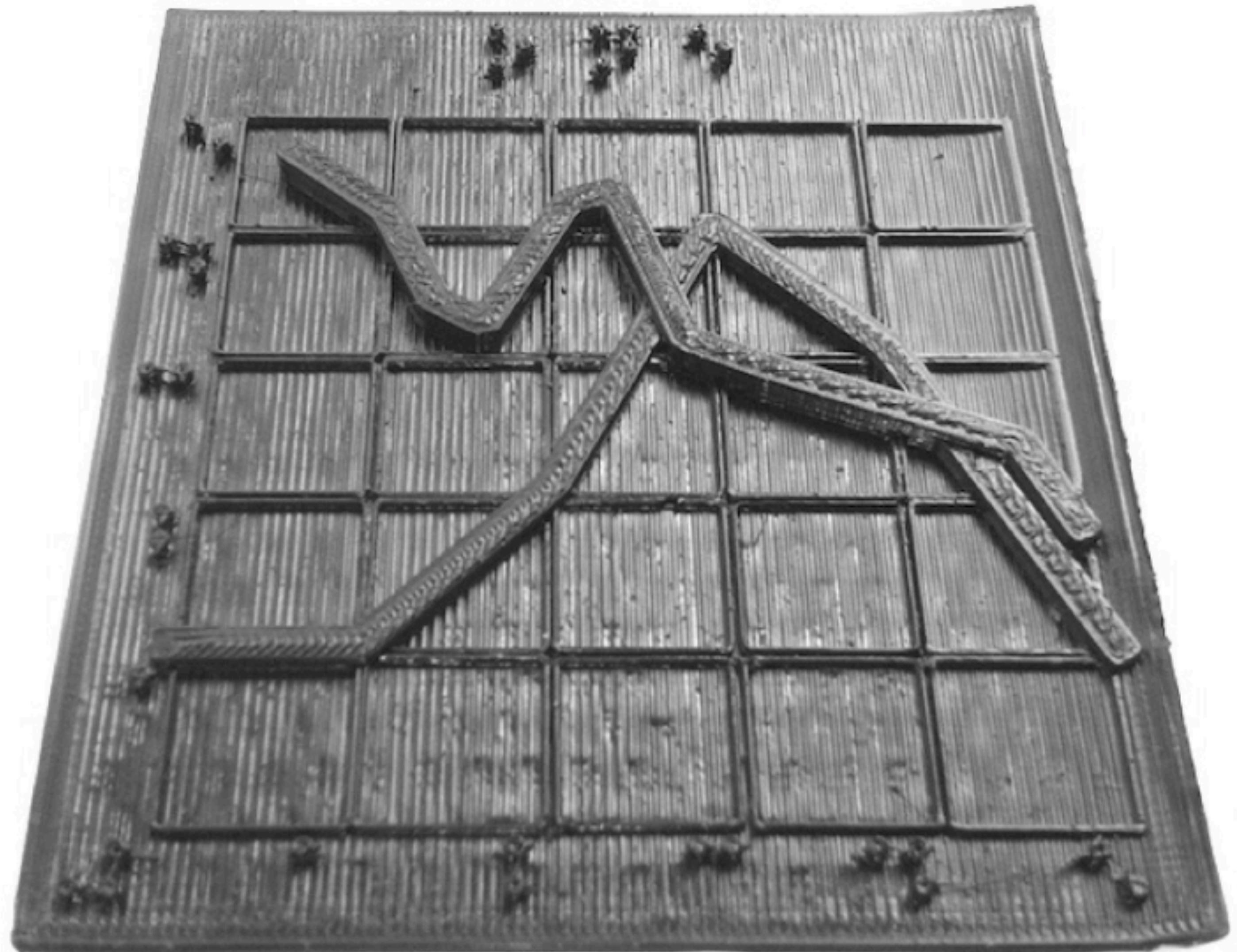


Tactile Interaction



Where we're at in the course

- The end of the semester 😭
- What's left:
 - Tactile graphics (this week)
 - Collaborative accessibility and DIY AT
 - Cognitive accessibility
 - Crowdsourcing
 - Finishing up the projects

Remaining work

1. A few reading assignments
2. Our last mini-assignment: designing tactile graphics (in class Wednesday)
3. Game project

Prep for Wednesday

- We'll be making and testing tactile graphics
- Think about materials you might want to use, and get them

Project demos

- We will present our projects during our last class meeting
- Wednesday May 1, 4:30-5:45pm
- Invite friends if you'd like
- Informal awards for best demo

Tactile Graphics & Tangible Interaction

The big idea

- Tactile interaction can be a good way to communicate information
- New technology makes it easier to create and distribute tactile graphics
- **But:** tactile perception works differently than vision
- Translation forces us to consider what's important

About tactile graphics

- Does anyone have experience using tactile graphics?

Tactile graphics

- Purpose
- Technologies
- Perception
- Cool examples (including from CU)
- Open challenges
- Activity

Purpose

- Provide spatial and visual information to people with vision impairments
- Maps, diagrams, some art
- Can provide much needed access to independence, support learning (often in STEM fields)
- Also useful for multimodal learners

Benefits of tactile vs. audio?

- Or... come up with examples that would work well in tactile but not audio

Benefits of tactile vs. audio

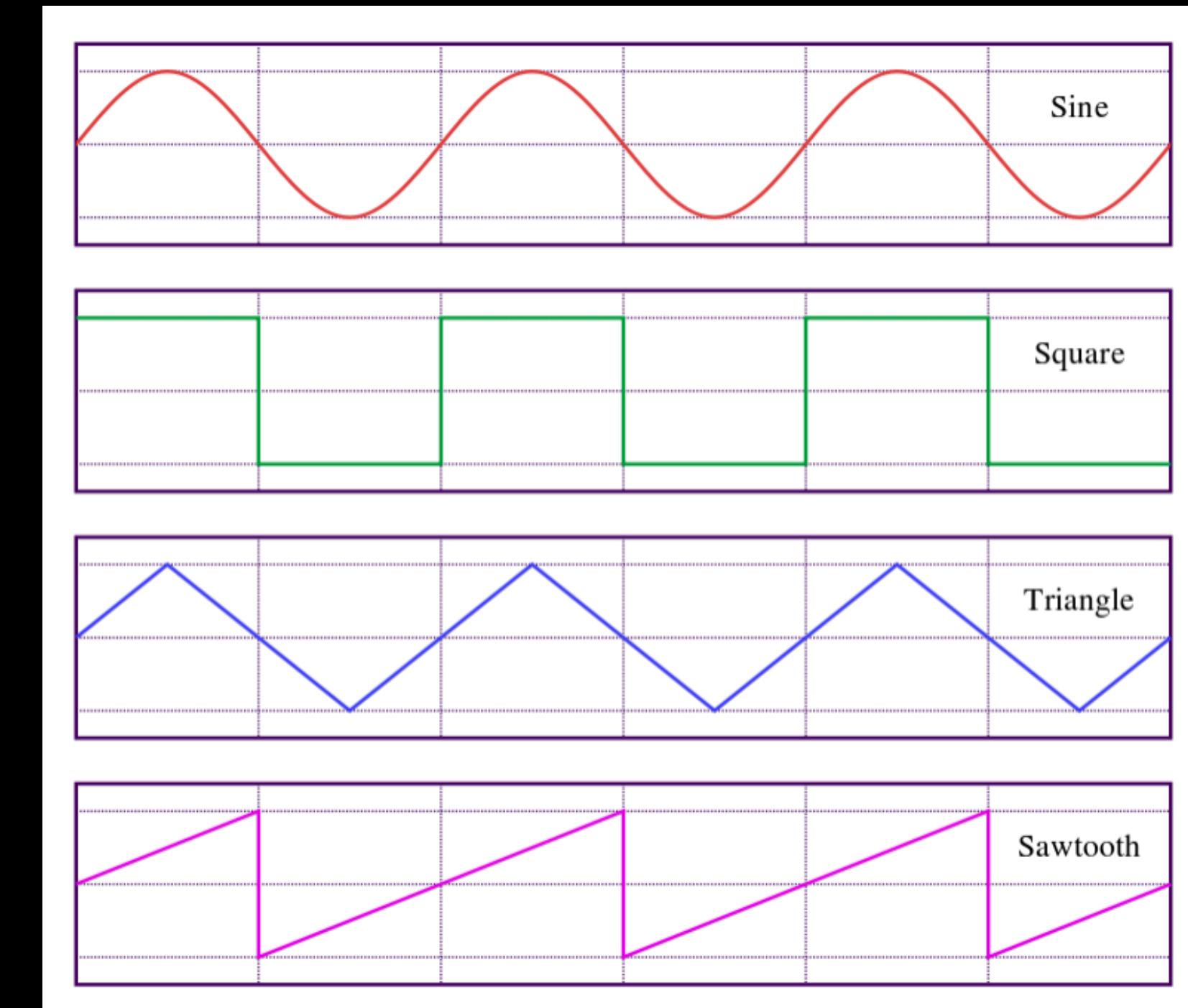
Some benefits

- Multiple simultaneous information streams
- Can be combined with audio
- Some things just can't easily be described in prose

Use cases

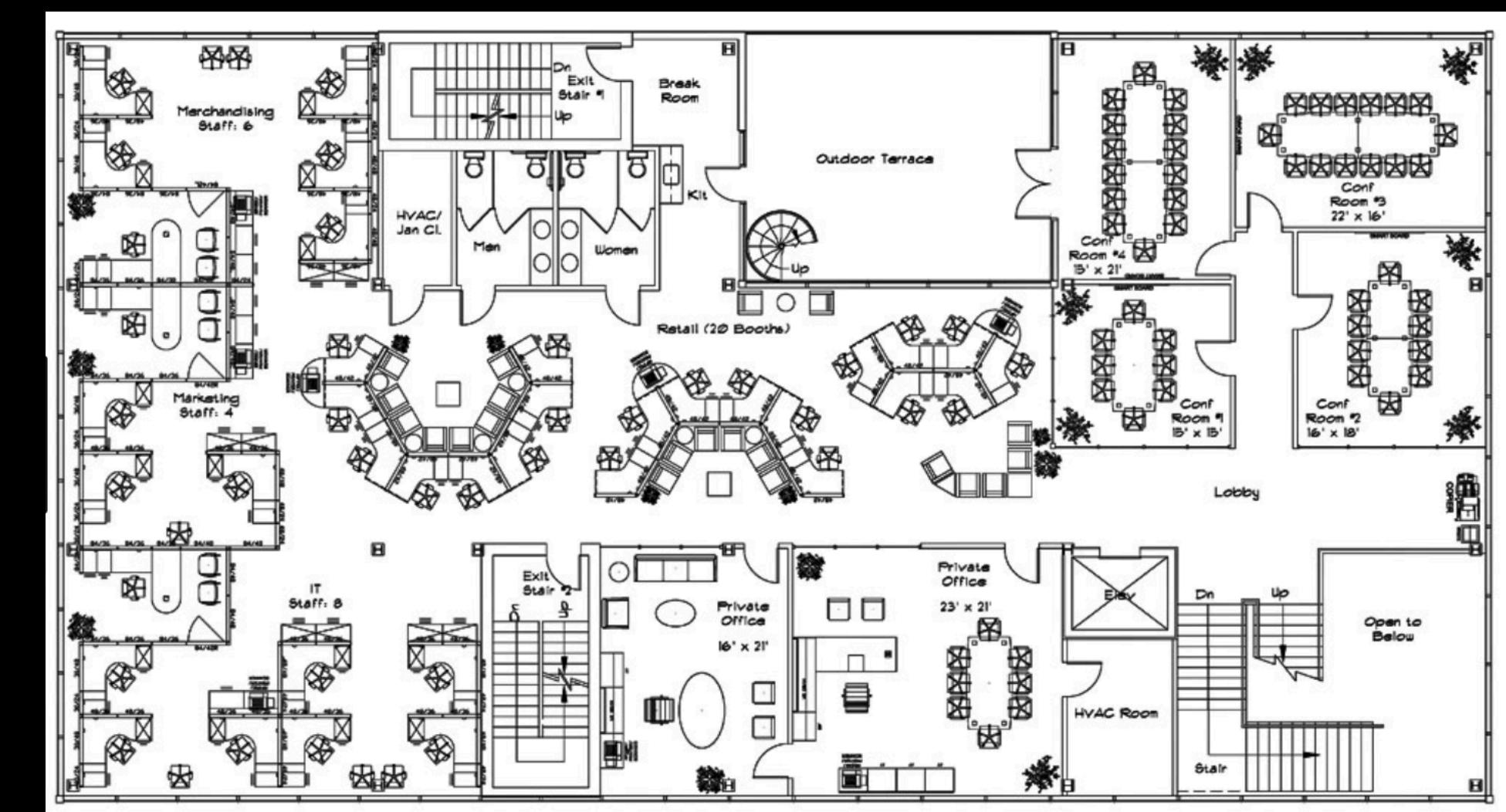


Complex contours



Comparing shapes

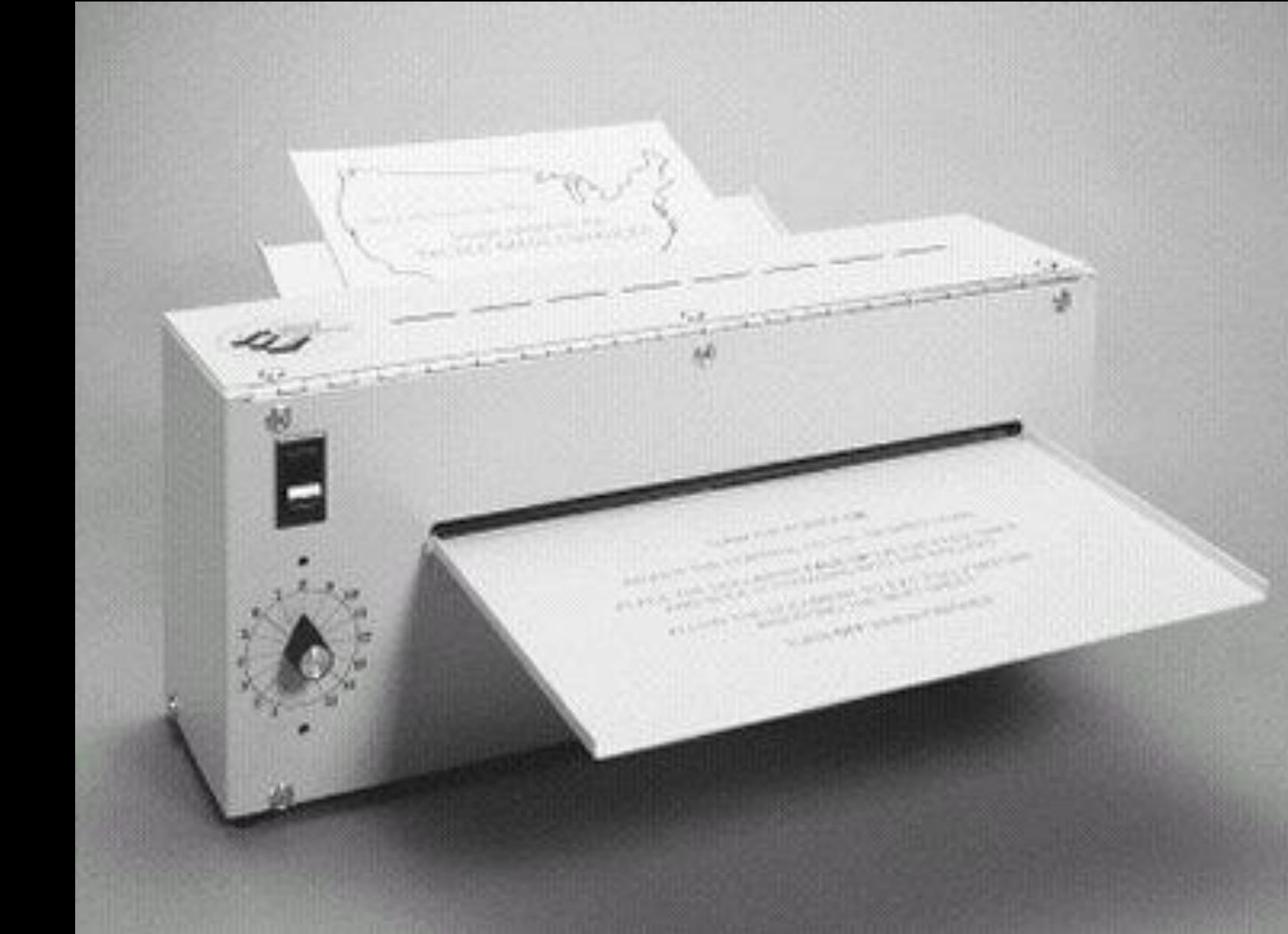
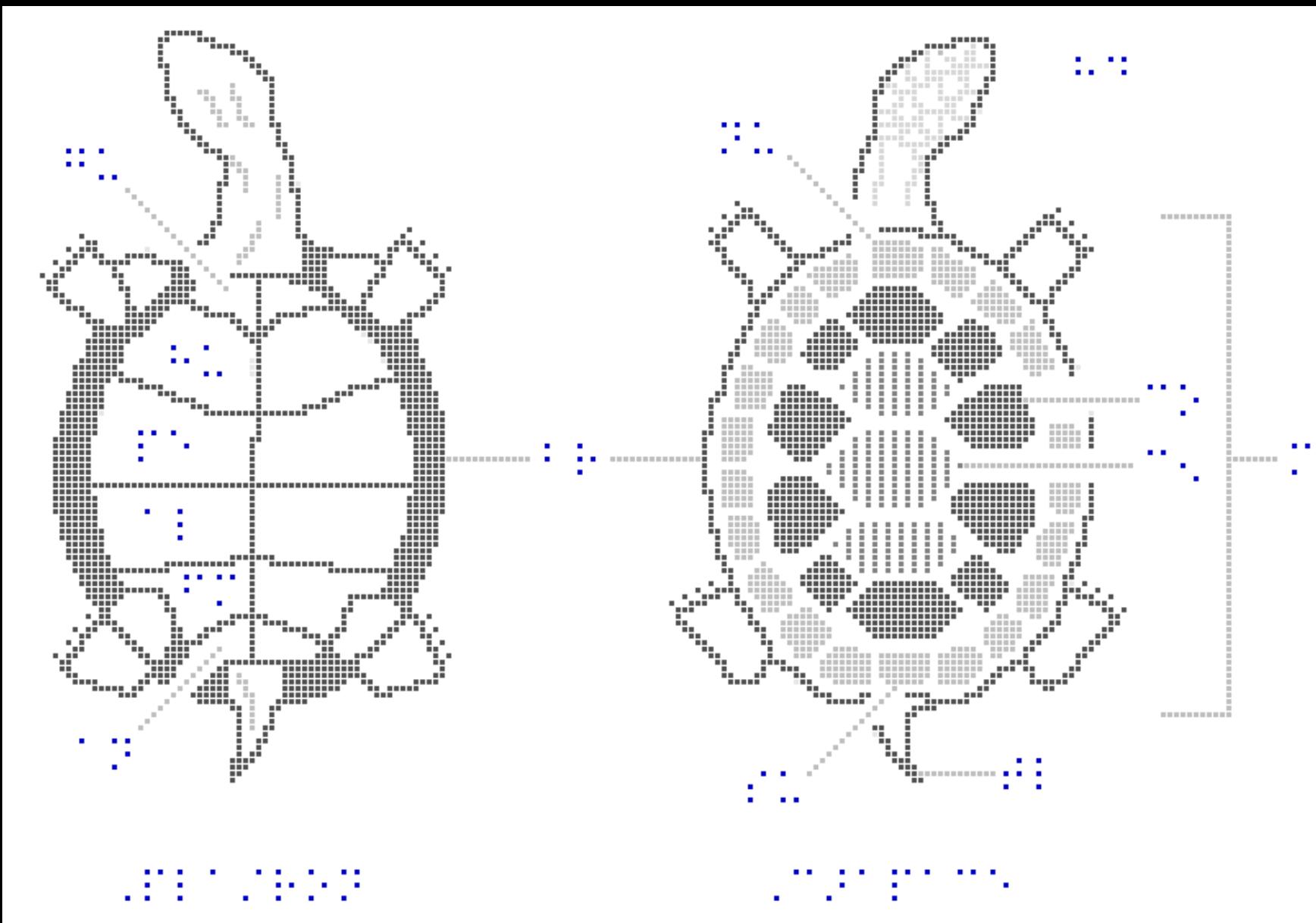
Complex spatial relations



