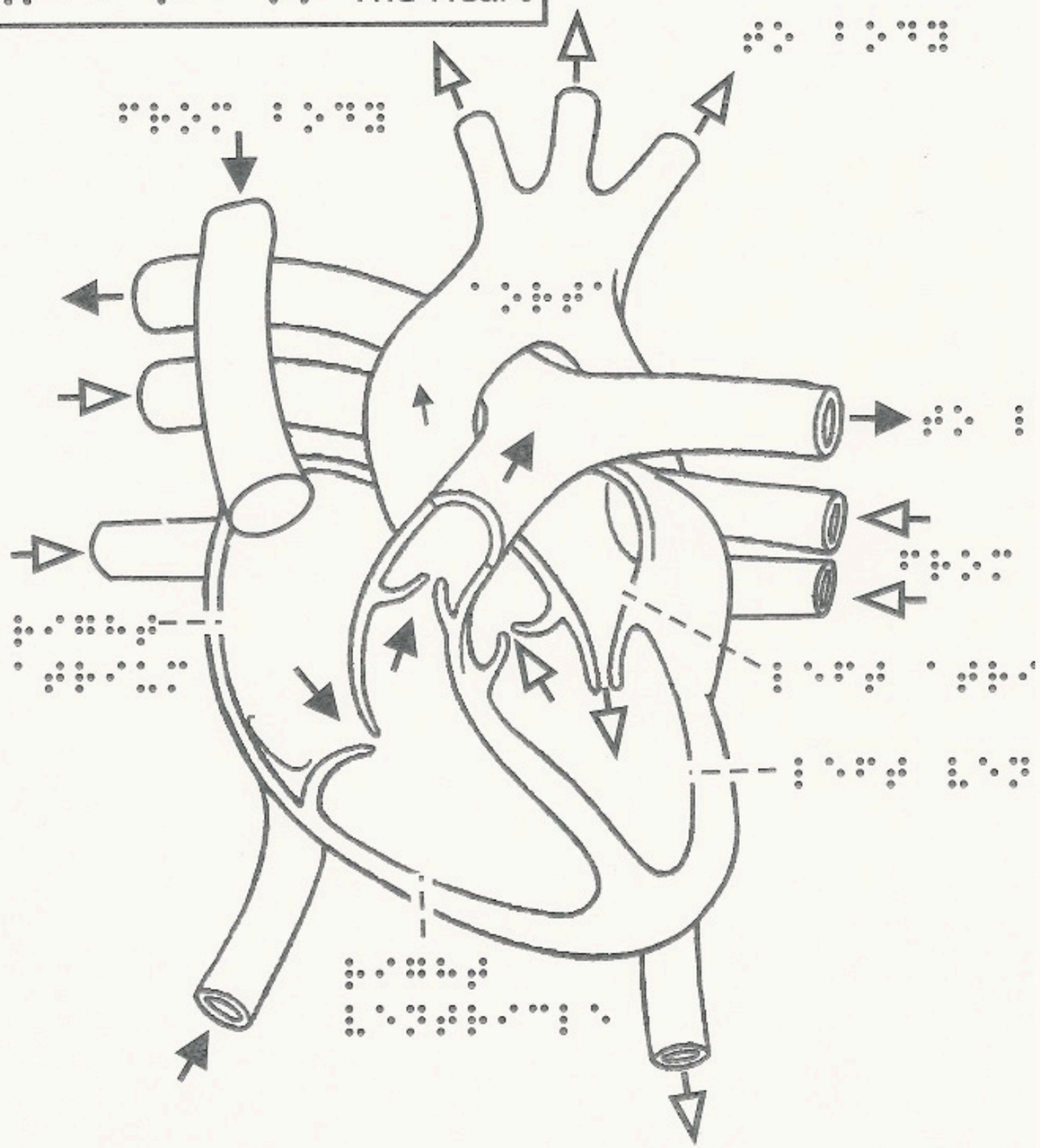
University of Colorado Boulder

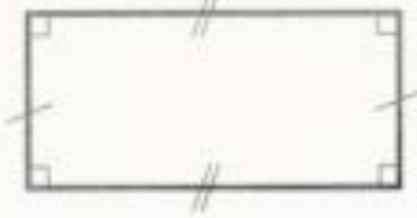
FluxMarker: Enhancing Tactile Graphics with Dynamic Tactile Markers

Ryo Suzuki, Abigale Stangl, Mark D. Gross, Tom Yeh

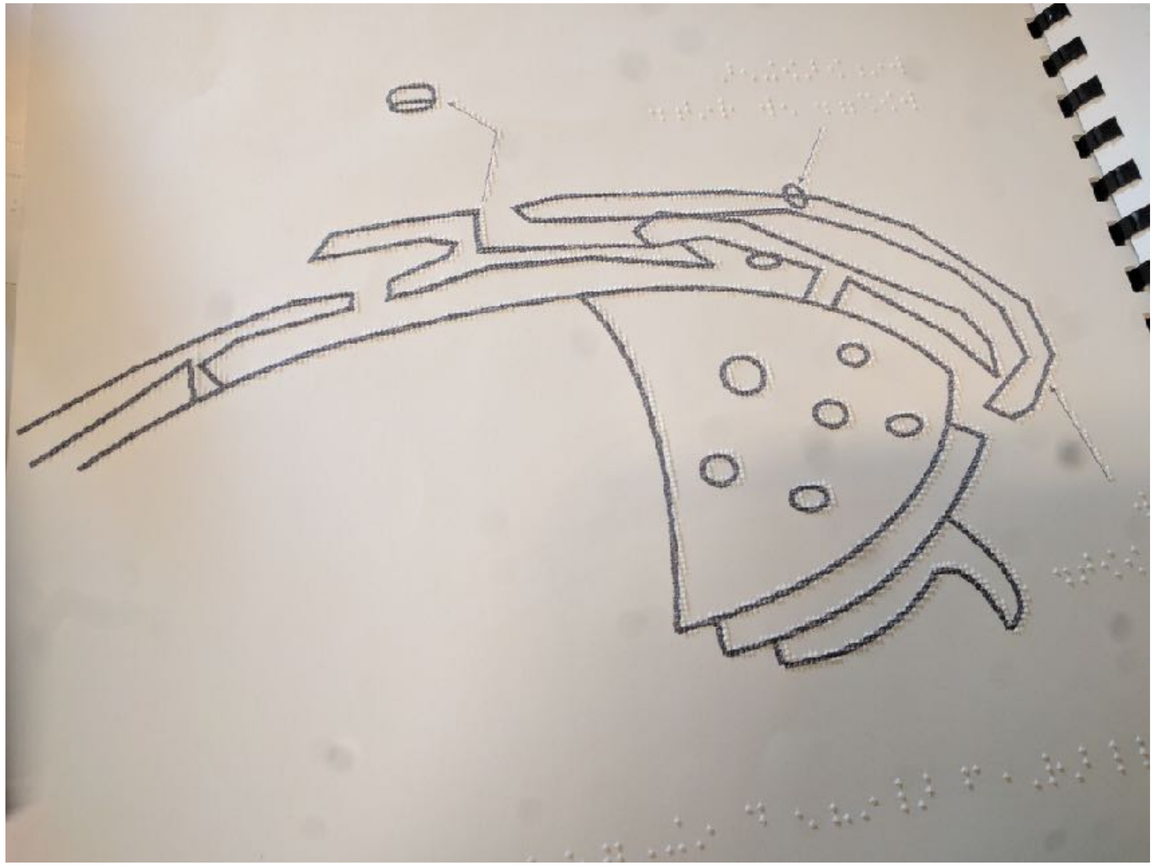
⠠⠓⠑ ⠠⠓⠑⠁⠗⠞ The Heart



⠠⠉⠇⠁⠎⠎⠊⠋⠽⠊⠝⠛ ⠏⠕⠇⠽⠛⠕⠝⠎ Classifying polygons

Traditional Tactile Graphics



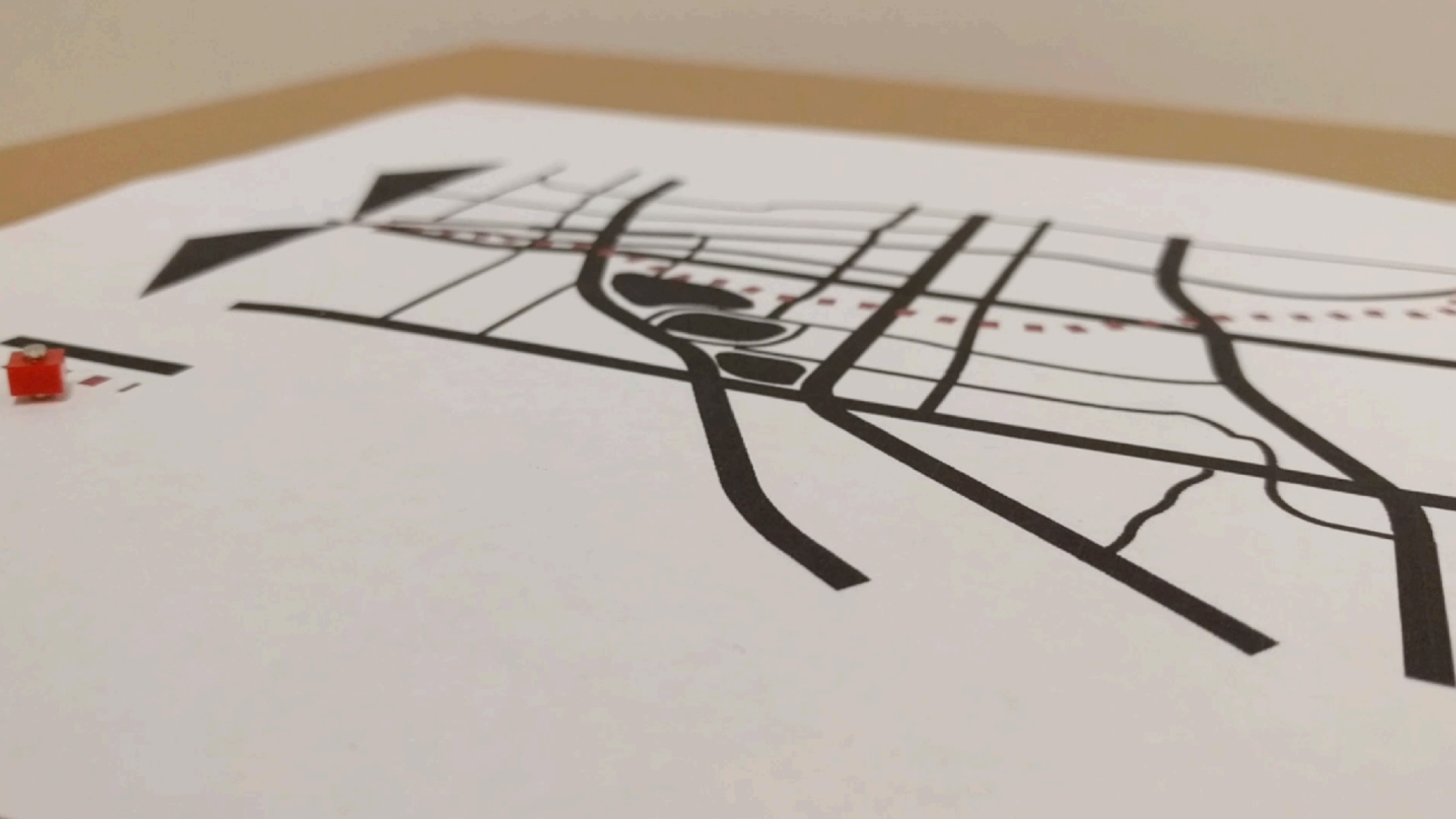
static and **not interactive**

Refreshable Braille Display

expensive and **small**

static and **not interactive**

Are there any coffee shops around campus?



