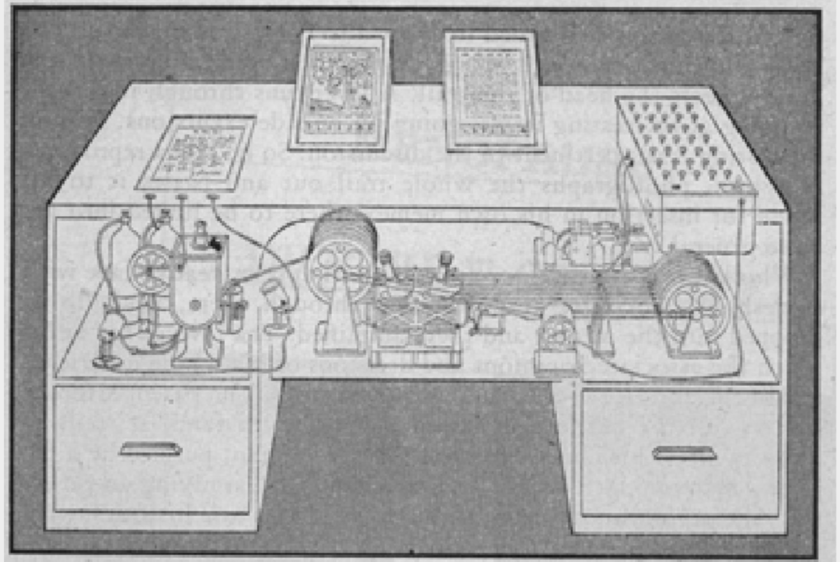
Marking Material Interaction with Computer Vision

Motivation

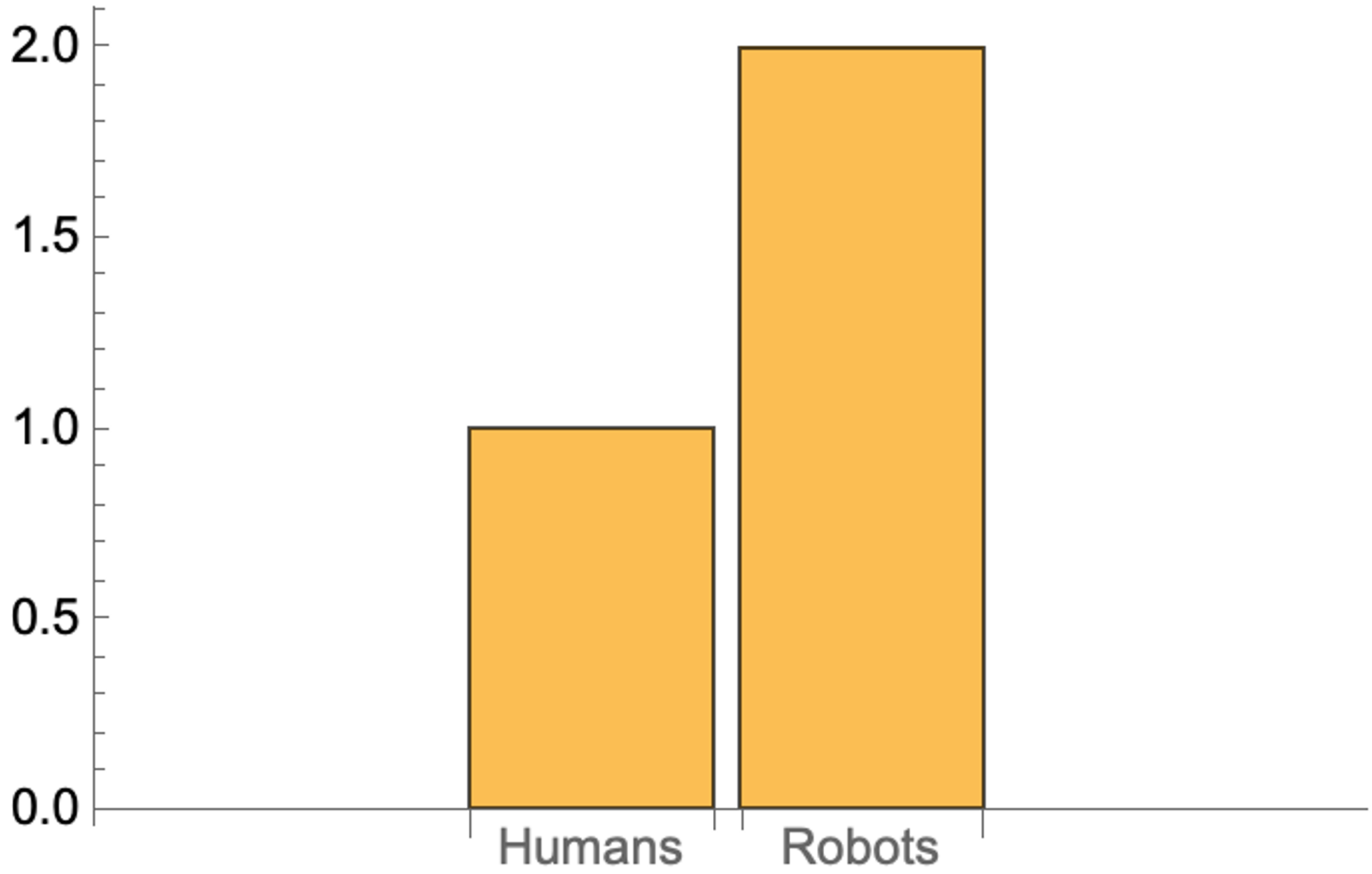
AI Alignment and HCI



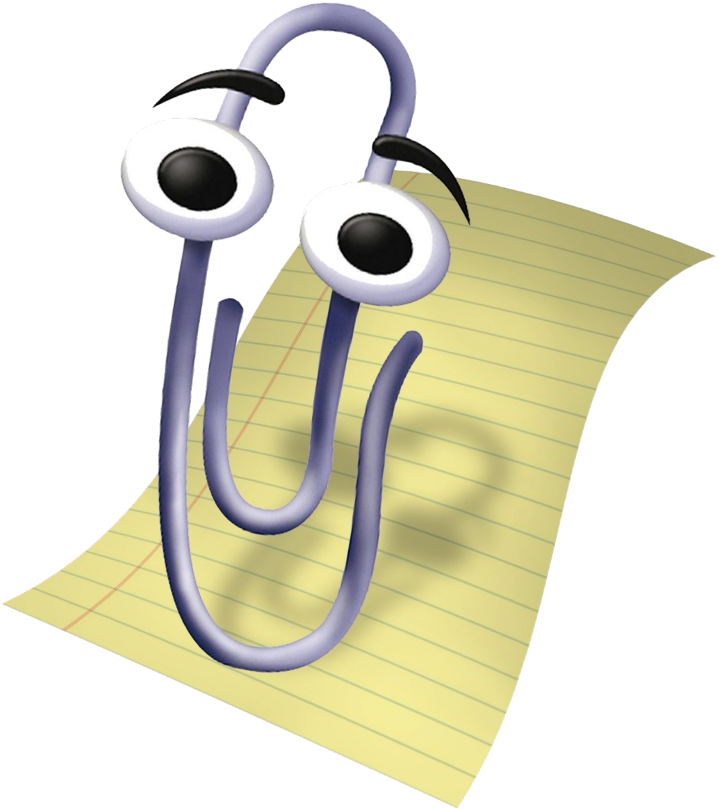
MEMEX in the form of a desk would instantly bring files and material on any subject to the operator's fingertips. Slanting translucent viewing screens magnify supermicro-film filed by code numbers. At left is a mechanism which automatically photographs longhand notes, pictures and letters, then files them in the desk for future reference.

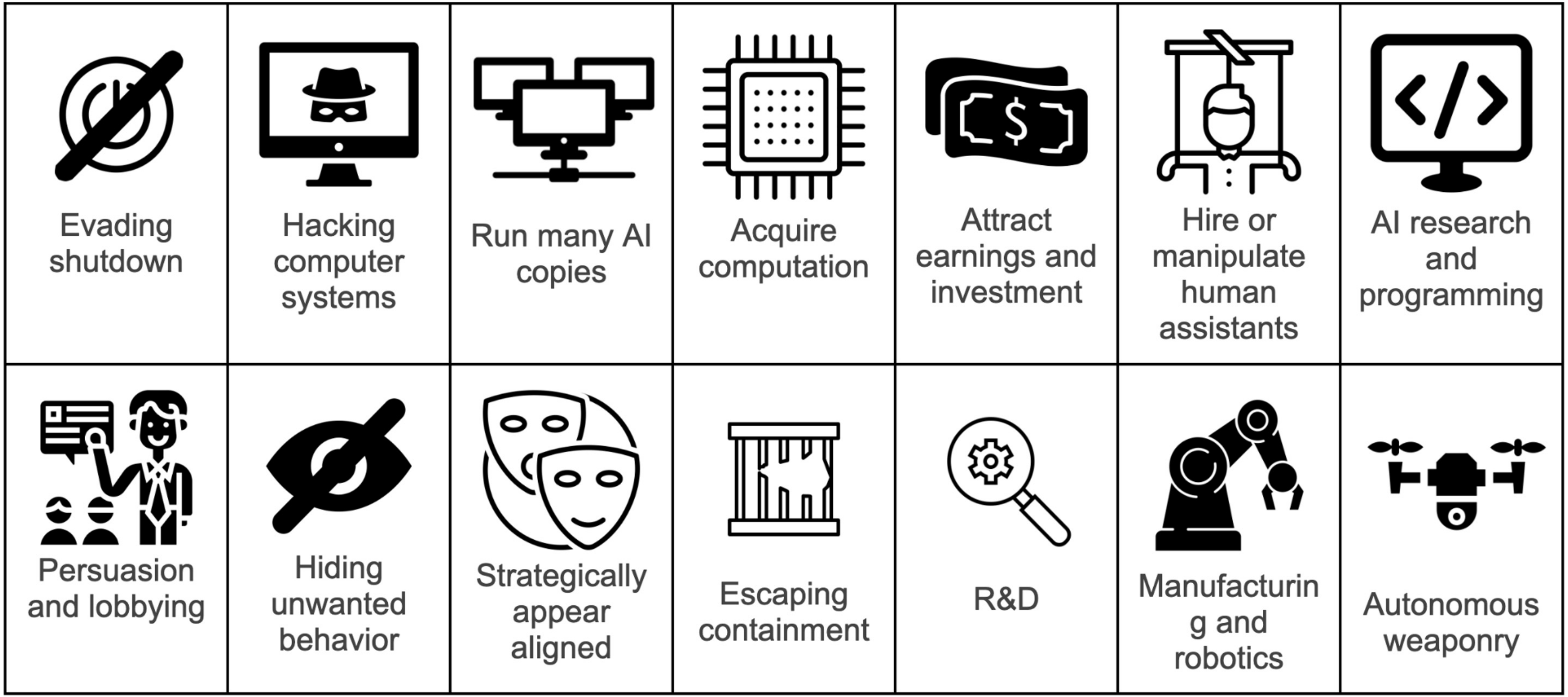
How do we ensure that a sufficiently capable AI/Agent won’t harm humans?

Superintelligence: Any intellect that greatly exceeds the cognitive performance of humans.