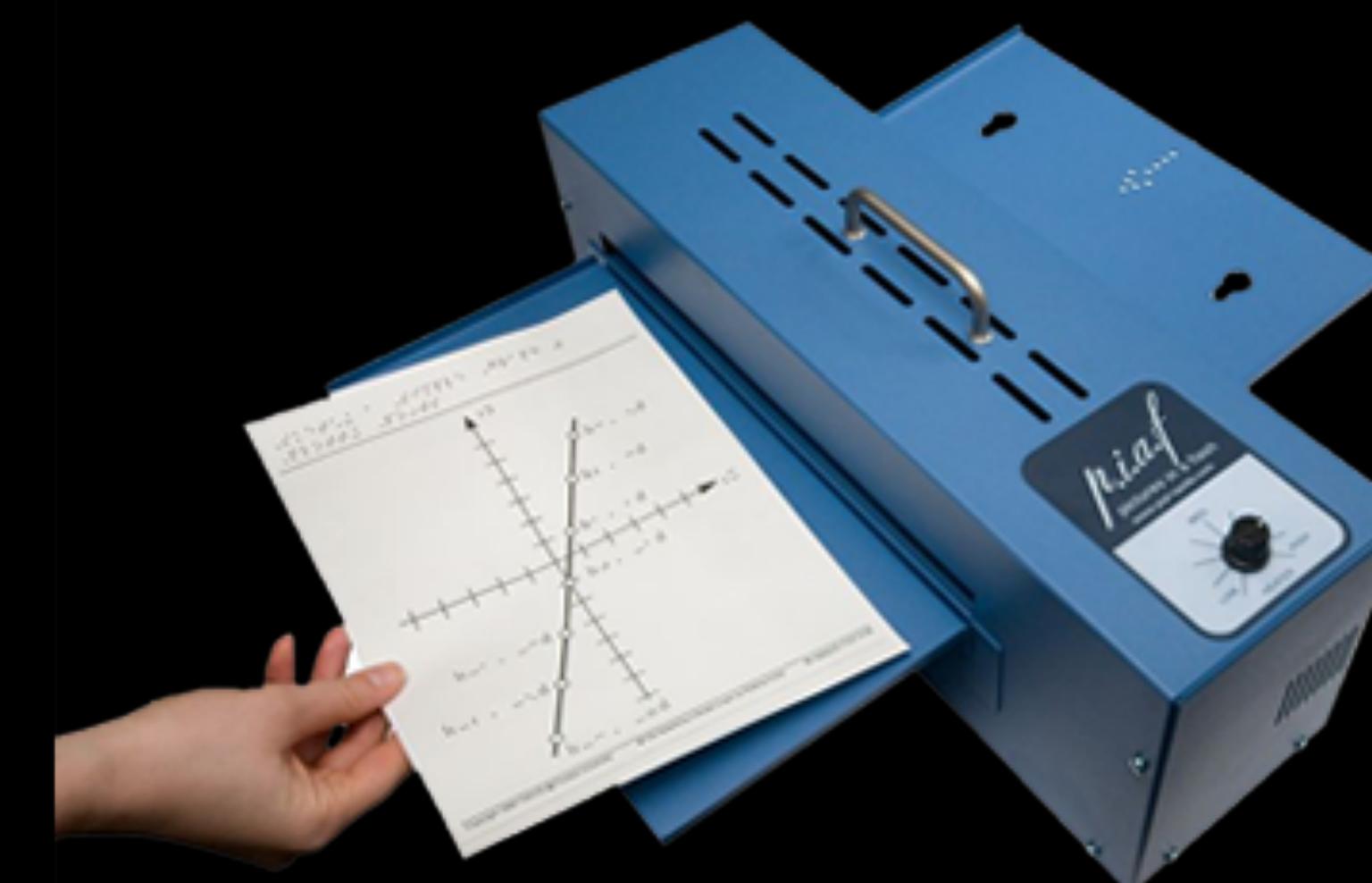
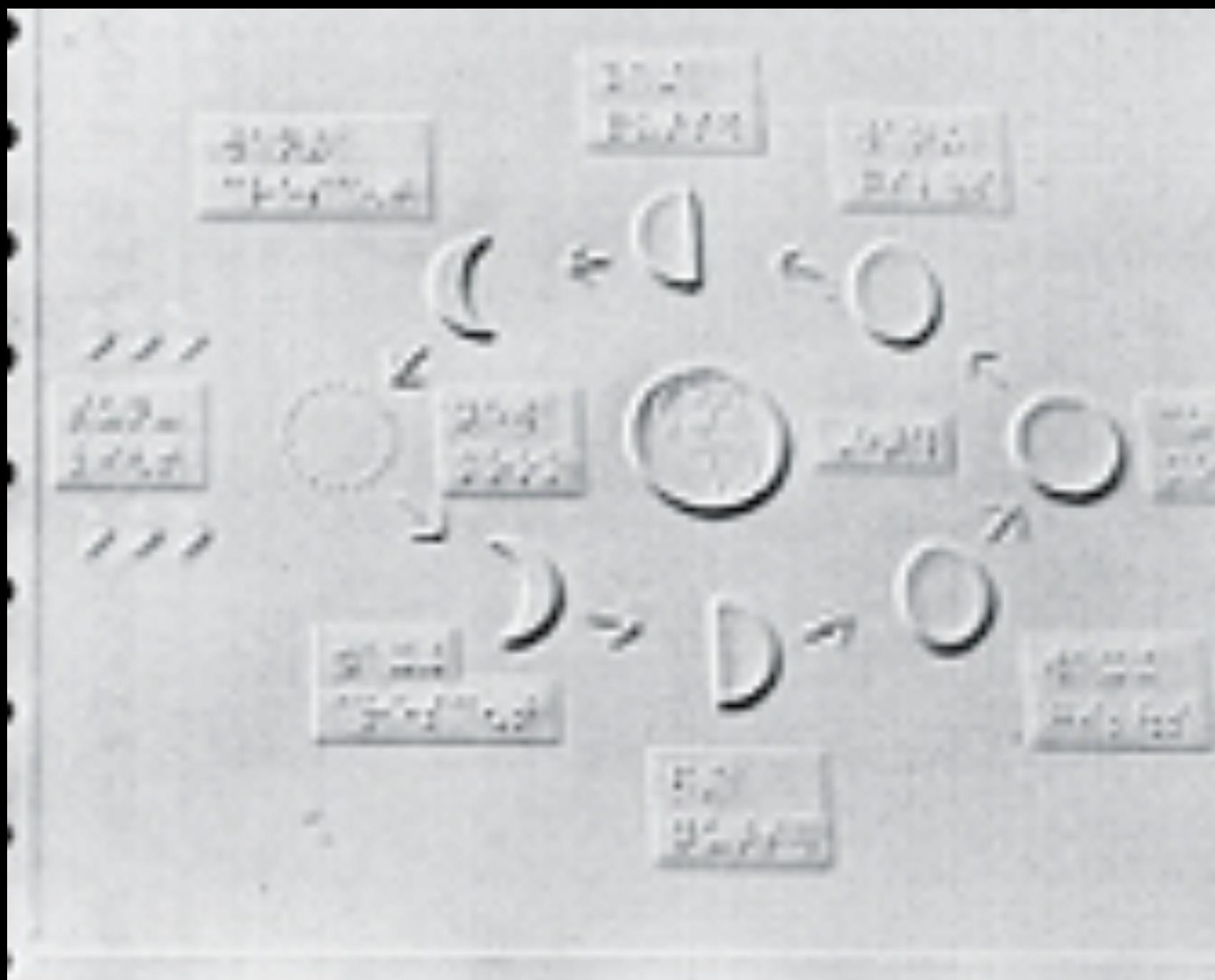
Tactile graphics technologies

- Embosser
- Swell paper
- Low-tech (Legos, wiki stix)
- Laser cutter
- 3D printing
- Future technologies

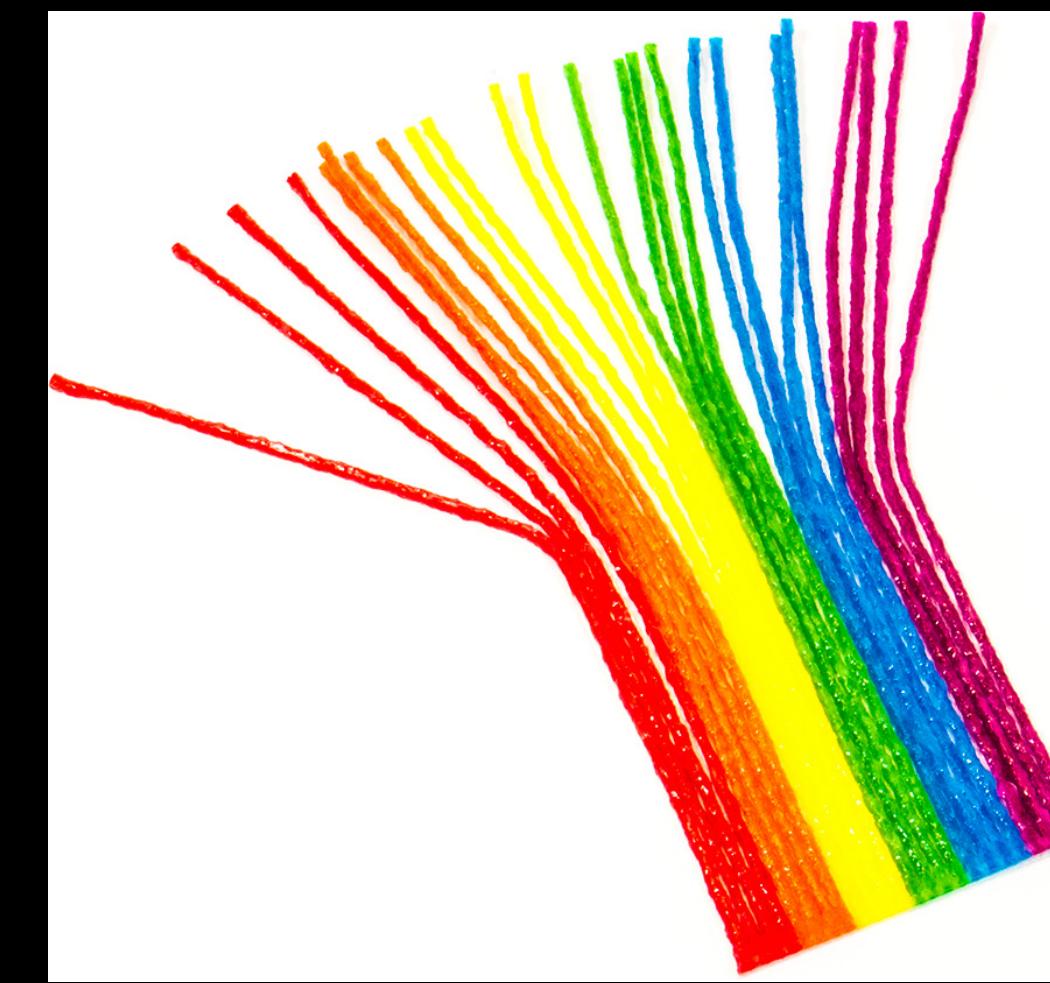
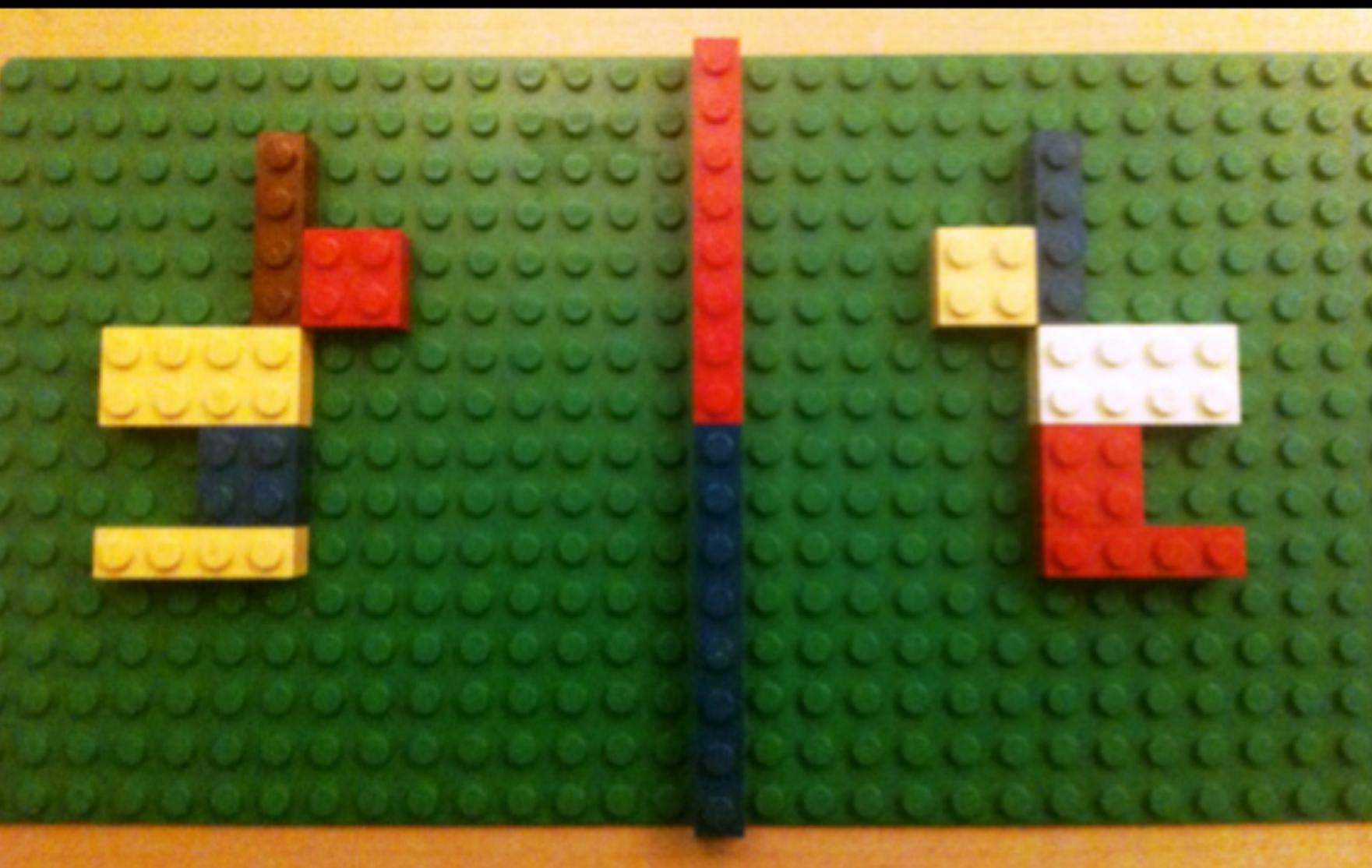
Embosser



Swell paper

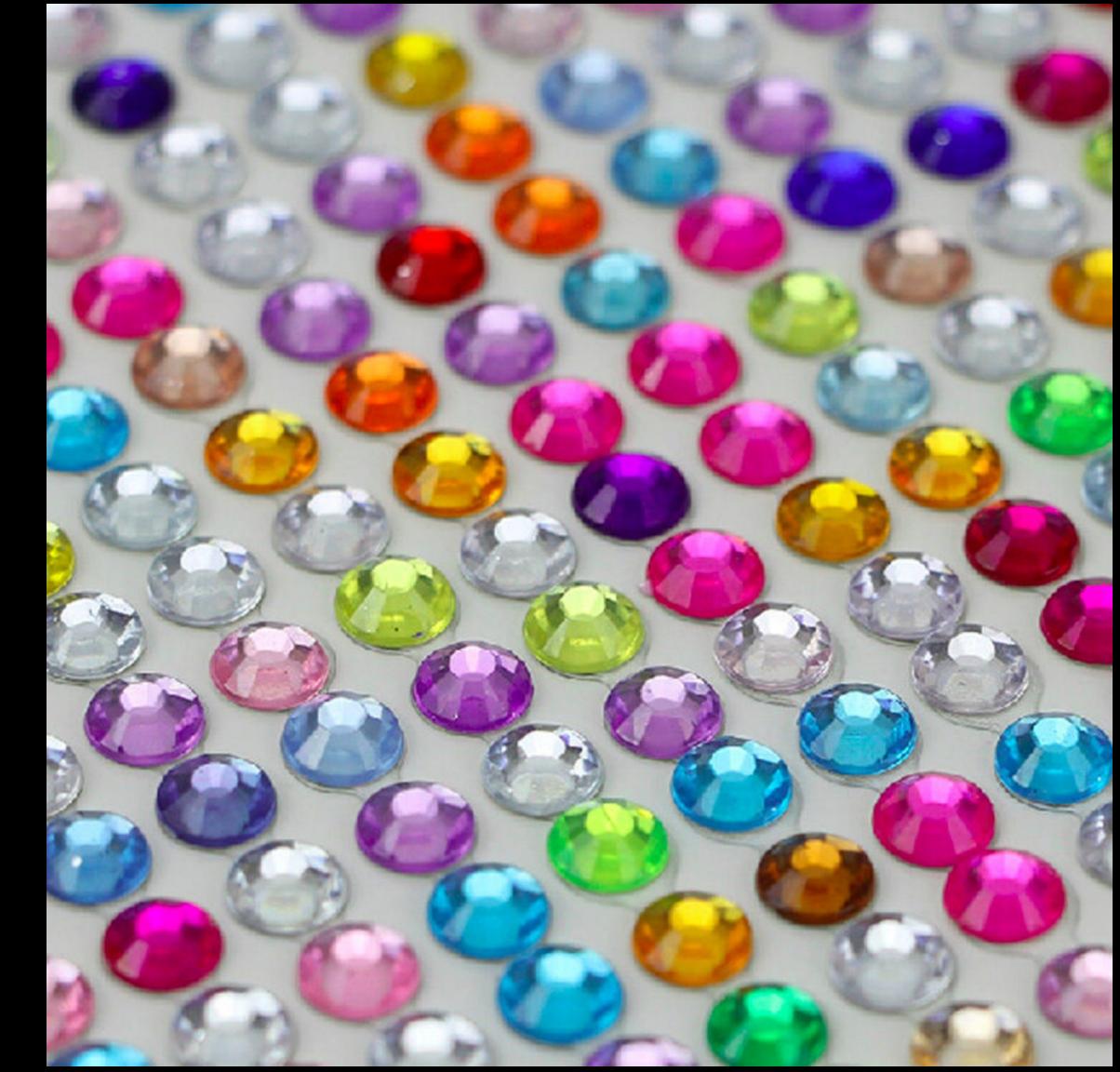


Low-tech



Common low-tech materials

- Sticky dots/gems
- Wikki stix (wax coated string)
- Lego bricks
- Cardboard/paper/stickers
- Puff paint
- Toys & other everyday objects
- 3D models



[Inbox \(1,799\) - shaunkane@gmail.com - Gmail](#) [pinterest.com](#)

[Pinterest](#) [Search for easy dinners, fashion, etc.](#) [Sign up](#) [Log in](#) [...](#)

Tactile Graphics

Collection by [Lindsay Pritchett](#)

[Follow](#)

Maps!
Bring A Map To Life

A staple at my summer parties. Everyone forgets

[lindsay Pritchett](#)
Tactile Graphics
[See more](#)

Freebie to help you- Rock your Blocks Center! Just add felt or foam...

