CNC4Everyone

How we built a CNC machine for every classroom, college and makerspace

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FABLAB KERALA

KERALA STARTUP MISSION

IndiaFOSS 2026



How 3D Printers Revolutionized Manufacturing

A monumental shift from commercial monopolies to public open-source champions.

The Prusa effect democratized fabrication.



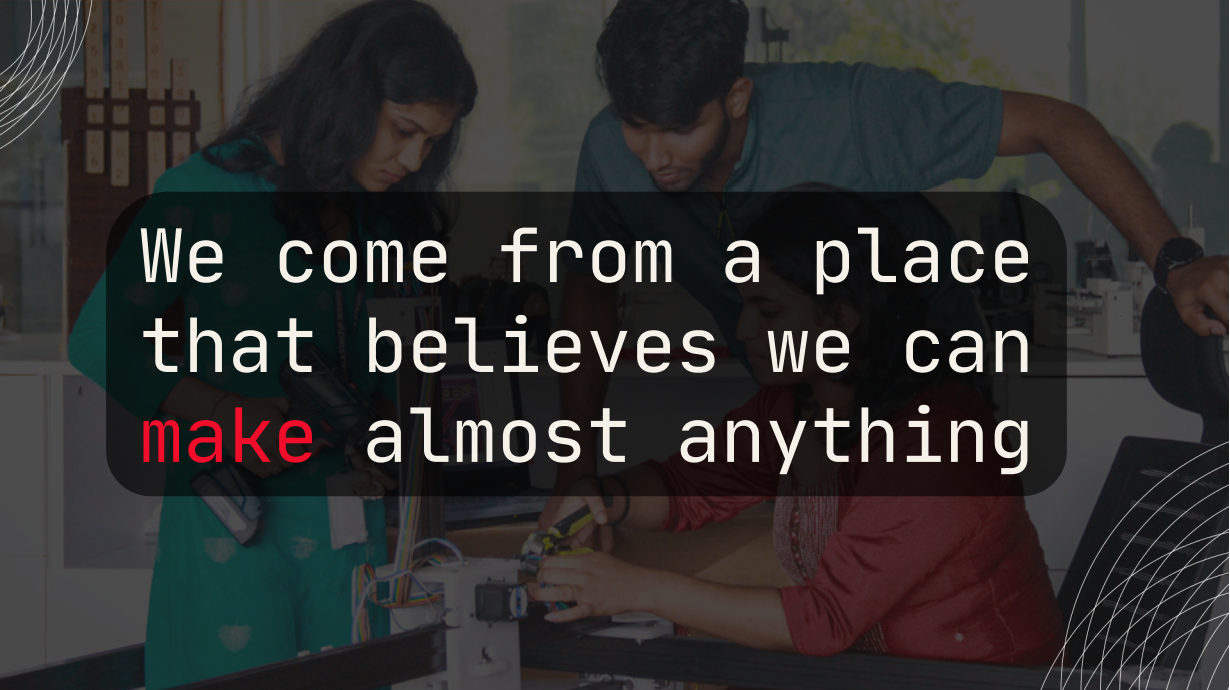
What AI did to open source and personal software, giving unprecedented creative power to individuals...

We want to do something similar for Hardware



Most of the existing solutions are not user accessible to the core.

We want to give makers the power.


We come from a place
that believes we can
make almost anything





China can fill a stadium with CNC operators.
We can barely fill a classroom.

— Balu Babu, IndiaFOSS 2025



ACCESSIBILITY ≠ INDEPENDENCE



Community Workshops

Capital-intensive infrastructure
Industrial machines
Steep learning curve



Shared Manufacturing

Global supply chains
Geographic restrictions
Reduced insight into the making process



Affordable Ownership

Manufacturer dependency
Software & Hardware discontinuation
Paid ecosystems

We reduced **cost**. We didn’t remove **dependence.**

That's why we made Urumi.

