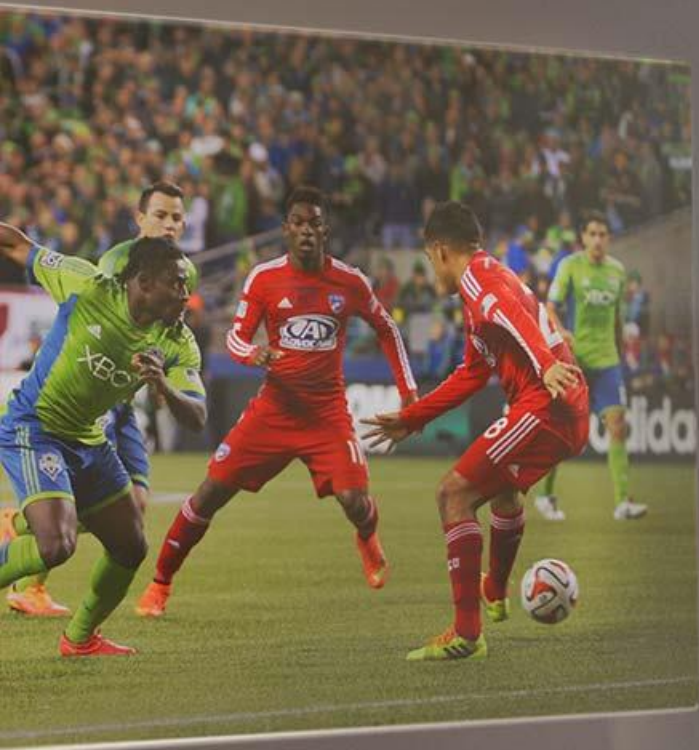


Interacting with Photons

Creating Interactive Projected Augmented Reality Experiences

Hrvoje Benko
Microsoft Research
October 2015



Maui

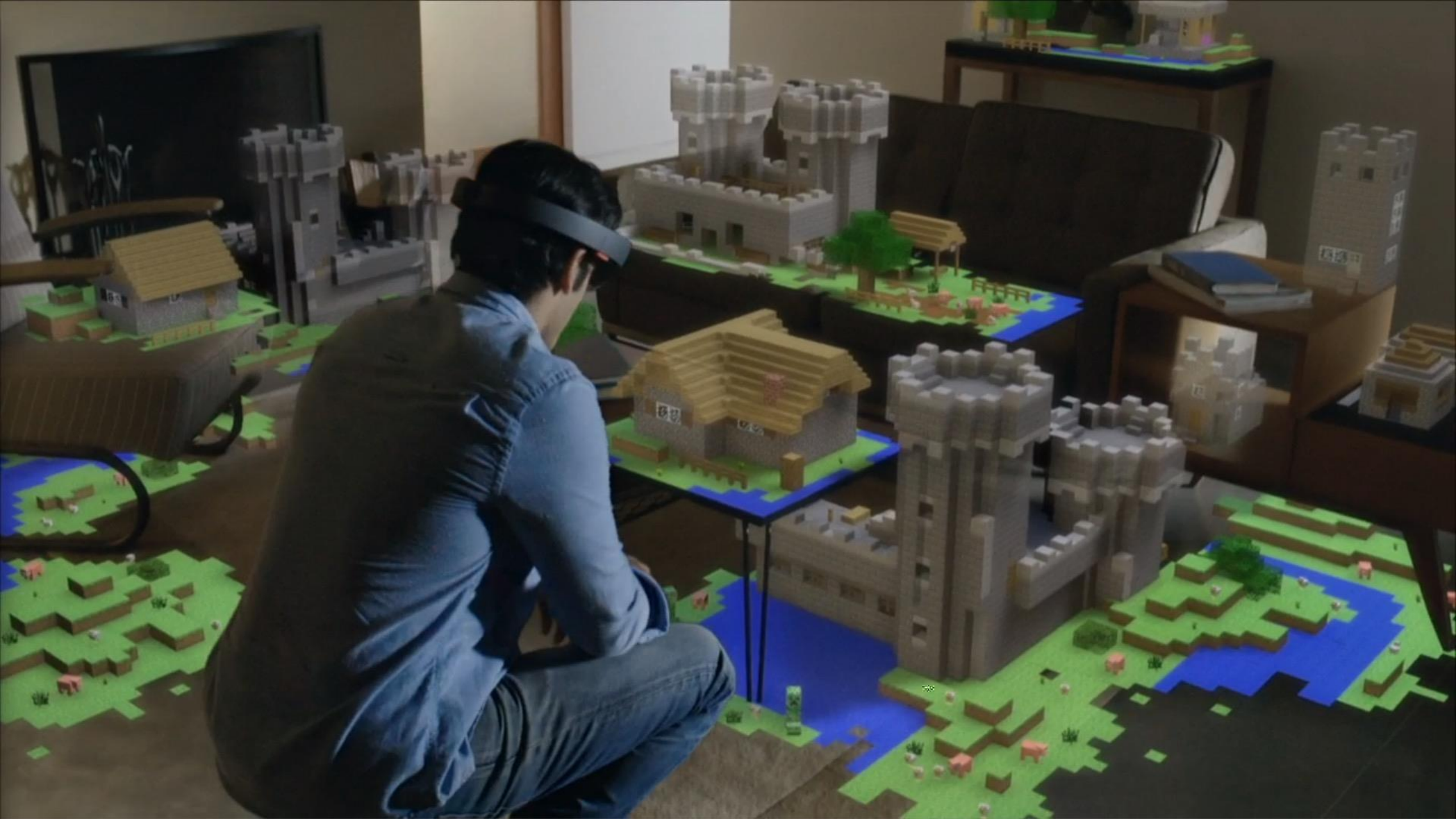
Mon	Tue	Wed
		
71°F	74°F	76°F



Vacation To-Do List

- Ticket
- Sun screen
- Beach towel
- Sunglasses
- Charger

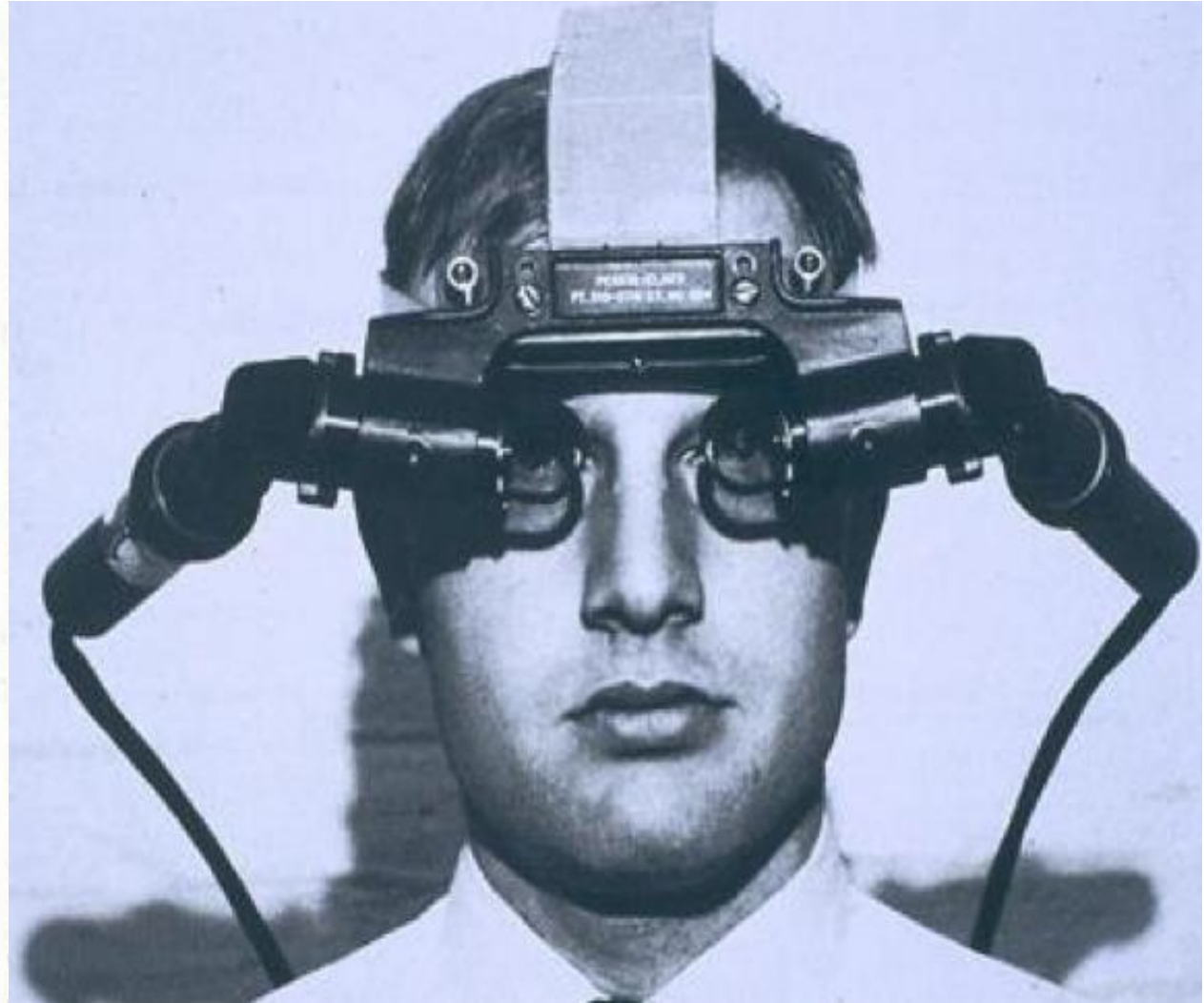






 **MetaPro**
PROTOTYPE v3.8