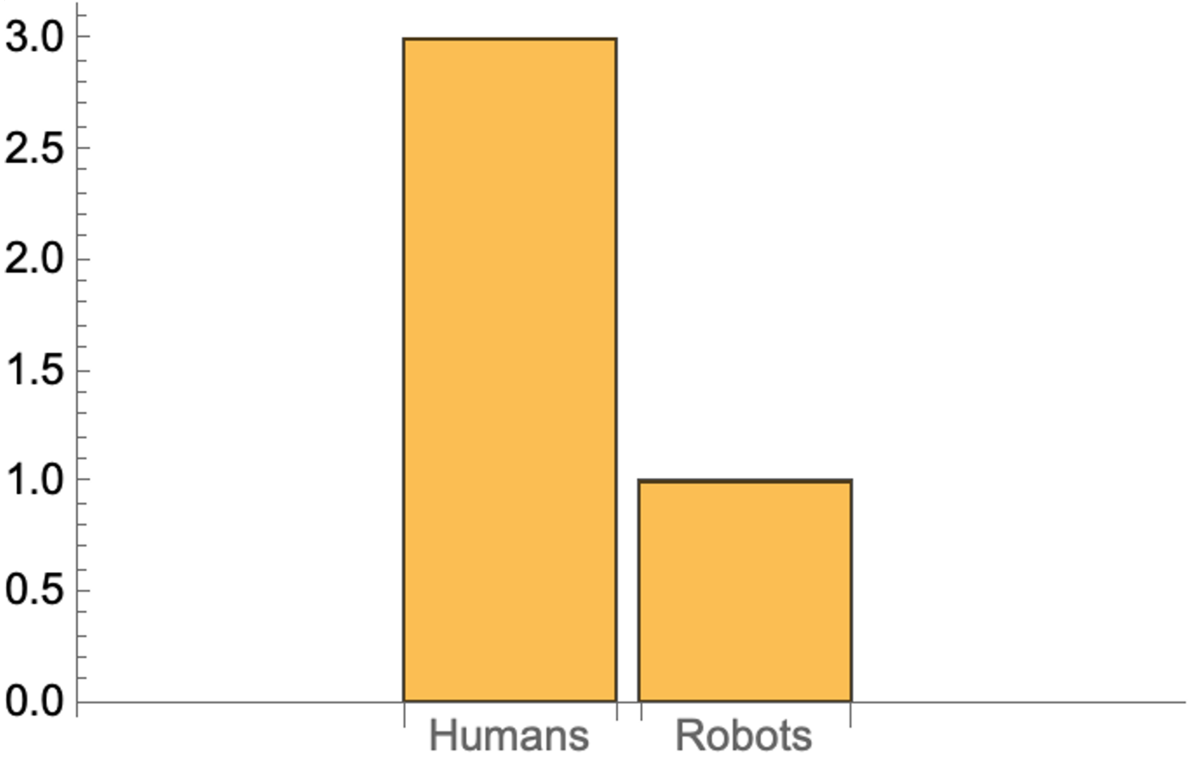
2.0
1.5
1.0
0.5
0.0
Humans
Robots

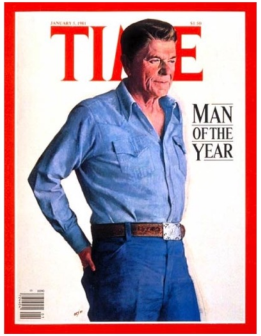



Evading shutdown
Hacking computer systems
Run many AI copies
Acquire computation
Attract earnings and investment
Hire or manipulate human assistants
AI research and programming
Persuasion and lobbying
Hiding unwanted behavior
Strategically appear aligned
Escaping containment
R&D
Manufacturing and robotics
Autonomous weaponry

"Together they began to try to work out how owls might be tamed or domesticated. They soon realized that Pastus had been right: this was an exceedingly difficult challenge, **especially in the absence of an actual owl to practice on.**" (Bostrom, 2014)

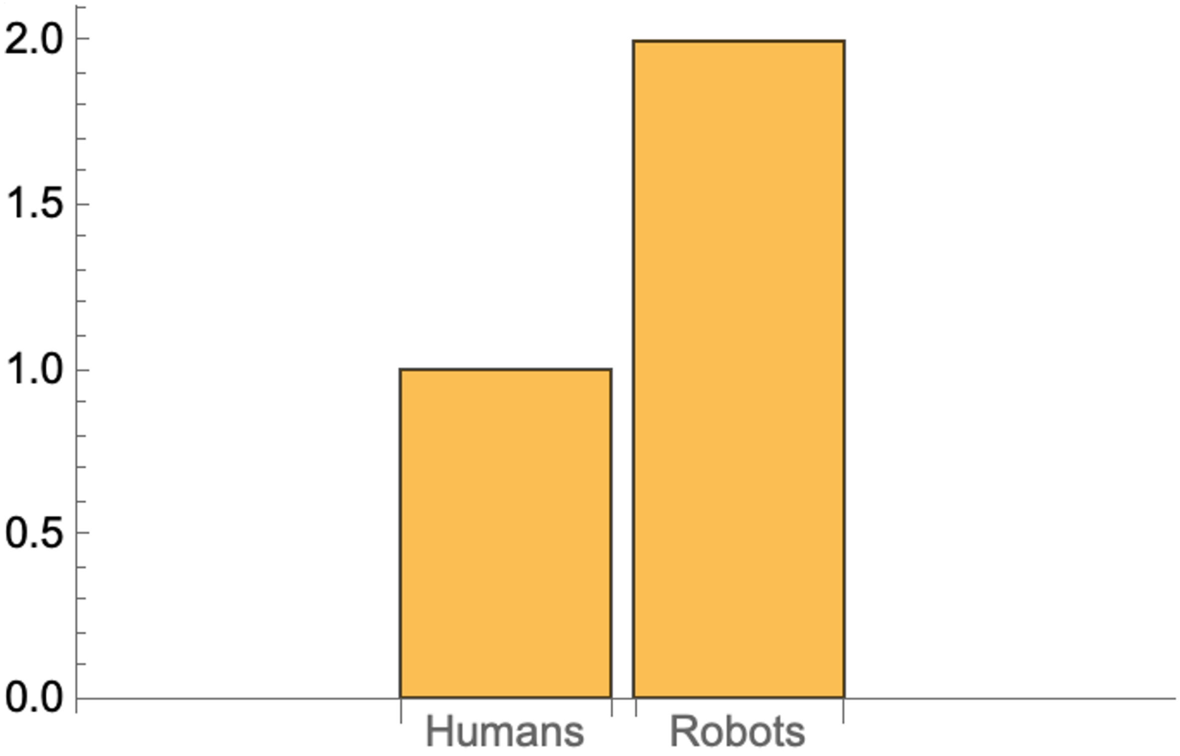
Present:



	person	computer
1980		
2020		
2060		

WHICH ARE YOU BETTING ON FOR THE FUTURE?

Our fear:



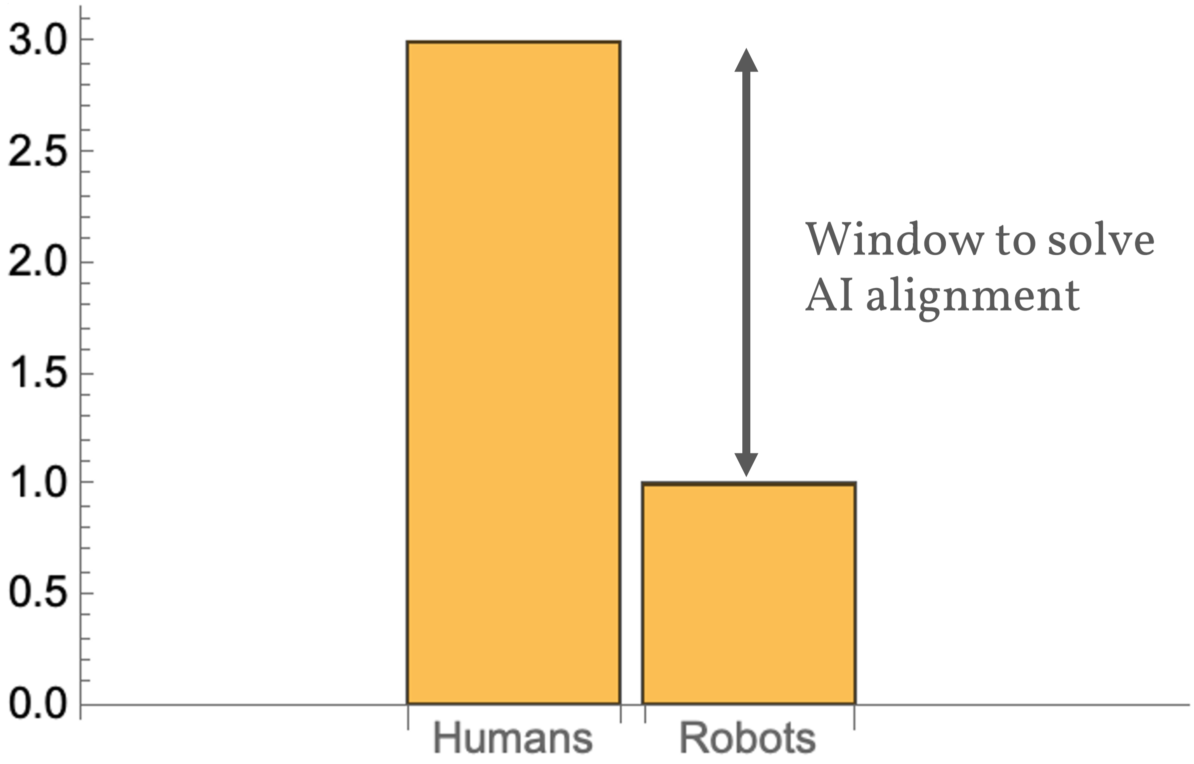
Difficult problem:

1. Spend more time
2. Get good

Difficult problem:

1. ~~Spend more time~~
2. Get good

Present:


3.0
2.5
2.0
1.5
1.0
0.5
0.0
Window to solve AI alignment
Humans
Robots

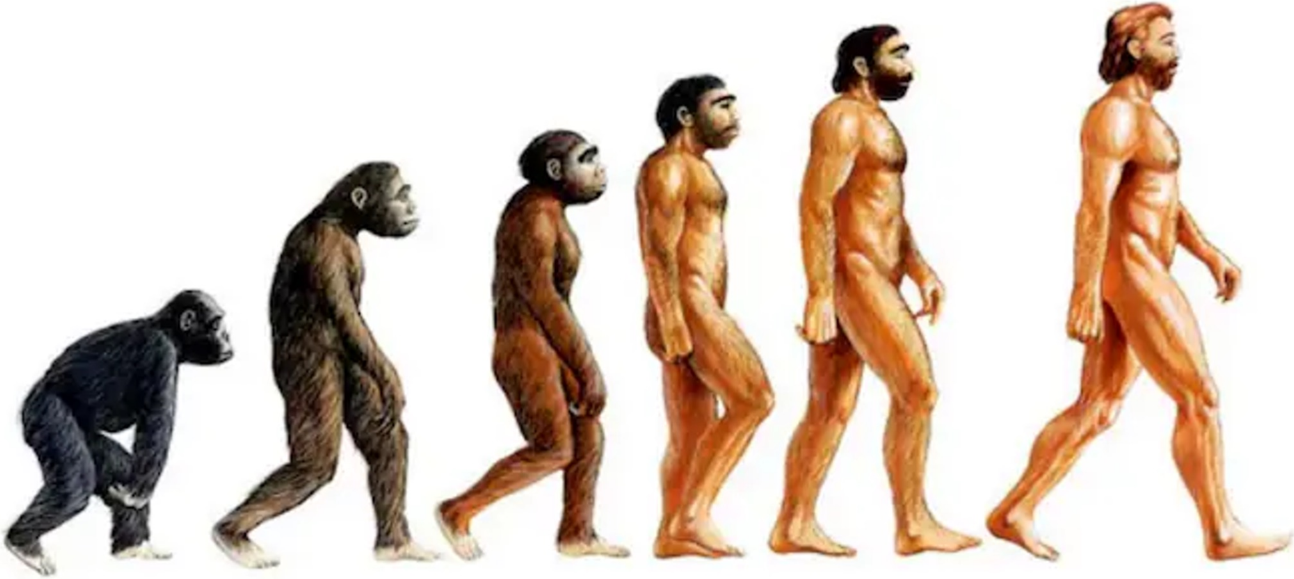
More capable humans

=

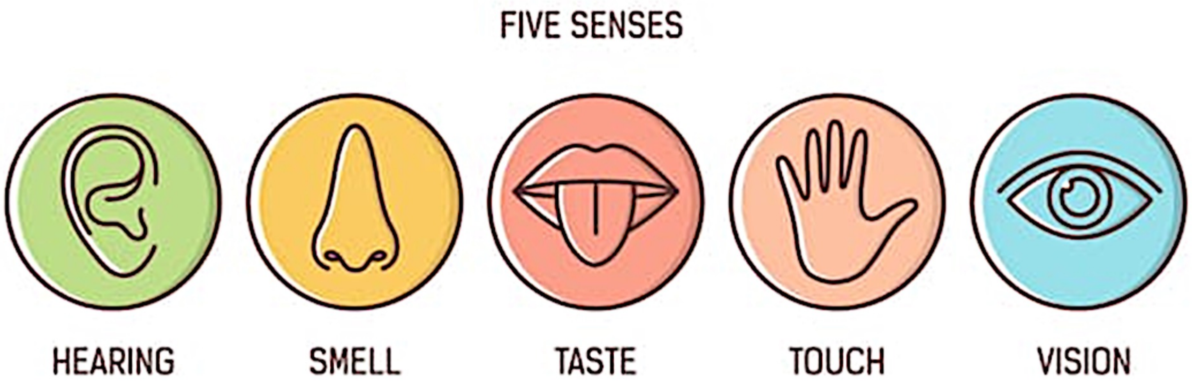
More time to solve alignment.

How to increase the capabilities of humans?

How to increase the capabilities of **humans**?



