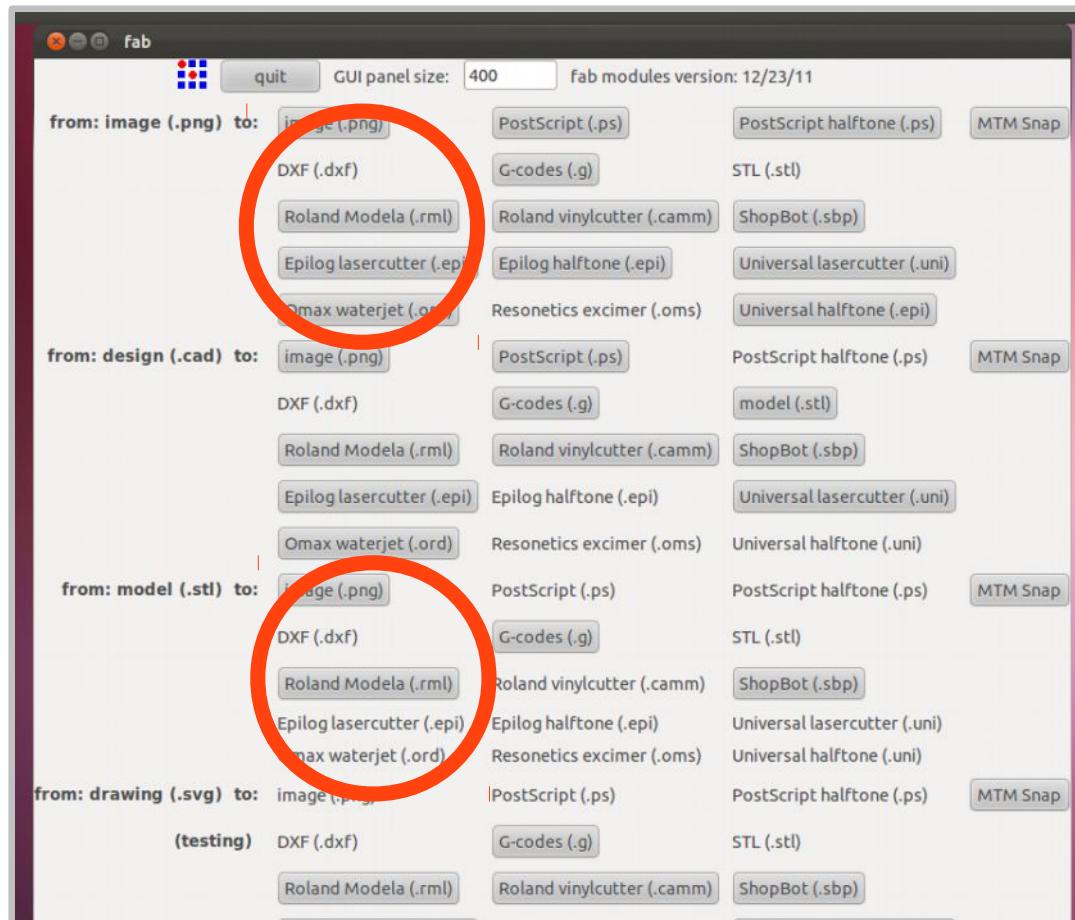
Layers: Ripples, by Toyo Ito



The whole manufacturing process of the table, it is worth watching not only for the CNC part but also for understanding the complexity behind the object.