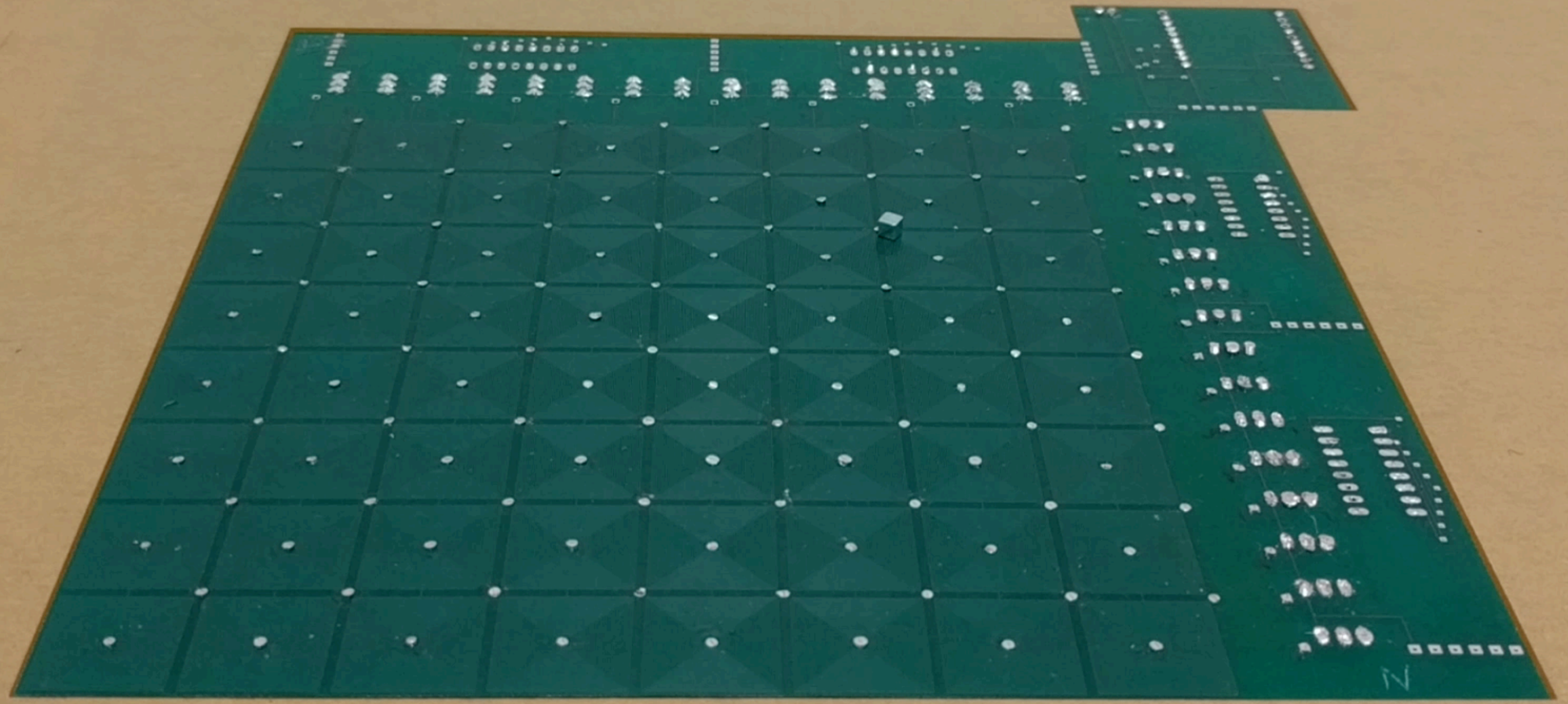

Show me the nearest coffee shops?

Dynamic
Tactile Markers

=

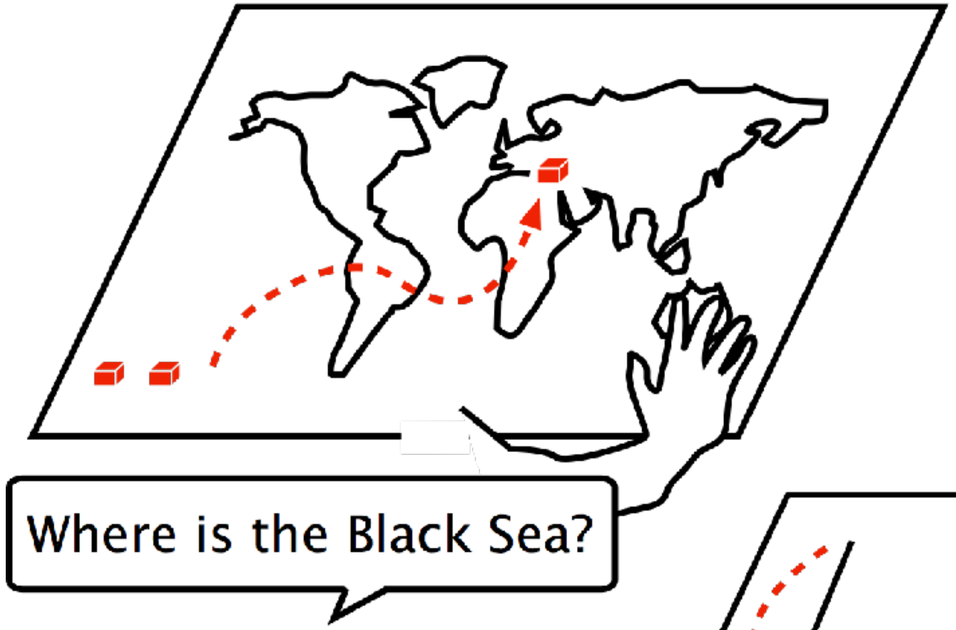
Interactive
Tactile Output

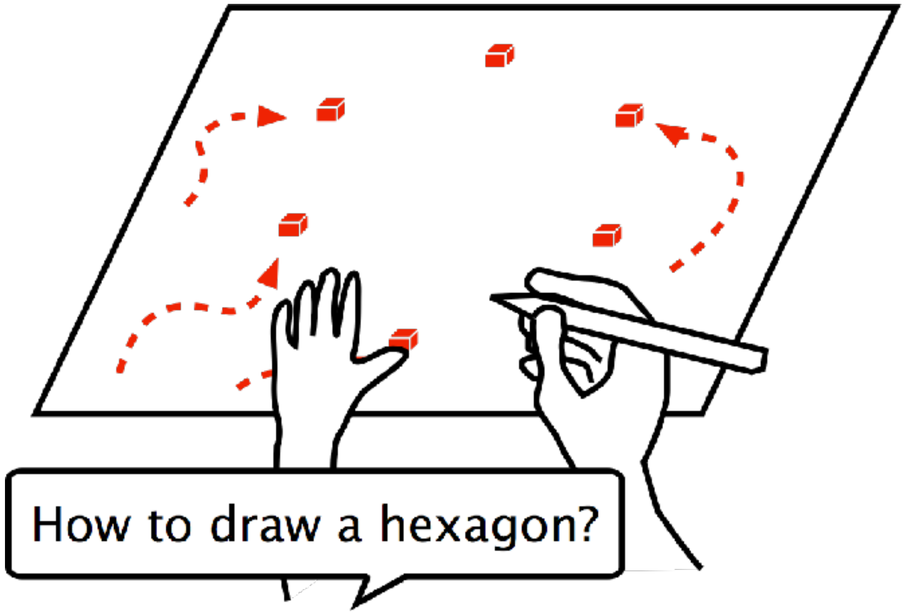
low-cost + scalable



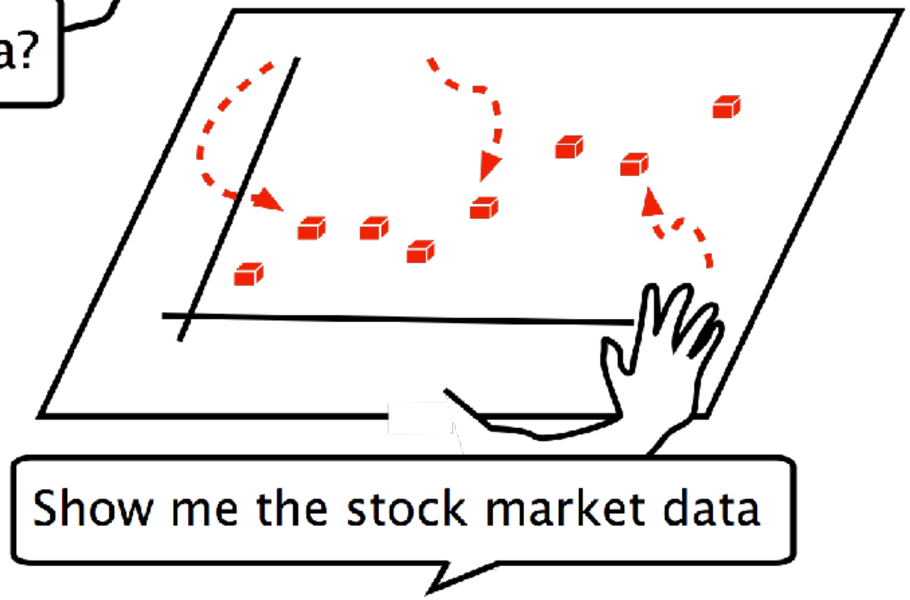
(15cm x 15cm: **$40**, 100cm x 100cm: **$200**)

1. Spatial Navigation





3. Guided Drawing



2. Data Analysis

1. Summary

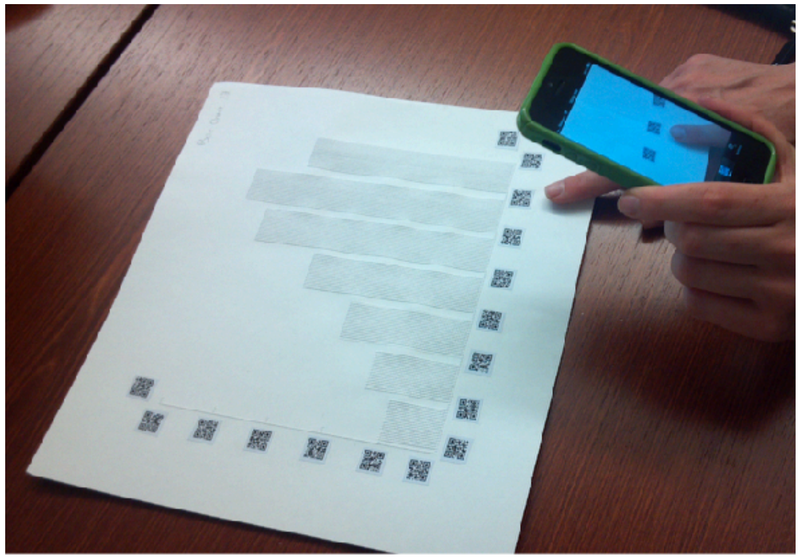
2. Motivation

3. Design and Implementation

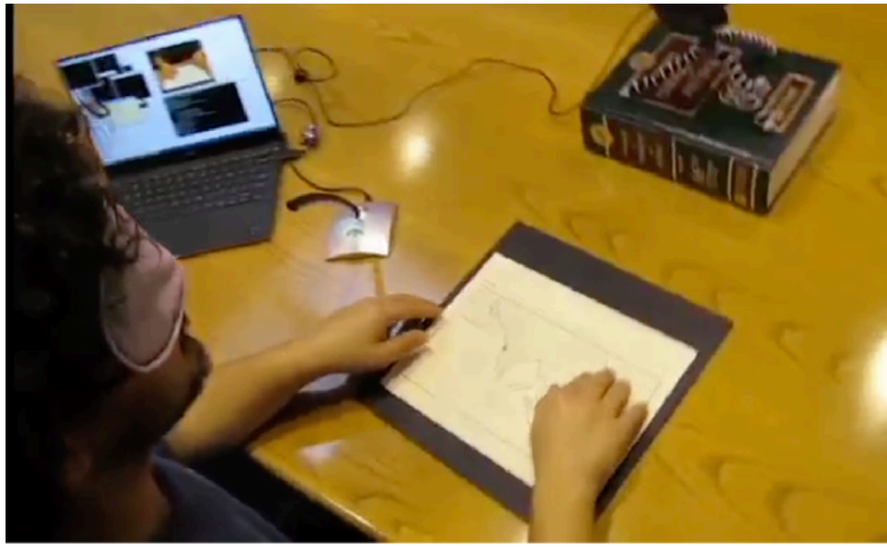
4. User Study

Interactive Tactile Graphics

Talking Tactile Tablet [2001]