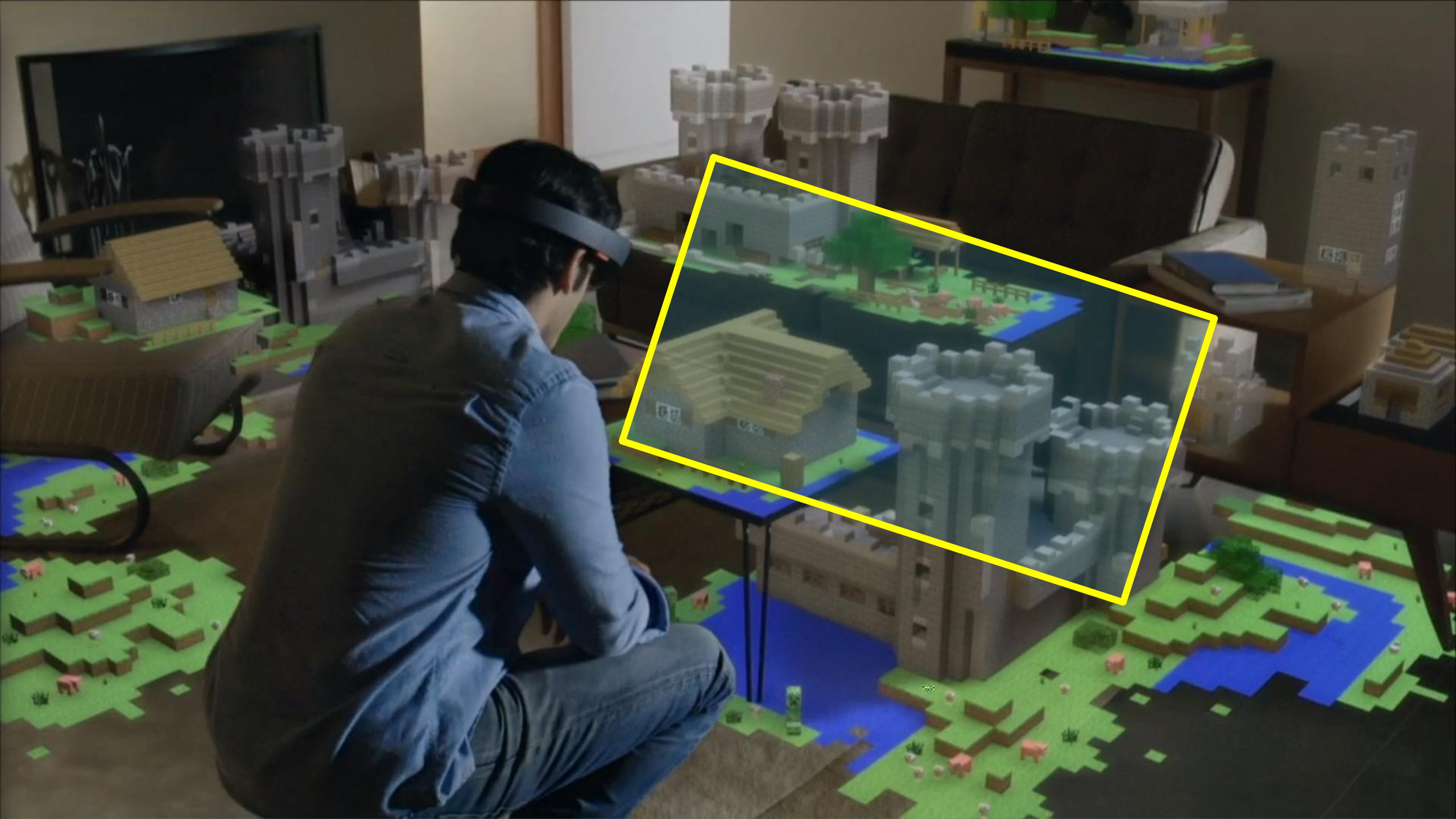
Ivan Sutherland, 1968.

Challenges with glasses



Columbia Touring Machine. ISAR 2001.





Alternate AR vision

To create authentic augmented reality experiences that are situated in the real world, don't require additional gear to be worn, yet enable a high degree of interactivity with computer-generated content.

Pro-Cam Unit



Projector

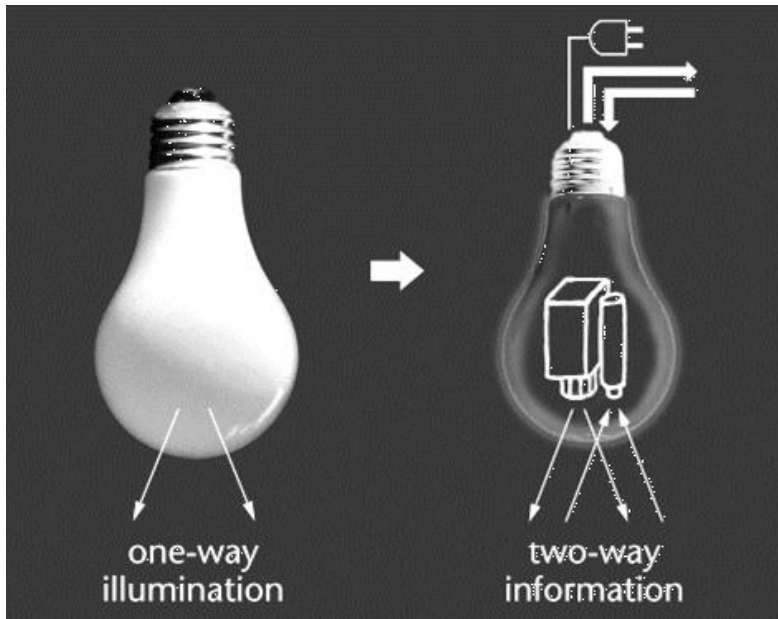


Depth Camera
(Kinect)



