Christian@Sandor.com

16 November 2022

Augmented Reality Evangelist

Leader: VENISE Team

广州市大湾区虚拟现实研究院
GUANGZHOU GREATER BAY AREA VIRTUAL REALITY RESEARCH INSTITUTE

GUANGZHOU GREATER BAY AREA VIRTUAL REALITY RESEARCH INSTITUTE

Professor

cnrs

université PARIS-SACLAY

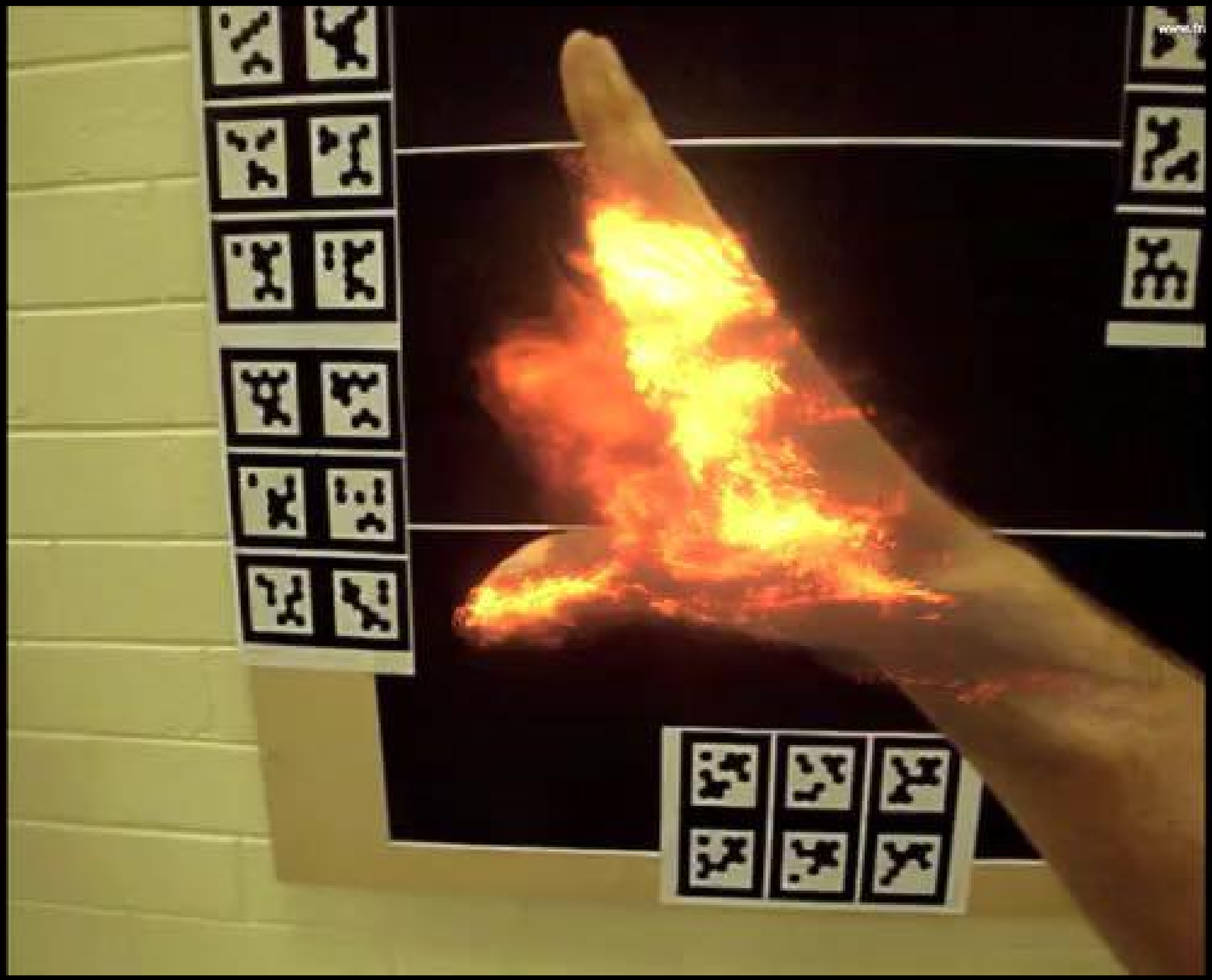
My Past And Upcoming 22 Years With Augmented Reality

Keynote at MediaFutures Annual Meeting

Media Futures

BURNAR: FEEL THE HEAT

Matt Swoboda, Thanh Nguyen, Ulrich Eck, Gerhard Reitmayr, Stefan Hauswiesner, Rene Ranftl, and Christian Sandor. Demo at *IEEE International Symposium on Mixed and Augmented Reality*, Basel, Switzerland, October 2011. **Best Demo Award**



BURNAR: INVOLUNTARY HEAT SENSATIONS IN AR

Peter Weir, Christian Sandor, Matt Swoboda, Thanh Nguyen, Ulrich Eck, Gerhard Reitmayr, and Arindam Dey. *Proceedings of the IEEE Virtual Reality Conference*, pages 43–46, Orlando, FL, USA, March 2013.

