

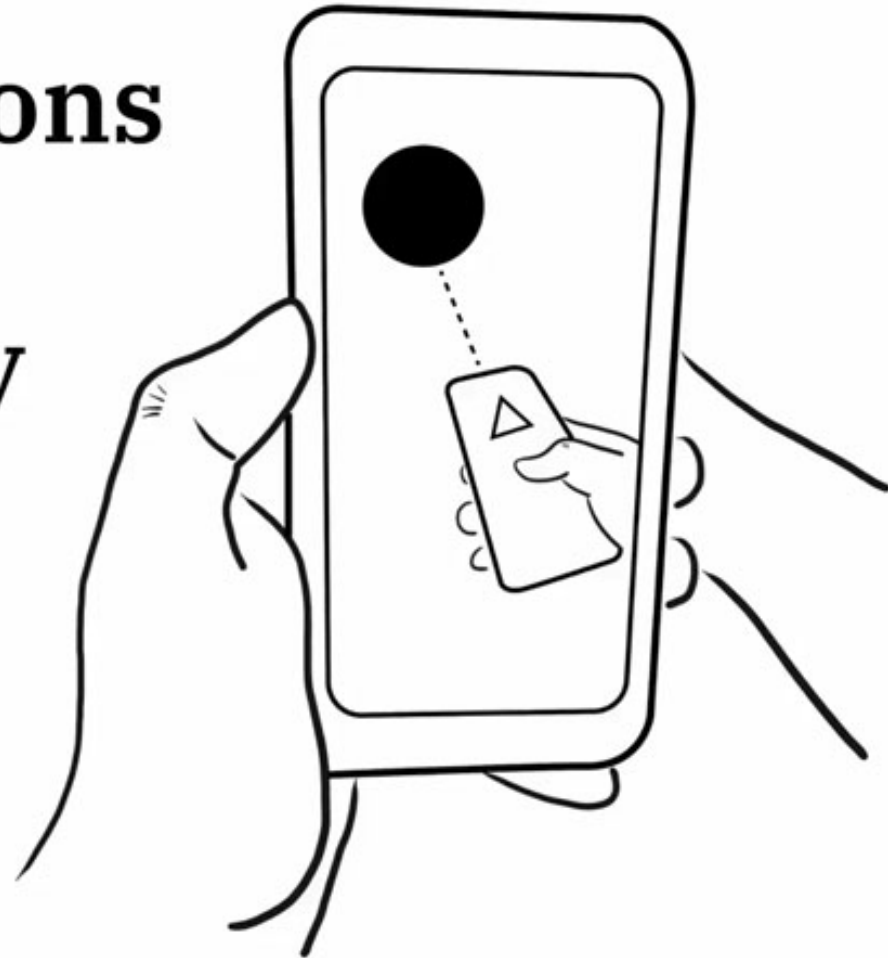
# Designing and Studying Interactions for Handheld Augmented Reality

A project by  
**Rishi Vanukuru**

Guide: **Prof. Jayesh Pillai**

*Summer 2020*

**IDC** School of Design  
अभिकल्प विद्यालय



Overview

# **This Presentation**

- 1. Introduction**
- 2. The Idea**
- 3. Demonstration**
- 4. Discussion**

Overview

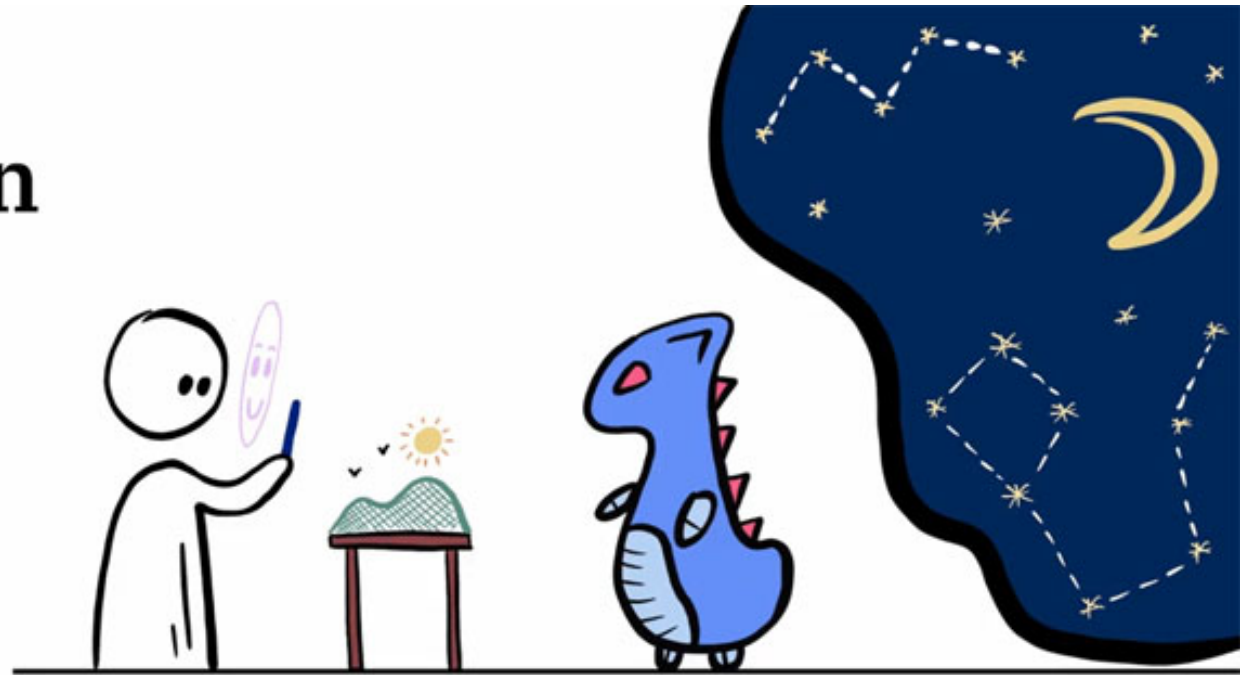
# This Presentation

## 1. Introduction

2. *The Idea*

3. *Demonstration*

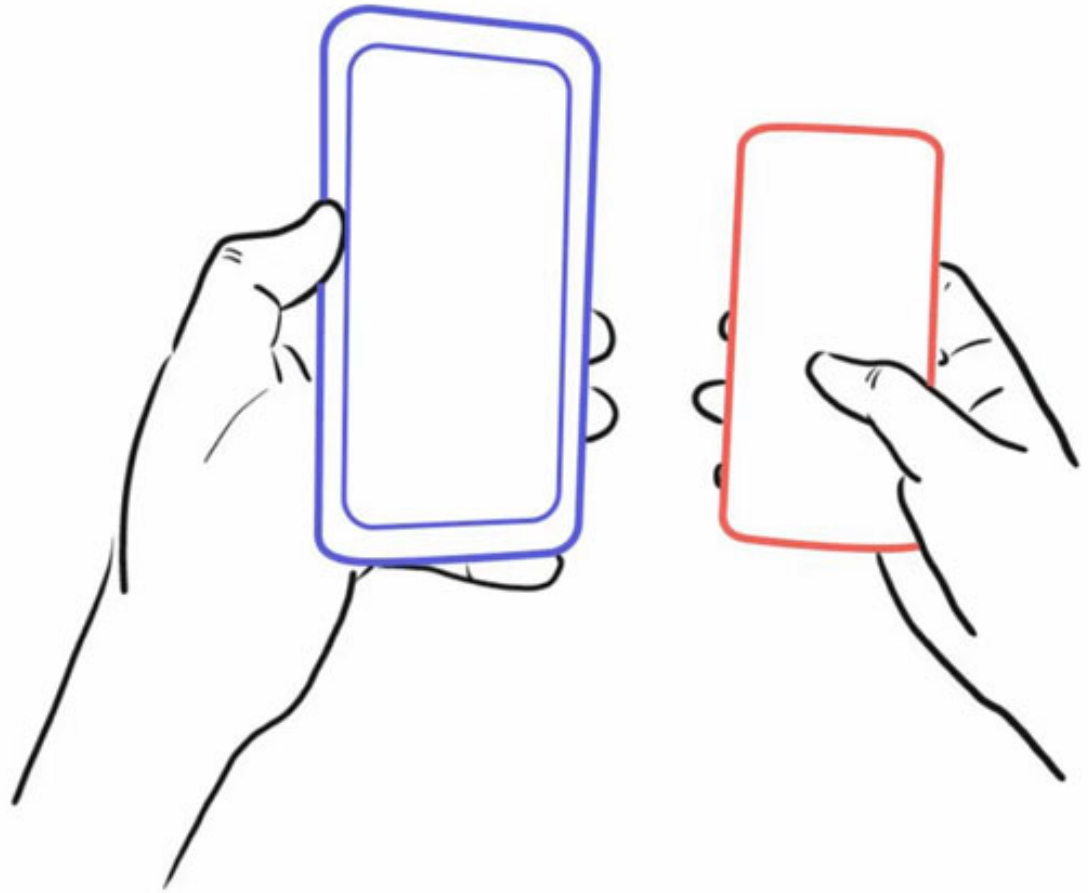
4. *Discussion*



Overview

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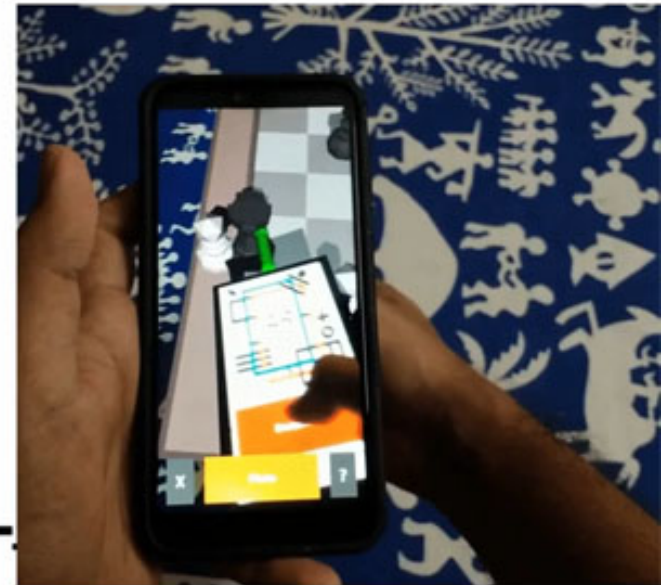
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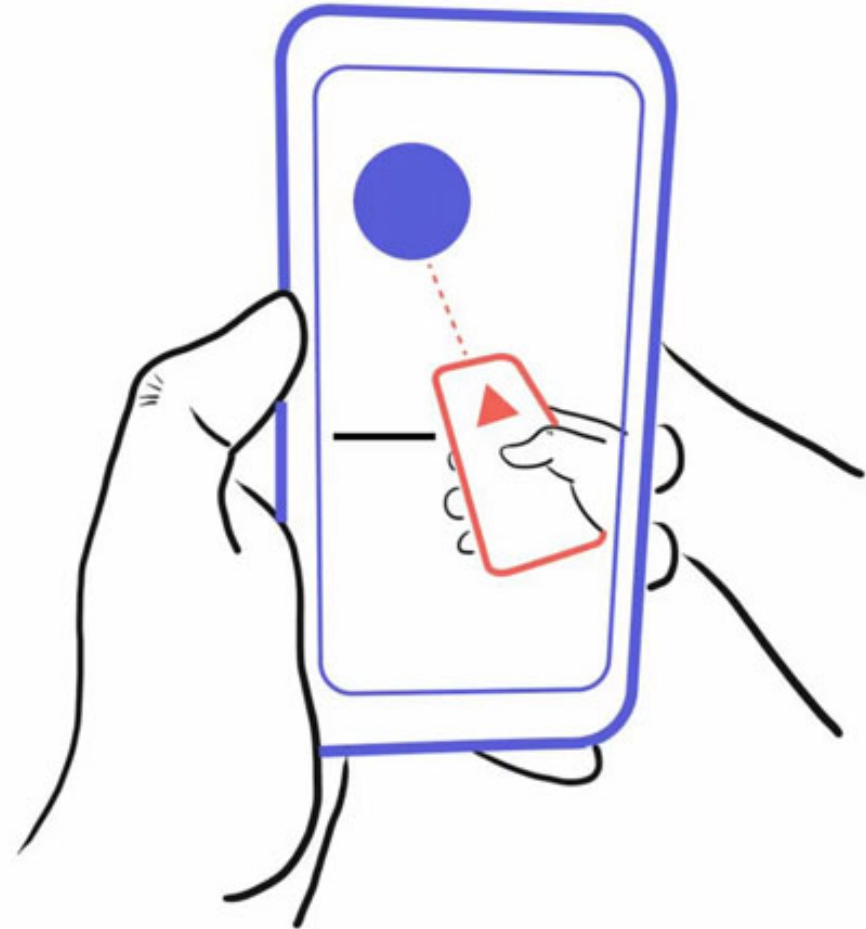
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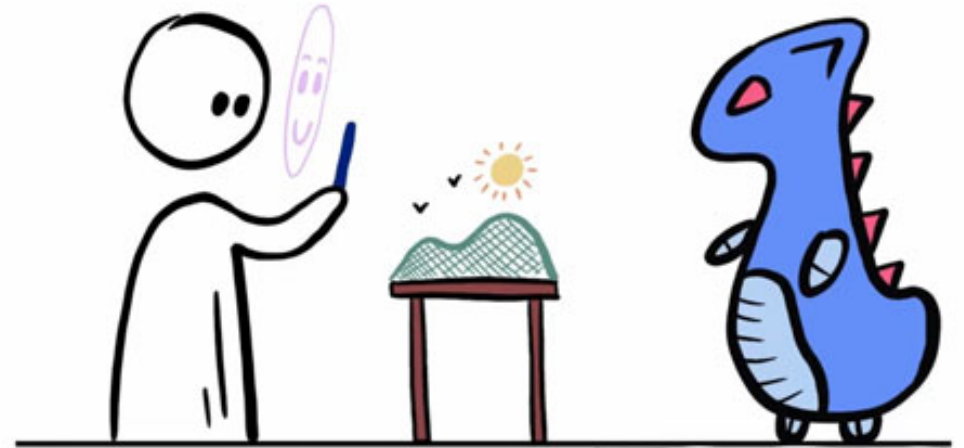