Source: <http://youtu.be/TbwUMYnPfQM>

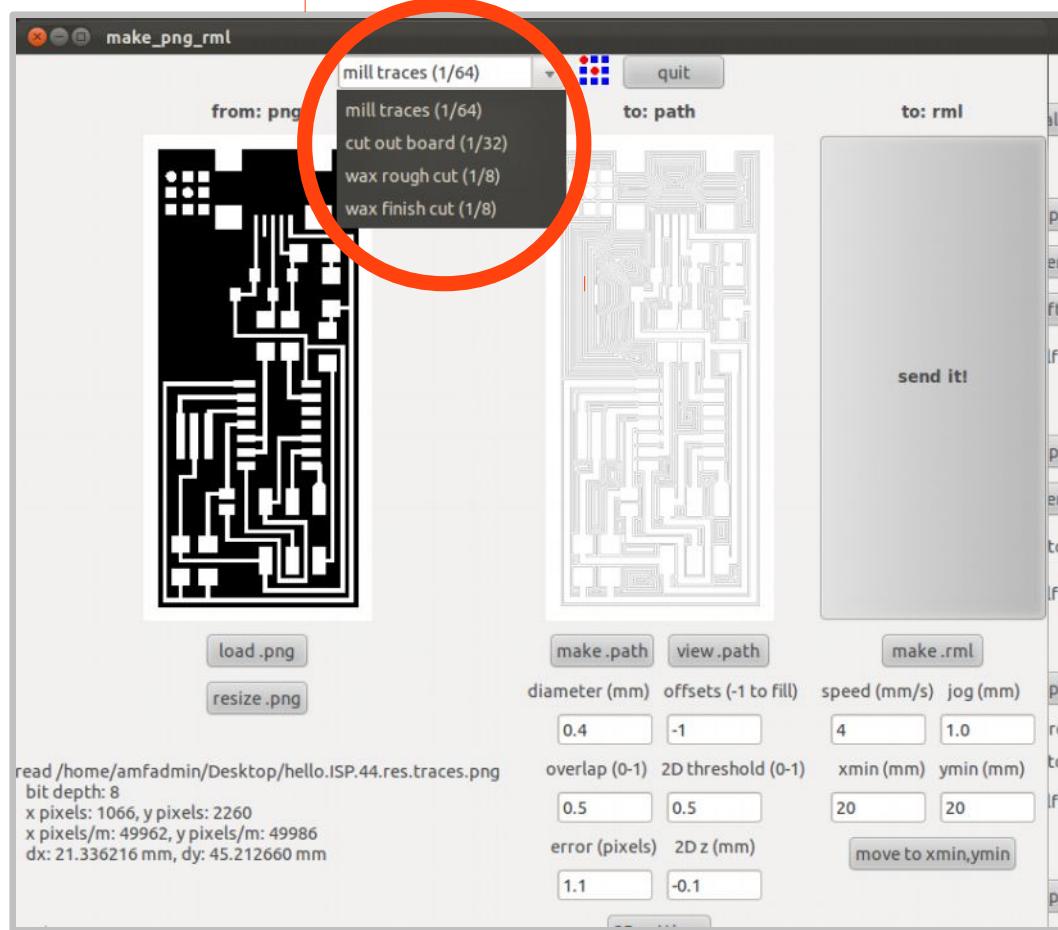
Fab Modules: the FabLab standard software



A software package to run all the FabLab machines on Linux and Mac (if you manage to install it ;-)).

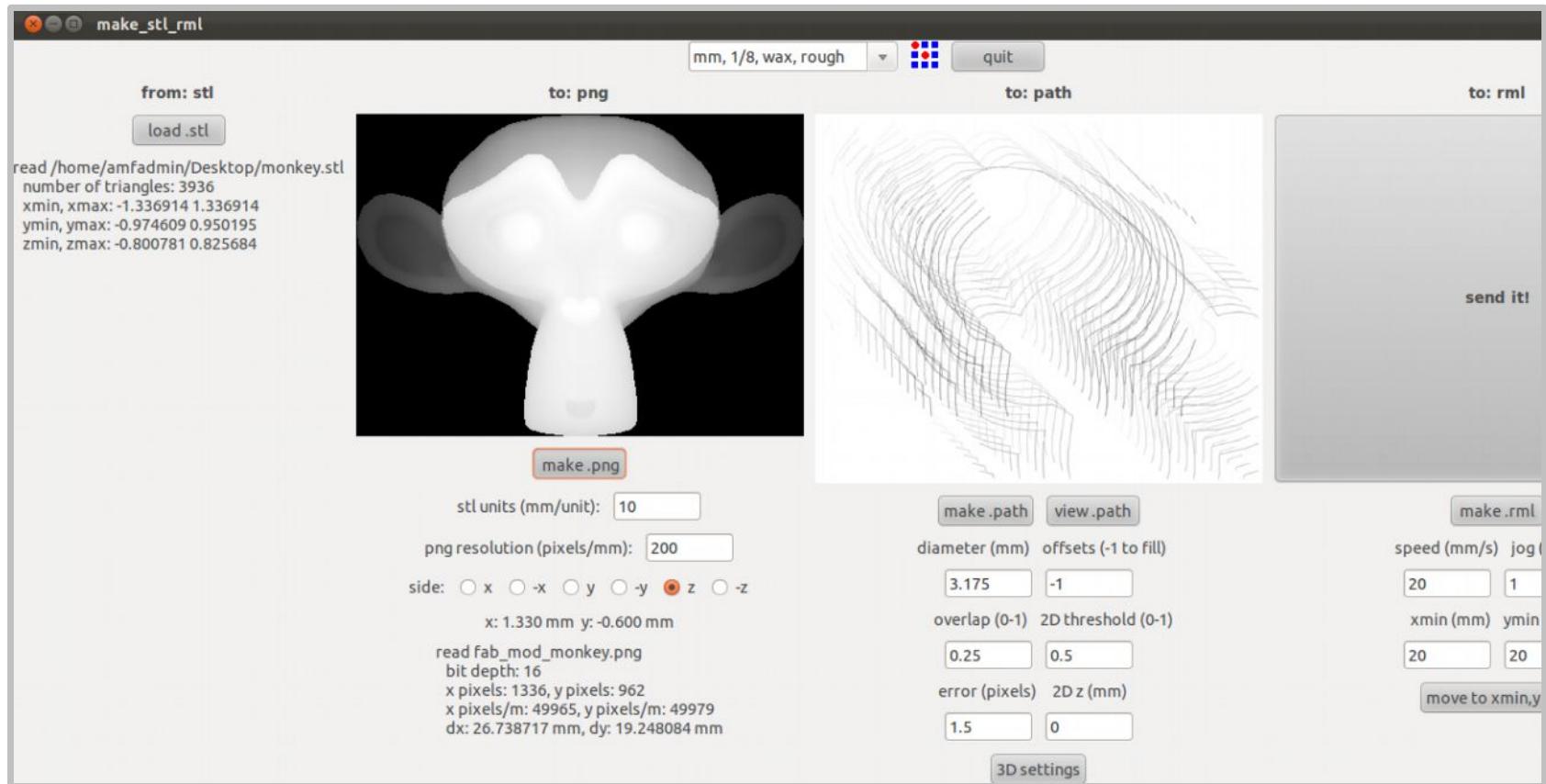
Source: <http://kokompe.cba.mit.edu/dist/index.html>

