GW SCHOOL OF ENGINEERING & APPLIED SCIENCE

Augmented and Virtual Reality

CSCI 3907/6907

Spring 2022

3:30 PM - 6:00 PM, Thursdays

Week 5

Dr. Hurriyet Ok

hurriyetok@gwu.edu

Course Grader – Bing Li

Help for projects, assignments, and check-out VR headsets.

Office Hours: 2:15 to 3:15 on Thursdays in SEH 4450

Confirm your appointment in advance by email bli88@gwu.edu

Overview of VR Project Deliverables

01/27: VR Concept Note

02/10: Submit VR development status update

02/24: Publish your VR app and produce a 2 min promo video

03/03: Provide project report & your evaluation of three classmates' VR design

03/03: Present your VR app in the classroom

All due by 3:30 PM

VR Project Collaboration

Last Name	First Name	Dev Platform Computer OS	Unity Version	VR Headset	VR App Name
Benevento	Nick	Ubuntu 20.04	2021.2.8f	Quest 2	The Maze
Burnett	Connor	Windows 11/Zorin OS 16	2020.3.26f1	Oculus Quest 2	Undercooked
Bury	Nathaniel	Windows 11	2020.3.25f3	Quest 2	Spiderperson
Chinitz	Noah	Windows 11/Zorin OS 16	2020.3.26f1	Oculus Quest 2	Undercooked
Chulet	Pushpak	Windows 11	2021.2.8f	Oculus Quest 2	Snake and Apples
Gao	Chengshu	windows 10	2020.3.25f1	Oculus Quest 2	Alchemy Simulator
Gbolahan	Olayinka	macOS Monterey	2020.3.26f1	Oculus Quest 2	Sports Maze Quest
Indla	Lakshmi Kesava Reddy	Windows 10	2020.3.26f1	Oculus Quest 2	Snake and Apples
Jacobs	Jett	macOS Catalina	2020.3.26f1	Oculus Quest	Undercooked
Jaimes	Nelson	Windows 10	2020.3.26f1	Oculus Quest 2	SpatialLearningVR
Kaczorowska	Monika	MacOS Monterey	2020.3.26f1	Oculus Quest2	Where's my gate?
Kanungo	Rishi				
Kim	Dongkun	MacOS Monterey	2021.2.8f	Oculus Quest 2	Gem Runer?
Letavish	Sean	Windows 10	2021.122f1	Oculus Quest 2	A Drive Through the Woods
Li	Luke	Windows 10	2021.2..8f	Oculus Quest 2	Where is my dog?
Li	Zongyao	windows 10	2020.3.25f1	Quest2	Alchemy Simulator
Oh	Saerom	MacOS Monterey	2021.2.7f1	Oculus Quest 2	Finding Coco
Phillips	Lanelle	Mac OS BigSur	2021.2.7f1	Oculus Quest 2	Snakes and Apples
Qin	Kusch	Windows 10	2020.3.26f1	Oculus Quest 2	Finding my classroom simulator
Rice	Neil	macOS Big Sur	2020.3.26f1	Oculus Quest 2	PodDash: Escape from Alienation
Scott	Jamie	macOS Catalina	2020.3.26f1	Oculus Quest 2	Phantasm
Shuai	Tiancheng	Windows 10	2020.3.26f1	Oculus Quest 2	Finding my classroom simulator
Smith	Tanner	macOS Big Sur	2020.3.26f1	Oculus Quest 2	PodDash: Escape from Alienation
Stevens	Sarah	macOS Catalina	2020.3.25f1	Oculus Quest 2	Underwater Treasure Hunt
Wang	Riva	windows 11	2021.2.8f	Oculus Quest 2	Where is my dog?
Zhang	Ruojia	windows 10	2020.3.25f1	Oculus Quest 2	Alchemy Simulator
Zheng	Sonny	Windows 10	2020.3.26f1	Oculus Quest 2	Finding my classroom simulator

VR Project – Feb. 10

Expected Progress

- Set up and build your VR project
- User interaction with the virtual world
- Decided on locomotion type
- Understand handling user input
- Testing your Unity VR App
- Experimenting with VR Audio
  Reference for practicing:
  https://learn.unity.com/tutorial/unit-7-sound-in-vr

In Class Exercise: VR Project Collaboration

Each student will pitch their VR app (up to 3 minutes)

- My VR Project is about ..
- The player experiences will be …
- I have completed so far these feature …..
- My major challenge is …. and I appreciate help on …..

VR Playground: In-Class Activity on Feb. 17

Demonstrate your VR app (beta):

- An interaction with a virtual object
- Background music / sound effect
- Text instructions (e.g., info bubble)

or

A demo video of your VR app

Video Editing

iMovie

Turn your videos into movie magic.