# What is **Mobile** **Augmented Reality?**

Introduction

# Mobile AR Today

AR is medium that allows us to experience and interact with digital content that appears to be situated in the real world around us





Introduction

# Mobile AR Today

AR is medium that allows us to experience and interact with digital content that appears to be situated in the real world around us

Increasingly popular and accessible

**Mobile AR Domains:**

Games, Utilities, Education, Entertainment, and much more



Introduction

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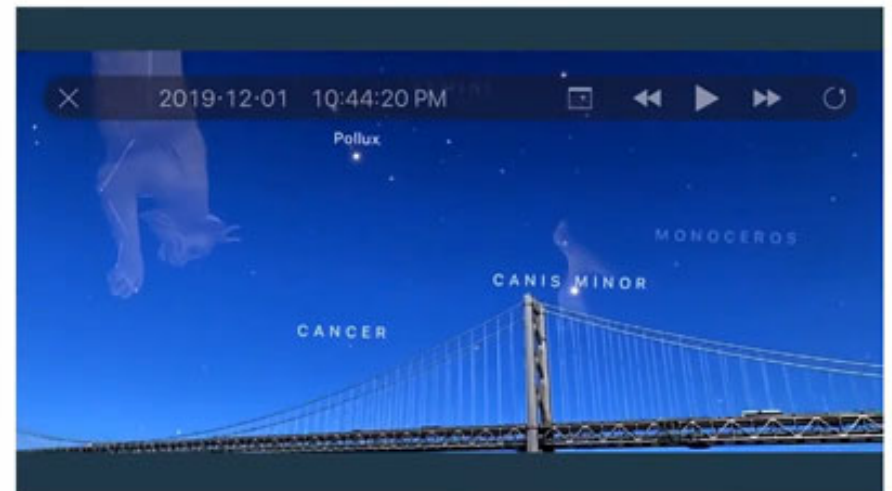
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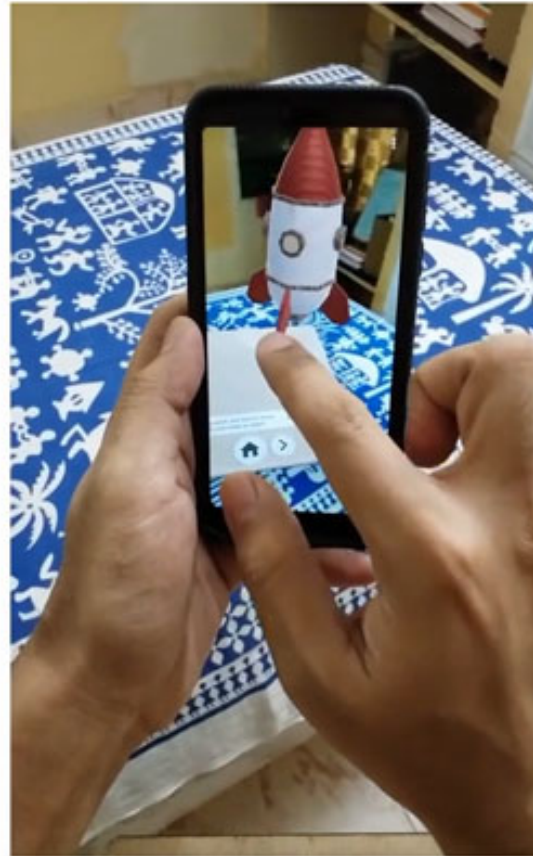


Introduction

# AR Tasks & Interactions

## Tasks:

- Place, move, and manipulate objects
- Draw in 3D



Introduction

# AR Tasks & Interactions

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- Place, move, and manipulate objects
- Draw in 3D



Introduction

# AR Tasks & Interactions

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Introduction

# AR Tasks & Interactions

## **Tasks:**

- Place, move, and manipulate objects
- Draw in 3D

## **Interactions:**

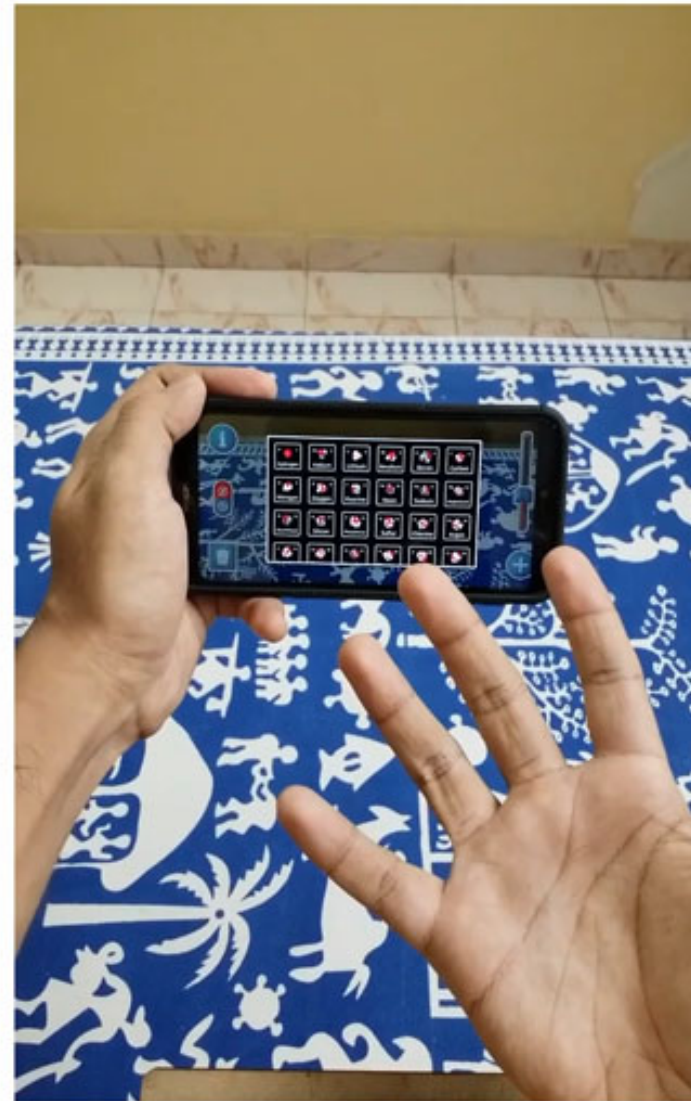
- Touch
- Move



Introduction

# Gaps & Issues

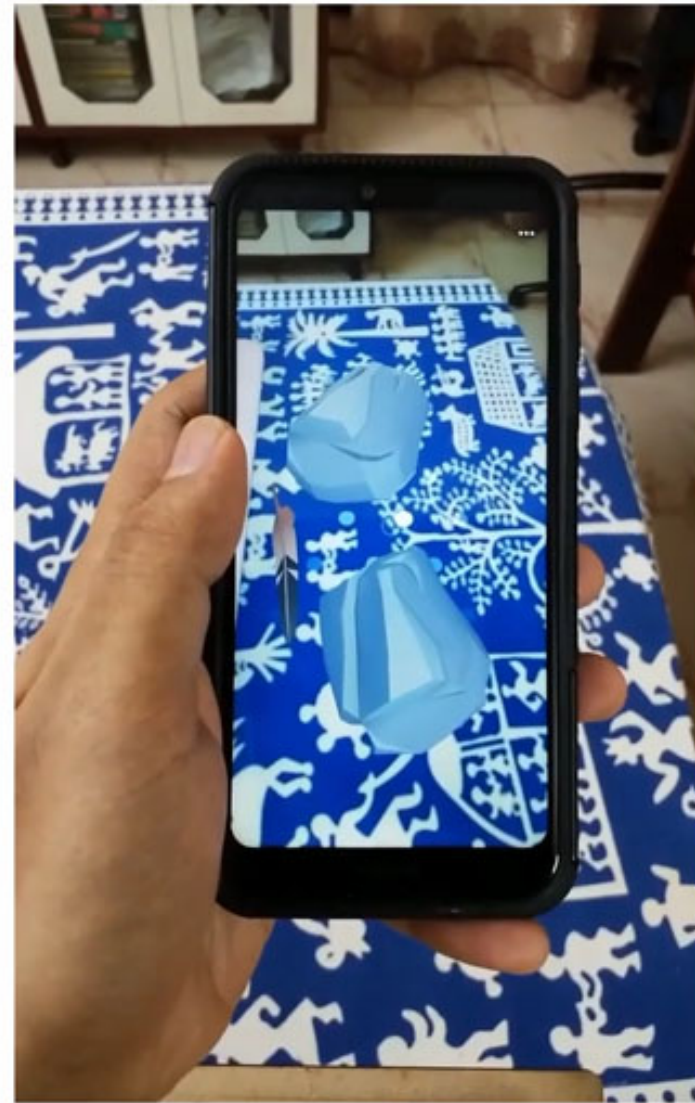
1. **Screen-space UI**
2. Missing Interface
3. Depth Perception
4. Spatial Movement



Introduction

## Gaps & Issues

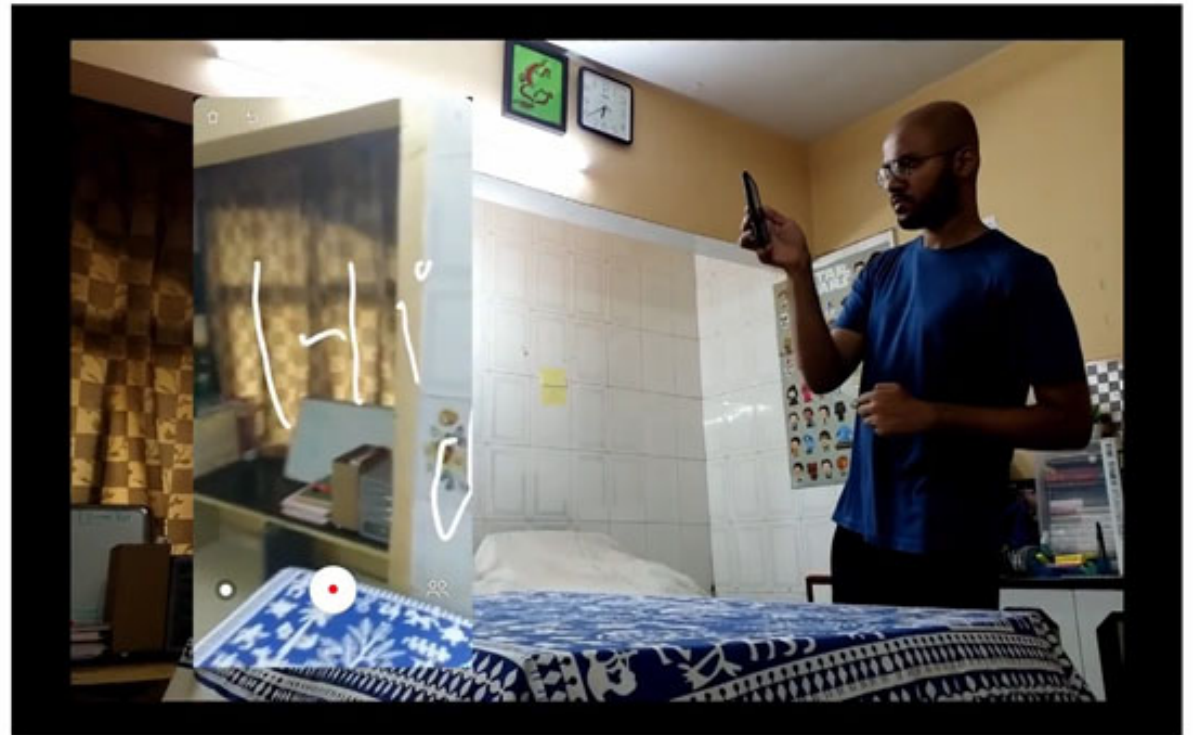
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Introduction

# Gaps & Issues

1. Screen-space UI
2. Missing Interface
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Introduction

# Gaps & Issues

1. Screen-space UI
2. Missing Interface
3. Depth Perception
4. **Spatial Movement**



Introduction

## **Related Work**

**LITHO**

**Portal-Ble**

**ARPen**

**BISHARE**

Introduction

# Related Work

## LITHO:

Handheld controller for  
Mobile AR.