[Play Urumi Video]

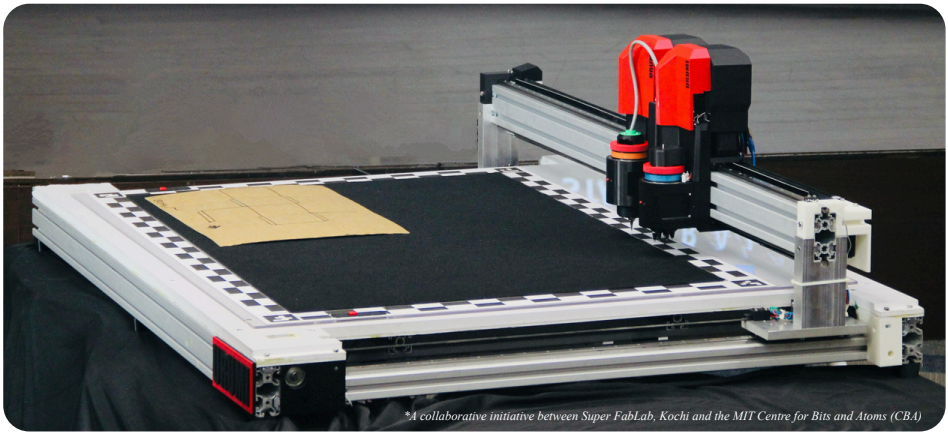
Meet...

Urumi
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/oo-roo-mee/

Urumi is a low-cost, open-source 4-axis desktop flatbed CNC machine that enables students, educators, and makers to create physical models, prototypes, and creative projects with ease.

- Accessible to absolute beginners.
- Designed to be maintained locally.



*A collaborative initiative between Super FabLab, Kochi and the MIT Centre for Bits and Atoms (CBA)

Why the name "Urumi"



The Urumi is a flexible sword used in Kalaripayattu, the traditional martial art of Kerala.
Unlike a conventional sword, its strength lies in its adaptability, precision, and fluid movement

We chose it because we wanted Urumi to protect the freedom to **create**, **repair**, **improve**, and **share**.

Like its namesake, the machine is:

Adaptable - To evolve with changing needs.
Precise - For accuracy and repeatability.
Flexible -To support many tools, materials, and workflows.

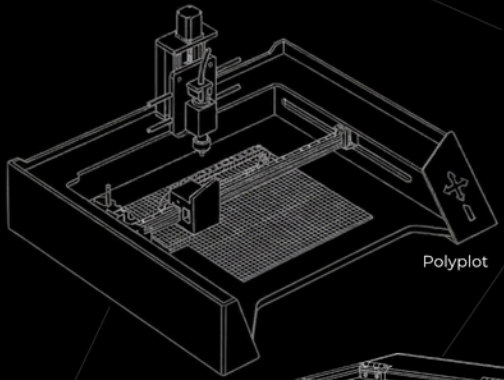
Machines That Make

BUILD

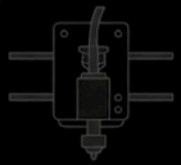
REPAIR

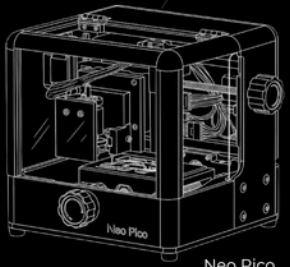
MODIFY

EVOLVE



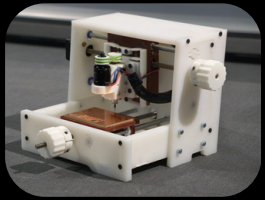
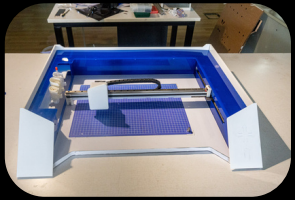
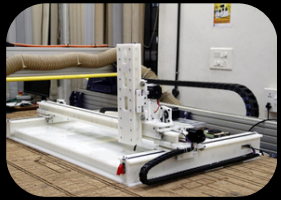
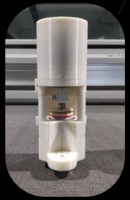
Polyplot

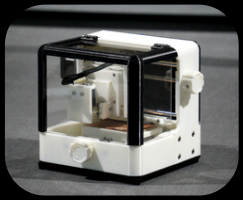
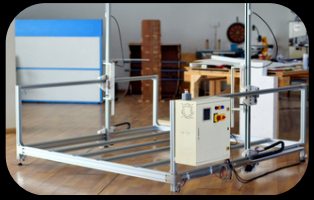
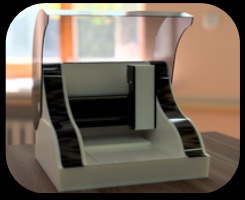