[lindsay Pritchett](#)
Tactile Graphics
[See more](#)

Free Tactile Teaching Aids!

[lindsay Pritchett](#)
Tactile Activities
[See more](#)

The Art of Finding - A...

Pool Storage | Diy Pool | Pool Fun | Pool >

A staple at my summer parties. Everyone forgets

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Tactile Graphics
[See more](#)

Perkins Teachable Moments

The Use of Wikki Stix Within the Classroom

Open

[lindsay Pritchett](#)
Tactile Graphics
[See more](#)

The Use of Wikki Stix Within...

No Vidente | Teaching Tools | Student Tea >

Kate Fraser talks about the use of Wikki Sticks within the classroom.

[lindsay Pritchett](#)
Tactile Graphics
[See more](#)

Creating Large Print and...

[lindsay Pritchett](#)
Tactile Activities
[See more](#)

Large Print and Tactile Graphs for Students who are Visually Impaired

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Tactile Activities
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Perkins

Teachable Moments

The Use of Wikki Stix Within the Classroom

Open

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Making Graphs tactful for students with visual impairments.

[lindsay Pritchett](#)
Tactile Graphics
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A User's Guide to TOUCH and LEARN Tactile Activity Book

SUN CLOUD RAINBOW

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Tactile Graphics
[See more](#)

National Braille Press offers blind children the power of literacy and...

[lindsay Pritchett](#)
Tactile Graphics
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Teaching Tactile Graphics

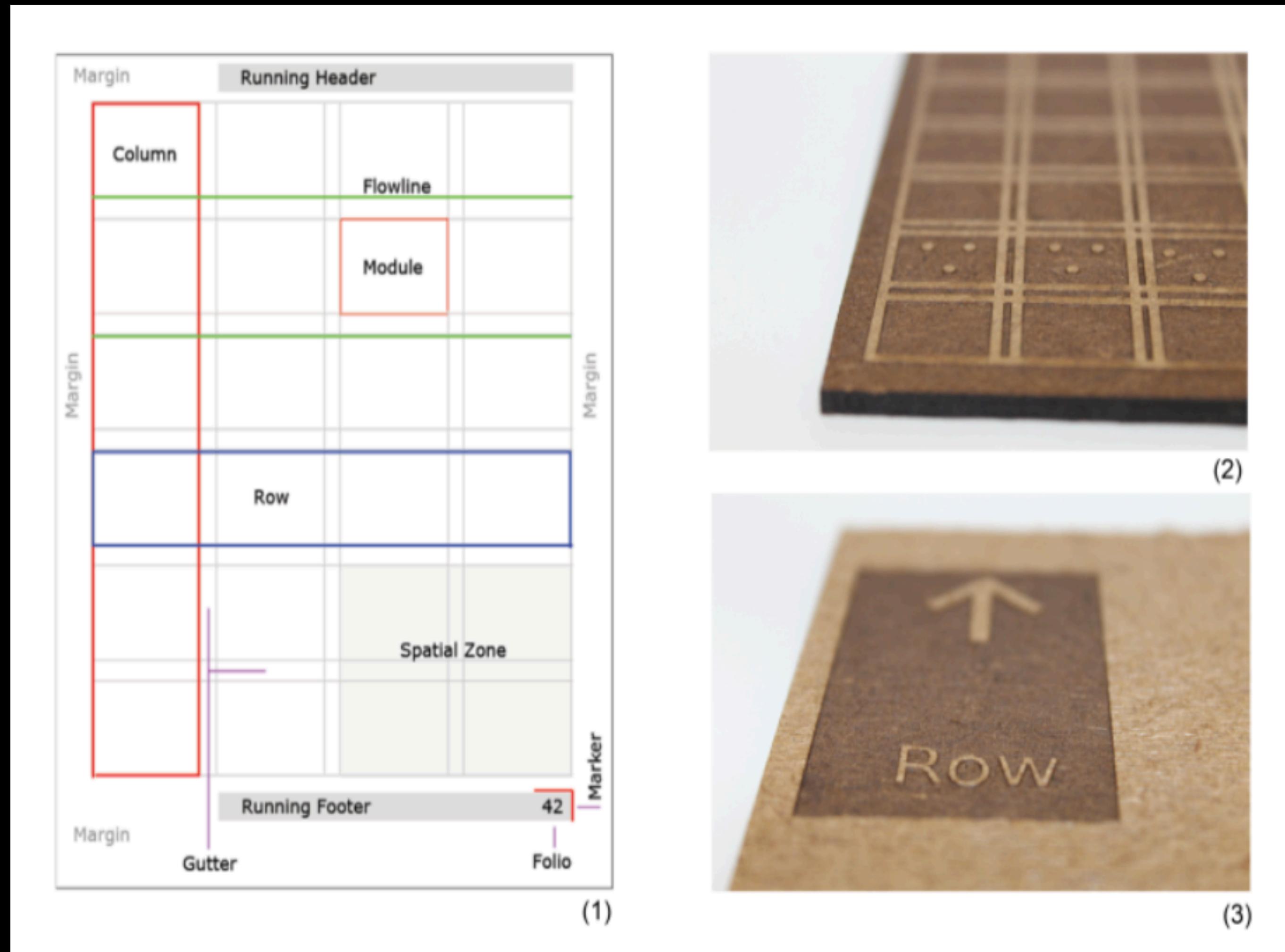
[lindsay Pritchett](#)
Tactile Graphics
[See more](#)

Sketchpad to Create Tactile Books

[lindsay Pritchett](#)
Tactile Graphics
[See more](#)

Privacy

Laser cutter



3D printing



www.thingiverse.com/tag:tactile_graphics

wil Tactile aids f... 3d printed ta... 3d-printing-... inform mit -... The GT Acce... Ask MetaFilter drawing cat... cute kitten p... Things tagge... +

Thingiverse DASHBOARD EXPLORE EDUCATION CREATE Enter a search term SIGN IN / JOIN

Things tagged with 'tactile_graphics' (11 Things)

Silence tactile book (English ... by jenniferm Jan 14, 2017

5 5 0

Moon for the Blind by Feelform Nov 21, 2016

0 3 0

tactile graphics by JanBecker Nov 4, 2016

1 1 0

Silencio libro táctil (Texto en ... by jenniferm Sep 8, 2016

15 15 5

HomeMade Domotique by maxh96 Dec 5, 2015

1 1 0

Volcano Cutaway by jaqtikkun Oct 22, 2014

16 19 0

Convergent Boundary of tect... by jaqtikkun Oct 8, 2014

0 0 0

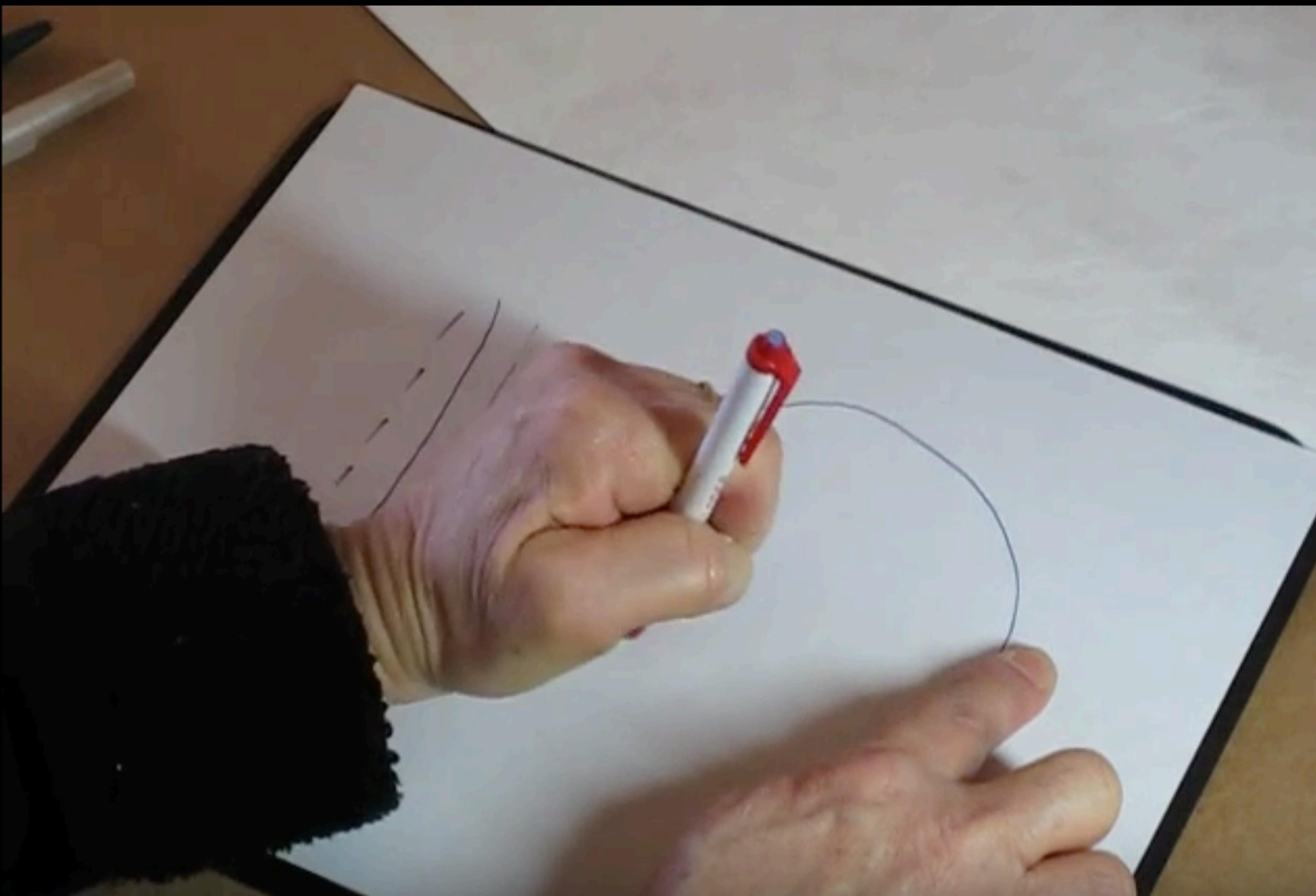
Soil Layer Blocks by jaqtikkun Oct 8, 2014

0 0 0

Dear Zoo by TactilePictureBooks Sep 8, 2014

0 0 0

Tactile input



Which technology is right?

- Consider:
 - Access to tech / ease of deployment
 - Tools / skills needed to create
 - Need raised line (“2.5D”) or 3D shape?
 - Need for interactivity

Tactile graphics vs. sonification



Tactile graphics vs. sonification

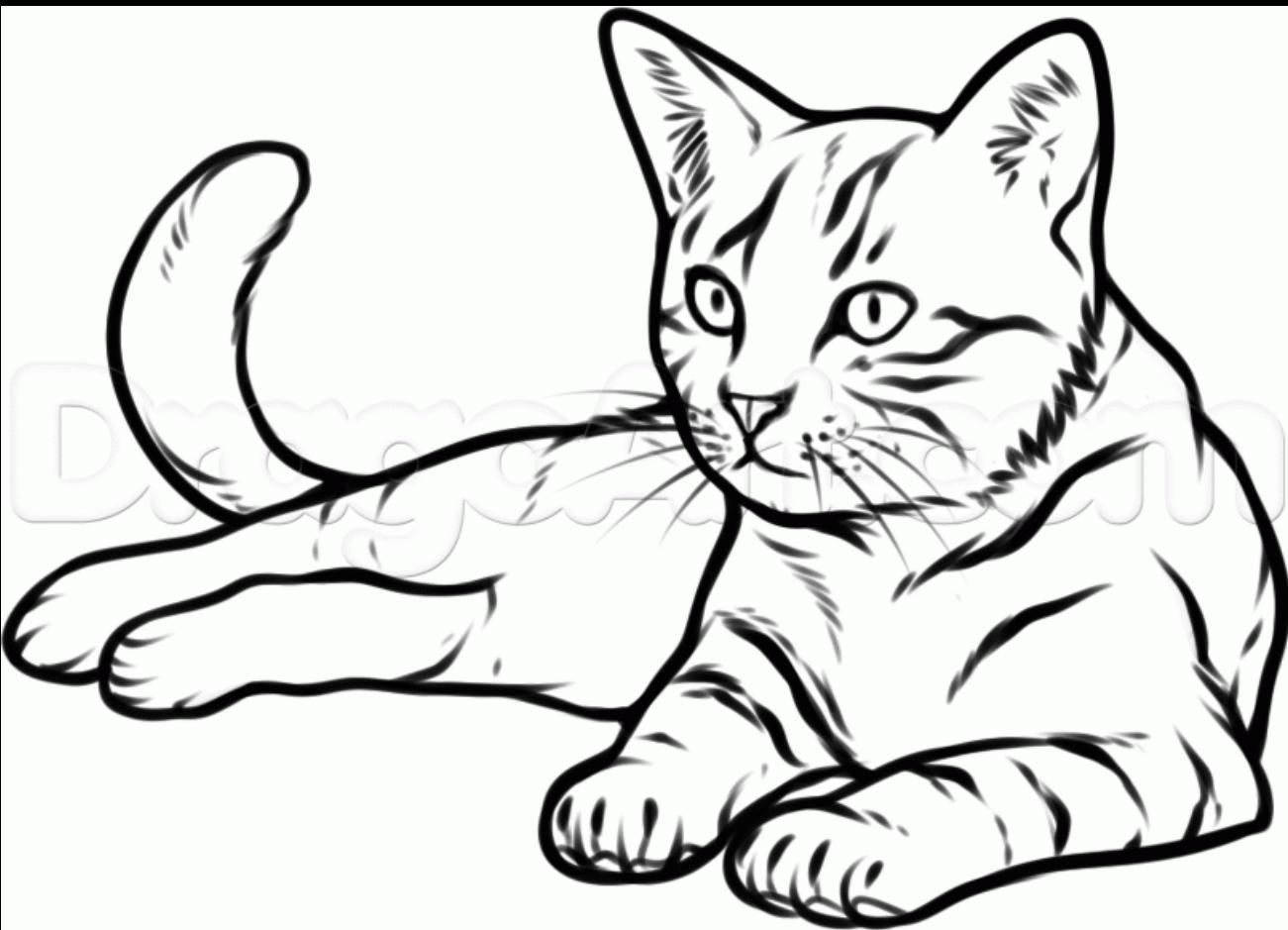
Challenges in tactile graphics

- Experts needed to translate (traditionally often done by prisoners)
- Understanding effective tactile representations
- Handling superimposed visual information
- Labeling
- Supporting multimedia and moving information