*LITHO Controller: litho.cc*



## Introduction

# Related Work

### Portal-Ble:

Gesture-based interaction

Qian, J., Ma, J., Li, X., Attal, B., Lai, H., Tompkin, J., ... & Huang, J. (2019, October). *Portal-ble: Intuitive Free-hand Manipulation in Unbounded Smartphone-based Augmented Reality*. In *Proceedings of the 32nd Annual ACM Symposium on User Interface Software and Technology* (pp. 133-145).

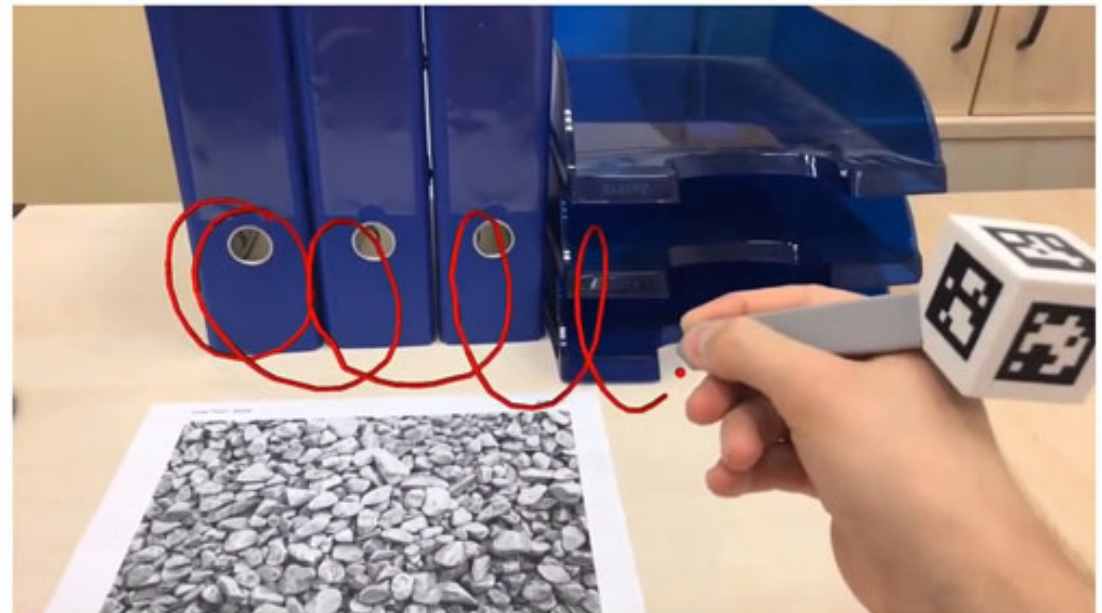


## Introduction

# Related Work

### AR-Pen:

Bi-modal interaction using  
a pen



Wacker, P., Nowak, O., Voelker, S., & Borchers, J.  
(2019, May). *ARPen: Mid-Air Object Manipulation  
Techniques for a Bimanual AR System with Pen &  
Smartphone*. In *Proceedings of the 2019 CHI  
Conference on Human Factors in Computing Systems*  
(pp. 1-12).

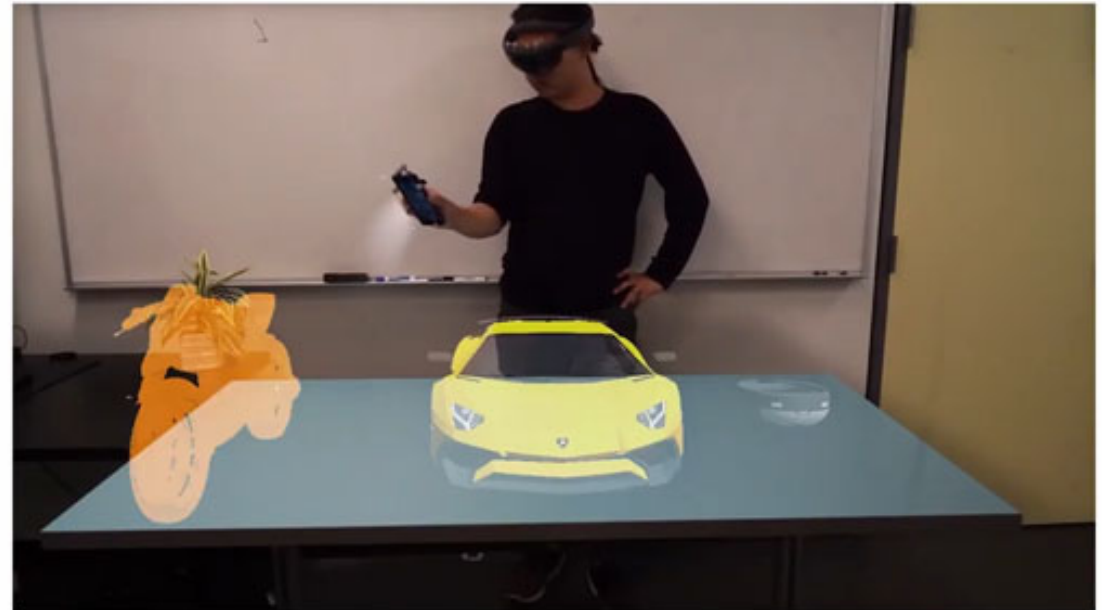


Introduction

# Related Work

## **BISHARE:**

Mobile Phones as controllers  
for Head-mounted AR



*Fengyuan Zhu and Tovi Grossman. 2020. **BISHARE:** Exploring Bidirectional Interactions Between Smartphones and Head-Mounted Augmented Reality. In Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems (CHI '20)*

Introduction

## Related Work

### **BISHARE:**

Mobile Phones as controllers  
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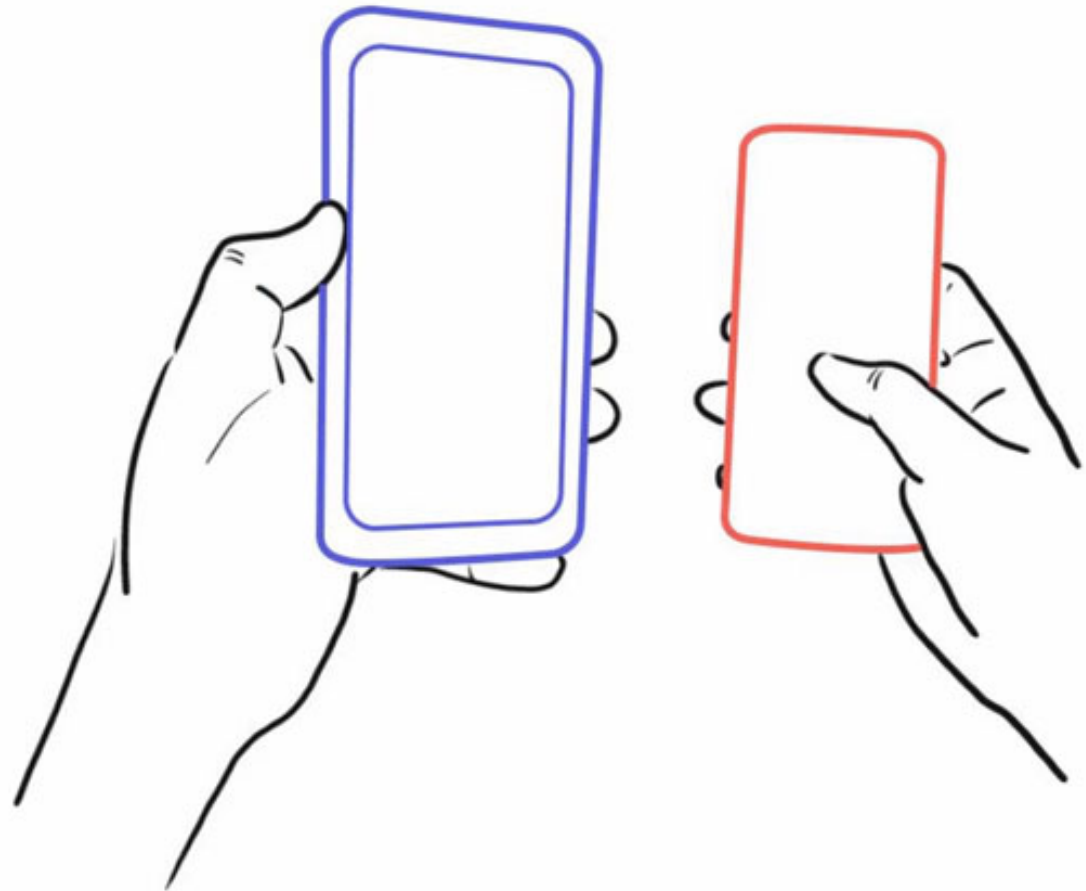
**What if we could use a  
second phone as a controller  
for Mobile AR?**

## The Idea

# Phones as Controllers

## Why Phones?

1. **Familiar**  
Commonly handheld, used for different functions with different grips
2. **Accessible**  
Some people have more than one, others can share in teams
3. **Feature-rich**  
Input through touchscreen, camera, Output through sound, visuals, haptics

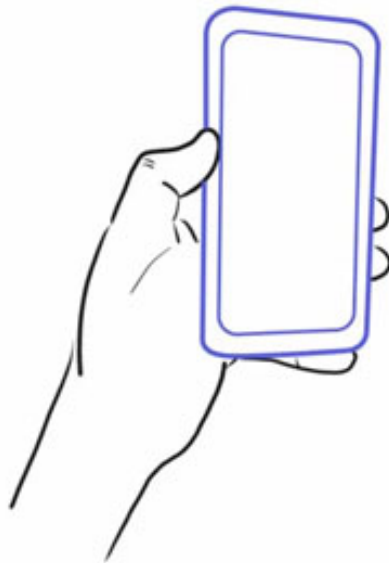


The Idea

# Dual Phone AR

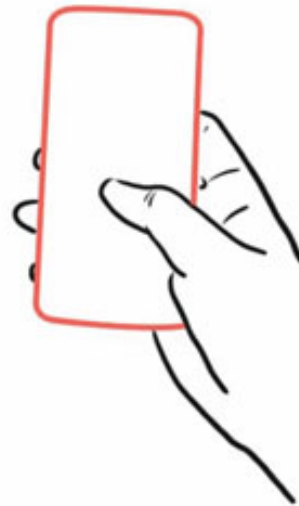
## The AR Phone

Used to **view** the AR world  
*Device runs AR app*



## The Controller Phone

Used to **interact** with AR  
*Device doesn't run AR app*



The Idea

# Design Space of Dual Phone AR

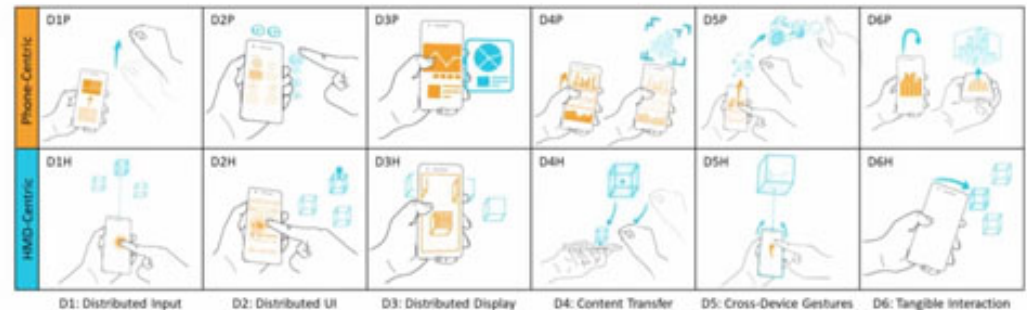
## Design Space:

Defining a collection of possible interaction methods for Dual Phone AR

Helps generate distinct, yet cohesive ideas

Builds upon work done in BISHARE (Zhu, 2019)

“Interaction Space”?