How humans interact with the world:



How humans think:

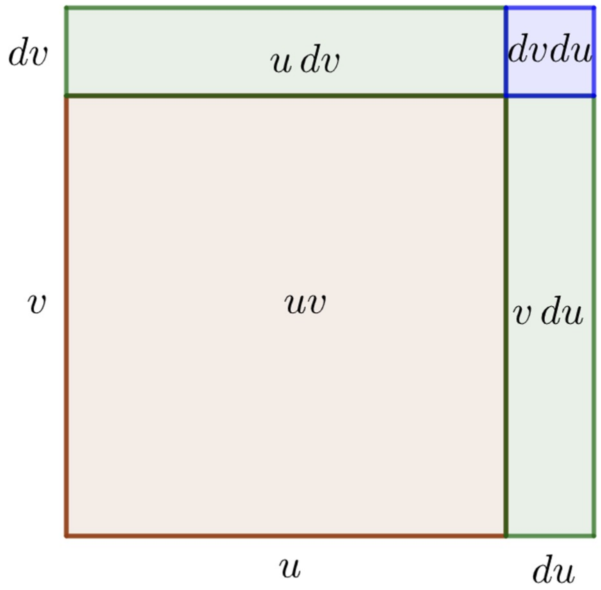
Kinesthetically

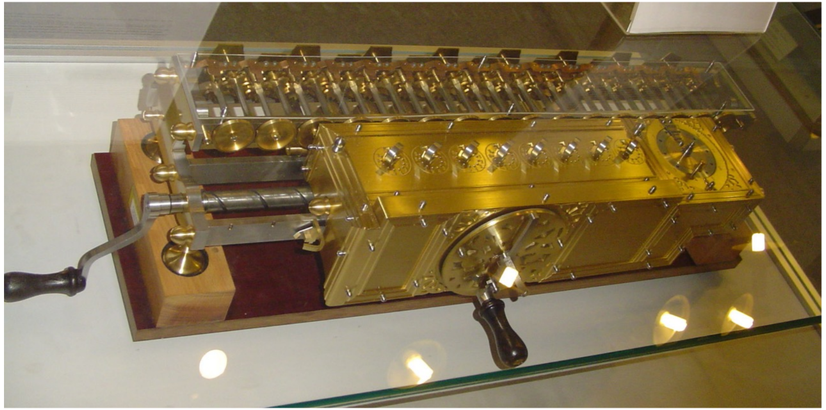
Visually

Symbolically

$$(x+y)^2 = x^2 + y^2$$

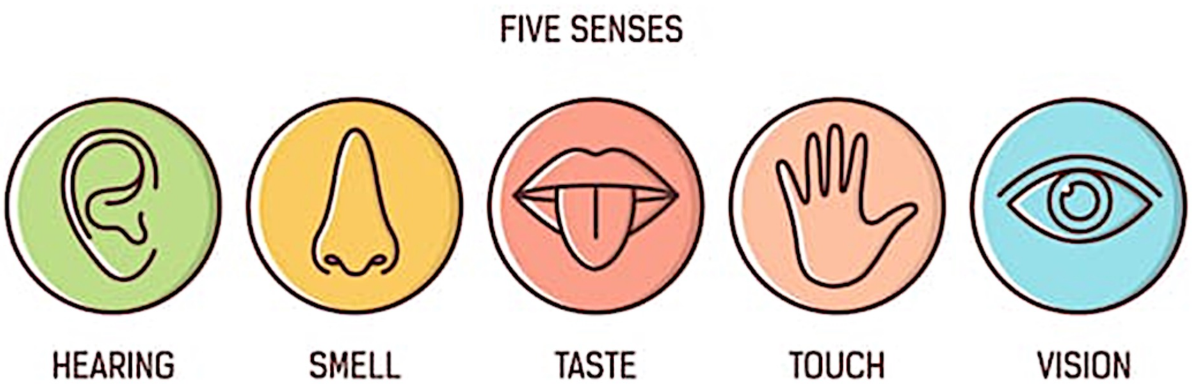
$$\mathrm{d}(uv) = (\mathrm{d}u)(\mathrm{d}v)$$





For it is unworthy of excellent men to lose hours like slaves in the labor of calculation which could safely be relegated to anyone else if machines were used

How humans interact with the world:



How humans think:

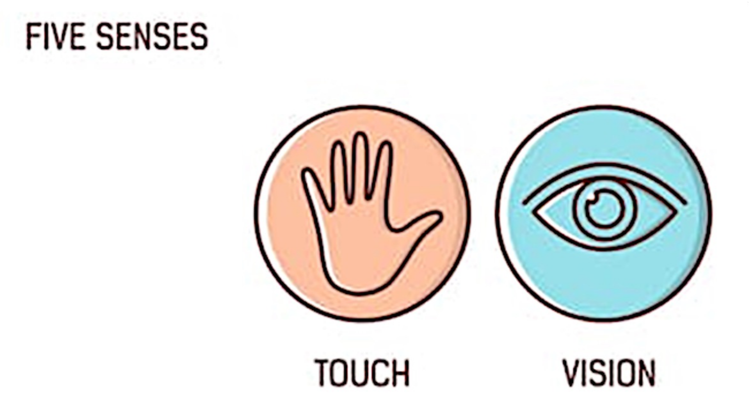
Kinesthetically

Visually

Symbolically


16:35
Wednesday 30 March

How humans interact with the world:



How humans think:

Visually

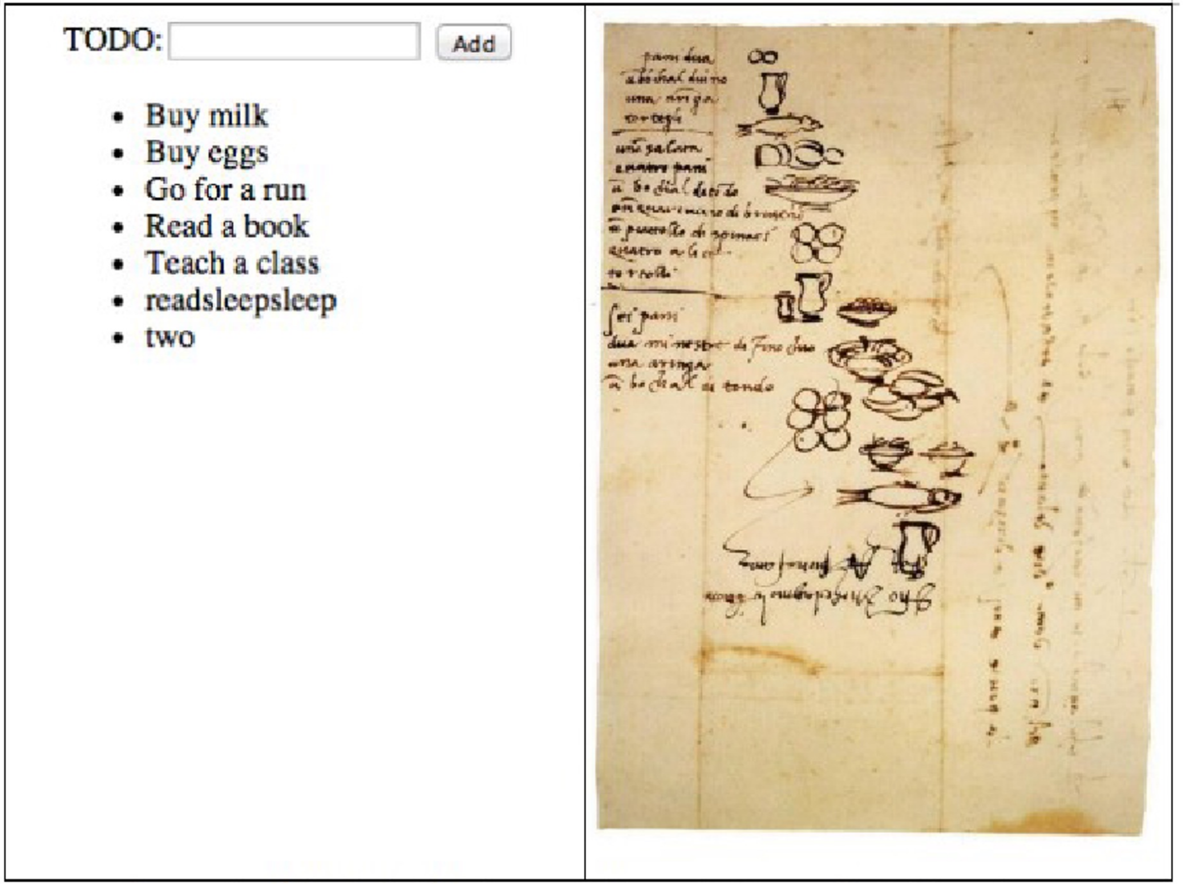
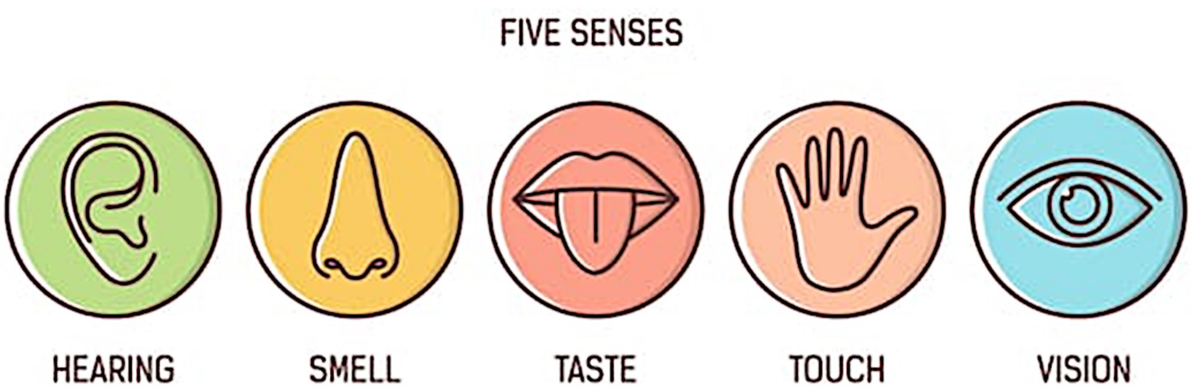


Illustration 4: Two examples of lists. On the left we have a to-do list created with an app. On the right we have Michelangelo's shopping list from the 16th century. Images: (left) Lubaouchan, Wikimedia Commons, CC-SA 4.0; (right) Michelangelo, Wikimedia Commons, Public Domain

How humans interact with the world:



How humans think:

Kinesthetically

Visually

Symbolically


IBM
IBM

How can we interact with computers through the real world?

Marking Material Interaction

e.g., what I was actually supposed to talk about

Marking Material Interactions with Computer Vision

Peter Gyory
peter.gyory@colorado.edu
ATLAS Institute
University of Colorado
Boulder, CO, USA

S. Sandra Bae
sandra.bae@colorado.edu
ATLAS Institute
University of Colorado
Boulder, CO, USA

Ruhan Yang
ruhan.yang@colorado.edu
ATLAS Institute
University of Colorado
Boulder, CO, USA

Ellen Yi-Luen Do
ellen.do@colorado.edu
ATLAS Institute & Computer Science
University of Colorado
Boulder, CO, USA

Clement Zheng
clement.zheng@nus.edu.sg
Division of Industrial Design &
Keio-NUS CUTE Center
National University of Singapore
Singapore

Figure 1: An abstract overview of the various physical interactions detected by computer vision markers used across fifteen projects in our annotated portfolio.

ABSTRACT

The electronics-centered approach to physical computing presents challenges when designers build tangible interactive systems due to its inherent emphasis on circuitry and electronic components. To explore an alternative physical computing approach we have developed a computer vision (CV) based system that uses a webcam, computer, and printed fiducial markers to create functional tangible interfaces. Through a series of design studios, we probed how designers build tangible interfaces with this CV-driven approach. In this paper, we apply the annotated portfolio method to reflect on the fifteen outcomes from these studios. We observed that CV markers offer versatile materiality for tangible interactions, afford the use of democratic materials for interface construction, and engage designers in embodied debugging with their own vision as a proxy for CV. By sharing our insights, we inform other designers and educators who seek alternative ways to facilitate physical computing and tangible interaction design.

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CCS CONCEPTS

• **Human-centered computing → Human computer interaction (HCI).**

KEYWORDS

Physical Computing, Tangible Interactions, Computer Vision, Making, Materiality

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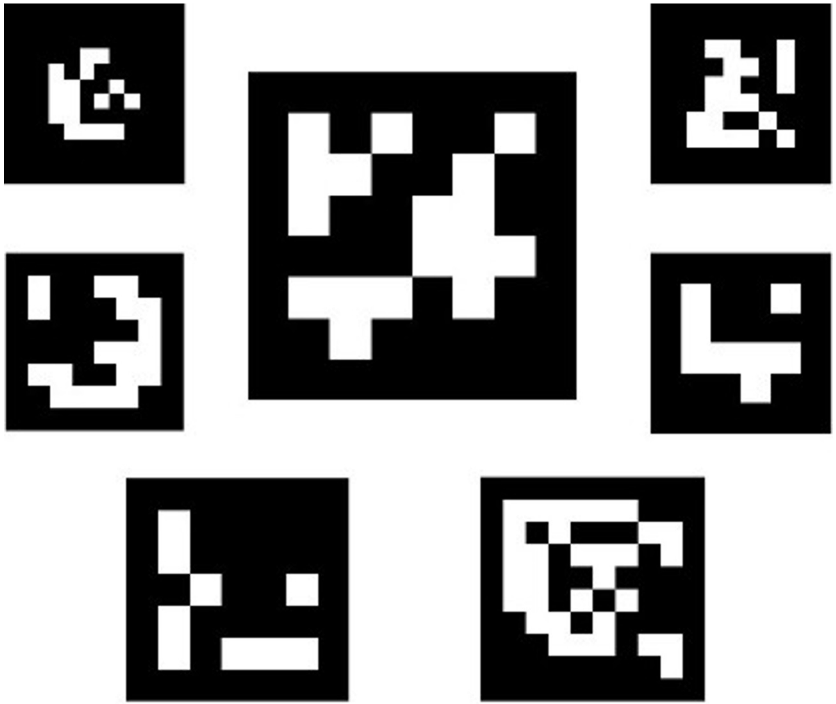
1 INTRODUCTION

As researchers and educators in the field of Tangible User Interface (TUI) design, we are tasked with both designing our own interactive systems as well as facilitating other designers. Building TUIs involves physical computing [36]—imbuing tangible artifacts with computational capabilities that can interact with the physical world. As both design practitioners and educators, we see our students as designers-in-training: budding creators who are at the beginning of their design careers and are actively acquiring the skills and knowledge they need to develop their own design practice. This paper is framed within our reflections on the experiences of other designers-in-training as they encounter physical computing for designing TUIs.

