



MobiPrint

A Mobile 3D Printer for Environment-Scale
Design and Fabrication



Daniel Campos Zamora
University of
Washington

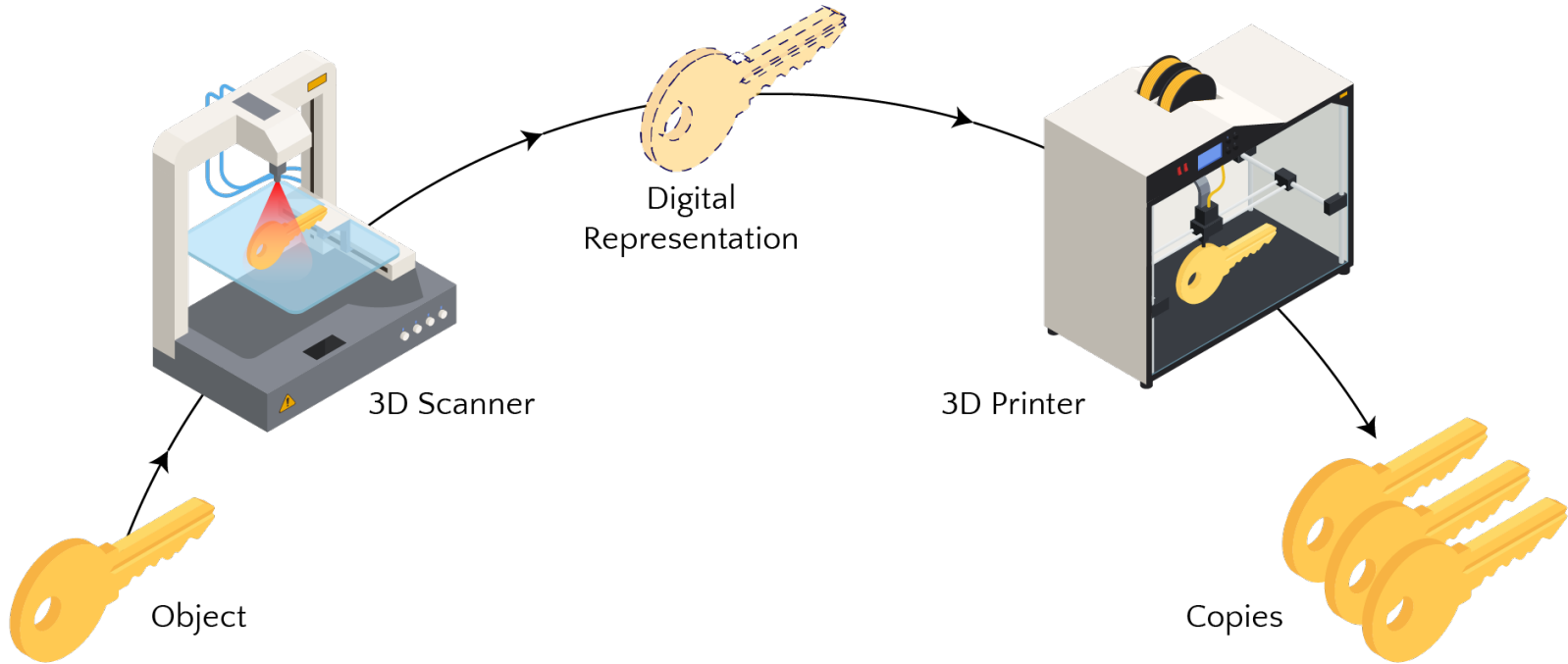


Liang He
Purdue University



Jon Froehlich
University of
Washington

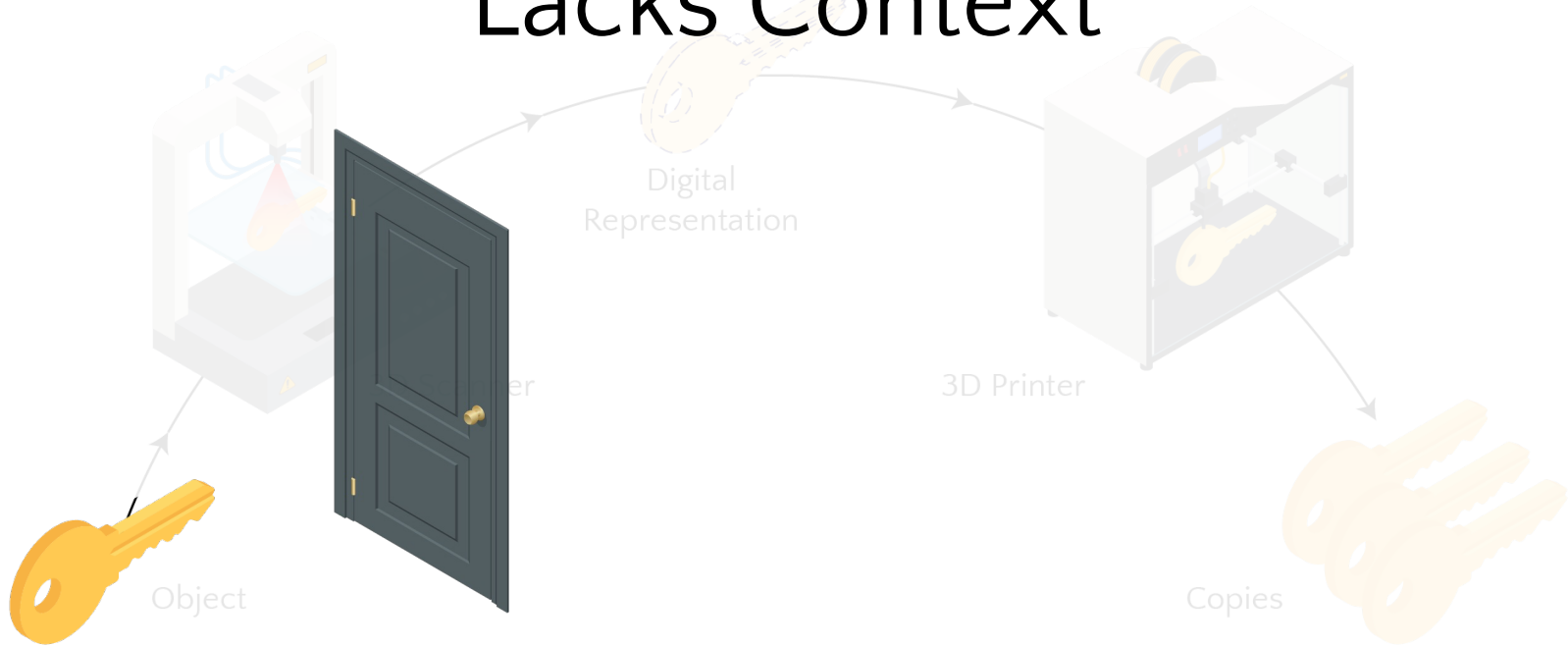




