ISMAR 2022 Tutorial

OpenARK -- Tackling Augmented Reality Challenges via an Open-Source Software Development Kit

Adam Chang, Dr. Mohammad Keshavarzi, Dr. Allen Y. Yang

University of California, Berkeley

Tutorial Contributors

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- Now work at Wall Street

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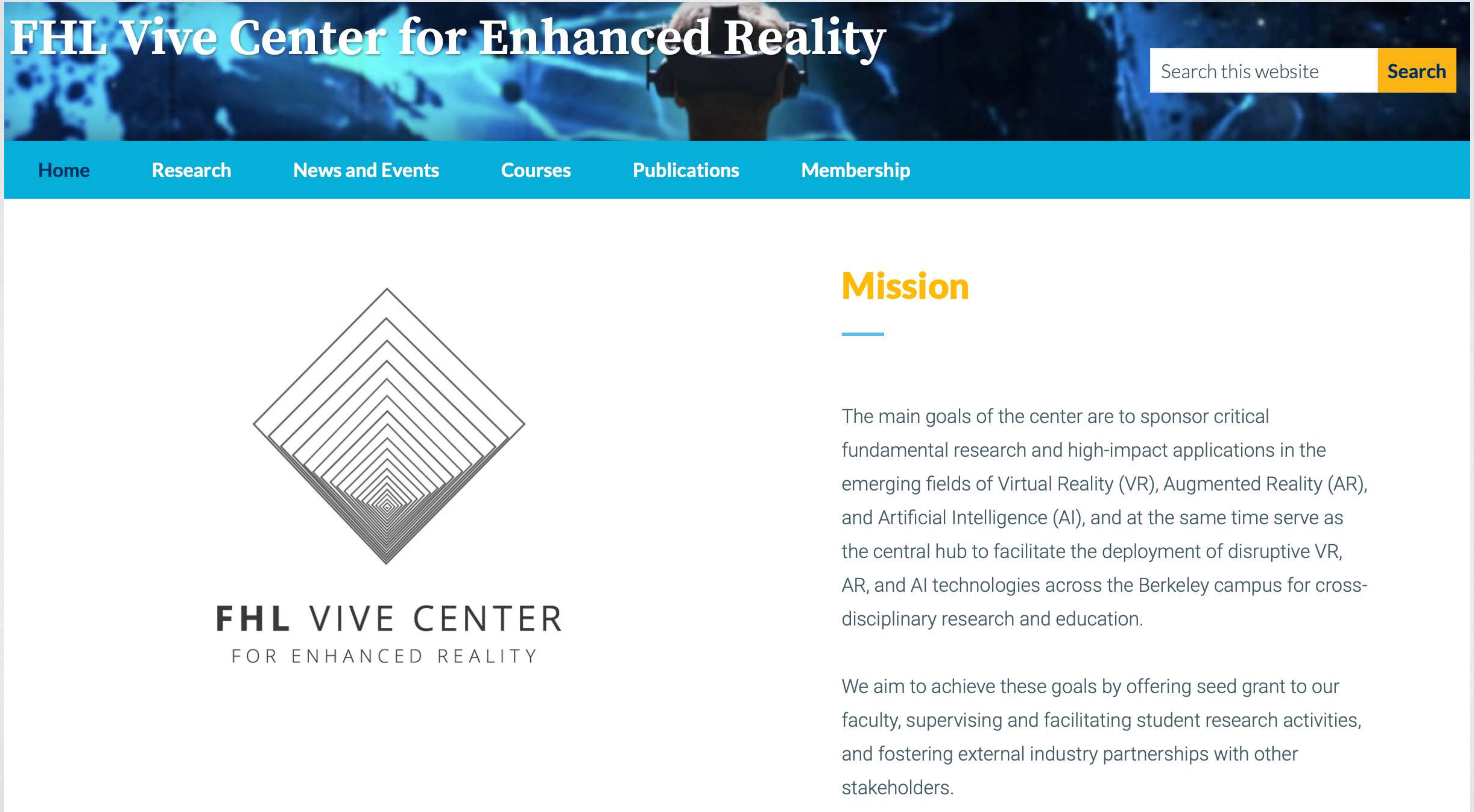
Slides available: vivecenter.berkeley.edu



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True Cost to Blur Reality and Virtuality

-- Understand the fundamental challenges in creating virtual 3D experience

Dr. Allen Y. Yang
with Adam Chang, Dr. Mohammad Keshavarzi

ISMAR 2022 Tutorial, Part I

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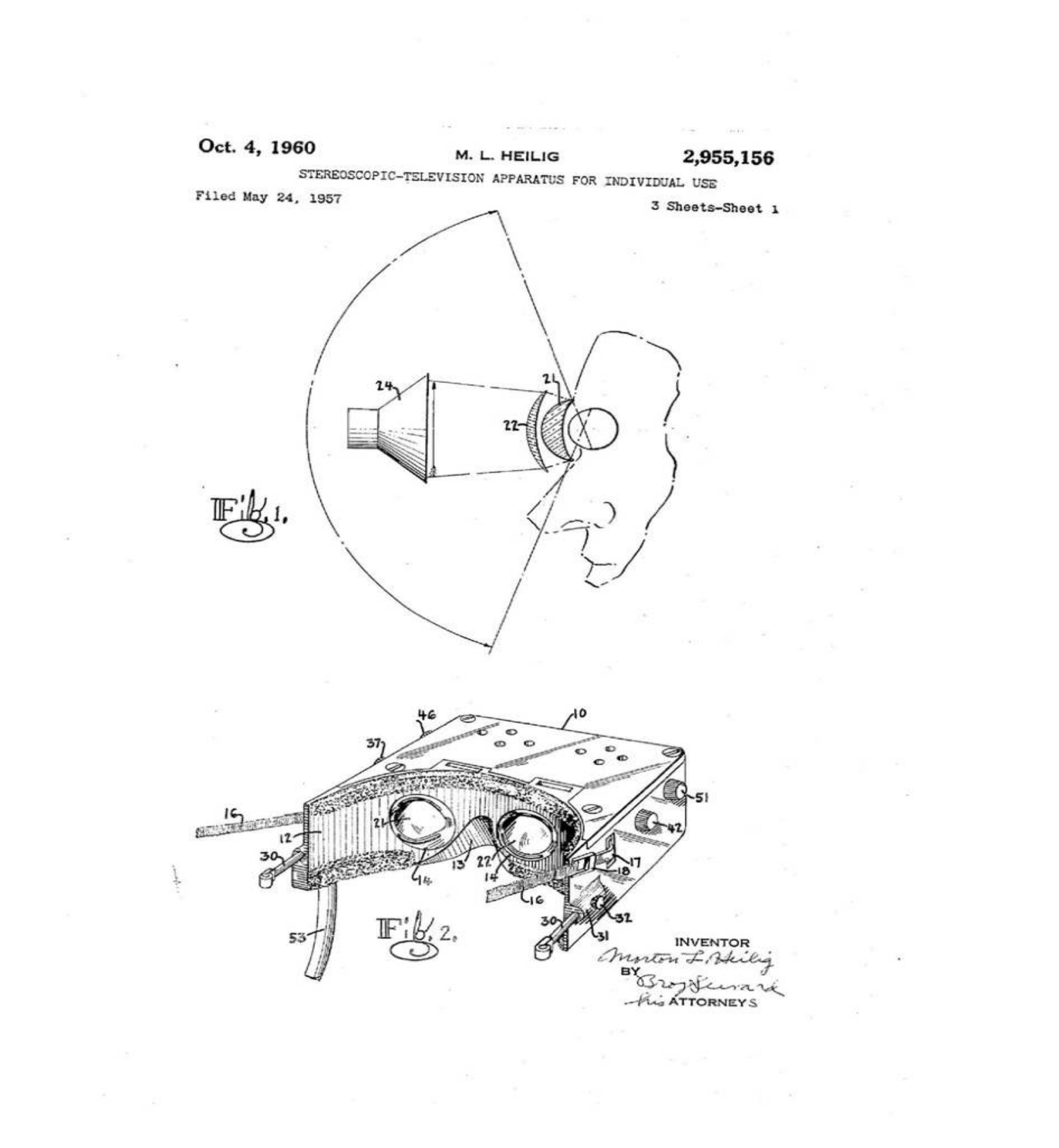
What consumers believe future of AR/VR/Metaverse could look like

Sixty Plus Years of AR/VR



Morton Heilig, 1960

Morton Heilig, 1962

Ivan Sutherland, 1968

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AR/VR System Form Factors

Simulation Environments

Tethered VR PCs

All-in-One Wearables

ARKit and ARCore on Smartphones

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AR/VR System Form Factors Pros and Cons

Form Factor	Simulation Environment	Tethered to PC	All-in-One	Smartphone
Cost	Very High	High	Medium	Very Low
Visual Fidelity	Best	High	Medium	Low
Motion-Tracking	High	High	High	Medium
User Input	Very Realistic	High	Low to Medium	Very Low

Our research will focus on Perception and UI/UX tasks for low-cost all-in-one applications

Near-Eye Display Space (NDS)