Inaccessible parts

circuitry



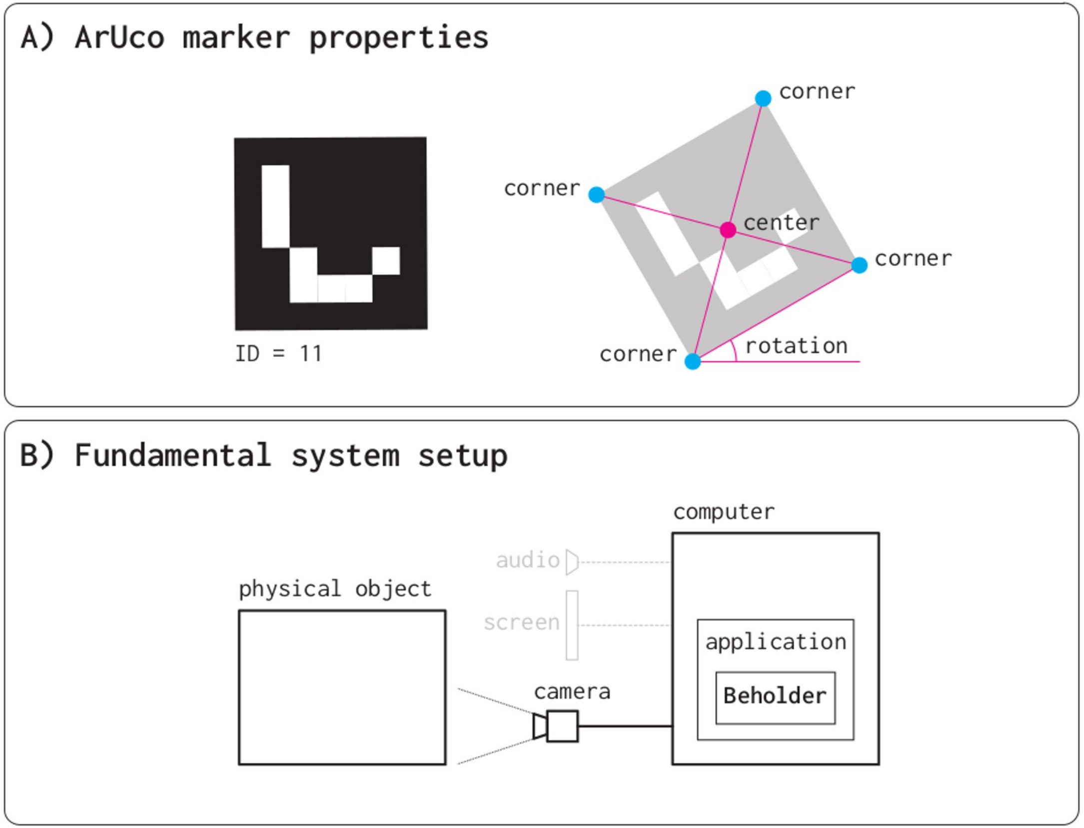
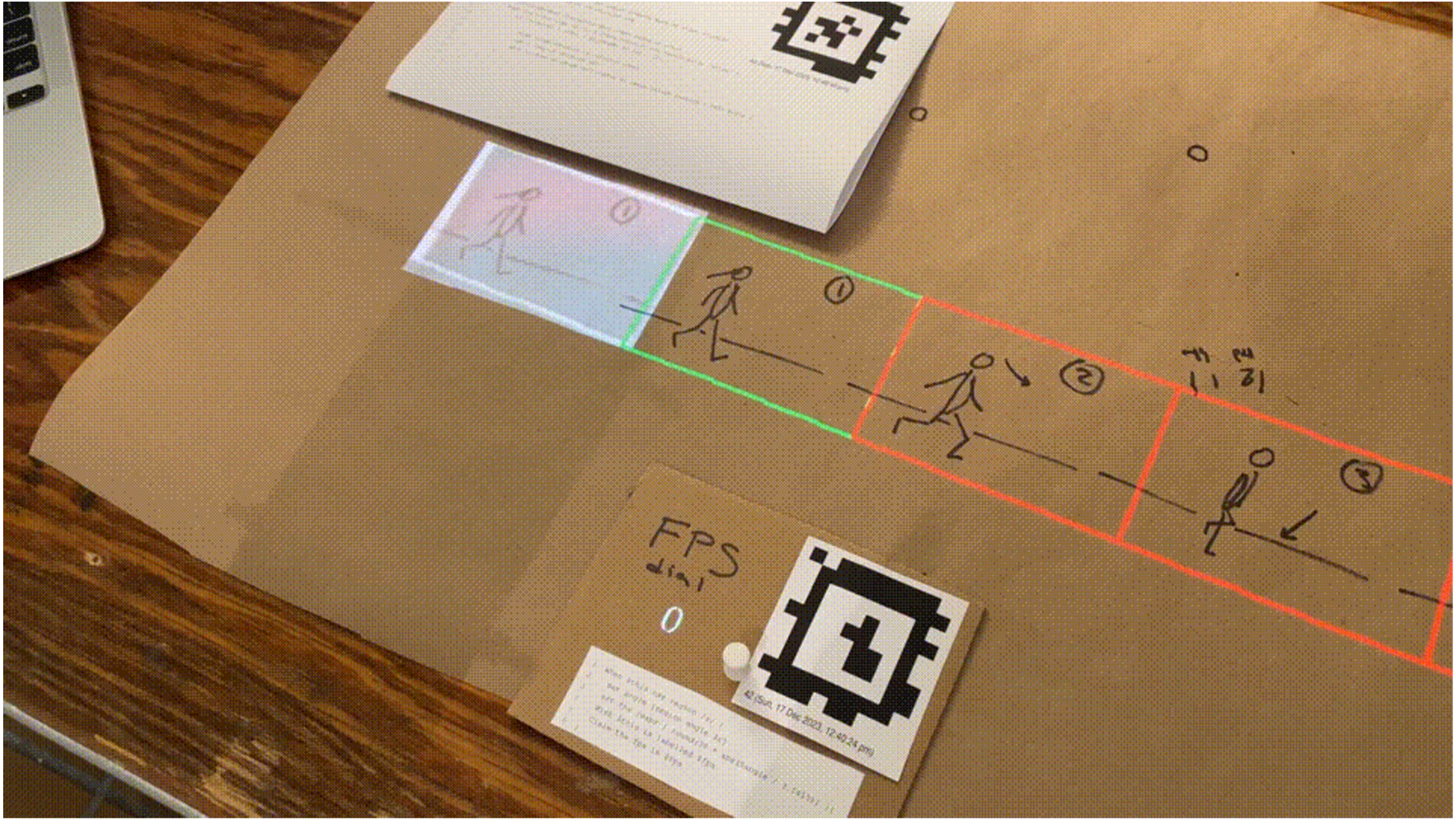