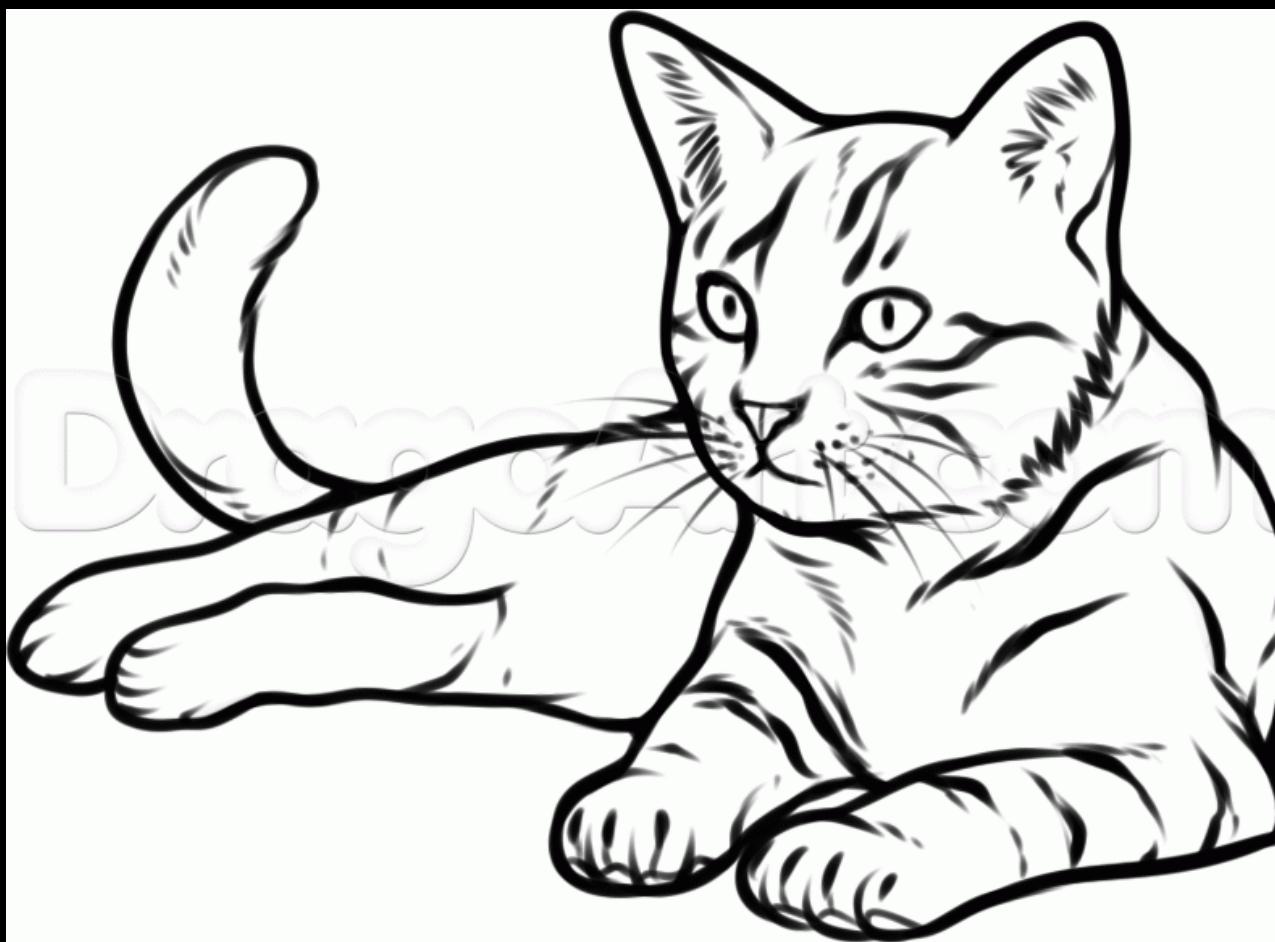
Tactile literacy

- Must be trained, not inherently known
- How to recognize different textures, identify shapes and markers
- Much of our understanding of images is inherently visual, not intuitive in non-visual contexts
- Whole-part learning