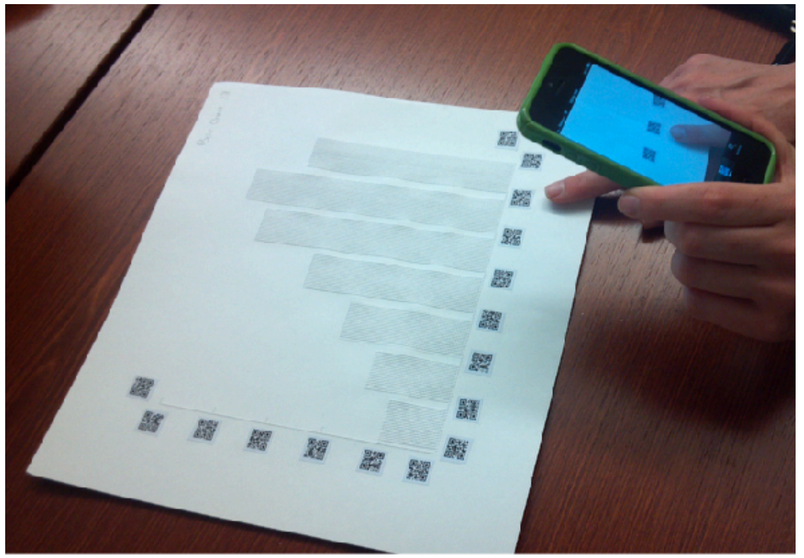
Baker et al. [ASSETS 2014]



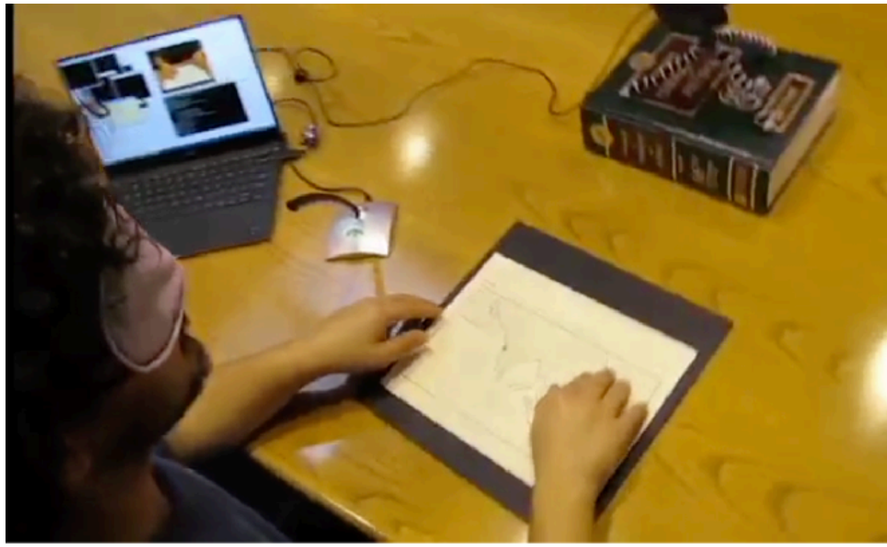
Fusco et al. [ASSETS 2015]

Interactive Tactile Graphics = **Audio** Output

Talking Tactile Tablet [2001]



Baker et al. [ASSETS 2014]

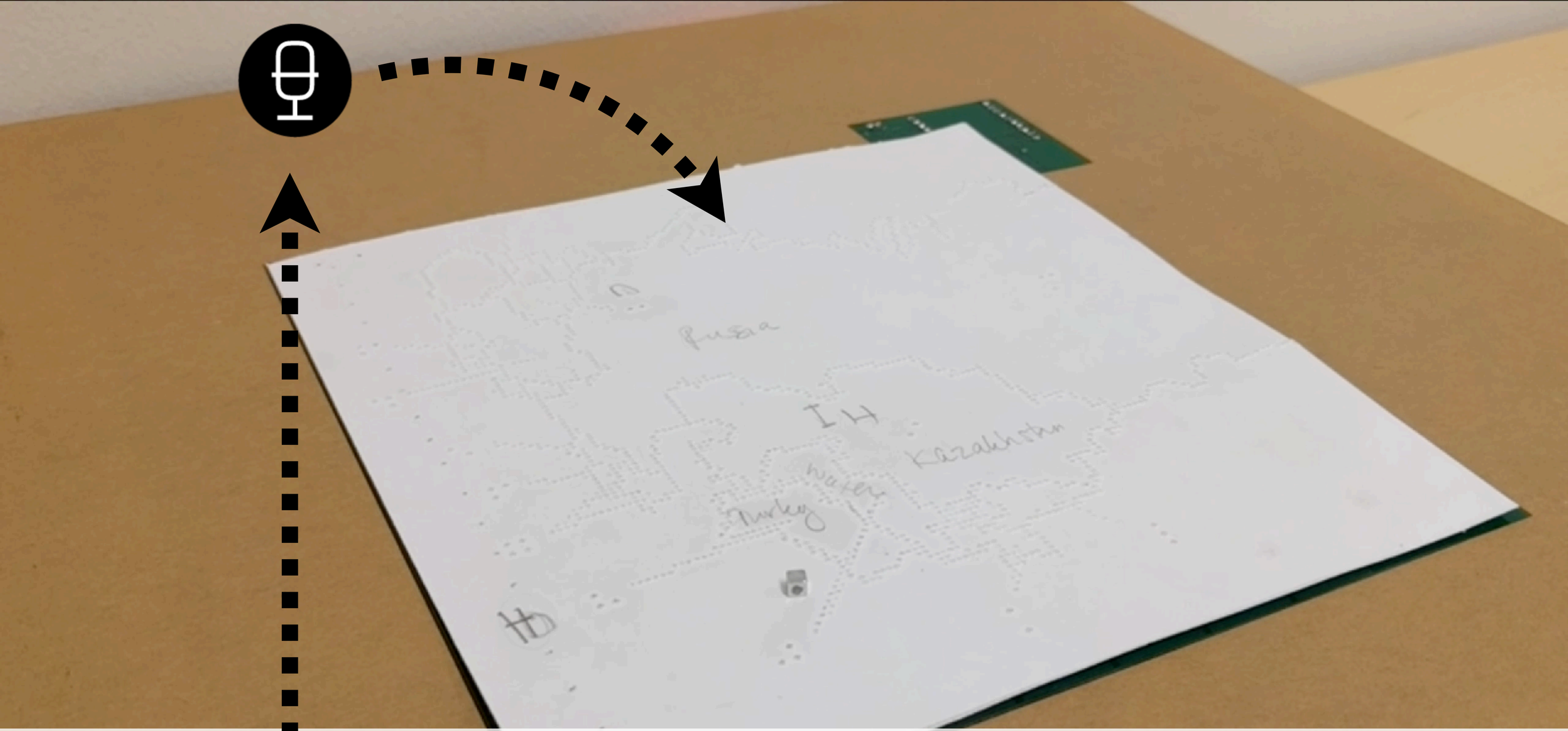


Fusco et al. [ASSETS 2015]

Spatial and Physical Guides

Audio Output

Tactile Output



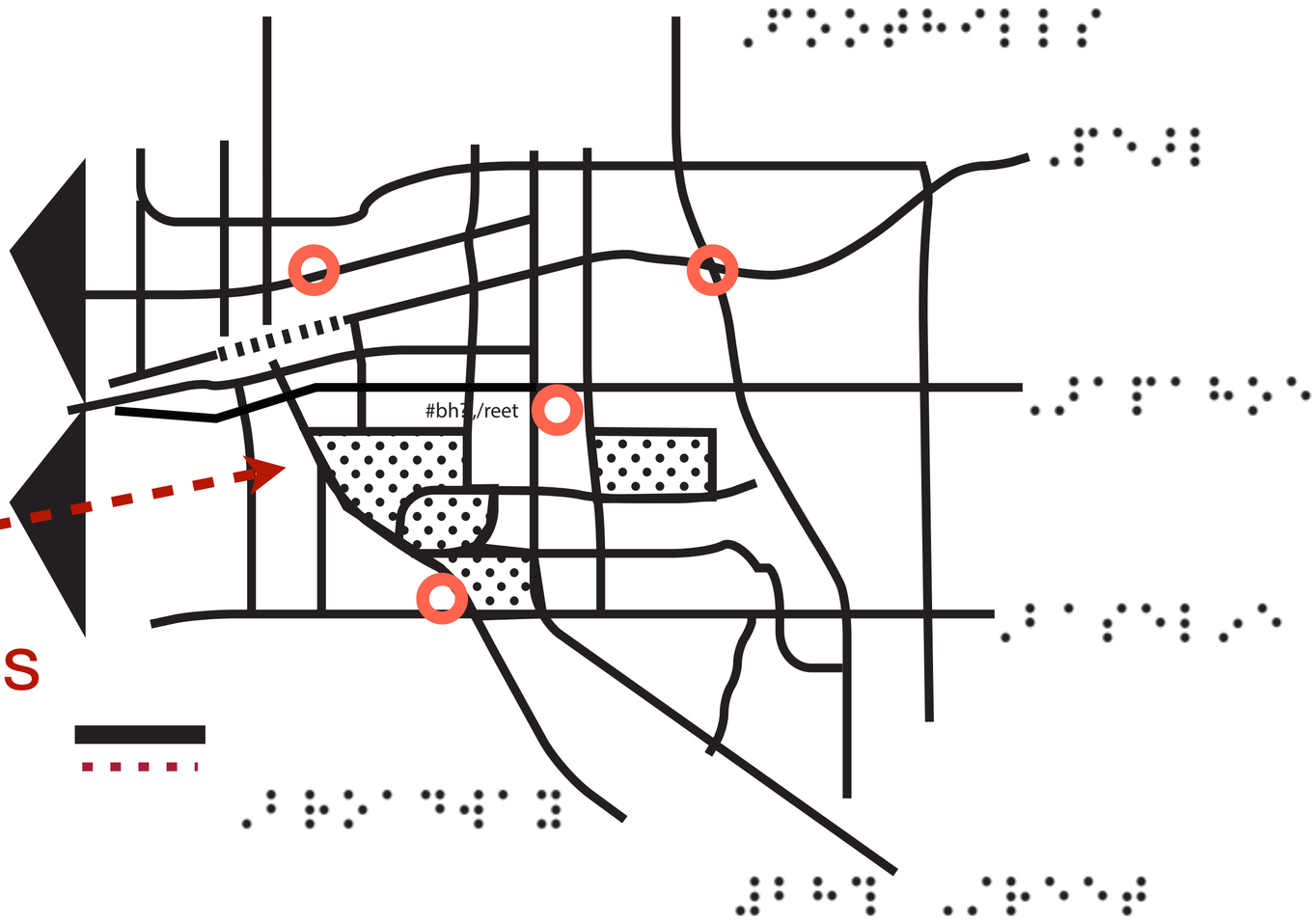
Where is the Black Sea?

keyword: **coffee shops**

specify

annotations

designer



keyword: **coffee shops**

blind user

“Show me the nearest **coffee shops**?”