Conventional Digital Fabrication



Lacks Context



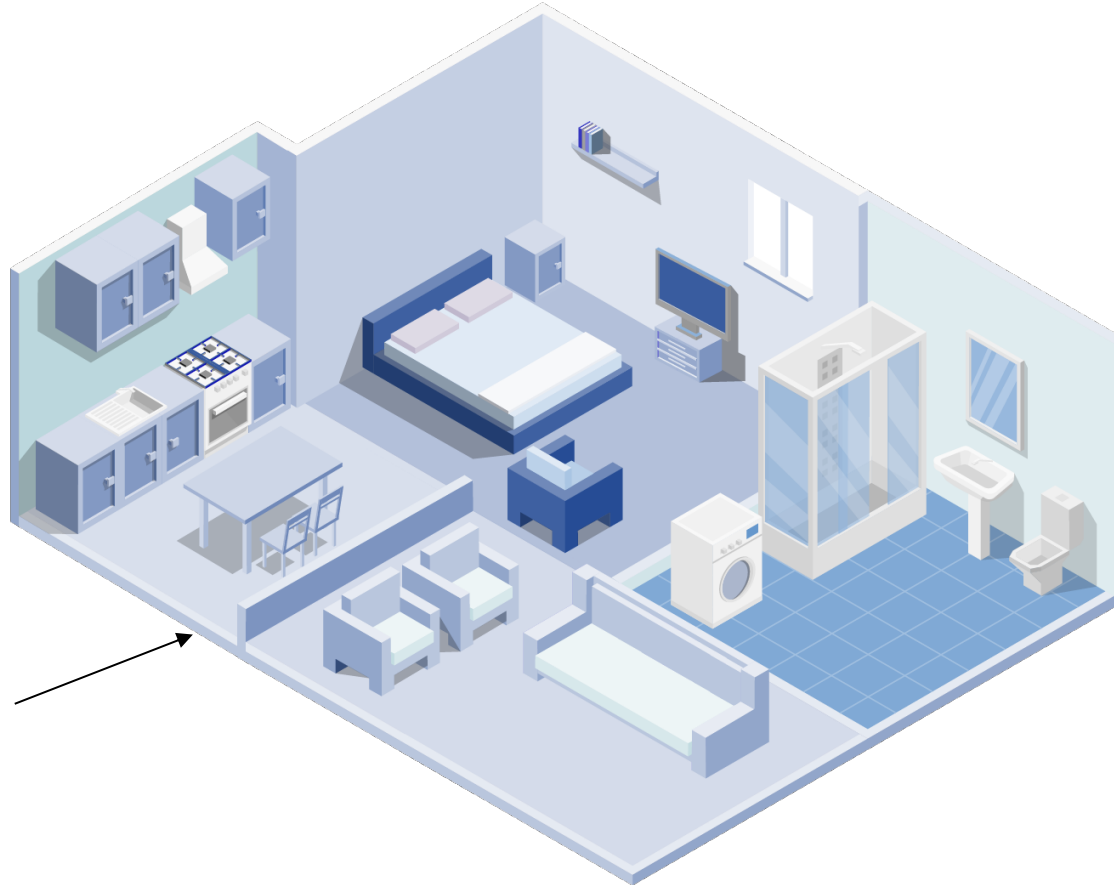
Conventional Digital Fabrication



Our Vision – Real-World Context for Fabrication

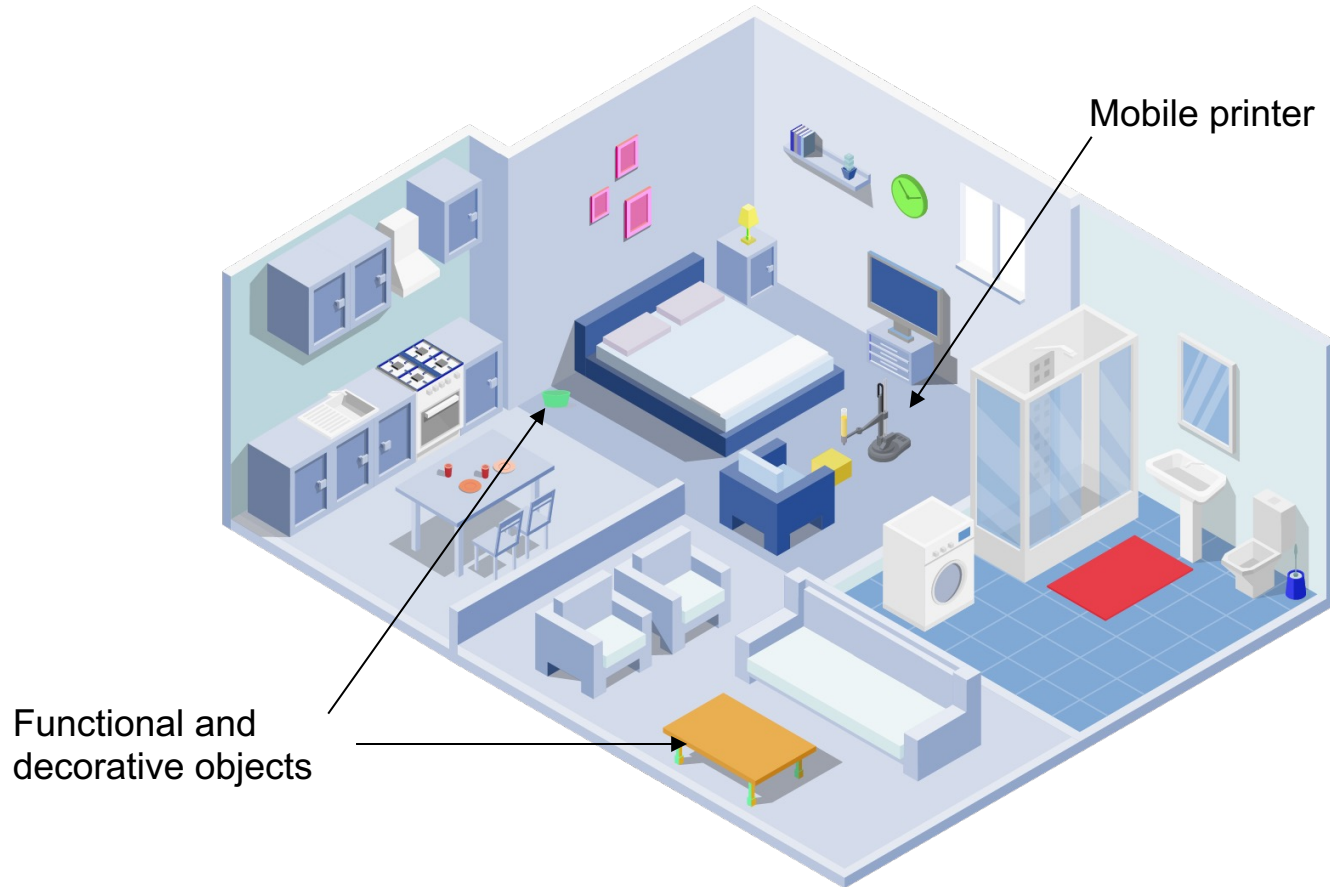


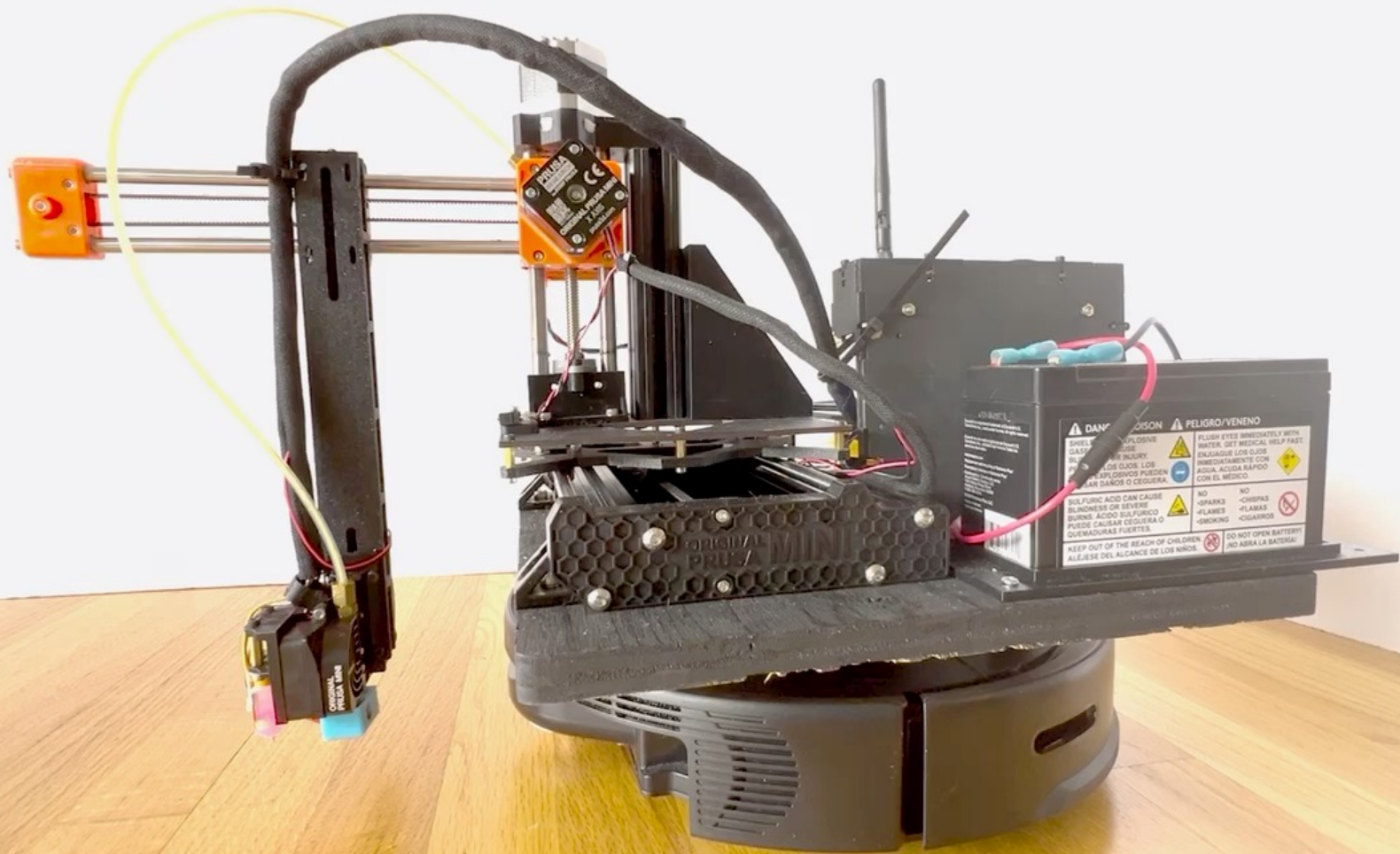
Our Vision – Converting space into printable canvas