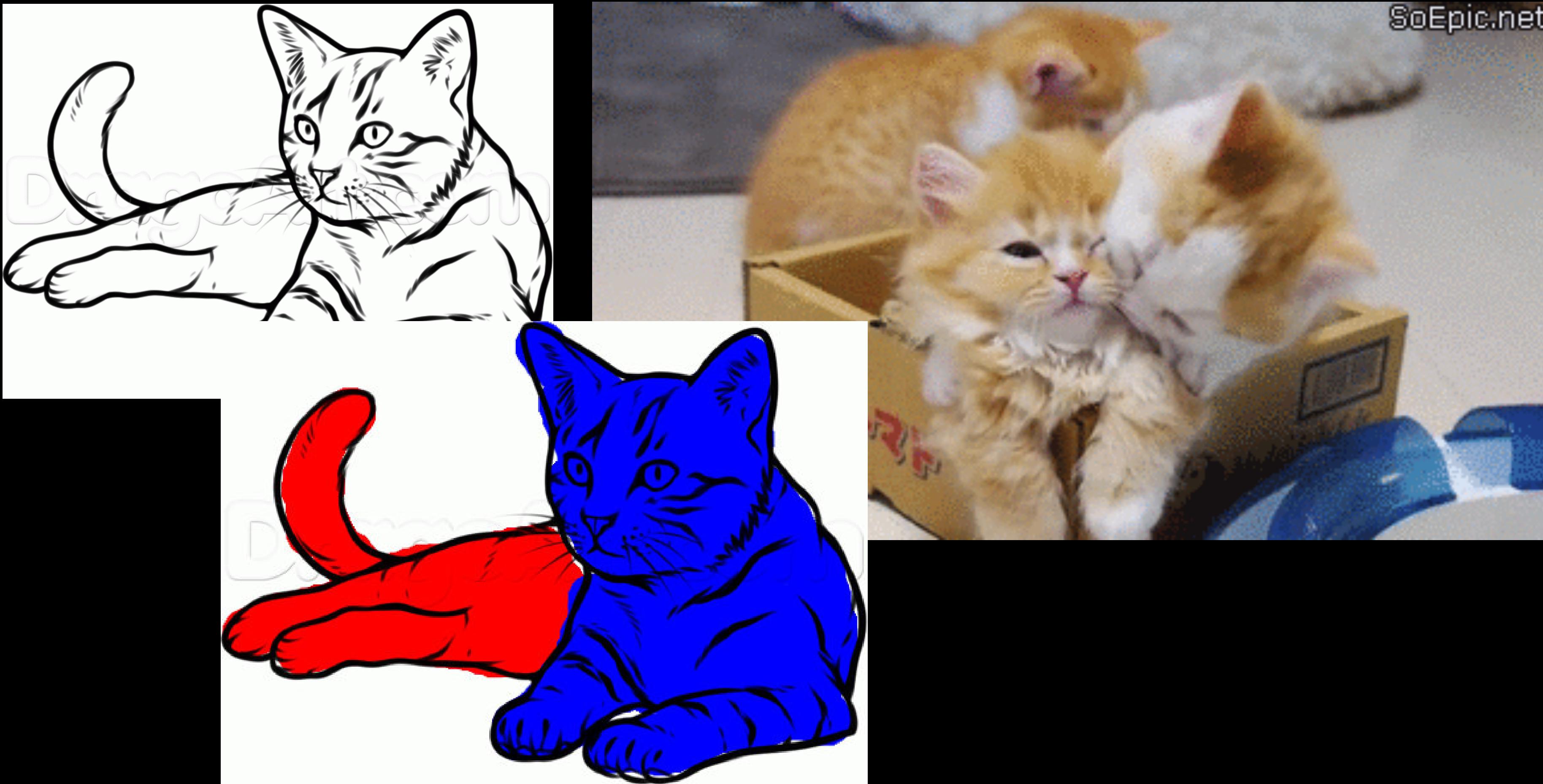
How to tactile-ize images



How to tactile-ize images

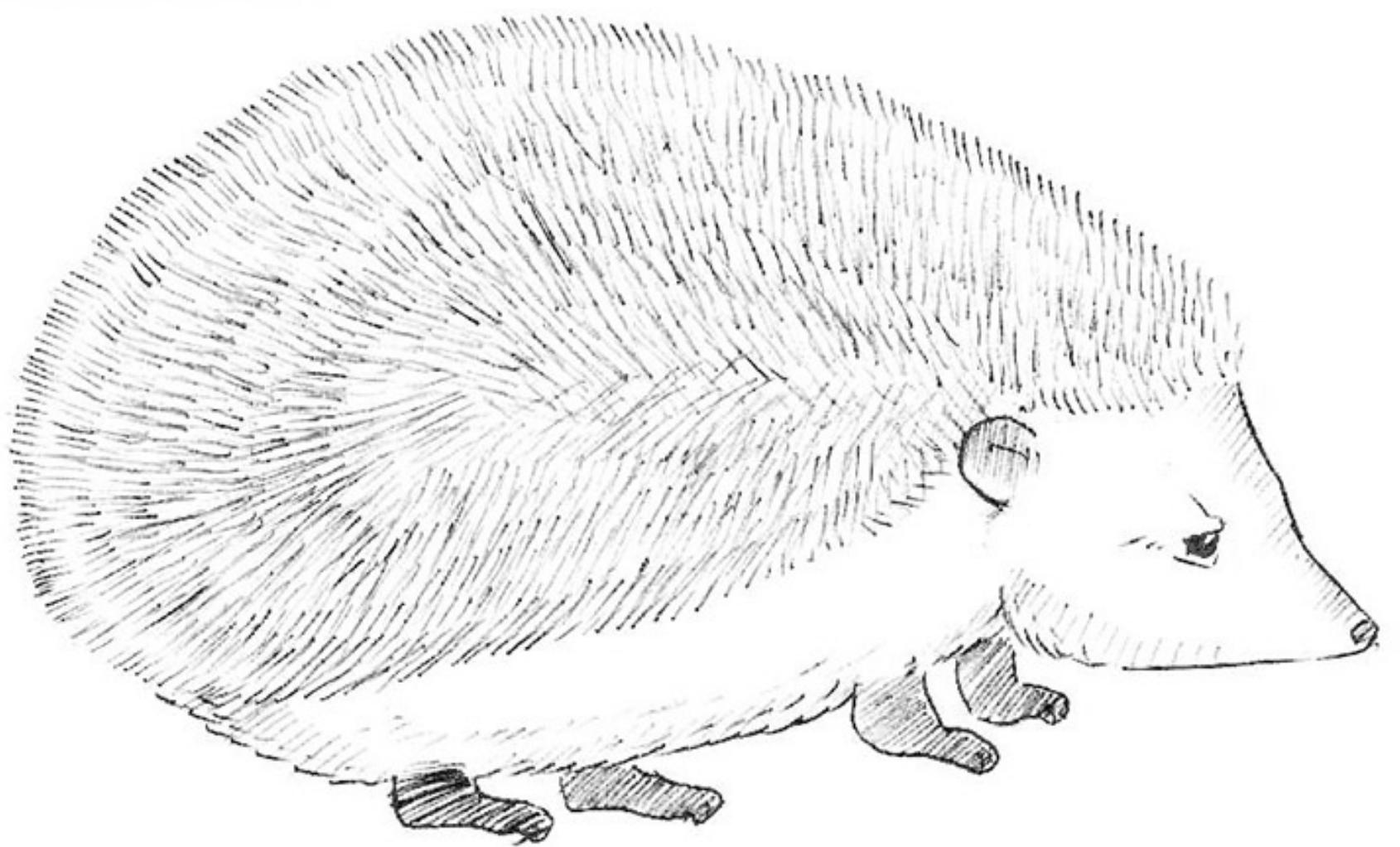


How to tactile-ize images

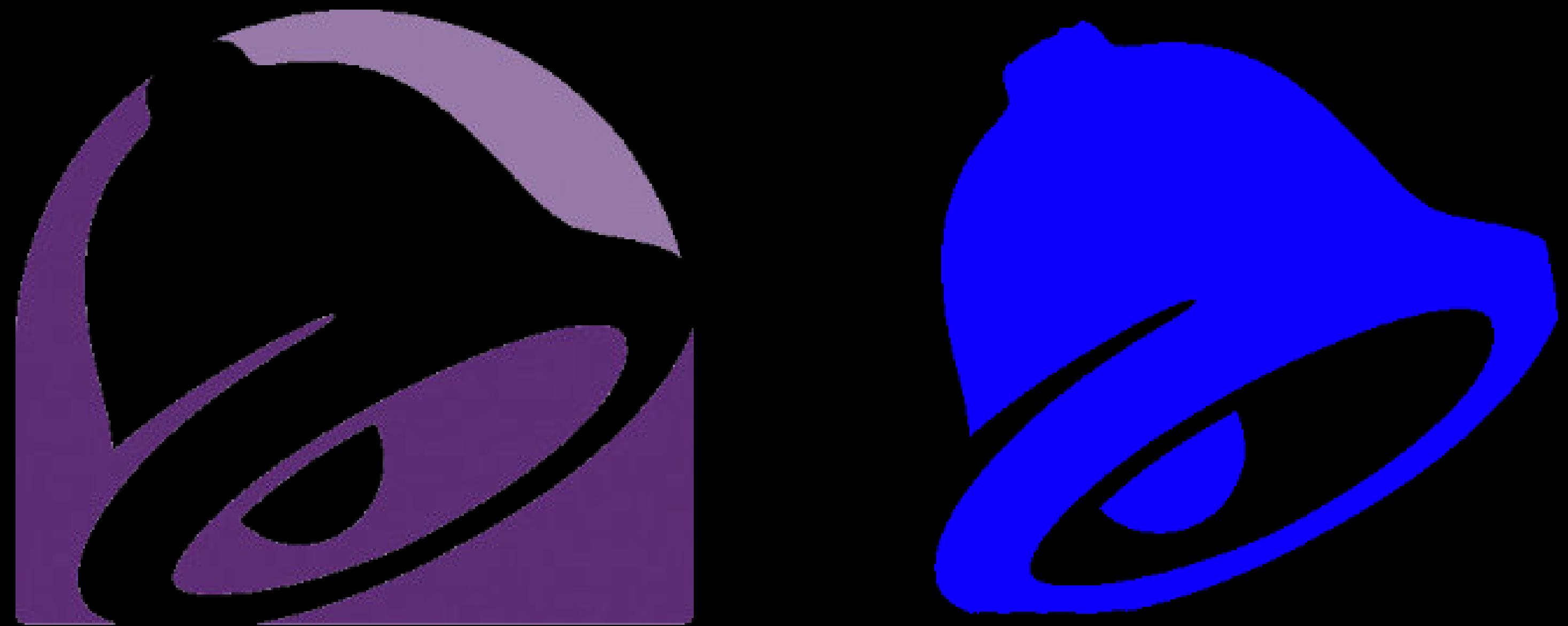


How it looks vs. how it feels

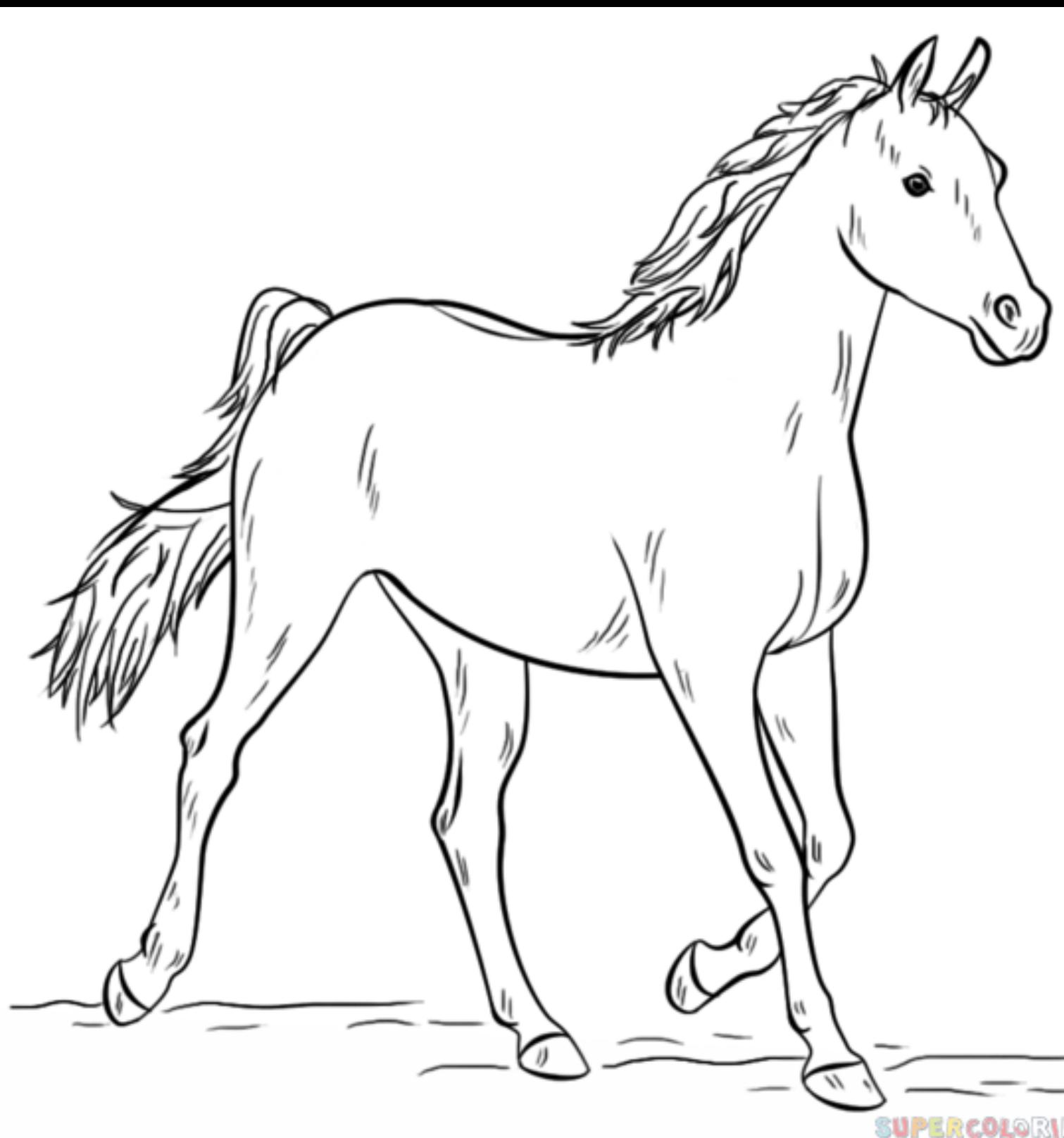
DRAWINGFORALL.NET



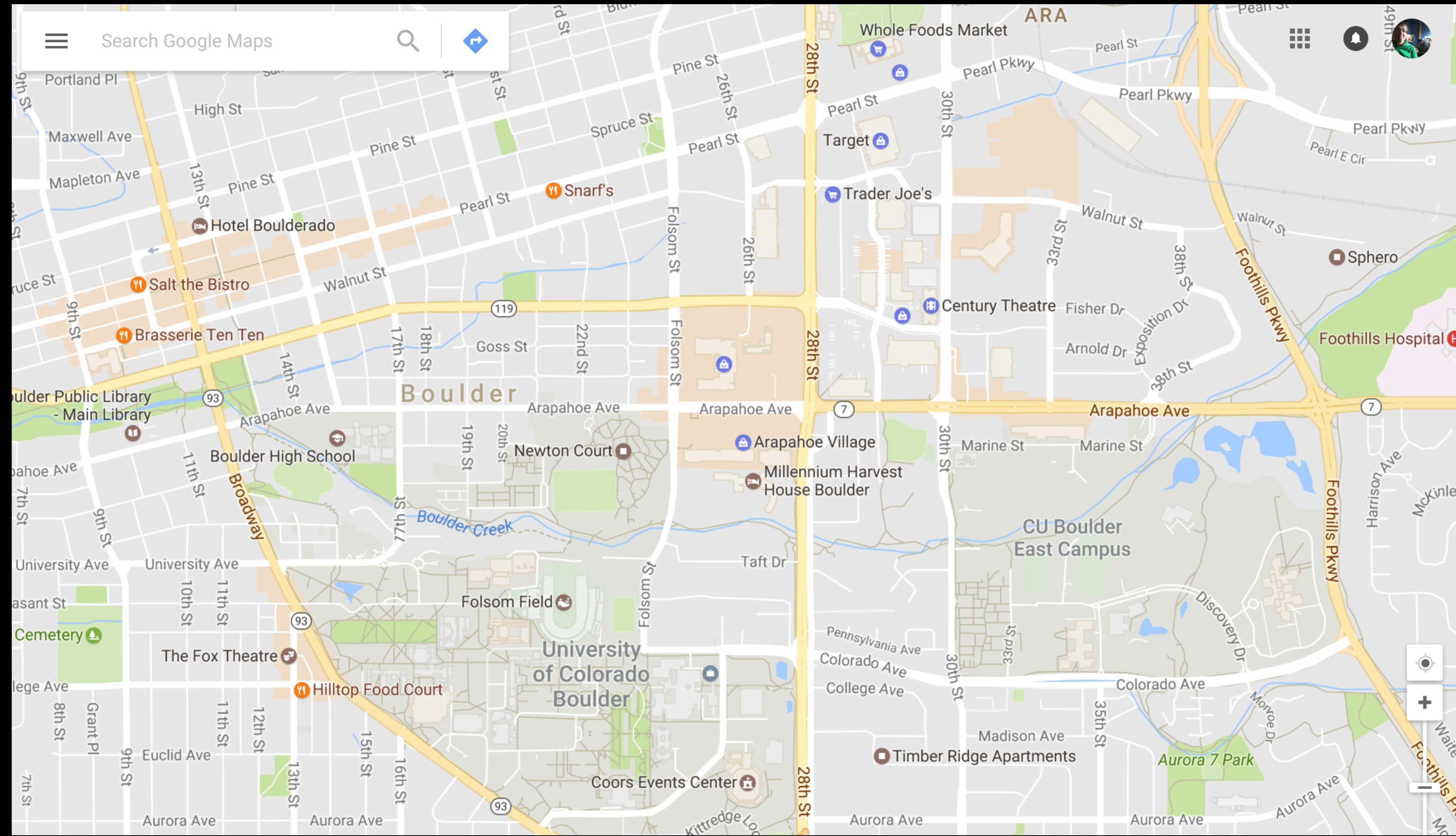
Direct translation vs. interpretation



Whole-part learning



Superimposed visual information



How to handle superimposed data?

Low resolution early test prints – “toy stack”



- textured features (black)
- intensity layers (white)
- each distance a separate layer



Labeling content

- How can we label items on a tactile graphic?

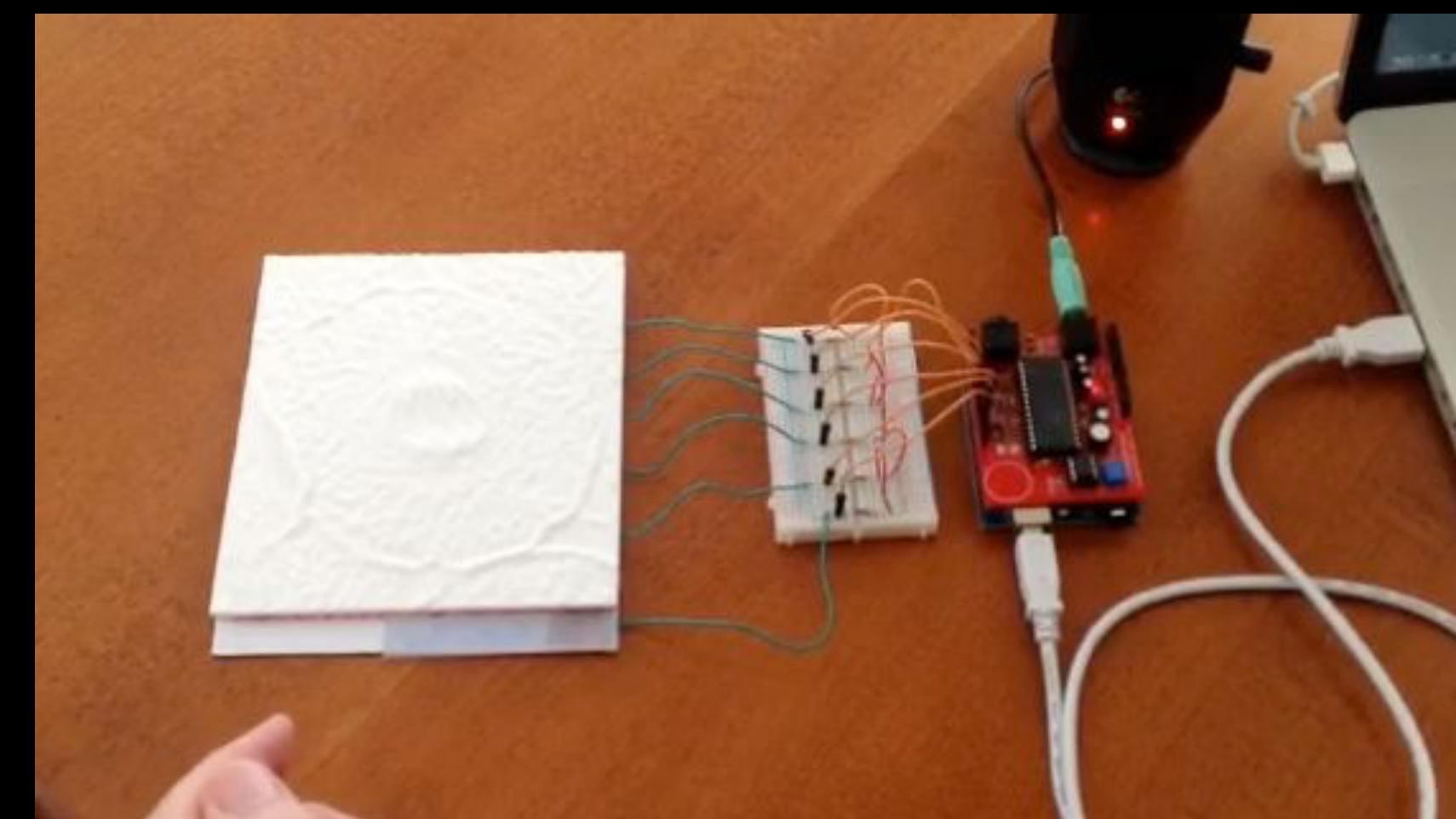
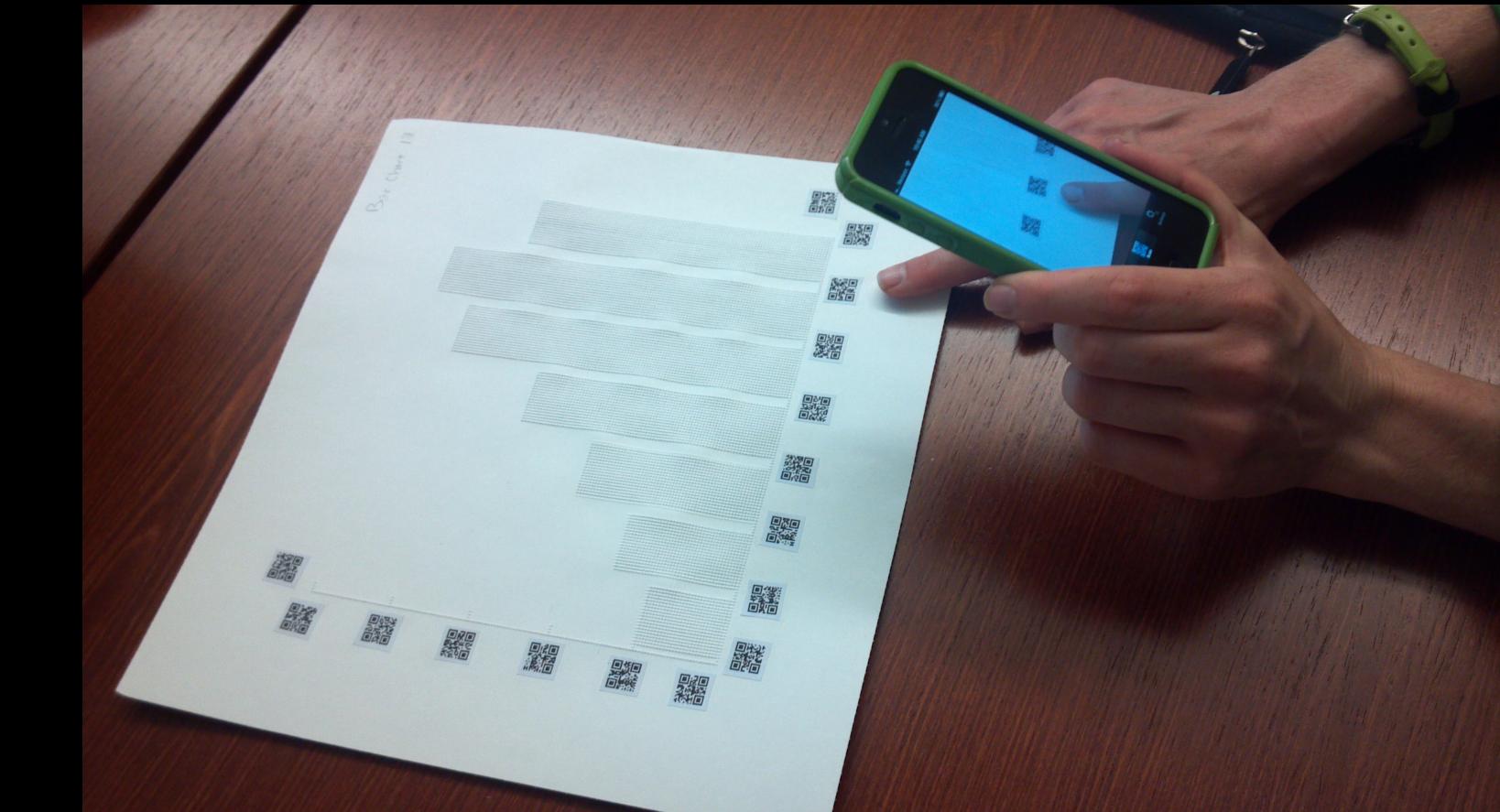
Labelling options

- Textures and shapes
- Braille
- Audio (integrated into model or separate)

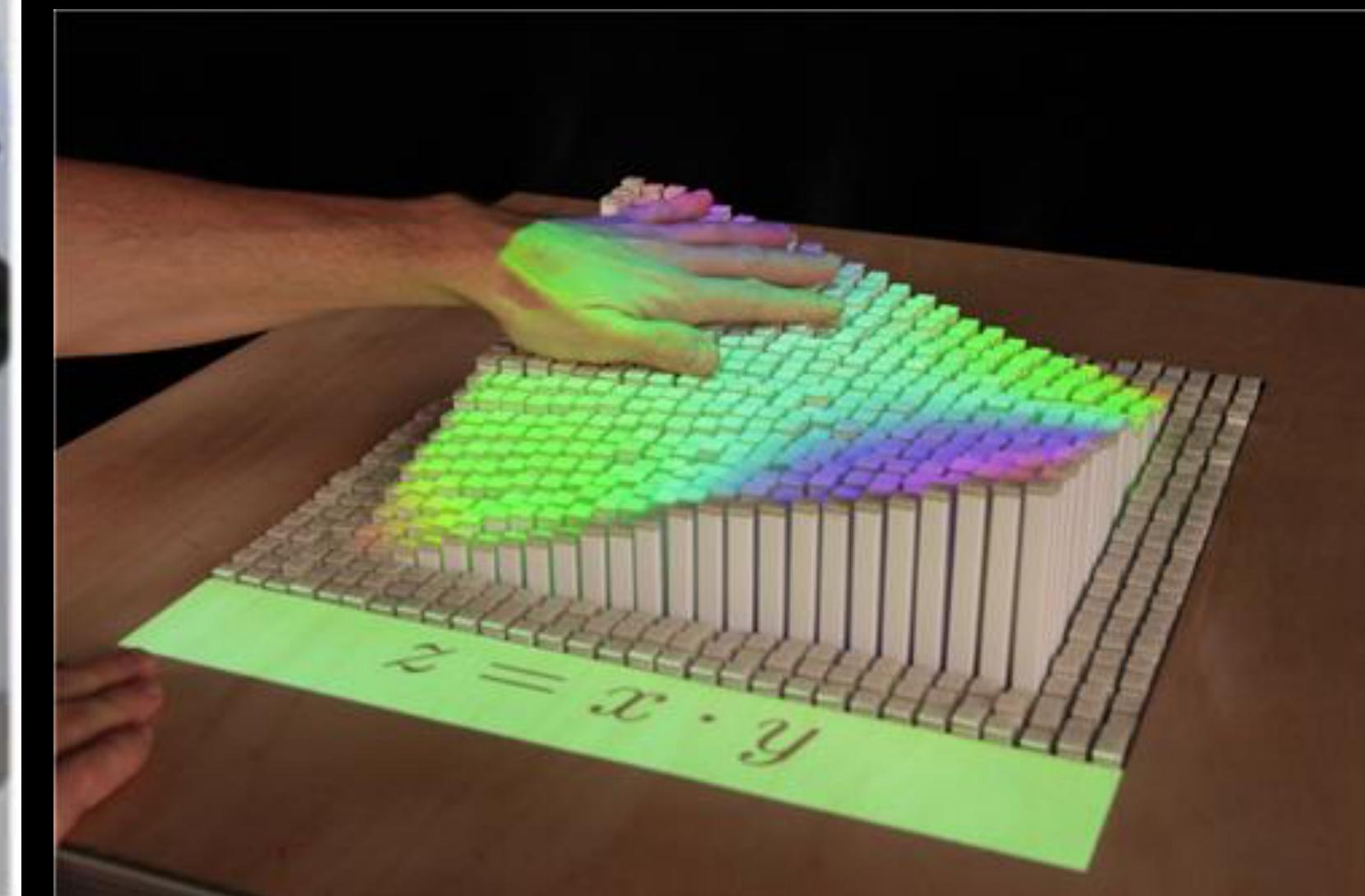
Braille literacy

- In 1960 about 50% of blind students were Braille literate
- Today it may be 10% or lower
- <https://braillevworks.com/braille-literacy-statistics/>

Audio in tactile graphics

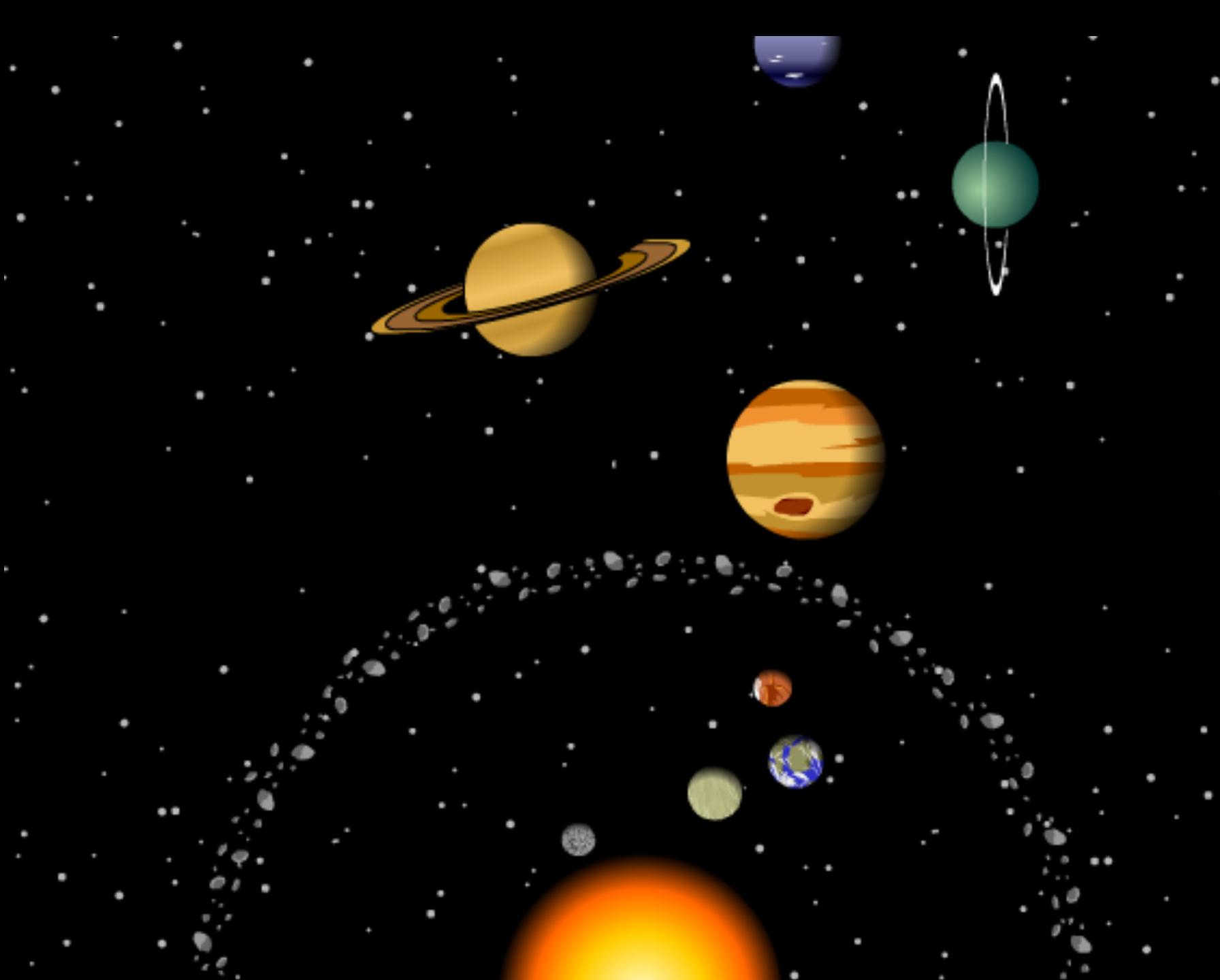


Future technologies



Handling images and multimedia

- An open challenge!