keyword: **coffee shops**

initial positions

blind user

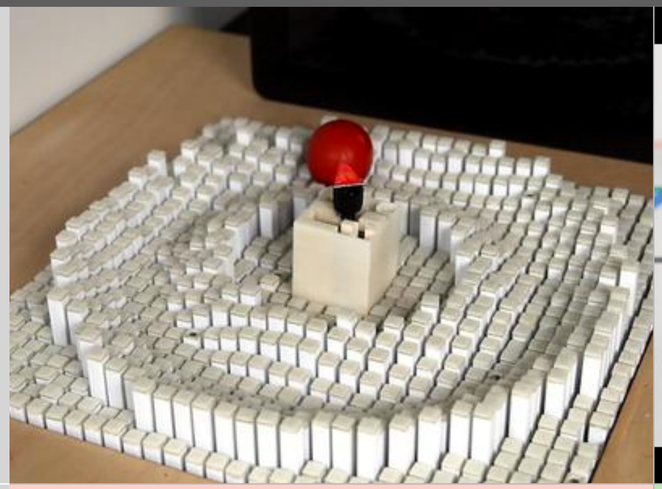
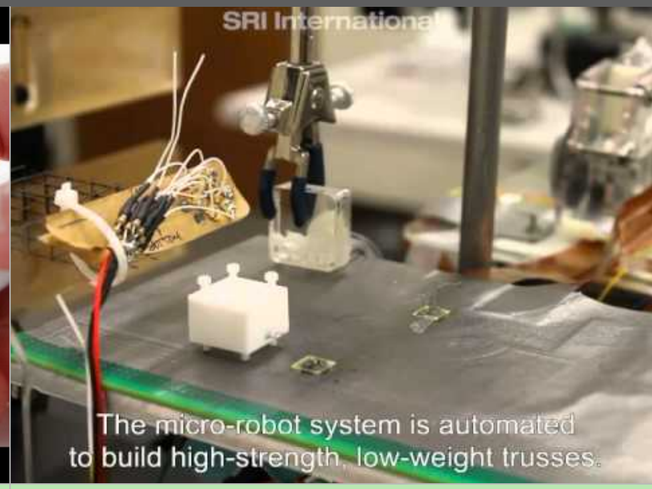
“Show me the nearest **coffee shops**?”

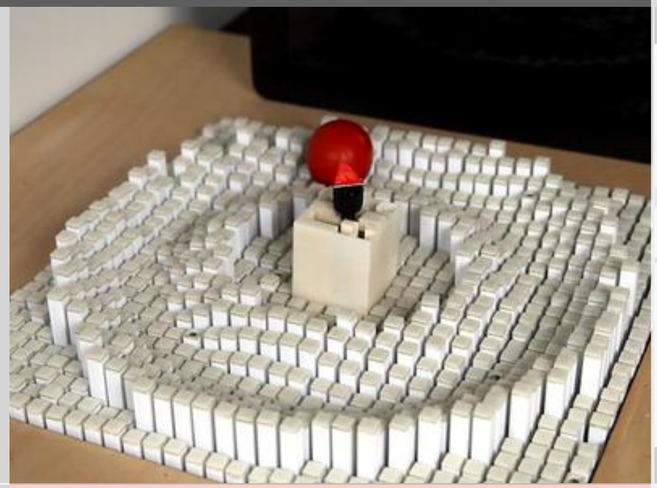
1. Summary

2. Motivation

3. Design and Implementation

4. User Study

	Pin-based	Movable Robots	Electro-magnetic
Example			
Cost and Scalability	✕ (10x10 = $500)	✔ (each marker = $50)	✔ (PCB = $10-20)
Resolution / Size of Markers	△ (resolution: 1-3cm)	△ (size: 3-5 cm)	✔ (size: 0.5-1cm)
Fabrication Complexity	✔	✔	?

	Pin-based	Movable Robots	Electro-magnetic
Example			
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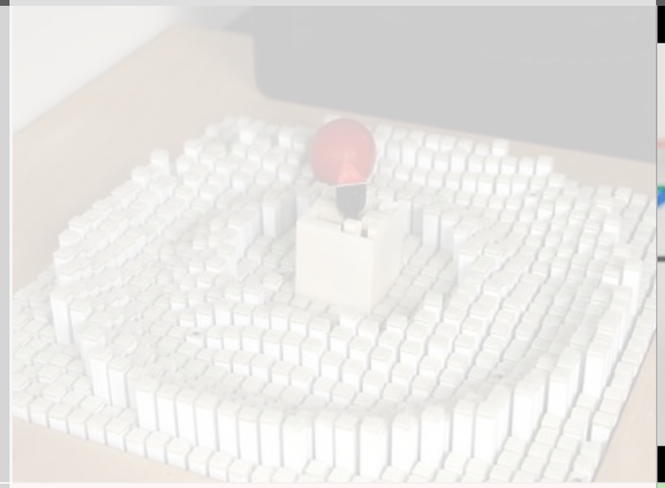
Example			
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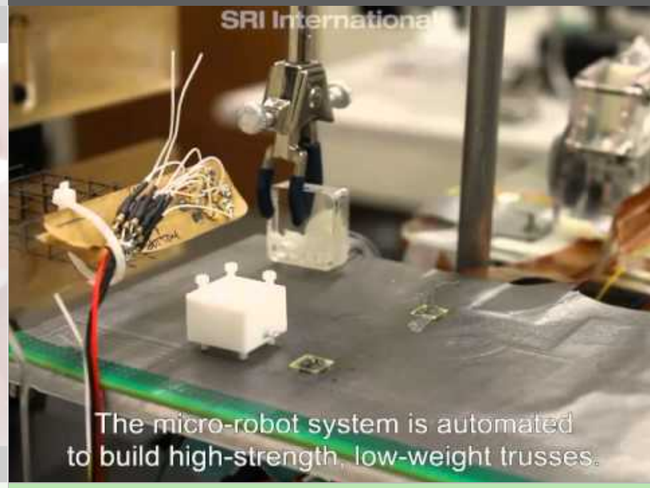
Example			
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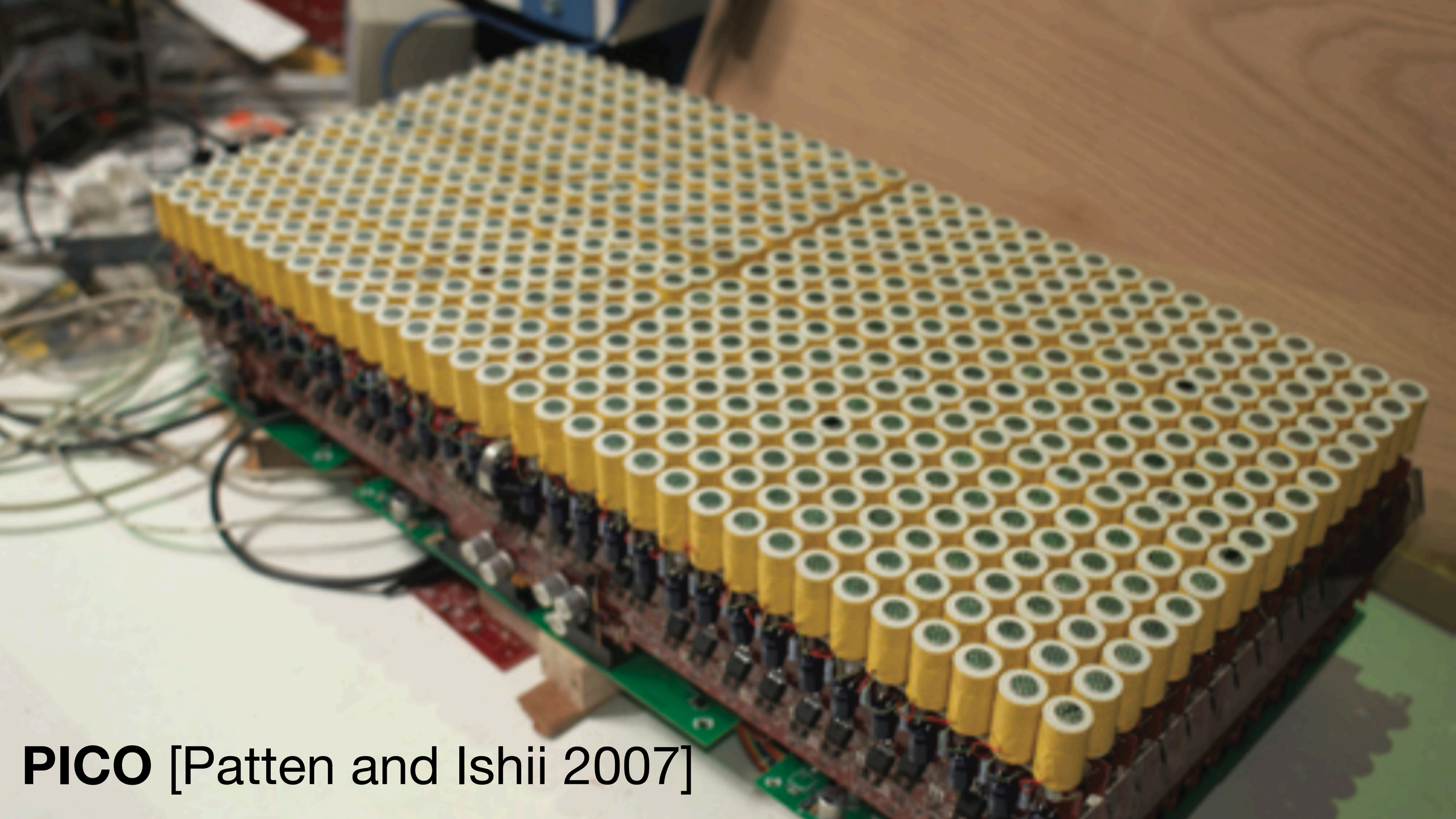
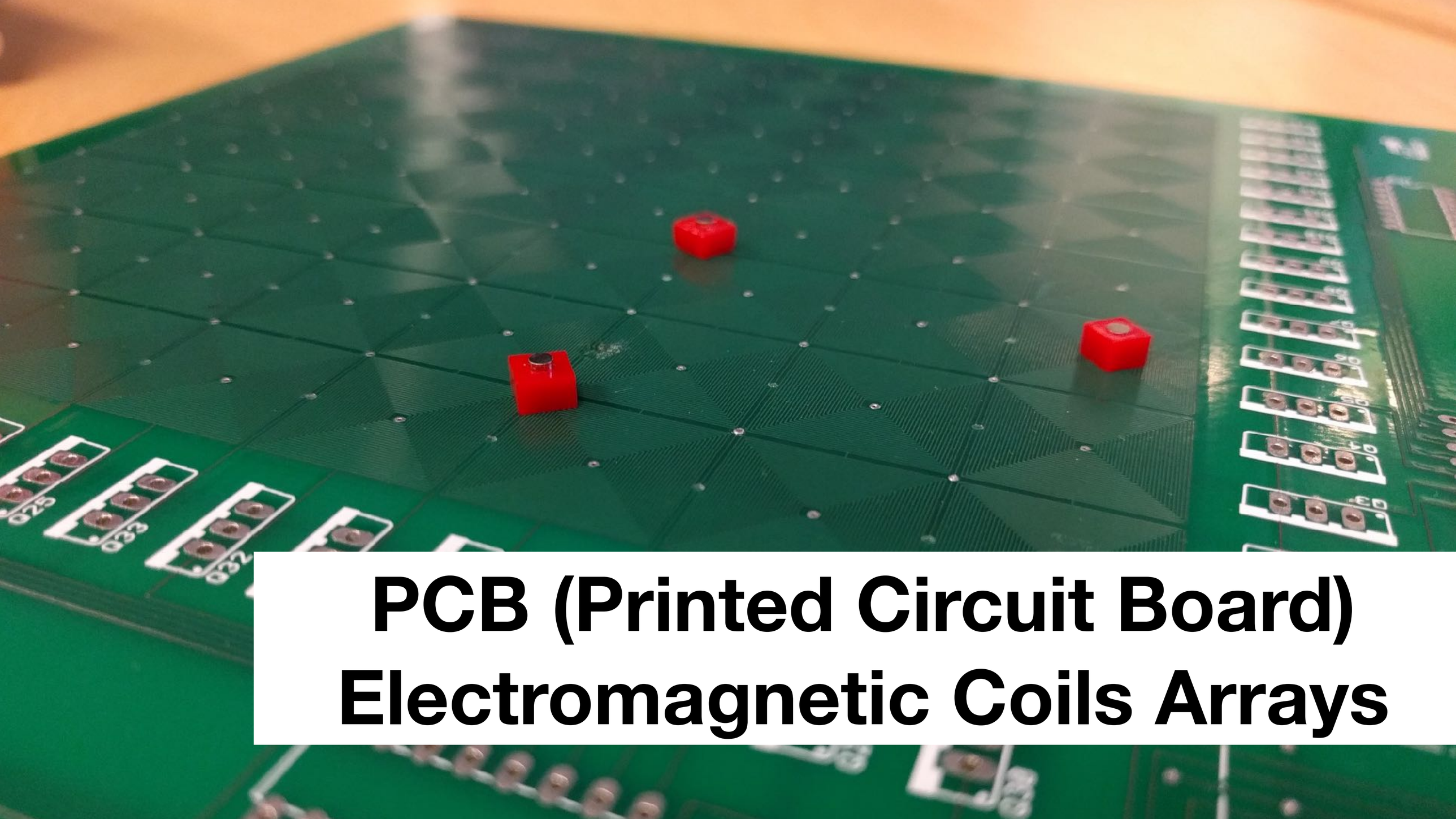
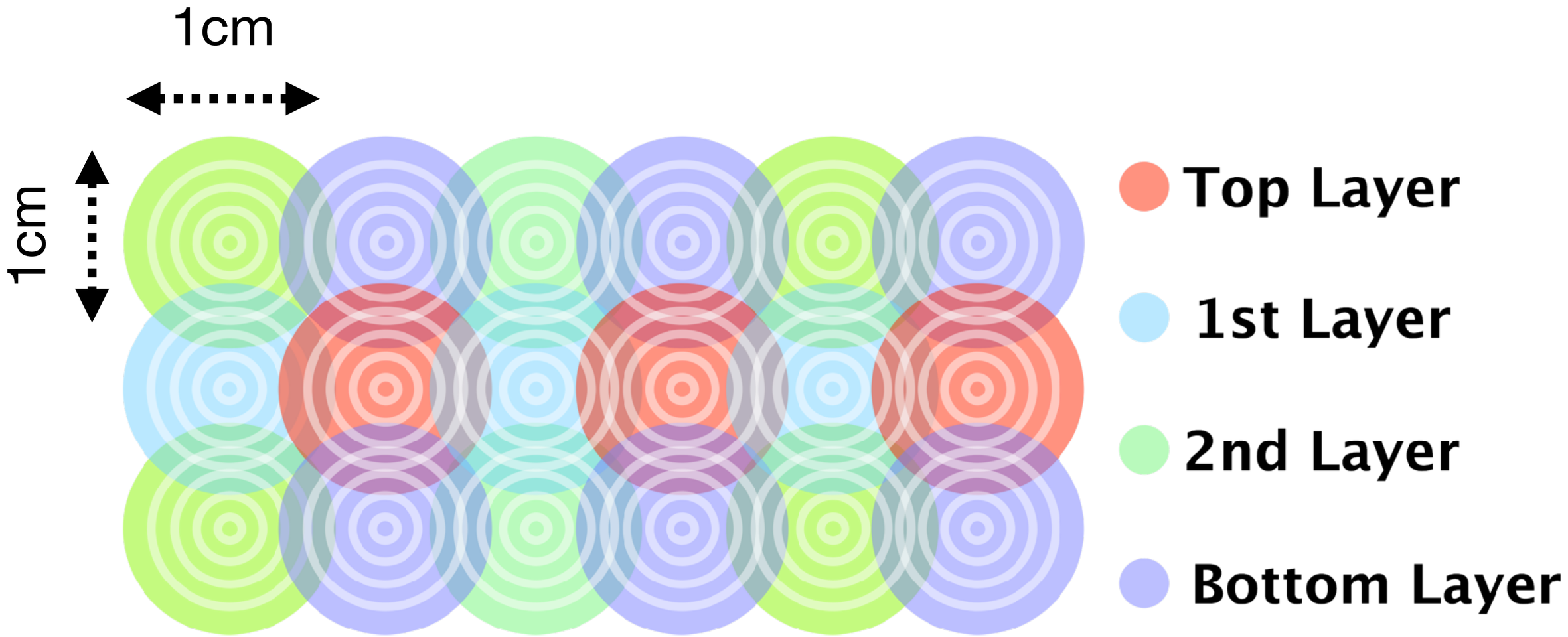
Fabrication Complexity	✔	✔	?