GPU-based computation

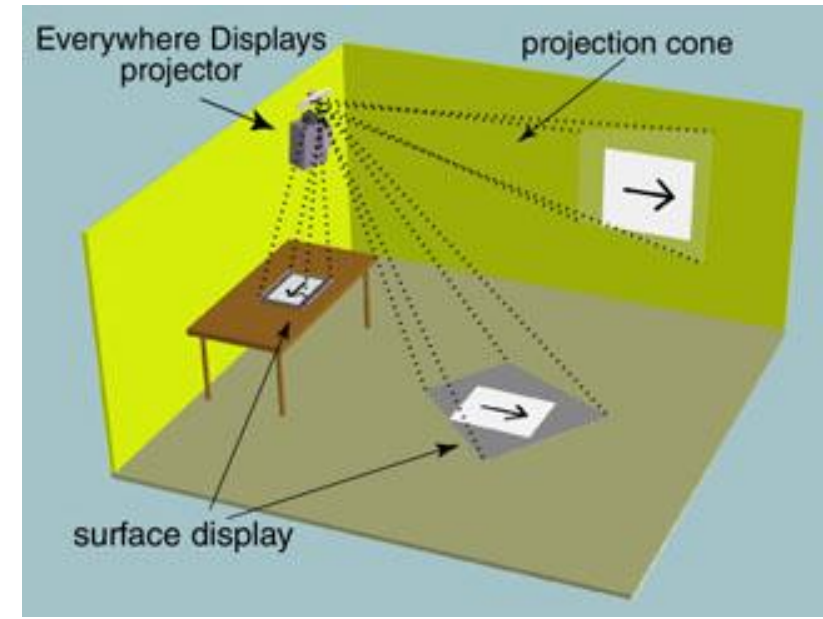
We are not the first



Underkoffler & Ishii, CHI '98



Raskar et al., SIGGRAPH '98

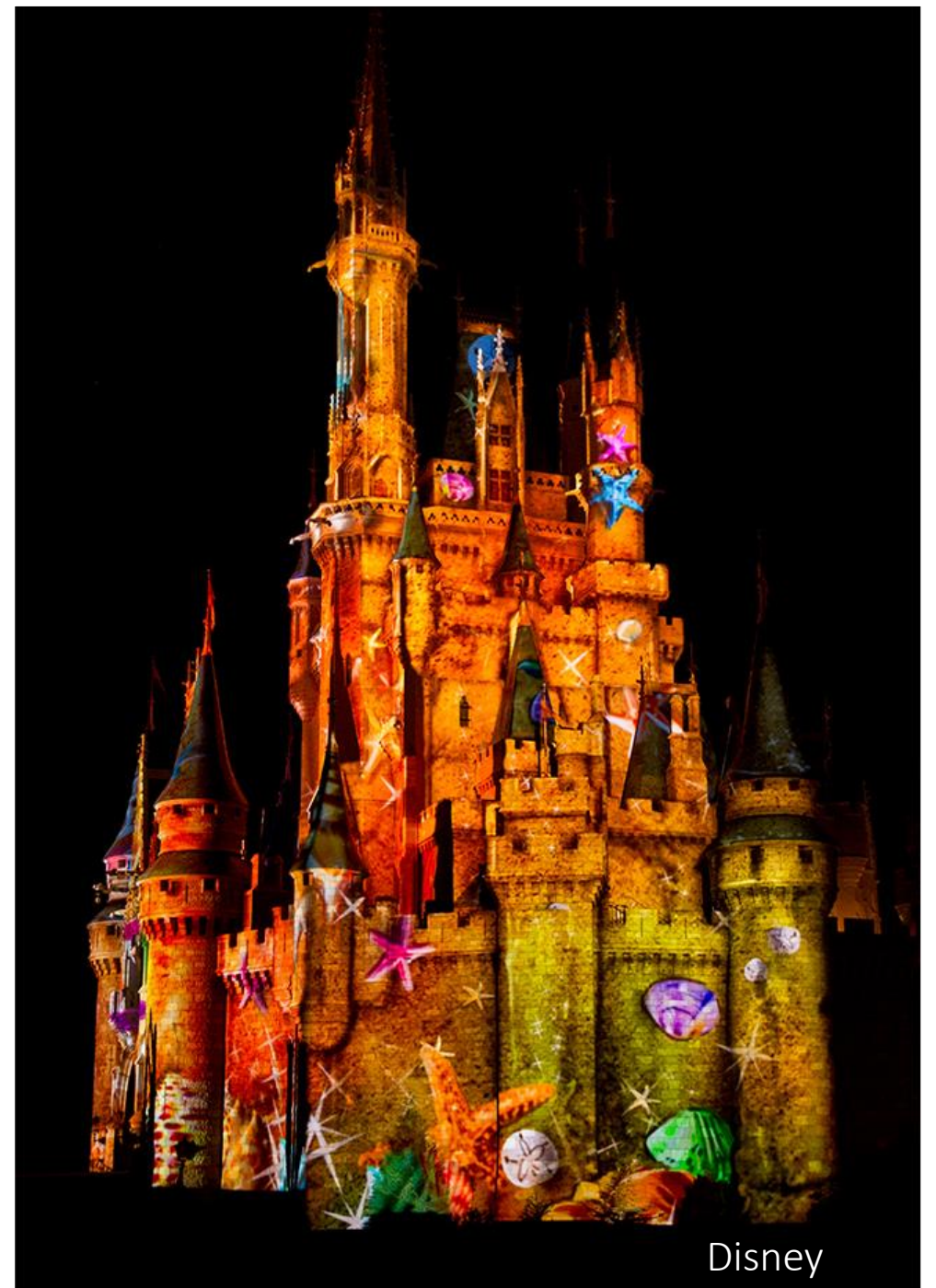


Pinhanez, UBICOMP '01

Projection mapping



[555 Kubik](#) - UrbanScreen



Disney

How our work differs?

Real-time! We don't assume static geometry.

Any surface is a display.

Procedural behaviors and rendering based on the current conditions in the environment.

Our experiences scale from 1 to many nodes.

We want the experiences to be highly interactive, beyond the simple controller input.

We want to enable “**analog**” interactions (i.e., mimic the experience of the real world), while still offering the user “**supernatural**” powers when interacting with computer-generated content.

Analog interactions

MirageTable

MirageTable

Any surface is a display

Beamatron

Beamatron



Pro-cams enable shared experiences

IllumiRoom



Oculus







Radiometric Compensation




Projected Image



Live Footage





Focus

Context Edges

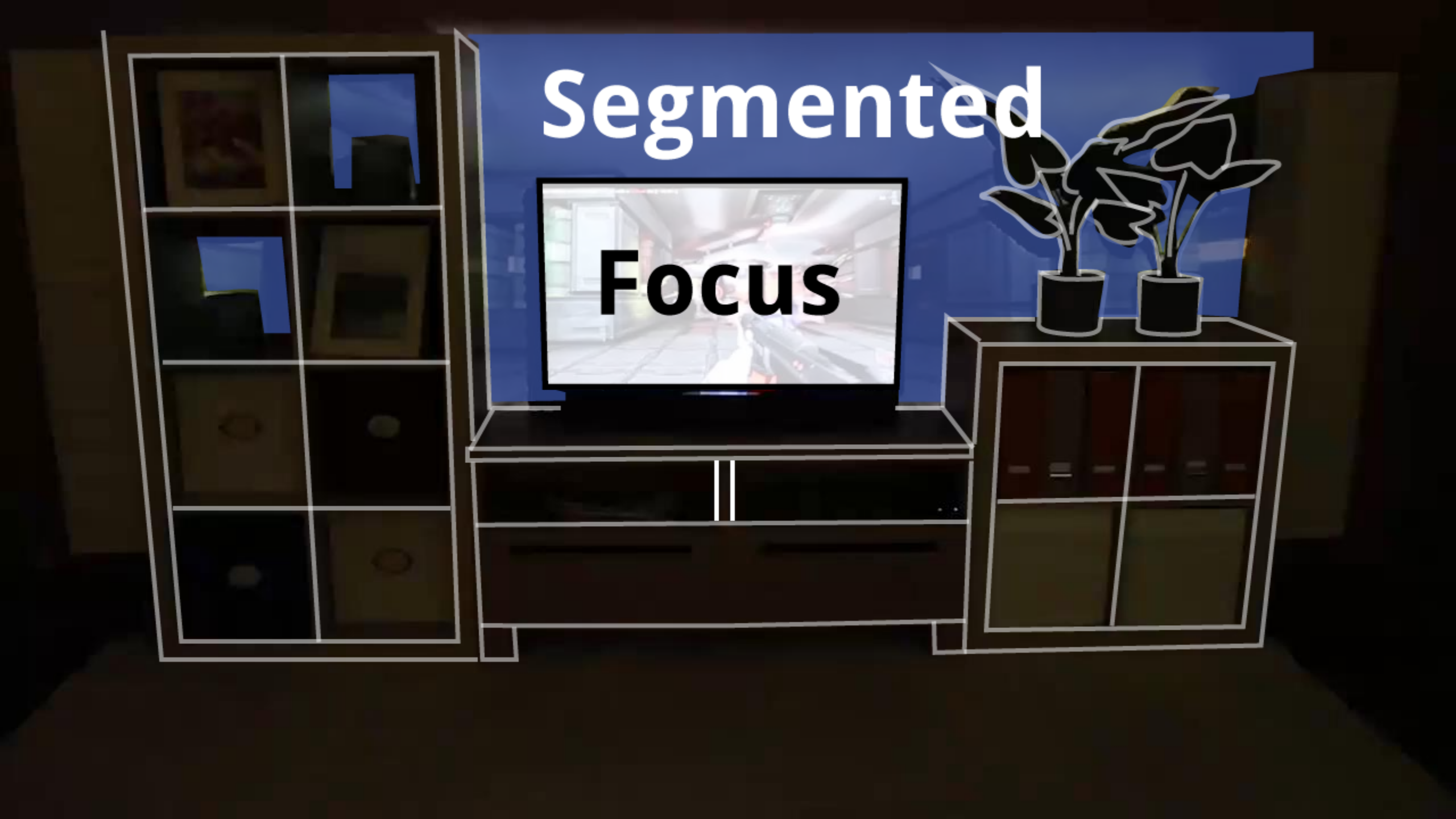
A living room scene with a television set on a stand. The TV screen displays the word "Focus" in a large, bold, black font over a blurred background of a modern interior. To the left is a tall shelving unit with a framed picture. To the right is a side table with two potted plants. The entire scene is overlaid with a white wireframe grid. A blue graphic element with the word "Selective" is in the bottom left.