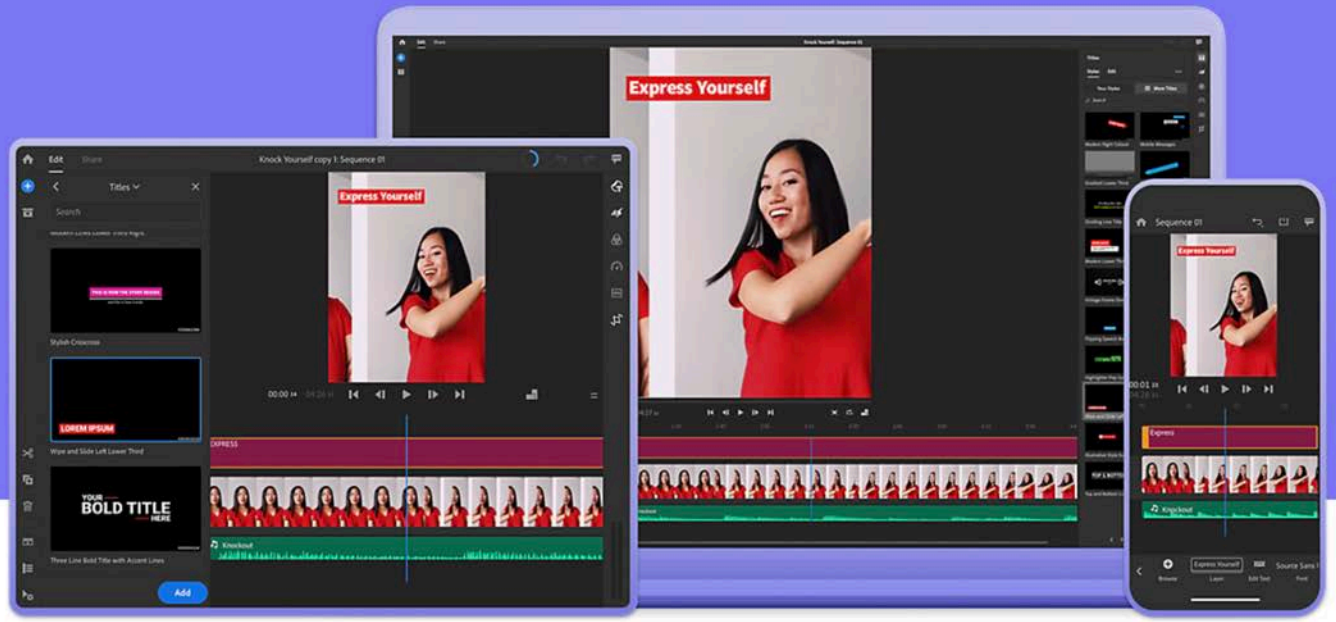
With iMovie for iOS and macOS, you can enjoy your videos like never before. It's easy to browse your clips and create Hollywood-style trailers and stunning 4K-resolution movies. You can even start editing on iPhone or iPad, then finish on your Mac.

Download iMovie for iOS

Download iMovie for macOS

Adobe Premiere Rush is the free mobile and desktop video editing app for creativity on the go. Wherever you are, from your phone to your computer, you can shoot, edit, and share high-quality videos. Fun, intuitive, and as fast as social media, it's the easiest way to star in your followers' feeds.

Download the Premiere Rush app for free on macOS, Windows, iOS, and Android.



OPTION 1: Adobe Premiere Rush

For macOS, Windows, iOS, and Android Users
https://it.gwu.edu/adobe-creative-campus

OPTION 2: iMovie

for macOS and iOS Users
https://www.apple.com/imovie

Human-Centered VR Design

Five Essentials Every Engineer Needs to Know

1. Design for multimodal input and output
2. Be aware of adverse health effects
3. Don’t assume intuitiveness
4. You are not your users
5. Iteration is required

Human-Centered VR Design

Five Essentials Every Engineer Needs to Know

Jason Jerald
NextGen Interactions

We don’t know all the answers about VR design, nor will we ever. However, five essential concepts discussed here can help you iterate toward building impactful VR experiences.

Although virtual reality (VR) has been around for over 50 years, VR as a creative medium beyond prototypes and research is relatively new, largely because it is now easier than ever to develop for VR. What once took us months just to get basic geometry displayed in a head-mounted display can now be done in minutes.

The rise of VR hackathons demonstrates how quickly VR experiences can be built. Hackathon projects don’t always turn out to be successful, but nowhere can so much learning by doing occur in such a small amount of time, and sometimes the results can turn out to be quite spectacular. One of my favorite examples is the Triangle VR Hackathon (https://trianglehack.devpost.com) Best of Show winning project. In under 48 hours, a group of students conceived, designed, and built a mobile constellation viewer called Astrogaze (https://devpost.com/software/astrogaze-exysu5) that provides the ability to not only visualize constellations but also to draw your own constellations in the night sky.

How can such a project be conceived and built in such a short amount of time? The results can largely be attributed to skilled hackers that are able to quickly take advantage of today’s easy-to-use technical tools. Yet that by itself does not guarantee a quality outcome. A design-thinking mindset is one of the most important skills hackers and engineers can have for VR development. *Human-centered design* is a philosophy that puts human needs, capabilities, and behavior first.[1] After all, users are literally at the center of VR experiences, and without the human there is no VR, no matter the technology. Below are some of the most essential high-level human-centered design concepts I’ve learned over the last 20 years of developing VR systems and applications.

DESIGN FOR MULTIMODAL INPUT AND OUTPUT

Most VR developers focus primarily on creating compelling visuals. Although visuals are obviously important, they are not the only way to immerse users in engaging experiences. Audio, touch, proprioception, and vestibular cues can make users truly feel like they are in and part of a

IEEE Computer Graphics and Applications
March/April 2018
15
Published by the IEEE Computer Society
0272-1716/18/$33.00 ©2018 IEEE

Group Exercise: VR Design

- Read the article "Human-Centered VR Design: Five Essentials Every Engineer Needs to Know".
- Discuss as a group.
- Explain two of the guidelines you felt the most important or you would prioritize for your VR project.
- Provide your answer on Blackboard.