- Renders 2D menu and items on head-mounted displays
  - Google Glass uses exclusively NDS
- Content in NDS typically is **not anchored with any physical objects**
- Limited user interaction in NDS:
  - **Voice**
  - **Gaze**
  - **2D Touch**
- NDS is often reserved for displaying private information, rarely shared between different users

Egocentric User Space (EUS)

- Egocentric User Space is an immersive virtual space with its origin **anchored from the user's perspective and typically moved with the user's movement**

- Typically, user interaction in EUS is projected within an arm's reach from user (1--2m):
  - **Hand gestures**
  - **3D Controllers**

- EUS content if shared, such as video calls, is **rendered individually for each user**

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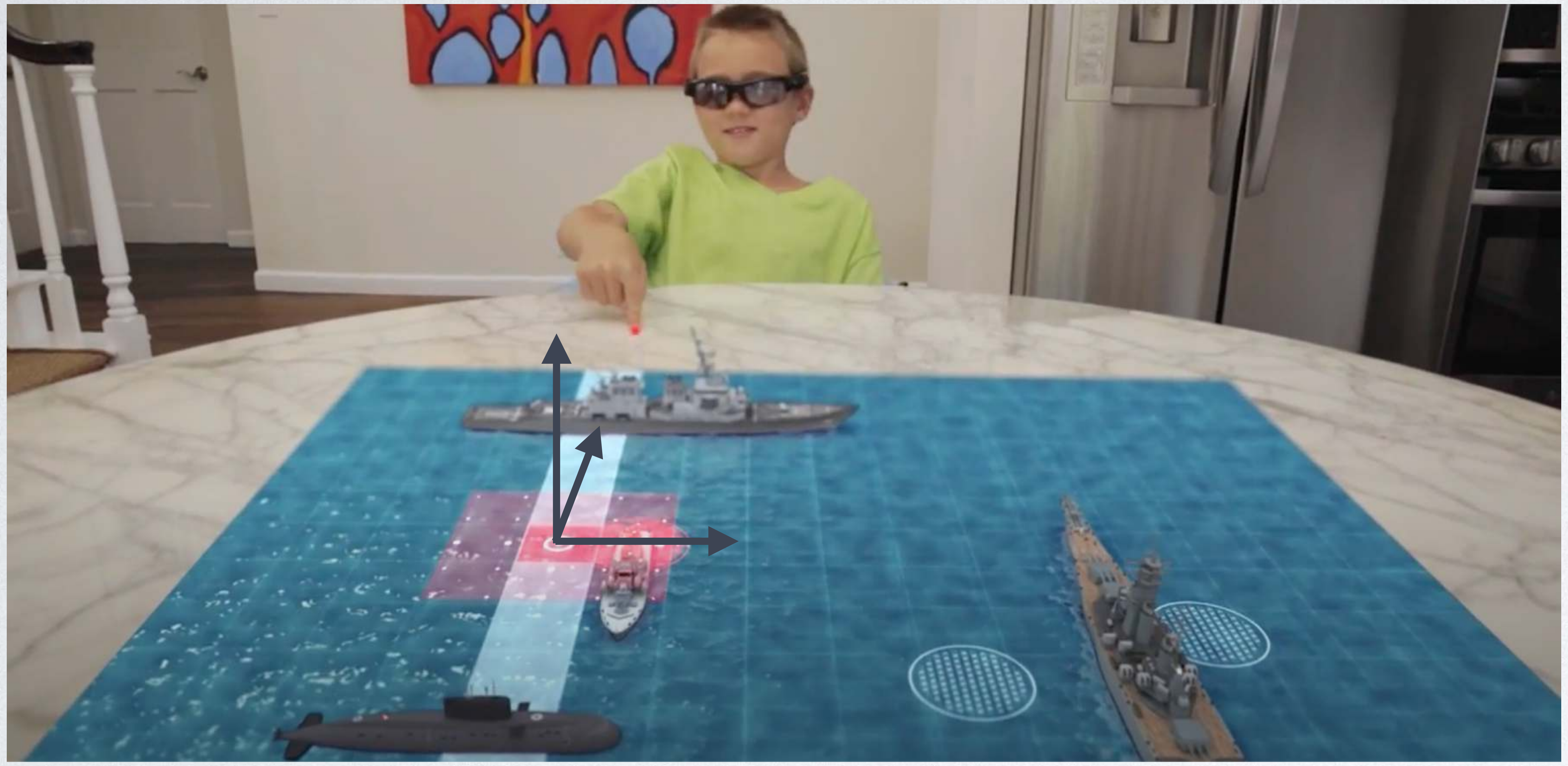
Overlay World Space (OWS)



- OWS models and coincides with the physical world
  - HoloLens
  - ARKit
- **Interacting with OWS content implies interacting with the real world**
- **Origin of OWS is anchored at a fixed 3D location**, typically does not change w.r.t. the user movement
- In multi-user applications, **an OWS and its content can be shared and manipulated by multiple users**

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Pros and Cons: Three Interactive Spaces

	Near-Eye Display Space (NDS)	Egocentric User Space (EUS)	Overlay World Space (OWS)
Anchor	Display Coordinates	Egocentric with arm length	World coordinate origin
Interaction	Voice, Gaze, 2D touch	Gestures, Controllers	Physical objects and environment
Multi-User Sharing	Very Rare	Rare	Popular

Selected Challenges to Blur Reality and Virtuality

	Near-Eye Display Space (NDS)	Egocentric User Space (EUS)	Overlay World Space (OWS)
Display	**"Retina Display" for rendering NDS**	-	-
Interaction	Voice, Gaze, 2D touch	**Perception for Egocentric 3D UI**	• **SLAM: Environment** • **Digital Twin: Objects**
Multi-User Sharing	N/A	N/A	• **Contextual Spatial Computing** • **Decentralized Privacy**

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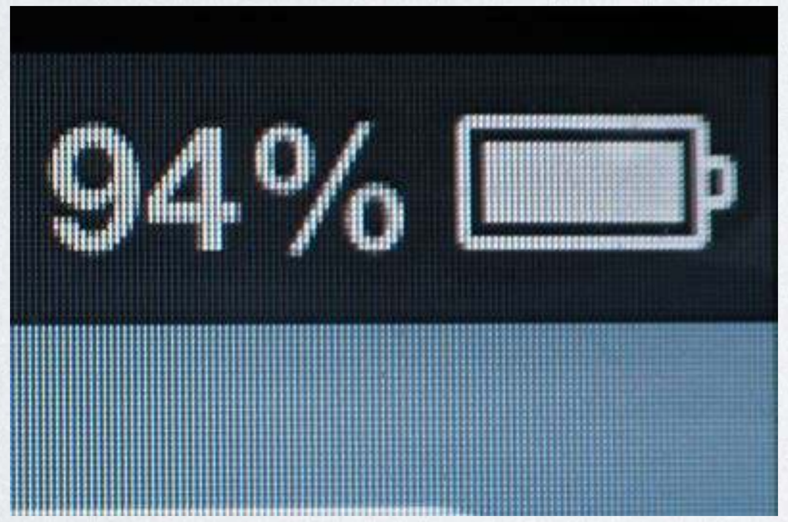
"Retina" Near-Eye Display for Mobile AR/VR

iPhone 3GS non-RD



iPhone 4 RD

Apple started marketing "Retina Display" in 2010 that aims to eliminate "screen-door effect"

Let's Calculate

- Fundamental Constraint:

Human perceives discrete pixels as continuous picture if

***pixel-per-degree* (PPD) > 60**

- In handheld smartphone case:

960 pixels ÷ 60 ppd = 16 degrees

Conclusion: a 960 resolution display is "retina display" when being viewed within 16 degrees

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"Retina" Near-Eye Display

- Each eye has a horizontal field-of-view of ~160° and a vertical field-of-view of ~175°. The two eyes work together for stereoscopic depth perception over ~120° wide and ~135° high FOV.

	PPD required	Horizontal FOV (deg)	Equivalent horizontal Kpixels	Vertical FOV (deg)	Equivalent vertical Kpixels	Total Mpixels required
Each eye	60	160	9.6	175	10.5	~100
Stereo vision	60	120	7.2	135	8.1	~60

Retina Near-Eye Display that offers 120-degree FOV

- Minimally dual 8K resolution for near-eye AR/VR display
- Ideally dual 16K resolution
- How to transfer such amount of data: 5Gbps in single 8K format

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"Semi-Retina" Near-Eye Display at CES 2018

LUCI alyx, First 4K Dual MicroOLED Near-Eye Display

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Egocentric 3D User Input

3D Controller

Hand Tracking

Full-Body Tracking

If speed and low-latency is a concern, controllers are still the best current option