Figure 3: A: An ArUco marker with the ID of 11 demonstrating the meta-data provided by *Beholder*. B: Fundamental system setup for using *Beholder* to instrument a tangible interface.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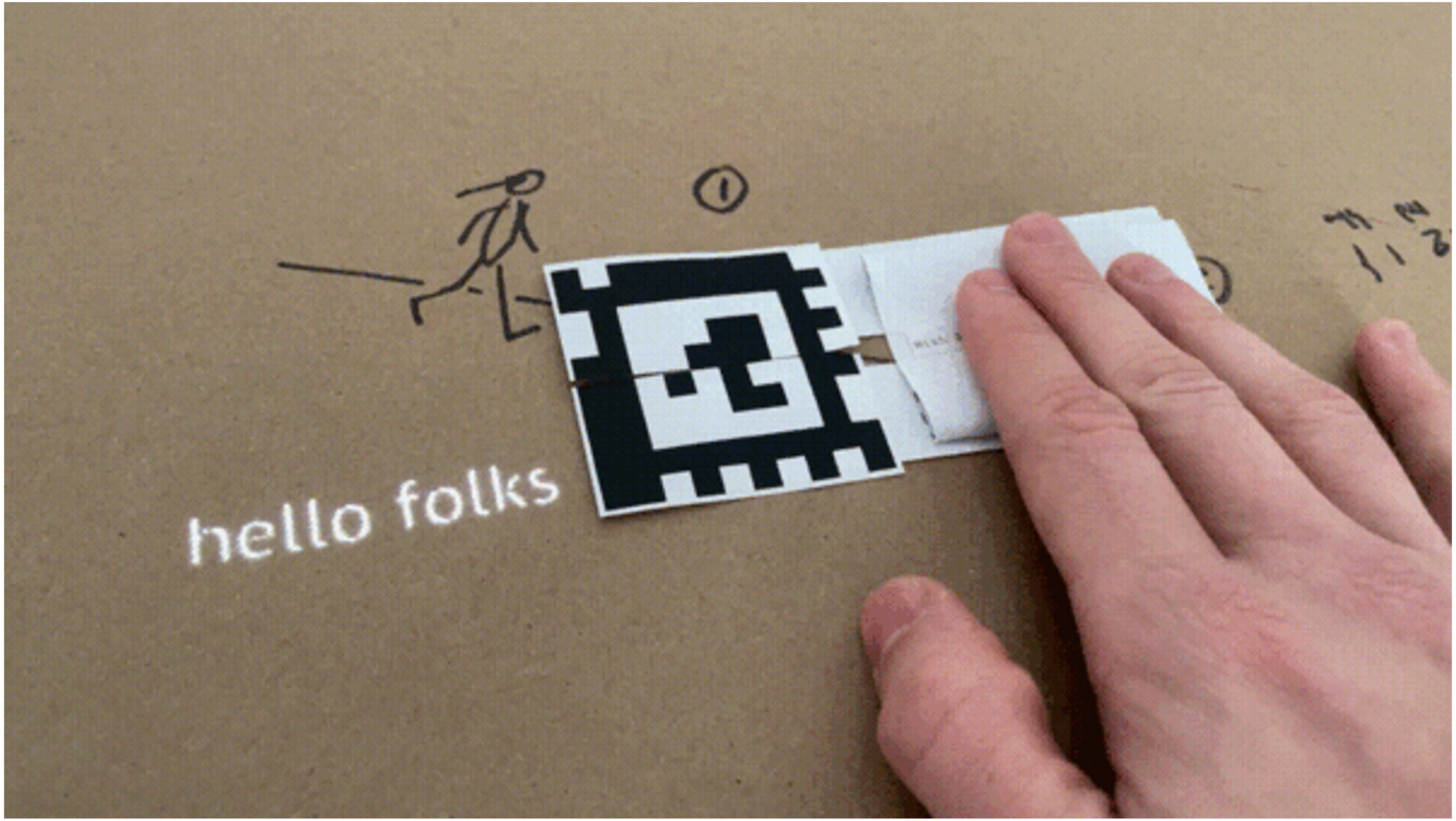
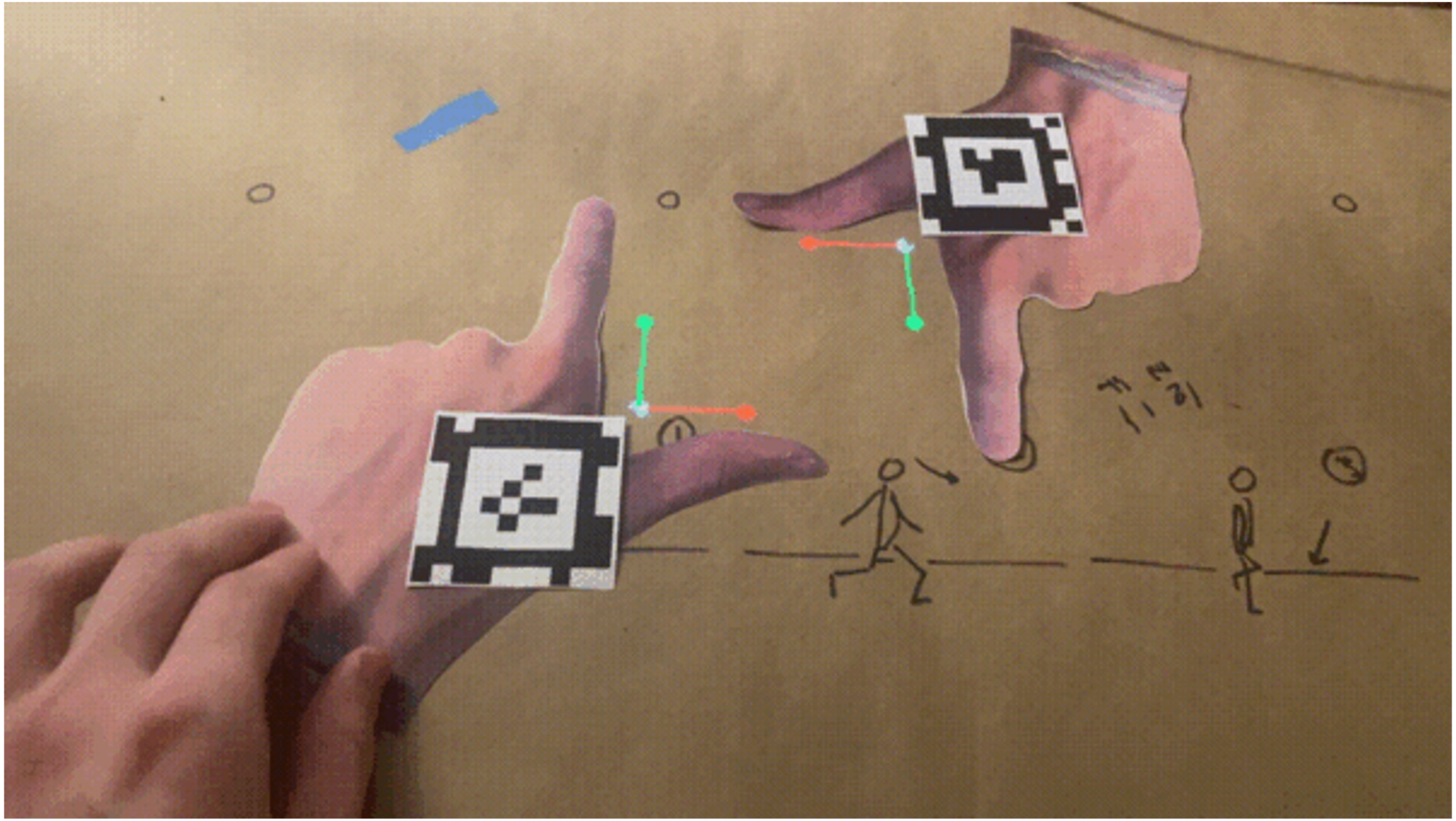
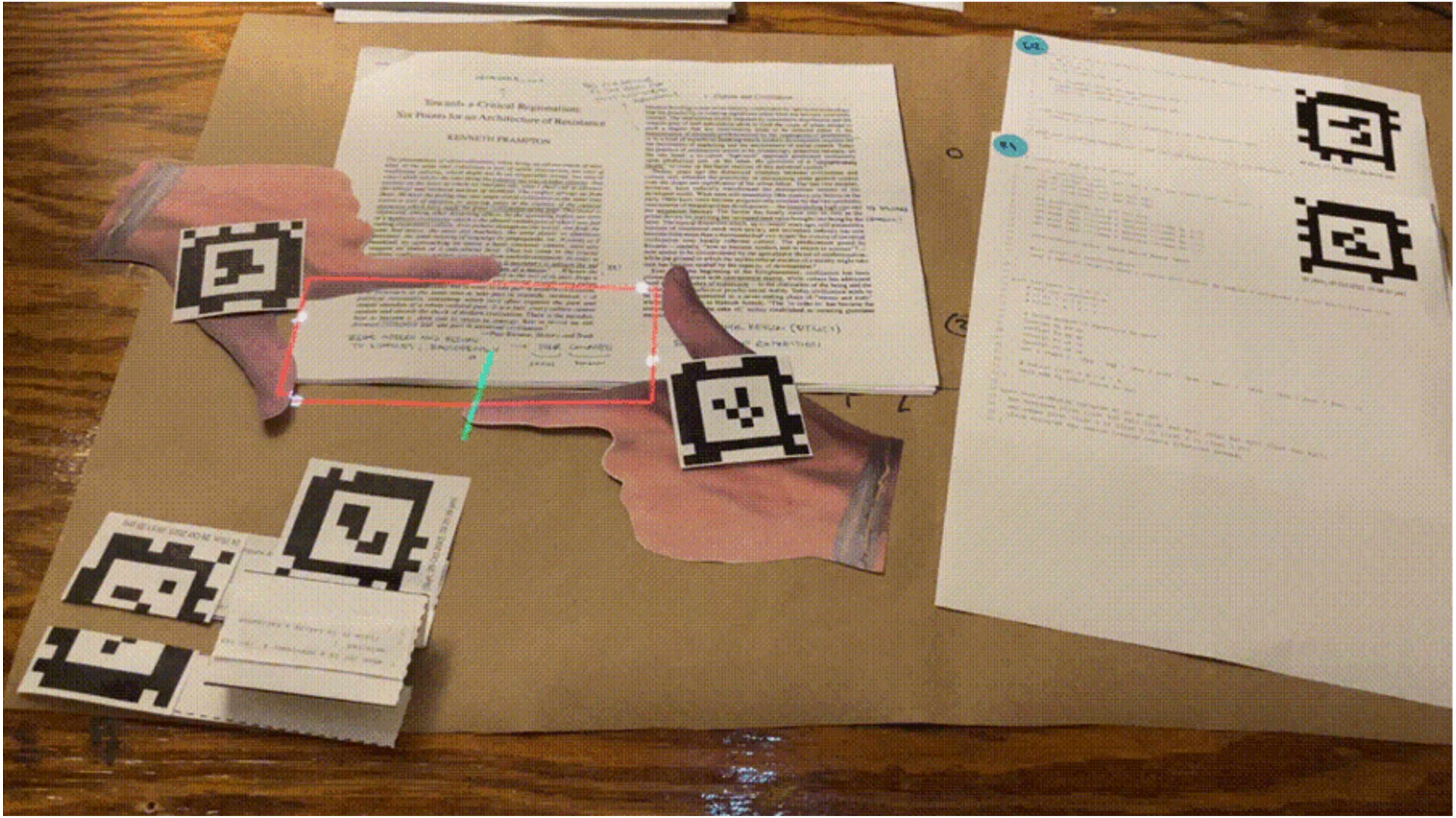
0
42 (Sun, 17 Dec 2023, 12:40:24 pm)

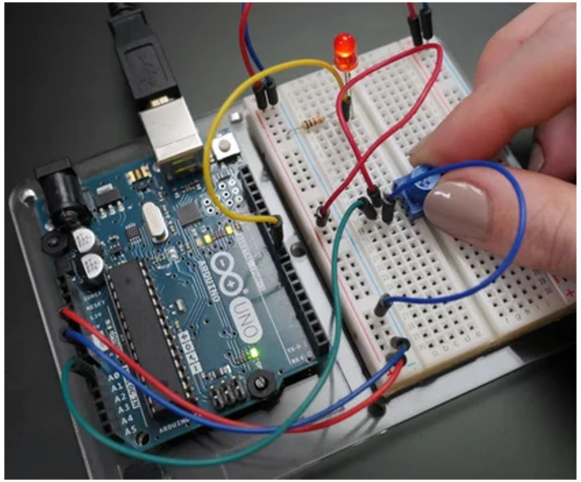

hello folks




Towards a Critical Regionalism:
Six Points for an Architecture of Resistance
KENNETH FRAMPTON

(1) How did designers use CV markers to detect physical interactions? What mechanisms did they construct to facilitate the use of CV markers for designing physical interfaces?


YAHBOOM
Microbit-Gamepad Ver:1.0
A
B


UNO


HDMI

(2) How does the practice of physical computing with CV markers compare to the practice of physical computing with microcontrollers? How did designers make sense of the workings of the physical interfaces they built with CV markers?

(3) What interface materiality did CV markers facilitate?

(3) What **interface materiality** did CV markers facilitate?

Materiality: How information manifests itself as physical "things."

Methodology


Get students to create things with CV markers
Create a portfolio of their projects
Use to the portfolio to reflect on the RQ’s


Get **students** to create things with CV markers
Create a portfolio of their projects
Use to the portfolio to reflect on the RQ’s

(1) DIY CV interfaces: design studio class at NUS.
(2) Tinycade: design studio at CU Boulder.
(3) CV Arcade: another design studio class at NUS.

1. DIY CV interfaces: design studio class at NUS.
   1. Focus on developing user interfaces for daily activities
   2. Anchored on “work,” “learn” and “play”.
2. Tinycade: design studio at CU Boulder.
3. CV Arcade: another design studio class at NUS.

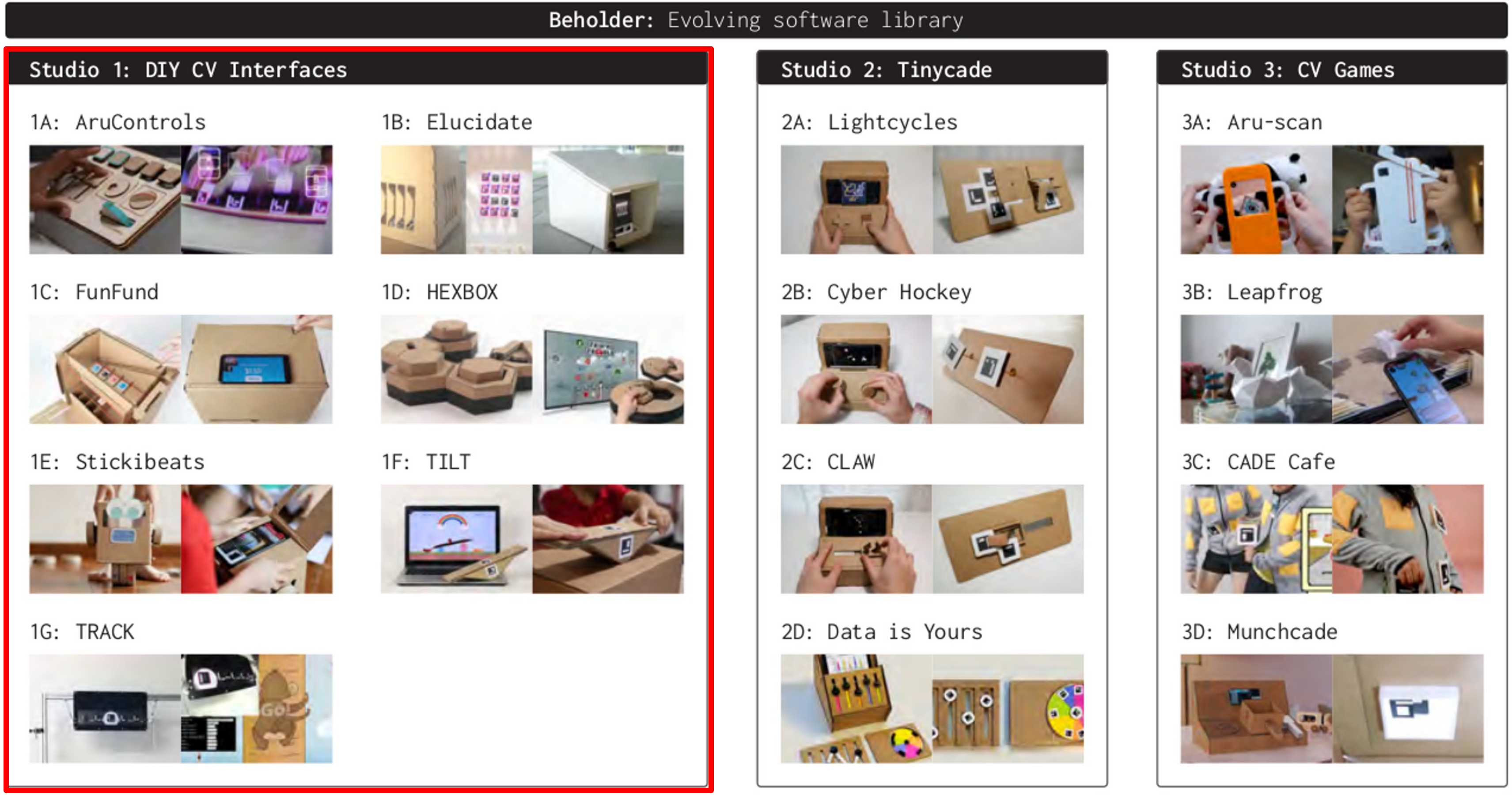
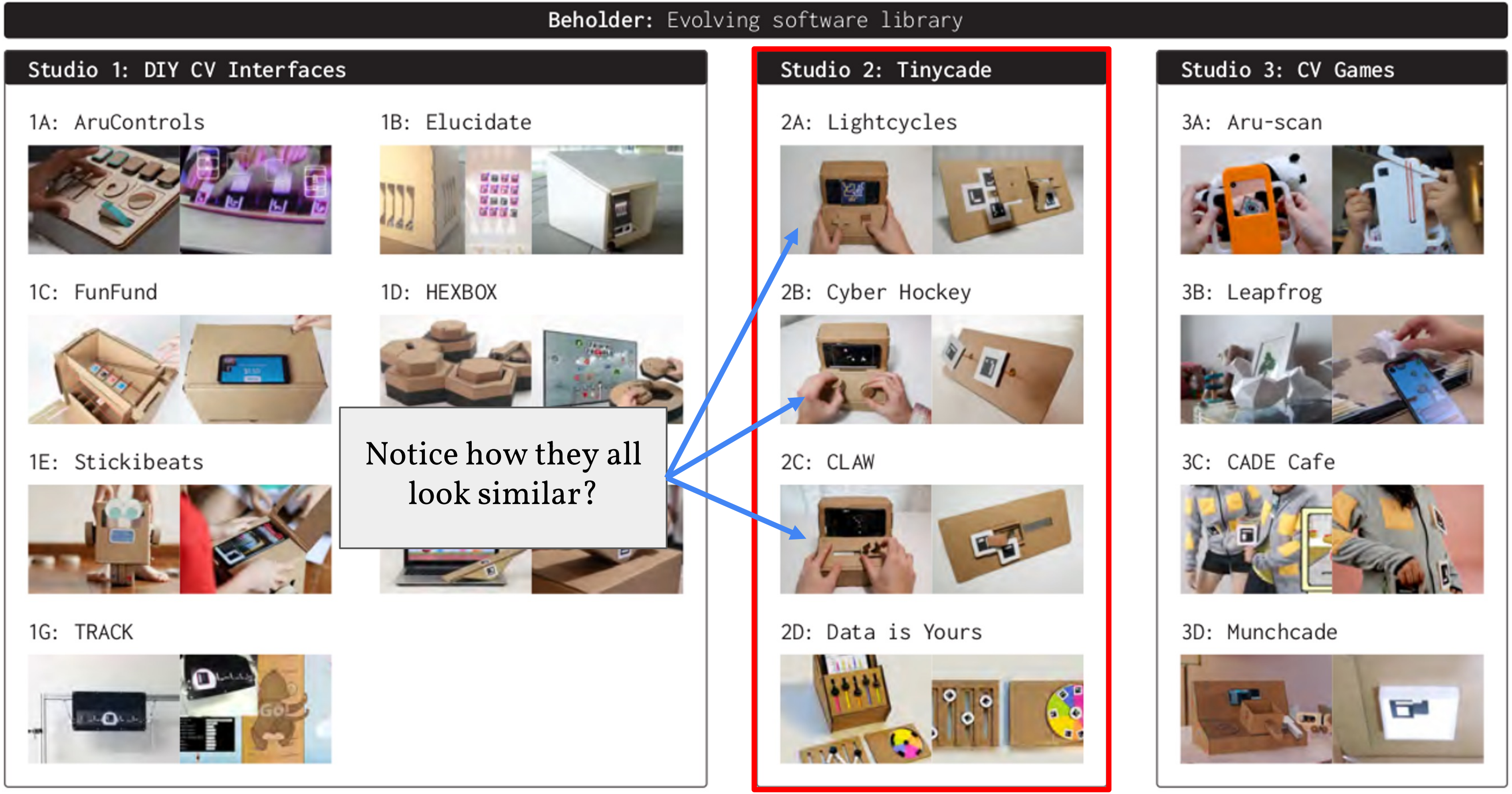