Digital twin

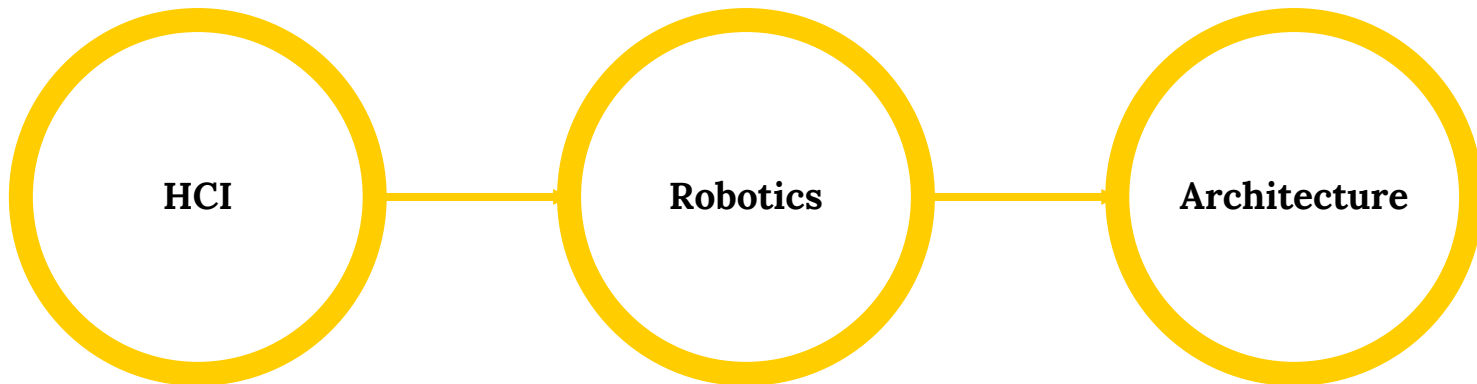
Our Vision – Converting space into printable canvas



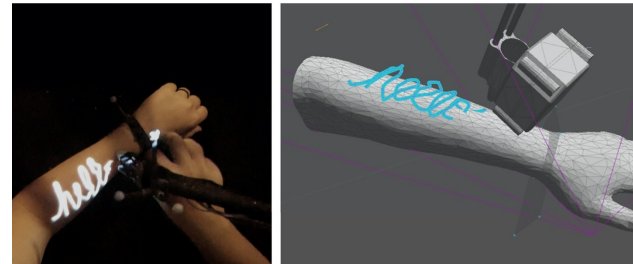
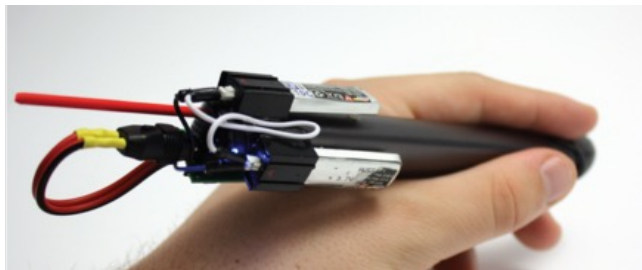
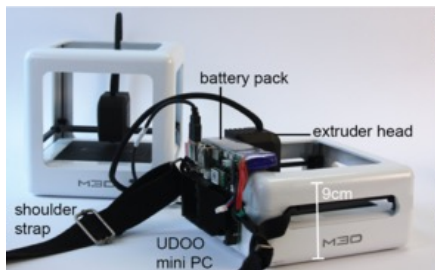
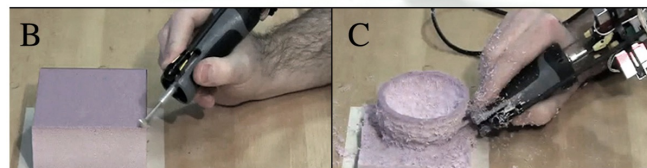
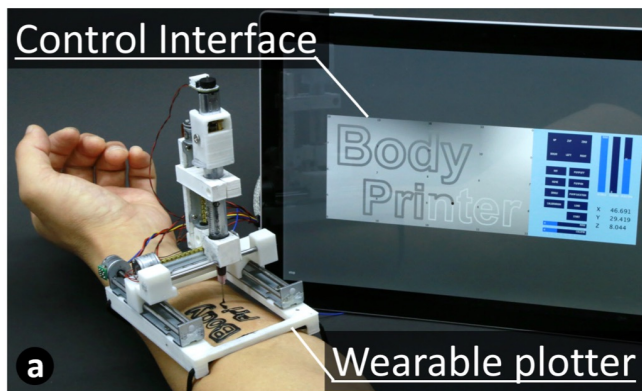
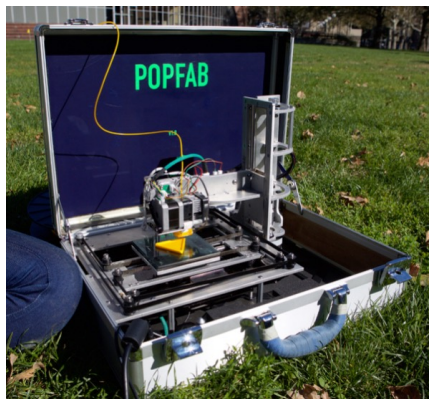