MY BIO IN A NUTSHELL: AR AROUND THE WORLD

Born and raised in Munich (Germany)

TU Munich: Master (2001) & PhD (2005)

Directed Labs

Australia: Magic Vision Lab (2010-2014)

Japan: Interactive Media Design Lab (2014-2018; co-director)

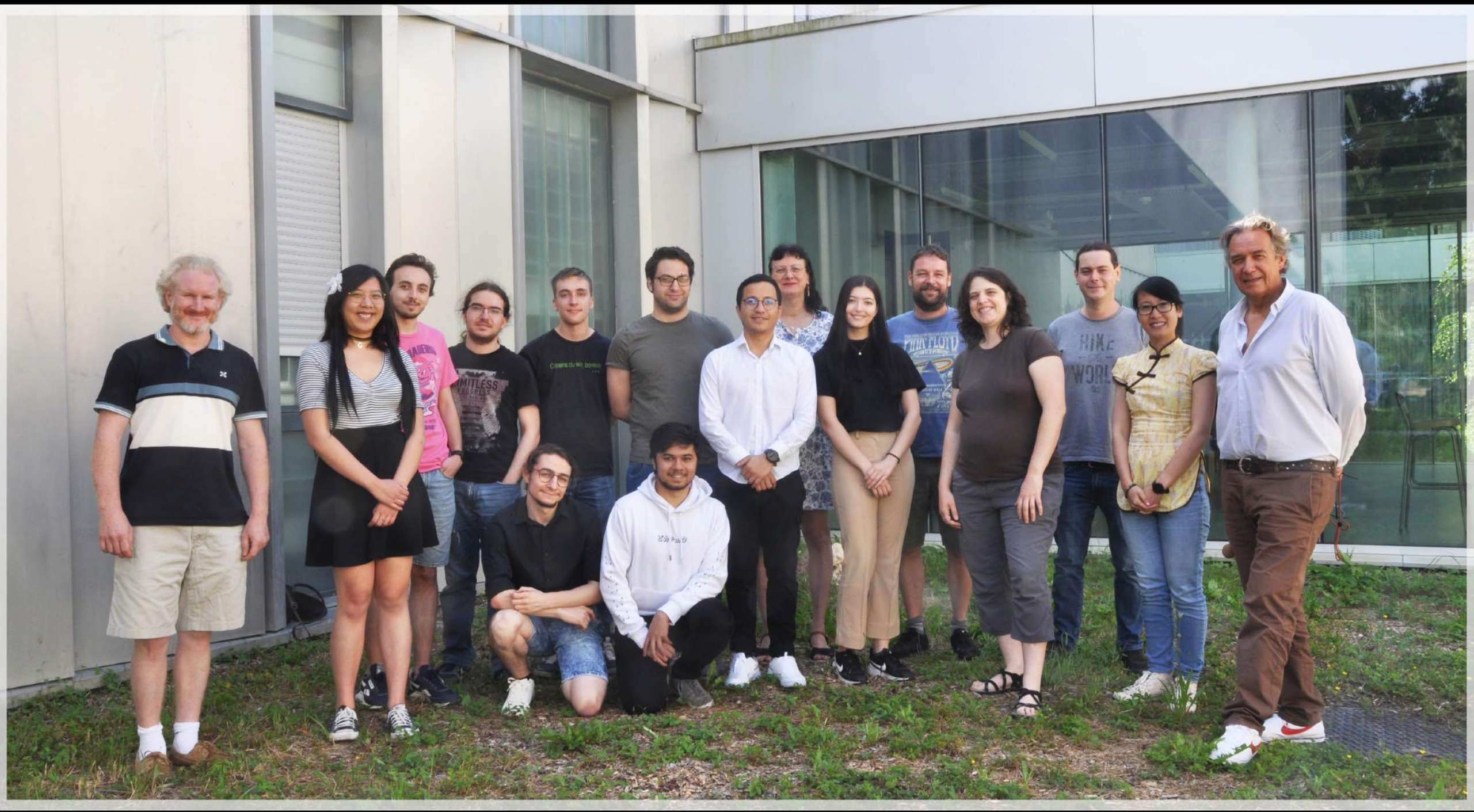
Hong Kong:

Augmented Reality Lab (2021)