Figure 2: Overview of the 15 projects created using *Beholder*. The 15 projects are the outcomes from three distinct design studios. We used an annotated portfolio methodology to uncover insights on how CV markers can be used for physical computing. See Sections 4.2, 4.3, and 4.4 for more details on each individual project.

1. DIY CV interfaces: design studio class at NUS.
2. Tinycade: design studio at CU Boulder.
   1. “Explore the potential mobile devices as an ‘all in one’ platform for marker based computing”
   2. Create a game controller platform using only a smartphone as a main computer.
3. CV Arcade: another design studio class at NUS.



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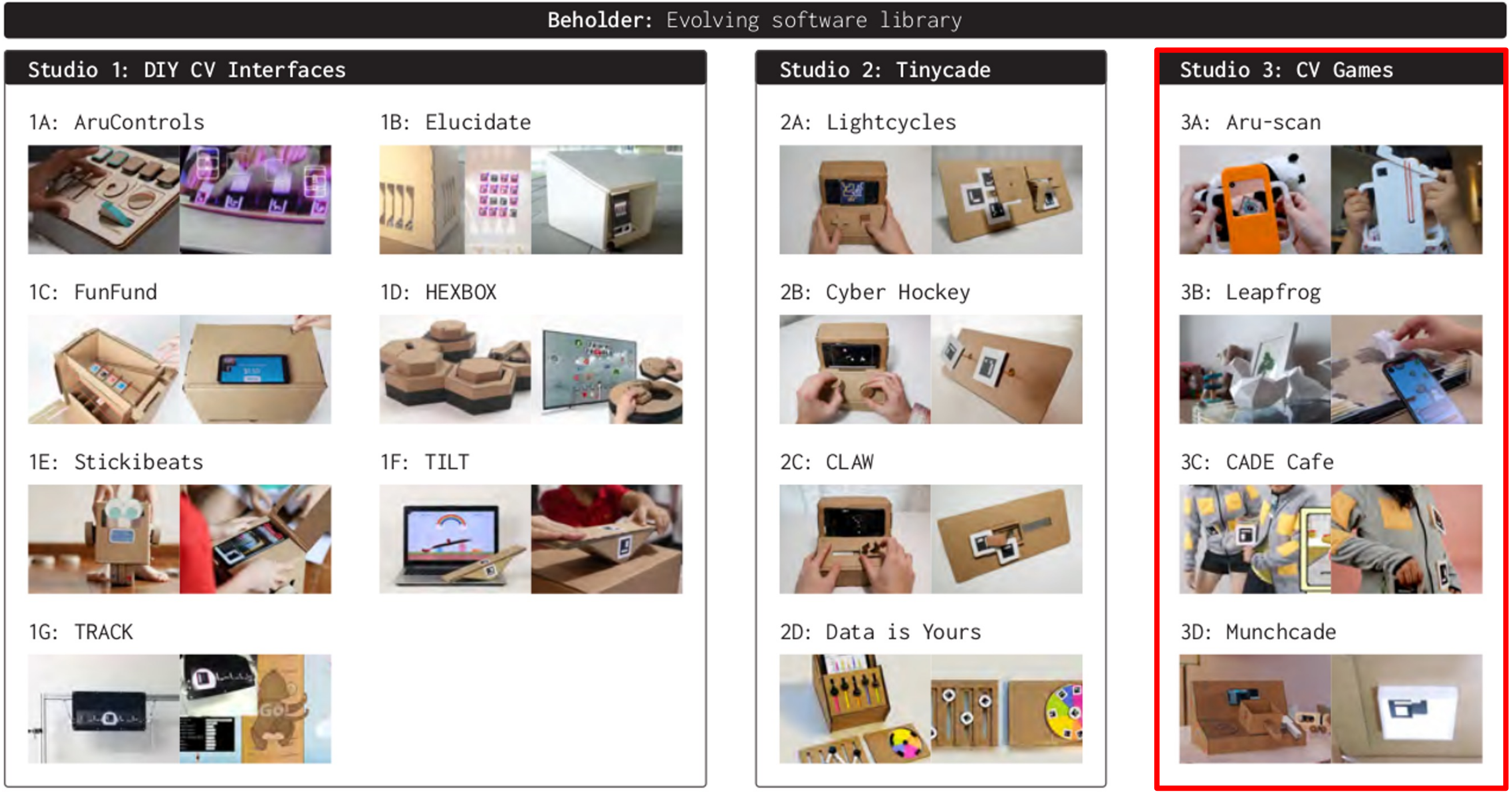
(1) DIY CV interfaces: design studio class at NUS.
(2) Tinycade: design studio at CU Boulder.
(3) CV Arcade: another design studio class at NUS.
    (a) Designed “new DIY video game platforms for a specific audience.”
    (b) Playtested their ideas with children



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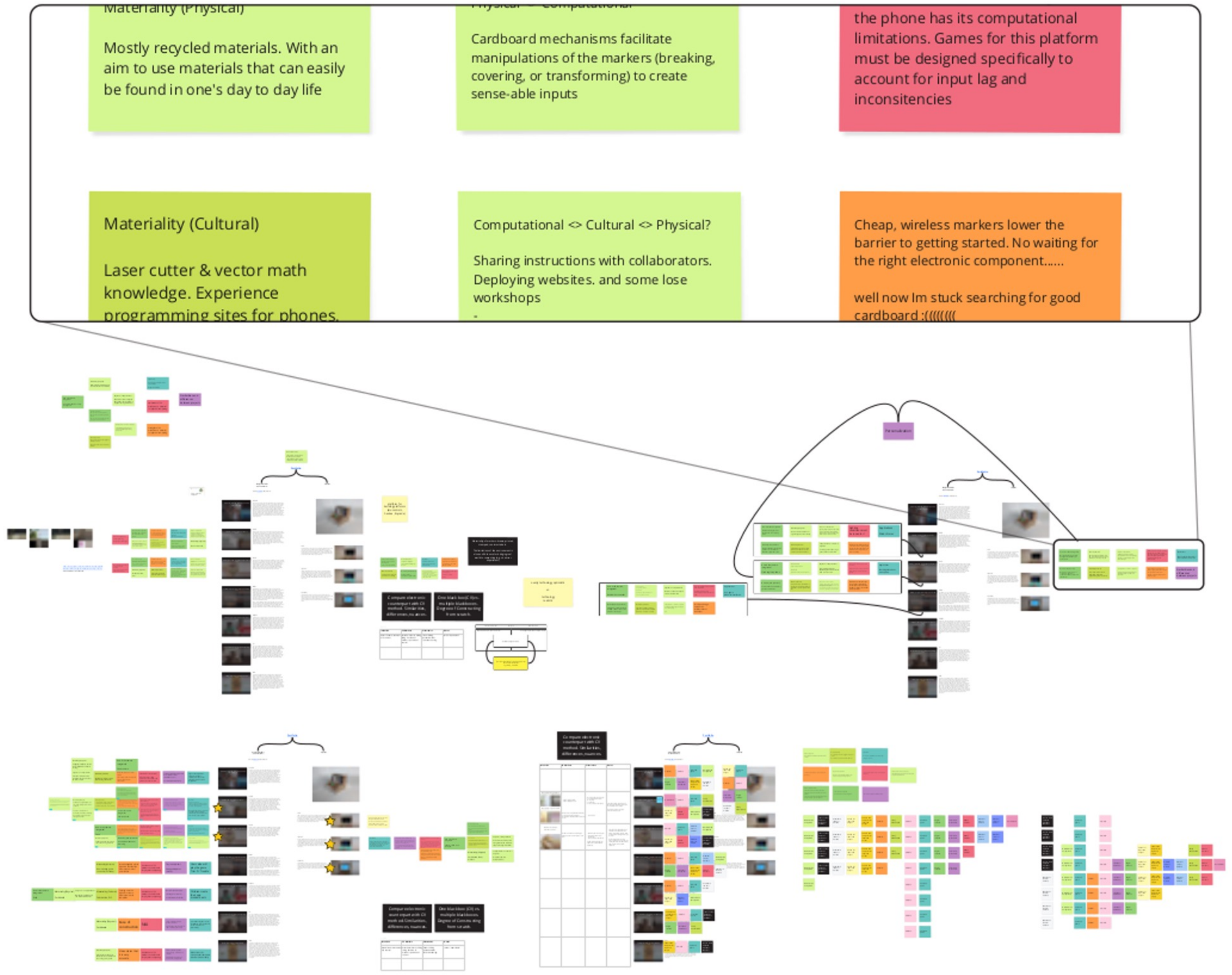
The Portfolio


Materiality (Physical)
Mostly recycled materials. With an aim to use materials that can easily be found in one's day to day life
Cardboard mechanisms facilitate manipulations of the markers (breaking, covering, or transforming) to create sense-able inputs
the phone has its computational limitations. Games for this platform must be designed specifically to account for input lag and inconsistencies
Materiality (Cultural)
Laser cutter & vector math knowledge. Experience programming sites for phones.
Computational <> Cultural <> Physical?
Sharing instructions with collaborators. Deploying websites. and some lose workshops
Cheap, wireless markers lower the barrier to getting started. No waiting for the right electronic component......
well now Im stuck searching for good cardboard :((((((((