Fab Modules: milling a 2D PCB



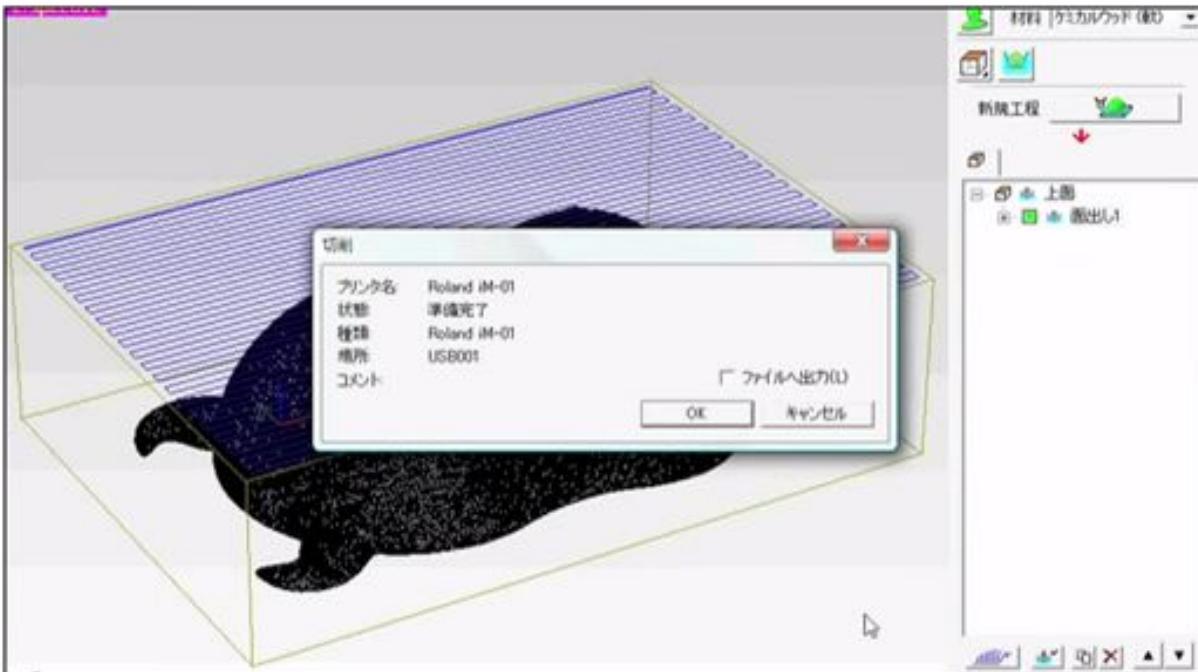
The white part will be milled away: the software generate the paths (each milling bit have its own function and path structure).

Fab Modules: milling a 3D object



The software will translate the 3D model into a BW gradient: white is the top, black the bottom (and then you can set the whole height).

Roland Modela Player 4: process



to start cutting.



03:57 / 10:05



A tutorial for iModela, but the process is the same for the MDX-200 as the software is the same.

Source: <http://youtu.be/ijHoaG6Y5E>

Roland Modela Player 4: finishing



If you have only 3 axis, splitting the model into two halves can be a good technique for achieving complex shapes.

Source: http://youtu.be/DVfJIU_wD0c

A”

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Thank you!!

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