Design and Fabrication for Tangible Interaction with Real-World Objects and Environments

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University of Washington

MAKEABILITY LAB

PAUL G. ALLEN SCHOOL
OF COMPUTER SCIENCE & ENGINEERING

Journey

Carnegie Mellon University

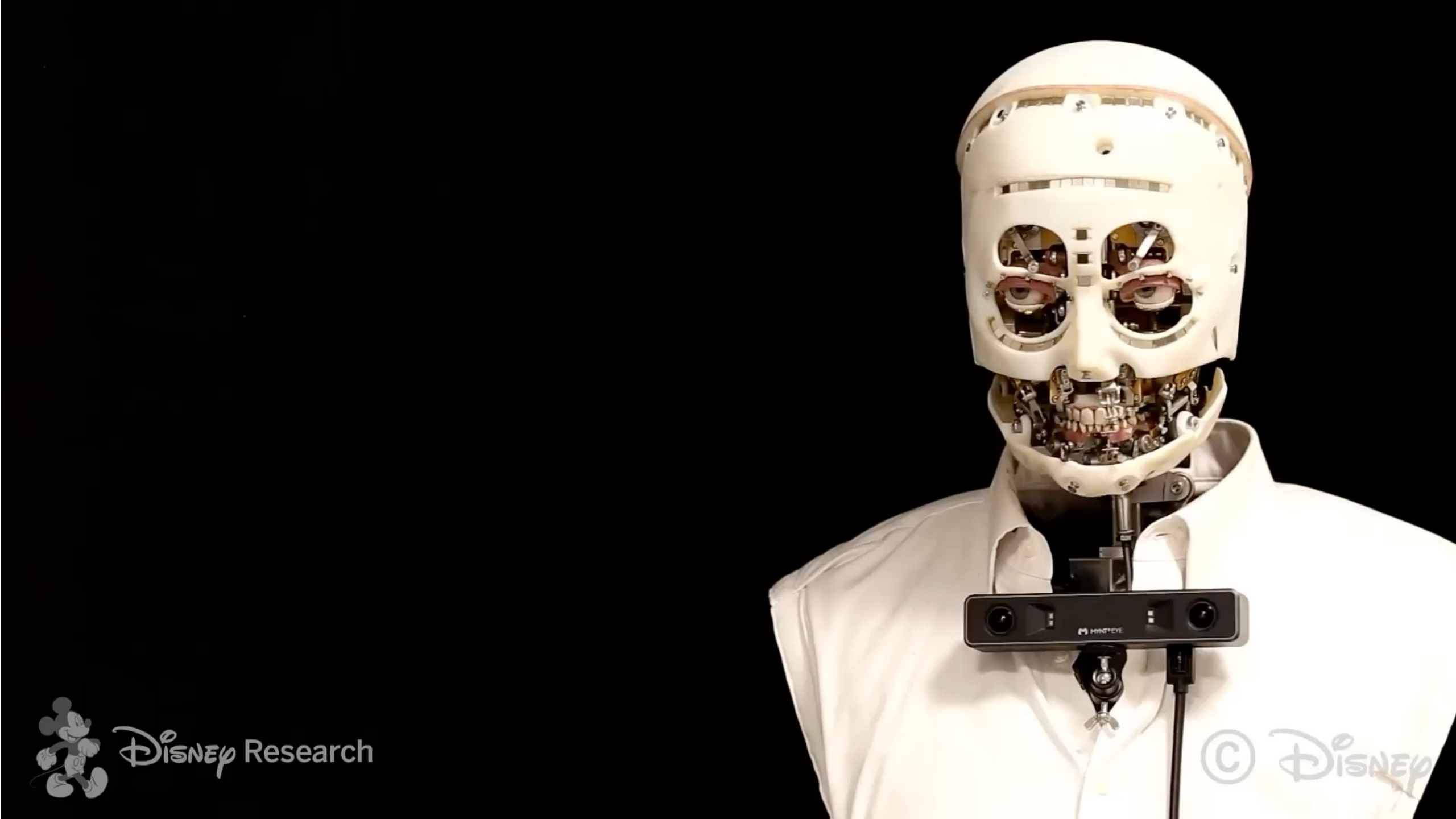
Undergrad

‘Externship’ at Interdisciplinary Media Arts Lab

Carnegie Mellon University School of Art

Disney Research

Research Associate


Disney Research
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Disney Research

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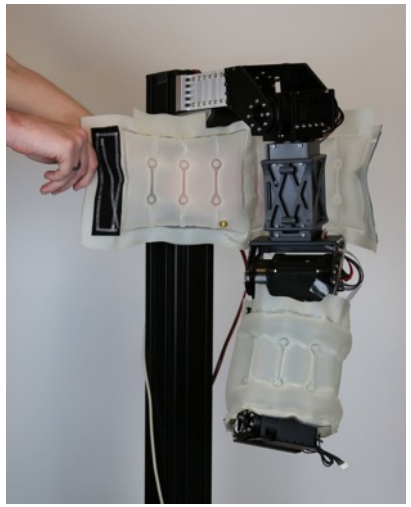
Social AR

Biped Robots



Soft Robotics

Journey

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Undergrad

‘Externship’ at Interdisciplinary Media Arts Lab

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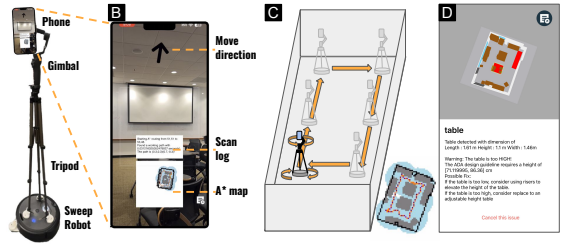
Research Associate

PhD Student at UW CSE
Working with Jon Froehlich

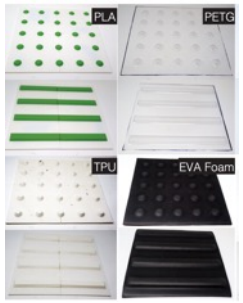
UNIVERSITY of WASHINGTON

Research Interests

Accessibility

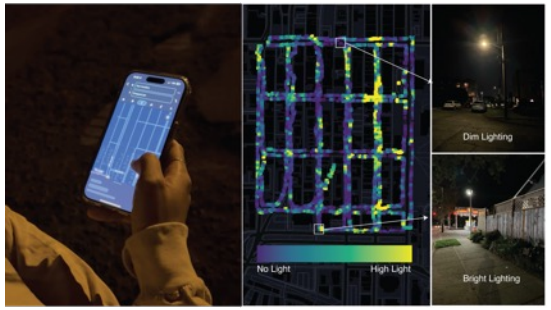


Automated Accessibility Audits



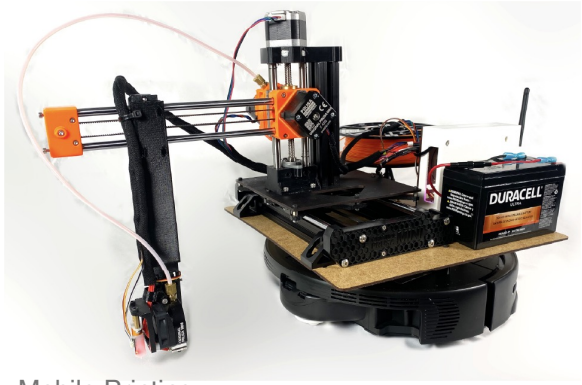
Surface Indicators

Tactile Graphics

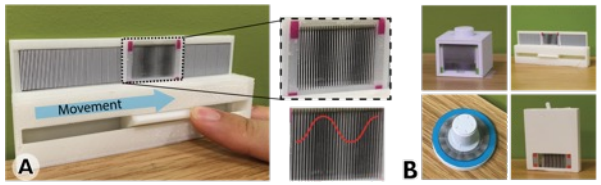


Safer Pedestrian Routing

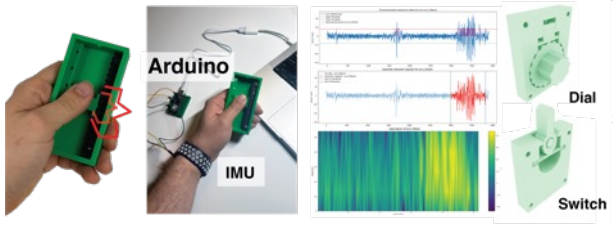
Fabrication + Tangible Interaction



Mobile Printing

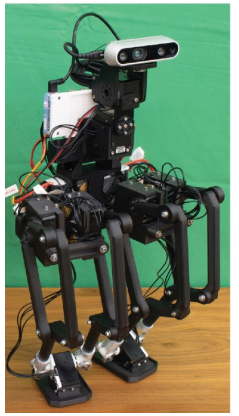


Vision based TUIs



Sensing + TUIs

Robotics



Bipeds

On-going

HRI, Tactile Sensing Grippers

Research Interests

Accessibility

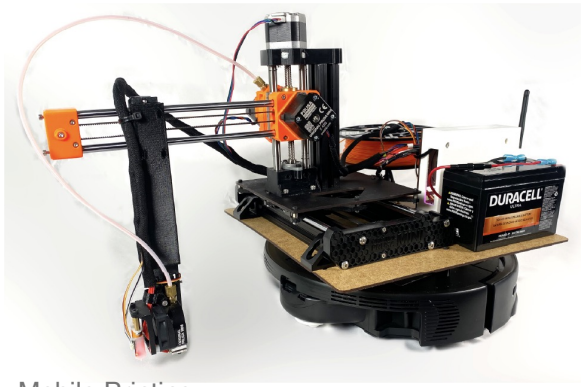
Automated Accessibility Audits

Surface Indicators

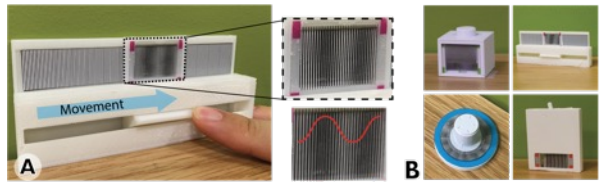
Tactile Graphics

Safer Pedestrian Routing

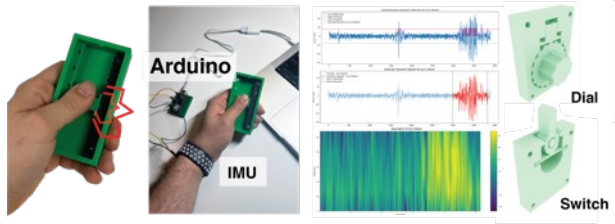
Fabrication + Tangible Interaction



Mobile Printing



Vision based TUIs



Sensing + TUIs

Robotics

Bipeds

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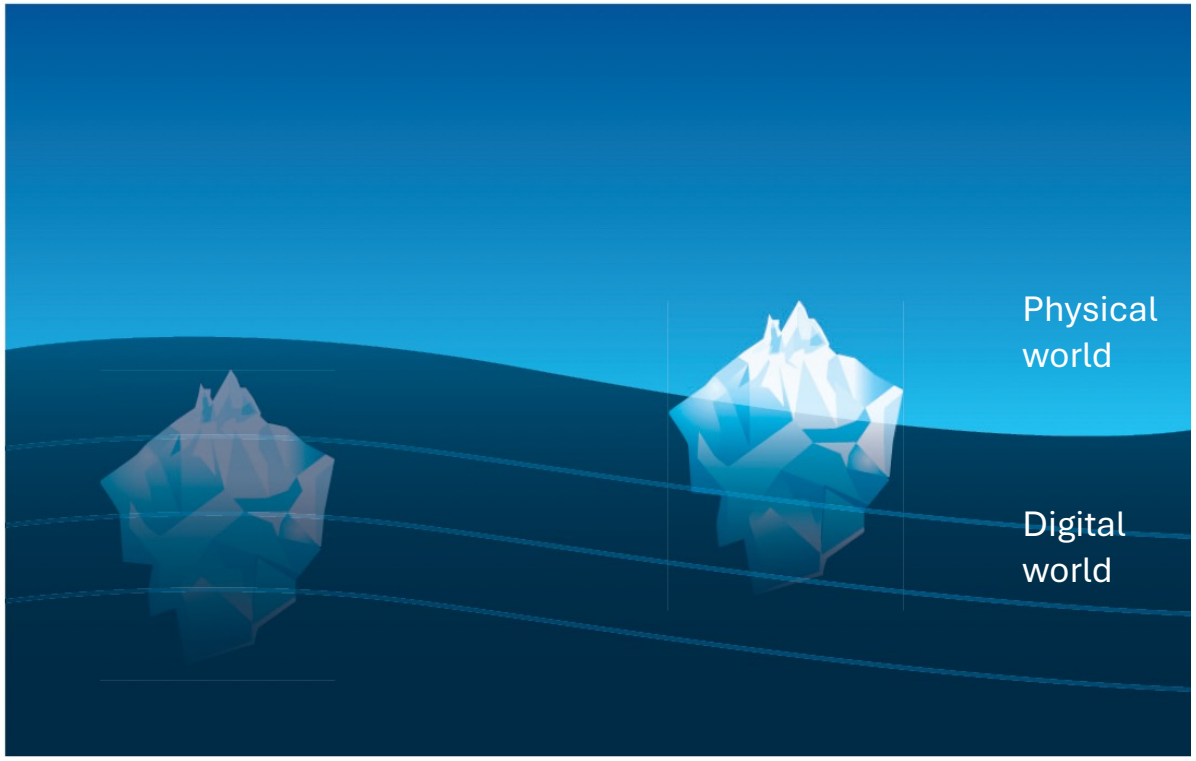
HRI, Tactile Sensing Grippers