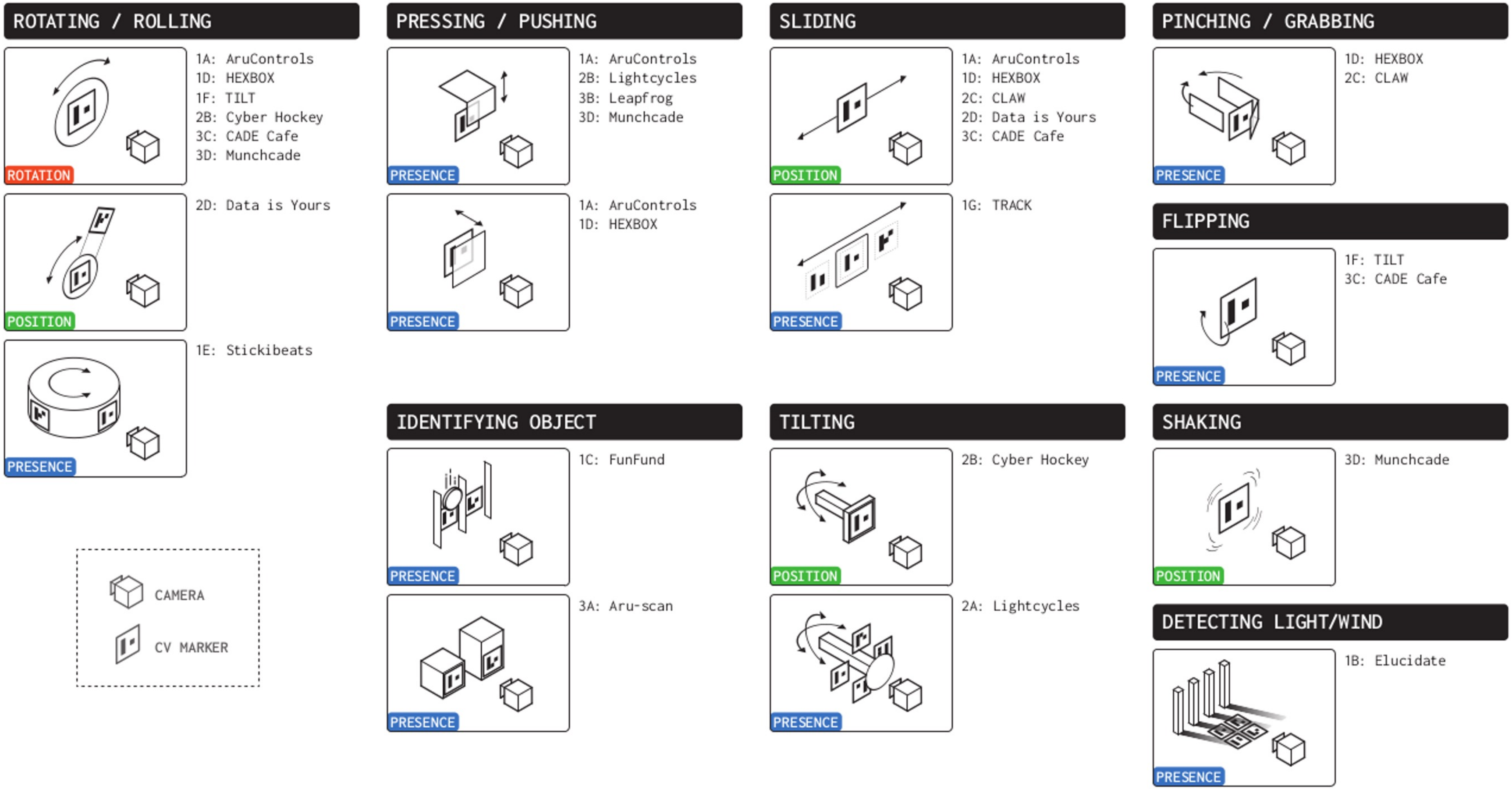


Figure 6: The range of CV marker configurations we observed in use through the portfolio to detect tangible interactions. Designers often found multiple ways to detect each desired interaction. Listed next to each technique illustrated are the projects that used them.

Kinesthetic thinking!

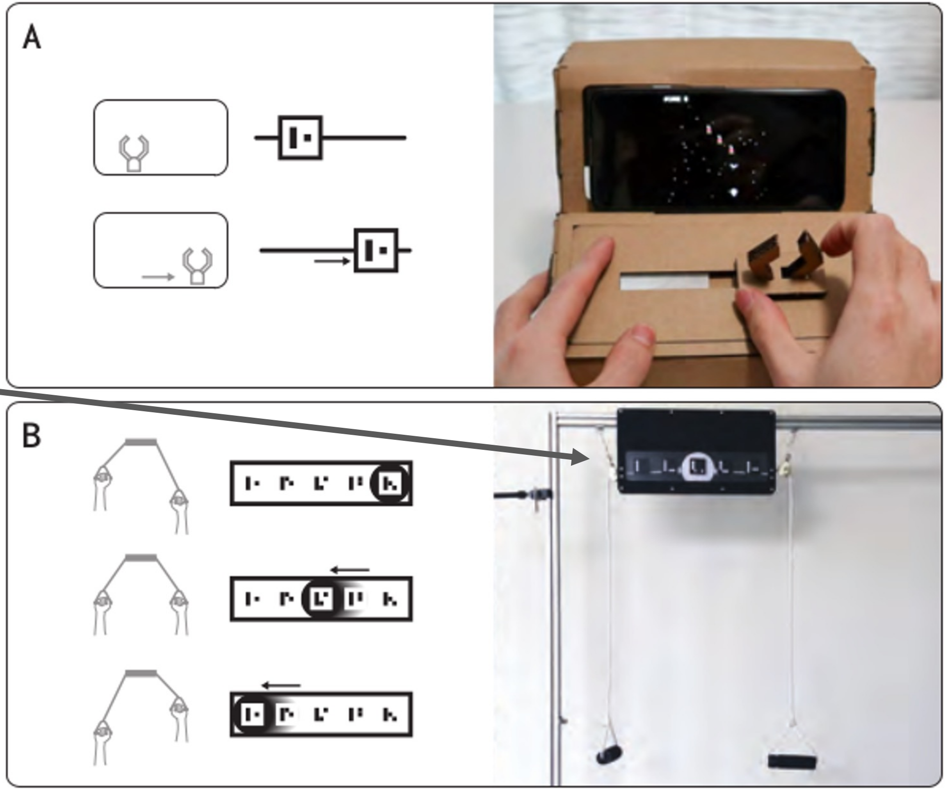
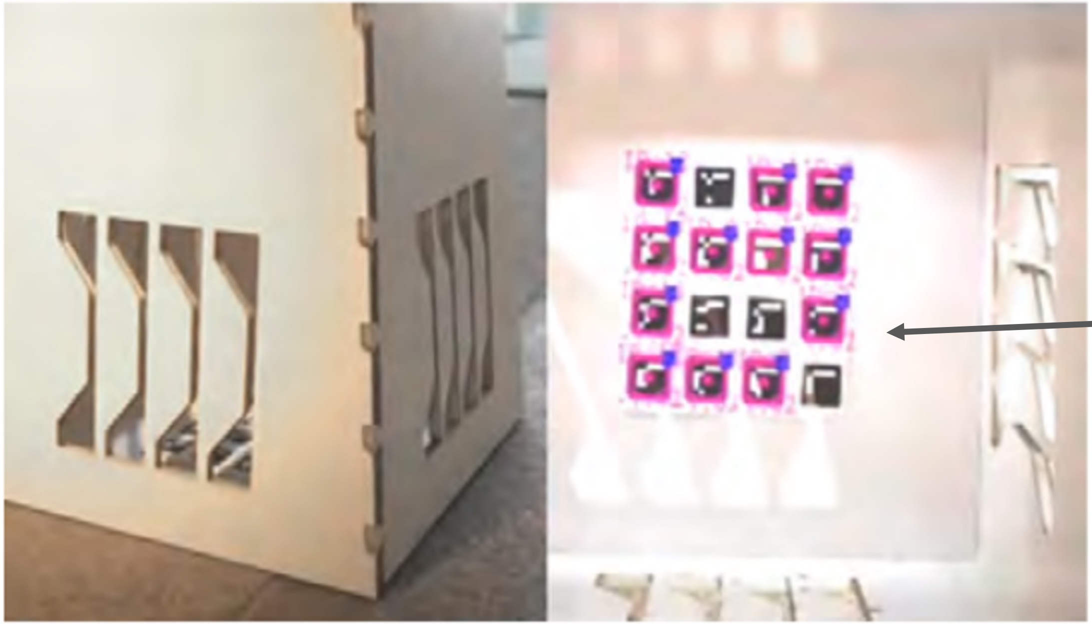


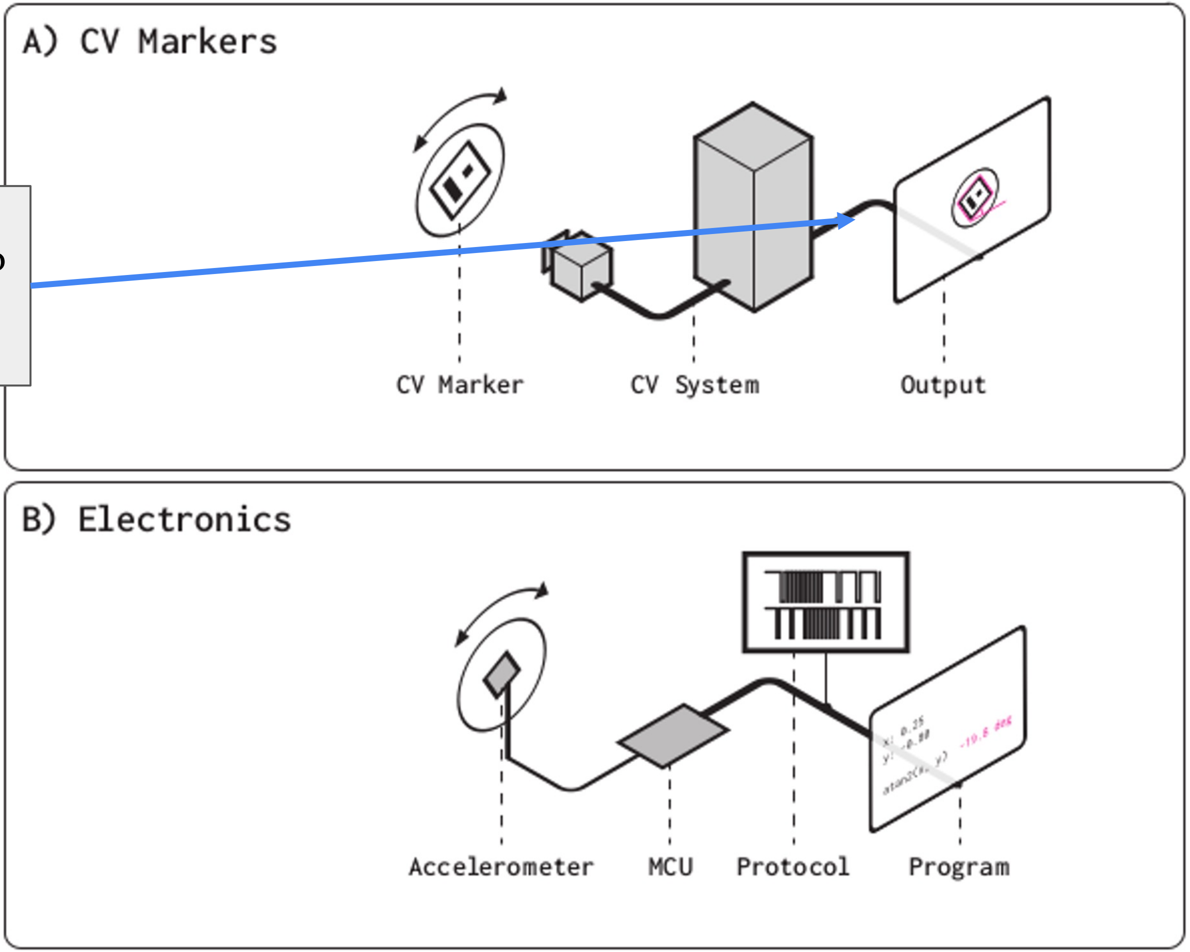
Figure 8: These projects showcase two different approaches to sense slider interactions. A: CLAW (project 2C) uses a single CV marker on the bottom to track the slider's position in pixel values. B: TRACK (project 1G) uses an array of markers in a line that become detectable as a white background moves behind them, discretely marking the position of the slider.



Using your sight!