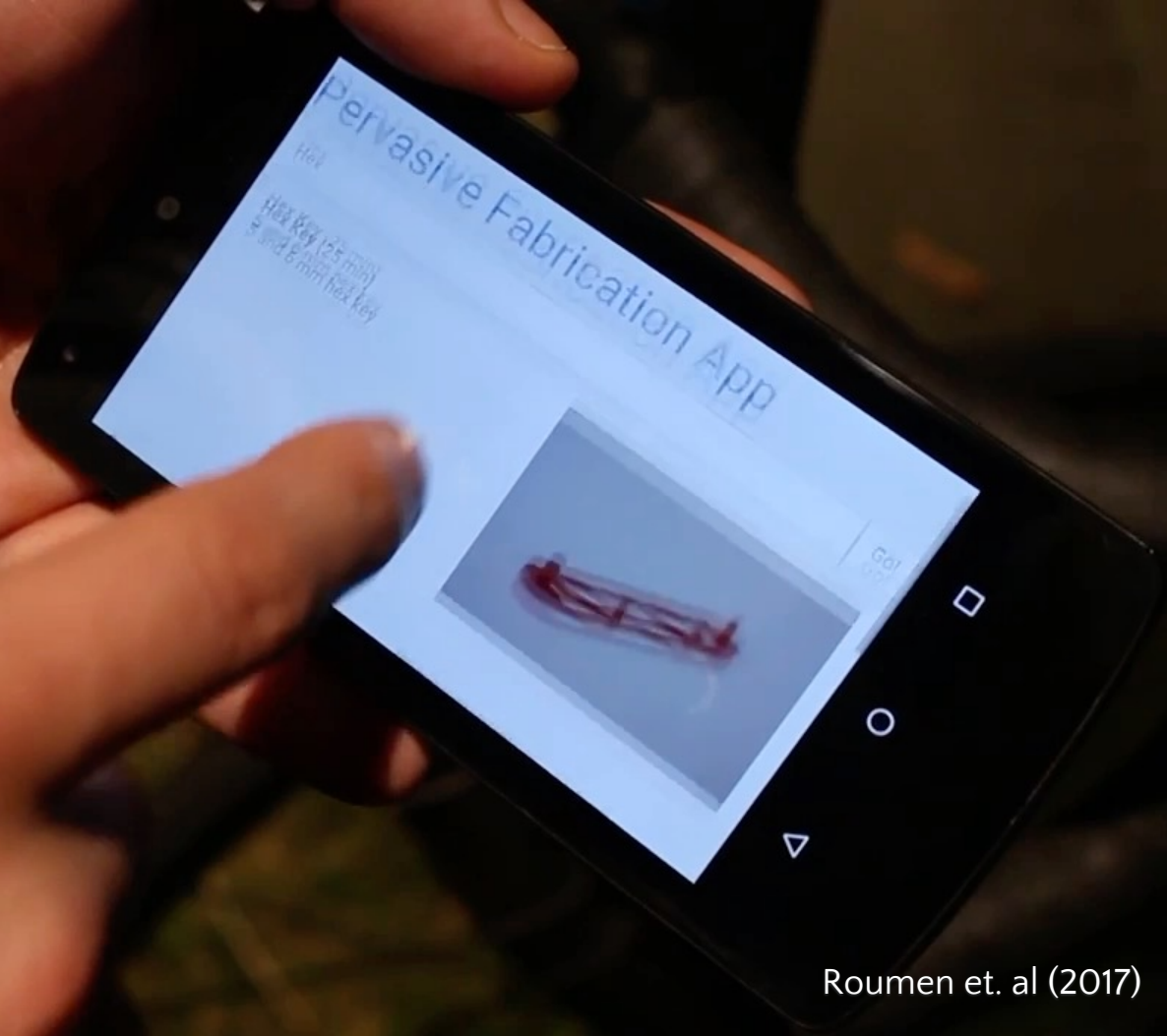


Related Work



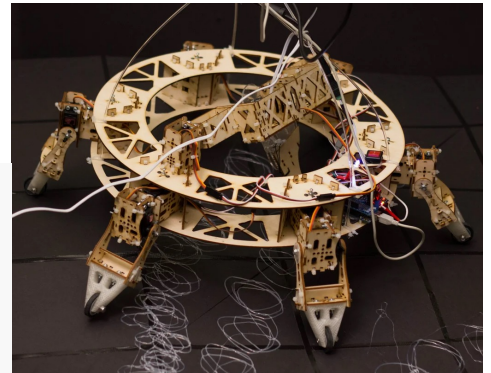
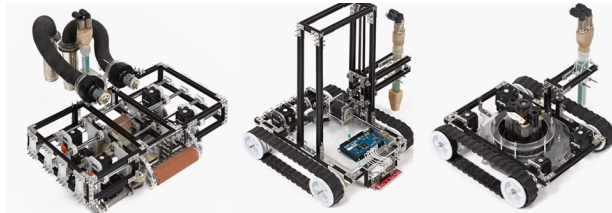
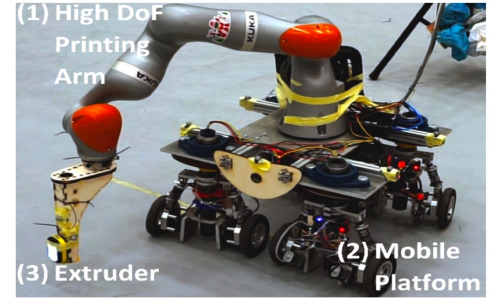
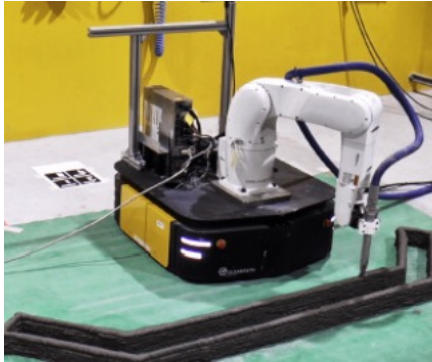
RW Mobile Fabrication - HCI





RW

Mobile Fabrication - Robotics



Environment-Scale Fabrication: Replicating Outdoor Climbing Experiences

Emily Whiting¹ Nada Ouf² Liane Makatura¹ Christos Mousas¹

Zhenyu Shu³ Ladislav Kavan⁴

Dartmouth College¹ University of Pennsylvania²

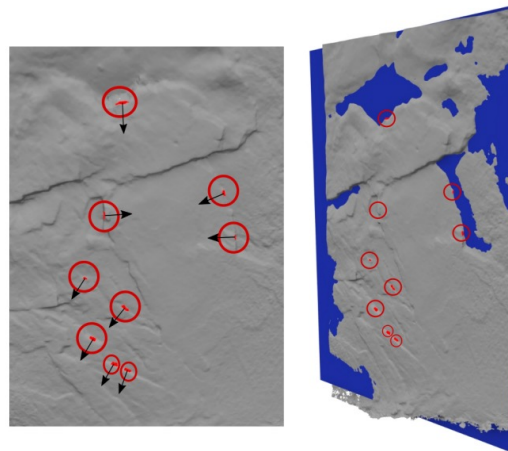
Ningbo Institute of Technology, Zhejiang University³ University of Utah⁴

ABSTRACT

Despite rapid advances in 3D printing, fabricating large, durable and robust artifacts is impractical with current technology. We focus on a particularly challenging environment-scale artifact: rock climbing routes. We propose a prototype fabrication method to replicate part of an outdoor climbing route and enable the same sensorimotor experience in an indoor gym. We start with 3D reconstruction of the rock wall using multi-view stereo and use reference videos of a climber in action to identify localized rock features that are necessary for ascent. We create 3D models akin to traditional indoor climbing holds, fabricated using rapid prototyping, molding and casting techniques. This results in robust holds accurately replicating the features and configuration of the original rock route. Validation was performed on two rock climbing sites in New Hampshire and Utah. We verified our results by comparing climbers moves on the indoor replicas and original outdoor routes.

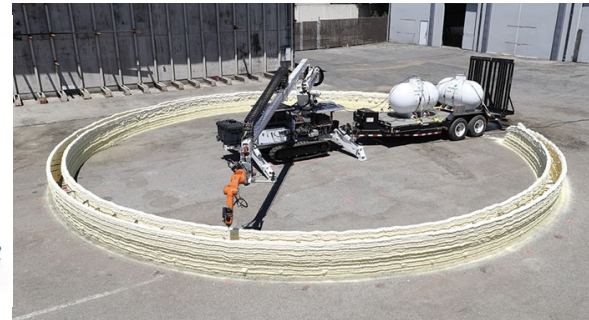
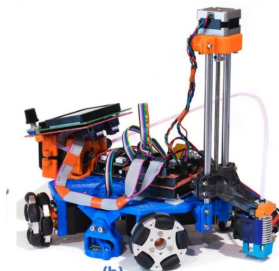
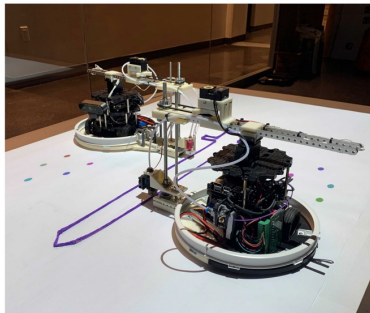
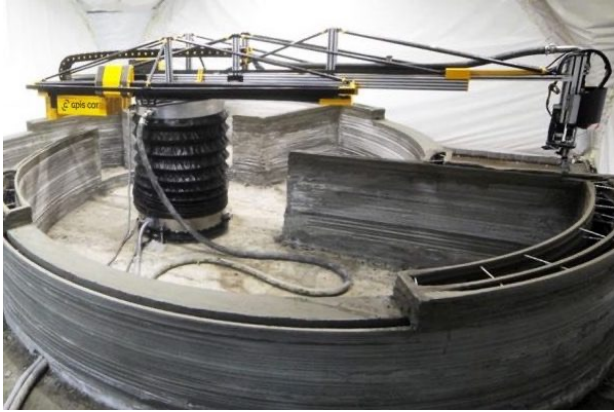


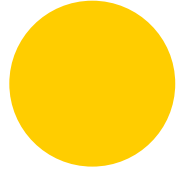
Figure 1. We capture the crux of an outdoor rock climbing route (left), fabricate the key holds and mount them in an indoor climbing wall (right). Our replica mimics the climbing experience of the original outdoor route.