Focus

Selective



Segmented



FOCUS



Appearance





IllumiRoom Projects Images Beyond Your TV for an Immersive Gaming Experience



Microsoft Research

Subscribe 35,328

4,796,611

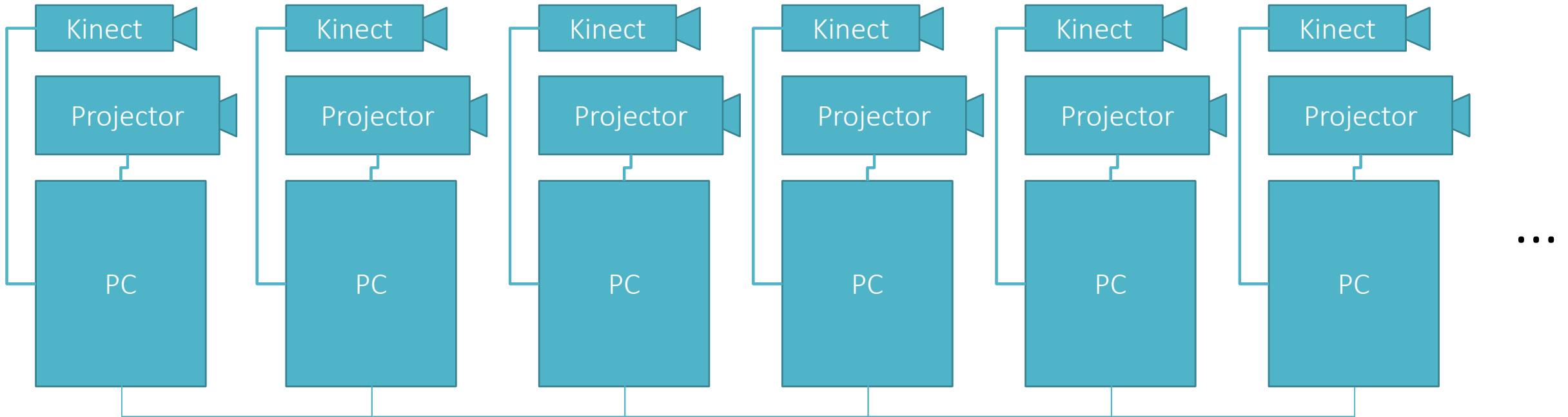
+ Add to Share ... More

25,554 1,292

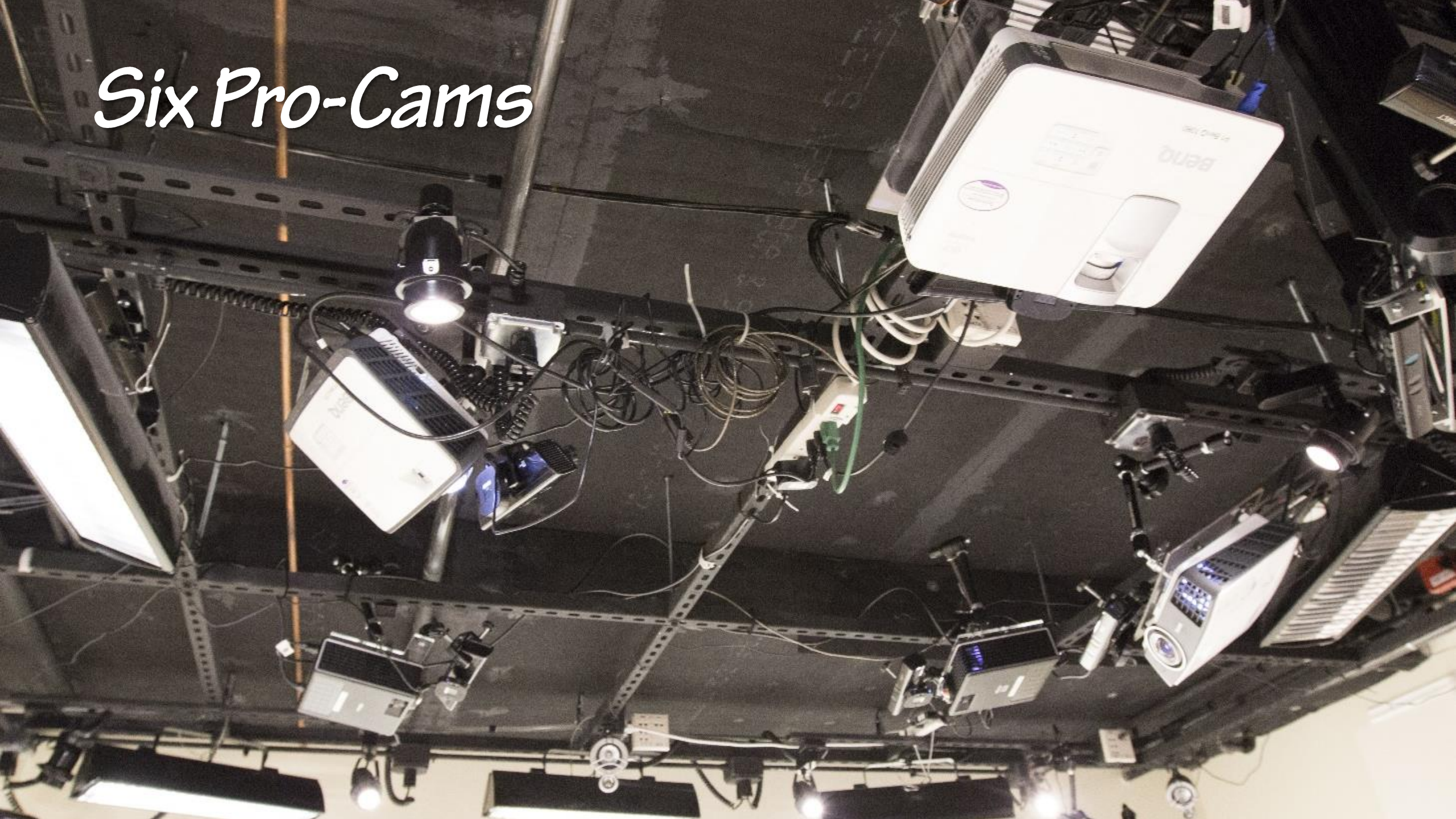
Scaling up to immersive AR rooms

RoomAlive

RoomAlive Distributed System

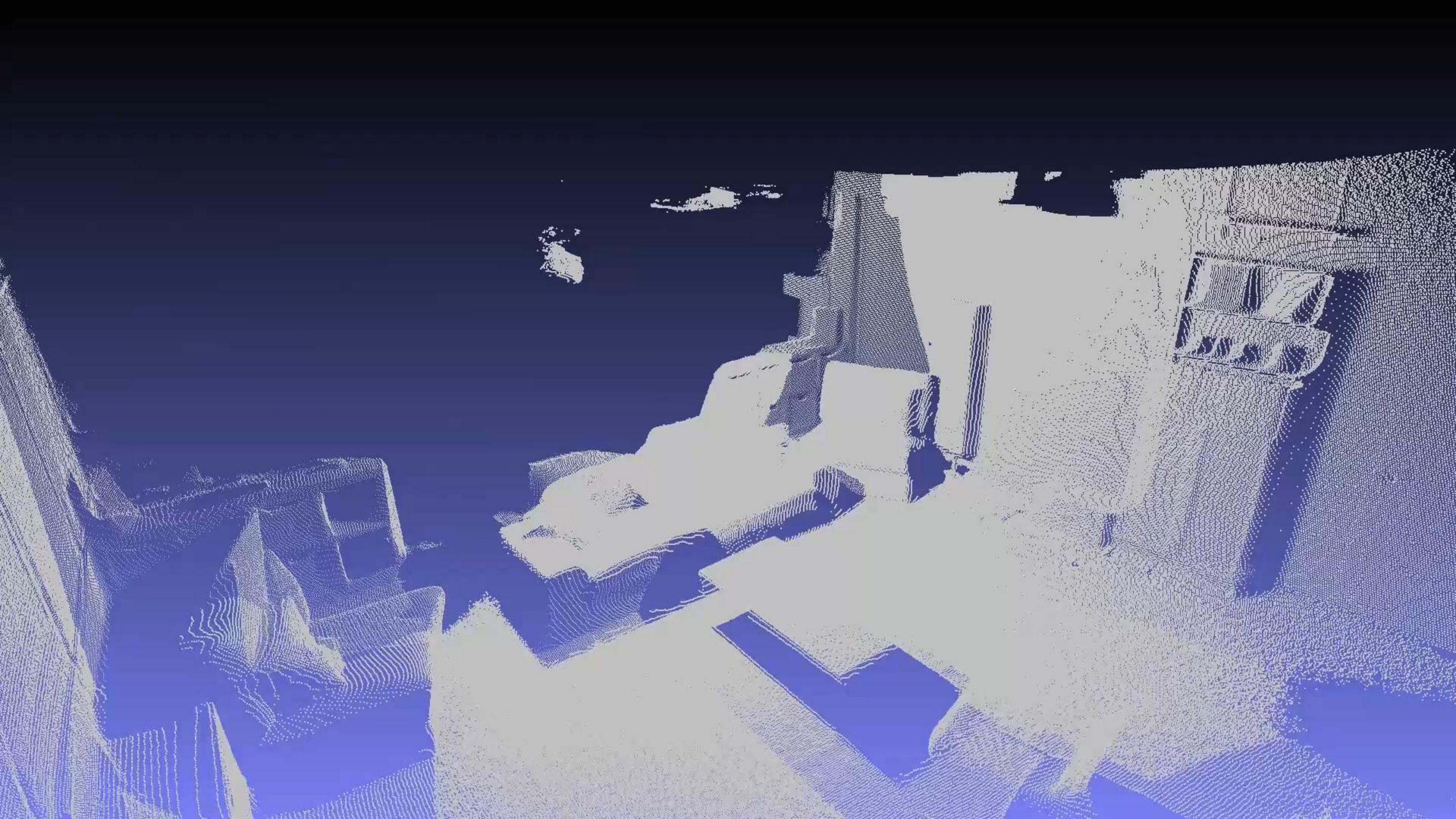


Six Pro-Cams