From BISHARE (Zhu, 2019)

The Idea

# Design Space of Dual Phone AR

## Dimensions:

Parameters whose states define different types of possible interactions

- 1. Dual Phone Configuration**
- 2. Device View**
- 3. User Focus**

The Idea

# Design Space of Dual Phone AR

## Dimensions:

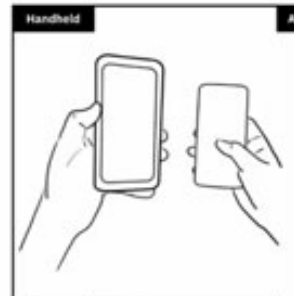
### 1. Dual Phone Configuration

- a. Handheld
- b. Supported
- c. Fixed

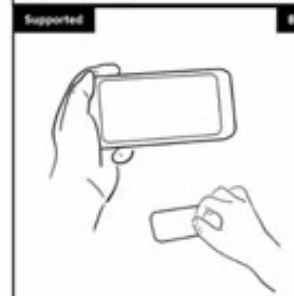
### 2. Device View

### 3. User Focus

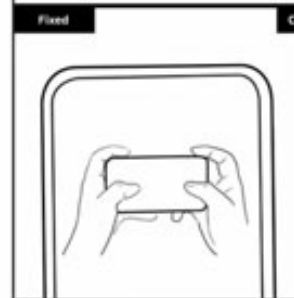
**Handheld:**  
Both AR Phone and  
Controller Phone



**Supported:**  
Controller phone supported  
on a surface



**Fixed:**  
AR Phone fixed in space





The Idea

# Design Space of Dual Phone AR

## Dimensions:

1. Dual Phone Configuration
2. **Device View**
  - a. Controller in AR View
  - b. Controller out of AR View
3. User Focus



Inside AR View



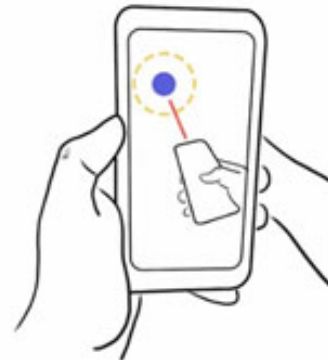
Outside AR View

The Idea

# Design Space of Dual Phone AR

## Dimensions:

1. Dual Phone Configuration
2. Device View
3. **User Focus**
  - a. AR World Focus
  - b. Controller Focus



World Focus



Controller Focus

The Idea

# Design Space of Dual Phone AR

## Dimensions:

- **Dual Phone Configuration**

- Handheld
- Supported
- Fixed

3

- **Controller Configuration**

- In AR View + World Focus
- In AR View + Controller Focus
- Out of AR View + World Focus
- Out of AR View + Controller Focus

4

**12 Possible  
Interaction  
States**

# A Design Space for Dual Phone AR

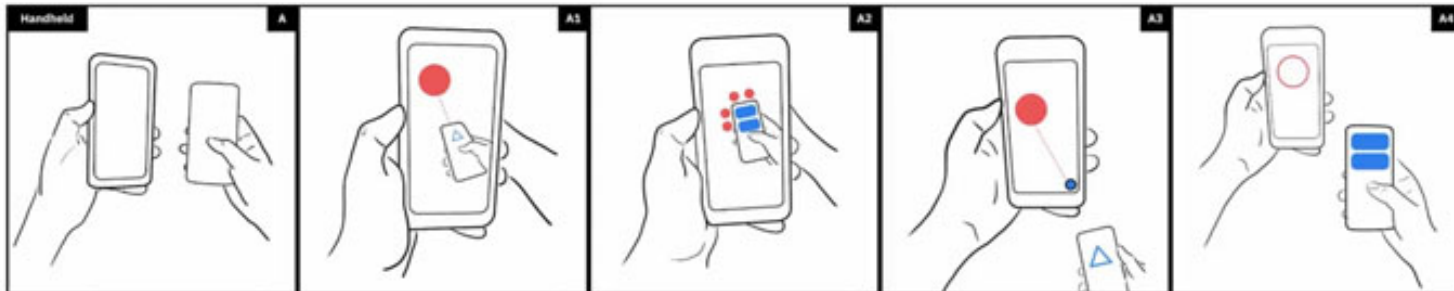
Controller Phone in AR View

Controller Phone out of AR View

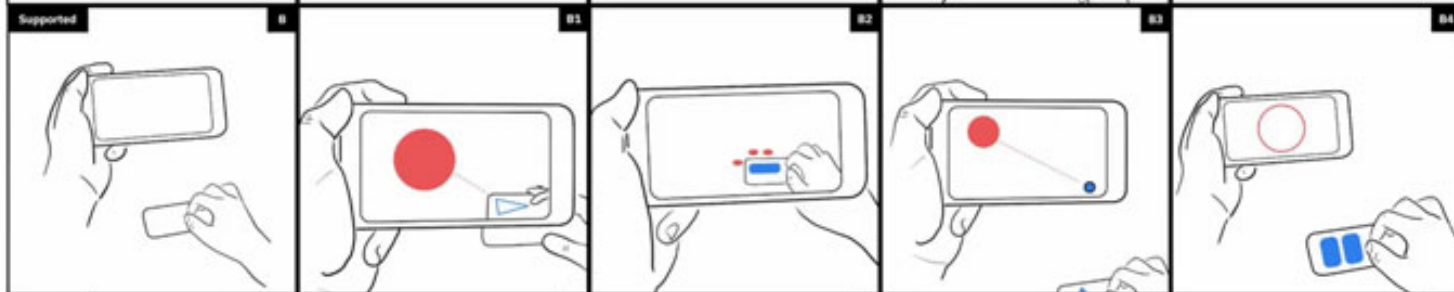
Focus on World Content      Focus around Controller

Focus on World Content      Focus around Controller

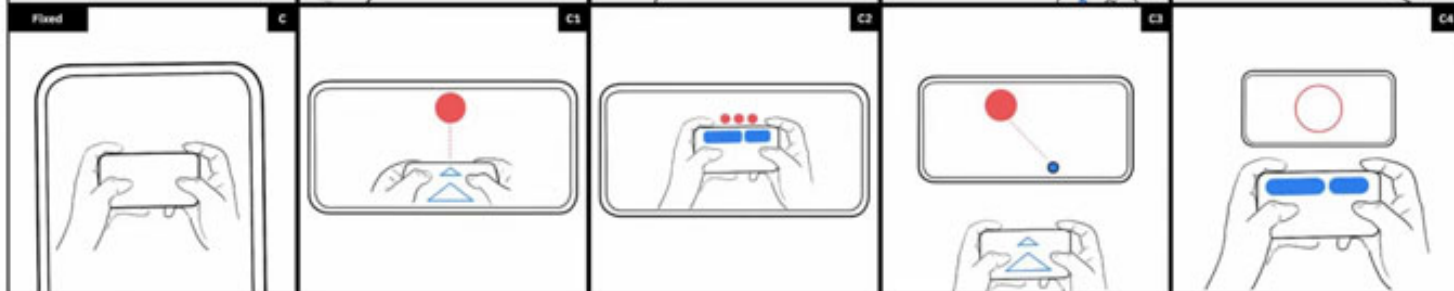
**Handheld:**  
Both AR Phone and  
Controller Phone



**Supported:**  
Controller phone  
supported on a surface



**Fixed:**  
AR Phone fixed in  
space



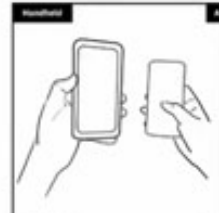
The Idea

# Exploring the Design Space

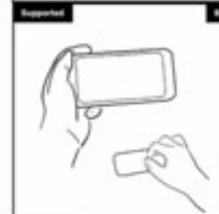
Developed AR prototypes  
for all 12 possible  
interaction states

Each prototype helped  
identify **basic tasks** and  
generate **potential  
use-cases** for the method

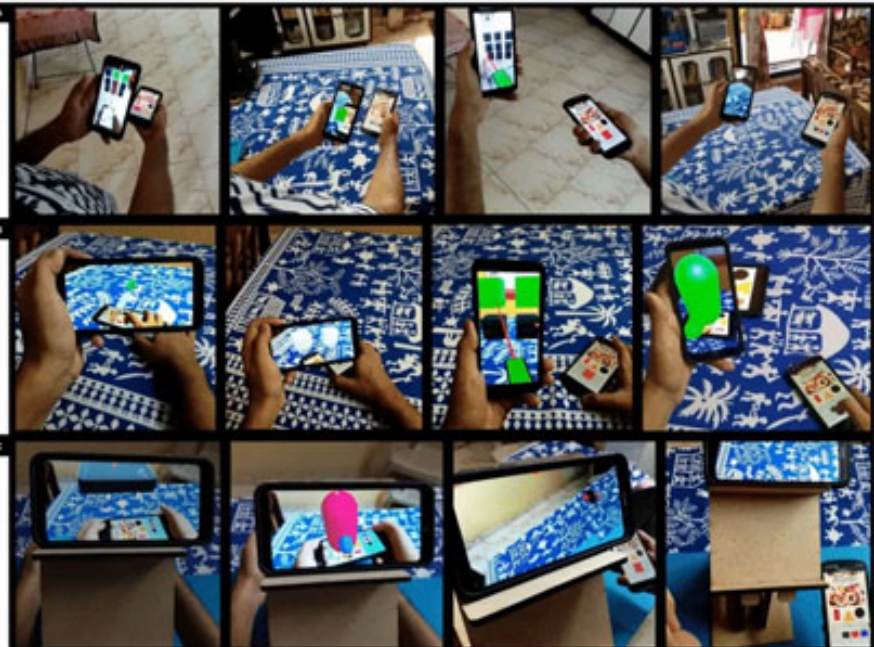
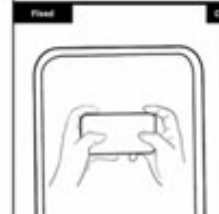
**Handheld:**  
Both AR Phone and  
Controller Phone