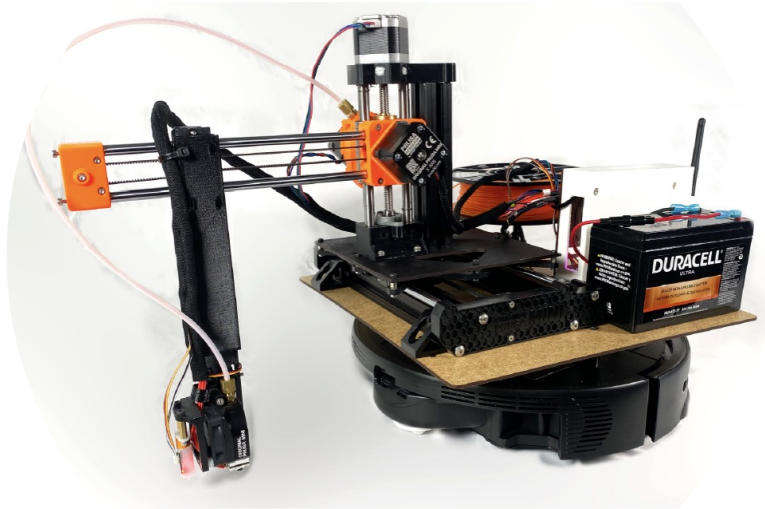
RW

Environment-Scale Fabrication





MobiPrint



- **Navigate, map, and print in ad-hoc environments**
- **Convert a floorplan into a 3D printable canvas**
- **Enable large working area**

Workflow

Map



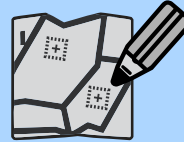
Robot completes initial scan
and generates map

Select



Select from model library
or upload a new design

Plan + Edit

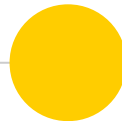


Arrange and edit objects in
the environment

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

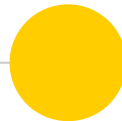


Arrange and edit objects in
the environment

Print

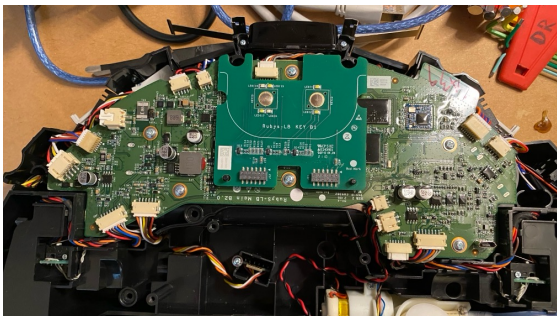


Robot navigates to target
location and prints objects

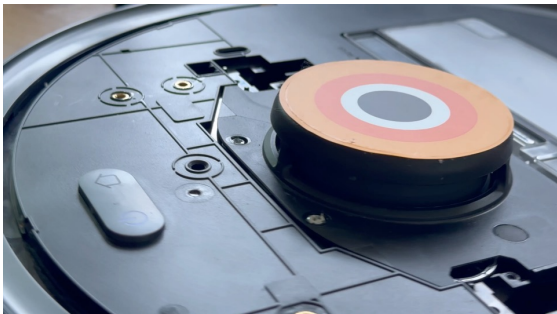




Mapping



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

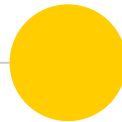


Arrange and edit objects in
the environment

Print



Robot navigates to target
location and prints objects



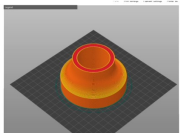


Selecting Objects

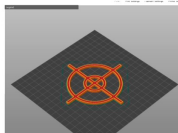
3D Files Library

Select the Models you would like to print

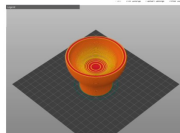
ADD MODEL



Cane-Holder.gcode

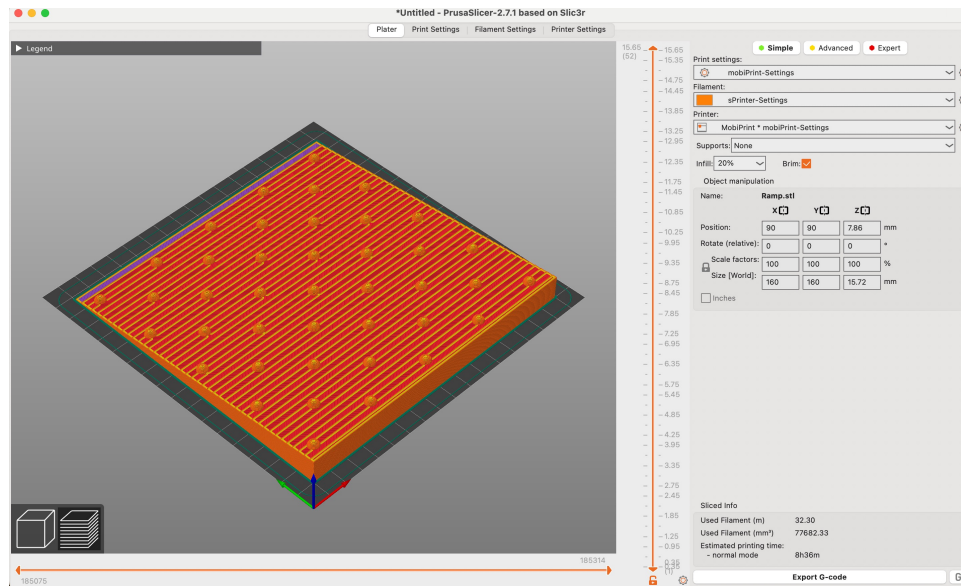


Target.gcode



Raised-Bowl.gcode

🕒 Preloaded Models



🕒 Slice & Upload New Objects

Workflow

Map



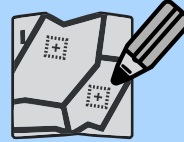
Robot completes initial scan
and generates map

Select



Select from model library
or upload a new design

Plan + Edit

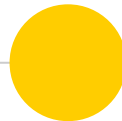


Arrange and edit objects in
the environment

Print

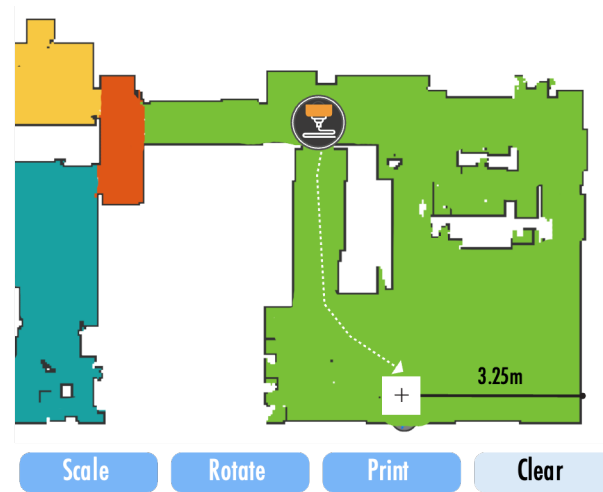
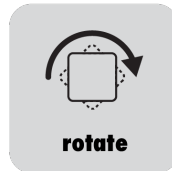
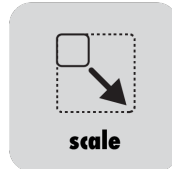