Tangible Interaction

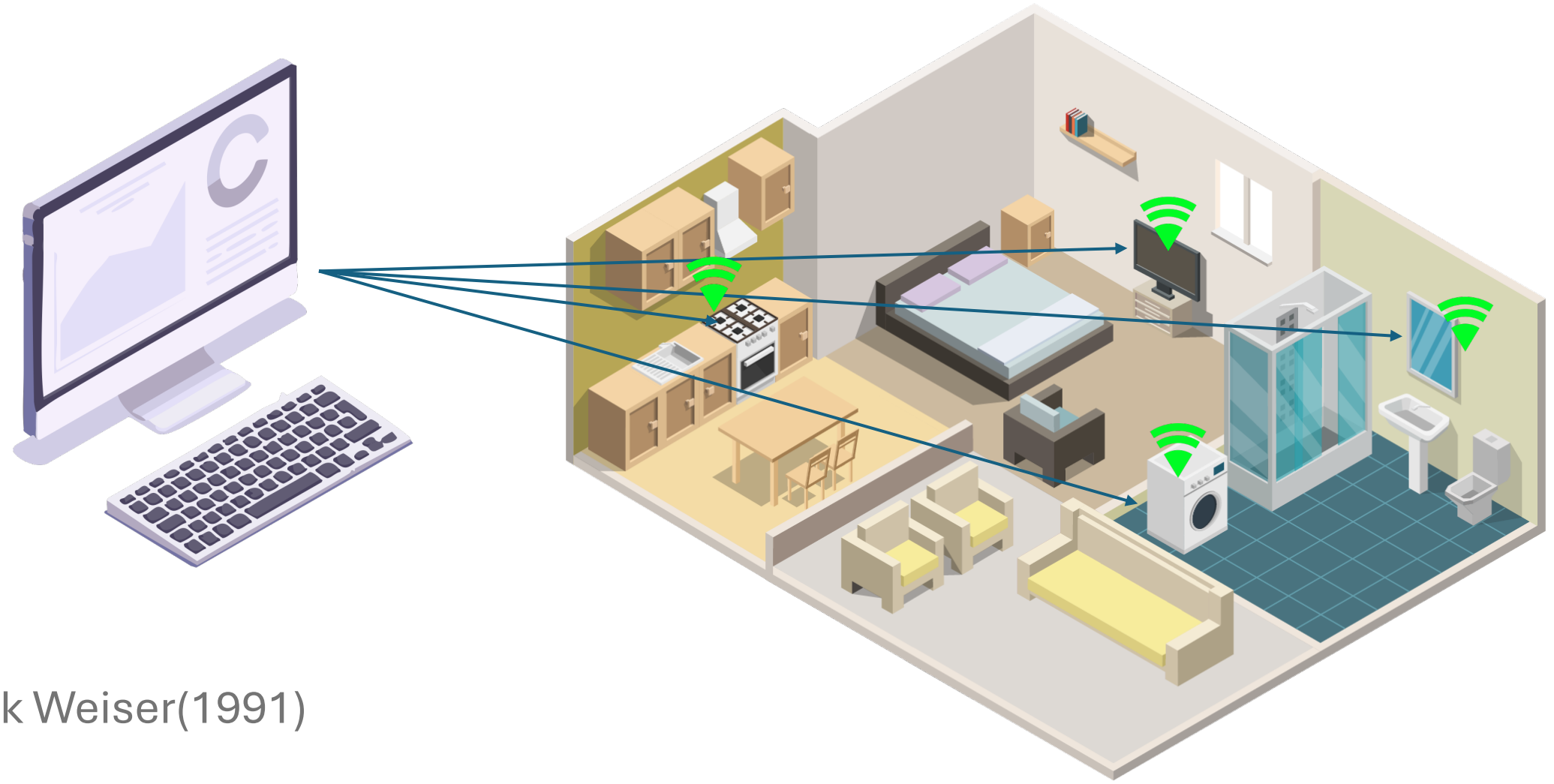
Hiroshi Ishii & Brygg Ullmer (1997)



“Our visual and auditory senses are steeped…in sea of digital information but our bodies remain in the physical world…one cannot **feel** and confirm the existence of digital information through one’s **hands** and **body**.”

Hiroshi Ishii (1997)

Ubiquitous Computing



Mark Weiser(1991)

Ubiquitous Computing

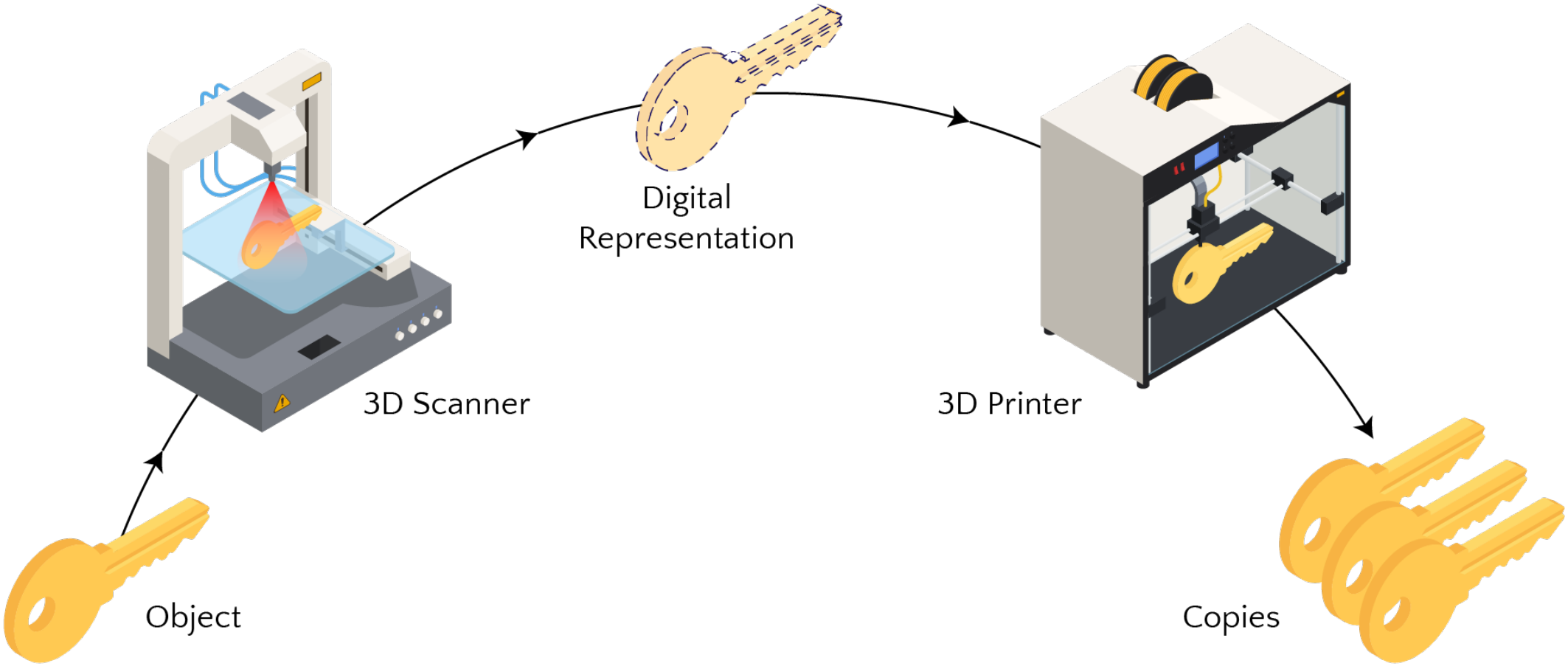
Ubiquitous Computing

Design and Fabrication

Digital Designs → Programmable Machines → Tangible Artifacts

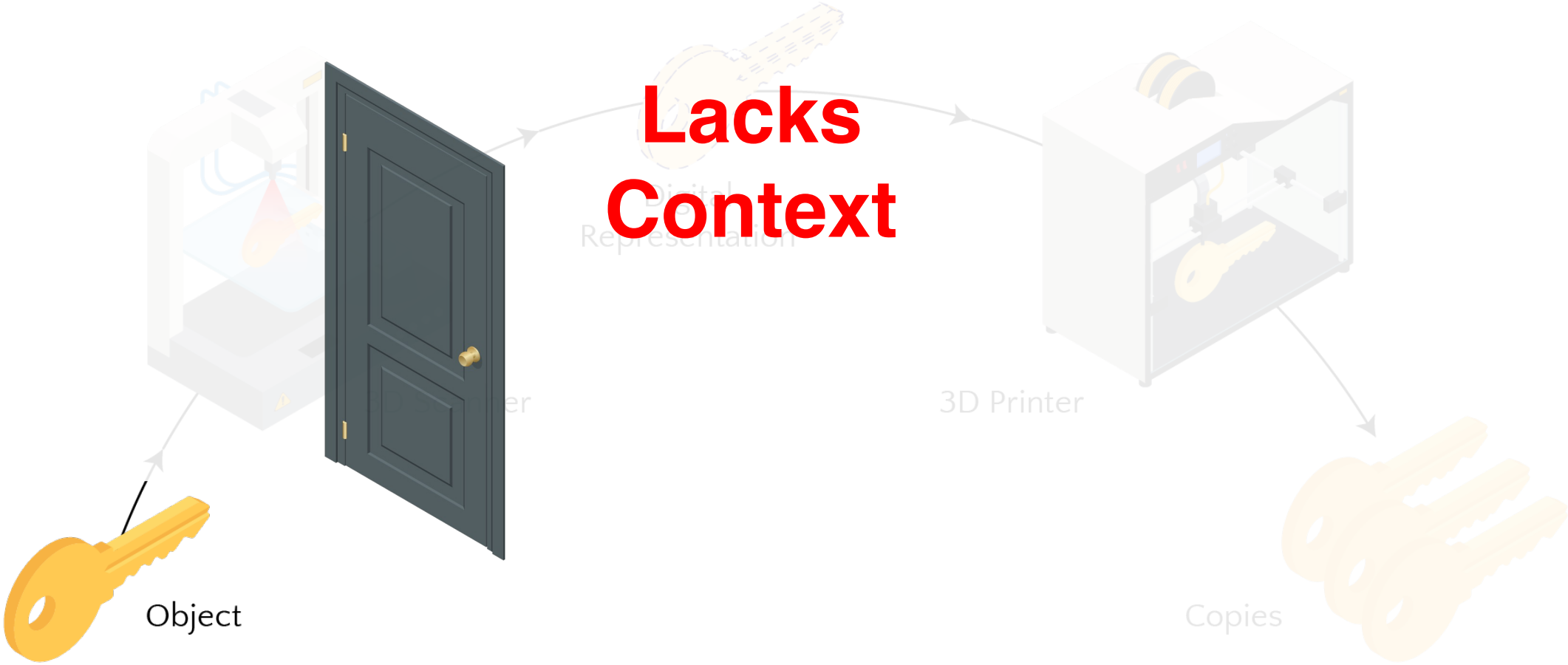
How can we work across real-world environments to enhance interactions?

How can we work **across real-world environments** to enhance interactions?