**Supported:**  
Controller phone  
supported on a surface



**Fixed:**  
AR Phone fixed in  
space



**How would we use**

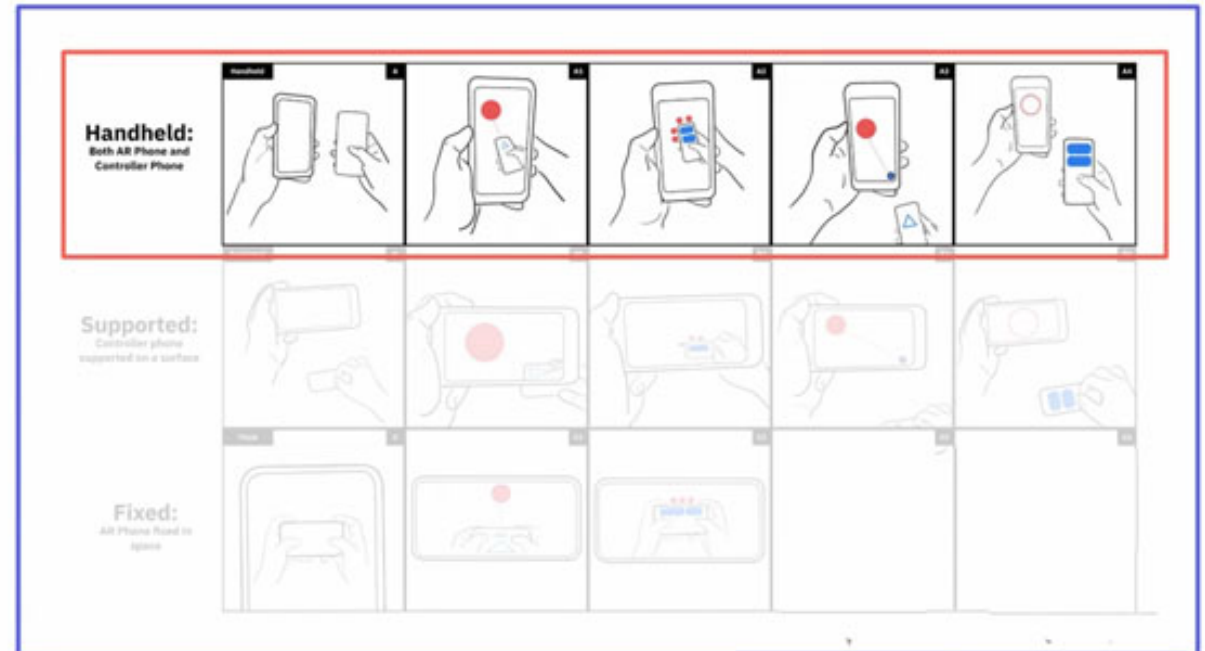
**Dual Phone AR for real tasks?**

Demonstration

# Building Dual Phone AR

## Why build a Demo Application?

1. To better communicate these potential interaction methods, and serve as an artefact by itself
2. Introduce a wider audience to the idea of Dual Phone AR, seek initial feedback



*We focused on the Handheld configuration - most spatial & compelling interactions*

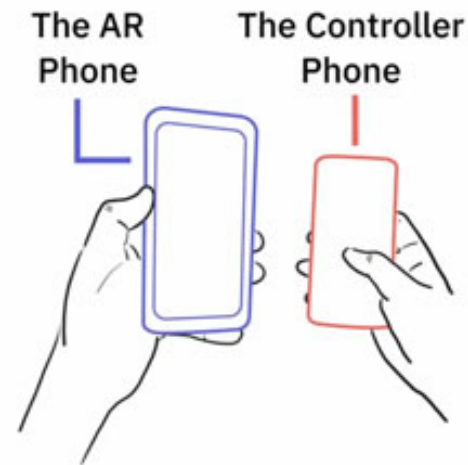
Demonstration

# ARTWO - Dual Phone AR

We designed and developed **ARTWO** - an Android application that demonstrates Handheld Dual Phone AR

ARTWO requires two phones, both running the same application, and connected to the internet

At least one phone must support AR





Demonstration

# ARTWO - Design & Development

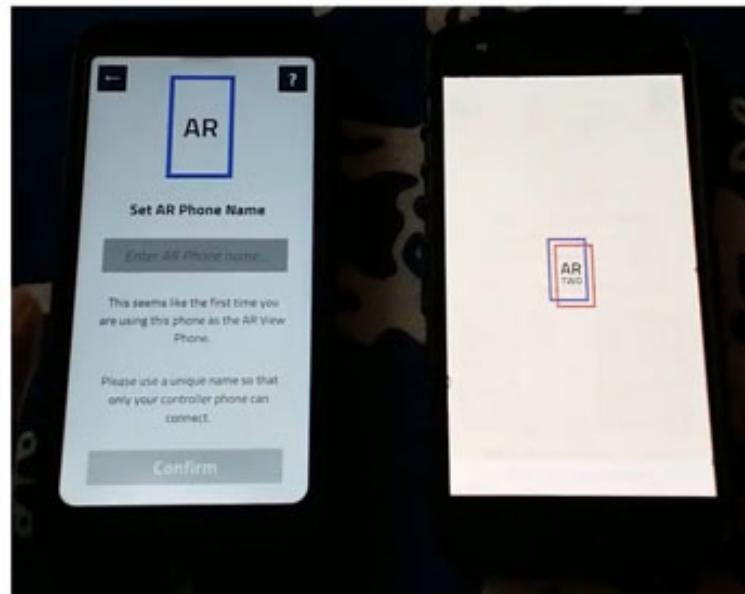
## Design:

ARTWO is quick and easy to set up, and assists users through onboarding and each of the demos

## Development:

ARTWO was built using Unity and AR Foundation

Full video documentation and click-through prototypes can be found at the project website: [rishivanukuru.com/pthree](http://rishivanukuru.com/pthree)



Demonstration

# ARTWO - Design & Development

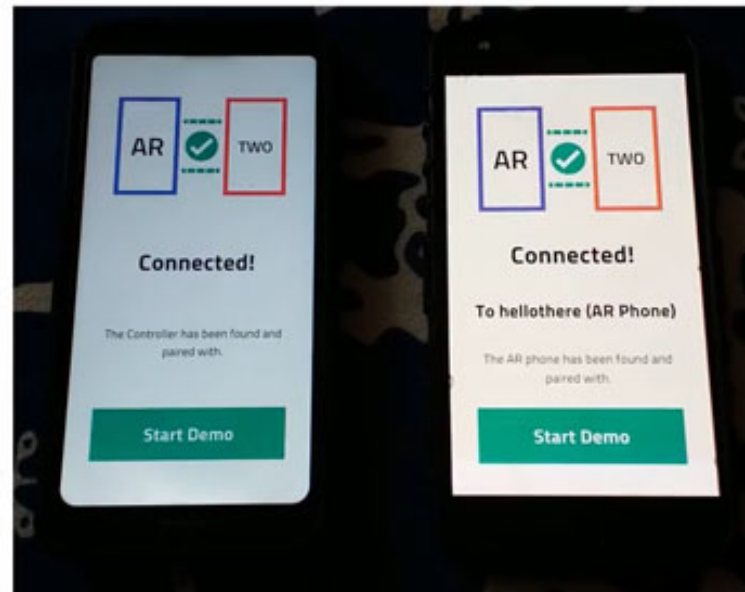
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Demonstration

# ARTWO - Dual Phone AR

ARTWO consists of

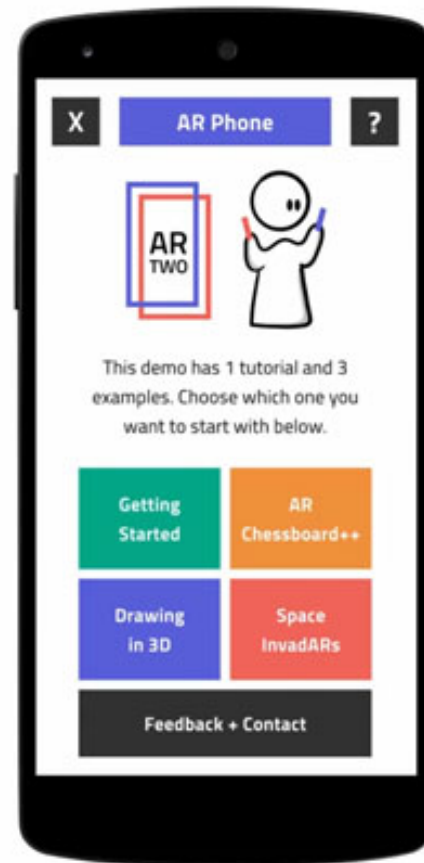
**1 tutorial** and **3 demos**:

**0. Getting Started**

**1. AR Chessboard ++**

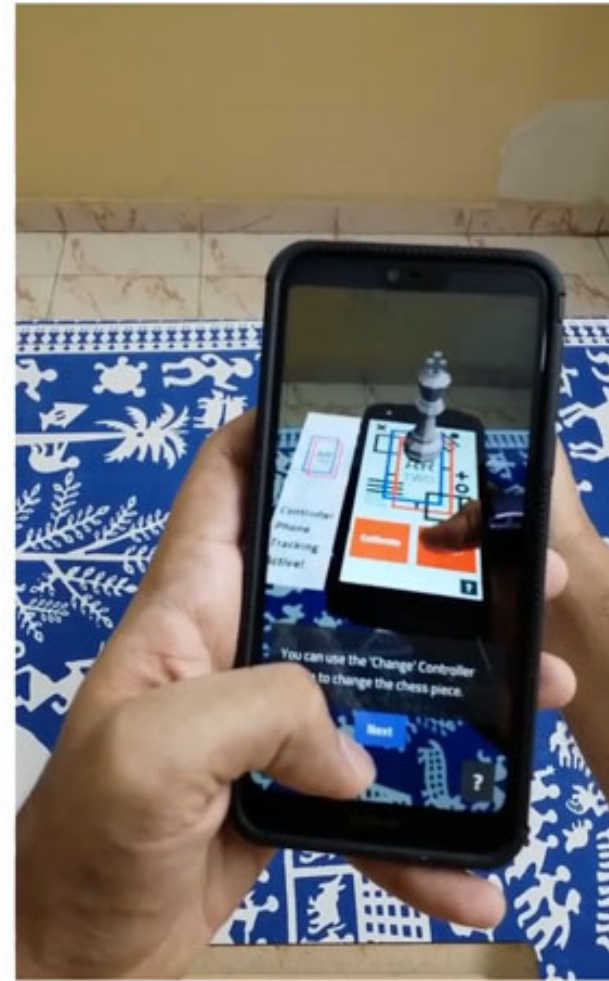
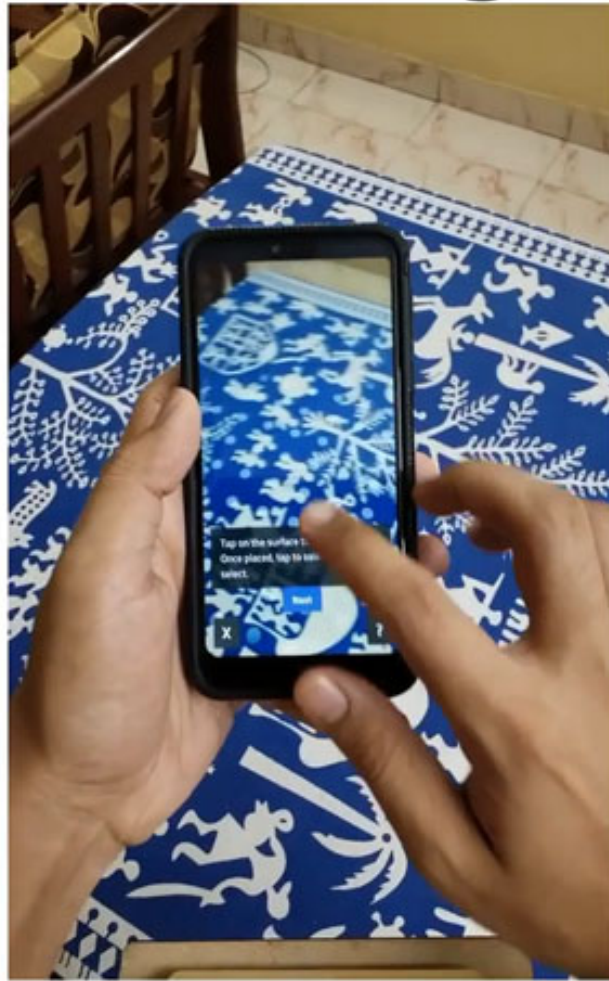
**2. Drawing in 3D**