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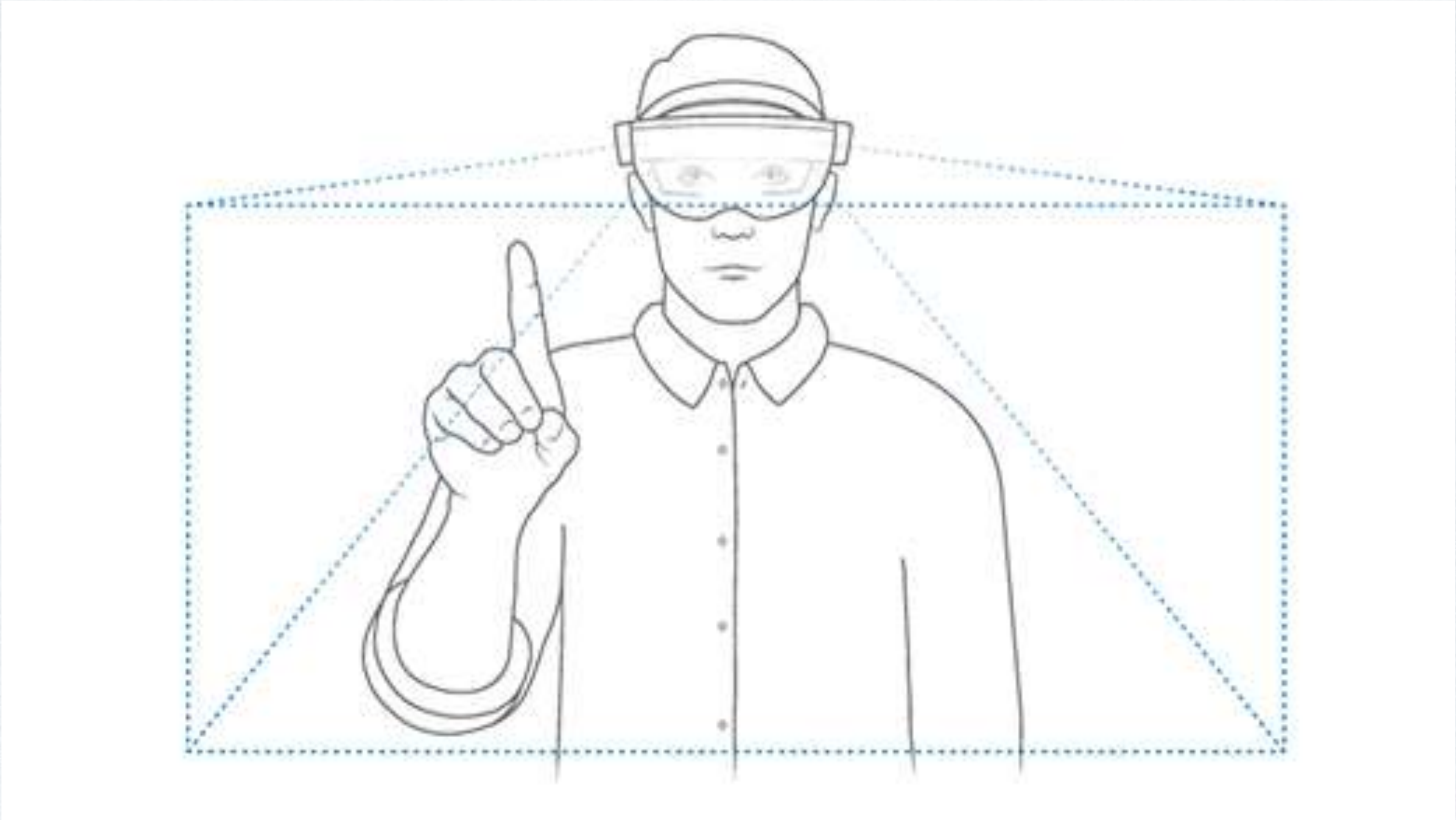
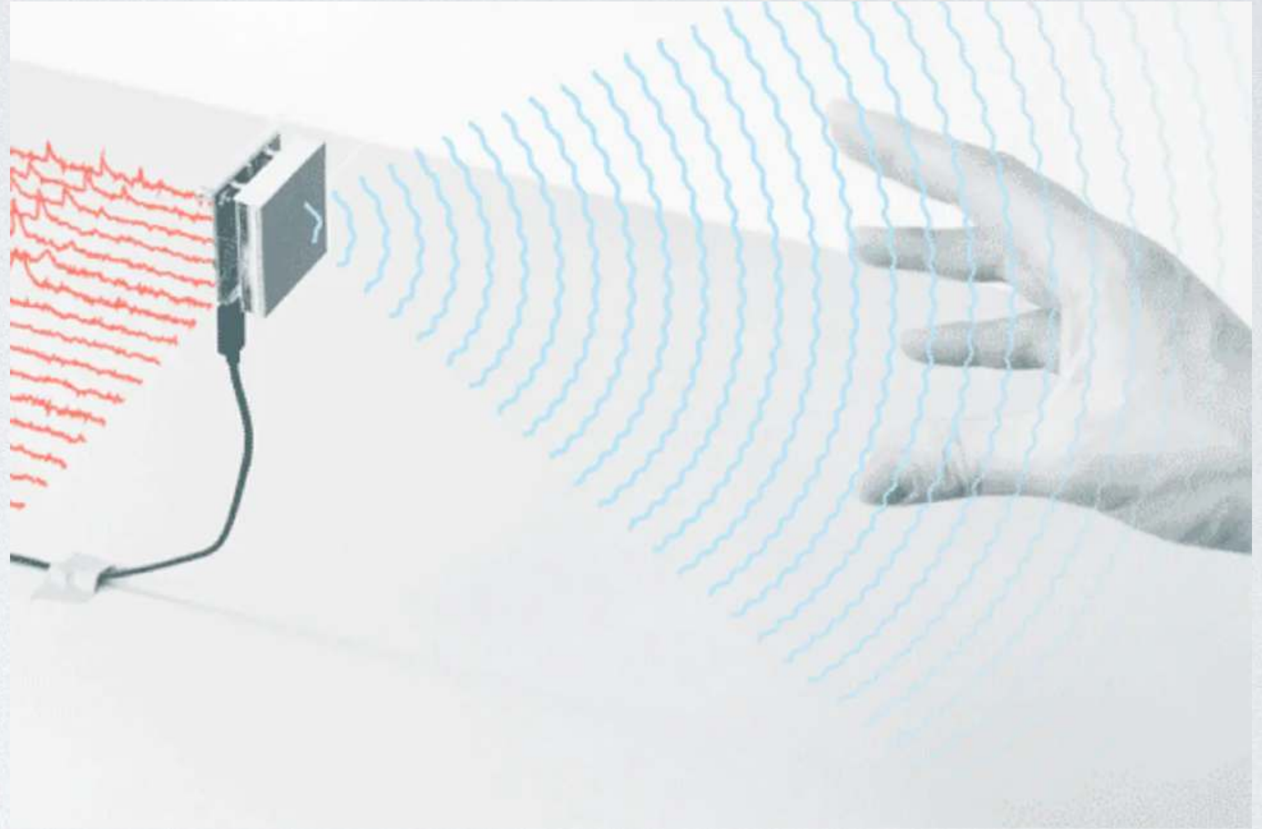
Hand Tracking Solutions

Depth-based
Atheer



Camera-based
HoloLens, Microsoft



Radar-based
Soli, Google

Advantage of Depth Cameras

None of the other solutions can support hand gestures to manipulate 3D virtual objects in absolute 3D coordinates

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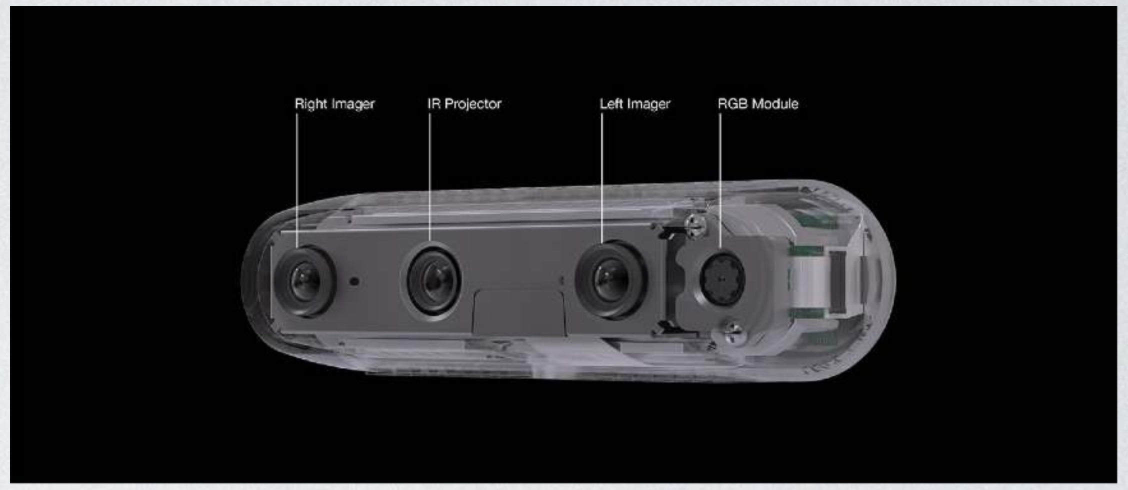
Depth-Based Avatar Tracking

State of the Depth Cameras

PrimeSense / Kinect 1
(Acquired by Apple)

SoftKinetic
(Acquired by Sony)

PMD by Infineon
(used on Magic Leap 2)



Intel RealSense
(Partially Discontinued)

StereoLabs ZED 2 Camera

Microsoft Azure Kinect

Apple iPhone LIDAR

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Four Depth Cameras Technologies