Conventional Digital Fabrication

(based on Mueller & Baudisch, 2017)



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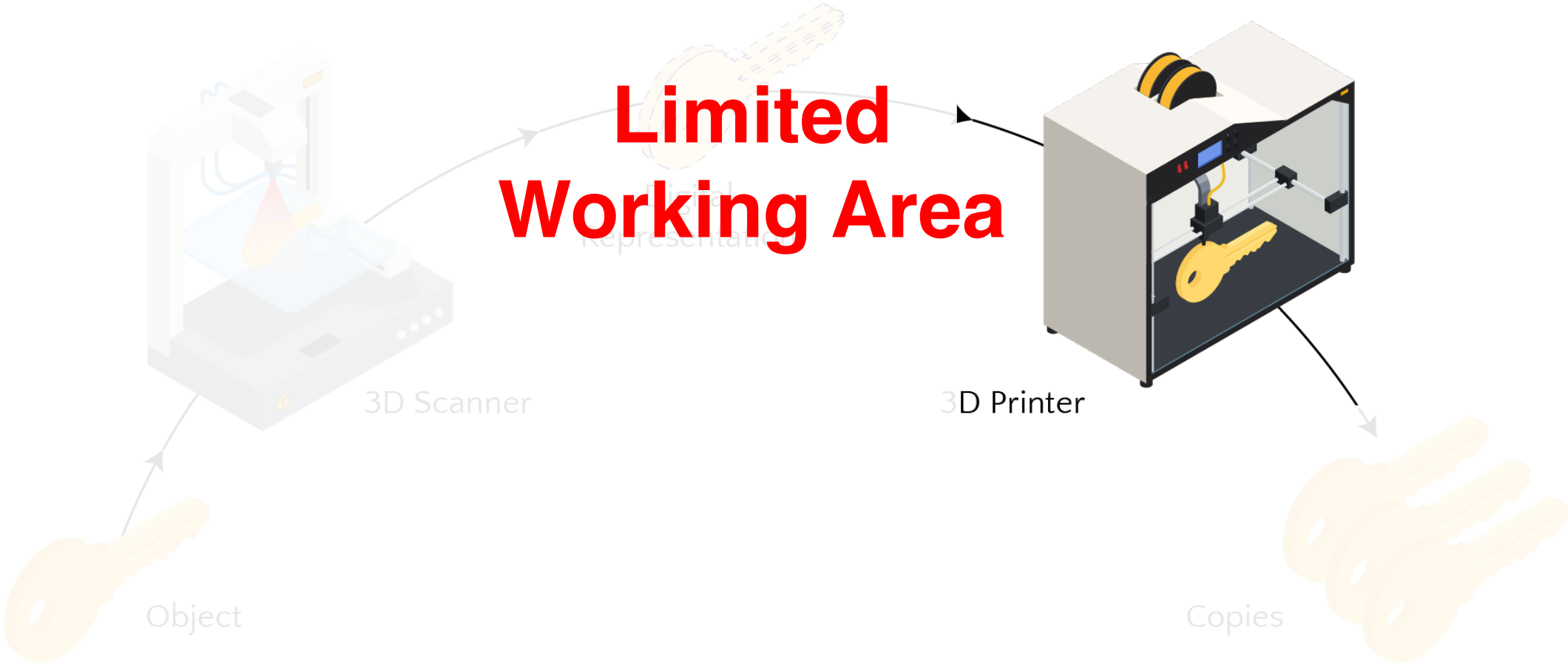

Conventional Digital Fabrication

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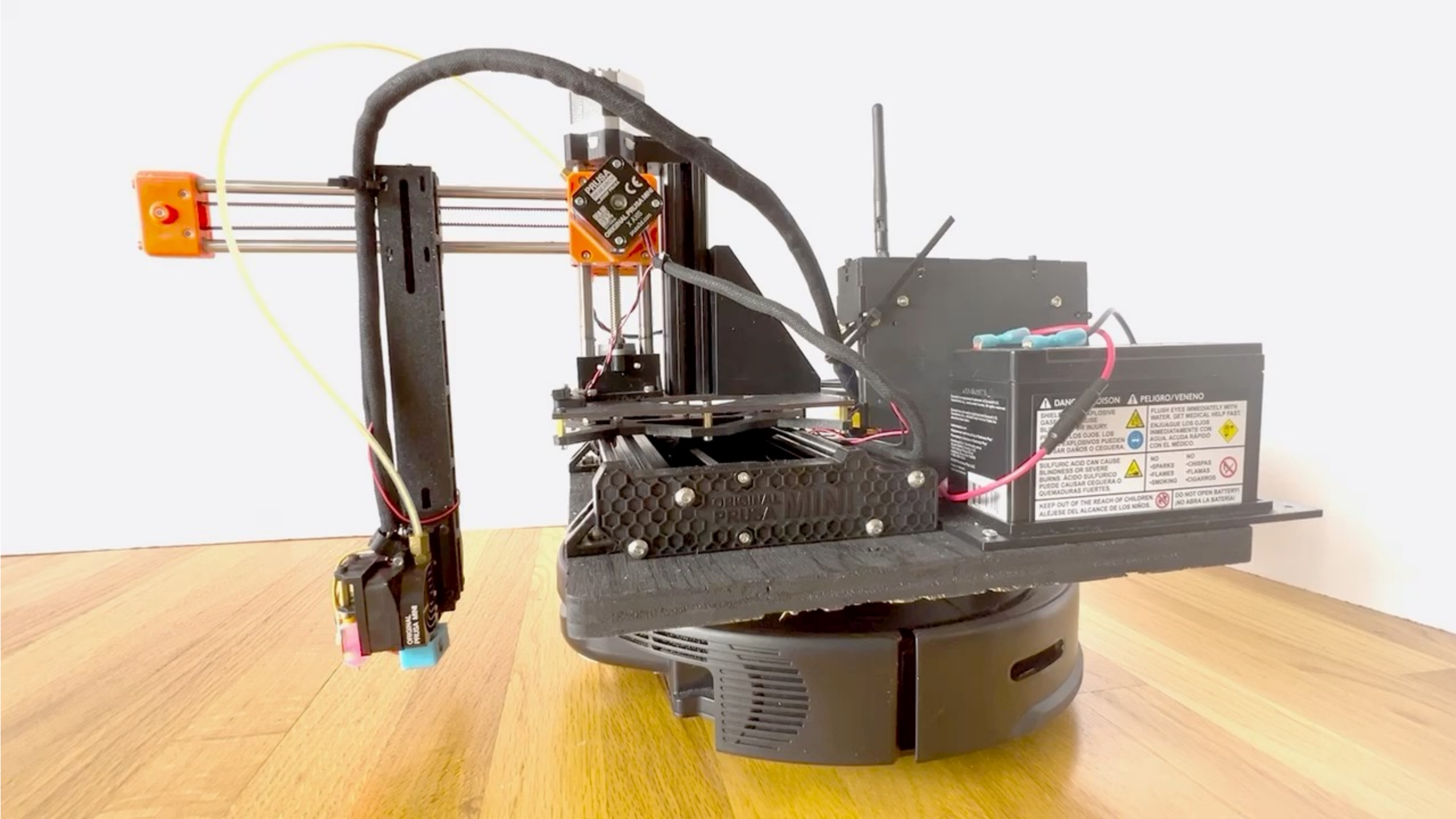

PRUSA
ORIGINAL PRUSA MINI
X AXIS
PRUSA3D.COM
ORIGINAL PRUSA MINI
PELIGRO/VENENO
SULFURIC ACID CAN CAUSE BLINDNESS OR SEVERE BURNS. ÁCIDO SULFÚRICO PUEDE CAUSAR CEGUERA O QUEMADURAS FUERTES.
FLUSH EYES IMMEDIATELY WITH WATER, GET MEDICAL HELP FAST. ENJUAGUE LOS OJOS INMEDIATAMENTE CON AGUA, ACUDA RÁPIDO CON EL MÉDICO.
NO SPARKS NO FLAMES NO SMOKING
NO CHISPAS NO FLAMAS NO CIGARROS
KEEP OUT OF THE REACH OF CHILDREN. ALÉJESE DEL ALCANCE DE LOS NIÑOS.
DO NOT OPEN BATTERY! ¡NO ABRA LA BATERÍA!

Workflow

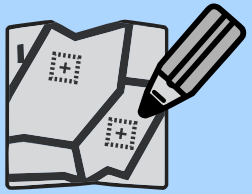
Map

Robot completes initial scan and generates map

Select

Select from model library or upload a new design

Plan + Edit



Arrange and edit objects in the environment

Print

Robot navigates to target location and prints objects

Workflow

Map

Robot completes initial scan and generates map

Select

Select from model library or upload a new design

Plan + Edit

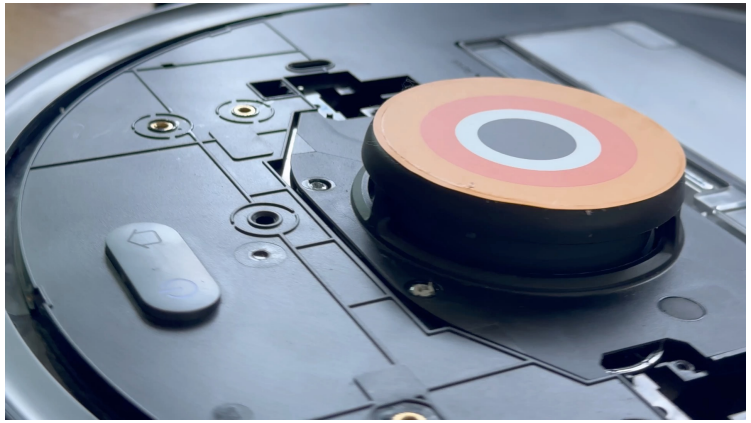
Arrange and edit objects in the environment

Print

Robot navigates to target location and prints objects

Mapping

Rooted Firmware



*Printer removed to show LiDAR

Workflow

Map

Robot completes initial scan and generates map

Select

Select from model library or upload a new design

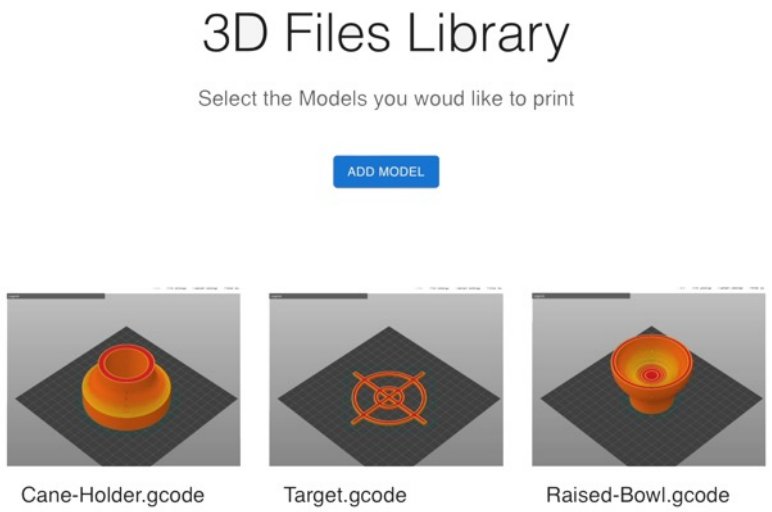
Plan + Edit

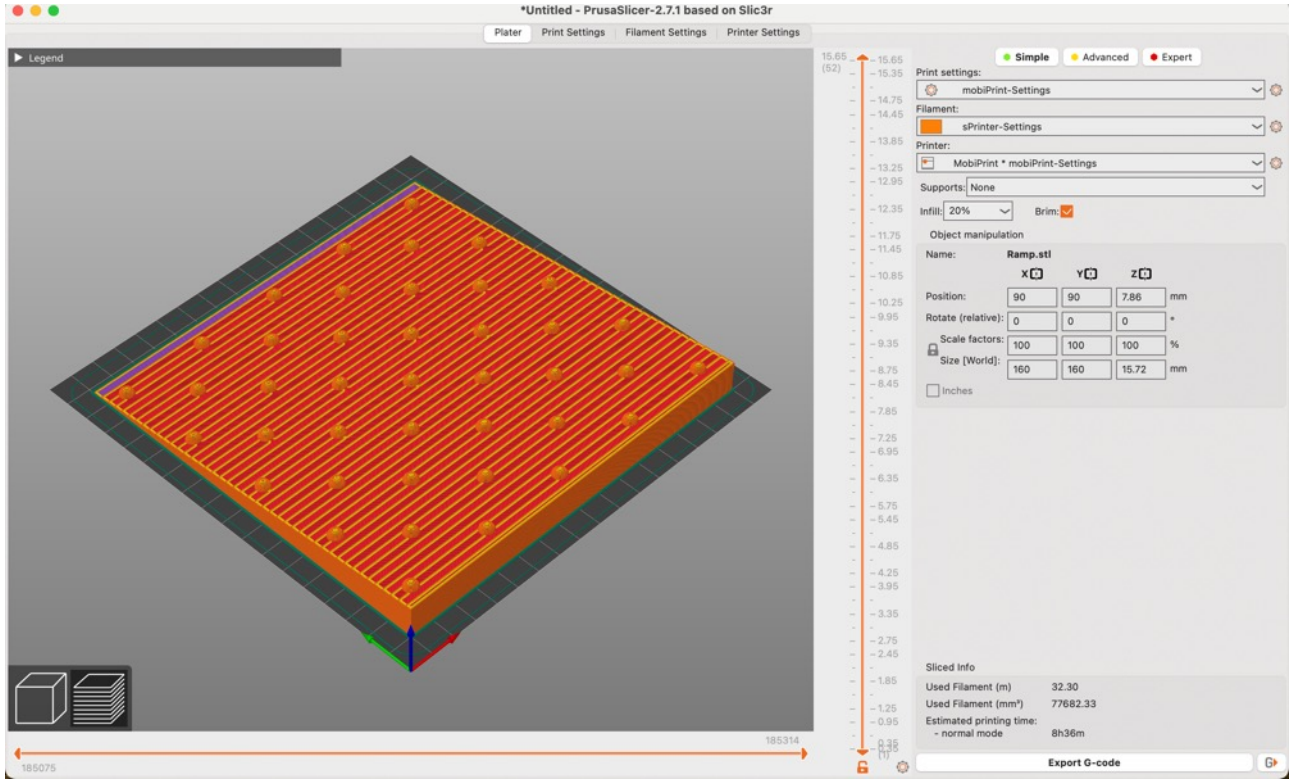
Arrange and edit objects in the environment