**3. Space InvadARs**



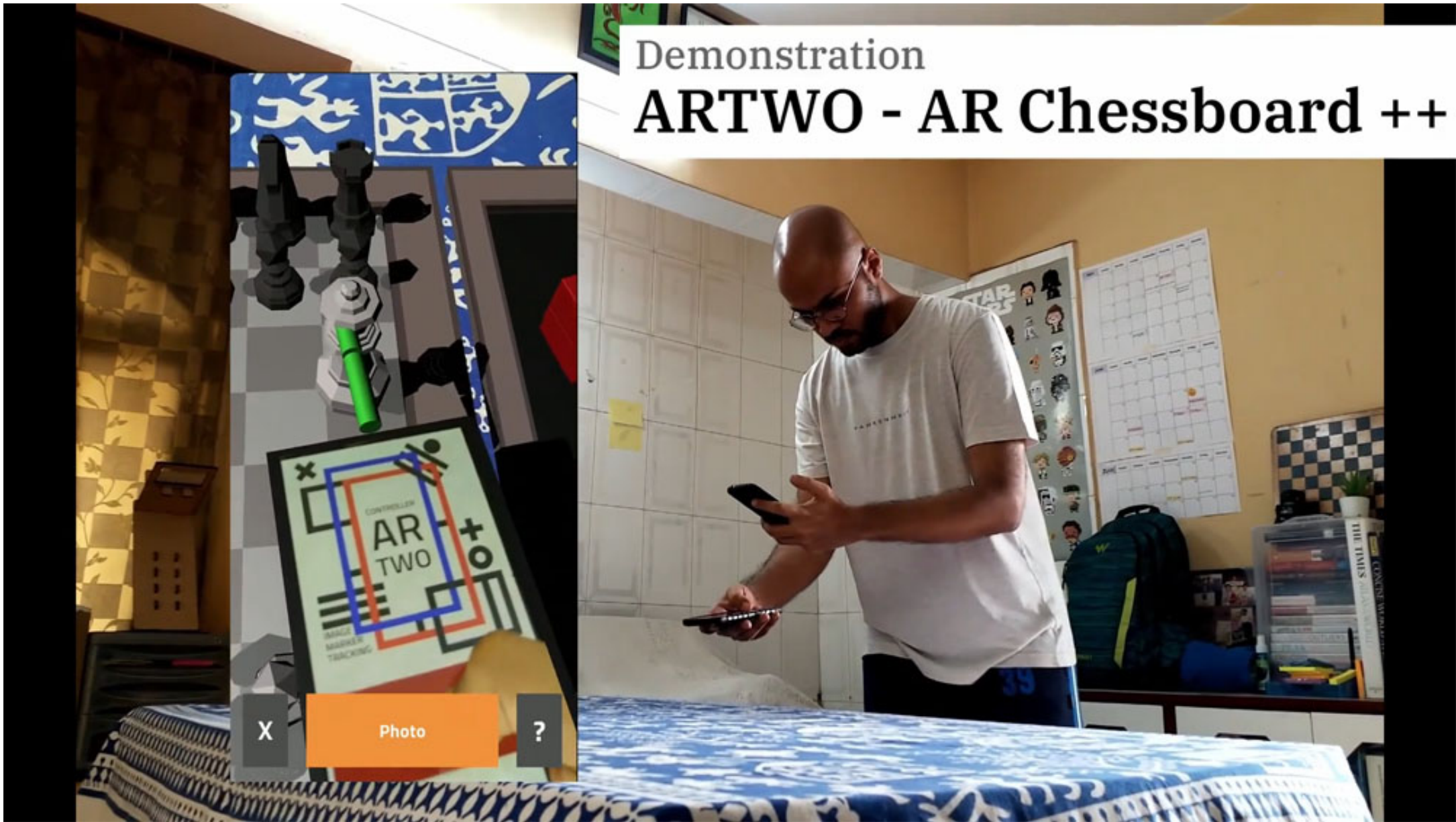
Demonstration

# ARTWO - Getting Started



Demonstration

# ARTWO - AR Chessboard ++



Demonstration

# ARTWO - AR Chessboard ++



X

Photo

?

Demonstration

# ARTWO - AR Chessboard ++



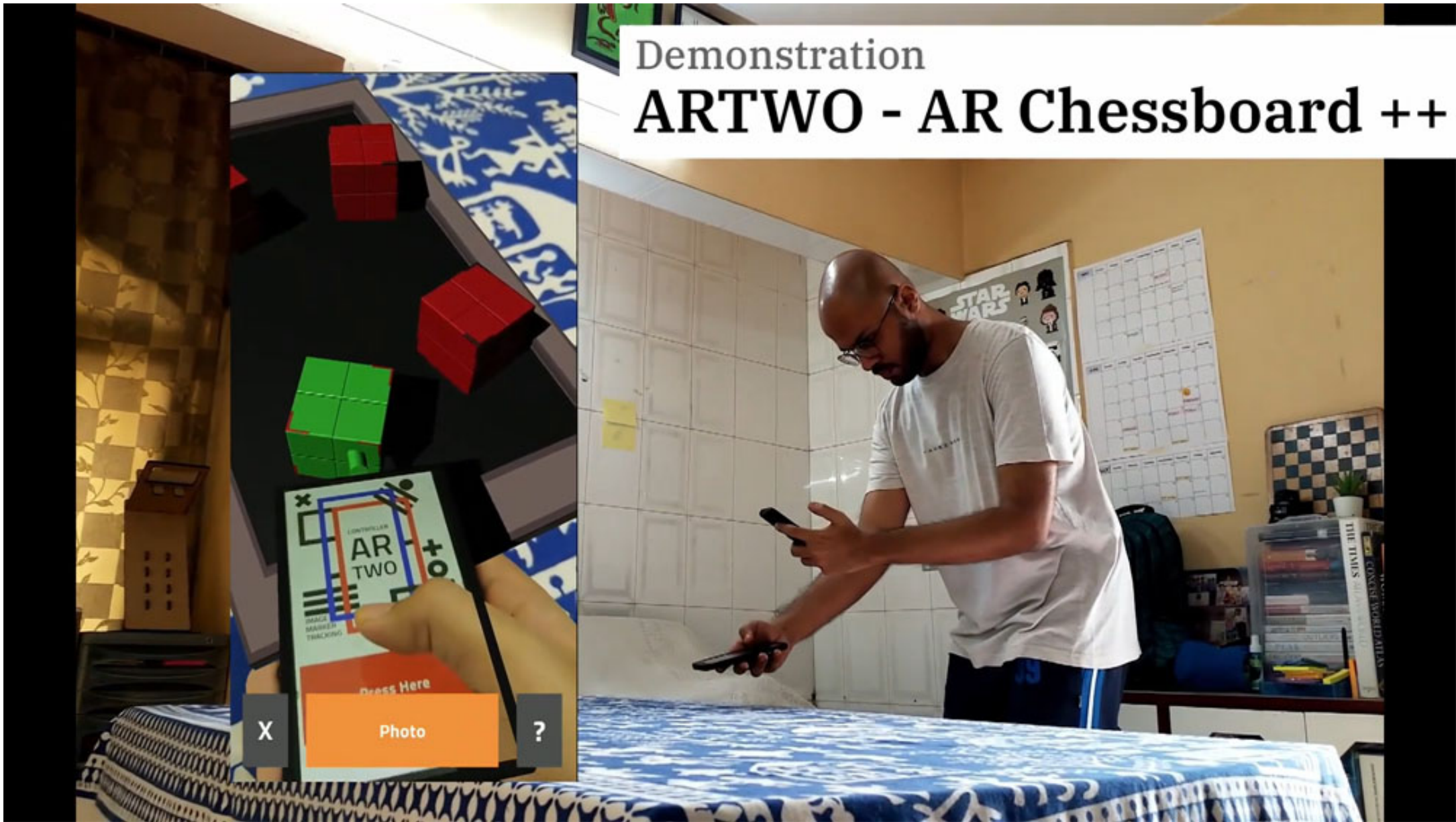
X

Photo

?