Human-Centered VR Design

Five Essentials Every Engineer Needs to Know

Jason Jerald
NextGen Interactions

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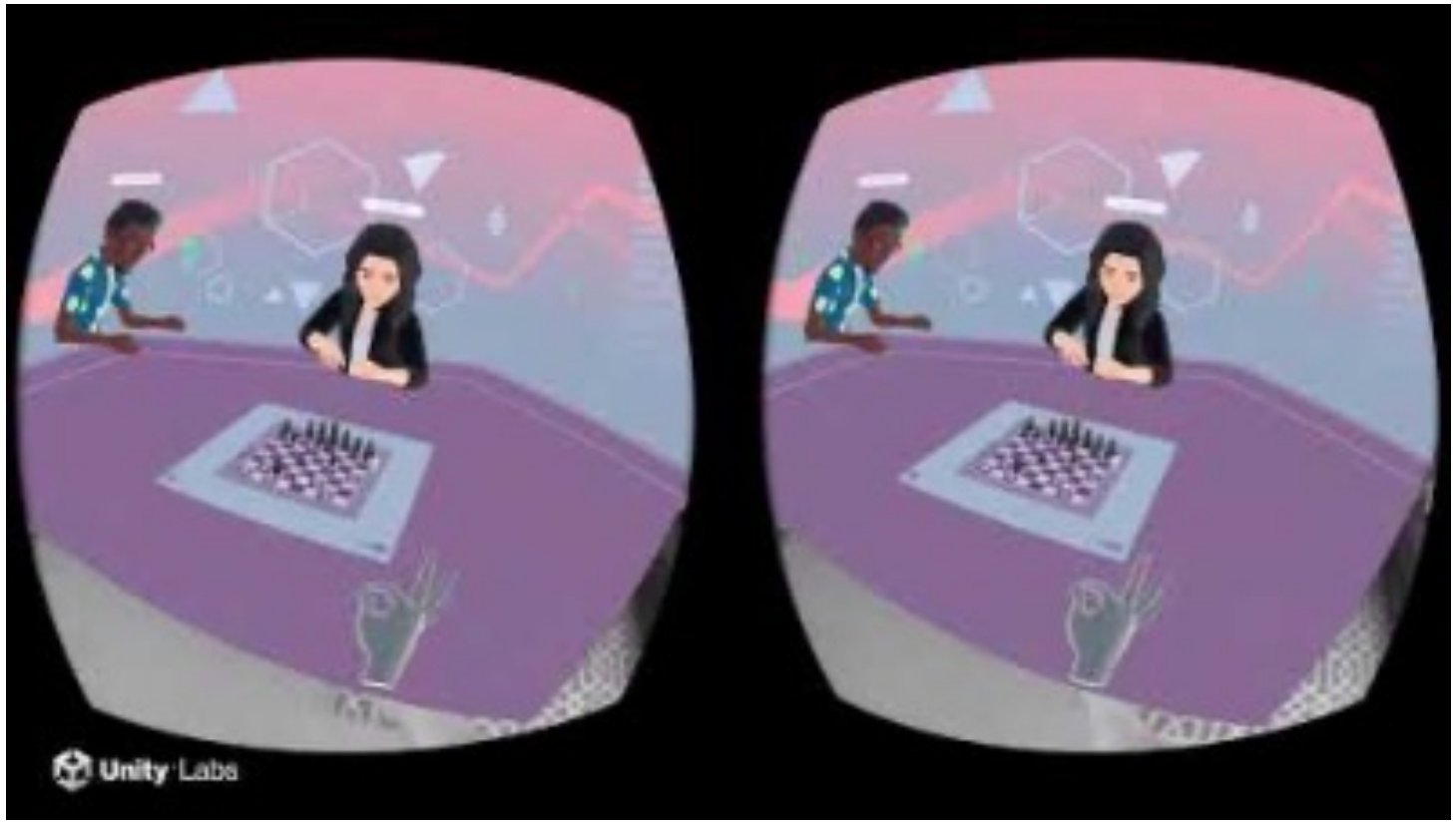
Mixed Reality

Unmodified XR-1 Video Footage by Varjo
https://youtu.be/L0sg-3EGbZs



“When we stop to think about the future, beyond the limitations of any device, there will no longer be any AR, MR or even VR... There is only a sliding scale of perception, along the spectrum of realities.” Greg Madison, Unity Labs

https://twitter.com/GregMadison/status/1453911010914422787

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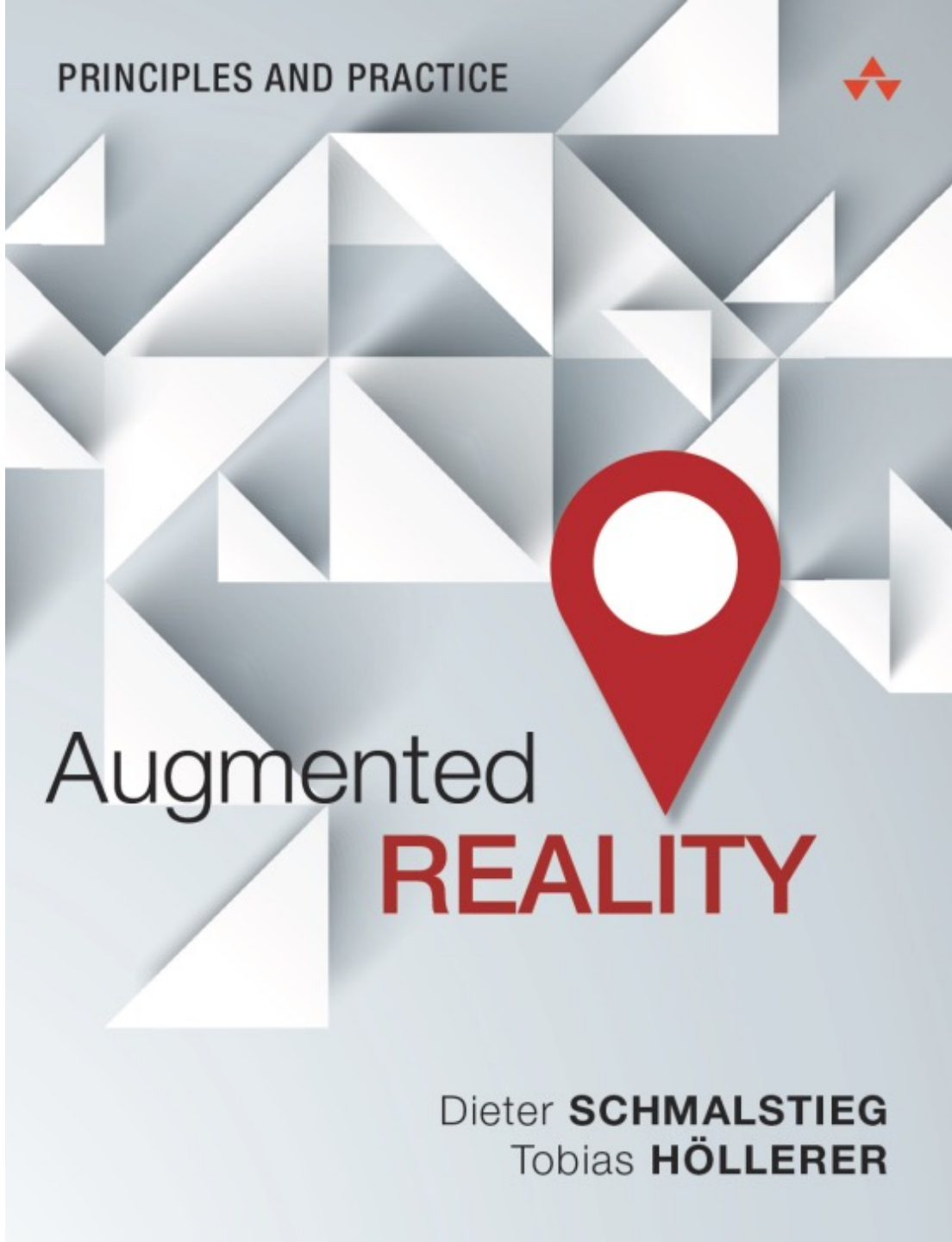
Chapter 4: Computer Vision