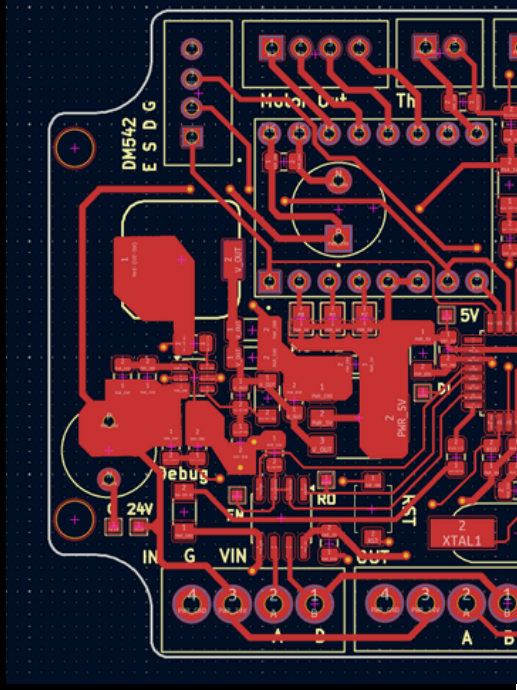
Neo Pico

Machines That Make

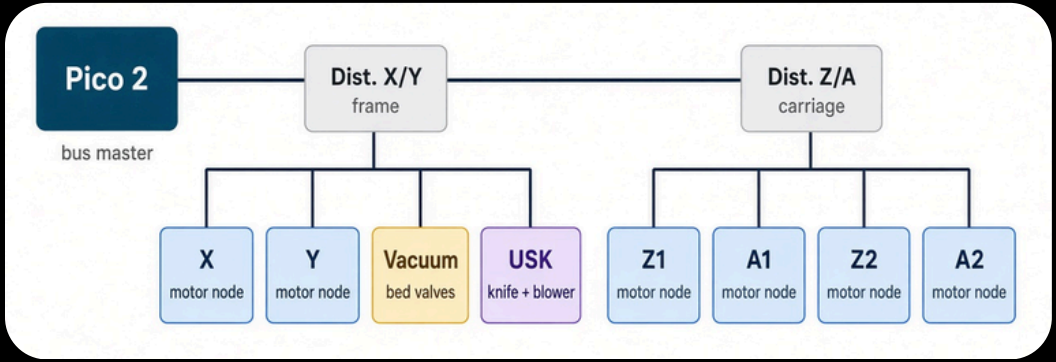




Urumi’s Modular Electronics



Decentralized CNC

Fix one board, or add a tool, and the rest of the machine stays up.



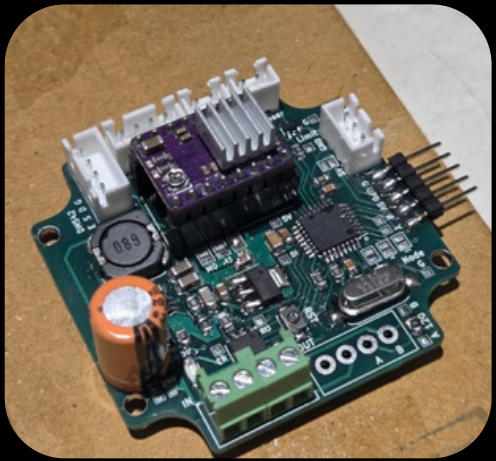
One Board
One Job
One Cable

- Raspberry Pi Pico 2 is the bus master
- Every node uses the same four wires: 24V · GND · A · B
- **RS485**: the data pair runs the length of the machine, next to motor noise
- Plug into a distribution port, or daisy-chain Input to Output

One Board Runs Every Axis

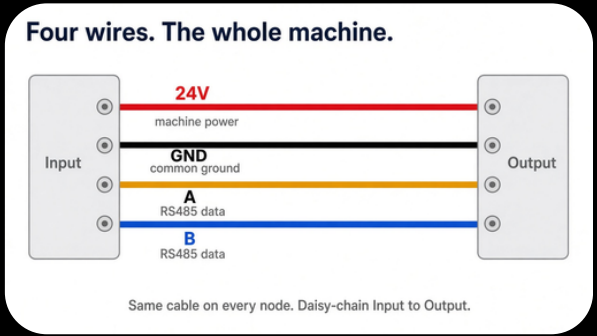
One controller board drives every axis

- Half Duplex RS485
- AVR128DB32 MCU
- Runs on 24V Power Network
- DRV8825 and External STEP/DIR Driver Compatible



One 4-Wire Bus

24V, GND, A, and B. The same cable on every node.