A dimly lit room, likely a living area, with a light-colored sofa and a coffee table. The room is dark, with some light coming from the ceiling. The text "RoomAlive Calibration @ 4x Speed" is overlaid at the bottom of the image.

RoomAlive Calibration @ 4x Speed



RoomAlive by the numbers

1 living room (99/3319) 5x6 meters

6 projectors (6.3 megapixels at 60Hz)

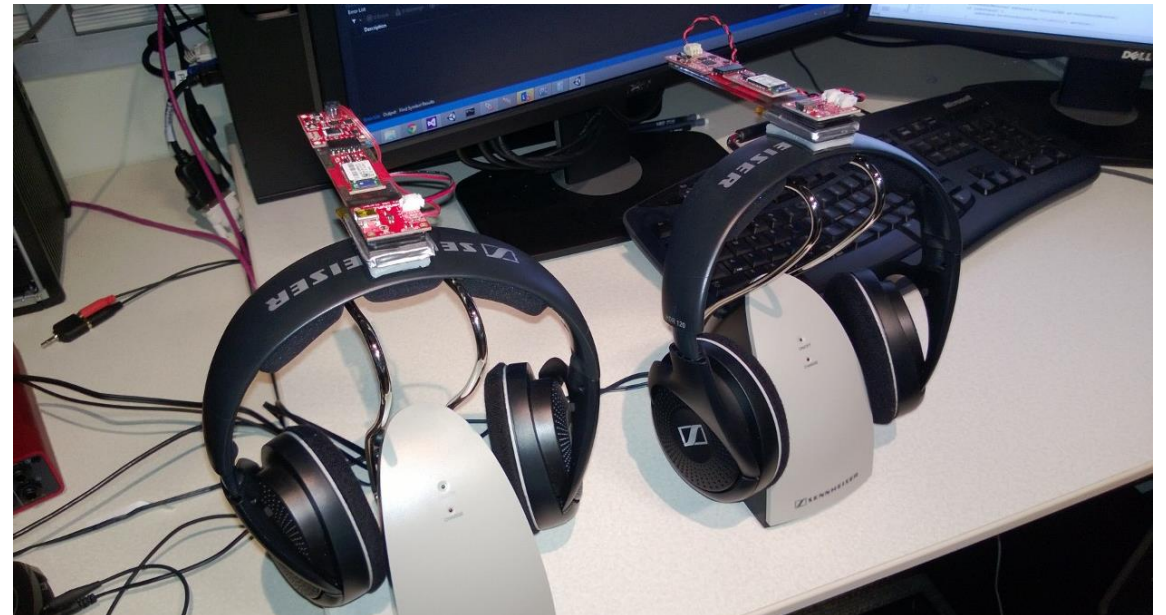
6 Kinect cameras (3.7 megapixels of image data processed at 30 Hz)

6 computers

Distributed game engine (Unity)