	Structure from Motion	Depth from Stereo	Structured Light	Time-of-Flight
Pros	• 3D localization & visual odometry • Large-scale reconstruction from big data photos	• Outdoor apps • Good tradeoff between accuracy and cost • Accuracy on texture regions	• Indoor apps • Low cost and low complexity	• High-precision applications • 3D localization • Dense 3D reconstruction
Cons	• Real-time 3D reconstruction and scanning • Dark environments	• High-precision applications • Hot/cold environments • Limited range	• High-precision applications • Limited range • Limited resolution	• Expensive • High power • Not always work under the Sun

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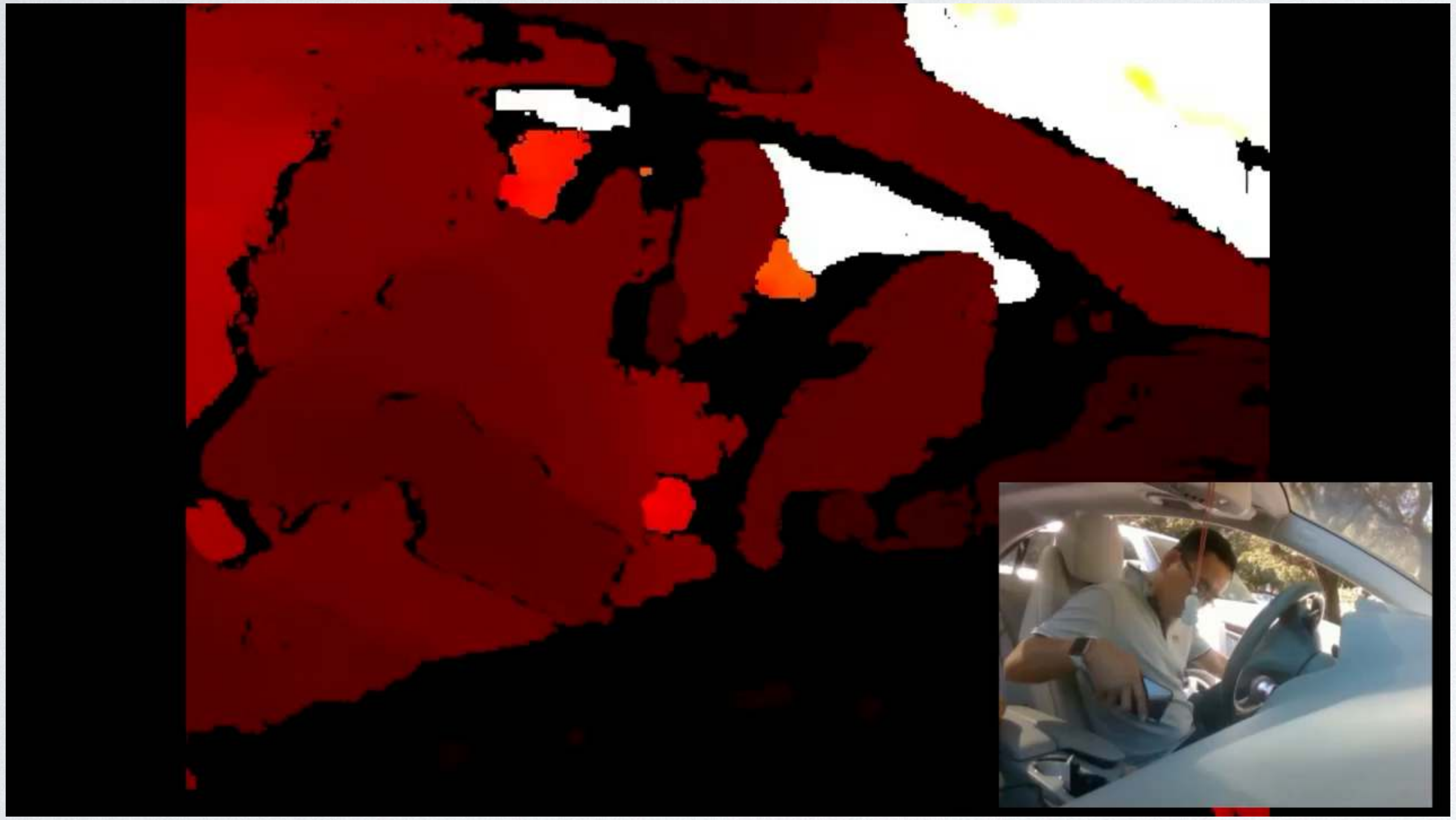
Quality of Depth Result is Critical for Applications



Intel RealSense D435i, Depth-from-Stereo technology

Azure Kinect, Time-of-Flight technology

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Depth Perception for Room-Scale 3D Hologram

Microsoft Holoportation, 2016

Google Project Starline, 2021

Availability of Accurate Depth is Critical

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3D Localization

Finding Virtual Asset in Physical World -- Pokemon Go AR Experience

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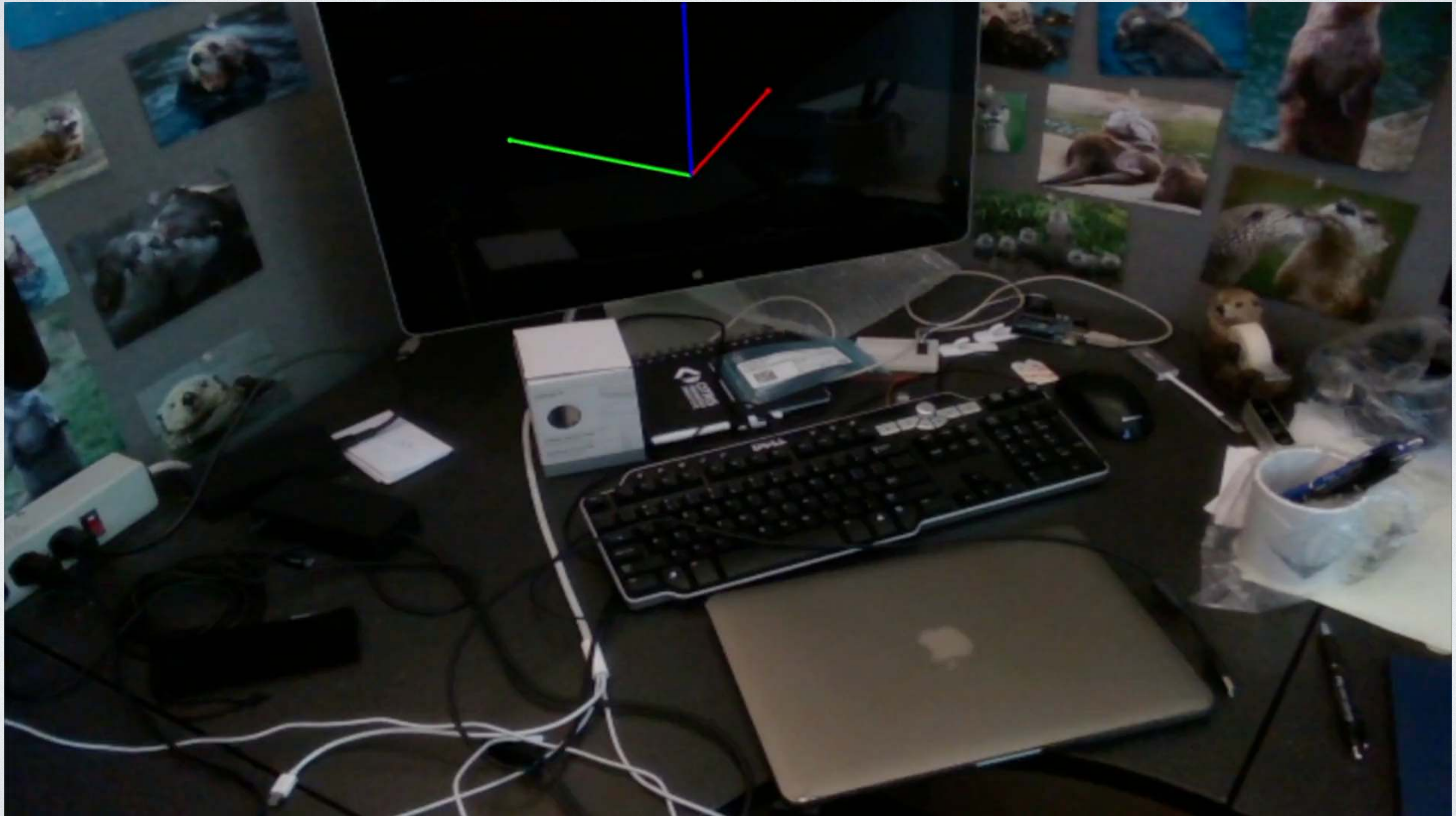
Visual-Inertial Odometry in OpenARK



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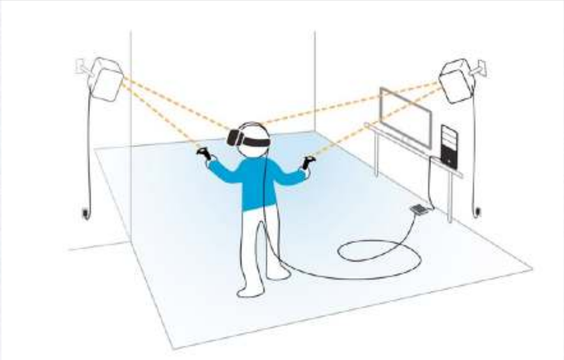
3D Localization Approaches