Print

Robot navigates to target location and prints objects

Selecting Objects





- Preloaded Models
- Slice & Upload New Objects

Workflow

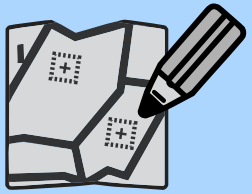
Map

Robot completes initial scan and generates map

Select

Select from model library or upload a new design

Plan + Edit



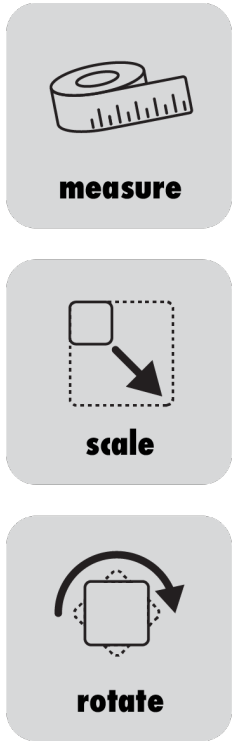
Arrange and edit objects in the environment

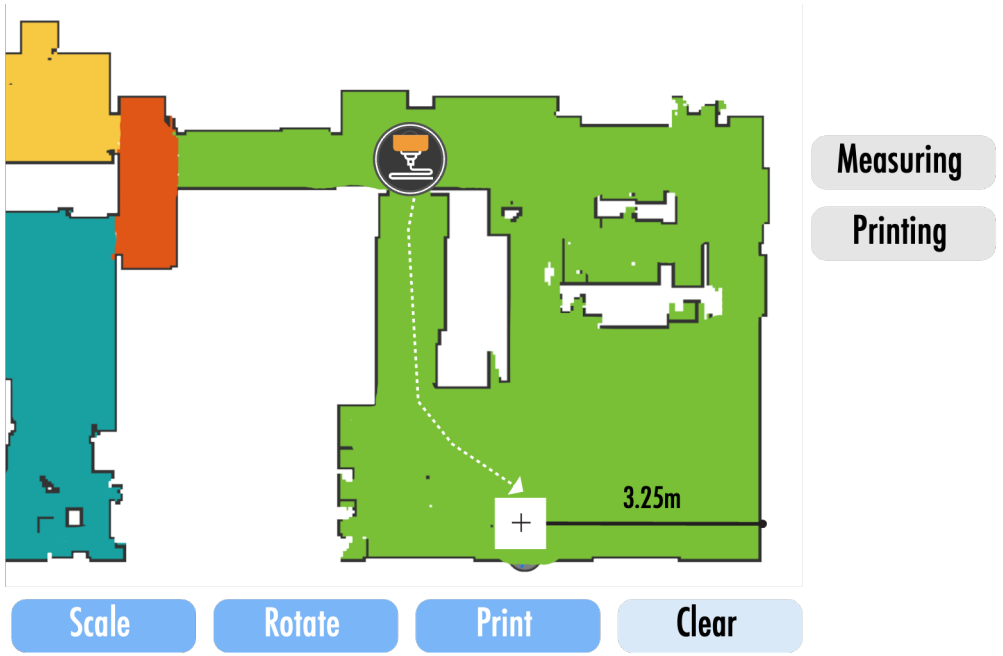
Print

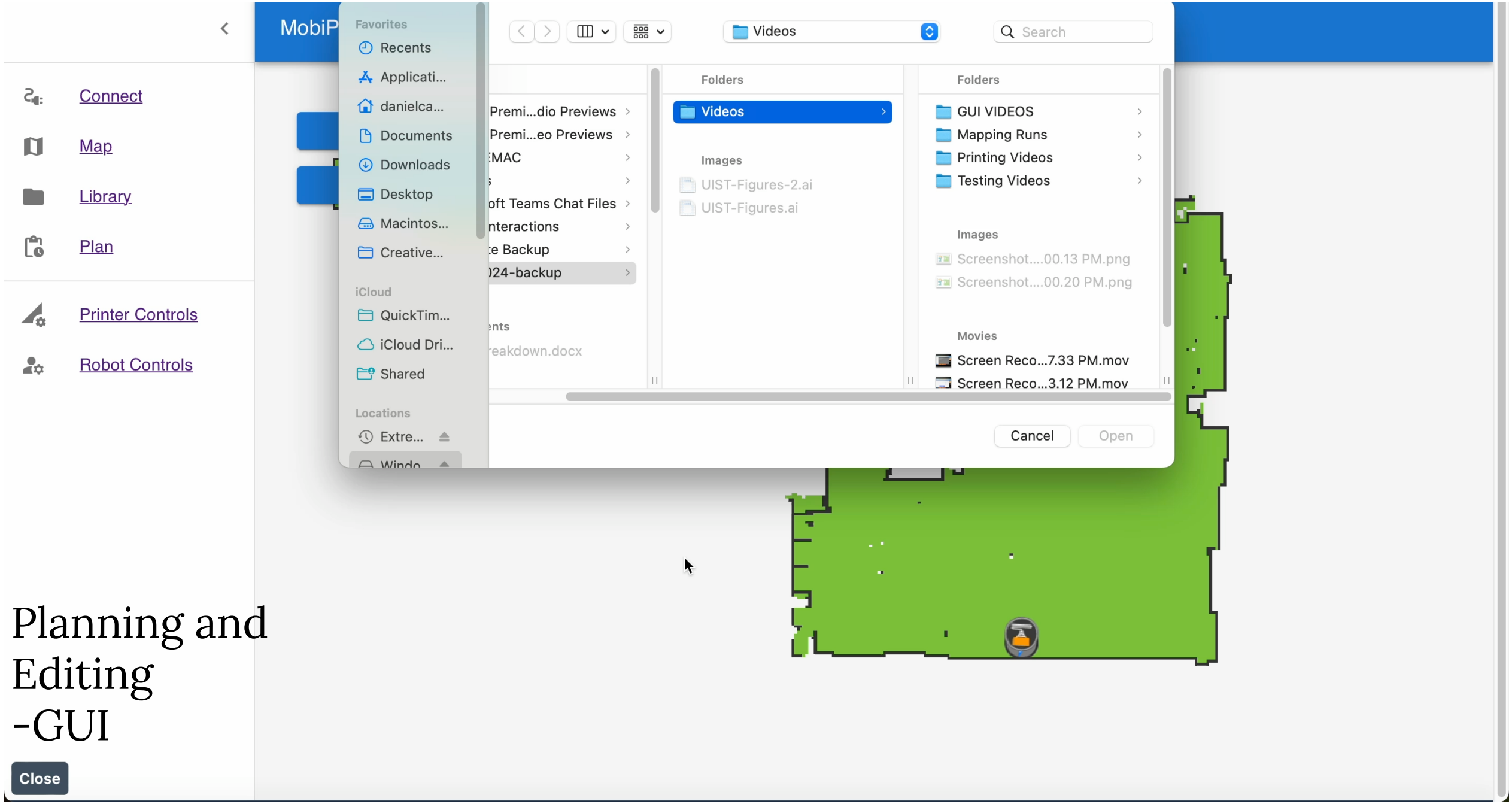
Robot navigates to target location and prints objects

Planning And Editing

Users can treat the map as a canvas to place and edit objects






MobiP
Connect
Map
Library
Plan
Printer Controls
Robot Controls
Favorites
Recents
Applicati...
danielca...
Documents
Downloads
Desktop
Macintos...
Creative...
iCloud
QuickTim...
iCloud Dri...
Shared
Locations
Extre...
Videos
Search
Folders
Videos
Images
UIST-Figures-2.ai
UIST-Figures.ai
Folders
GUI VIDEOS
Mapping Runs
Printing Videos
Testing Videos
Images
Screenshot....00.13 PM.png
Screenshot....00.20 PM.png
Movies
Screen Reco...7.33 PM.mov
Screen Reco...3.12 PM.mov
Cancel
Open
Planning and Editing -GUI
Close

Workflow

Map

Robot completes initial scan and generates map

Select

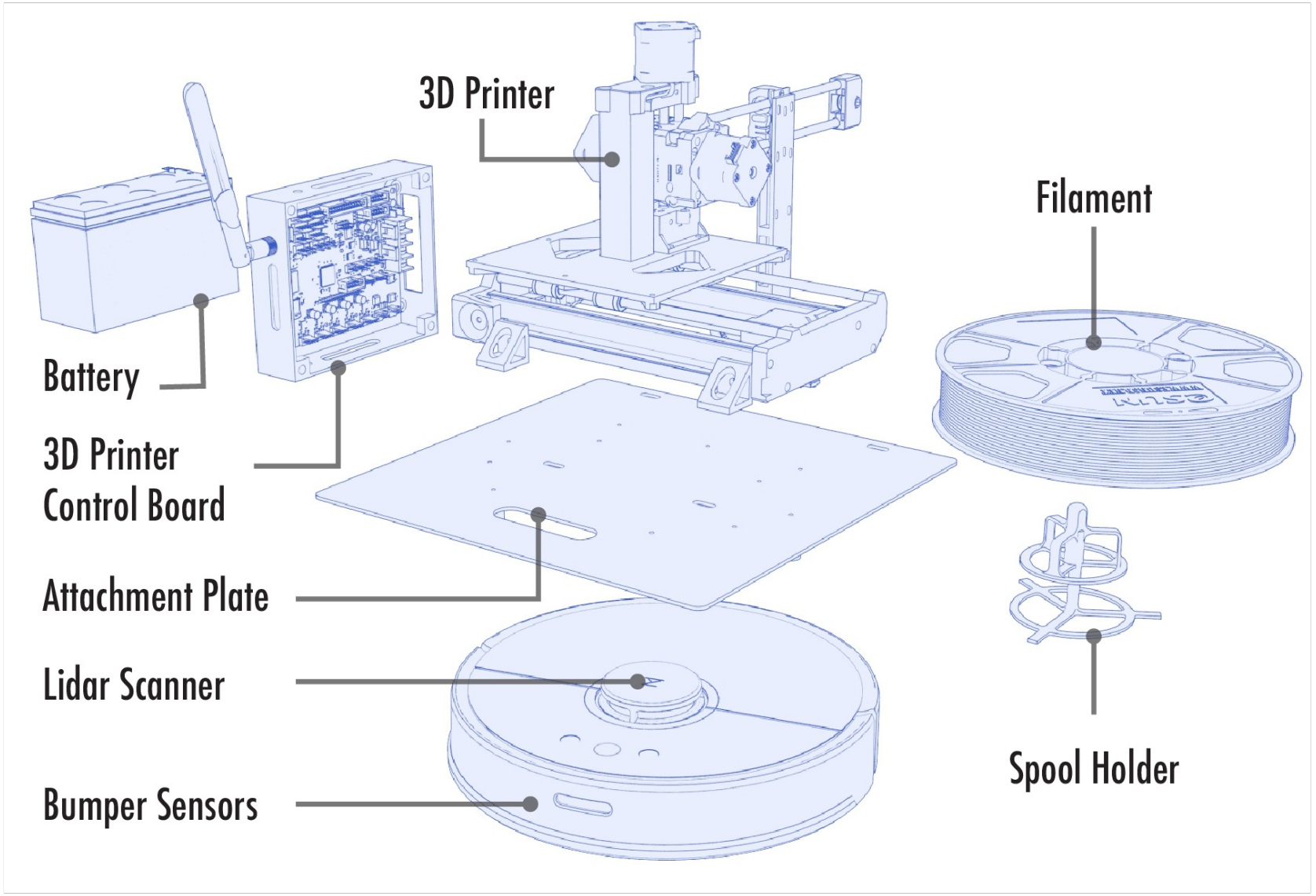
Select from model library or upload a new design

Plan + Edit

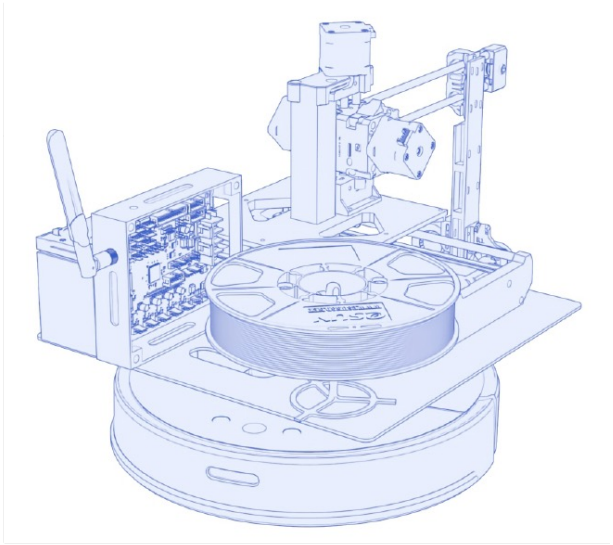
Arrange and edit objects in the environment