2 head-tracked users

Triton 3D sound spatialization

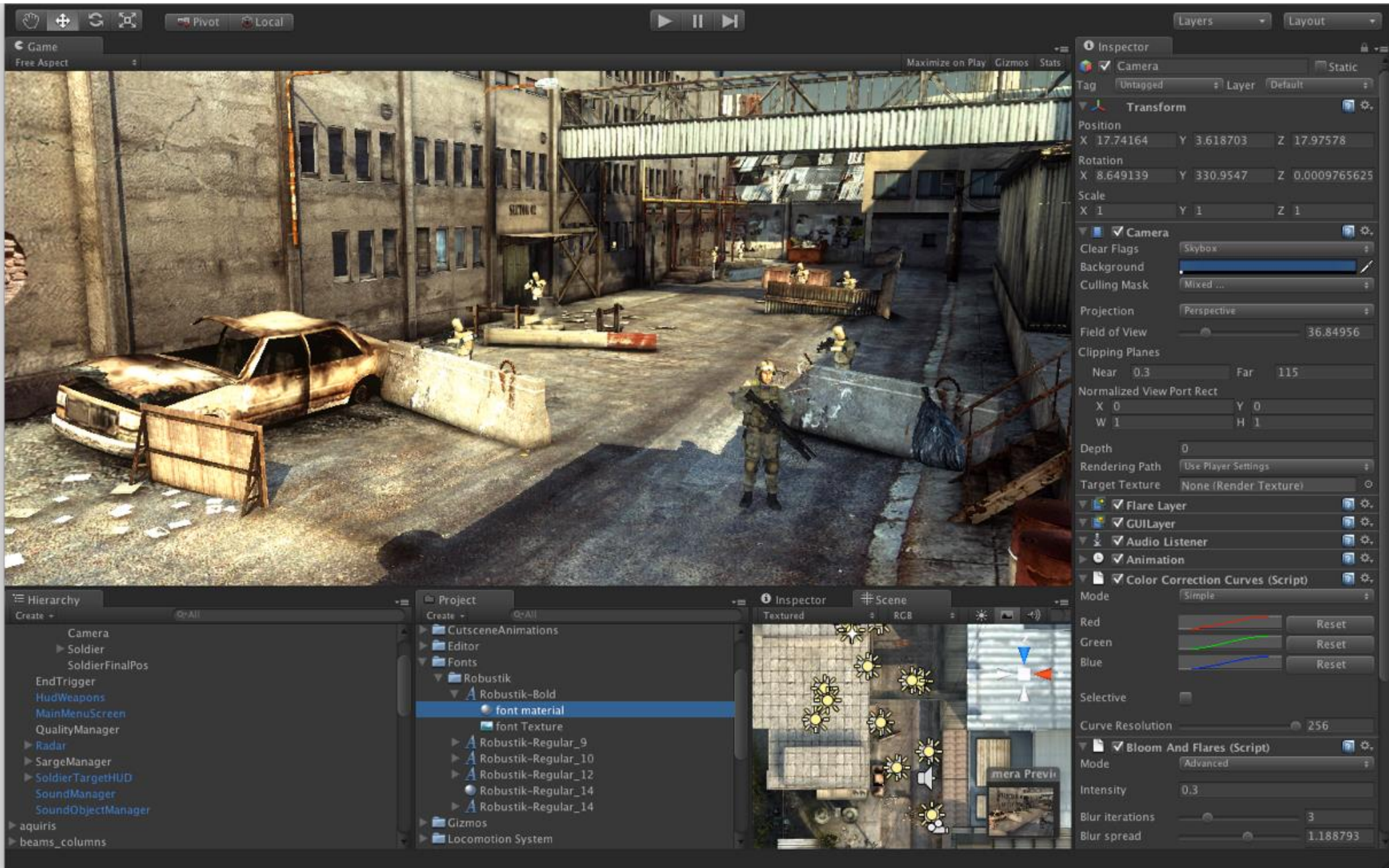








Authoring experiences

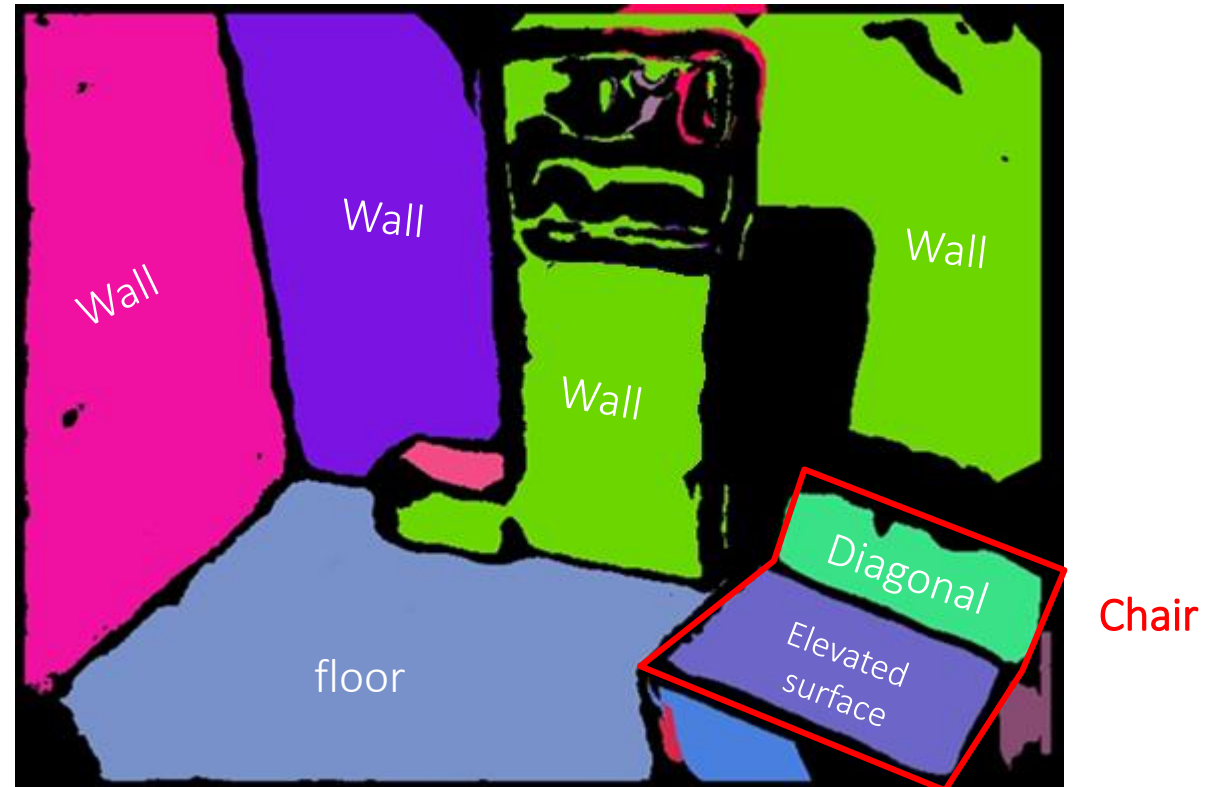




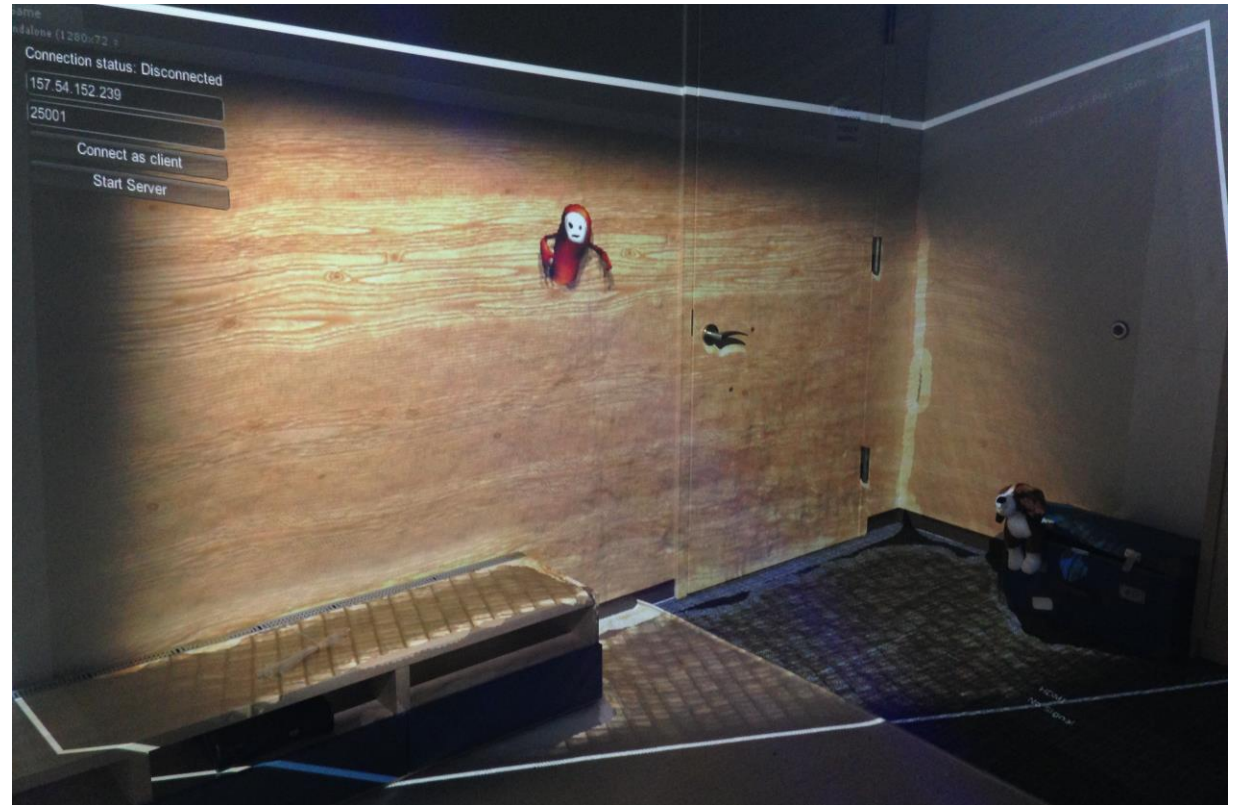
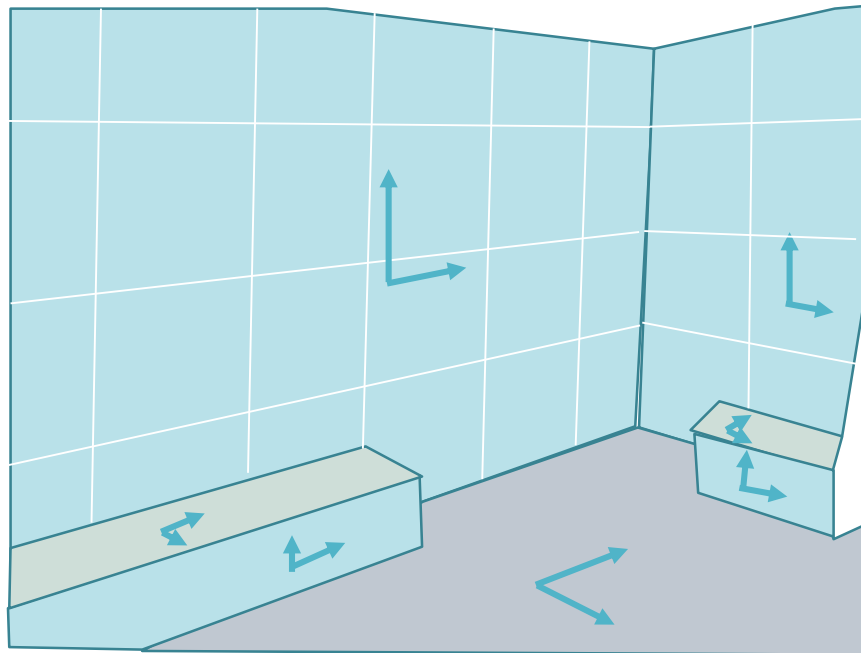
Authoring challenges

The environment is unknown at design time.