Augmented Reality – Principles and Practice

http://www.augmentedrealitybook.org



Computer Vision

Computer vision for AR:

- Electronically perceiving and understanding imagery from camera sensors.
- inform the AR system about the user and the surrounding environment.

AR necessitates real-time approaches

- Computer vision algorithms
- Optical tracking and scene reconstruction

- AR Input: Computer Vision Techniques
- AR Output: Computer Graphics Techniques
- Human-Computer Interaction: The Link between AR Input and Output

Textbook Case Studies – Reading Assignment

- Read Chapter 4 Computer Vision for Augmented Reality. Particularly, review these case studies on

  Marker Tracking (pages 123-132) and

  Simultaneous Localization And Mapping (SLAM) (pages 156-164, 170-176)
- Reviewing the information in blue boxes is encouraged but not required for the purpose of testing.
- You will answer the questions (to be provided) related to these two cases on February 17th

Marker Tracking

1. Capturing image with known camera
2. Search for quadrilaterals
3. Pose estimation from homography
4. Pose refinement

   Minimize nonlinear projection error
5. Use final pose

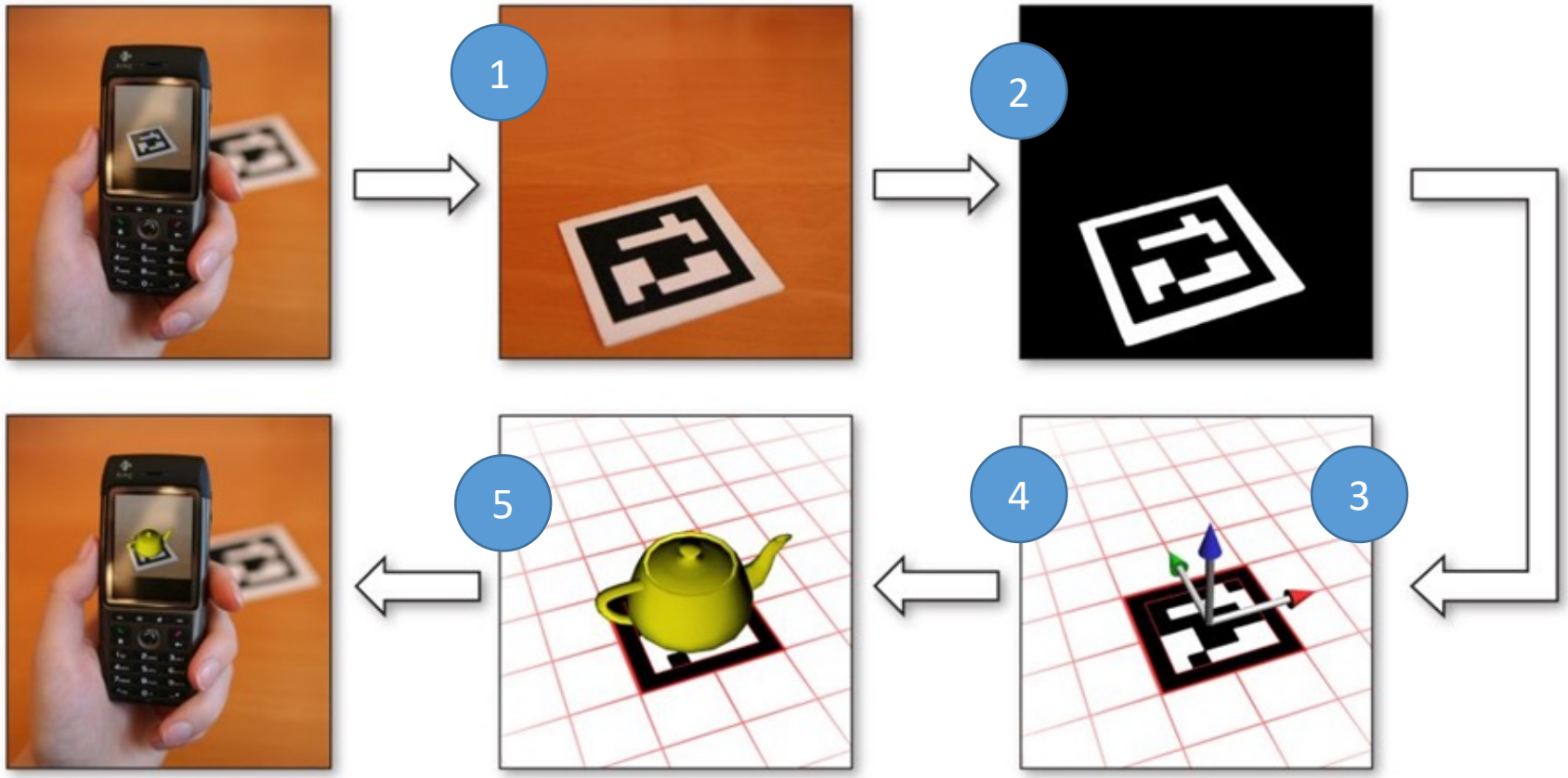
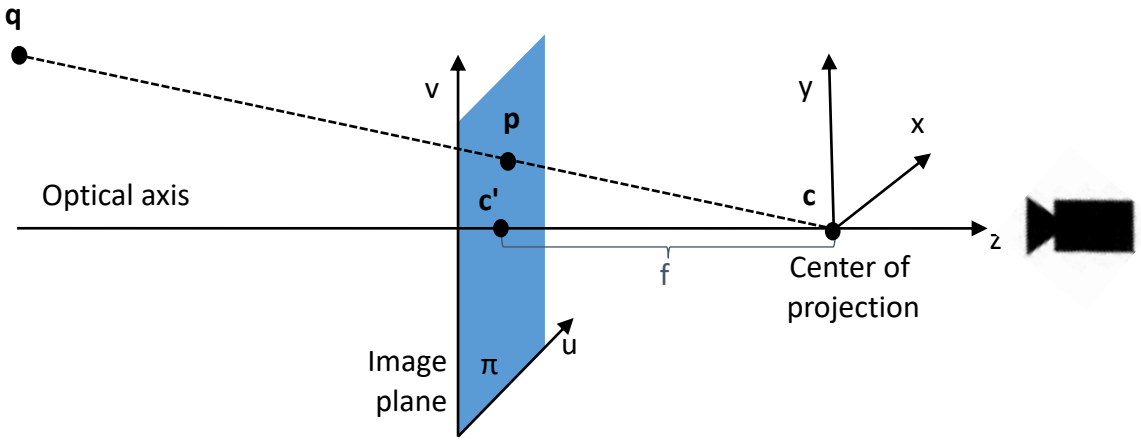