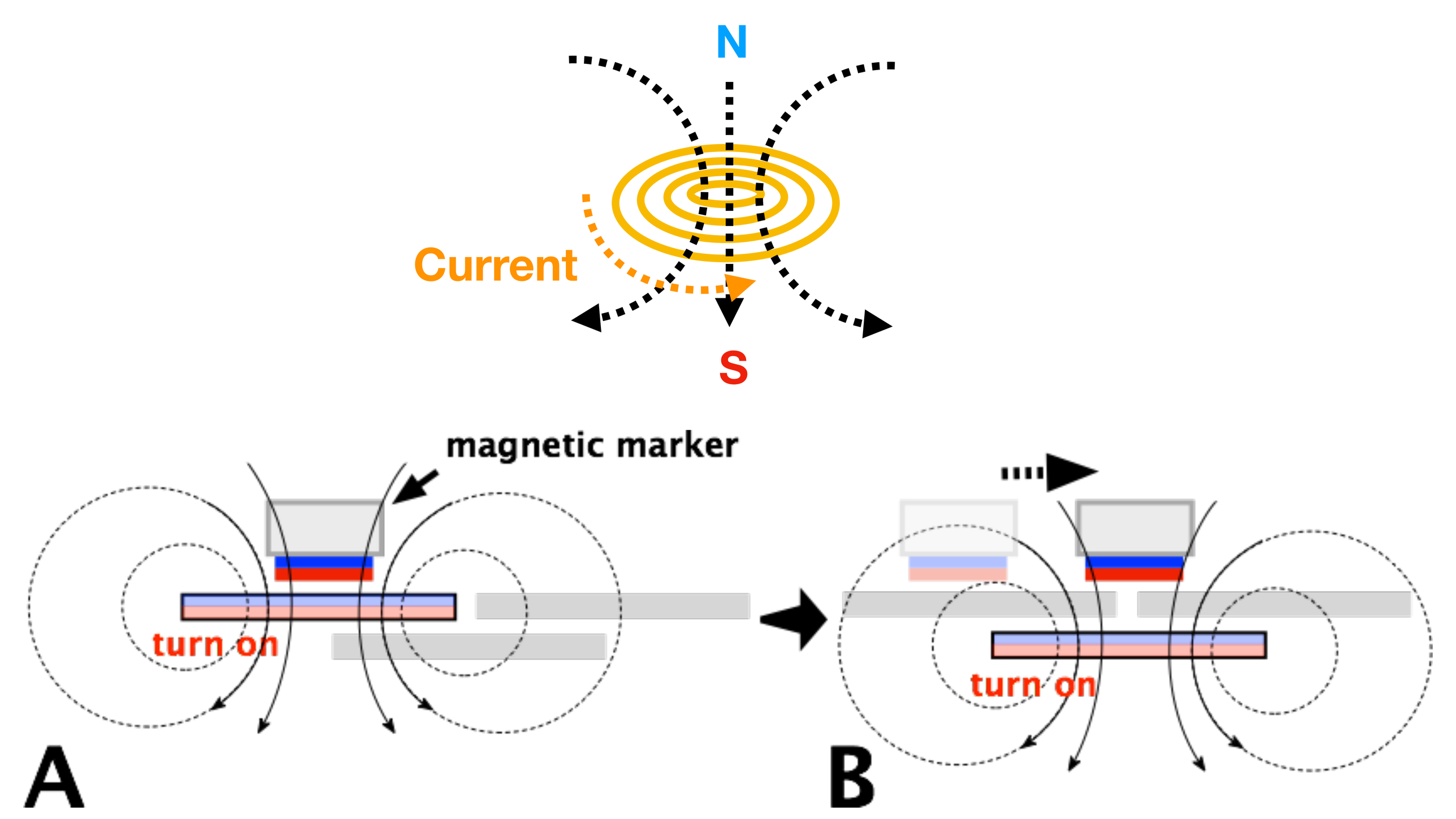
PICO [Patten and Ishii 2007]