Automatic extraction of scene polygons



Assignment of local uv coordinates





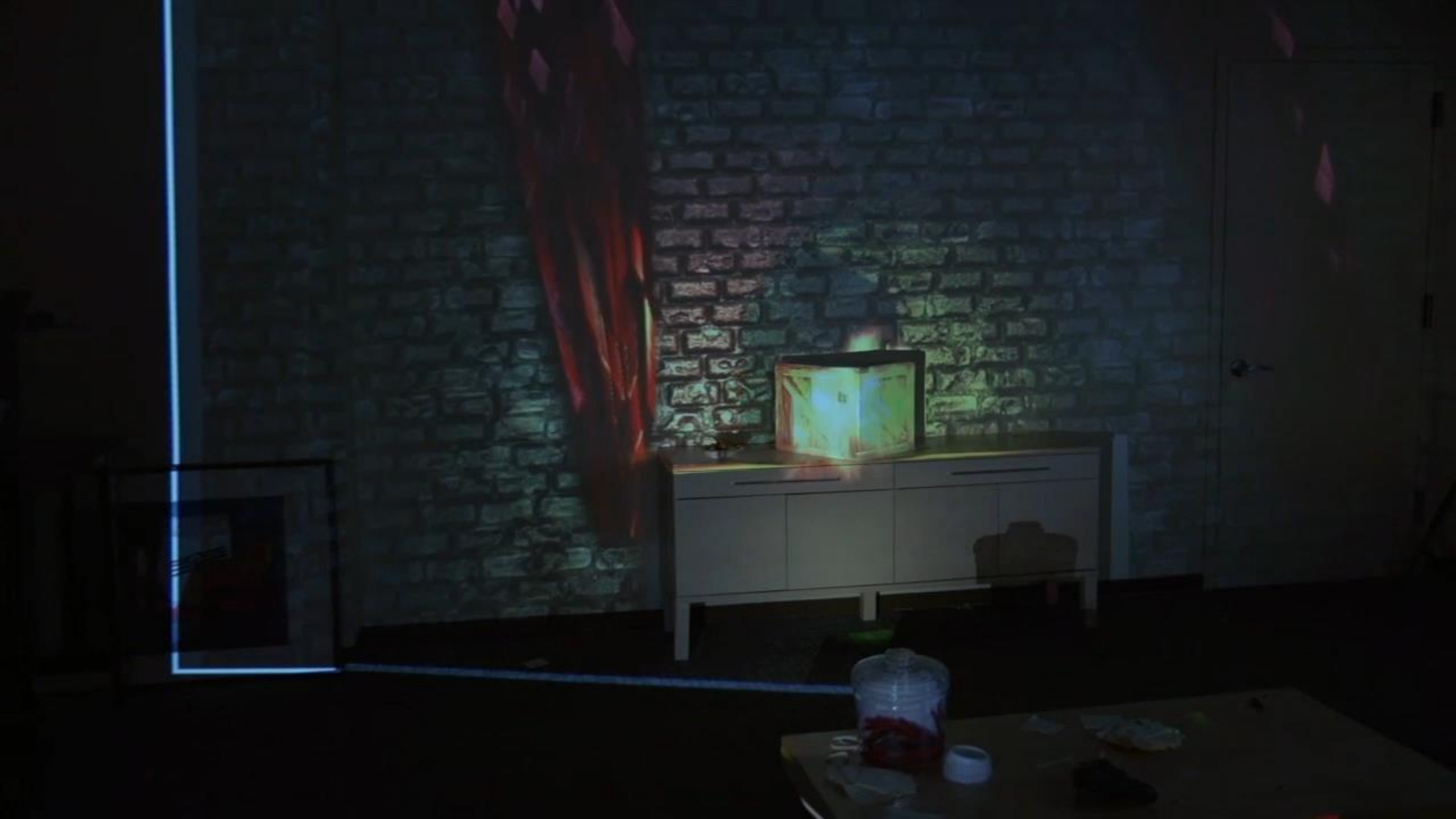
Authoring challenges

The environment is unknown at design time.

Designer is not in complete control of the experience.

If storytelling, need to direct the person's focus. More like theater/theme park than a movie/game.

Magic happens when virtual stuff interacts with the real world.



The Other Resident



Spotlight and virtual mirror effects

Enabling multi-perspective views

Dyadic Spatial Augmented Reality

Surface Shading



IllumiRoom, CHI 2013



LightSpace, UIST 2010



RoomAlive, UIST 2014





Felice Varini



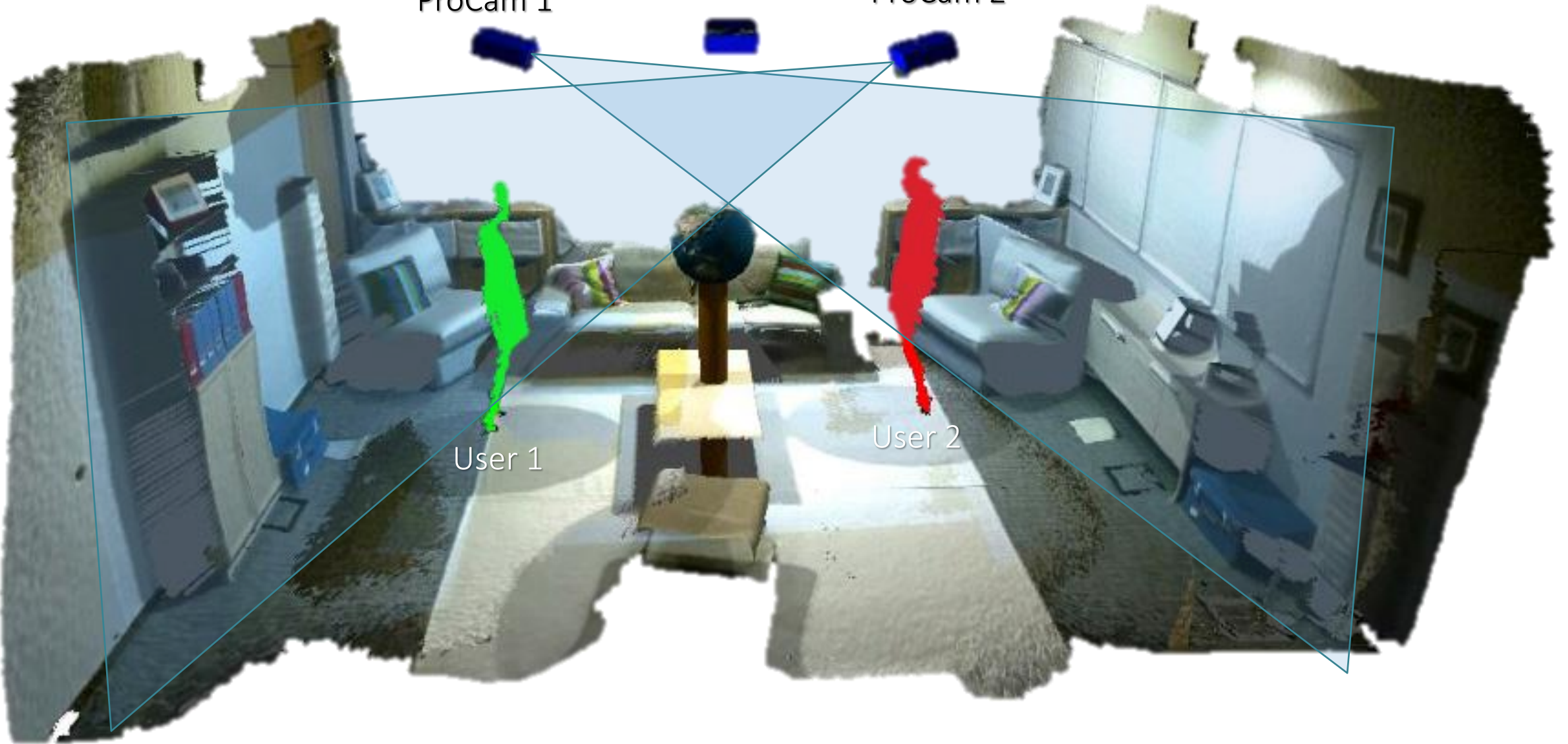
*How to support view dependent
graphics for multiple users?*