Image: Daniel Wagner

Pinhole Camera

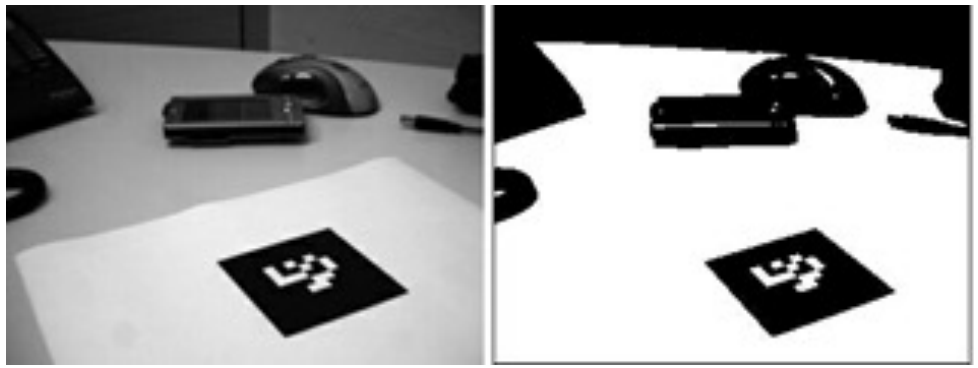
- Project 3D point **q** to 2D point **p**
- Center of projection **c**
- Image plane ∏
- Principal point **c'**
- Focal length *f*
- **p** = **M q** = **K** [**R**|**t**] **q**
- 5DOF for **K**, 3DOF for **R**, 3DOF for **t**
- Assume we known **K** (for now)