Tactile graphics standards

- Braille Authority of North America (BANA) Guidelines
- Difficult to keep up with new technologies, dynamic/multimedia data

Other benefits of learning tactile design

- Support design of tangible devices
- Material for diverse (and neurodiverse) learners
- Good practice for visual design too

Tactile design matters



Designing tactile graphics

How to design tactile graphics

1. Identify a source image (or video, or data)
2. Identify important information to preserve
 - Features, relationships, etc.
3. Try different representations, fix bugs

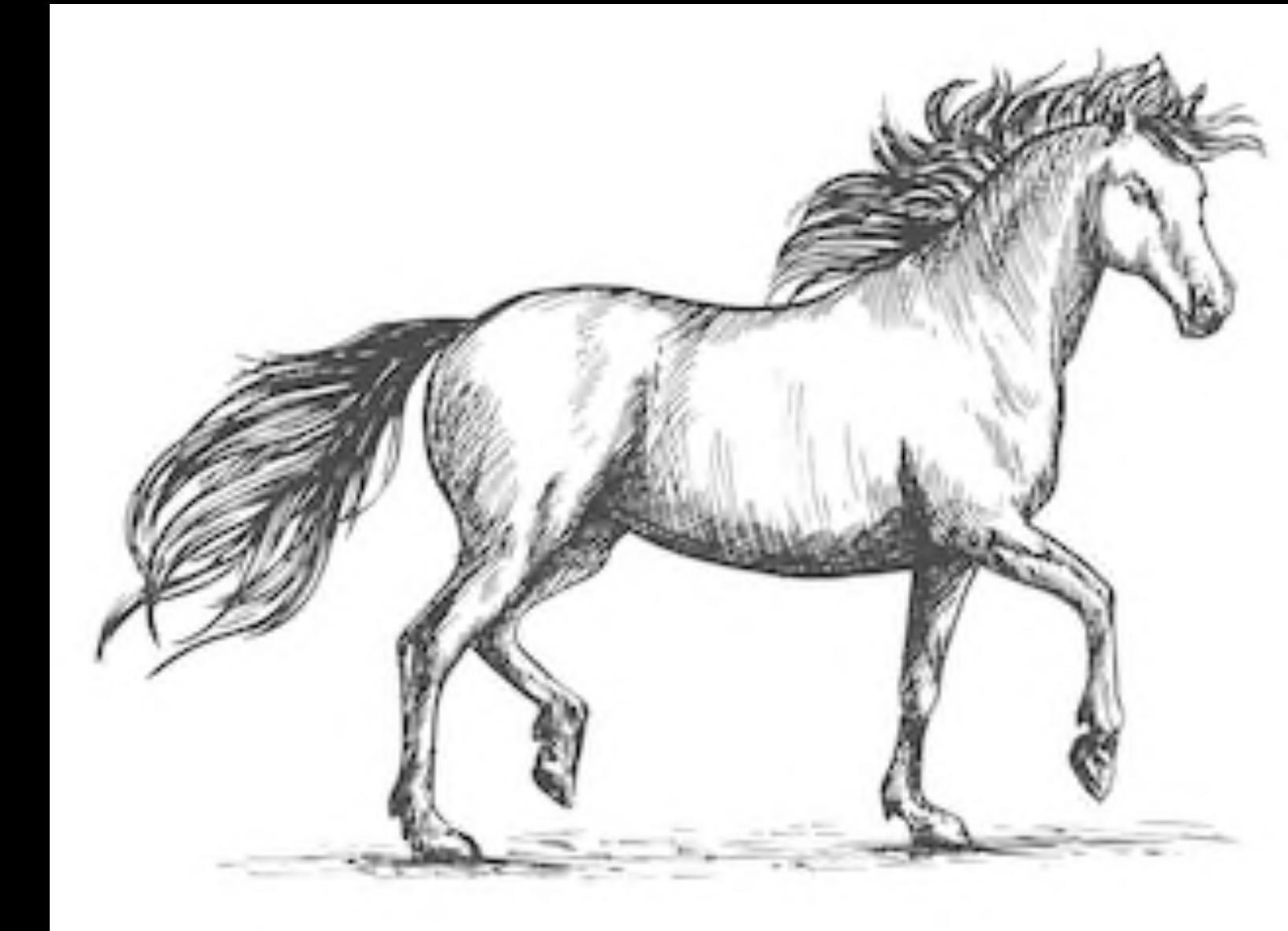
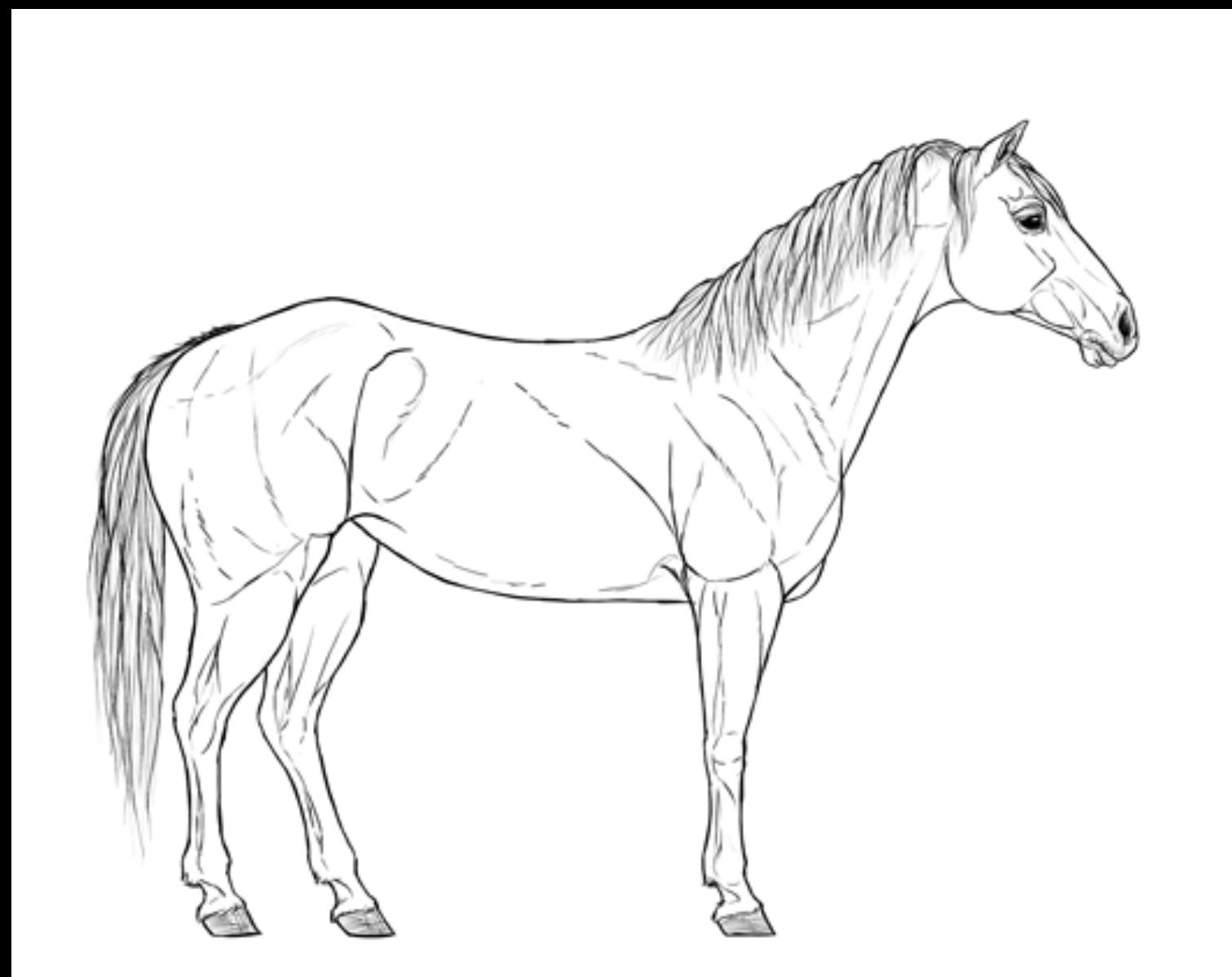
Mini activity

Discuss with your neighbor: what information is represented in this graphic?



Changing the source image

- You might want to choose a different source image, or modify the source image



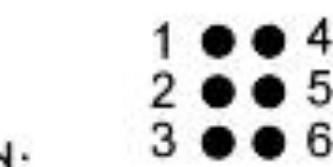
More about Braille

About Braille

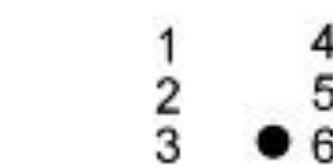
- 2 x 3 cells of a specified size (7.5mm tall)
- Typically takes ~6 months to learn
- Different **grades** – Grade 1 Braille is a letter-to-letter translation, Grade 2 involves contractions

Braille Alphabet

The six dots of
the braille cell are
arranged and numbered:



The capital sign, dot 6,
placed before a letter
makes a capital letter.



The number sign, dots 3, 4, 5, 6
placed before the characters
a through j, makes the numbers
1 through 0. For example a preceded
by the number sign is 1, b is 2, etc.

a	b	c	d	e	f	g	h	i	j
•	:	::	::	•:	::	::	::	•:	::
k	l	m	n	o	p	q	r	s	t
•:	•:	•:	•:	•:	•:	•:	•:	•:	•:
u	v	w	x	y	z				
••	••	••	••	••	••				

Capital Sign	Number Sign	Period	Comma	Question Mark	Semicolon	Exclamation point	Opening quote	Closing quote
•	•:	::	•	•:	•:	•:	•:	•:

Words and abbreviations

•	:	..	;;	‘’	’’	;;	:	:
a	but	can	do	every	from	go	have	just	knowledge	like	more	not	
;;	;;	;;	;	;;	;;	..	;;	;;	;;
people	quite	rather	so	that	us	very	will	it	you	as	and	for	
;;	;;	;;	;;	;;	:
of	the	with	child/ch	gh	shall/sh	this/θ	which/θ/wh	ed	er	out/ou	ow	bb	
..	;;					
cc	dd	en	gg; were	in	st	ing	ar						

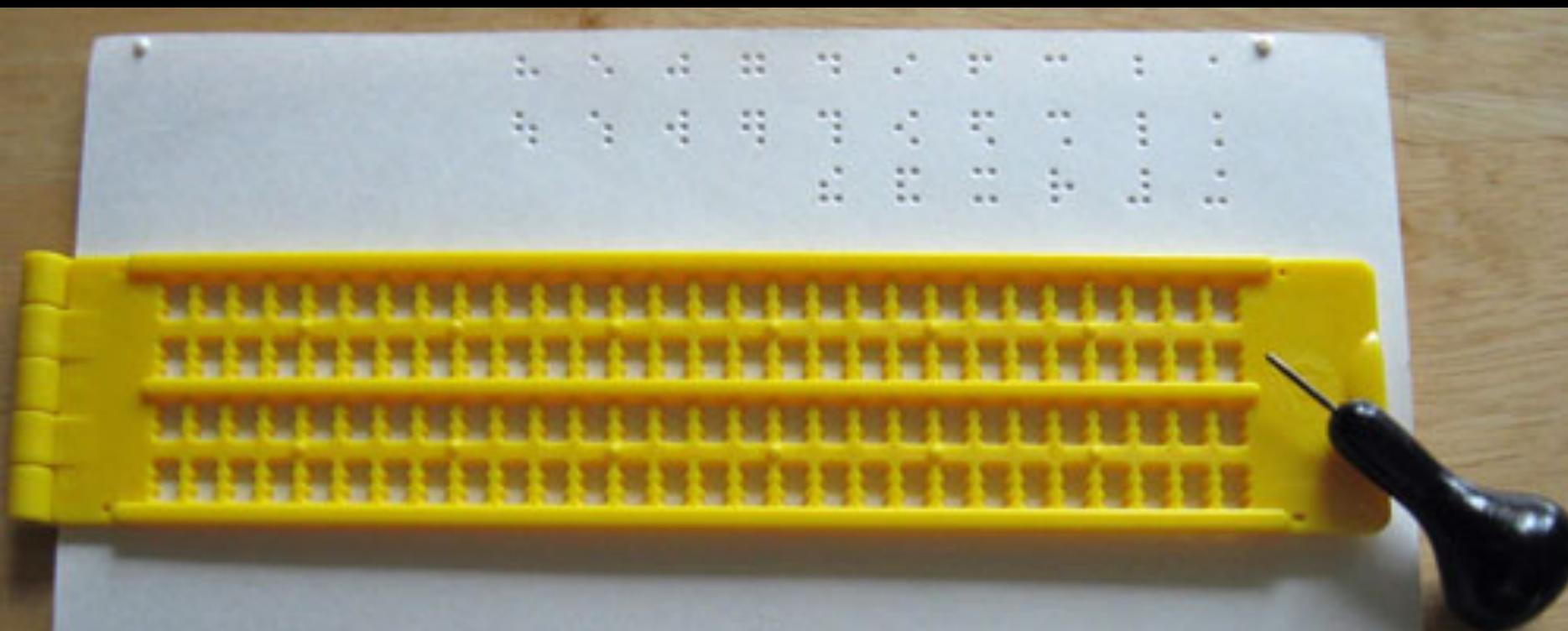
Specialized Braille notations

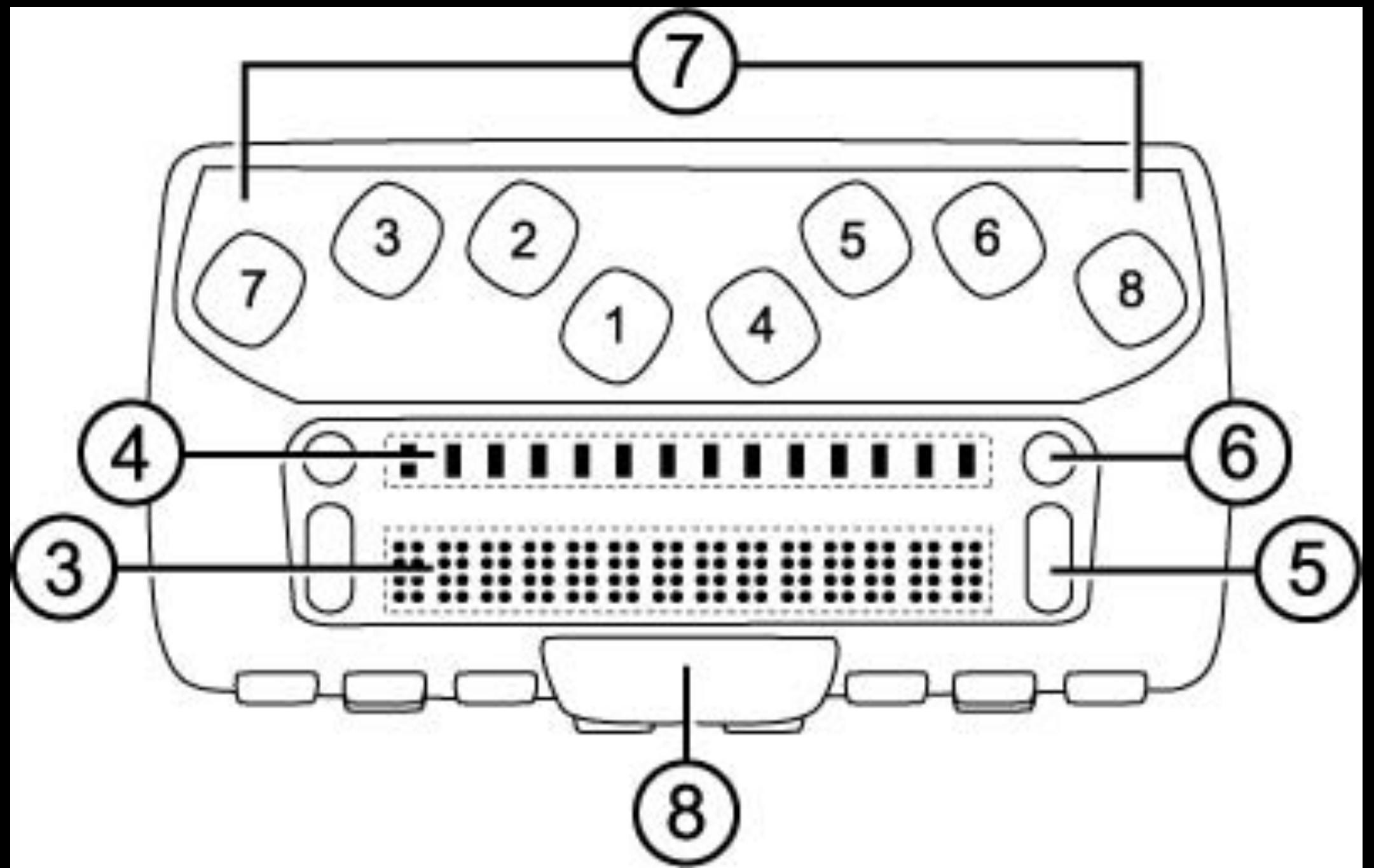
- Nemeth code - Braille for mathematical notation
- Music Braille
- ...

$$(13) \quad \frac{(1-x) \frac{d}{dx}(2x) - 2x \frac{d}{dx}(1-x)}{(1-x)^2}$$

(a hypercomplex fraction)