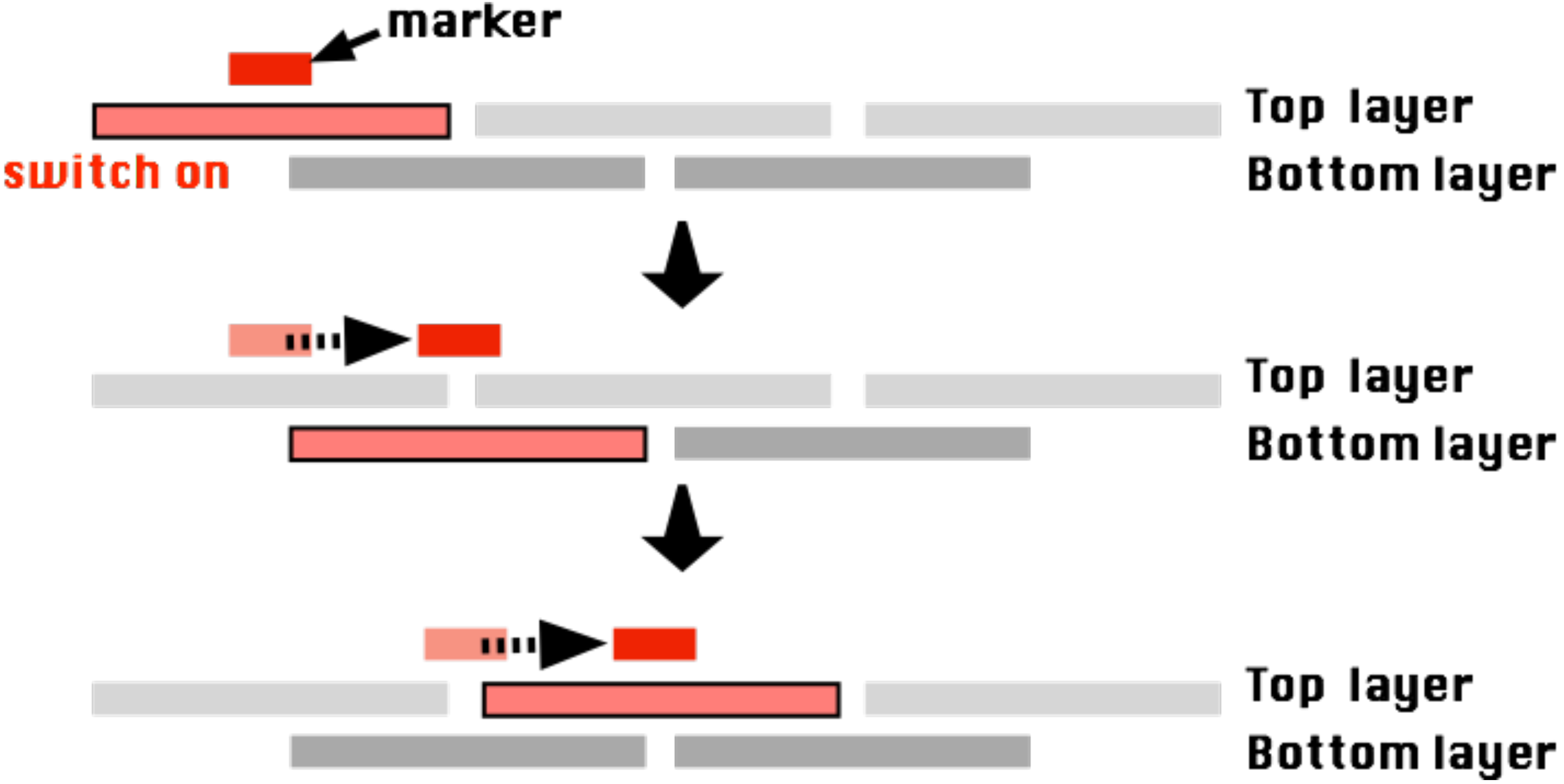


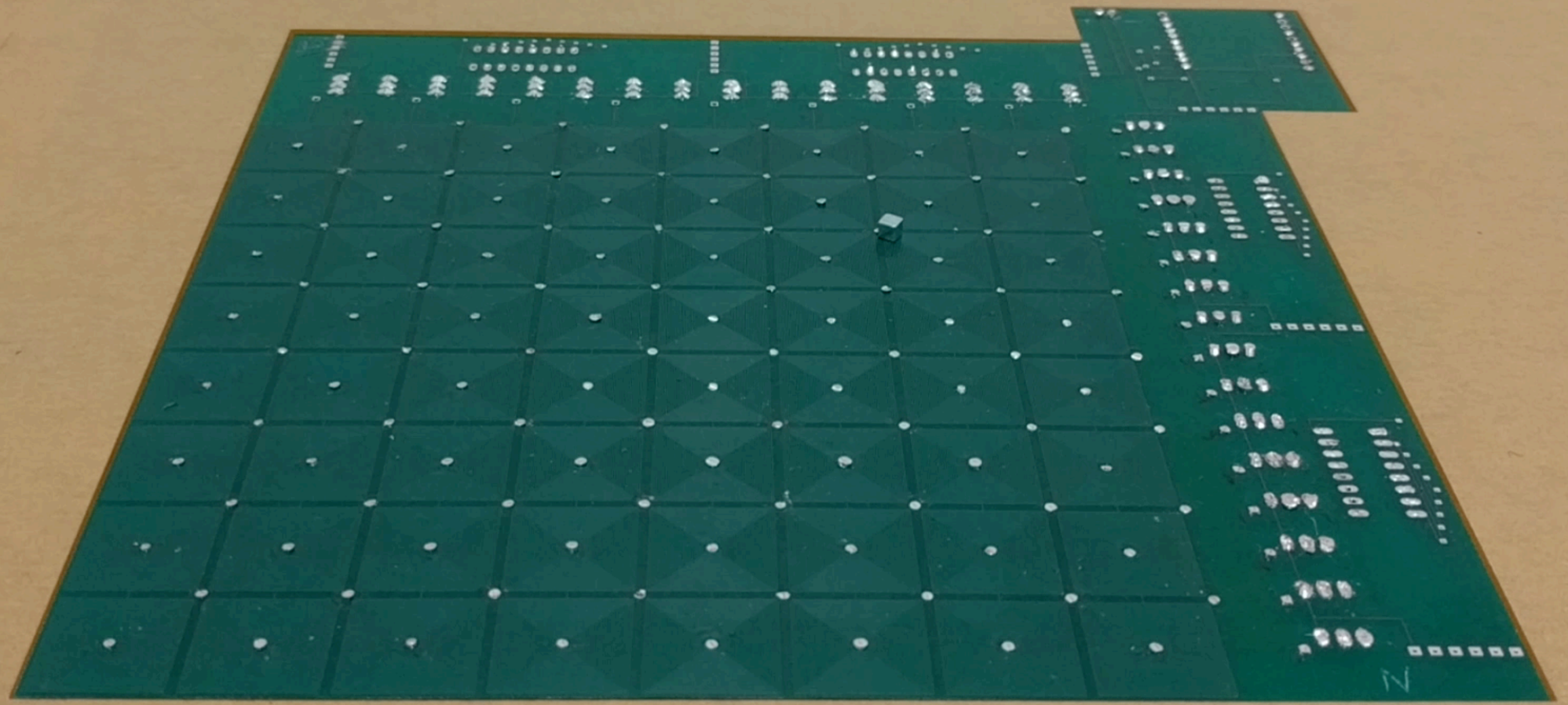
PCB (Printed Circuit Board) Electromagnetic Coils Arrays