- One cable type, on every board
- Common 24V Power line to power the Motors as well as the nodes
- 2 RS485 Wires for the communication

One Controller

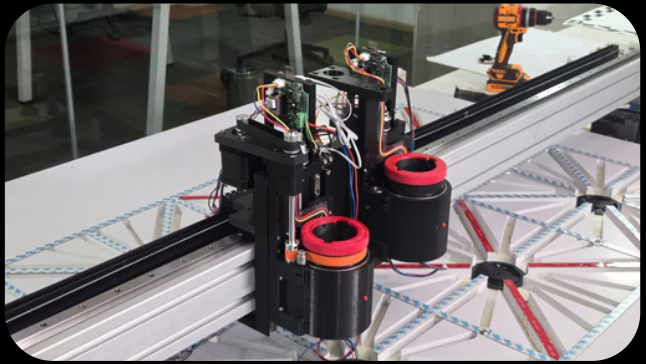
The Pico plans the move. Each node pulses its own motor.



- One Raspberry Pi Pico 2 for the whole machine
- It is the bus master
- Laptop on one side, RS485 nodes on the other

Add, Remove, Replace

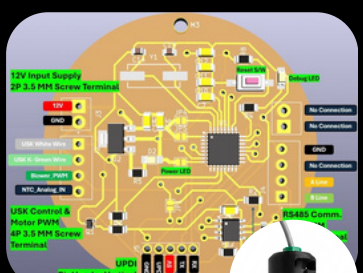
Screw a node on, pull a node off, or swap the one that failed.



- **Add**. Screw the four wires into the green terminal, then give the board an address.
- **Remove**. Pull the node off its port and the other nodes stay on the bus.
- **Replace**. Put a spare on the same four wires with the same address.

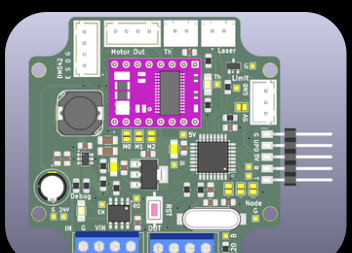
Same Bus, different Jobs

A motor, a knife, or the vacuum bed. Same four wires.