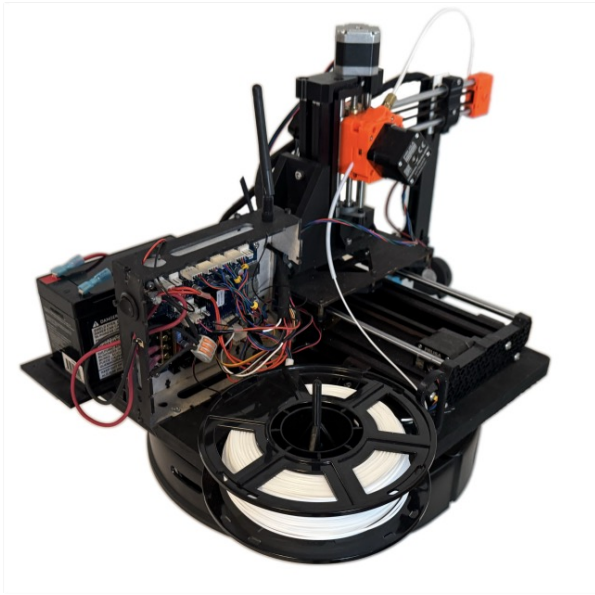
Print

Robot navigates to target location and prints objects



Exploded View

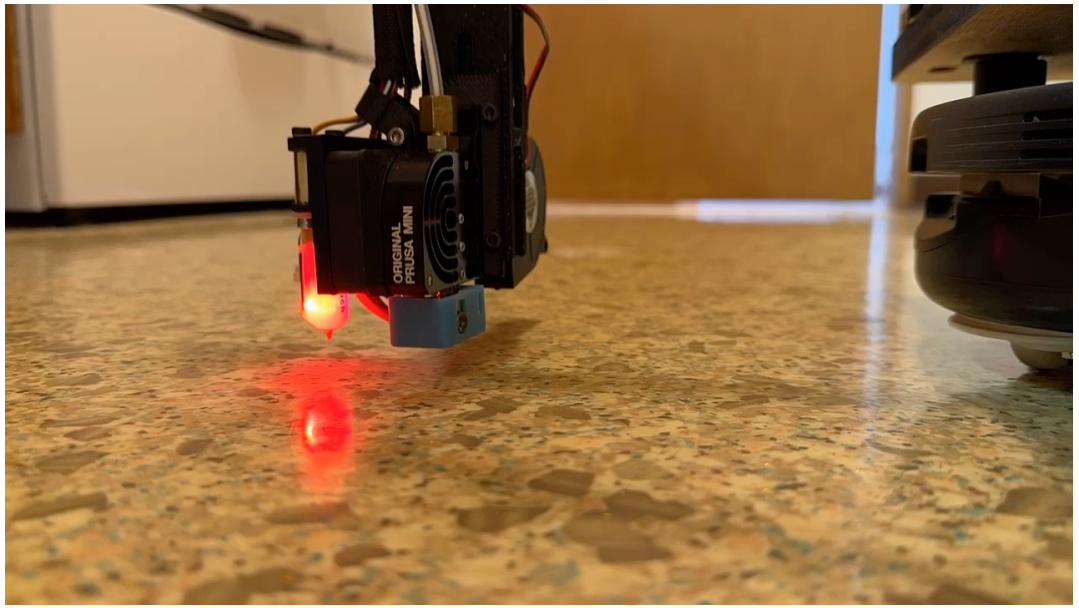


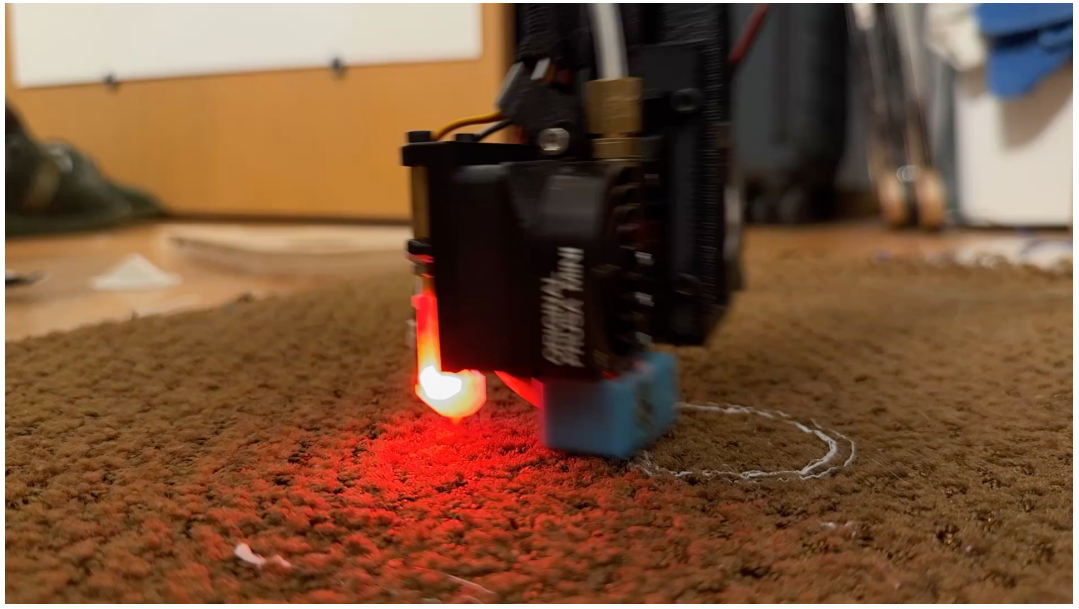


Assembled Views

Printing

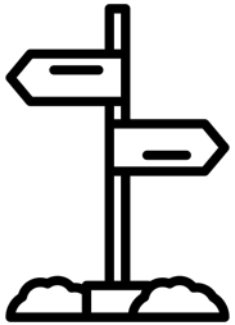
Prints directly on the ground surface



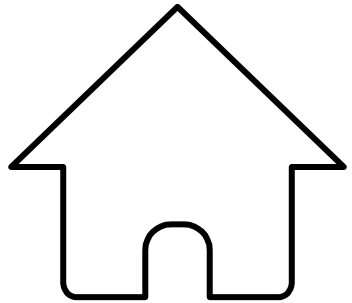


Scenarios

Accessibility



Signage and Wayfinding



Home Furnishing

Accessibility

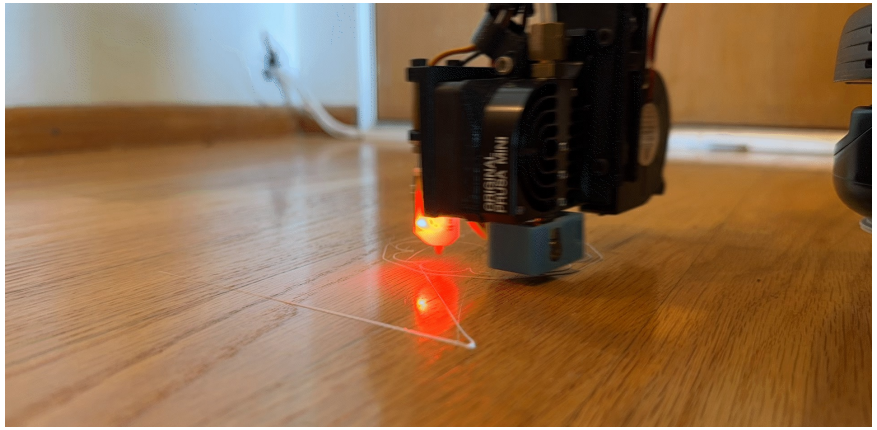
Tactile Surface Indicators

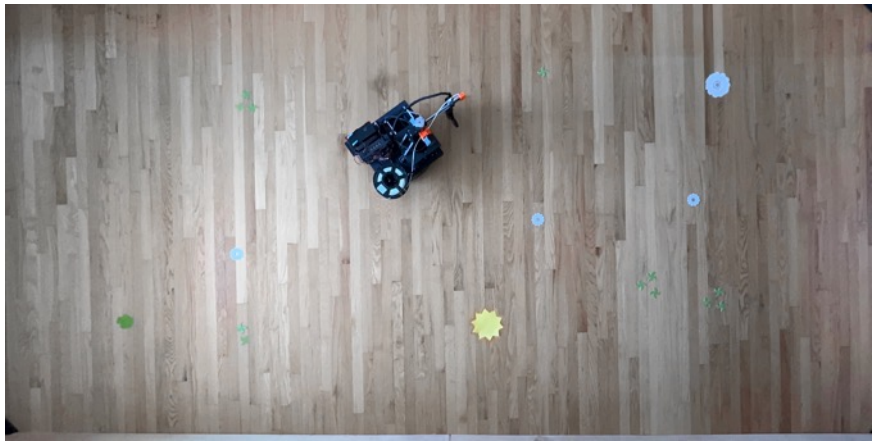
Cane Holder

Signage and Wayfinding

Conference Signage

Home Furnishing





Floor mural

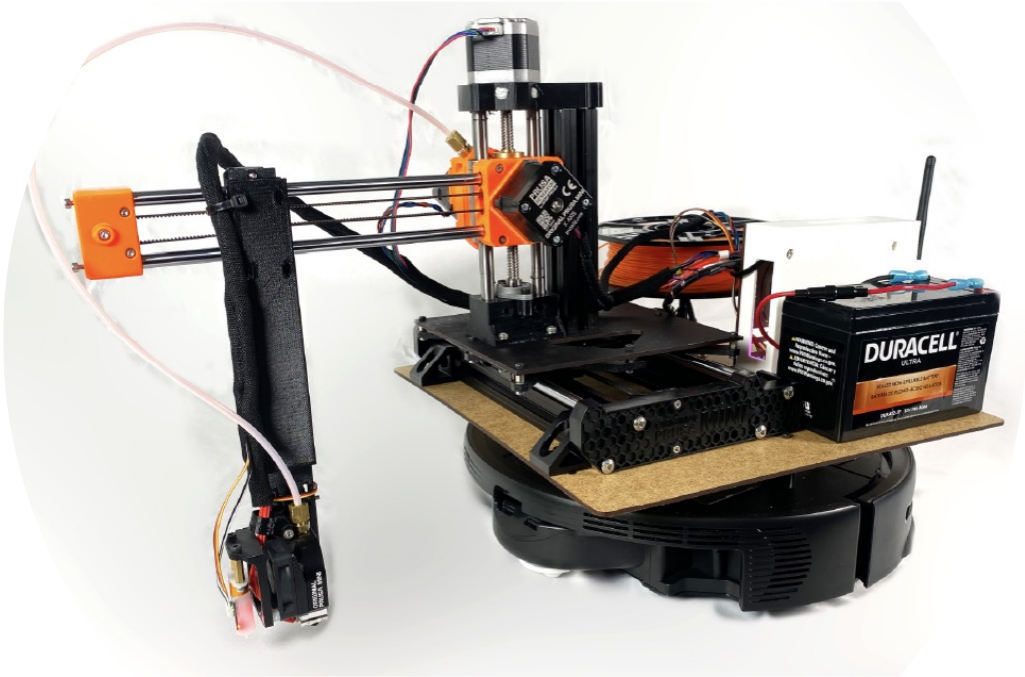
Ergonomic footrest

Raised pet bowl

Design Considerations

- Integrate Environment and Context Information into Design Process
- Support a Spectrum of Automation
- Work Directly In/On the Environment
- Consider Permanence, Removal, and Lifecycle

Summary



- Mobiprint can navigate, map, and print in ad-hoc environments
- Convert a floorplan into a 3D printable canvas
- Enable large working area across real-world environments

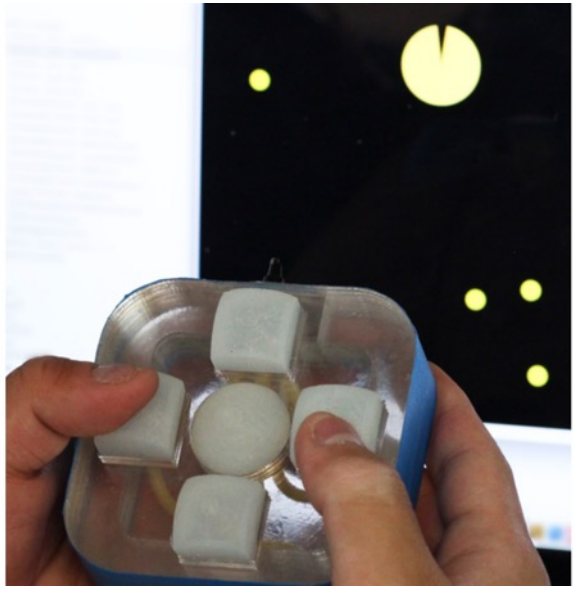
How can we work across real-world environments to **enhance interactions**?