Method	Outside-In	Inside-Out	Digital-Twin Localization
Hardware	Satellites or Base Stations	Dual Cameras, Synchronized IMU	Camera, LIDAR, IMU
Algorithm	Triangulation	Visual-Inertial Odometry	3D Object Localization
Use Cases	Installation of basestations in limited space	All-in-One Wearable AR/VR	Pre-trained on Known Objects, Utilize three sensing modalities
			

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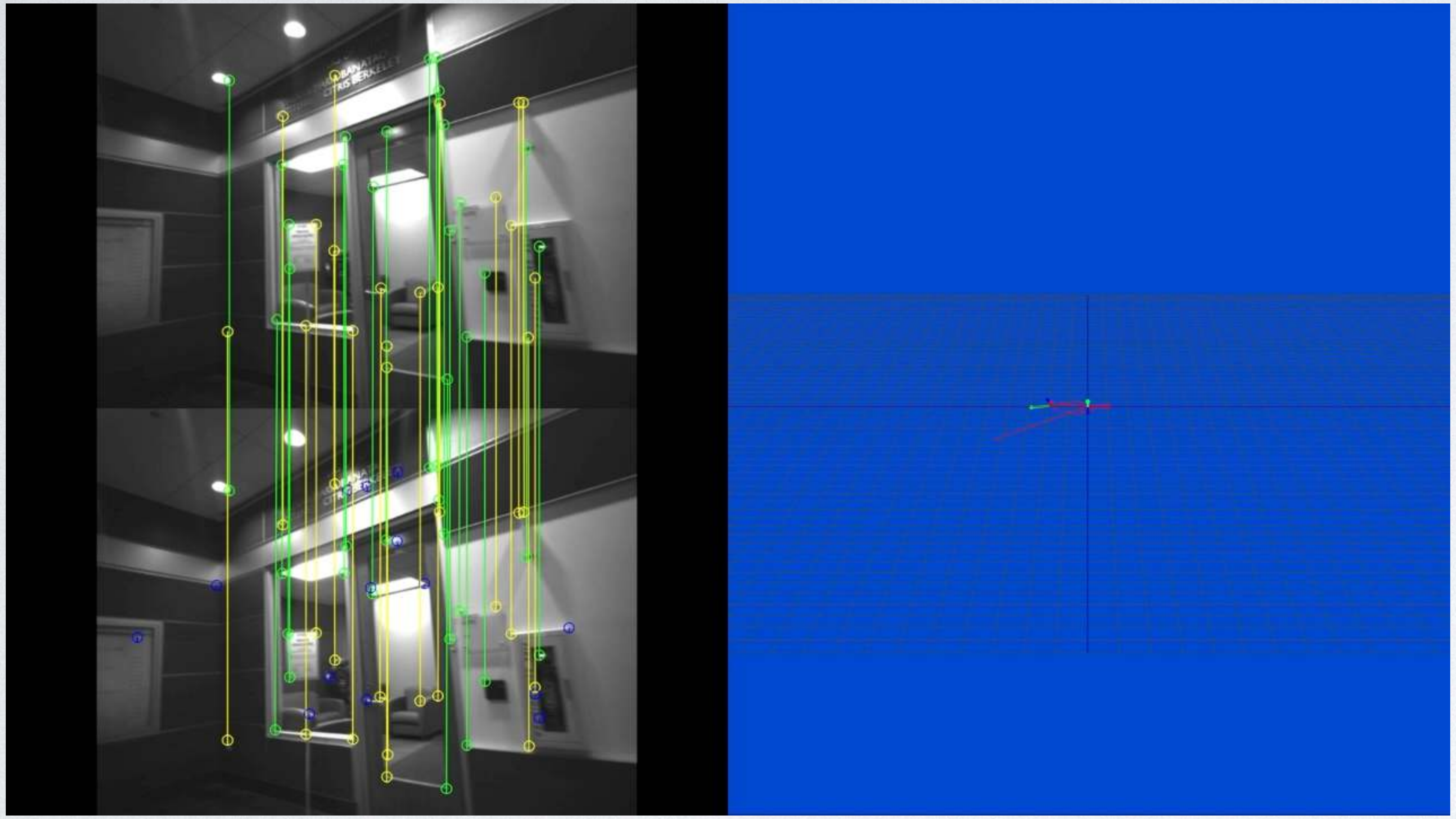
Simultaneous Localization and Mapping (SLAM)



Limitations

- Hardware sync (cameras, IMUs, LIDAR) is a must
- Dual camera is better than single
- More is not always better: Depth data are significantly more noisy (Azure Kinect do not natively support SLAM)
- Less is not always better: SLAM may fail when 3D surface lacks visual features

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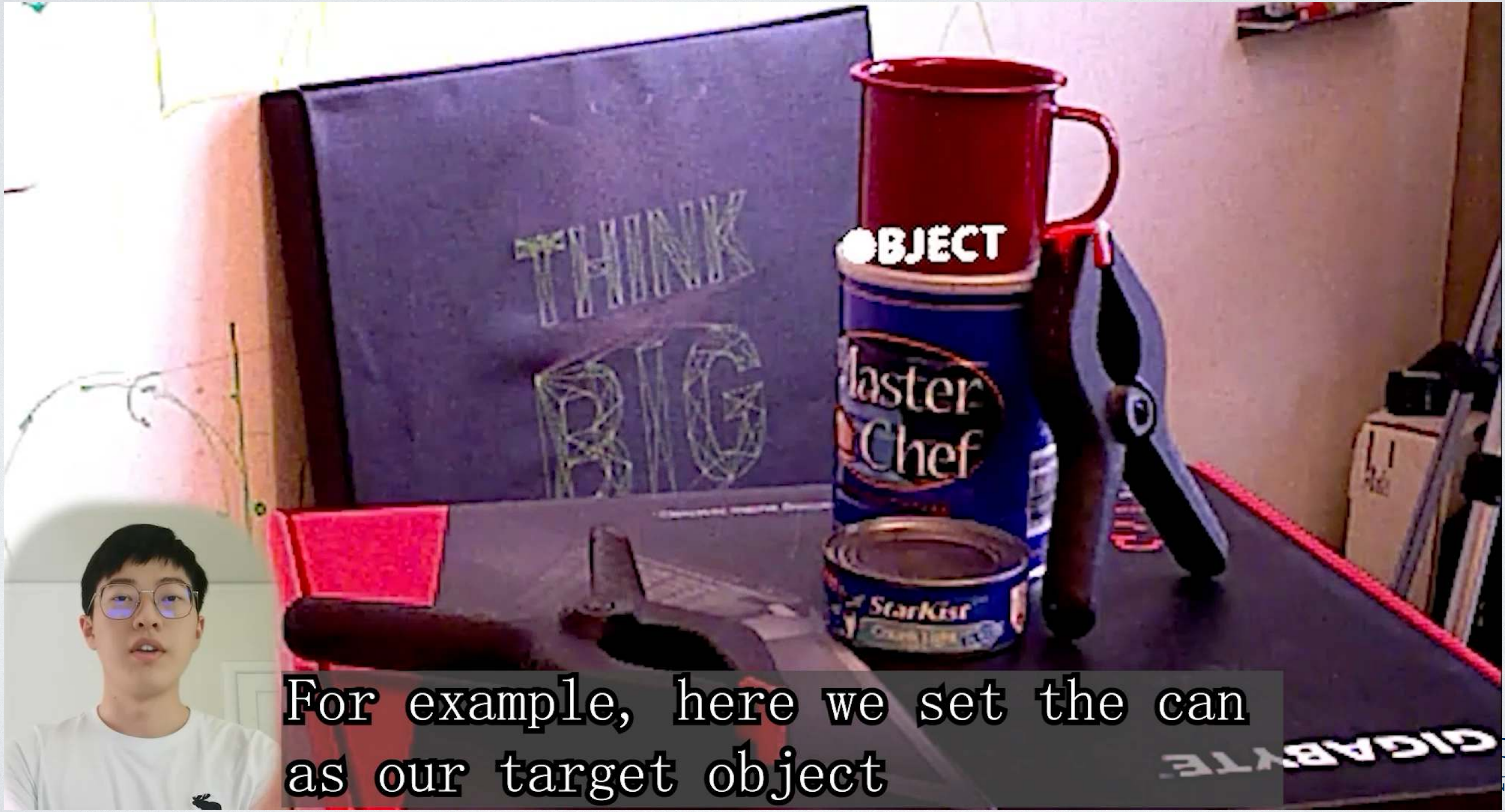
Digital-Twin 3D Localization