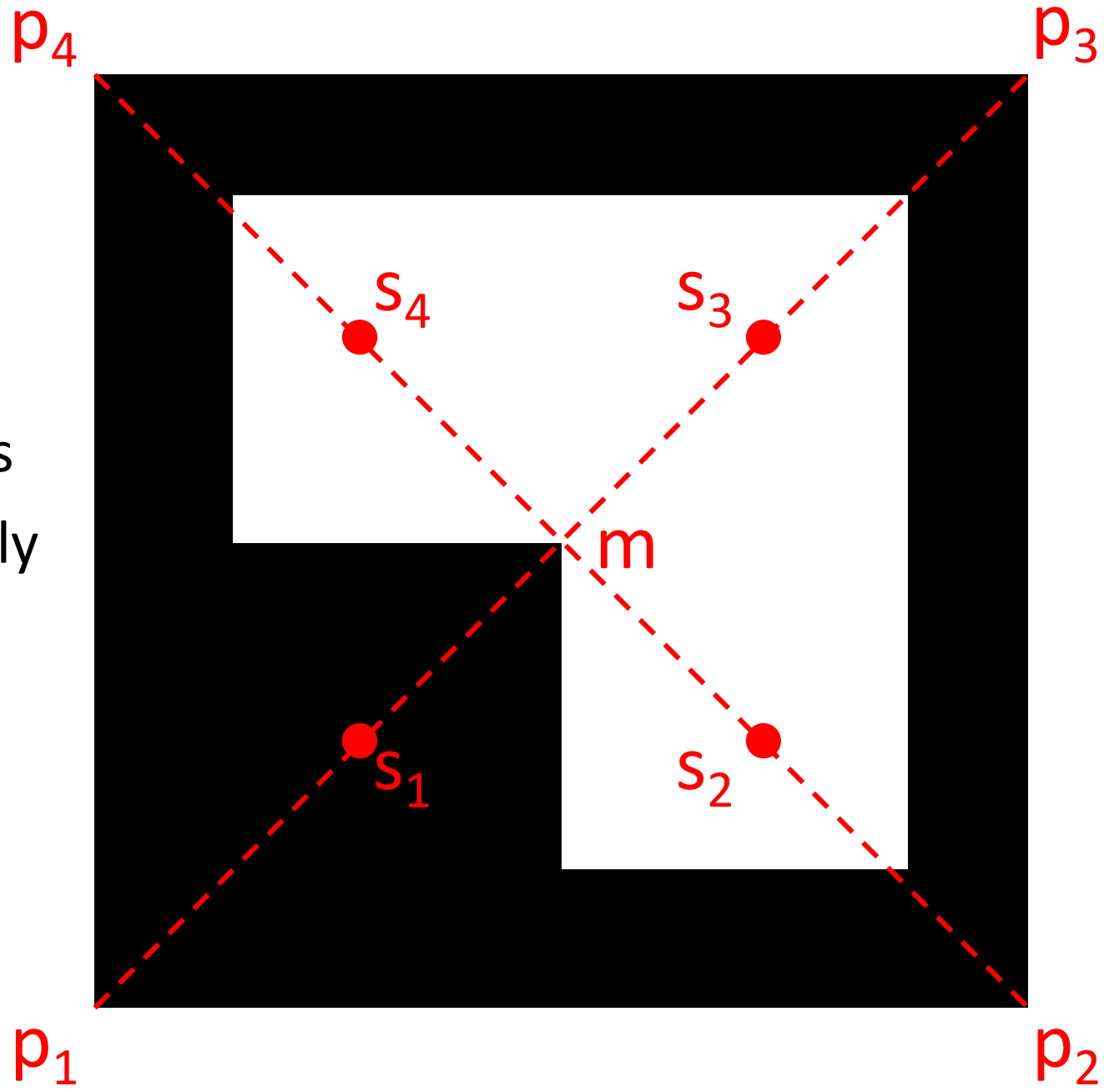


$$\mathbf{K} = \begin{bmatrix} f_u & s & c_u \\ 0 & f_v & c_v \\ 0 & 0 & 1 \end{bmatrix}$$

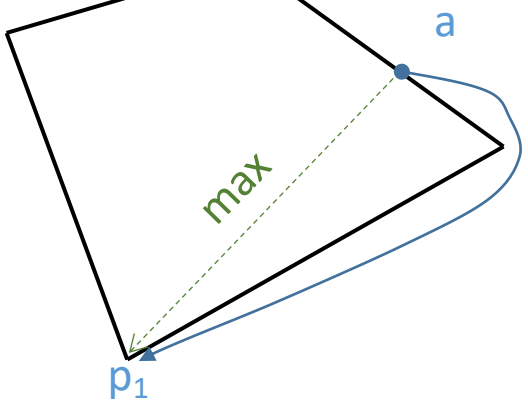
Marker Detection

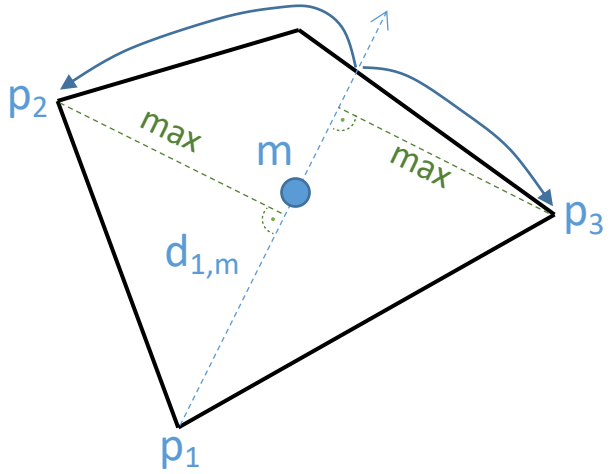
- Grayscale image
- Adaptive image threshold with gradient of logarithm of intensities
- Cheaper threshold: compute locally and interpolate

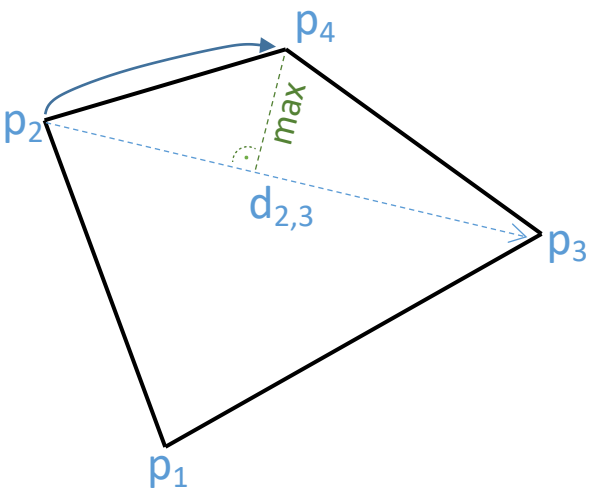




Quad Finding







- Find edges (black pixel after white) on every *n*-th line
- Follow edge in 4-connected neighborhood
- Until loop closed or hitting border
- Start at **a** and walk contour, search $\mathbf{p}_1$ at maximum distance
- Compute centroid **m**
- Find corners $\mathbf{p}_2$, $\mathbf{p}_3$ on either side of $\mathbf{d}_{1,m}=(\mathbf{p}_2,\mathbf{p}_3)$
- Find farthest point $\mathbf{p}_4$
- Determine orientation from black corner at $\mathbf{s}_i=(\mathbf{p}_i+\mathbf{m})/2$

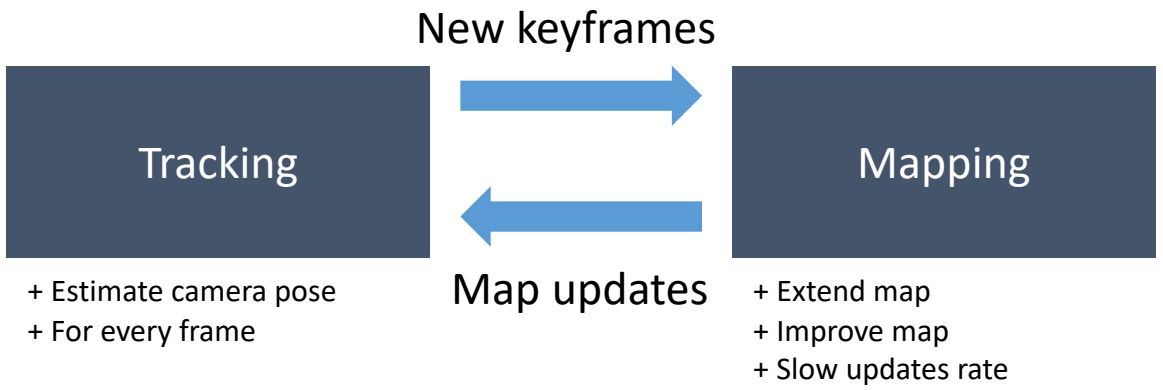
Simultaneous localization and mapping

- This case study explores pose computation from 2D–2D correspondences (five-point pose, bundle adjustment).
- We also look into modern techniques such as parallel tracking and mapping, and dense tracking and mapping.