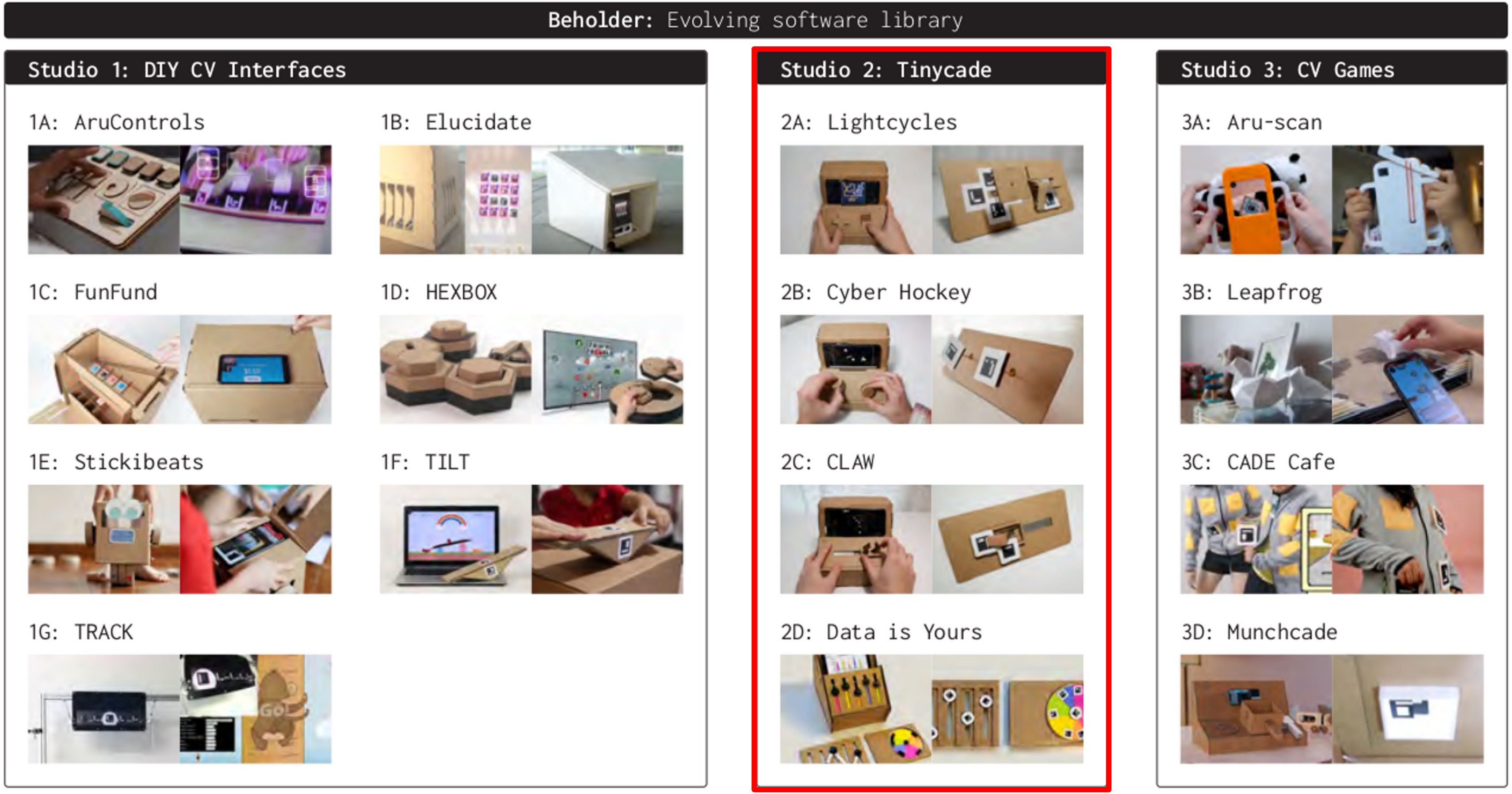
Figure 12: Elucidate (project 1B) uses a grid of CV markers that appear and disappear from CV detection due to the shadows cast by the movement of sunlight over time.

Using your sight to debug your tool!



Issues with CV marking:

1. Doesn't work well with fast movement
2. Doesn't work well in bad lighting.
3. Changes in the environment break it.



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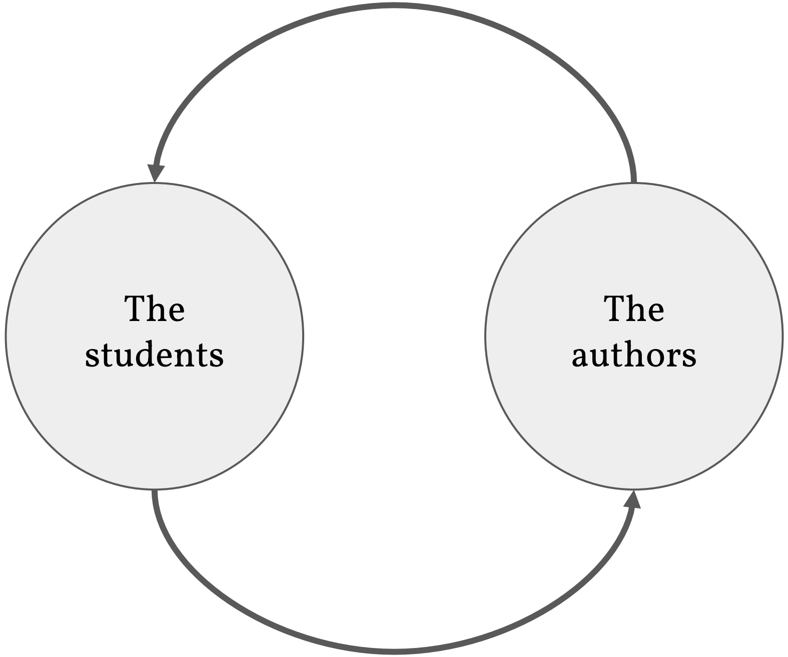
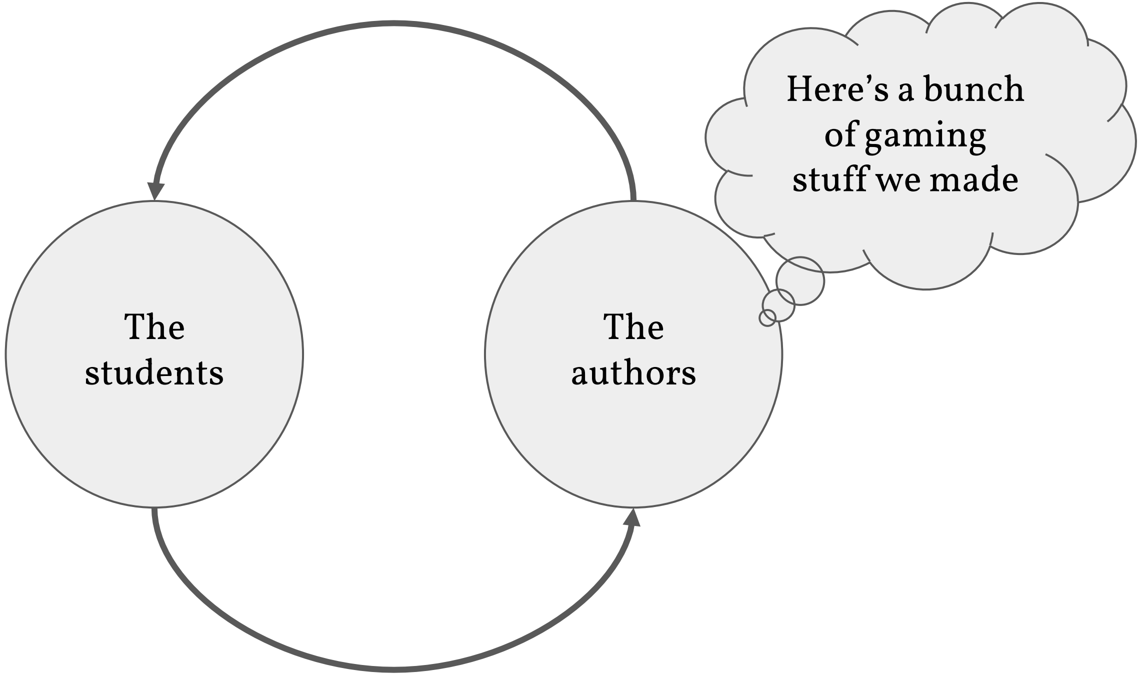
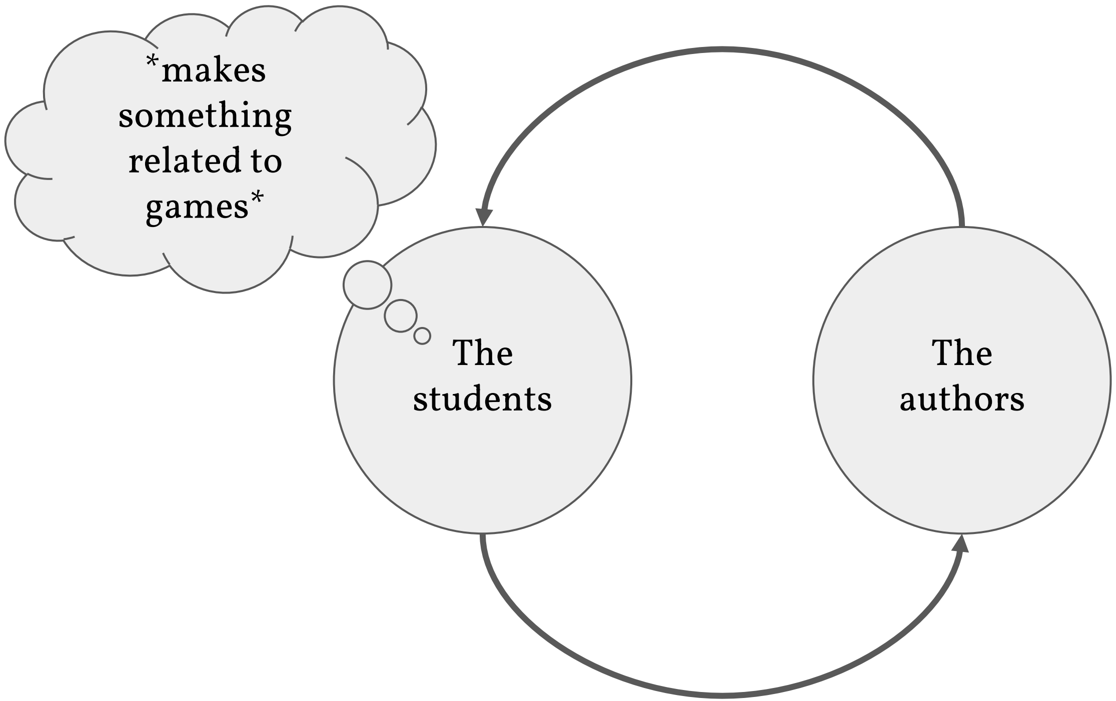
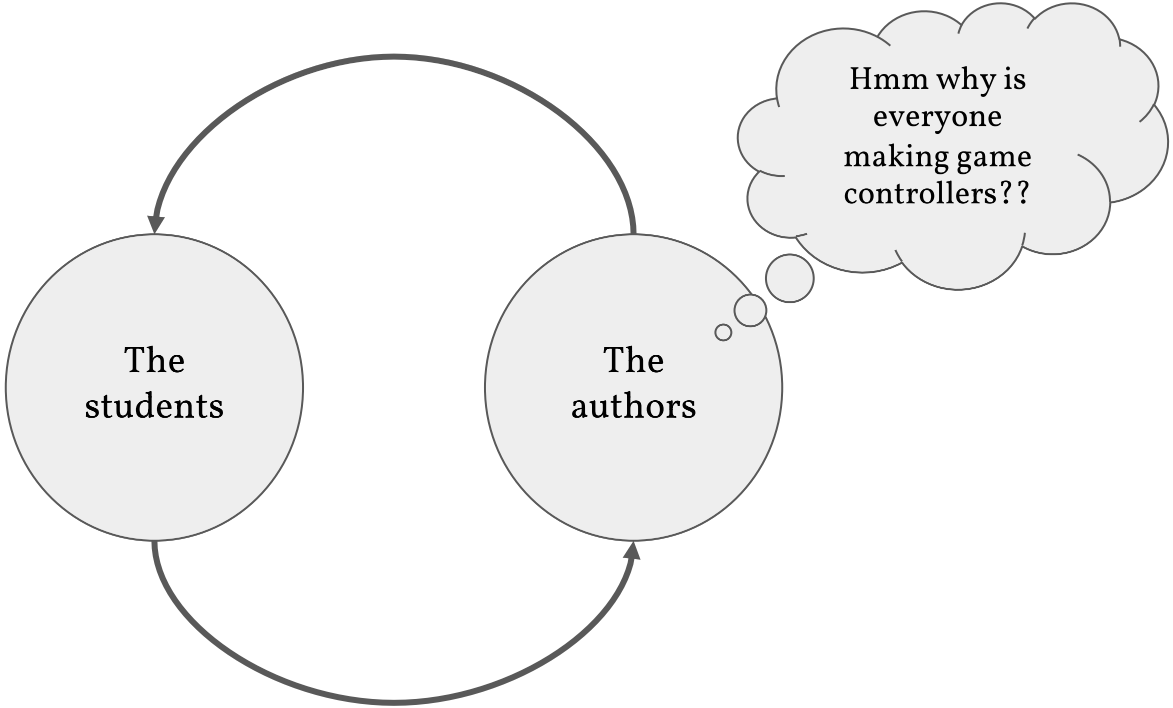
(1) They can be applied to physical materials to sense a wide range of interactions through a CV system.
(2) They can be used to directly mark interaction events, enabling designers to "program" system logic in the physical world.
(3) They can be debugged using human vision, thus enabling designers to draw connections between what they see and what a CV system detects.
(4) They enable designers to leverage a diverse materiality, including democratic physical materials. They are particularly sensitive to intangible environmental factors, which should be considered as an intangible material to shape when working with CV markers.

My issues with the paper


The students
The authors


Here's a bunch
of gaming
stuff we made
The
students
The
authors


makes something related to games
The students
The authors


Hmm why is everyone making game controllers??
The students
The authors

What does *materiality* mean?

Thanks for listening!