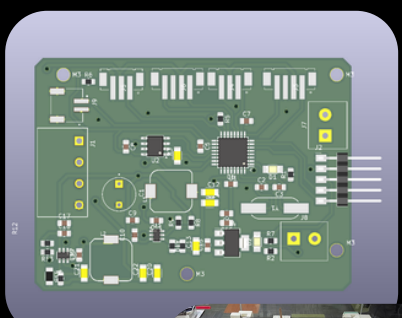


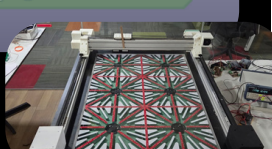
Ultrasonic Knife





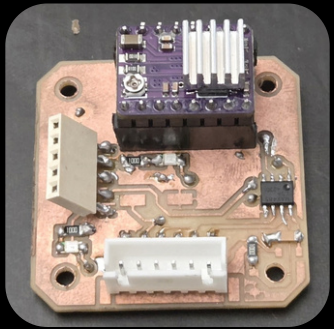
Motor Control



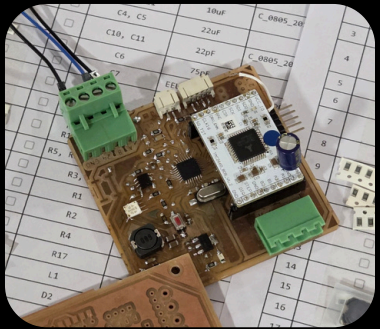


Vacuum Bed

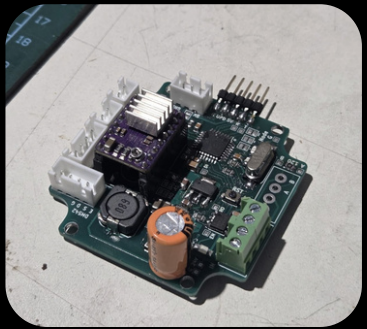
Iterative Prototyping



V1.0



V1.1



V2.1

Lets jump to

Urumi’s Mechanical



DESIGN PHILOSOPHY:

Built for the User, Maker, & Future Evolution

Tabletop Architecture

- Minimal desk footprint
- Easy to operate from a user perspective
- Safe and approachable for classrooms

Manufacturing Perspective

- Optimized for low cost
- Standardized parts
- Scalable local production

Modular Upgradeable Architecture

- Modular Architecture
- Future-Proof Upgrades
- Cost-Efficient Scaling

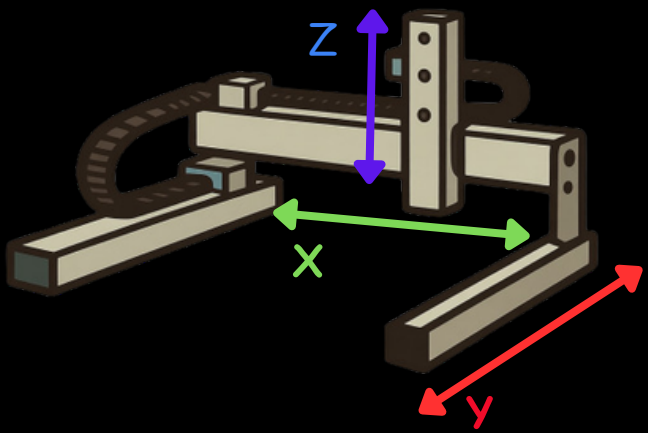
Urumi

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The Physical Form



MECHANICAL ARCHITECTURE



Cartesian Layout Foundation

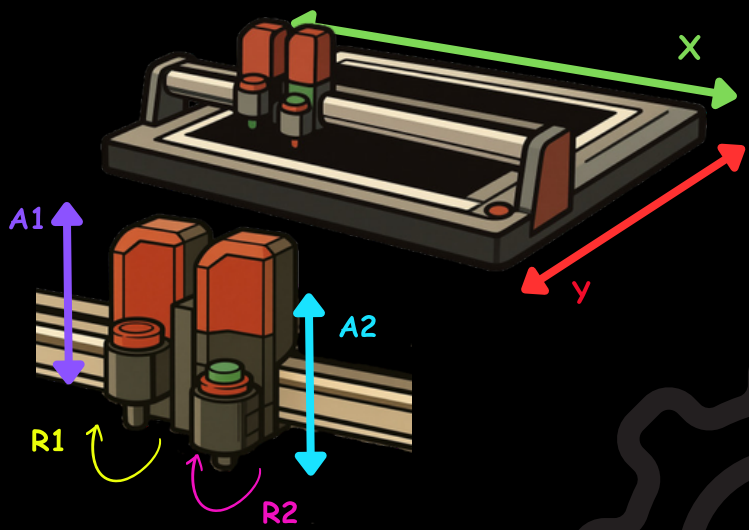
X and Y axes operating on separate planes for stability and clear workspace access.

MECHANICAL ARCHITECTURE

The 6-Axis Motion System

The6-Axis Breakdown

- 2 × Primary Axes (X & Y): Gantry travel and bed movement.
- 2 × A-Axes: Tangential tool orientation control.
- 2 × R-Axes: Tool rotation and auxiliary height control.



TOOLHEAD ECOSYSTEM:

Multi-Material & Custom Plug-and-Play Modules

Ultrasonic Knife & Creasing Wheel

Cleans cuts on tough sheet materials via active cooling; dedicated creasing wheels for clean packaging folds.





TOOLHEAD ECOSYSTEM:

Multi-Material & Custom Plug-and-Play Modules

Automatic Multi-Pen Module

Houses multiple pens simultaneously; switches dynamically via tool logic using cheap local refills.