1cm
1cm
Top Layer
1st Layer
2nd Layer
Bottom Layer

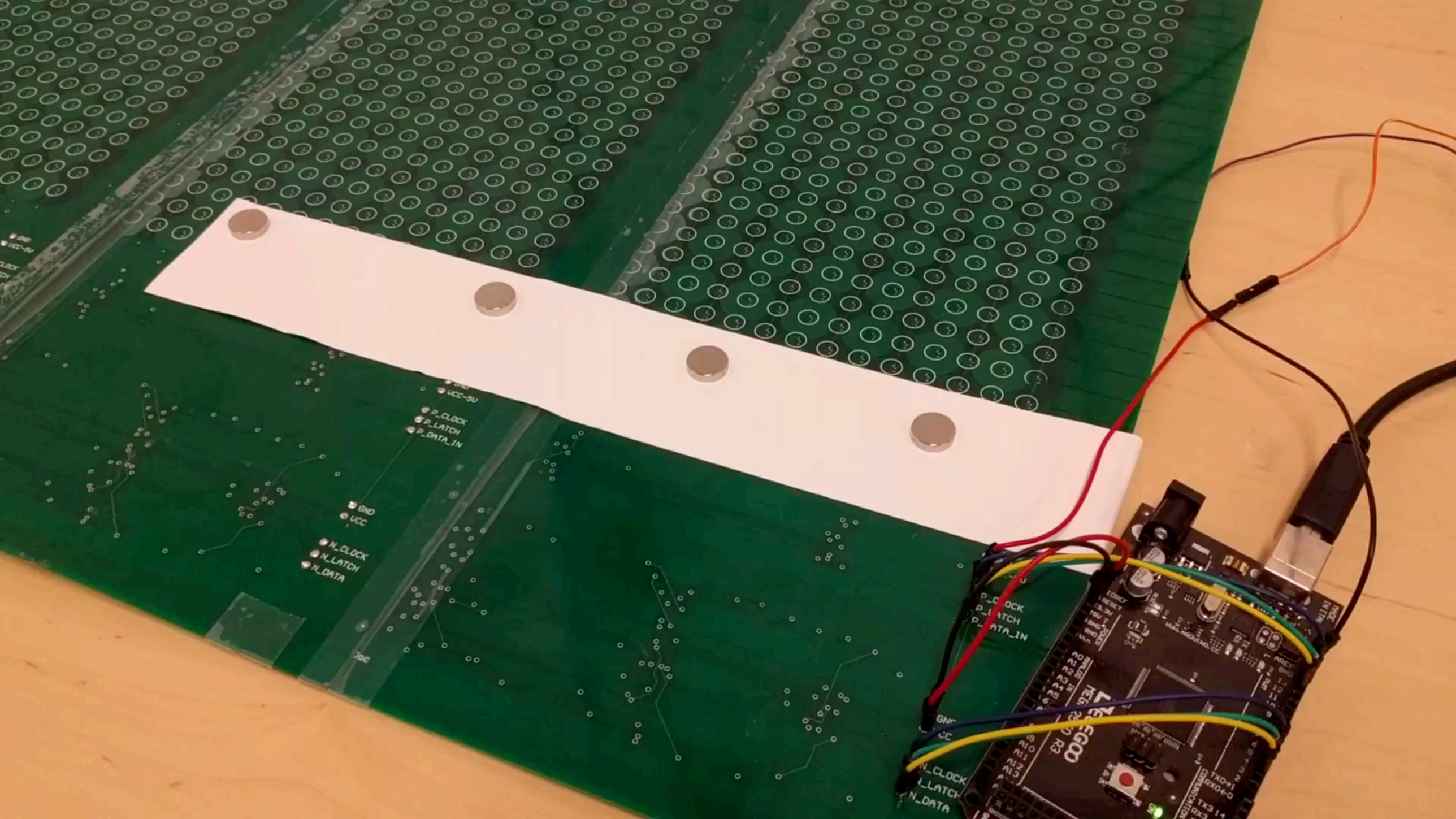

Current

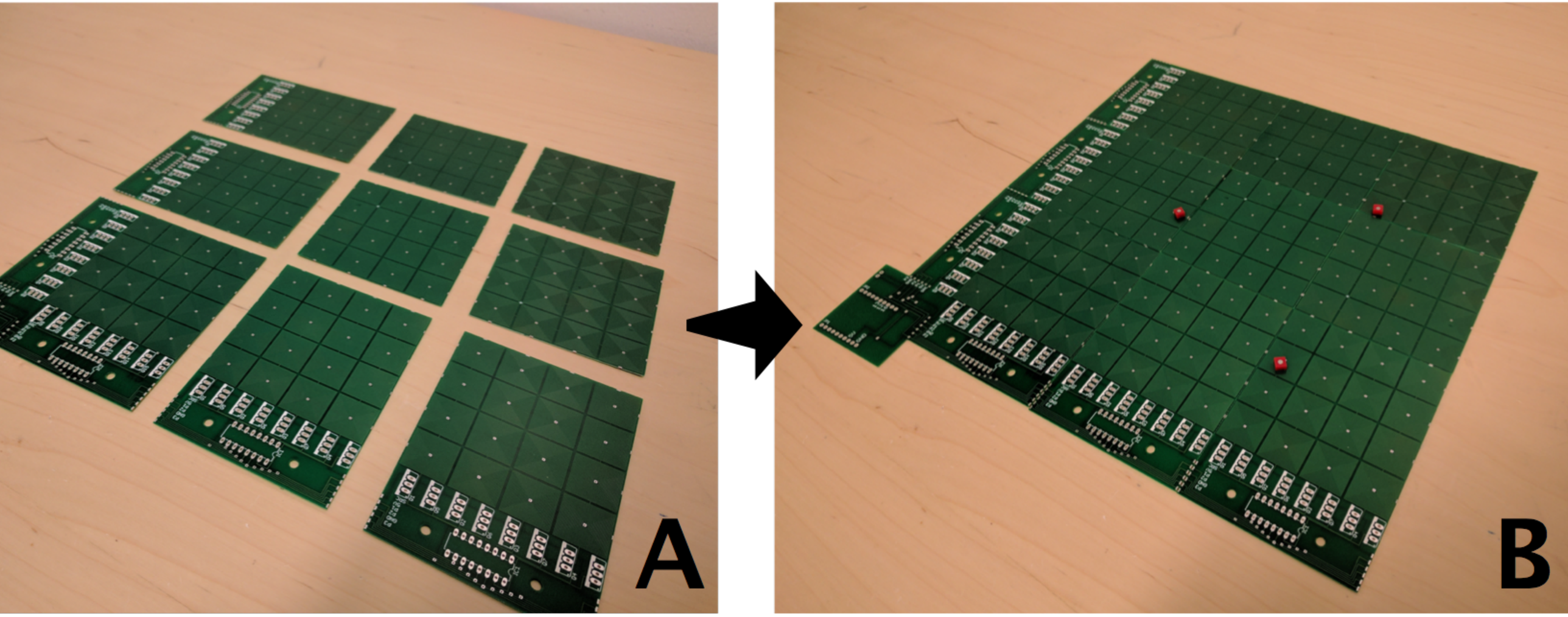

N
Current
S
magnetic marker
turn on
A
turn on
B

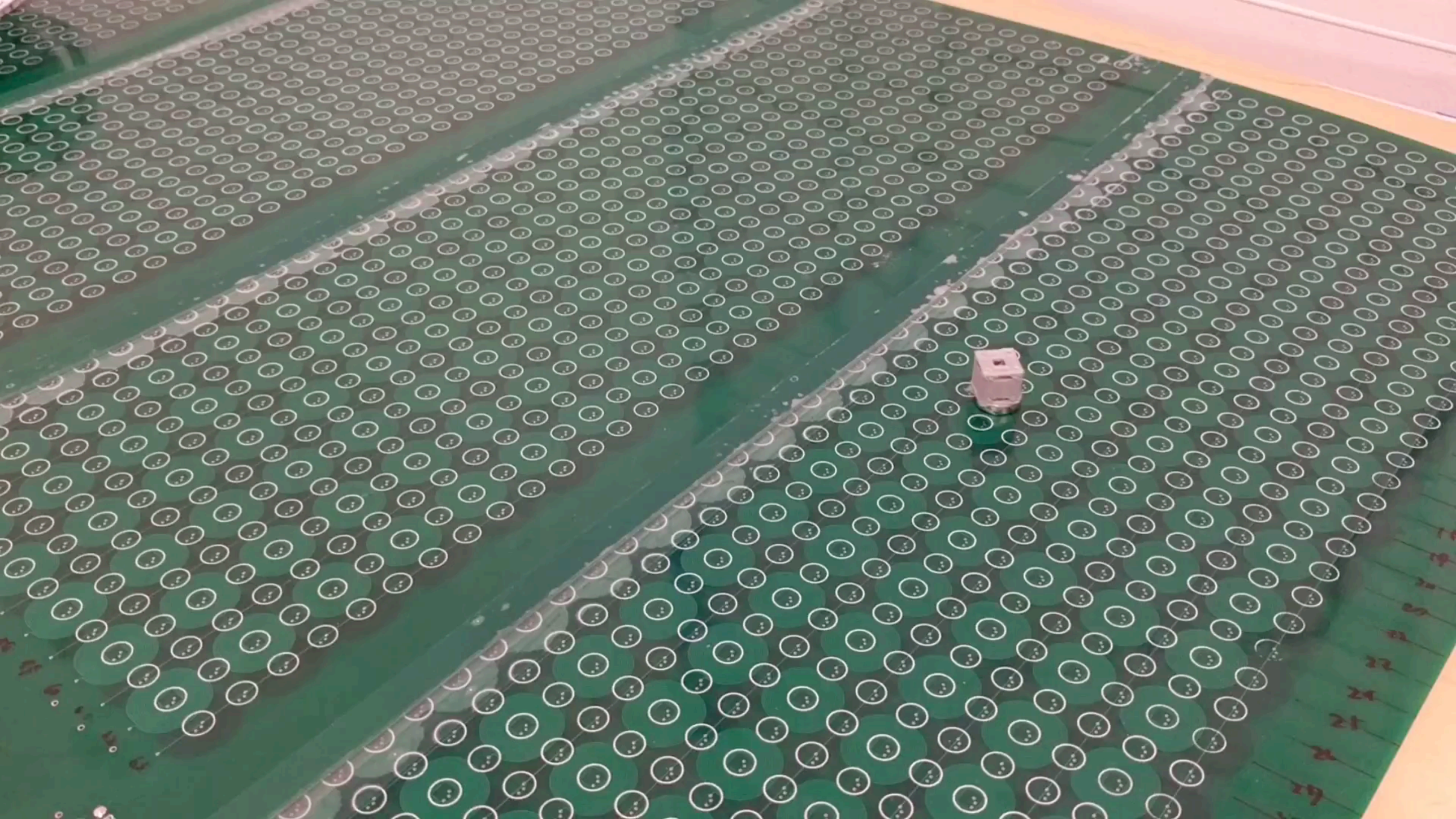

marker
switch on
Top layer
Bottom layer
Top layer
Bottom layer
Top layer
Bottom layer




USPS TRACKING #
9400 1116 9900 0337 2555 52
FIRST CLASS
GND


VCC-5V
P_CLOCK
P_LATCH
P_DATA_IN
GND
VCC
N_CLOCK
N_LATCH
N_DATA


A
B



These designs are informed by

our **Formative Study**

with **4** blind participants

1. Summary
2. Motivation
3. Design and Implementation

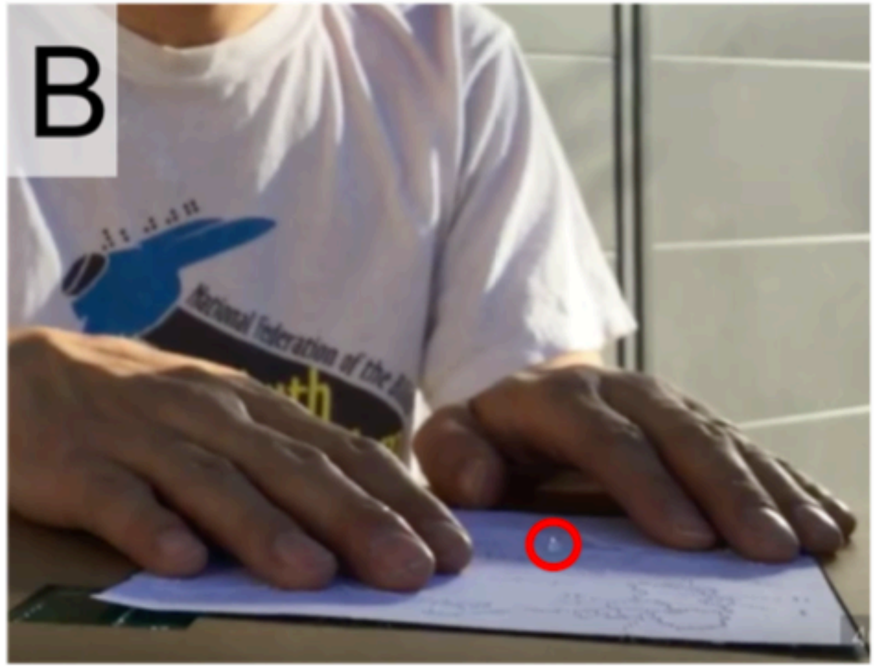
4. User Study

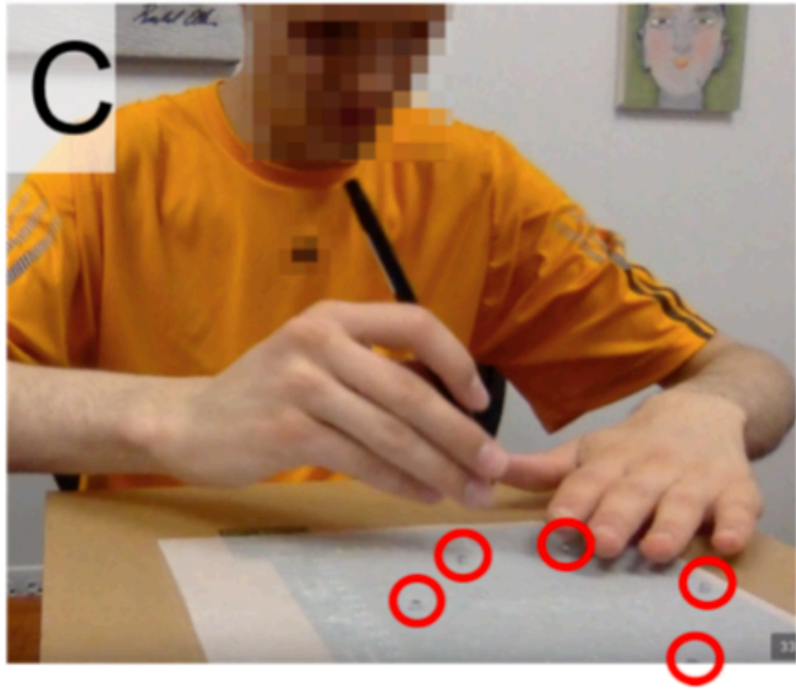
6 participants

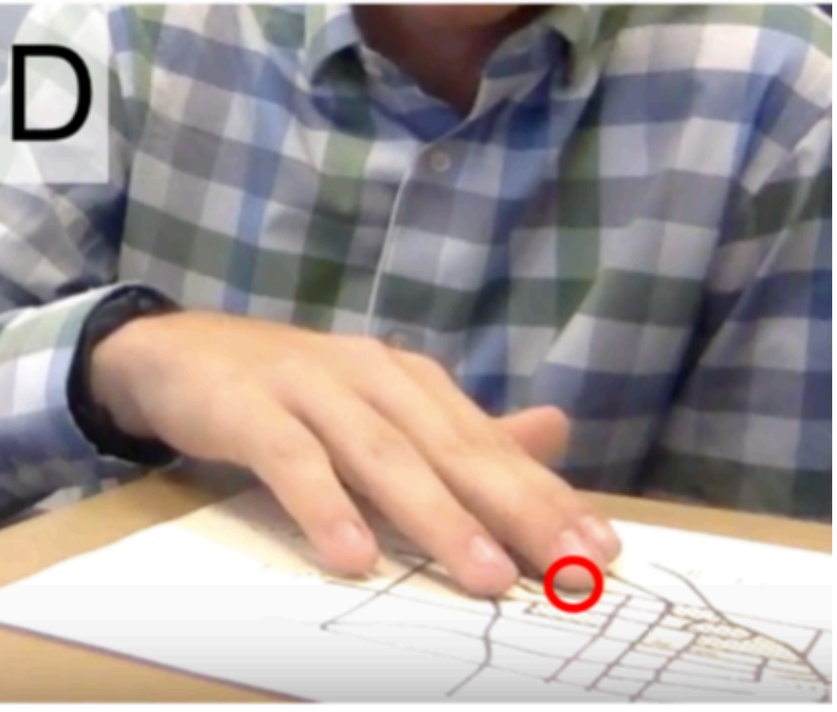
(4: blind, 2: low-vision, average age: 26.8)

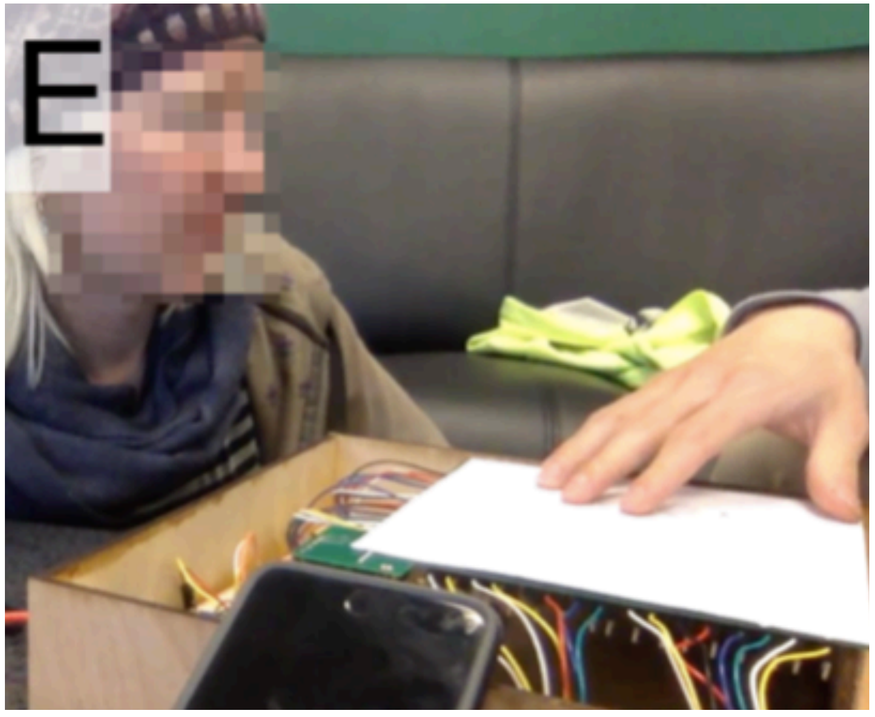
Participant	P1	P2	P3	P4	P5	P6
Gender	Male	Male	Female	Female	Male	Female
Age	22	28	26	36	23	26
Visual Impairment Status	Blind	Blind	Blind	Blind	Low Vision	Low Vision
Frequency of Tactile Graphic	Medium	Medium	High	Medium	None	None
Familiarity with Science Graphics	None	Medium	Medium	Medium	None	None
Familiarity with Tactile Maps	High	High	Low	High	Low	Low
Braille Fluency	High	High	High	Medium	Low	Low