ProCam 1

ProCam 2

User 1

User 2



Target



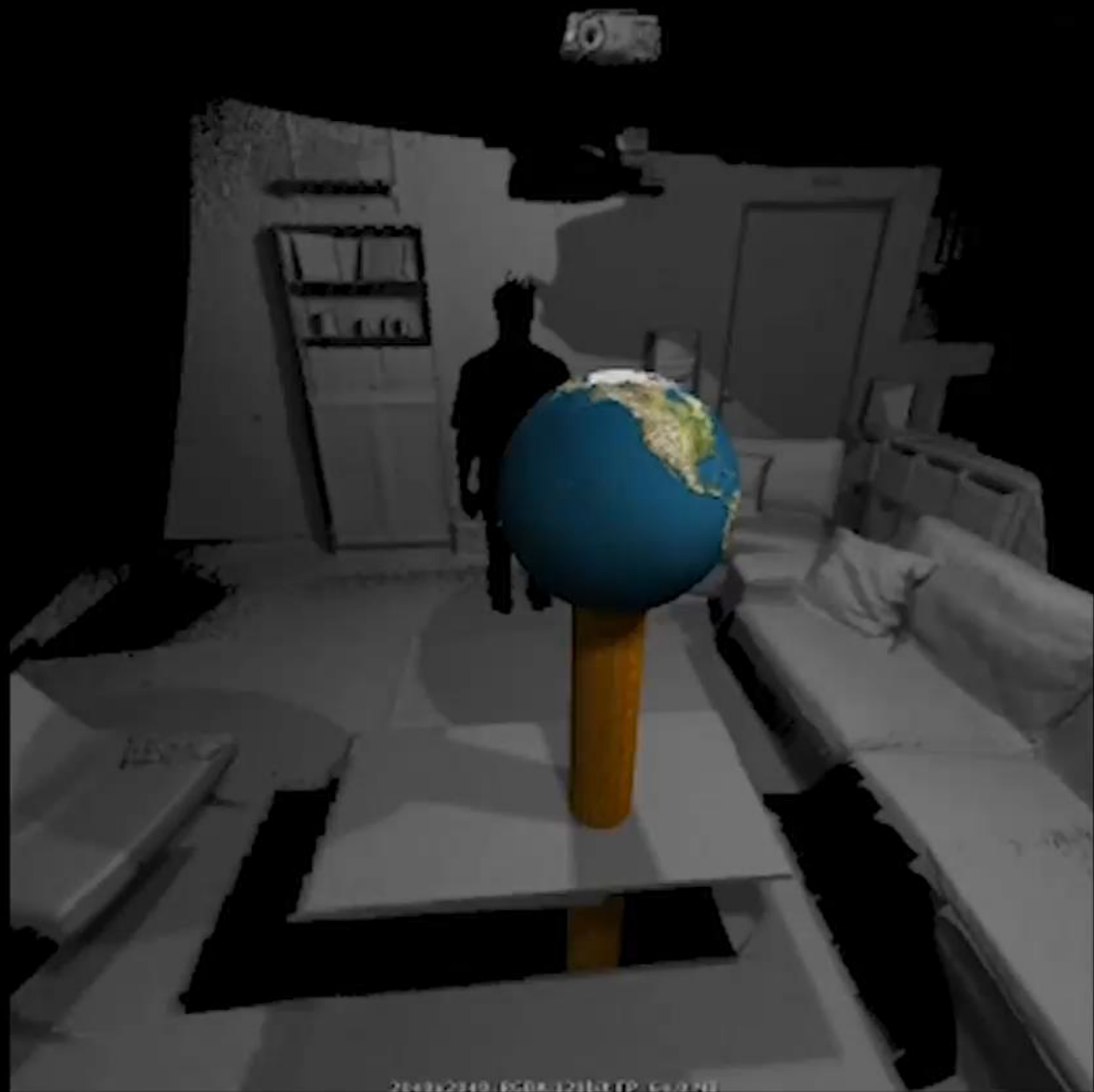
Projected



User's POV















Two User Experiments

Projected objects are perceived as spatial even without stereo rendering.

Users can understand their collaborator's spatial references.



Glasses + Pro-Cams

FoveAR

FoveAR



Connecting people

Room2Room

Room2Room





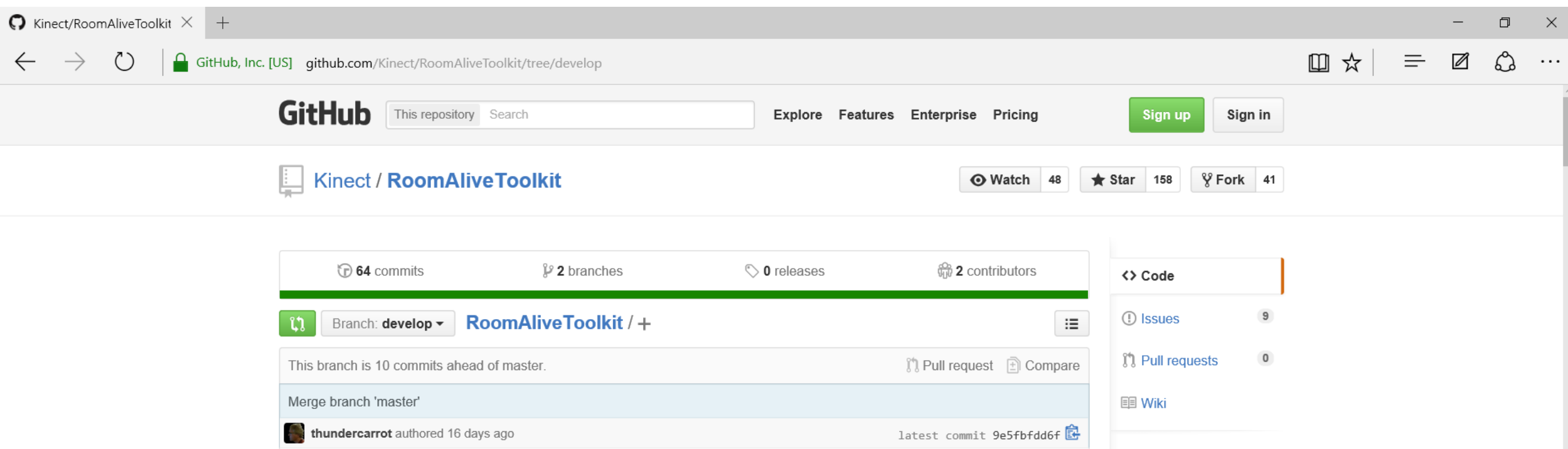
Feel inspired? Want to try it out?



RoomAlive Toolkit

Open source multi-Kinect multi-projector calibration tool and view-dependent rendering samples.

Get the code: <https://github.com/Kinect/RoomAliveToolkit/>



The screenshot shows the GitHub web interface for the repository `Kinect / RoomAliveToolkit`. The browser address bar shows the URL `github.com/Kinect/RoomAliveToolkit/tree/develop`. The repository page displays the following information:

- Repository:** Kinect / RoomAliveToolkit
- Actions:** Watch (48), Star (158), Fork (41)
- Statistics:** 64 commits, 2 branches, 0 releases, 2 contributors
- Branch:** develop (10 commits ahead of master)
- Latest Commit:** authored 16 days ago by thundercarrot, commit hash 9e5fbfdd6f
- Navigation:** Code, Issues (9), Pull requests (0), Wiki

RoomAlive Toolkit



Thanks to my collaborators



Andy Wilson



Eyal Ofek

Bret Jones
Rajinder Sodhi
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Tomislav Pejisa
Julian Kantor
Feng Zheng
Ravish Mehra
Yan Wang
Ricardo Costa Jota

Chris Harrison
Federico Zanier
Blair MacIntyre
Shahram Izadi
Nikunj Raghuvanshi
Lior Shapira
Ran Gal

A man with short grey hair, wearing a red button-down shirt, is sitting at a desk. He is looking towards the camera with a slight smile. In front of him is a computer monitor displaying a colorful abstract image. The background is a plain wall with two framed pictures. To the right, a door handle is visible.

Hrvoje Benko

benko@microsoft.com

<http://research.microsoft.com/~benko>