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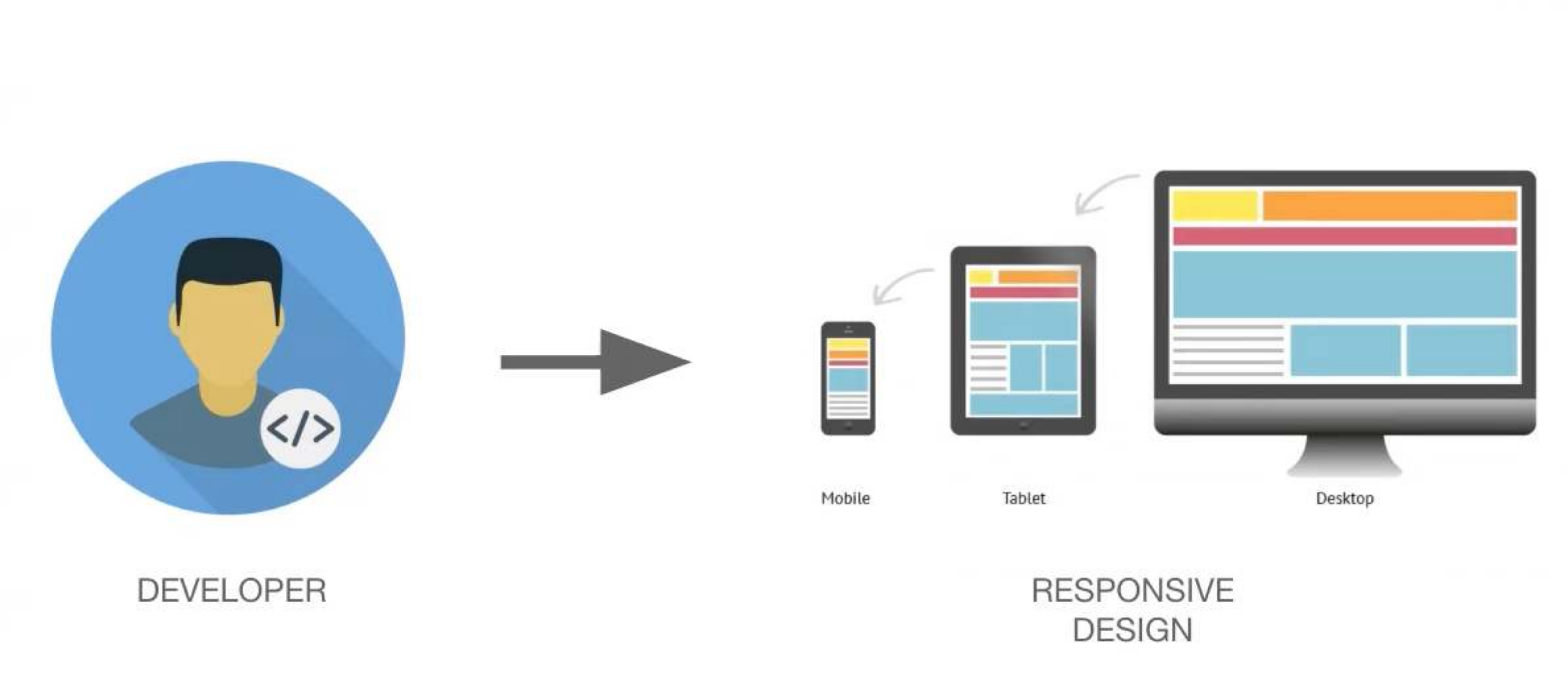
Spatial Computing Merging Virtual and Physical Worlds



Asset Placement across Platforms

- One code across multiple computer platforms (Java/HTML)
- Developer doesn't know screen size/resolution/orientation (Separation of content and layout: CSS)
- But, within the web browser, UI functionality is uniform

* Mohammad Keshavarzi, Contextual Spatial Computing: A Generative Approach, Berkeley PhD Dissertation, 2022

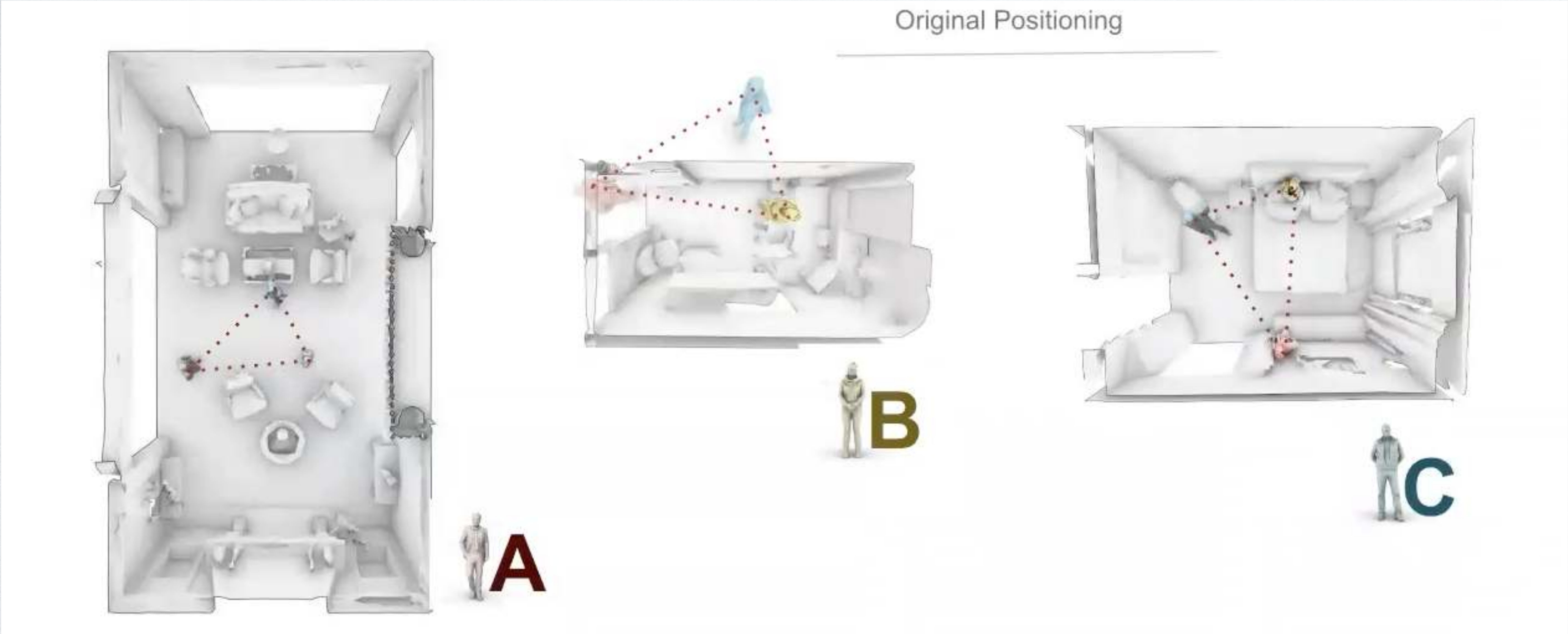
Spatial Computing Merging Virtual and Physical Worlds

Asset Placement in AR

- One code across multiple computer platforms (Game Engines)
- Developer doesn't know varying 3D space shapes
- Layout and furniture in 3D space have different contextual functions

* Mohammad Keshavarzi, Contextual Spatial Computing: A Generative Approach, Berkeley PhD Dissertation, 2022

Spatial Computing Merging Virtual and Physical Worlds



Unknown User Input

- User interacts with 3D virtual content from different perspective
- User's own posture and actions possibly drive the content
- User have expectations when interacting with other users

* Mohammad Keshavarzi, Contextual Spatial Computing: A Generative Approach, Berkeley PhD Dissertation, 2022

* Keshavarzi, Yang, Caldes, et al. SceneGen: Generative Contextual Scene Augmentation using Scene Graph Priors, IEEE VR Conference, 2020.

* Keshavarzi, Yang, Caldes, et al. Optimization and Manipulation of Contextual Mutual Spaces for Multi-User Virtual and Augmented Reality Interaction, IEEE VR Conference, 2020.

* Keshavarzi, Yang, Caldes, et al. Synthesizing Novel Spaces for Remote Telepresence Experiences, ISMAR 2022.