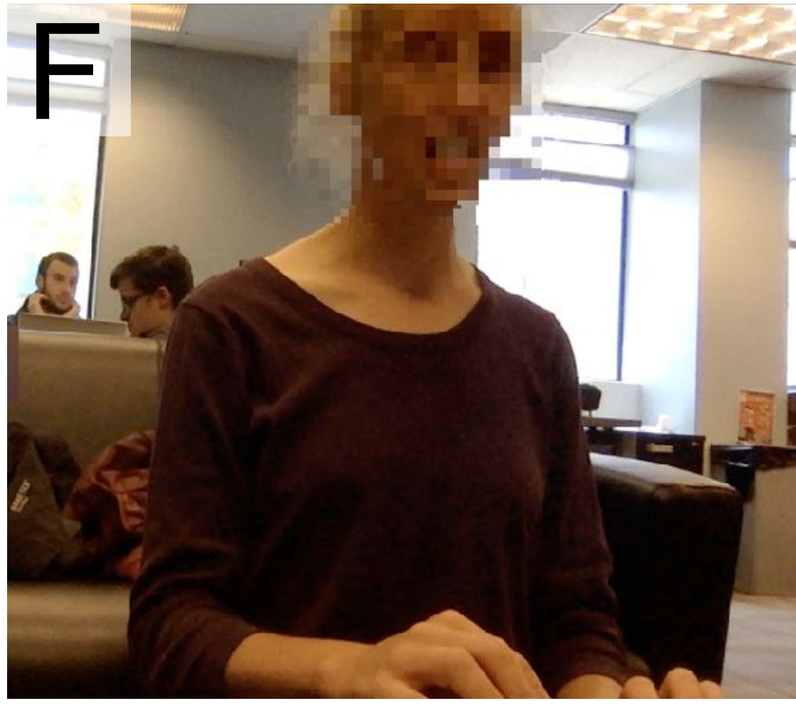

A


B


C


D


E


F

Find a specific point

without FluxMarker ⟷ with FluxMaker

1. Tactile map of East Europe area
2. Human brain model
3. Drawing hexagon

Findings

Real-time Spatial Navigation
as Important Application

*P1: “The best application I could see is to have **the marker move with the user following along**, so that the teacher could trace a path out for me in real-time.”*

Increase an Independence

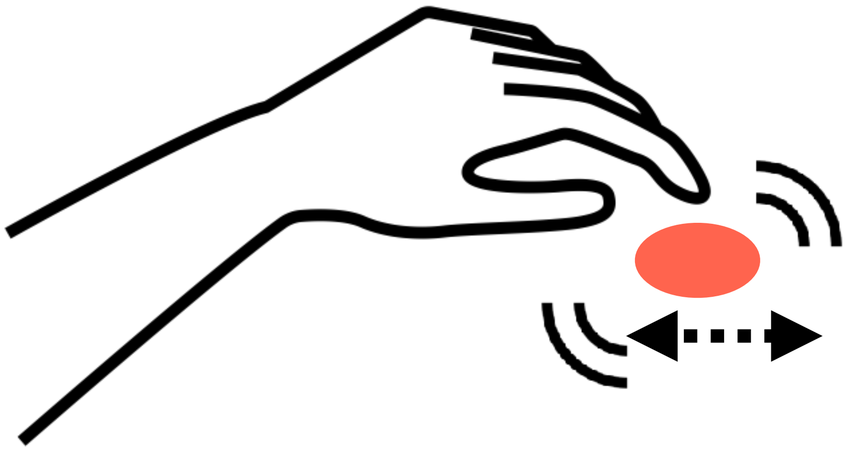
*P4: “**It works better than having another person poking at the spot**. Even if you start taking time to explore around, they might think you are lost —which you are not— and try to show you around.*

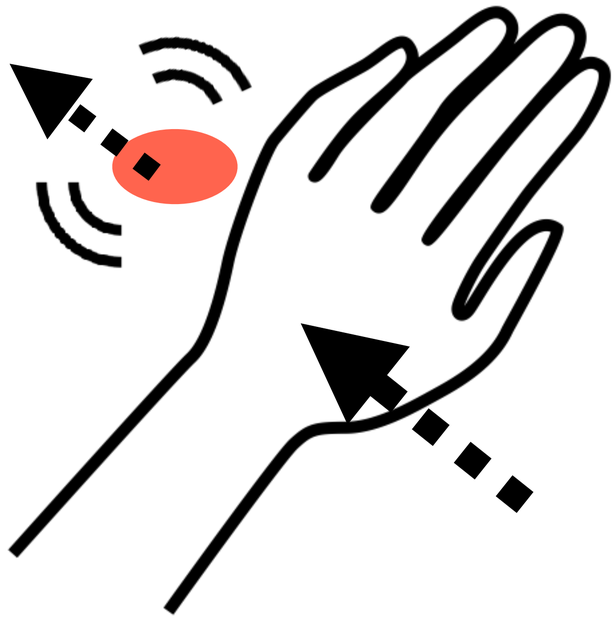
Educational application
for classroom use

P6 “This would be useful if it was ***synced up with a lecture and graphics****, or even if it was* ***synced with an instructors laser pointer****; if it was tracking what was up on the board, and I could follow along, that would be amazing.”*

Limitations

Unstable Position

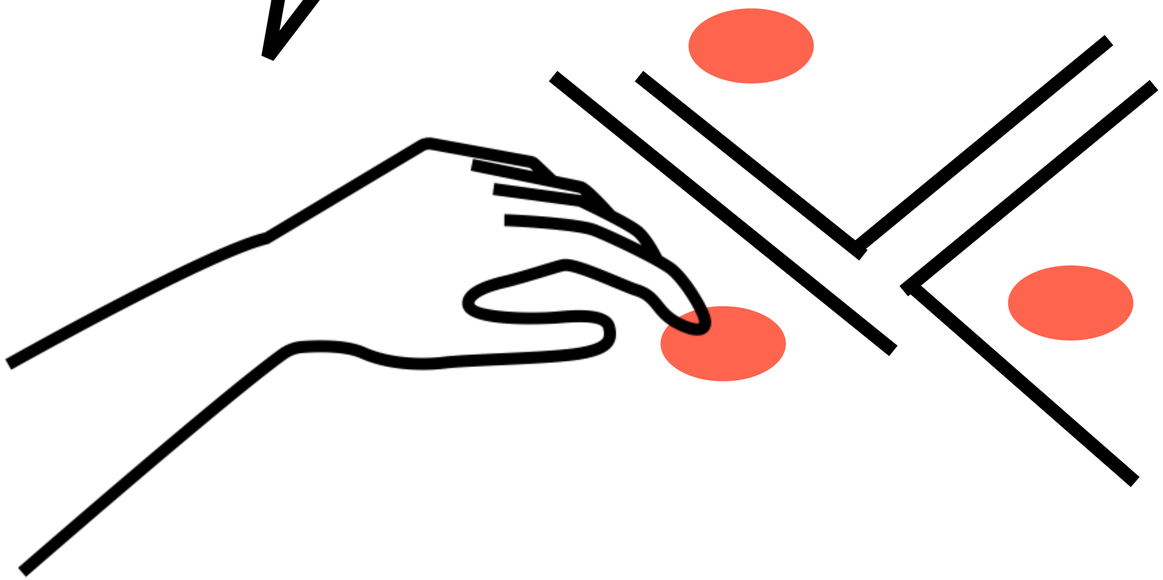




Touch Interaction

Show me the nearby restaurants

Tell me a **menu** and **open hours** of this



Future Vision


UbiSwarm [Kim et al 2017]

Permission to Take Part in a Human Research Study

What happens if I do not want to be in this research, or if I say yes, but I change my mind later?

Participants are welcome to leave at any time. Leaving will not be held against you. Partially answered interviews (80% completion or less) will not be used for this research.

What happens to the information collected for the research?

During the interview, the researchers will collect data on subjective feedback about the experience. The data will be used to assess the development product qualitatively, to improve the usability of the technology, and to plan further development.

Efforts will be made to limit the use and disclosure of your personal information, including research study records, to people who have a need to review this information. We cannot promise complete secrecy. Organizations that may inspect and copy your information include the IRB and other representatives of this organization. No identifiable information about participants will be shared in reports; direct identifiers will be removed from the data to ensure anonymity.

What else do I need to know?

This research is funded by a grant from the National Science Foundation.

Permission to Take Part in this Research:

Your signature (typing in your name and date) documents your permission to take part in this research.

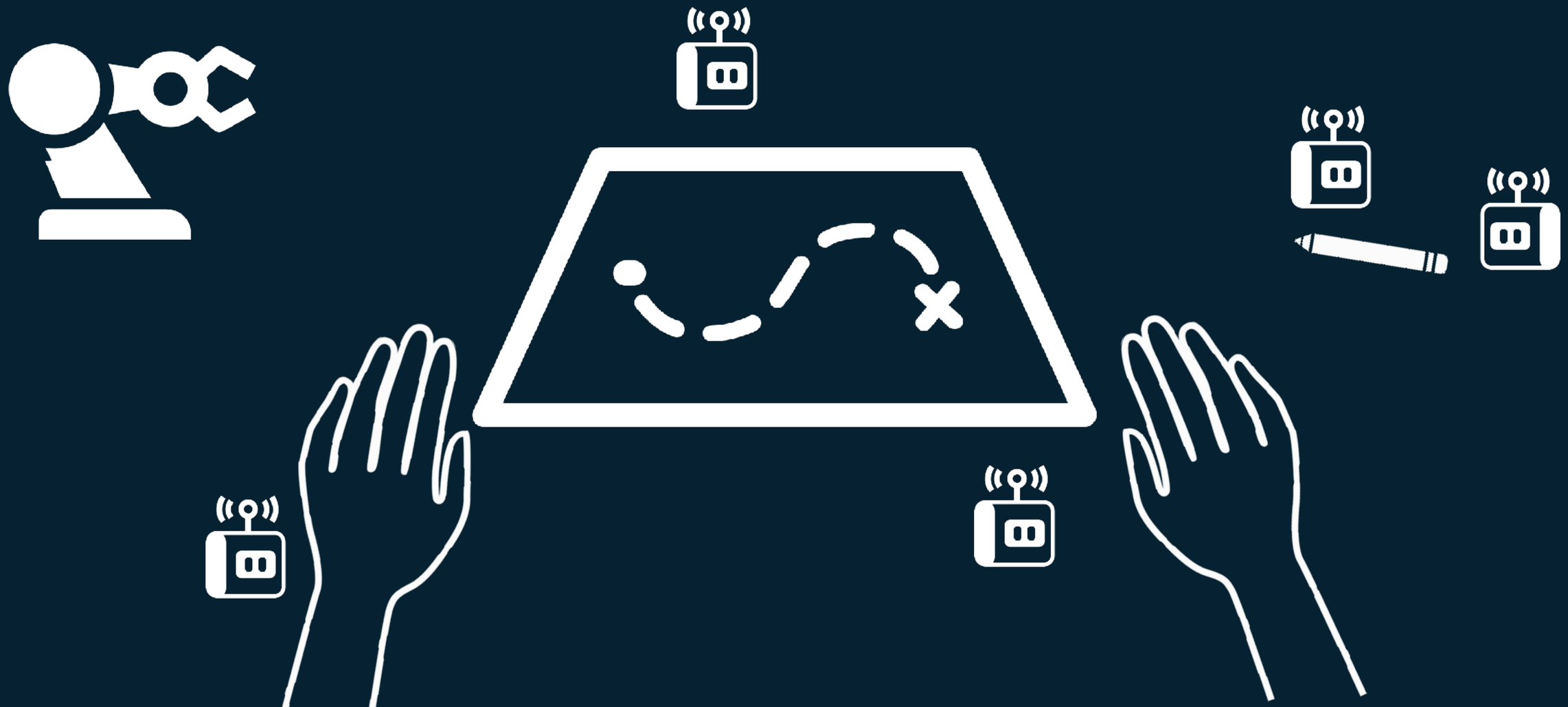
Signature: ______________________

Date: ______________________

I agree to take part in this research YES NO

IRB Approval Date

Interactive Physical Assistant



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