TOOLHEAD ECOSYSTEM:

Multi-Material & Custom Plug-and-Play Modules

User-Defined Custom Tool Modules

- Custom tool heads can be built independently by users to suit specific workflow needs.
- Seamless integration: simply connect the custom module to the machine's network bus for instant auto-recognition and control.



WORK-HOLDING & ACOUSTICS

Zoned Vacuum & Silence

6-Zone Independent Vacuum Bed

- Split into 6 separate sections that can be individually toggled on/off to match material size.
- Custom-designed mechanical valves actuated by cheap, reliable MG996 hobby servos.







WORK-HOLDING & ACOUSTICS

Zoned Vacuum & Silence

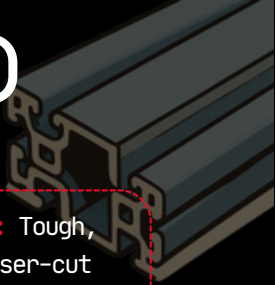
Acoustic Engineering

- Custom-built enclosure for the vacuum motor.
- Tailored air-velocity muffler and sound-absorbing foam coating to reduce operational noise in classrooms.



DESIGN FOR REPAIR (DFMR)

Locally Sourced & Field-Serviceable



Structural Framing: Standard Aluminum Extrusions for universal compatibility and rigid alignment.

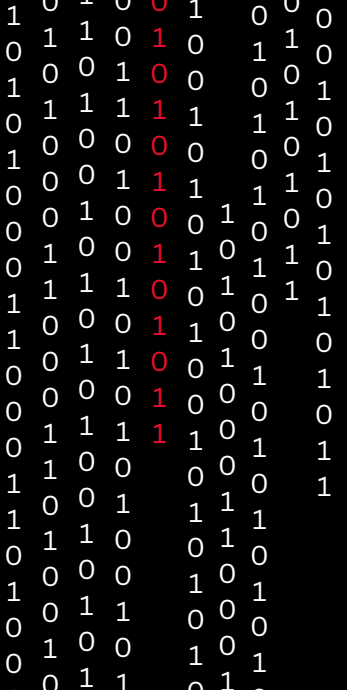
Enclosures & Accents: Tough, easily machinable laser-cut acrylic and 3D-printed parts.

Bed Materials: Weather-resistant, air-permeable multi-wood layered for flat-tolerance vacuum distribution and low cost.

Local Sourcing Philosophy: Designed so that every part—down to the servo valves—can be locally sourced, diagnosed, and repaired by students.

Lets jump to

Urumi’s Software Architecture



How a Classroom Changed the Approach

Limited Computers · Long Wait Times · Complex Workflow Short Attention Spans · High Teacher Workload





Rethinking the Workflow

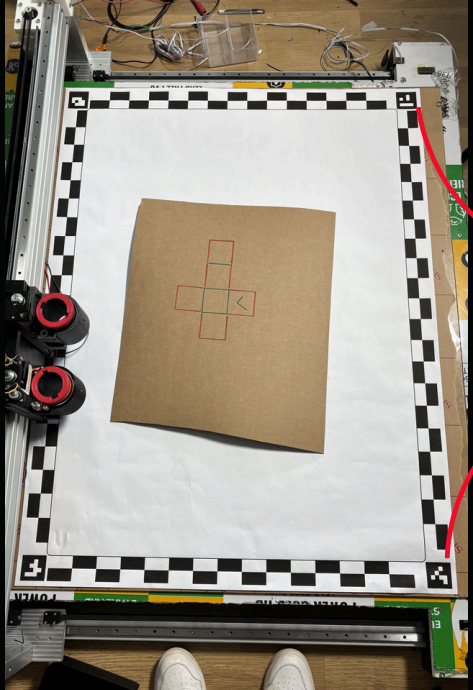


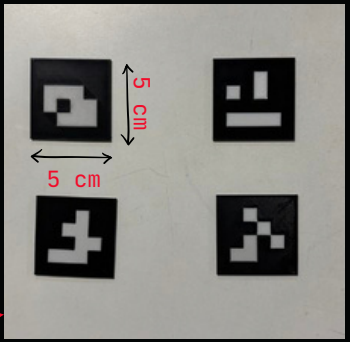
Instead of asking children to adapt to machines... What if machines adapted to children?