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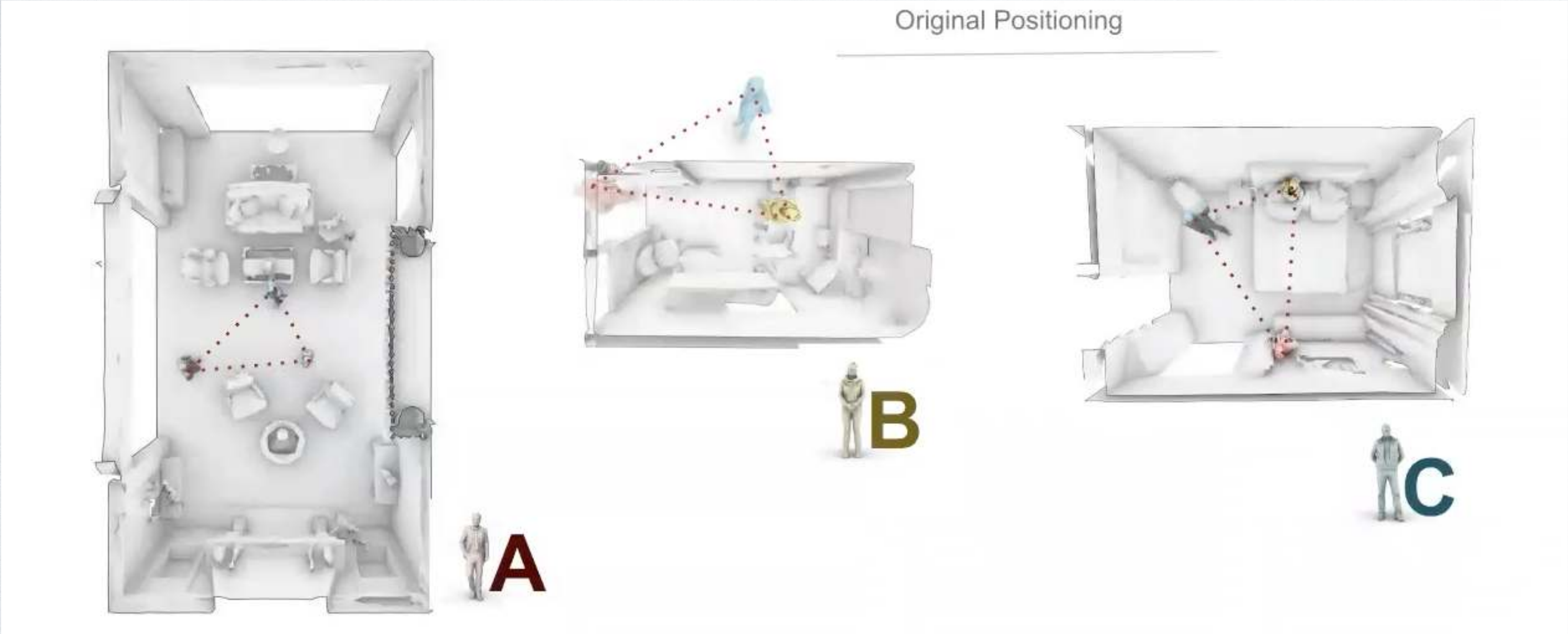
Does Multi-User Metaverse Compromise Privacy?



Privacy Concerns

- Other users may infer user's own private 3D space
- Other users may infer user's own meta data
- Bad actors may create fraudulent counter-parties to scam users

* Vivek Nair, et al. Exploring the Unprecedented Privacy Risks of the Metaverse (MetaData), 2022.
* Vivek Nair, et al. Going Incognito in the Metaverse (MetaGuard), 2022.

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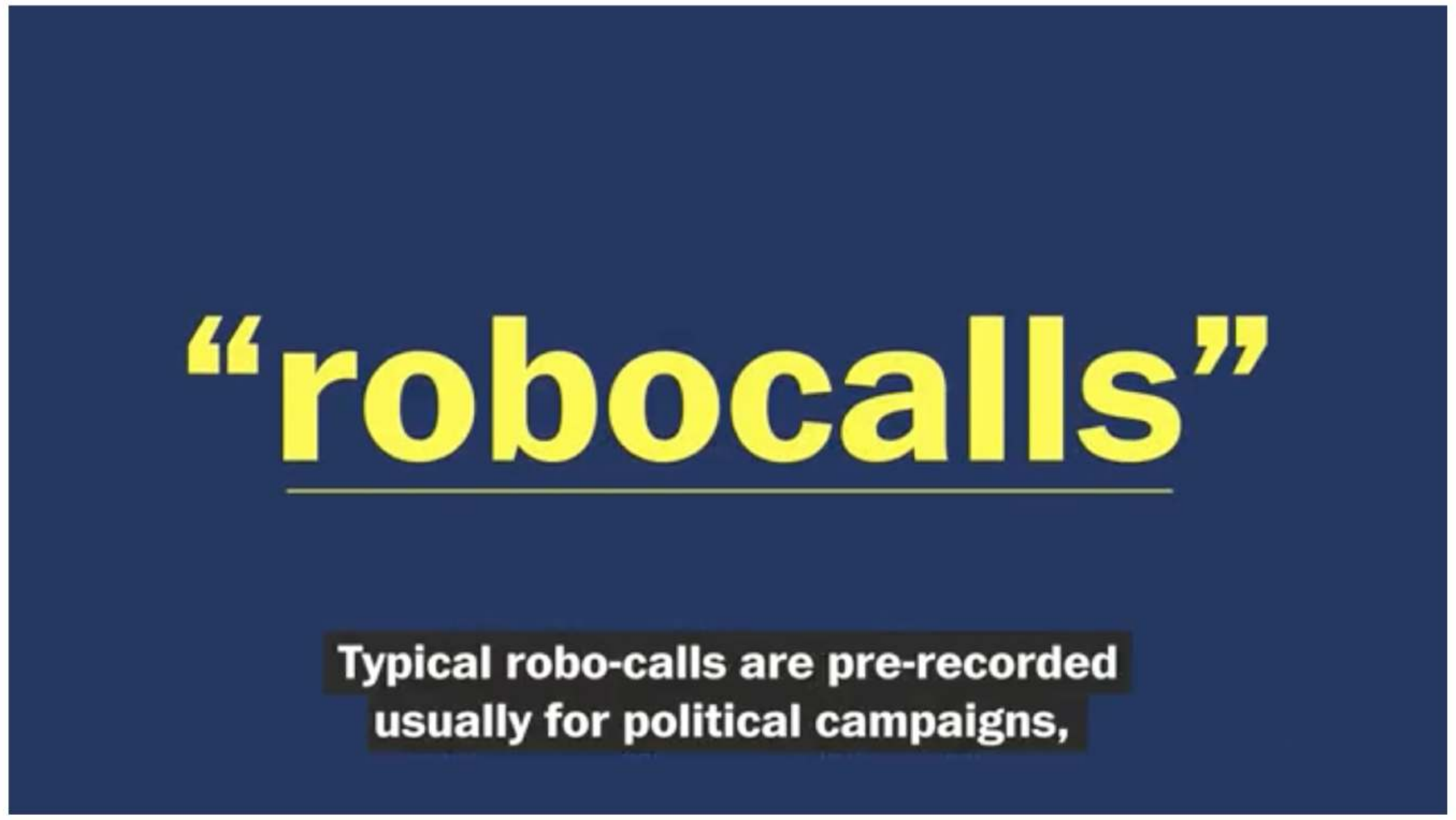
Challenges in Safeguarding User Privacy before the Internet

The Washington Post
Democracy Dies in Darkness

THE SWITCH

Nearly half of cellphone calls will be scams by 2019, report says

By Hamza Shaban
September 19, 2018 at 9:24 a.m. EDT



Ever get a phone call from a number that looks suspiciously like your own? This video explains them, and what you should do about them. (Video: Jhaan Elker/The Washington Post)

Gift Article Share

Nearly half of all cellphone calls next year will come from scammers, according to First Orion, a company that provides phone carriers and their customers caller ID and call blocking technology.

IRS
Department of the Treasury
Internal Revenue Service

Washington, DC 20224
Phone: (202) 852-4216
Fax: (202) 852-5756
Website: www.IRS.gov

Steven Terner Mnuchin
Secretary of Treasury

Charles Rettig
IRS Commissioner

October 10, 2018

Re: IRS Audit Number: [redacted]

Dear

My name is Lewis J. Fernandez. I am the Associate Chief Counsel with the income tax and accounting division of the Internal Revenue Service (IRS). The IRS is now mandated to conduct preliminary audits of U.S. tax payers and you were selected for an audit. The preliminary audit has indicated major issues with your filings of the years 2012, 2013, and 2014 and I need to speak with you concerning those income tax filing years.

You must contact me within the next five (5) working days of receipt of this letter between the hours of 8AM EST and 4PM EST at (202) 852.4216. If I am not available when you call, please be sure to leave a message. When you call, please have with you the following:

1. Your income tax filings for 2012, 2013 and 2014;
2. Your social security number, State ID or driver's license;
3. Your current banking information;
4. Current employment information if applicable;
5. Information concerning your personal assets (i.e. car, home, etc.)

Your cooperation in this matter is expected. In the event you elect or fail to contact me, understand you will be subjected to additional fines and a full audit requiring you to appear at a regional IRS office and face a potential investigation.

Be sure to have this letter with your IRS Audit number above so I can quickly reference your case when you call.

Sincerely,

Lewis J. Fernandez
Associate Chief Counsel,
IRS income tax & accounting

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Challenges in Safeguarding User Privacy in Web 2.0


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TECH · TWITTER

Bob Iger says Disney abandoned Twitter acquisition in 2016 after discovering 'substantial' amount of bots

BY KYLIE ROBISON
September 7, 2022 at 5:59 PM PDT

KIMBERLY WHITE/GETTY IMAGES FOR VANITY FAIR

Former Disney CEO Bob Iger says that he was spooked by the prevalence of bots on Twitter long before Elon Musk.

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At Vox Media's Code conference on Wednesday, Iger discussed Disney's efforts to acquire Twitter in 2016, and pointed to Twitter's bot spam accounts as one of the factors that led Disney to ultimately decide against moving forward with an acquisition.