Robot navigates to target
location and prints objects



● Planning and Editing

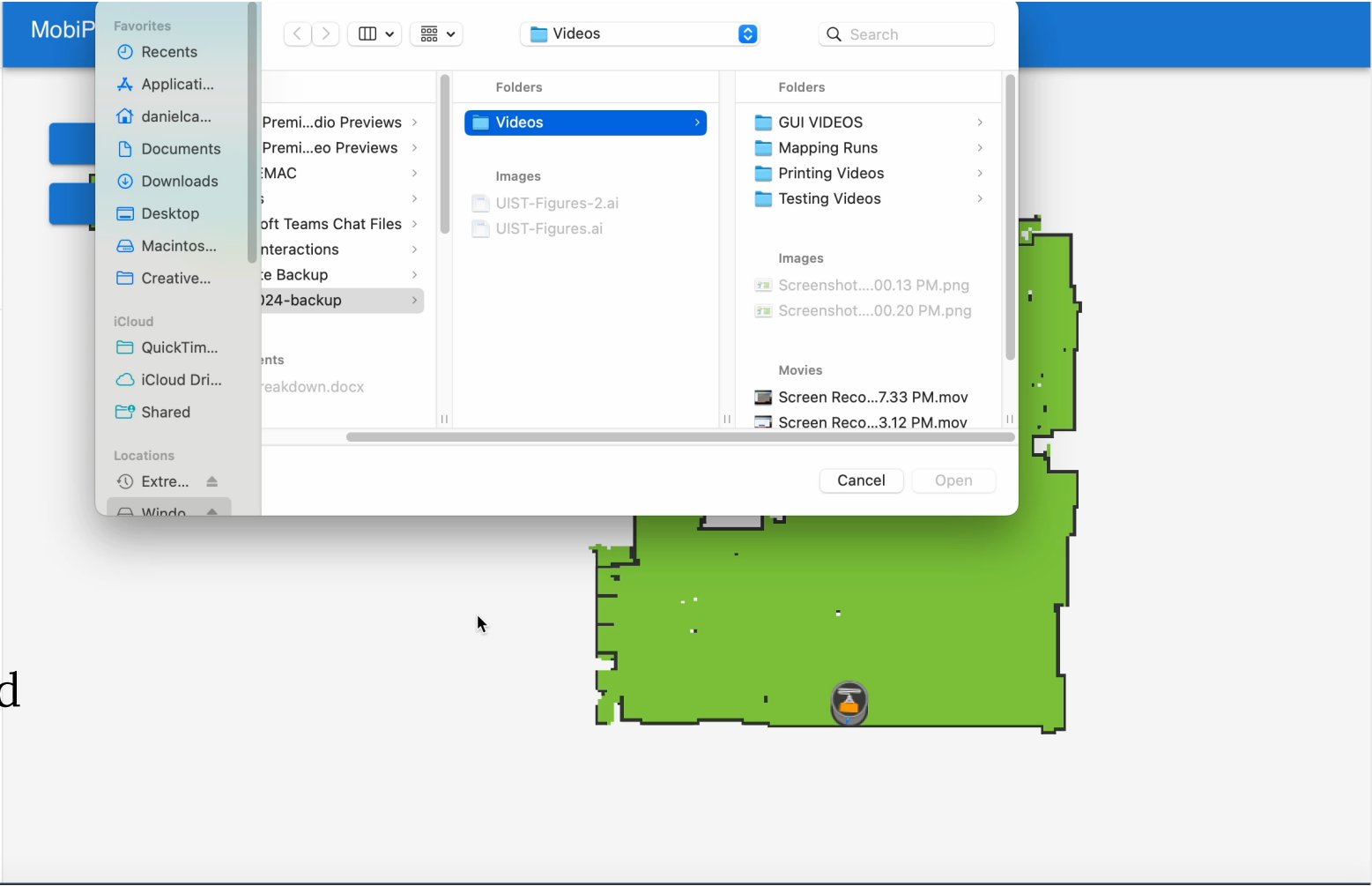
Users can treat the map as a canvas to place and edit objects



- [Connect](#)
- [Map](#)
- [Library](#)
- [Plan](#)
- [Printer Controls](#)
- [Robot Controls](#)

Planning and Editing -GUI

Close



Workflow

Map



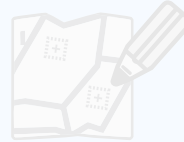
Robot completes initial scan
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Select



Select from model library
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Plan + Edit

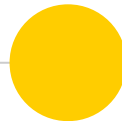


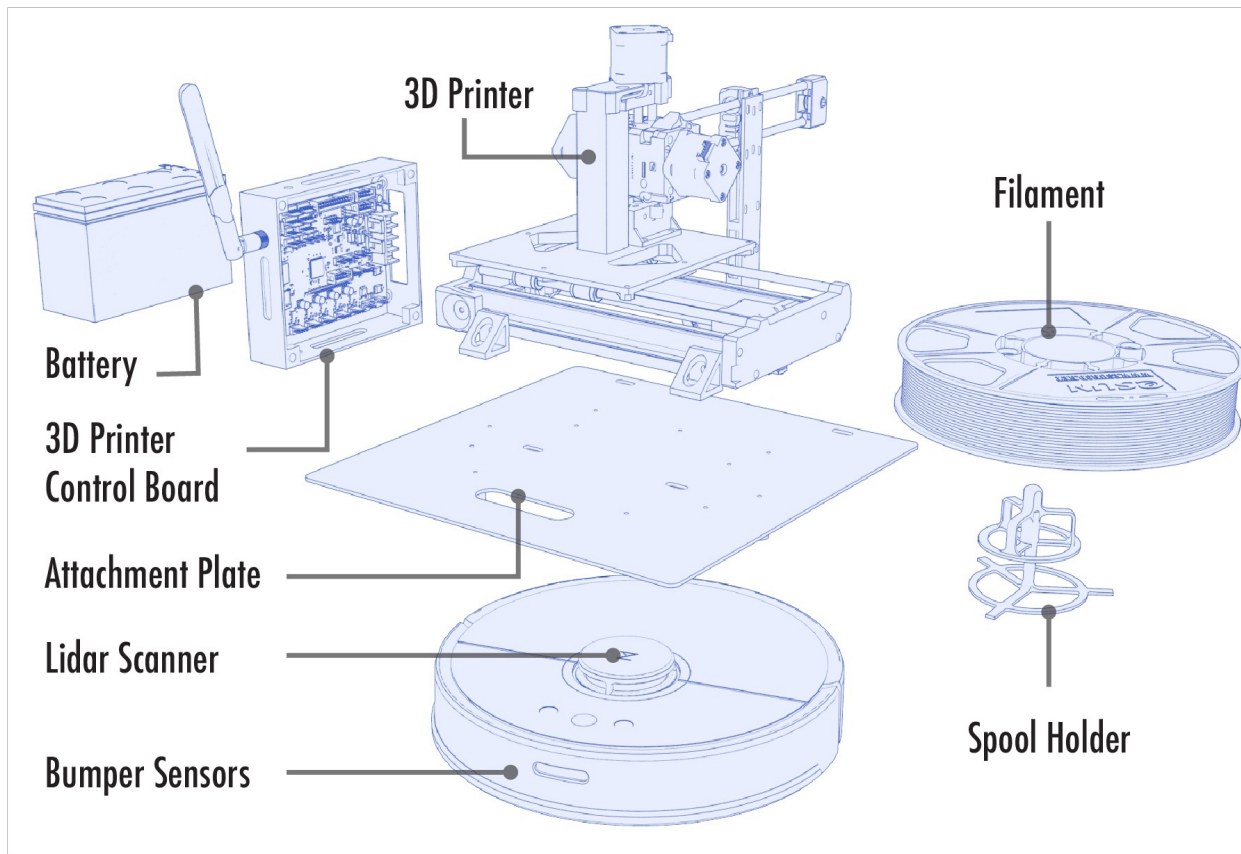
Arrange and edit objects in
the environment