Visual Tracking Approaches

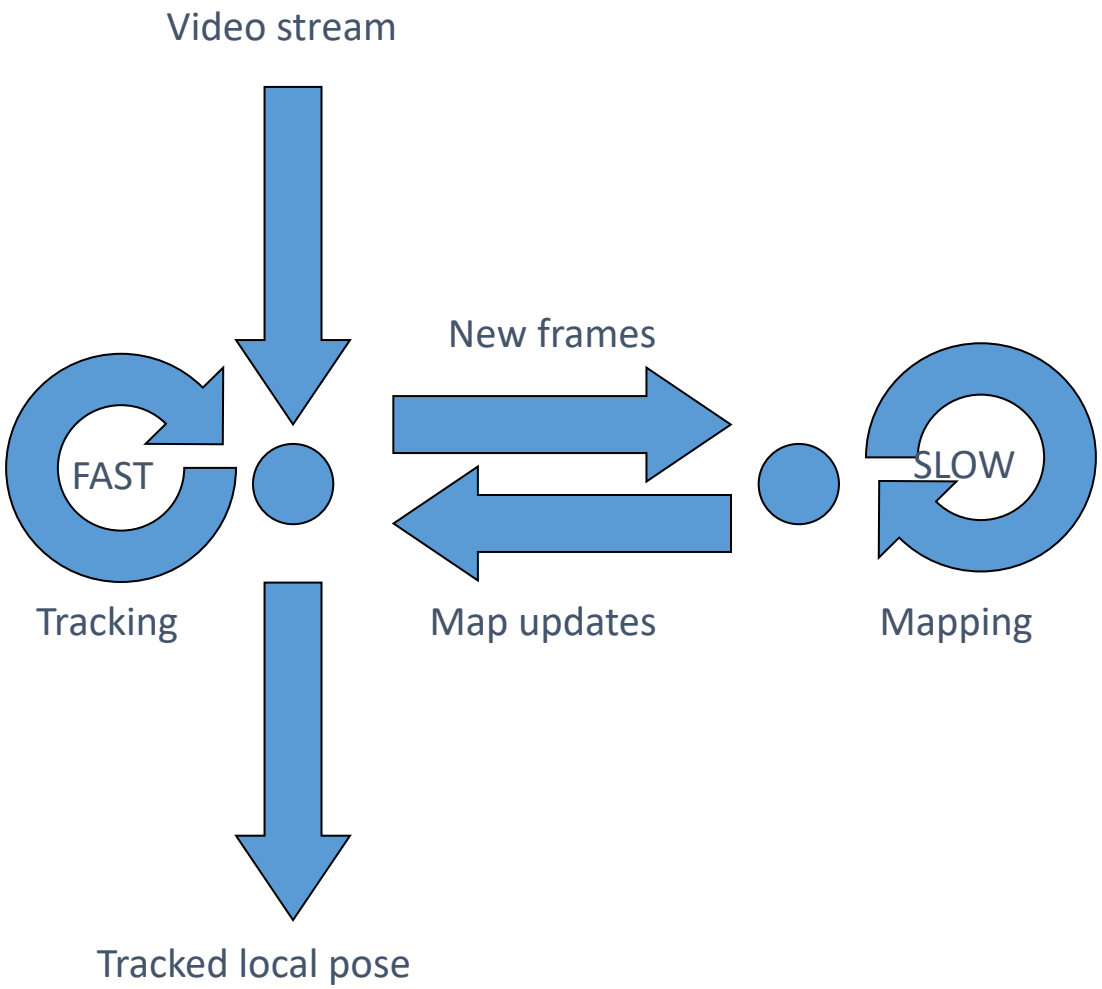
- Marker based tracking with artificial features
  - Make a model before tracking
- Model based tracking with natural features
  - Acquire a model before tracking
- **Simultaneous localization and mapping**
  - Build a model *while* tracking it
  - Example 1: Parallel Tracking and Mapping with Monocular Camera
  - Example 2: KinectFusion

Parallel Tracking and Mapping



Parallel tracking and mapping uses two concurrent threads, one for tracking and one for mapping, which run at different speeds