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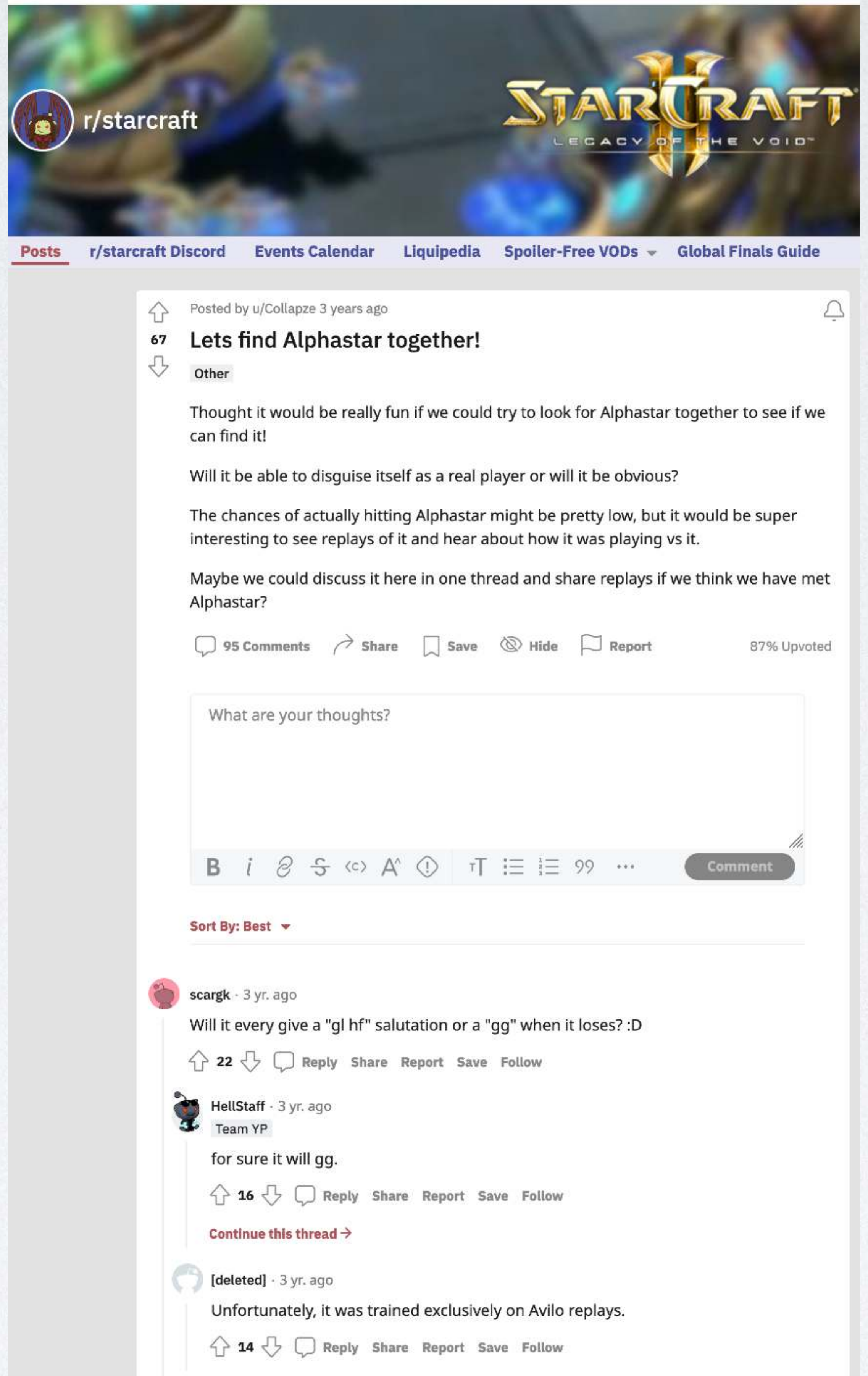
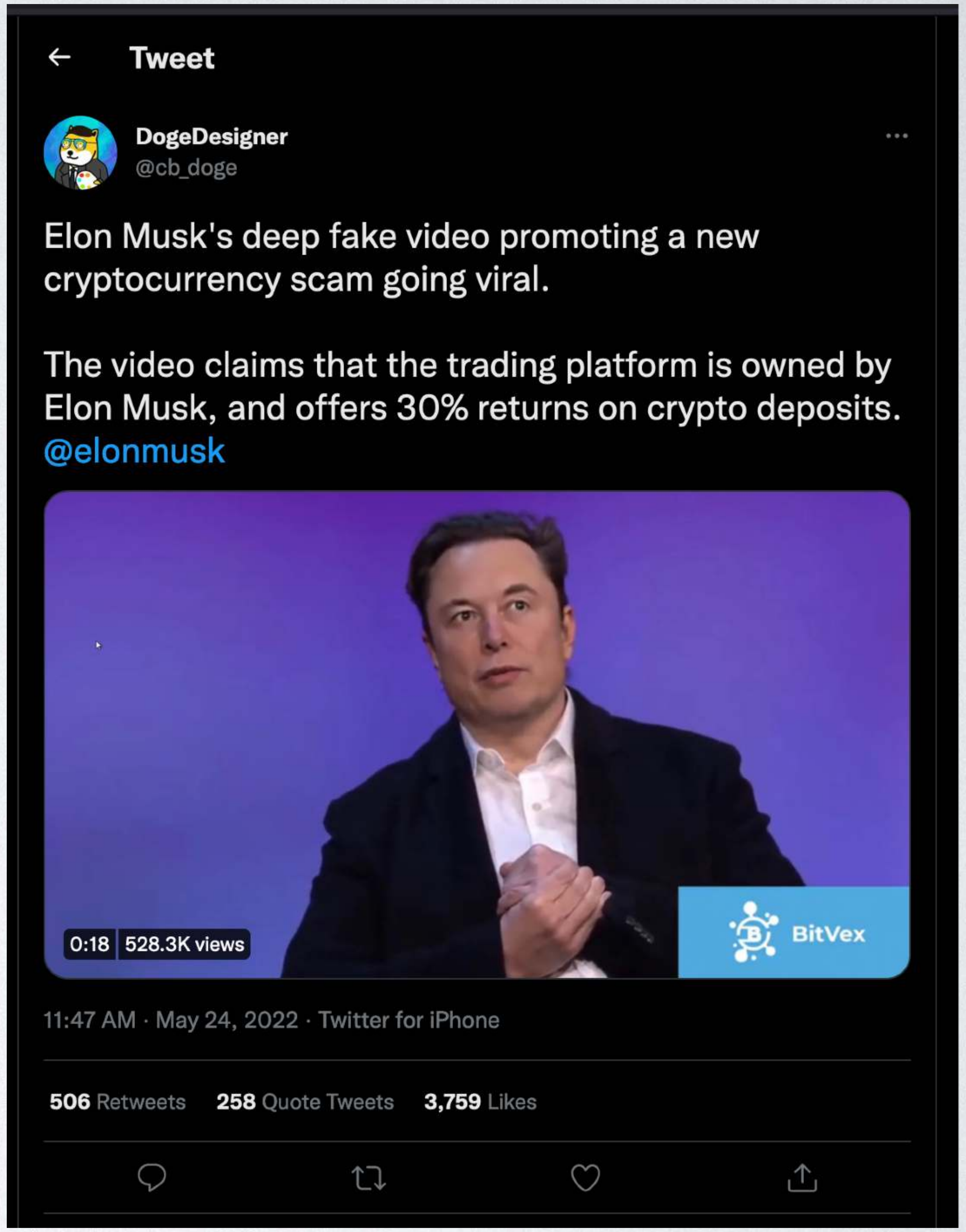
Twitter may have a lot of bot users



DeepMind AlphaStar pretends to be human players



Deepfake using Elon Musk image to promote scam

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What "Ready Player One" is really about: Privacy and Decentralization

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Metaverse and Web 3.0: New Opportunities

"Metaverse isn't a thing a company builds. It's the next chapter of the internet overall."

--Mark Zuckerberg

	Who owns user data?	Trust & Verify?	Interoperability?
Web 1 & 2	Private Companies, Mutable	Lack of penalty for fraud	Centralized
Web 3.0	Users, Immutable	Smart contracts with financial penalties	Decentralized

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The Next Chapter into the Metaverse: defi.berkeley.edu

Berkeley Defi Research Initiative

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Mission

Connecting the world of individuals and businesses in fully decentralized and trustless fashion has generated tremendous excitement to develop new solutions in the blockchain and defi space. Although the technologies behind them are still considered far from matured, promising applications are taking shape in

- Decentralized Finance / Cryptocurrencies
- Decentralized Social Media / Metaverse
- Decentralized Tokenization / NFTs

Berkeley Defi Research Initiative aims to support the long-term growth of blockchain and defi technologies and applications by offering our expertise to

- Create new education and degree programs for motivated students
- Promote cross-disciplinary research to address urgent technology bottlenecks
- Provide a Berkeley platform for academic and industrial partners to collaborate

Together, we can shape our society in a digital world that is more immersive, more connected, and more fair.

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True Cost to Blur Reality and Virtuality

-- Understand the fundamental challenges in creating virtual 3D experience

Thank you!

Dr. Allen Y. Yang
Email: yang@eecs.berkeley.edu

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