Print

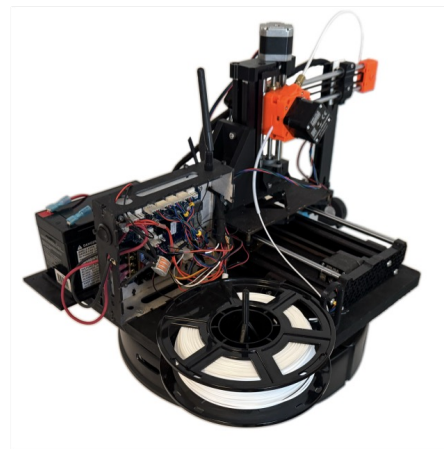
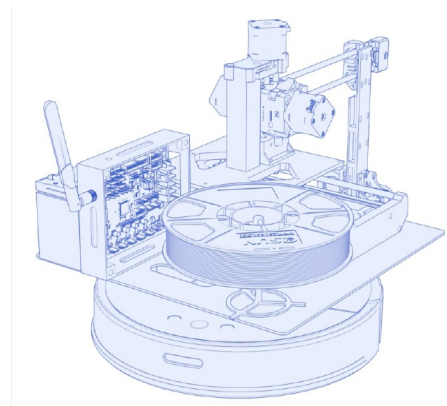


Robot navigates to target
location and prints objects





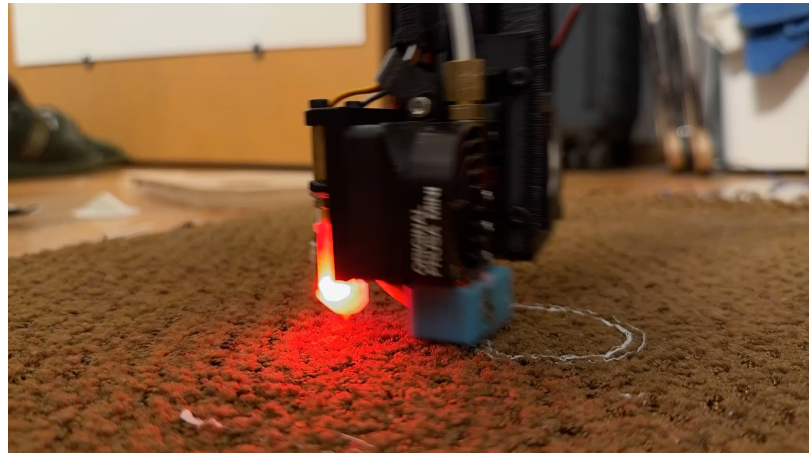
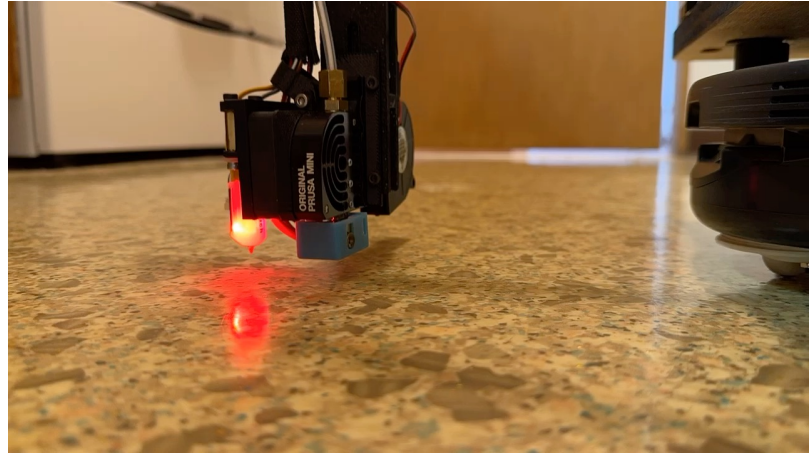
Exploded View

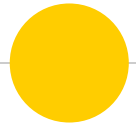


Assembled Views

● Printing

Prints directly on the ground surface

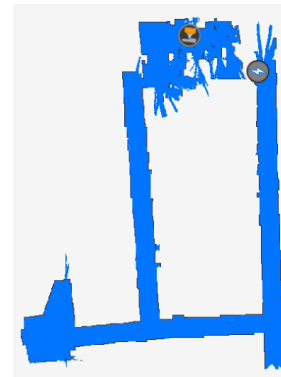
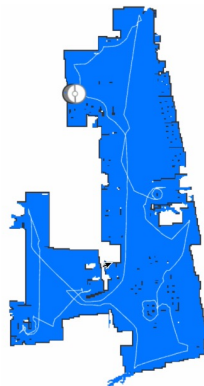
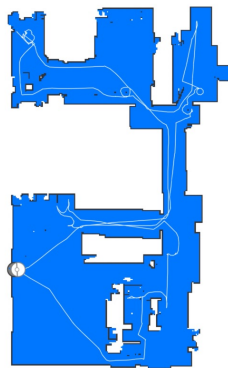