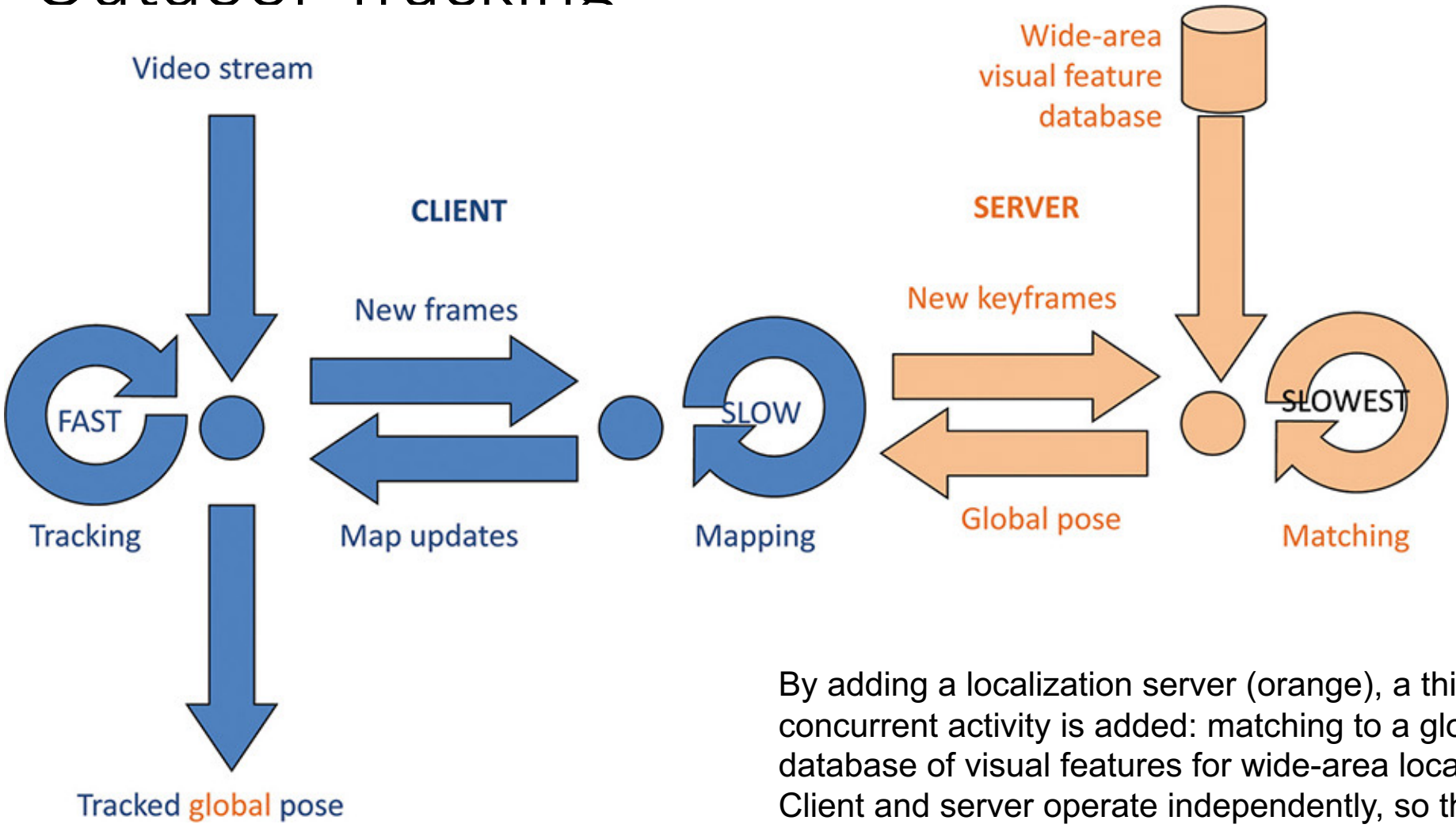
Conventional SLAM



Simultaneous
localization and mapping
(SLAM)
in small workspaces

Klein/Drummond, U. Cambridge

Outdoor Tracking



By adding a localization server (orange), a third concurrent activity is added: matching to a global database of visual features for wide-area localization. Client and server operate independently, so the client can always run at the highest frame rate.

Class Exercise: VR and Visual SLAM

Powered by AI: Oculus Insight

https://ai.facebook.com/blog/powered-by-ai-oculus-insight/

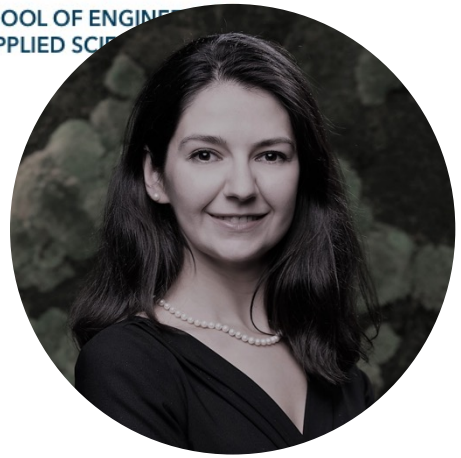
- Concept: Generating real-time maps and position tracking with visual-inertial SLAM
- You will answer the questions (to be provided on BB) related to this article as a group discussion.

Class Exercise: VR and Visual SLAM

Powered by AI: Oculus Insight

https://ai.facebook.com/blog/powered-by-ai-oculus-insight/

- What are the three new and important concepts you learned in the context of VR application development?
- Explain your initial concept choices to your group members.
- Listen everyone else's selection of concepts.
- Provide your own final list of novel concepts and explain them in your response.



Can AR/VR enrich everyday human life?

A Lecture by Cezara Windrem

(Recorded on Oct. 17, 2019 at GW)

https://echo360.org/section/97ea9450-8a3b-4c27-b112-609f0bbd231a/public

Bio

Cezara Windrem is an innovation and product executive employing immersive media and spatial computing to create valuable solutions that span generations. She heads up the work in virtual reality at AARP Innovation Labs, and is the creator and producer of Alcove - a simple and accessible platform of curated content that takes into account the needs and considerations of an ageless consumer, and brings cross-generational families together in VR. Cezara's professional background is at the intersection of media and technology. She has over 15 years of experience applying human centered design and modern product management principles to create, lead, and scale products that enhance people's lives at work, and at home. Her educational background includes Global Management studies at the University of Oxford, and an MBA from Georgetown University. She is a frequent speaker at various national and global events that in the past included AWE, AdWkDC, Games4Change, MAVRIC, Smithsonian Digitization, SXSW, VRX.

Also watch: **XR for Every Age Creating content for an ageless consumer by Cezara Windham at 2019 MAVRIC Conf**
https://youtu.be/7JN-rUqbIzE

VR App of the Week: Alcove by AARP

A Family-oriented VR App

"Alcove was developed to help combat social isolation and loneliness by bridging physical distance between family members and friends through virtual experiences. "

https://press.aarp.org/2020-8-20-Innovation-Labs-Introduces-Alcove-Virtual-Reality-App-on-Oculus-Quest

Game Modes: Single User, Multiplayer, Co-op

Supported Player Modes: Sitting, Standing, Roomscale

Supported Controllers: Oculus Touch, Hand Tracking

Supported Platforms: Quest

https://www.oculus.com/experiences/quest/3895528293794893/