Why we scrapped the onboard gantry Camera

Heavy, *expensive*, and nearly impossible to *calibrate*.
We replaced it with the smartphone in your pocket.







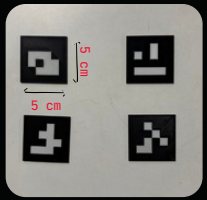
3D Printed ArUco Markers



Perspective Rectification

1. ArUco Anchors

3D Printed frame sets physical scale.



2. Distortion Correction

Eliminates smartphone lens warp.





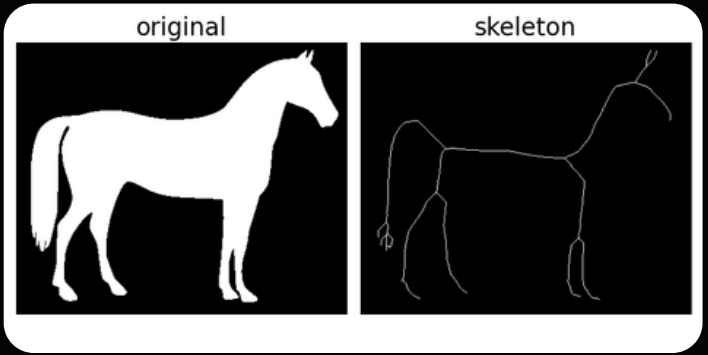
3. Coordinate Mapping

1:1 physical canvas generation.



Extracting intent from ink.

Converting messy, thick hand-drawn marker lines into precise, 1-pixel geometric paths.



Credit: Lingdong Huang 2020

Semantic Ink

HSL filtering maps physical marker colors to distinct CAM toolpaths.



Red Marker Ink

Shallow material scoring.



Blue Marker Ink

Full-depth thru-cut.



Green Marker Ink

Folding crease pass.

The Ink2Axis Pipeline

1. Capture

Smartphone photo over ArUco frame.

2. Rectify

OpenCV perspective correction.

3. Skeletonize

HSL voting and path extraction.

4. Execute

WebSerial direct hardware control.



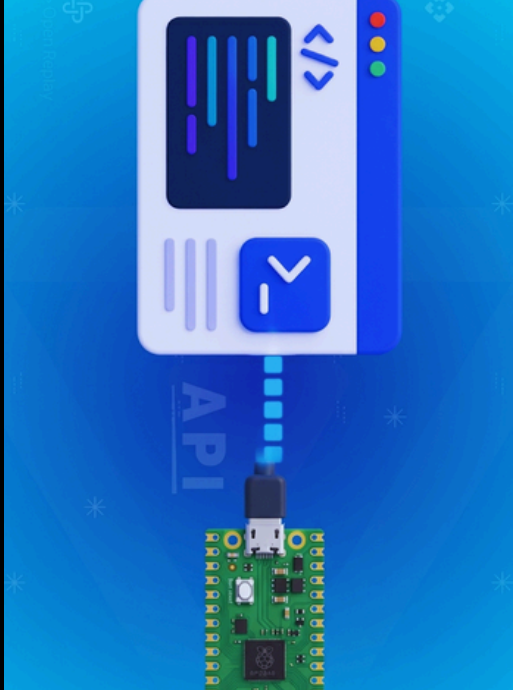
Traditional CAM requires installations, proprietary senders, and heavy G-code translation.

So we built a zero-dependency stack.

WebSerial API

The browser talks directly to
the machine over the RS-485 bus.

- ✗ No backend servers.
- ✗ No middleware senders.
- ✓ Easy and Instant classroom setup
- ✓ Plug and Play.



Client-Side CAM Math

Vanilla JavaScript doing the heavy lifting in-browser.



Bezier Flattening

Native curve subdivision math.

Arc-Length

Uniform step parameterization.



Knife Angles

Tangential orientation calculation.

Zero G-Code

We process raw SVG path geometry and translate it directly into synchronized stepper pulses.

Join the Journey

Urumi is open source. Build it. Improve it. Make it your own.



Humans behind Urumi

Project Documentation

Freedom to fabricate. Decentralized CNC. CNC4Everyone.