Braille technologies





- | | |
|---|---|
| 1 | 4 |
| 2 | 5 |
| 3 | 6 |

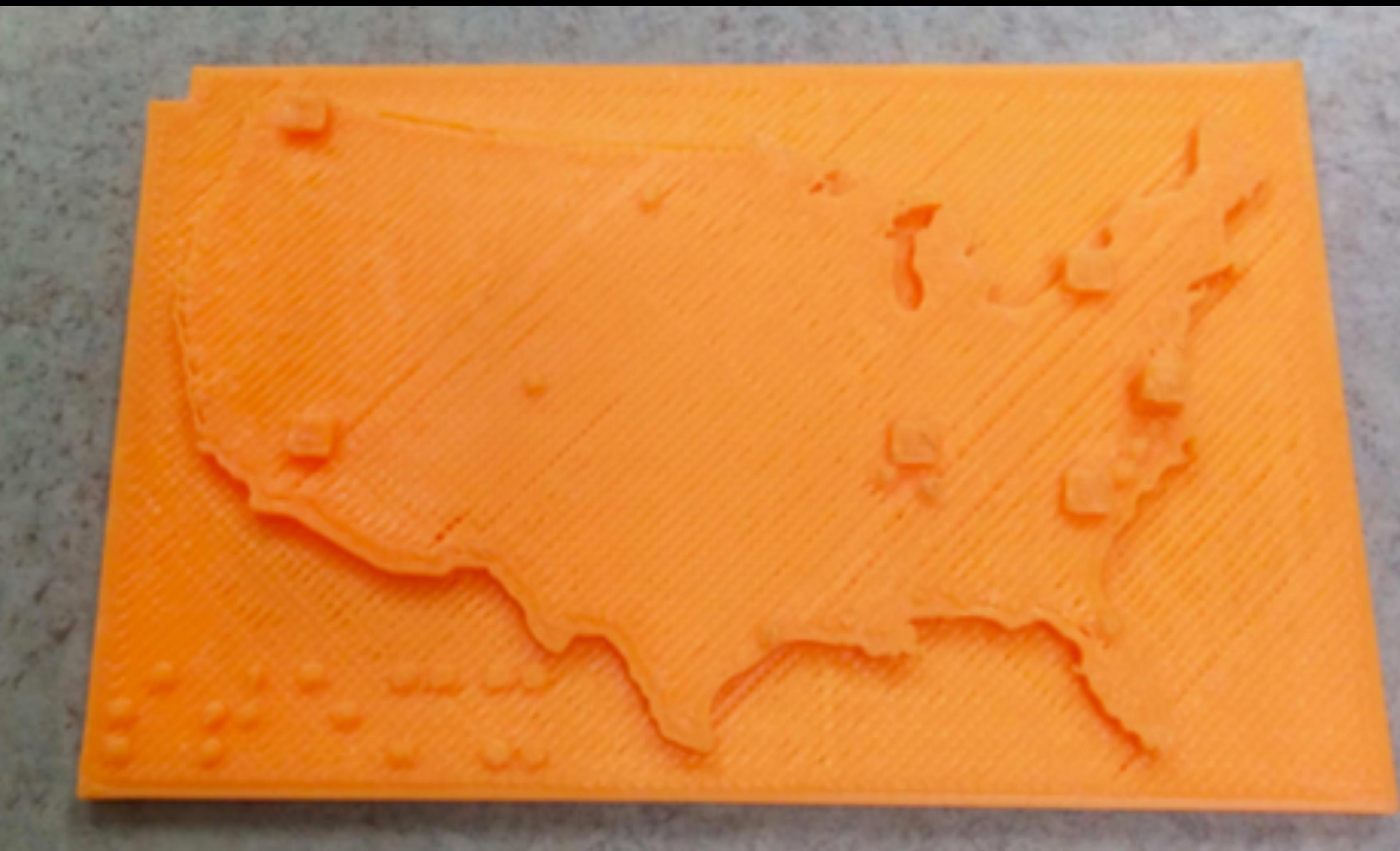
Braille reading speed

- 124 wpm – Braille ([Legge et al. 1999](#))
- 250-300 wpm – Adult reading speed ([Bell 2001](#))
- 300-500 wpm – Screen reader ([Borodin et al. 2010](#))

Things to know

- Braille must be kept to standard sizes and layouts or it can't easily be read
- Many blind and visually impaired people won't know alphabetic letter shapes
- Need orientation guides for Braille documents and tactile graphics

Orientation



What do we know about tactile perception?

- Easier to perceive cutouts than raised items ([Khalia et al. 2014](#))
- Provide space between textures to aid in disambiguation ([BANA 2010](#))
- Tactile perception requires movement over an area ([Hasty](#))

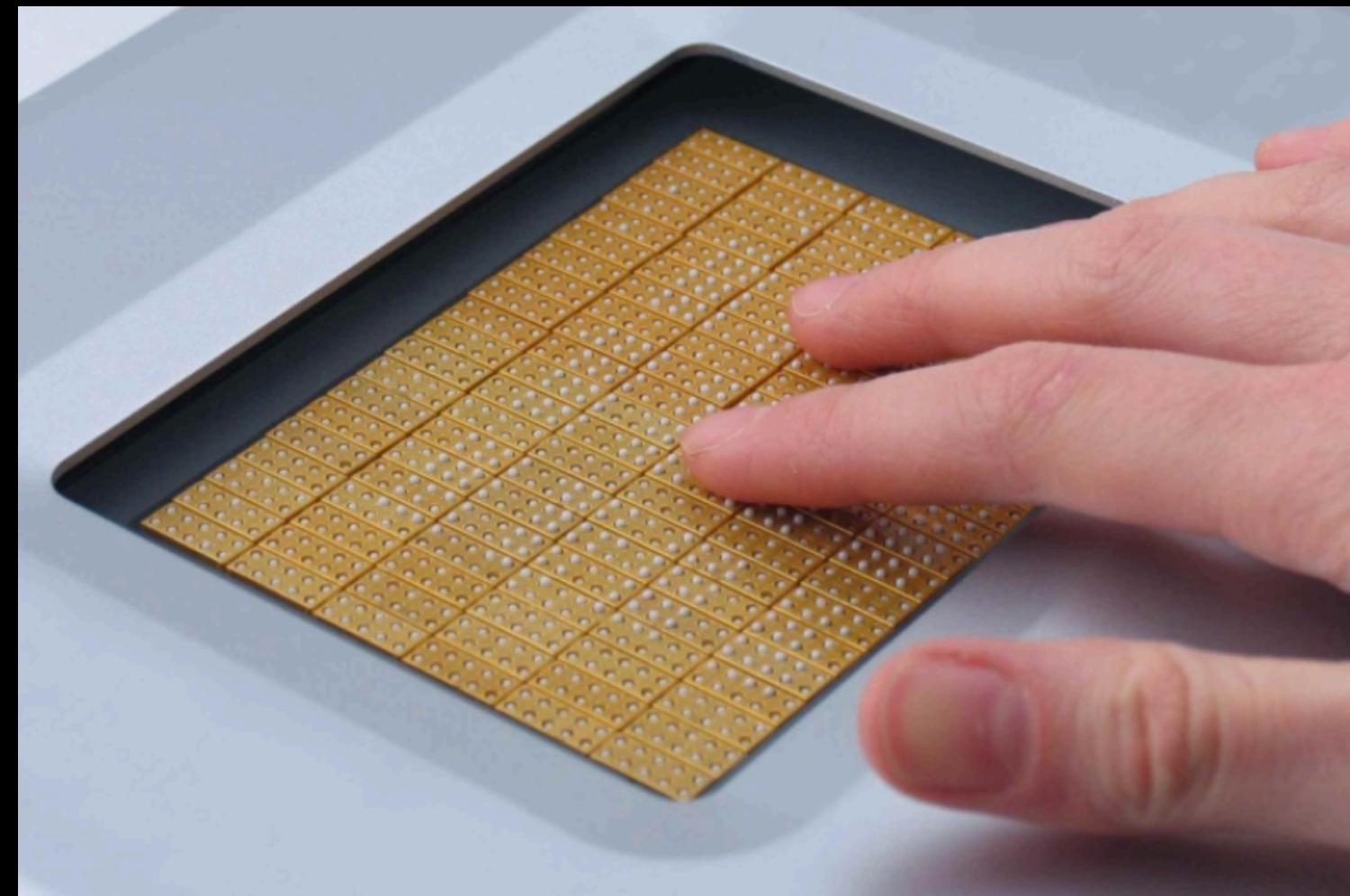
Cool research
projects 😎

Open challenges

- Creating low cost usable tactile displays
- Providing additional feedback while exploring tactile graphics
- Supporting non-designers in creating tactile images

BrailleDis [\(Volkel et al. 2008\)](#)

- 60×120 pins = 7200 pins!
- Supports multitouch input



Graphiti - Interactive Tactile Graphics Display



Graphiti is an Interactive Tactile Graphics Display based on revolutionary Tactuator technology from Orbit Research. It represents a breakthrough in non-visual access to any form of graphical information such as charts, drawings, flowcharts, floorplans, images and photographs, through an array of moving pins.

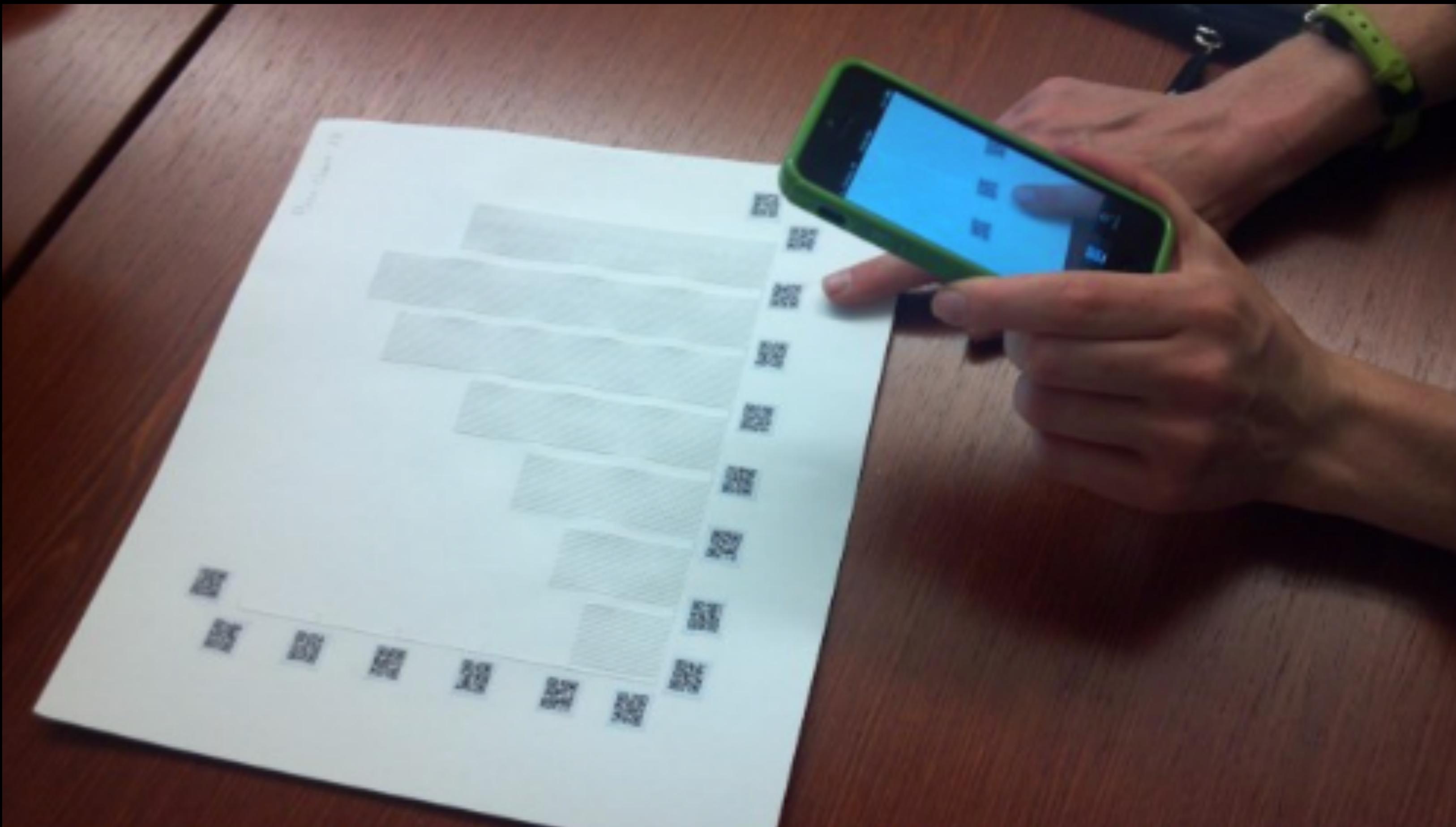
The Tactuator technology provides the ability to set each pin to different heights, which enables the display of topographical maps and other graphical elements such as grey shades and color represented as varying heights of pins that can be readily sensed by the user's fingers.

Graphiti features a touch interface to enable the user to "draw" on the display; tracing a shape with a fingertip raises the pins along the path traced. The touch interface allows traditional forms of touch commands such as scrolling, multi-touch gestures such as pinch-to-zoom, etc. In addition, it enables novel

Electrovibration



Tactile graphics with a voice ([Baker et al. 2014](#))



Tactile Graphics Helper



Tactile Picture Books

- Develop tactile versions of childrens' picture books
- Support co-reading between parents and children
- Current work focusing on involving community members in authoring books; creating mechanical and other features in 3D prints

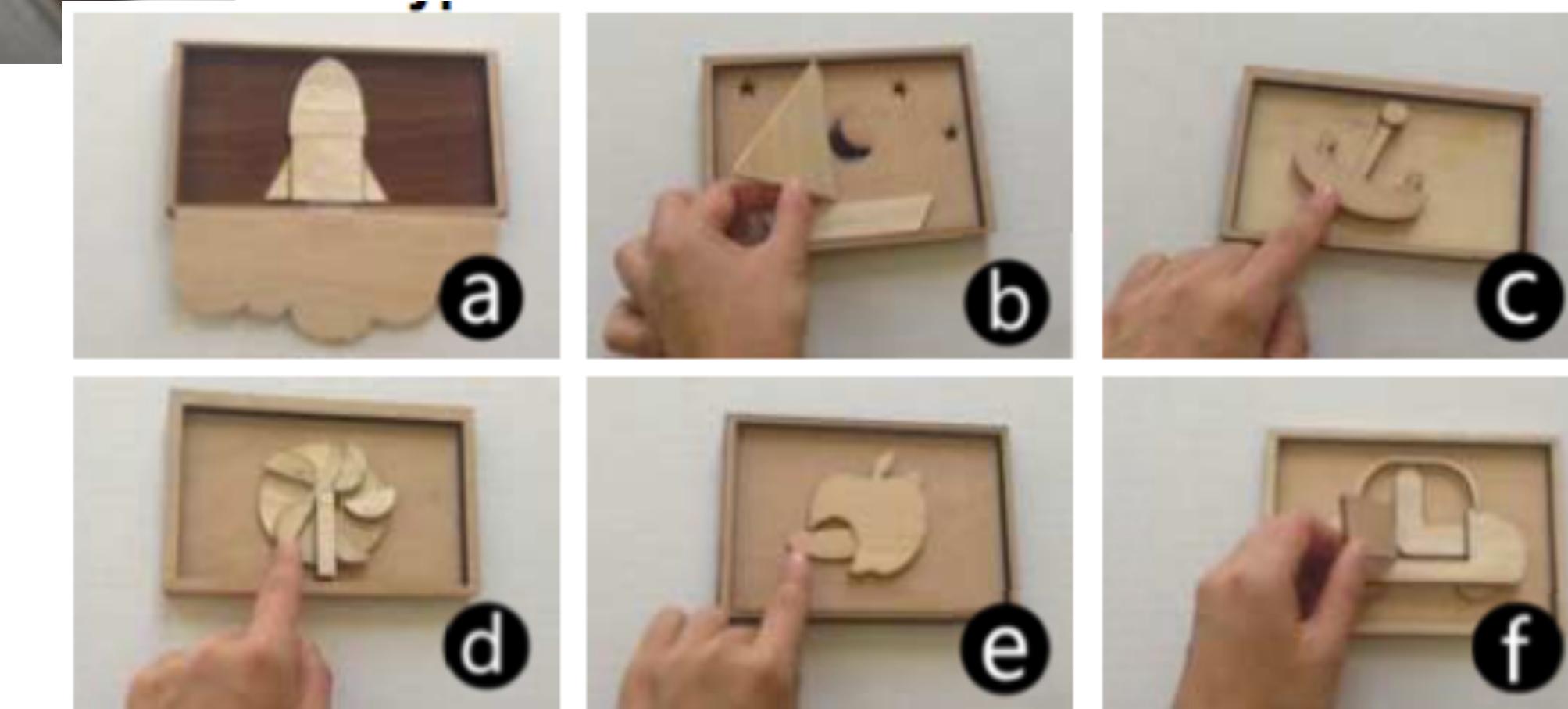
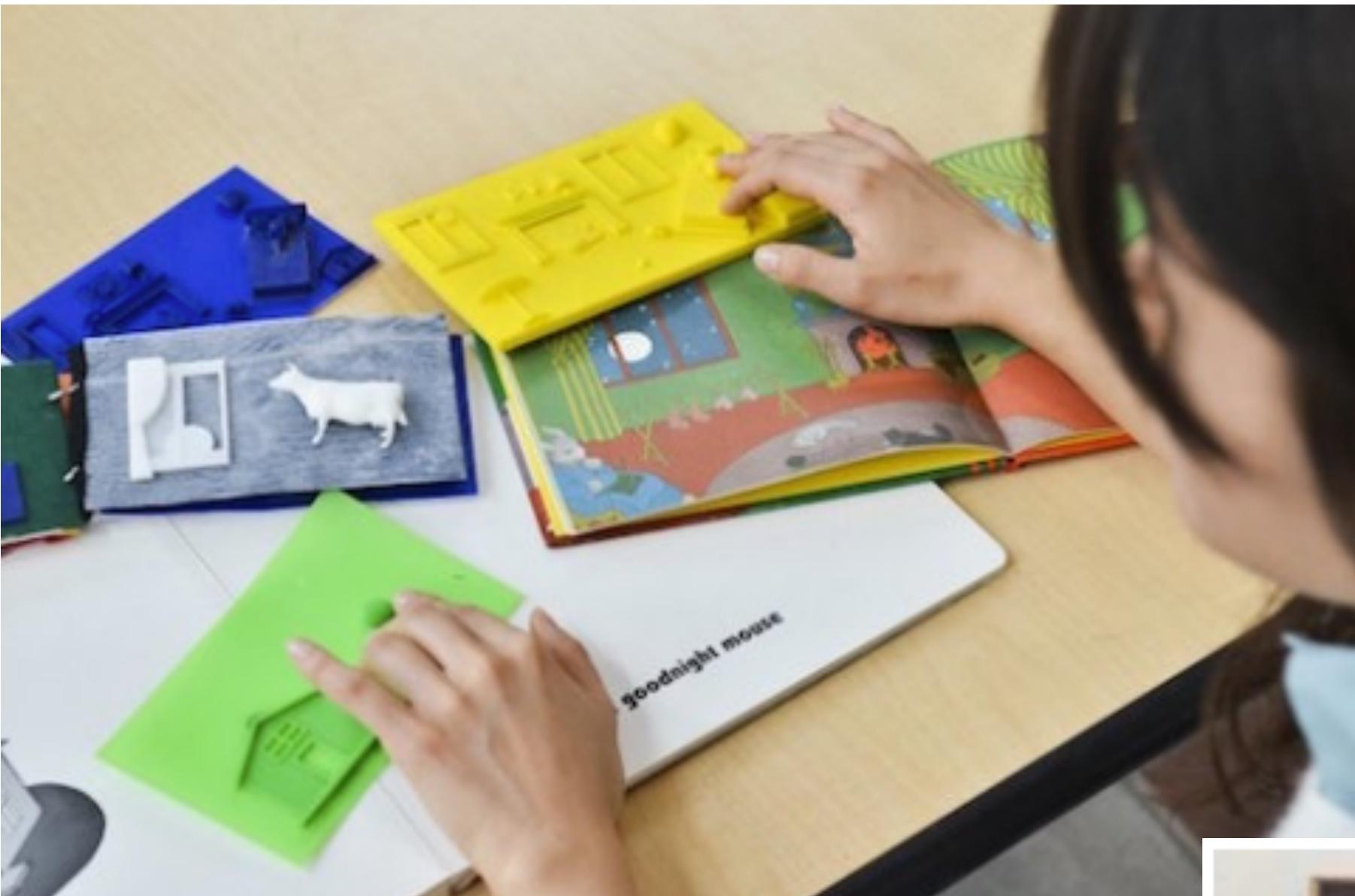
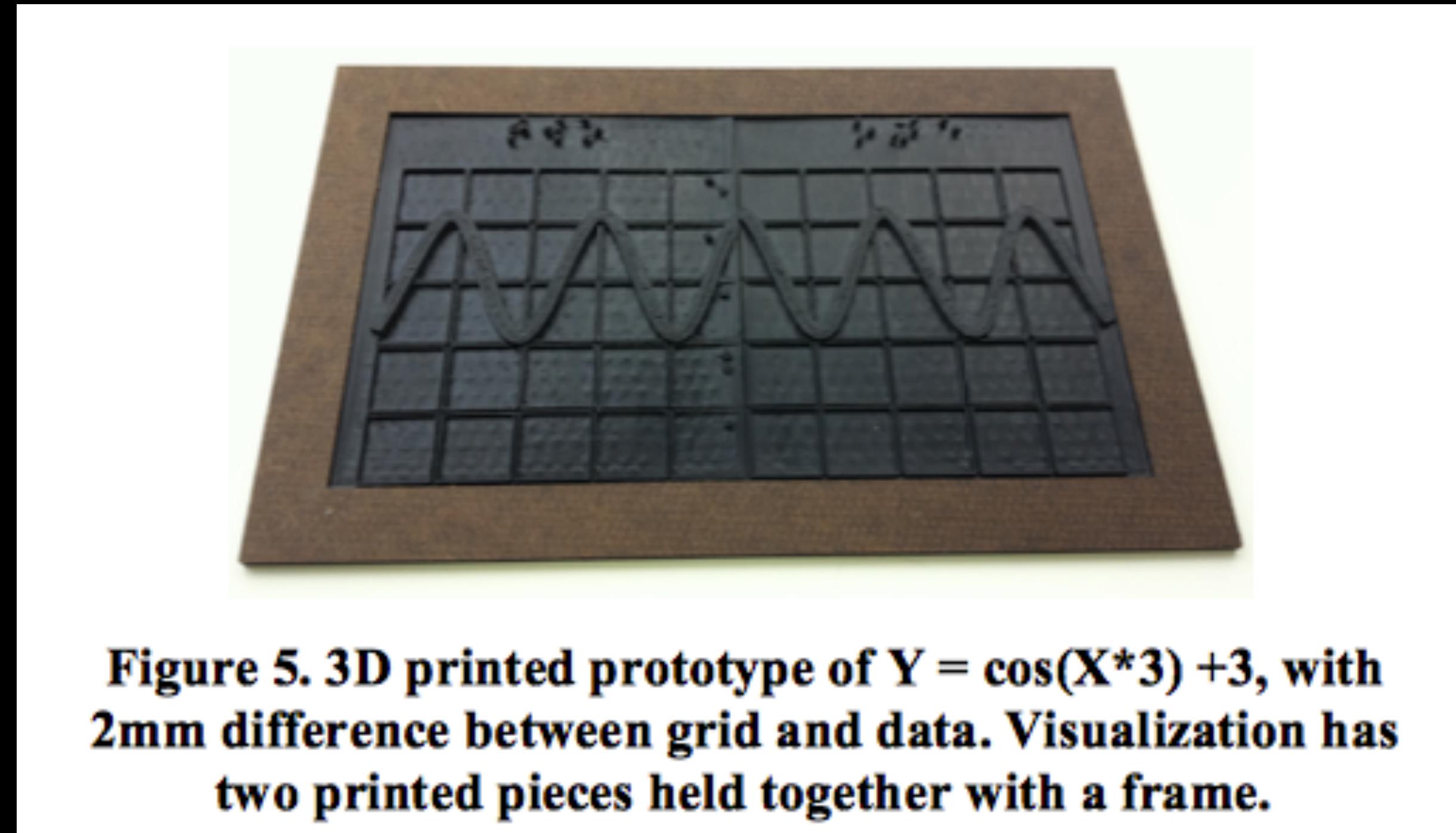