Evaluation



Evaluation – Mapping Speed



	1 Bedroom Apartment	Makerspace	Computer Lab and Hallway
Area	120 m ²	80 m ²	174 m ²
Mapping Time	12 min	15 min	43 min



10N

Evaluation - Adhesion Strength



Evaluation – Adhesion Strength



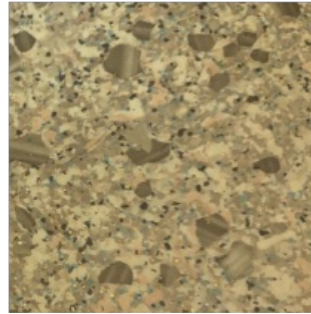
Carpet

>50N



Hardwood

8.7N



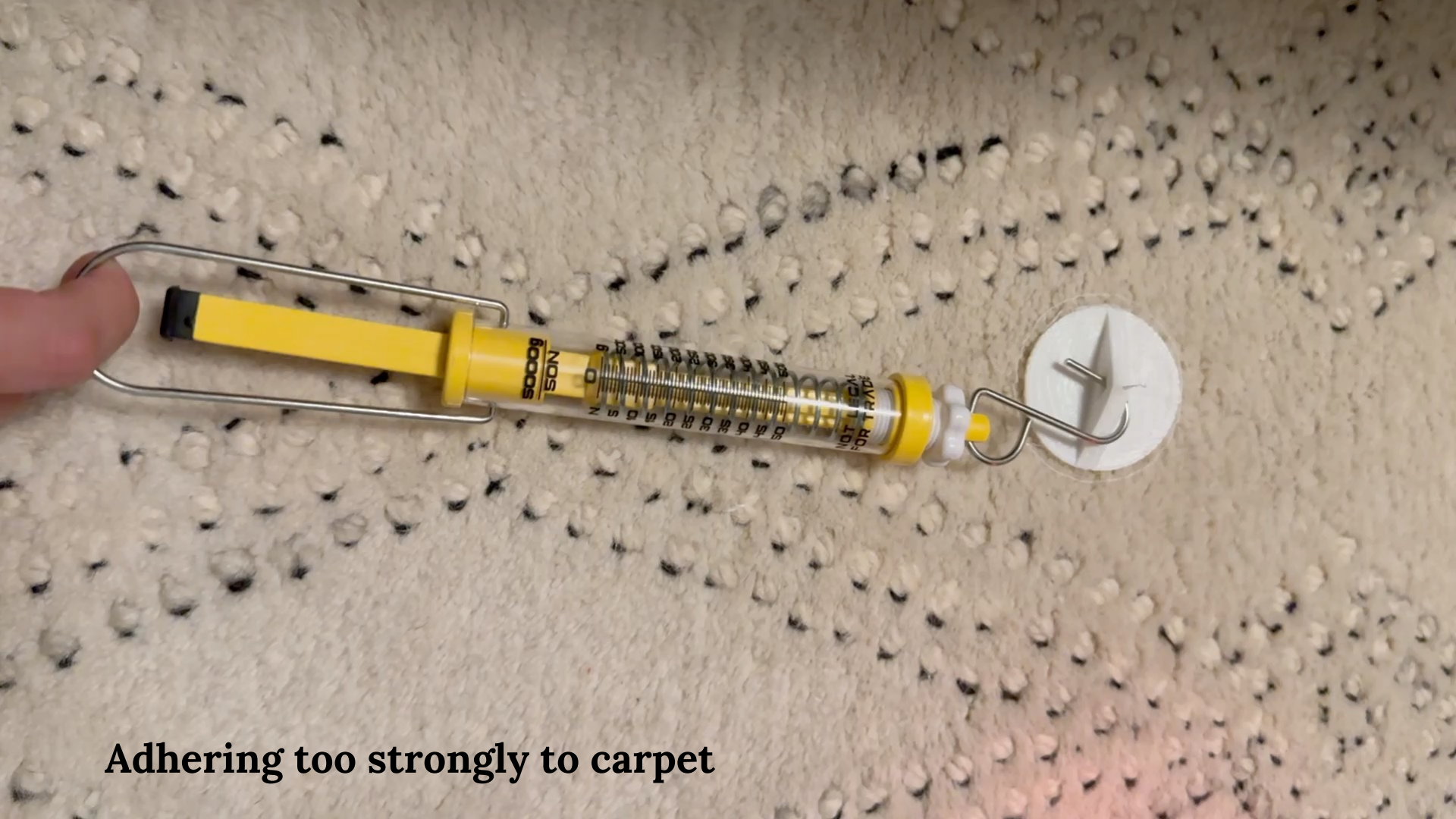
Vinyl

37N



Tile

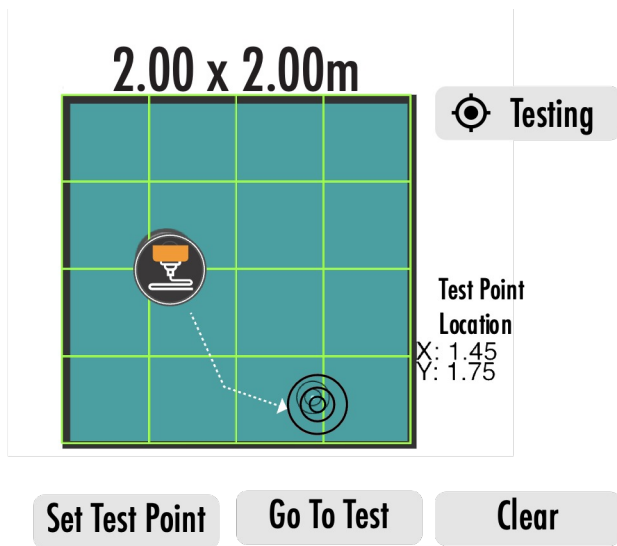
N/A



Adhering too strongly to carpet



Evaluation – Localization



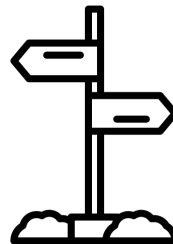
Average Error was 5.1cm



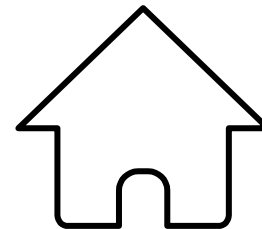
Scenarios



Accessibility



Signage and Wayfinding



Home Furnishing



Accessibility

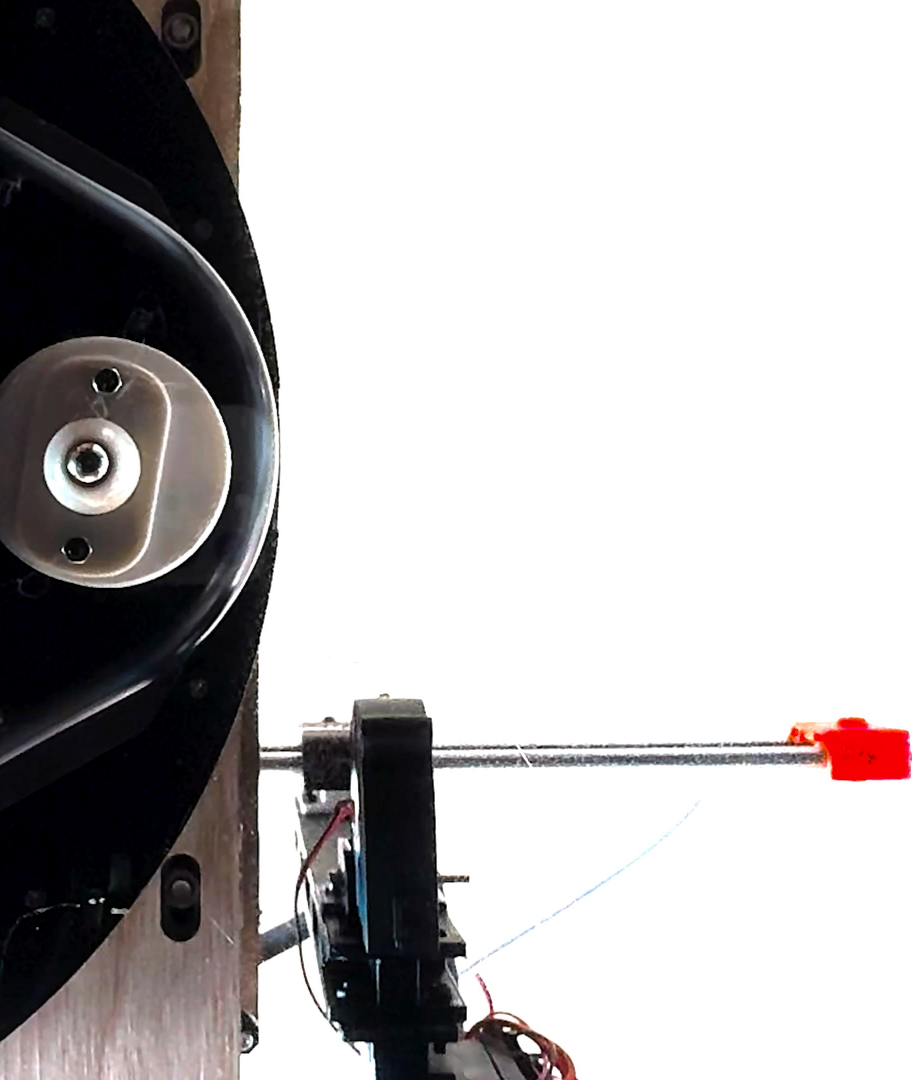


Tactile Surface Indicators



Cane Holder

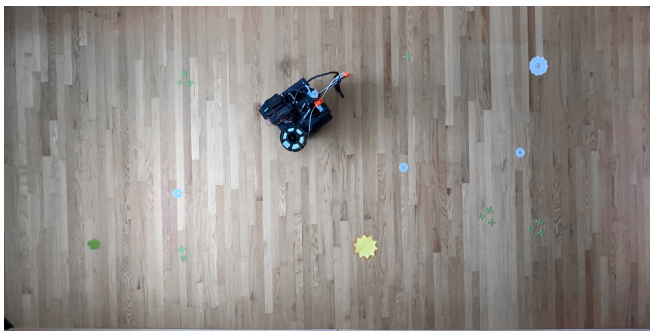
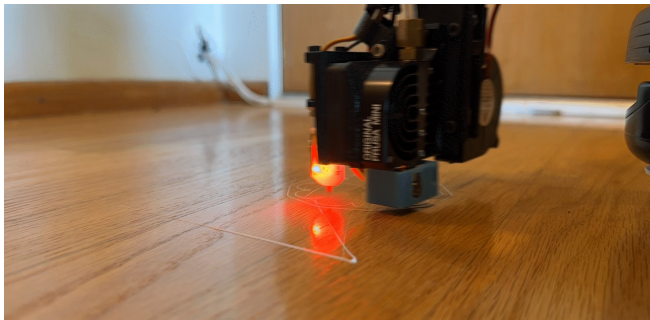
Signage and Wayfinding



Conference Signage



Home Furnishing



Floor mural

Ergonomic footrest

Raised pet bowl



Discussion

Limitations

- ⦿ Can't print on-the-move
- ⦿ Limited Design Operations
- ⦿ Can only store one environment at a time and can't share the map with other machines

Future Work

- ⦿ Improve hardware precision and slicing algorithms
- ⦿ More expressive design tool (patterning, annotations)
- ⦿ Support for multiple maps and robots



Design Considerations for Mobile and Environmental-Scale Fabrication

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

MobiPrint

A Mobile 3D Printer for Environment-Scale Design and Fabrication



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Thank you!