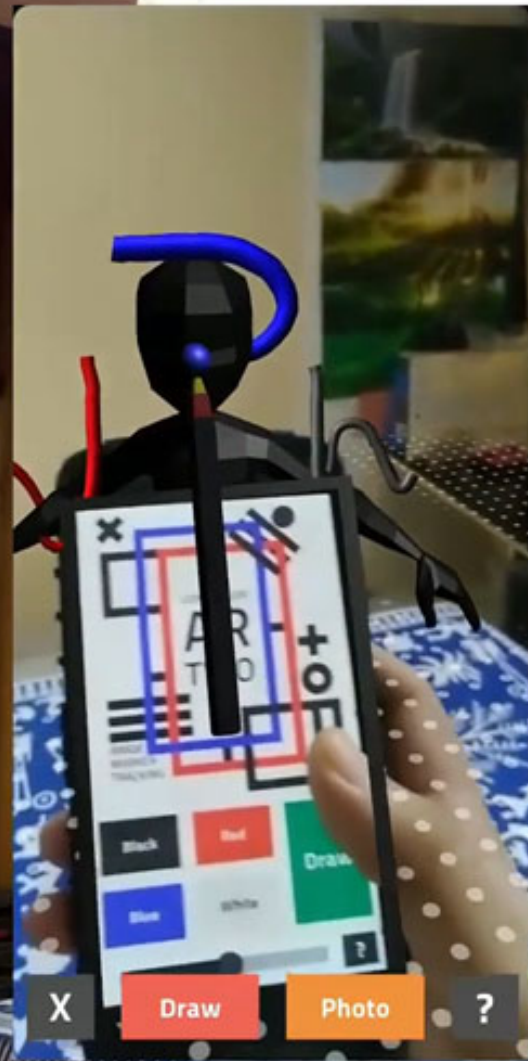
Demonstration

# ARTWO - AR Chessboard ++

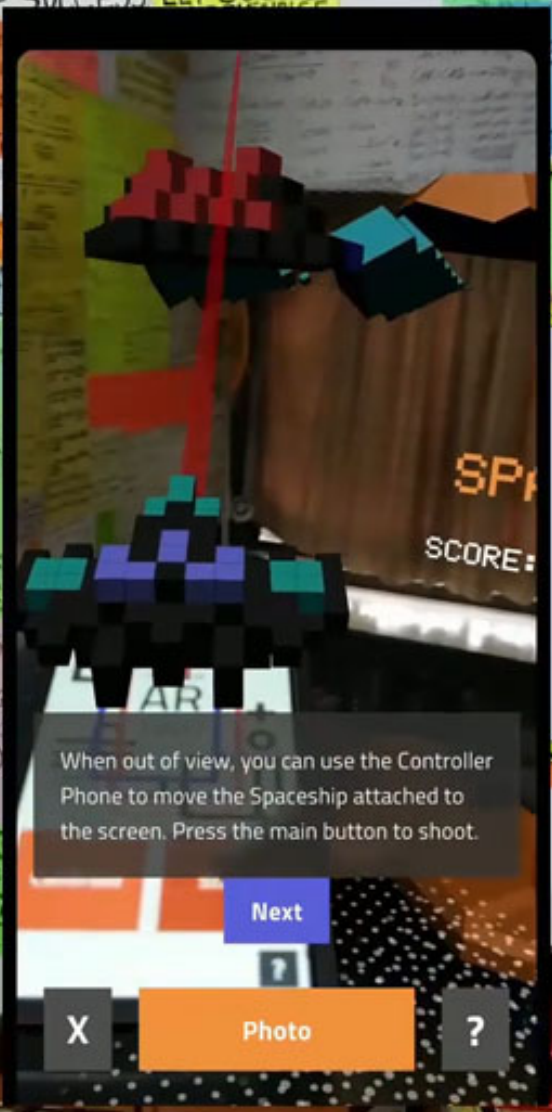


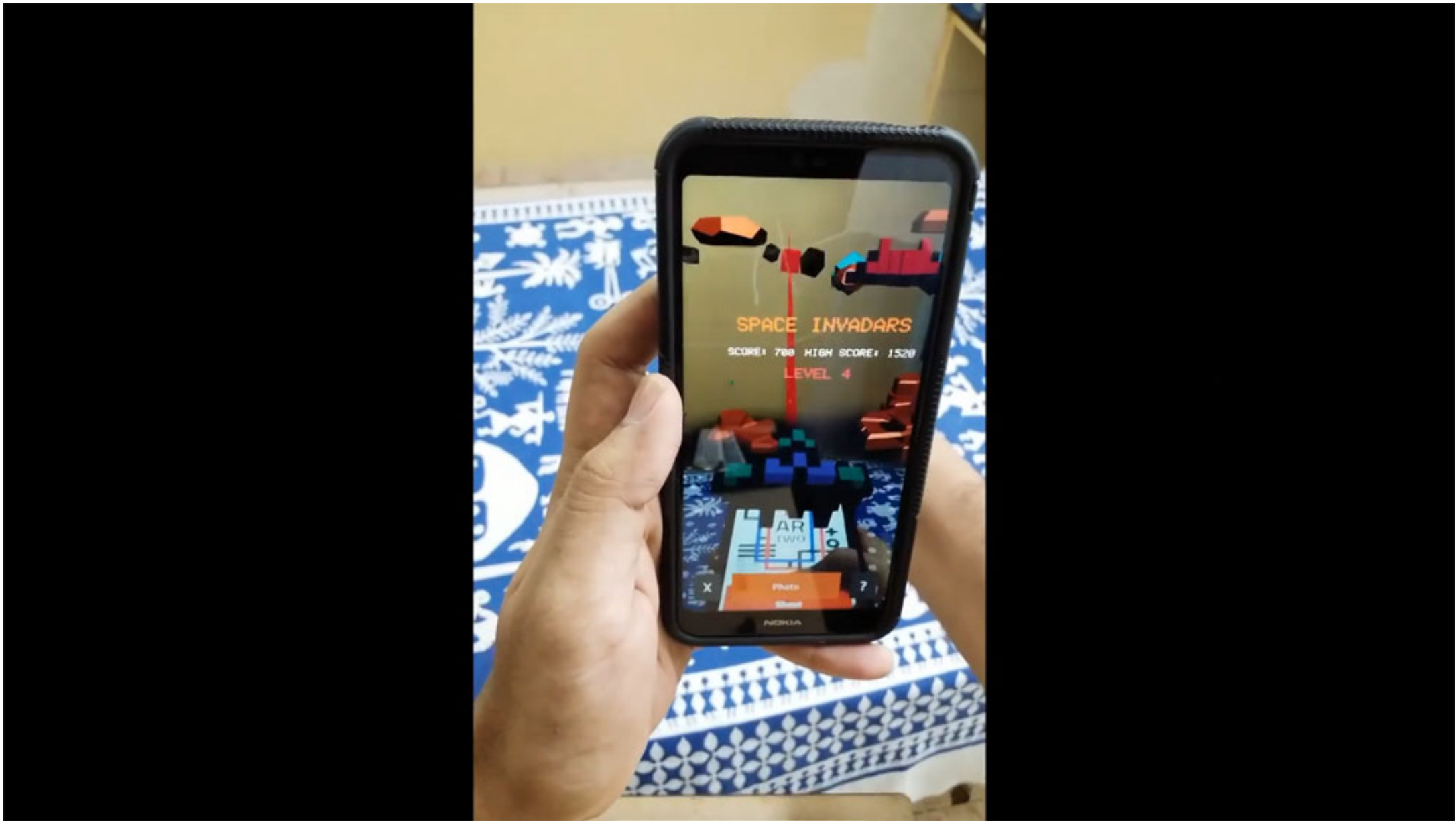


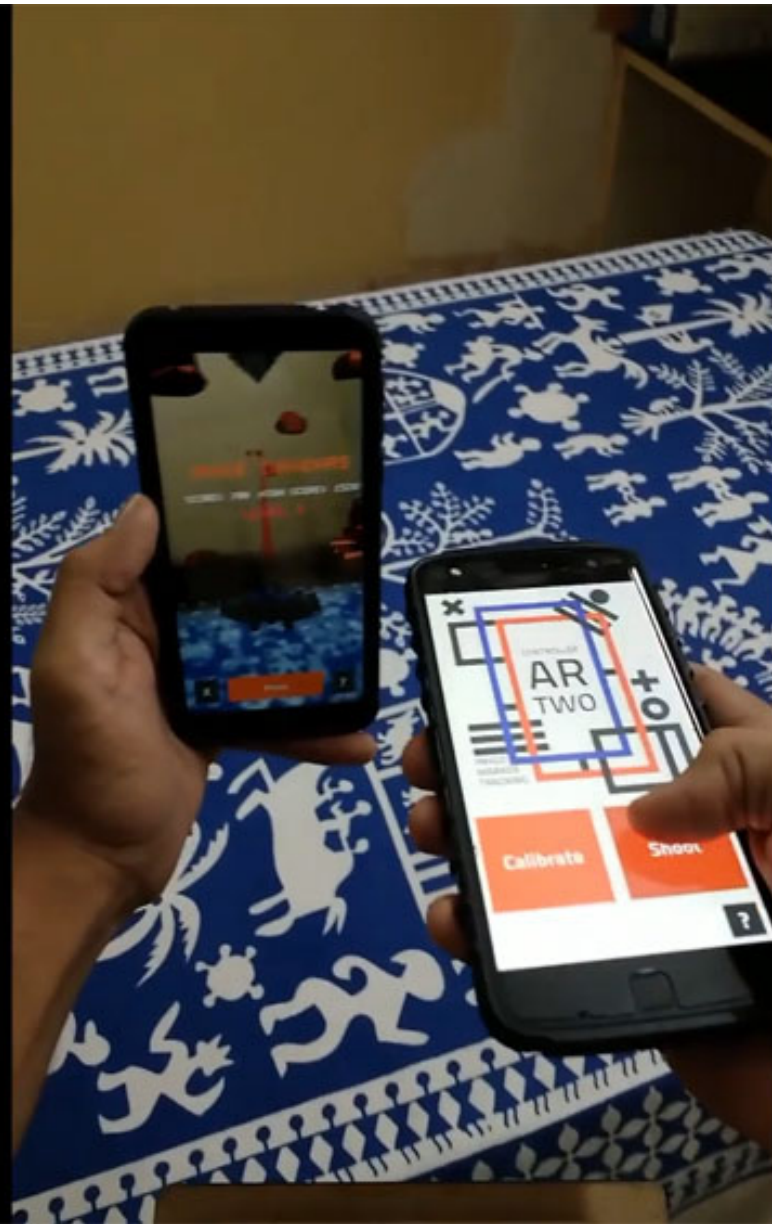
# Demonstration ARTWO - Drawing in 3D



# Demonstration ARTWO - Space InvadARs







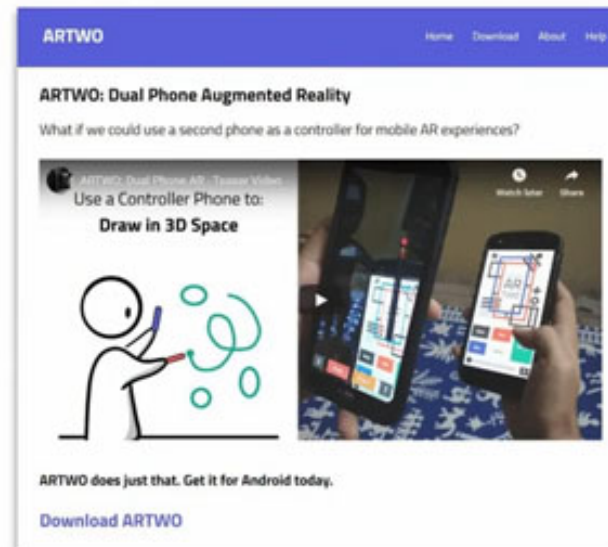
Demonstration

# ARTWO - Dual Phone AR

ARTWO is available for download on the Google Play Store, as well as on the app website :

[rishivanukuru.com/artwo](http://rishivanukuru.com/artwo)

The app website also contains further video documentation and instructions



**So, does Dual Phone AR work?**

*Where do we go from here?*

Discussion

## **Solving issues, filling gaps**

ARTWO, as a finished application / research prototype, clearly addresses the issues with conventional AR interactions:

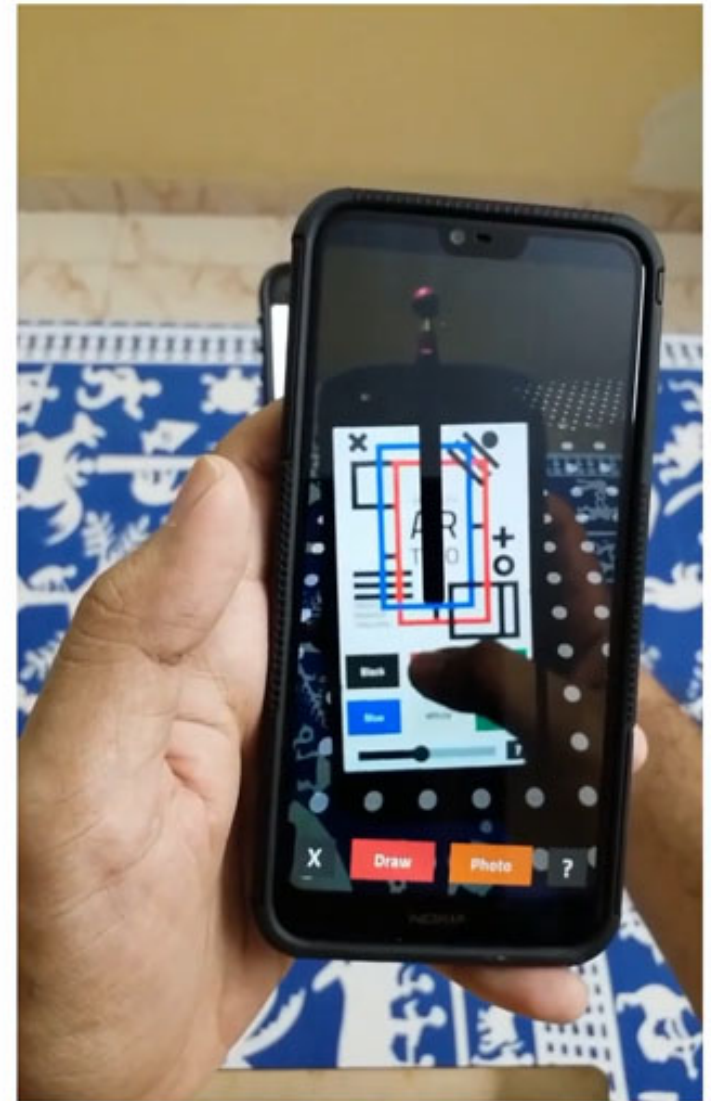
- 1. Screen-space UI**
- 2. Missing Interface**
- 3. Depth Perception**
- 4. Spatial Movement**