Figure 7. Wooden prototypes of movable tactile pictures. A rocket hidden by cloud (a), the moon uncovered by the waving sail (b), swinging biking (c), a spinning giant wheel with falpping carts (d), a warm passing through the apple (e), and a car with opening door and two spining wheels (f)

VizTouch ([Brown and Hurst 2012](#))

- Automatically generate tactile charts from spreadsheets or math data



Facade ([Guo et al. 2017](#))

- Automatically generate tactile overlays for appliances



TactileMaps.net

This site allows you to create customized tactile maps. Search for a location and the site will create a 3D printable file of the roadways in the surrounding area. The 3D map file is compatible with commercially available 3D printers or can be sent to a 3D printing service. Once printed, you will have a physical map of the location.

Enter a place or address into the 'Location' text box and hit enter or click the 'Search' button to begin. The search result will be described under the 'Location Found' heading.

Search for a Location

Location:

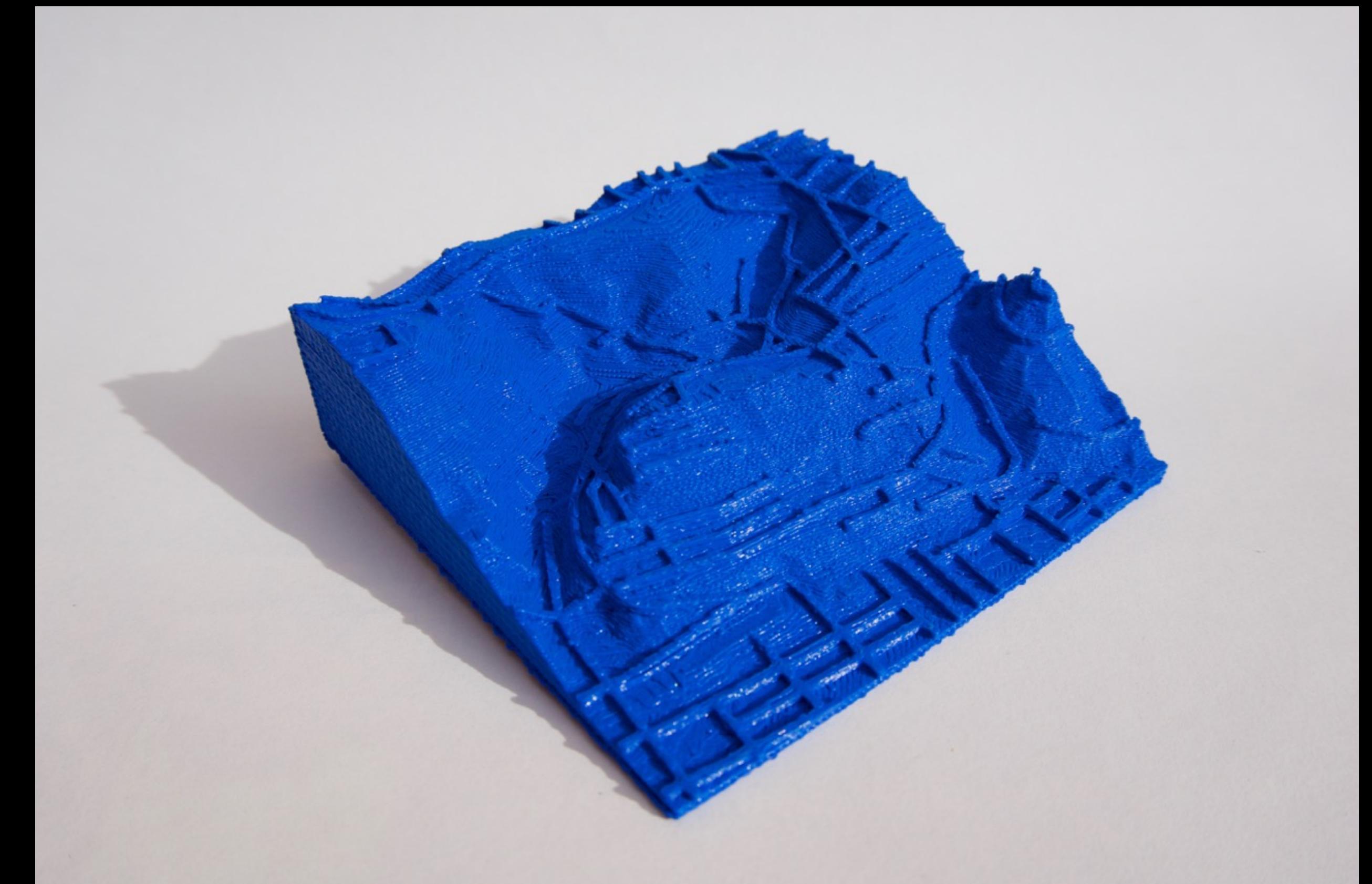
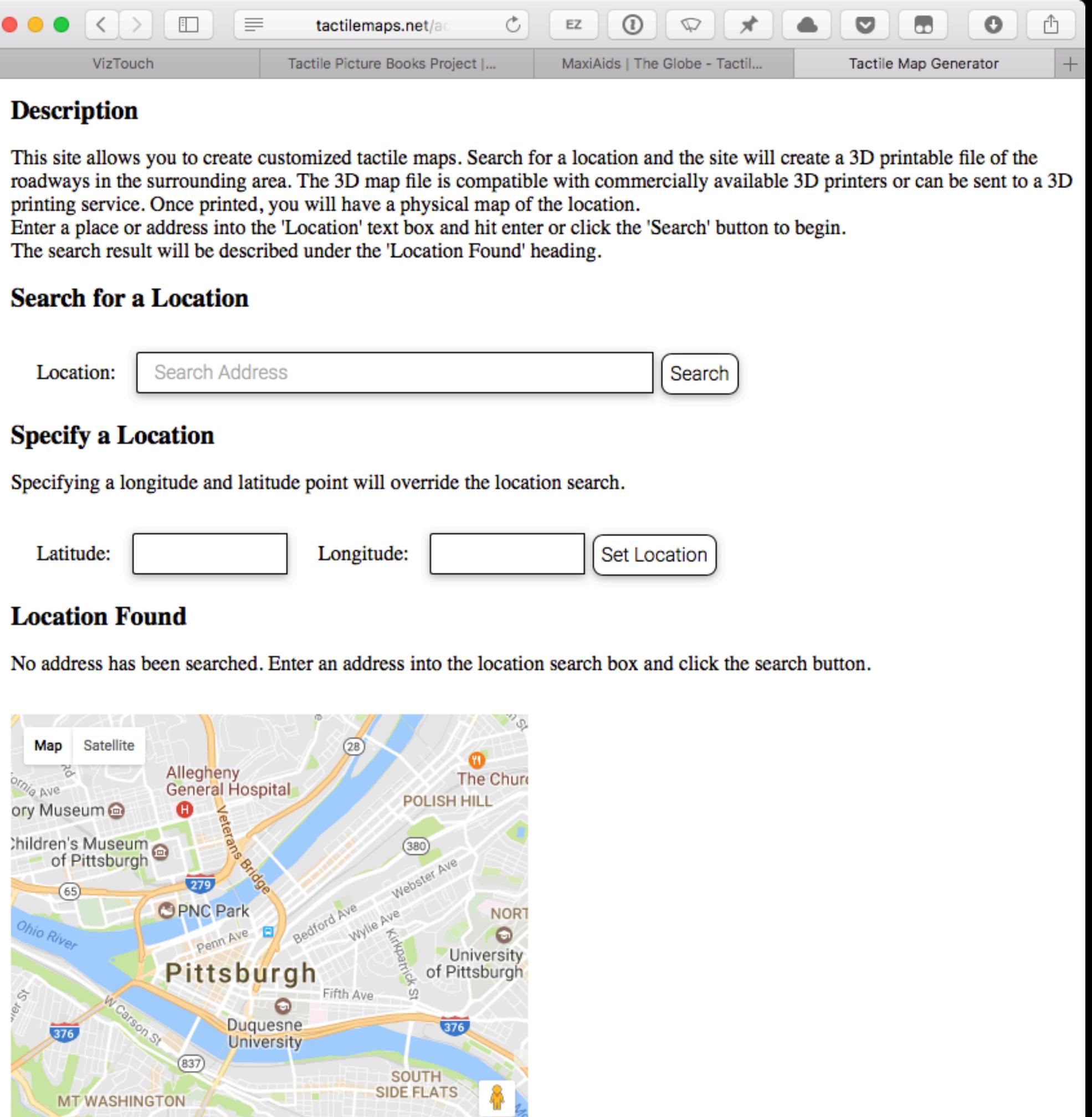
Specify a Location

Specifying a longitude and latitude point will override the location search.

Latitude: Longitude:

Location Found

No address has been searched. Enter an address into the location search box and click the search button.



Annotating 3D models

Touch Graphics, Inc. Retweeted

Yue-Ting Siu @TVI_ting · Mar 1

Love the talking whale model with scaled human swimmer to show size relationship @TouchGraphicsUS #CSUNATC17



The image shows a large blue whale model standing next to a scaled human swimmer figure on a display stand. The display stand has a blue base with text and a wooden frame. A person's hands are visible at the bottom left, interacting with the display. In the background, there are other people and a computer monitor.

Blue Whale and Swimmer
Please touch to hear whale sounds

This model figure is 10 feet tall, representing 100 feet.

The blue whale is a marine mammal belonging to the baleen whales. At up to 100 feet in length, it is the largest animal known to have ever existed.

4 10

Markit and Talkit



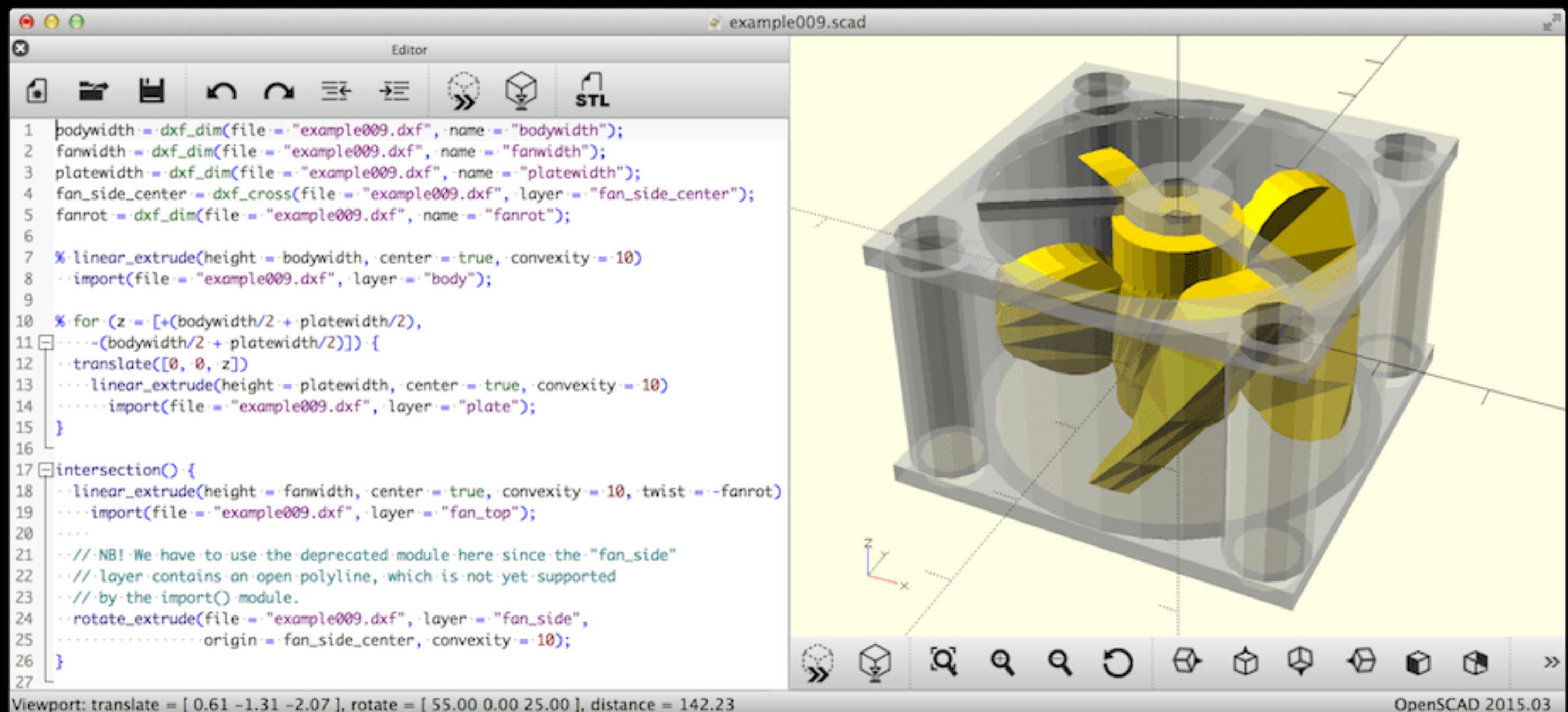
3D printing mini-tutorial

How to do it

- Start with a low-fidelity prototype
- Build or download/modify a 3D model
- 3D print it

Beginner-friendly 3D modeling tools

- [TinkerCAD](#)
- [Fusion 360](#)
- [OpenSCAD](#)



Where to 3D print on campus

- ITLL
- BTU lab
- Idea Forge
- 3D printers at CU Bookstore

Printing tactile graphics

- Know 3D printer's build volume
- Often need to print base
- Add orientation guide
- Don't resize or otherwise mess up Braille

For next class

- Check in on Project 3 ideas / tools
 - You should have an idea and a sense of how to do it
- Tactile graphics
 - Prototype a tactile graphic that illustrates 3 things, and test it