Tangible User Interfaces

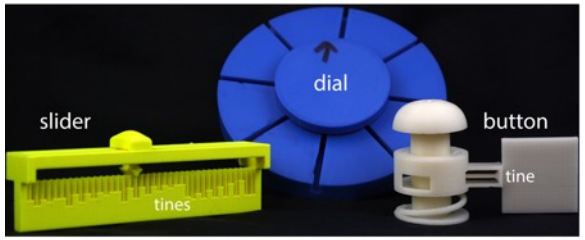
Tangible User Interfaces

Battery Free and Passive TUIs

Sound



He et al. (2017)



Savage et al. (2015)

Capacitance

Götzelmann et al. (2016)

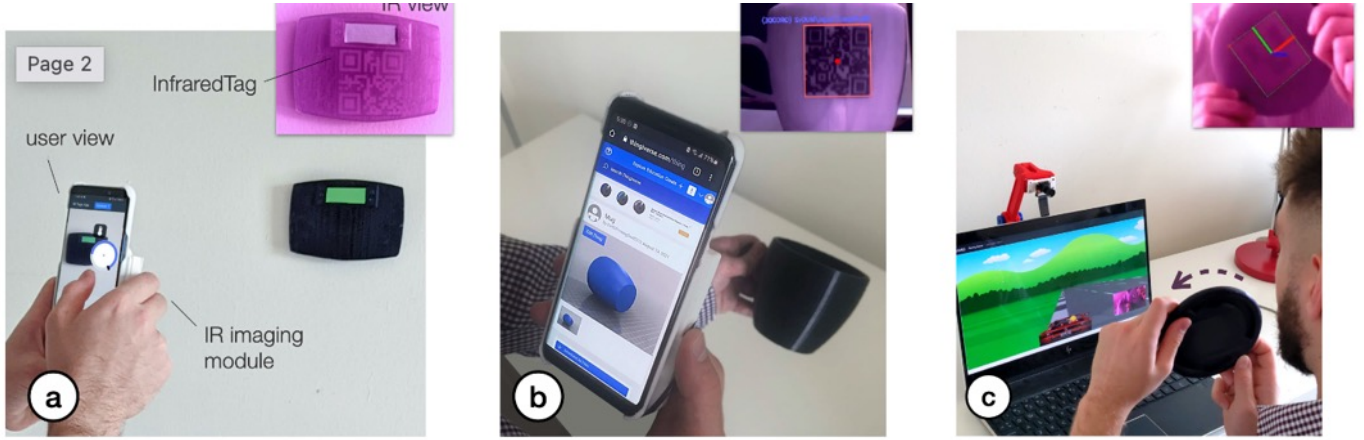
Schmitz et al. (2015)

Other Sensors

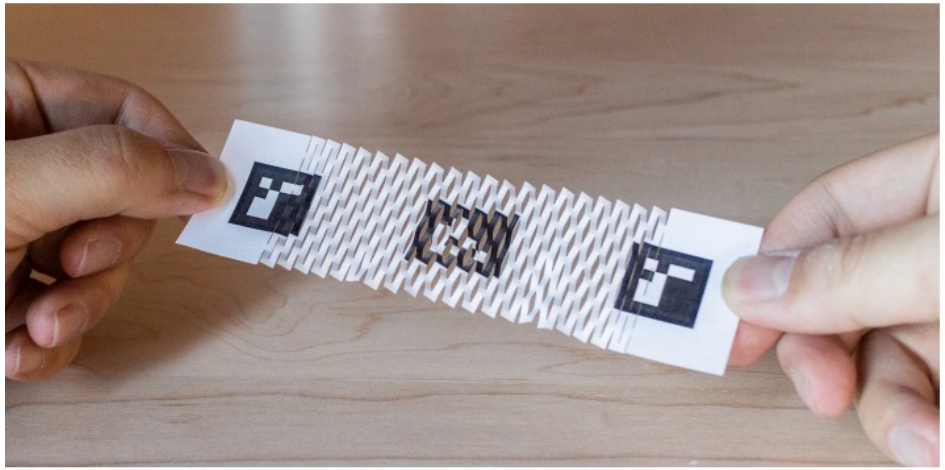
Hwang et al. (2013)

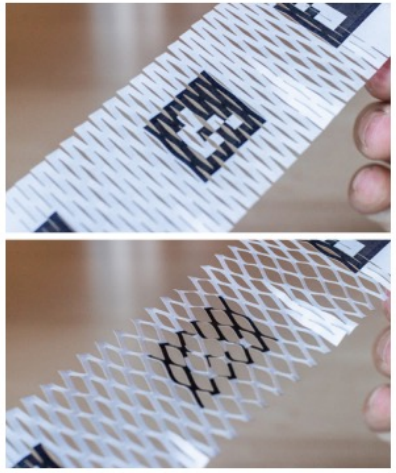
Iyer et al. (2018)

Battery Free and Passive TUIs

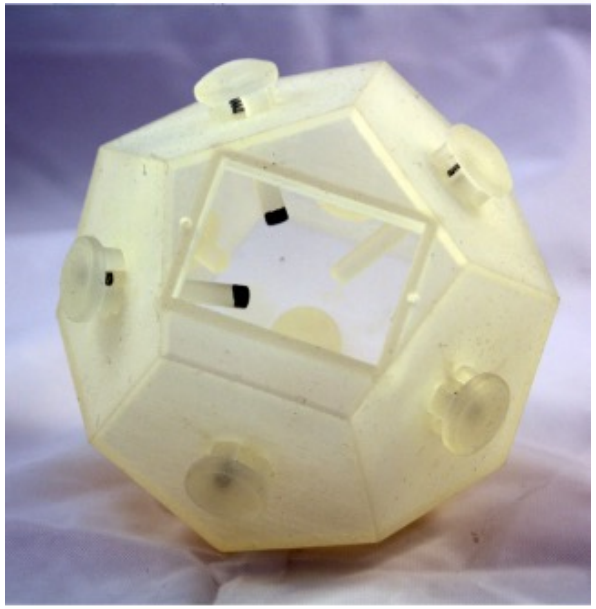


Dogan et al. (2022)





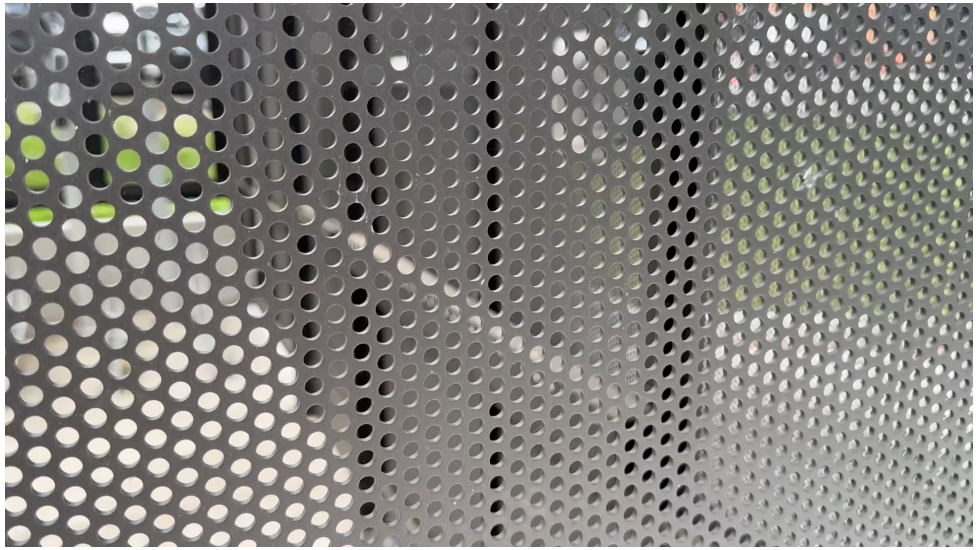
Zheng et al. (2021)

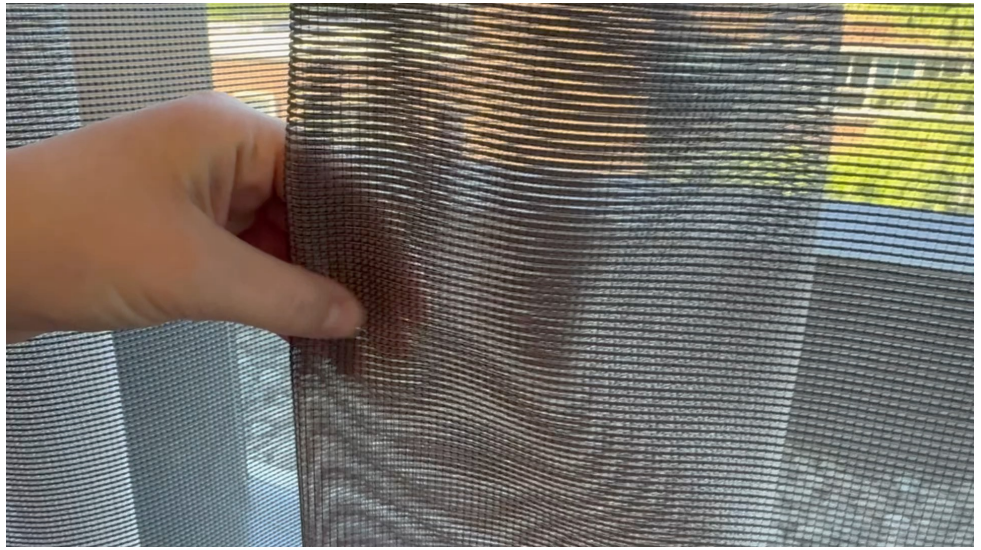


Savage et al. (2023)

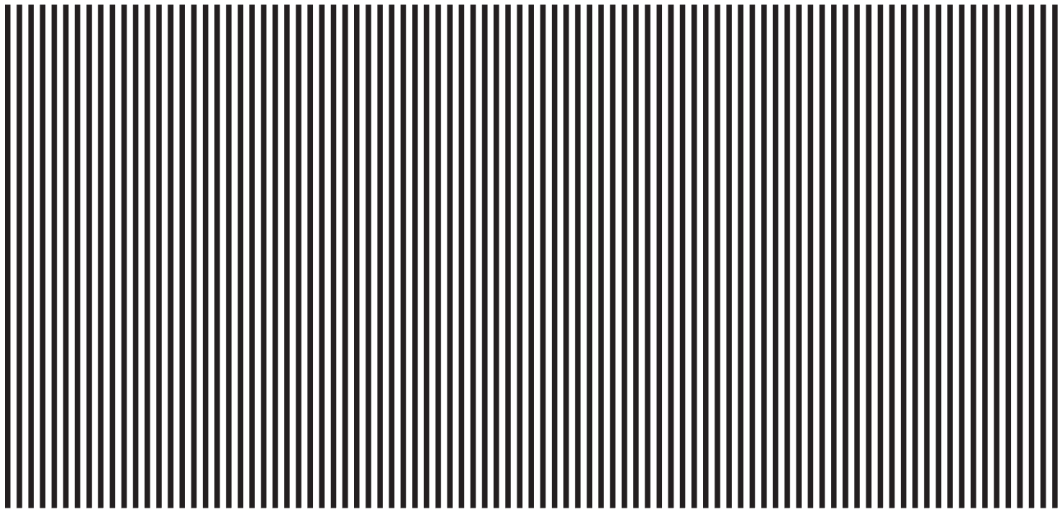
3Dconnexion

Our Method

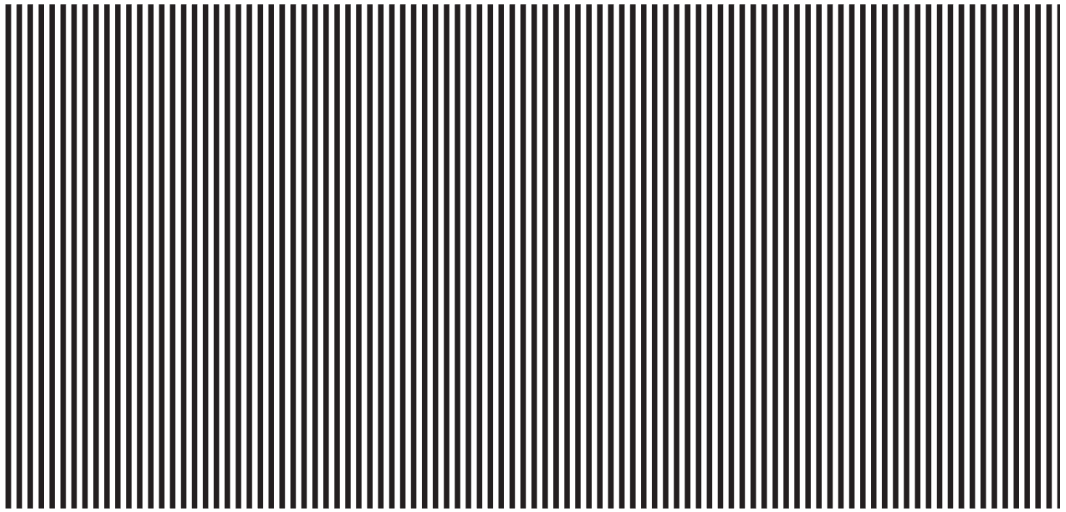




Moiré Effect



Layer 1



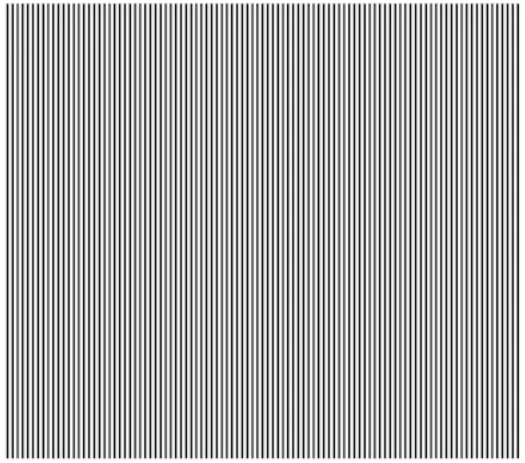
Layer 2

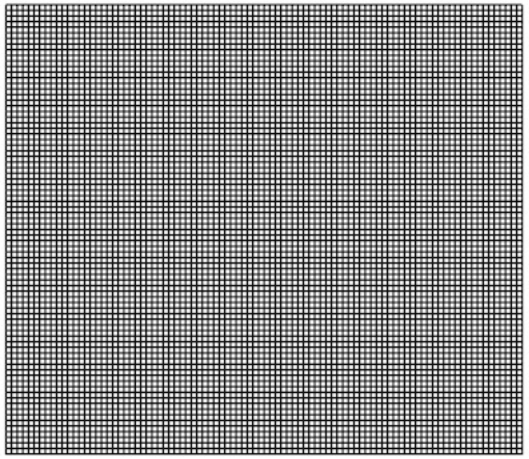
$$\Delta moire = \frac{T_{Layer1}\Delta_{Layer2}}{T_{Layer1} - T_{Layer2}}$$

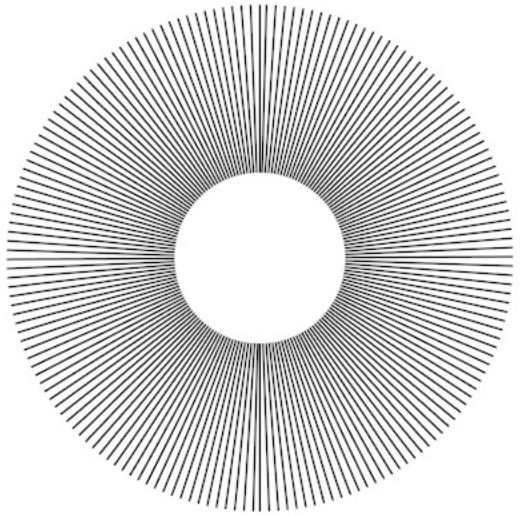
Can we use the Moiré effect to track inputs?