Discussion

# Solving issues, filling gaps

## Screen Space UI:

Distributed, Diegetic, Contextual



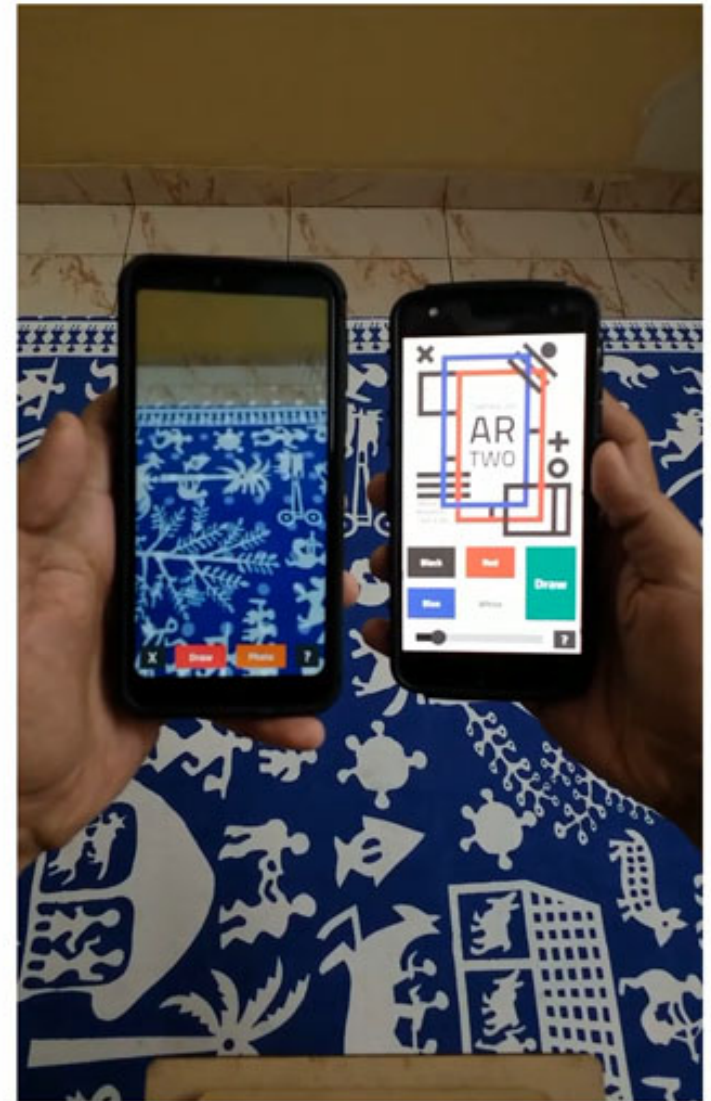


Discussion

# Solving issues, filling gaps

## Screen Space UI:

Distributed, Diegetic, Contextual

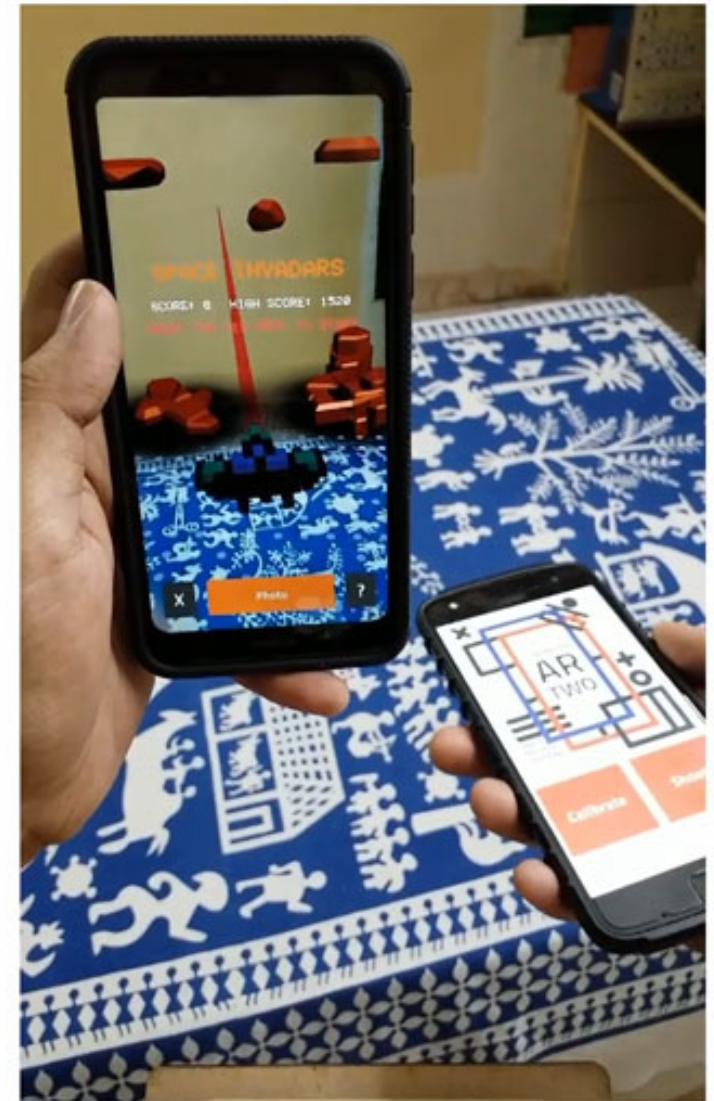


Discussion

# Solving issues, filling gaps

## Screen Space UI:

Distributed, Diegetic, Contextual

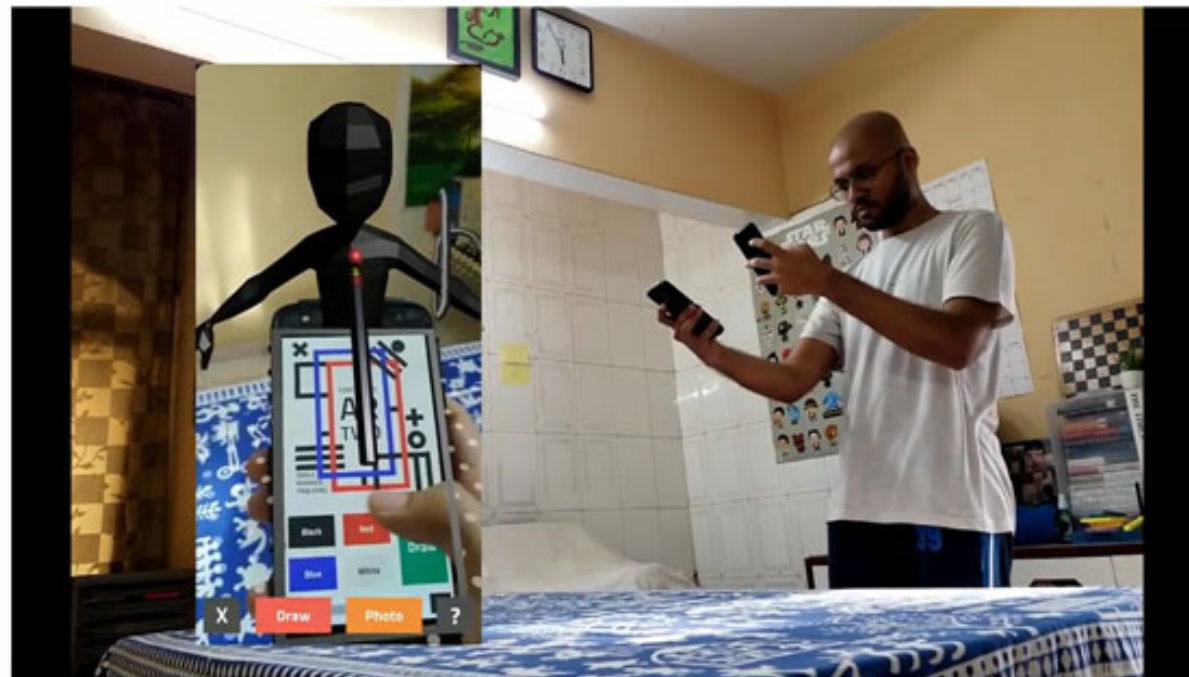


Discussion

# Solving issues, filling gaps

## Depth Perception:

Assisted by motor feedback, familiarity



Discussion

## User Feedback

### **Initial conversations with:**

- Developers of AR/VR apps
- PhD students in the field of Immersive Media research
- Users having some experience with AR

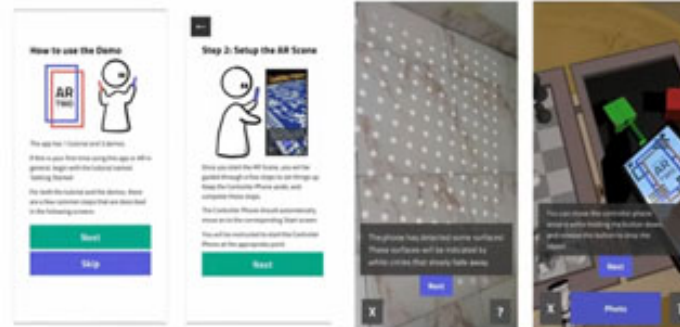
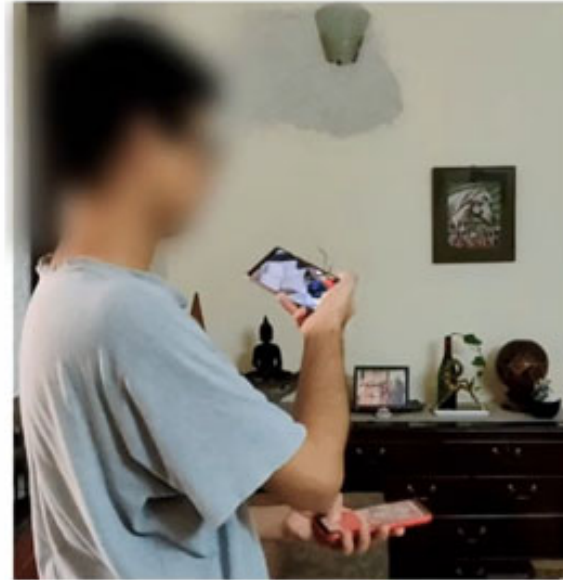
*Dual Phone AR is not envisioned  
as a way to introduce new users to AR*

# Discussion

## User Feedback

### The Positives:

- The Idea and Promise of Dual Phone AR:  
*More engaging, makes spatial experiences more accessible*
- The Demo Experience  
*The right amount, and perhaps too much assistance*



## Discussion

# User Feedback

### The Concerns:

- Frustrations with Tech Limitations  
*Issues with AR tracking technology, cross-device communication*
- Ergonomics of Dual Phone AR  
*Fatigue, mirrored / independent motion of hands*
- Economics of Dual Phone AR  
*AR-capable phones are not as common, and quite expensive, VR headsets may be cheaper*

## Discussion

# Moving Forward

### Potential Directions:

- Segue into HMD + Phone research  
*AR Glasses seem to be right on the horizon,  
Dual Phone AR could help prepare for that*
- Collaborative AR experiences  
*Individuals may not have two phones, but  
groups could share AR Phones and Controllers  
among themselves*
- True 'Dual Phone' AR  
*Better spatial tracking with two AR-capable  
phones, cross-device computation*

Discussion

## Next Steps

*This is an ongoing project*

- **Develop Demo Applications** for the other configurations:  
Supported and Fixed
- **Reach out to more users:** Collect feedback, search for collaborators



Discussion

## **Project Documentation**

**Project website:**

[\*rishivanukuru.com/pthree\*](http://rishivanukuru.com/pthree)

[\*rishivanukuru.com/projects/artwo\*](http://rishivanukuru.com/projects/artwo)

**ARTWO application website:**

[\*rishivanukuru.com/artwo\*](http://rishivanukuru.com/artwo)

*For the report, videos, downloads, and more*

Discussion

# Looking Back

## What is this Project

A **Research Project**

on Interactions for Mobile Augmented Reality

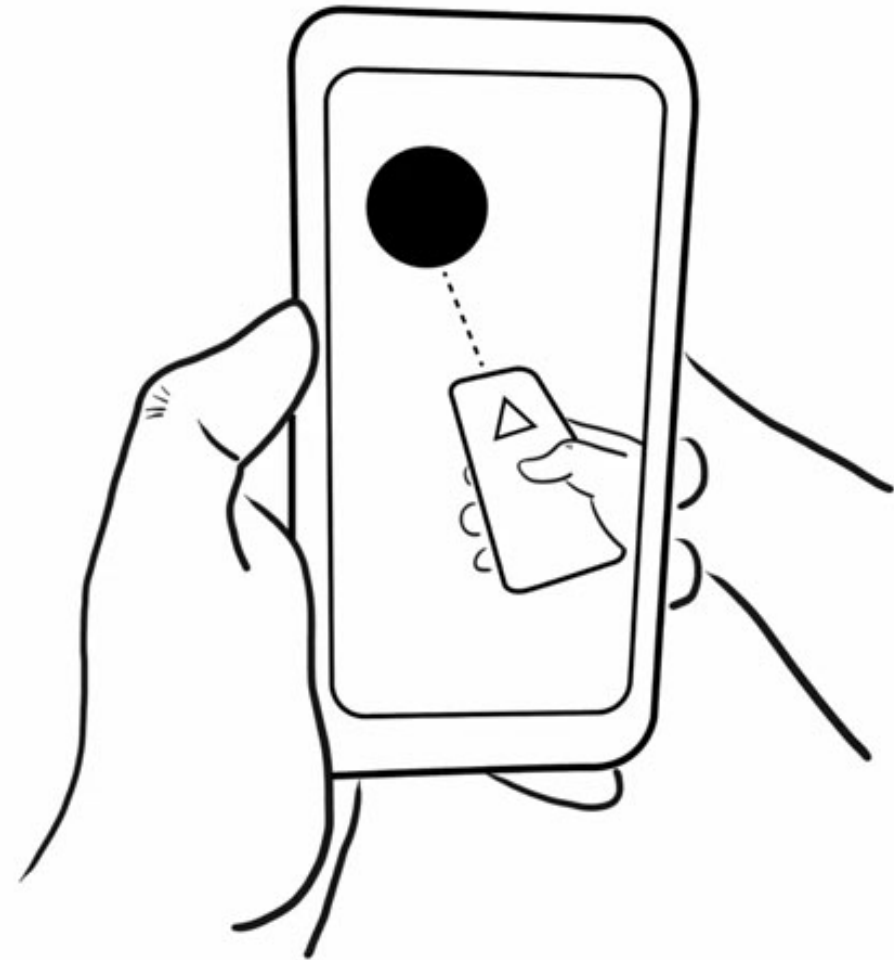
## Main Contributions:

1. **The Design Space** - Exploring Dual Phone AR
2. **The Artefact** - ARTWO Demo Application
3. **Insights** - Initial, ongoing feedback from users

# Designing and Studying Interactions for Handheld Augmented Reality

## Thank You!

**IDC** School of Design  
अभिकल्प विद्यालय



# Credits

*Project Guide:* Prof. Jayesh Pillai

*Technical Advice:* Amarnath Murugan, Rajandeep Singh

*Photography and  
Video, Lighting,  
Beta testing,  
Rigging, Practical  
advice:*

Ritvik Vanukuru

*Video source credits included in the project website*