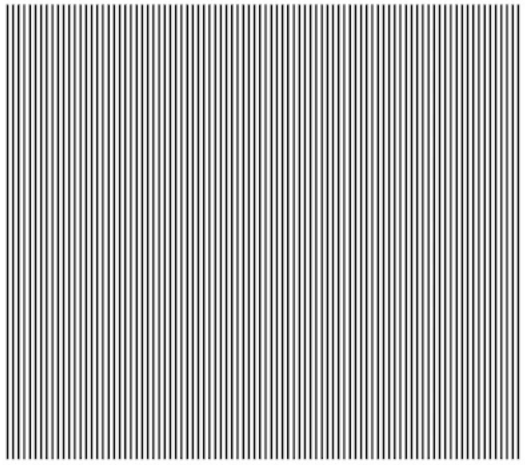
Movement Types

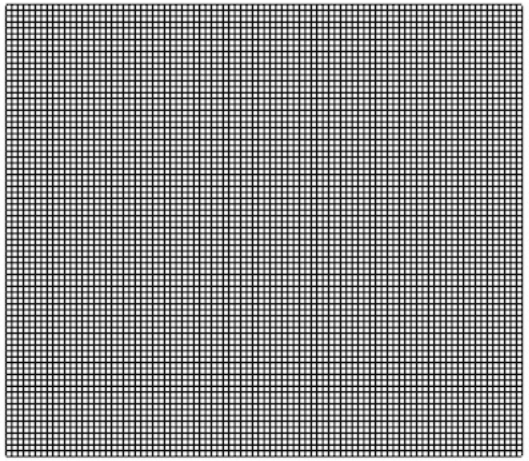
Top Layers

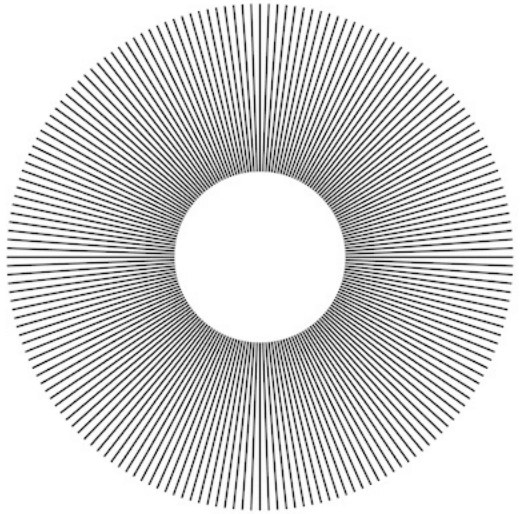






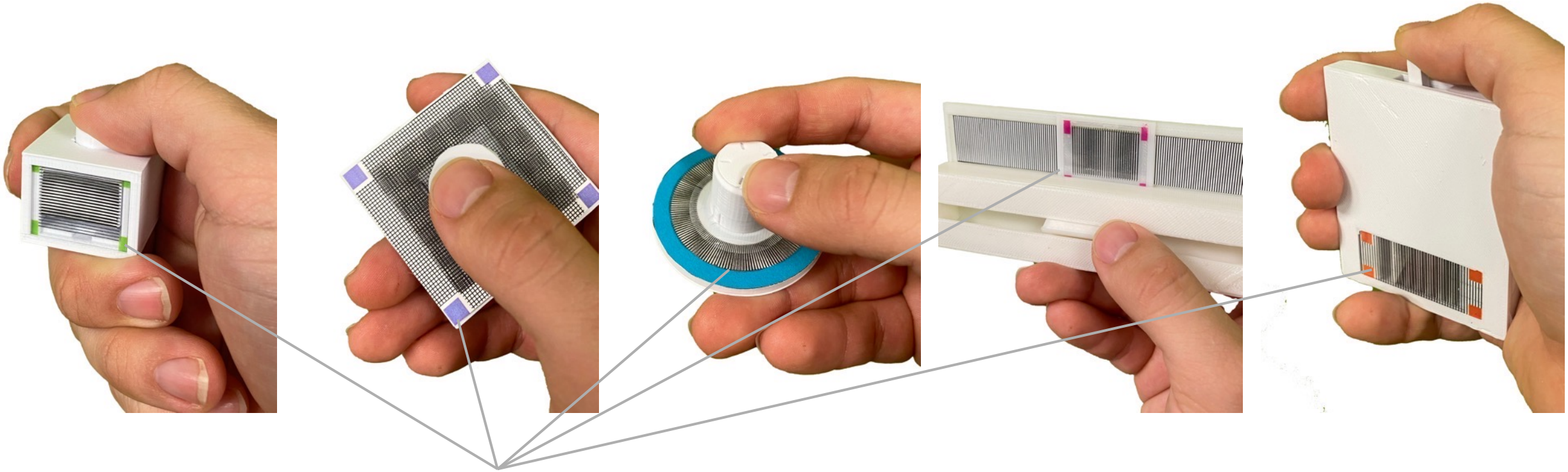




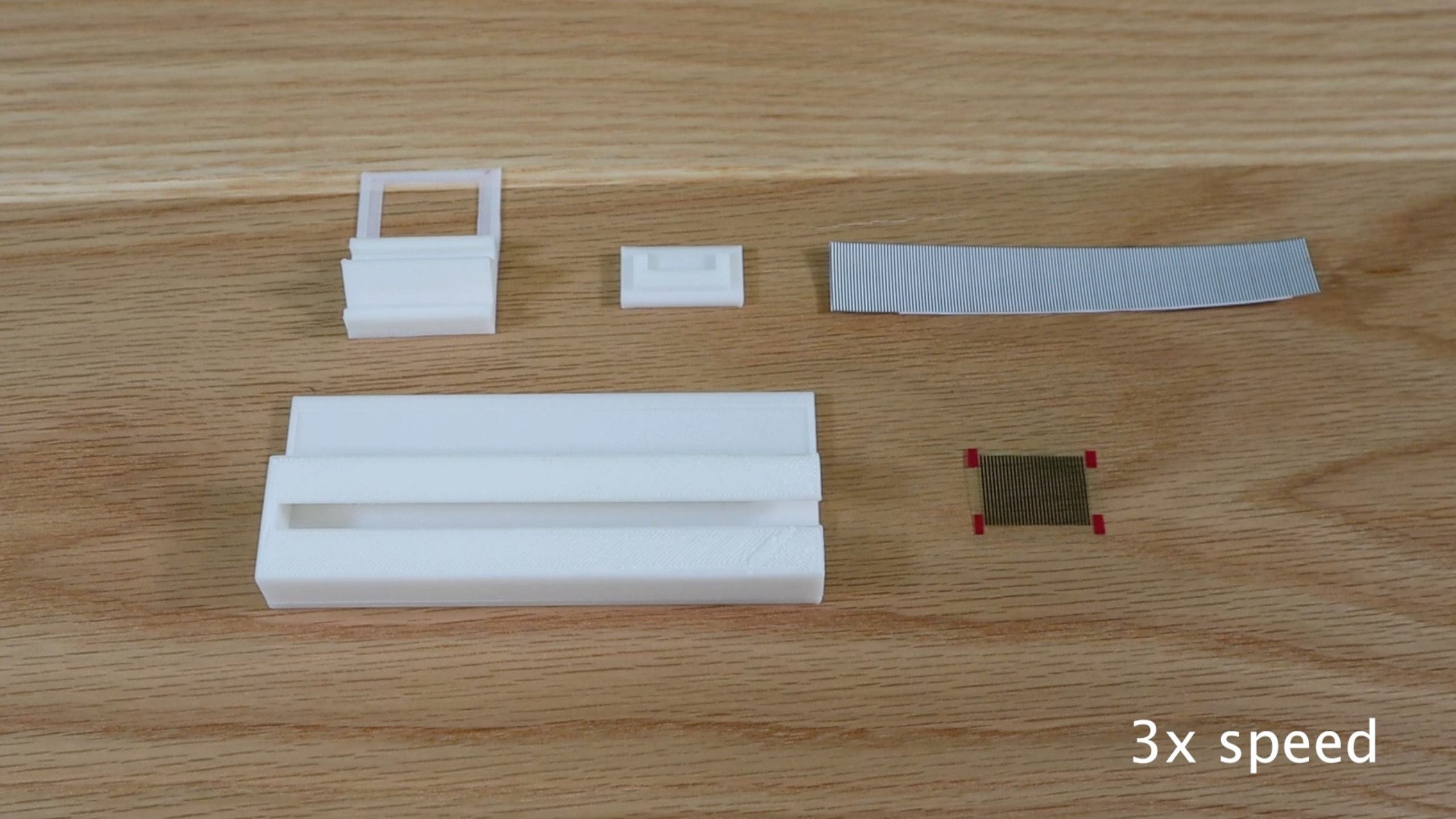


Bottom Layers

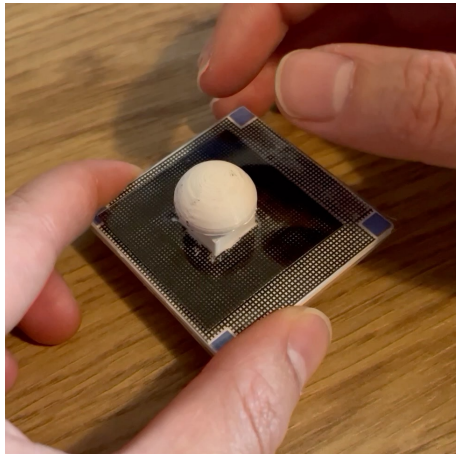
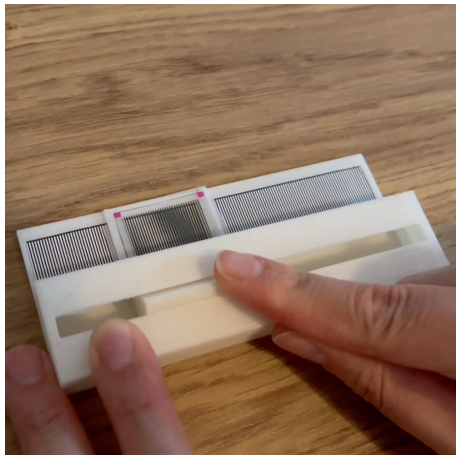
MoiréWidgets

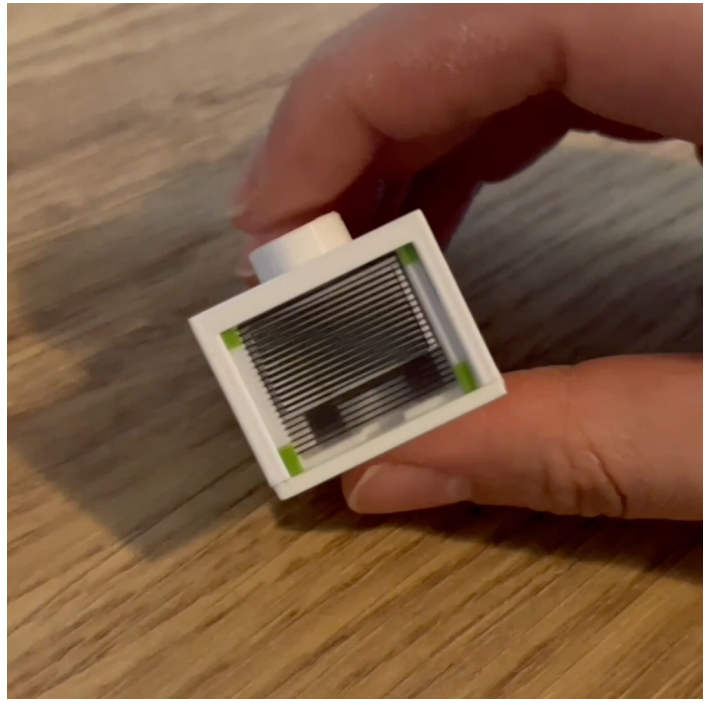


Colored Markers for Extracting Moiré Pattern

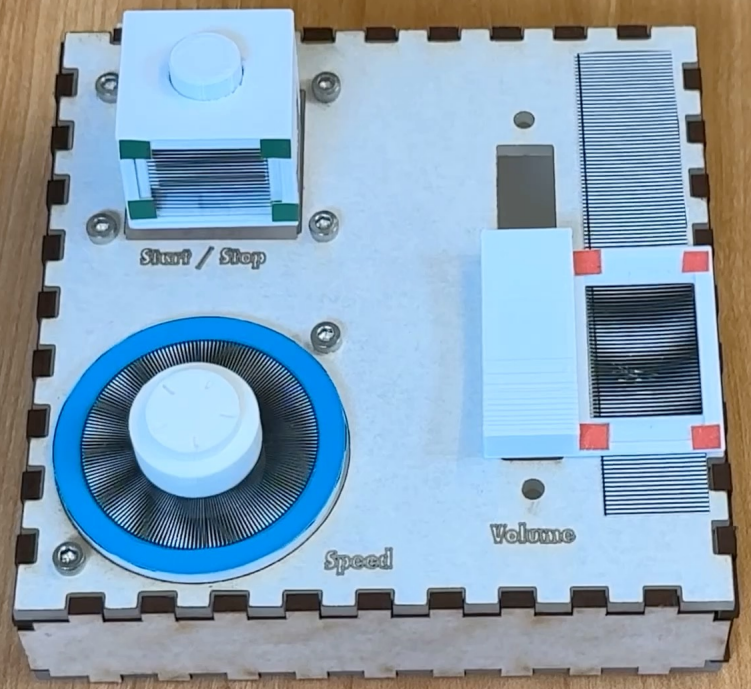

3x speed

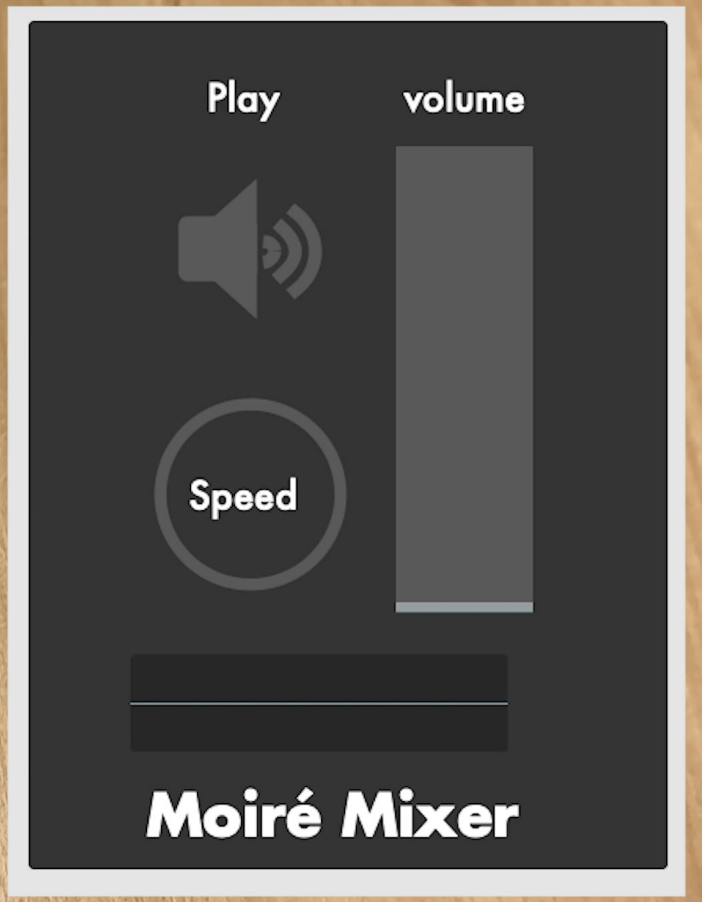
Widgets

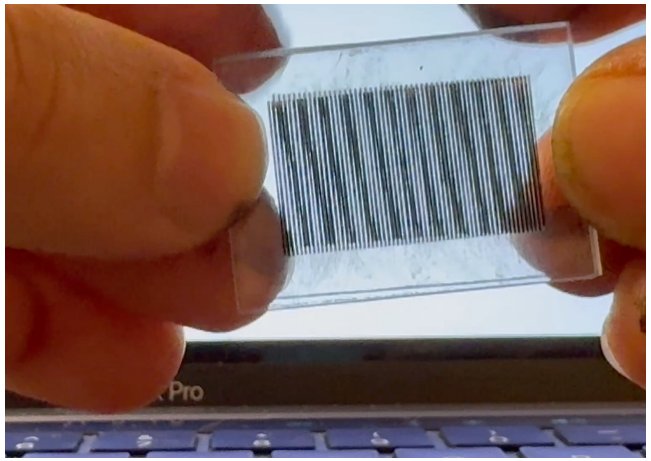


Demo

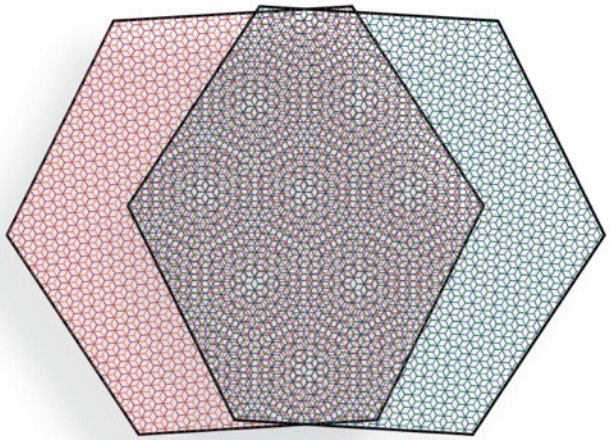




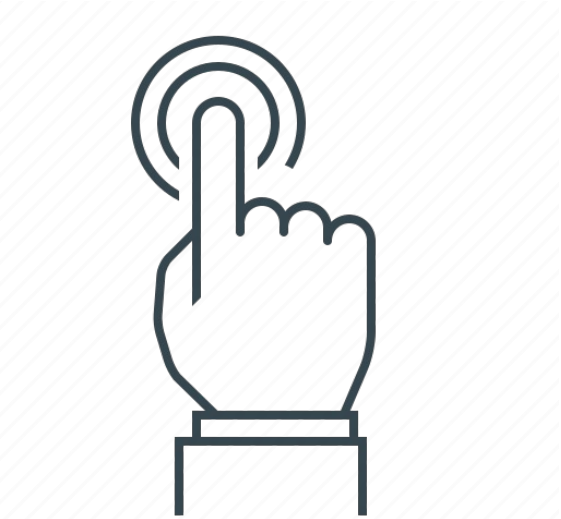
Future Work



Streamlined Fab Process



Different Moiré Aesthetics



Explore Interaction Modalities

Summary

- Enabling interaction with passive objects
- Amplifies subtle movements
- Flexible Design and Applications

Research Interests

Accessibility

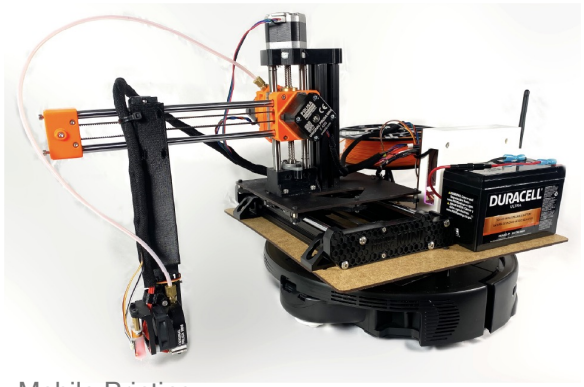
Automated Accessibility Audits

Surface Indicators

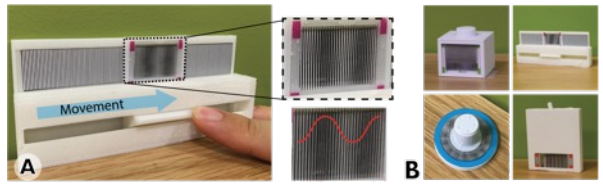
Tactile Graphics

Safer Pedestrian Routing

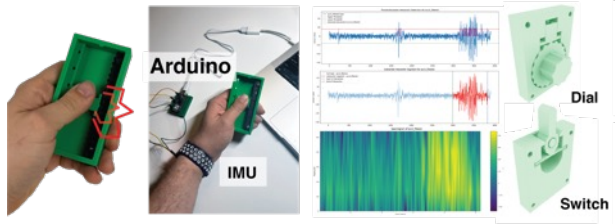
Fabrication + Tangible Interaction



Mobile Printing



Vision based TUIs



Sensing + TUIs

Robotics

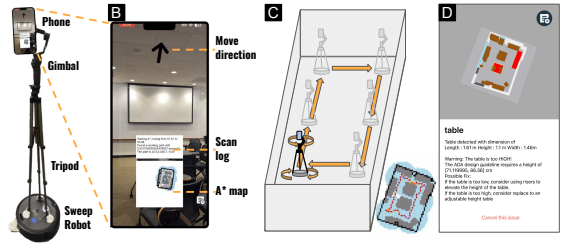
Bipeds

On-going

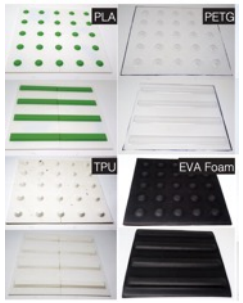
HRI, Tactile Sensing Grippers

Research Interests

Accessibility

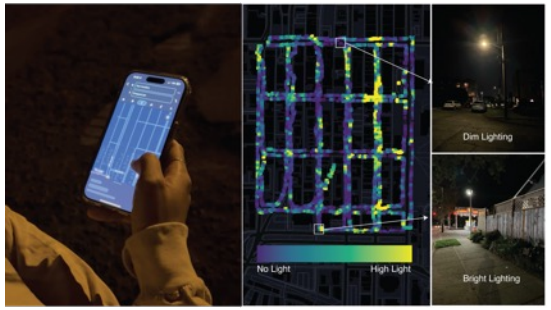


Automated Accessibility Audits



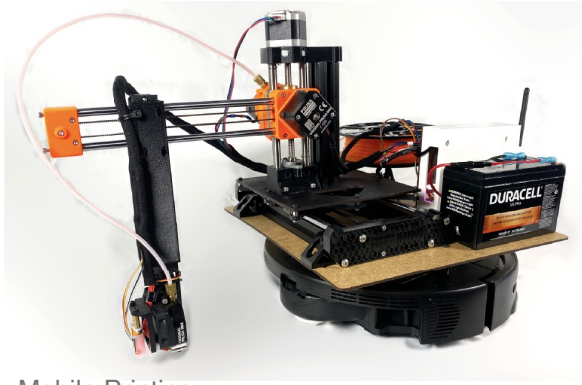
Surface Indicators

Tactile Graphics

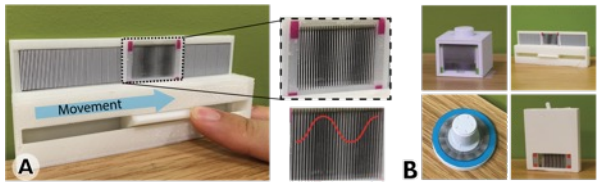


Safer Pedestrian Routing

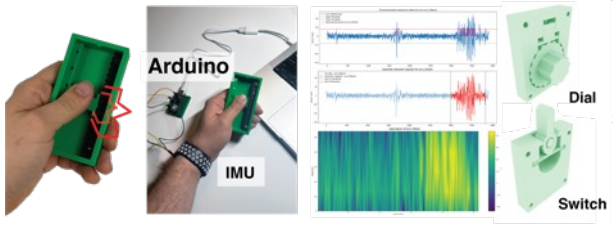
Fabrication + Tangible Interaction



Mobile Printing

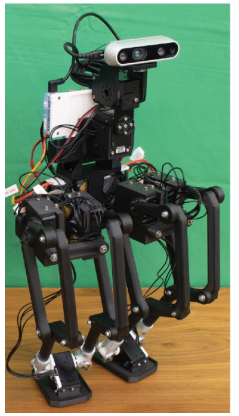


Vision based TUIs



Sensing + TUIs

Robotics



Bipeds

On-going

HRI, Tactile Sensing Grippers

Design and Fabrication for Tangible Interaction with Real-World Objects and Environments

Daniel Campos Zamora, PhD Student
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MAKEABILITY LAB

PAUL G. ALLEN SCHOOL
OF COMPUTER SCIENCE & ENGINEERING