Extended Reality Lab (2019-2020; co-director)

France: VENISE (since 2021)

THE VENISE TEAM



THE VENISE TEAM

Leader

Christian Sandor

Founder

Patrick Bourdot

Associate Professors

Nicolas Férey

Huyen Nguyen

Tifanie Bouchara

Research Engineers

Jeanne Vezien

Nicolas Ladévèze

RECENT US INVESTMENTS INTO AR & VR

3/2014: Facebook buys Oculus

2 Billion USD

10/2014: Google and others invest into Magic Leap

542 Million USD

1/2015: Microsoft releases Hololens

1 Billion USD

3/2018: More investments into Magic Leap; total now

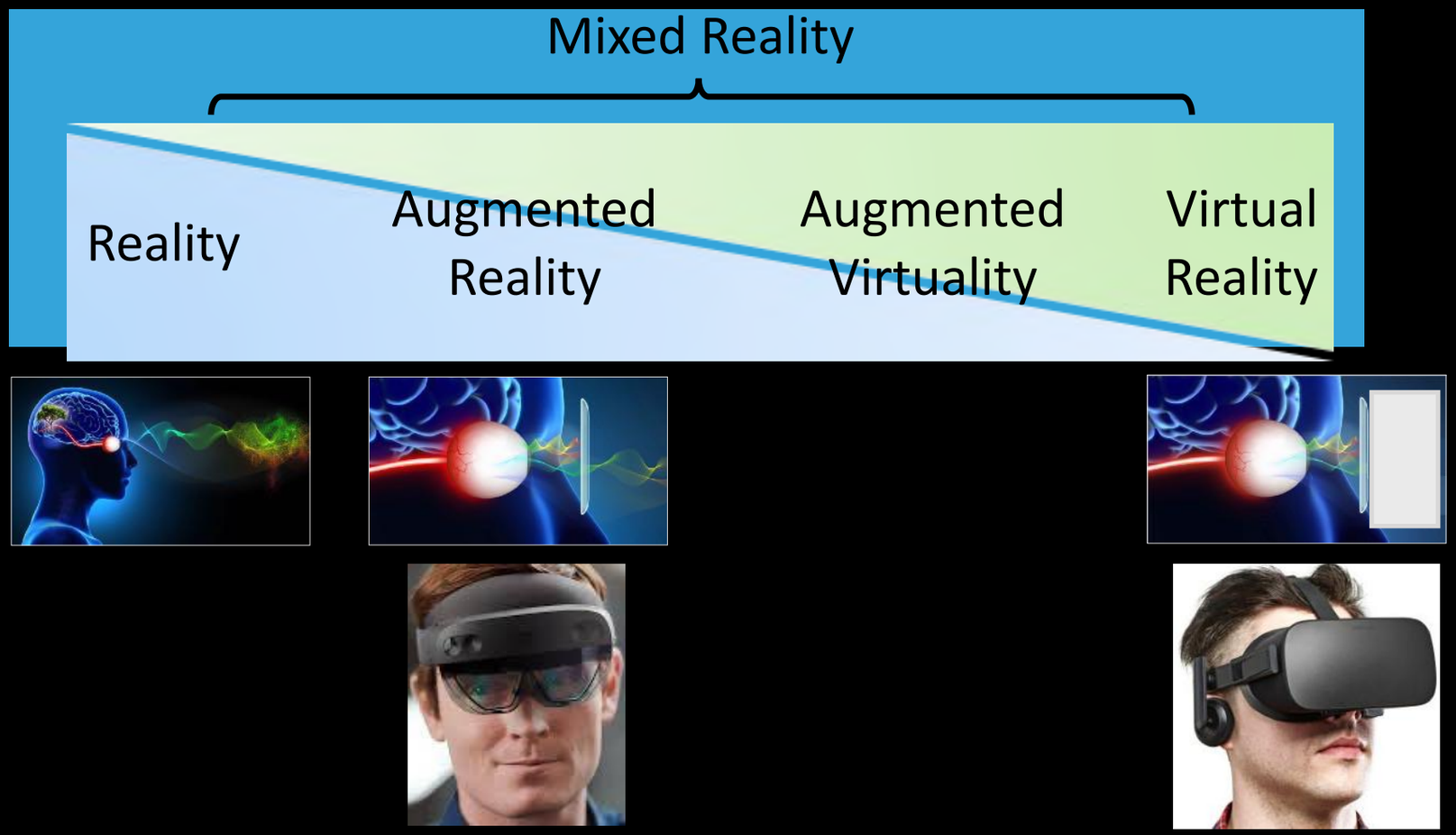
2.3 Billion USD

10/2021: Facebook announces Metaverse initiative

>10 Billion USD per year

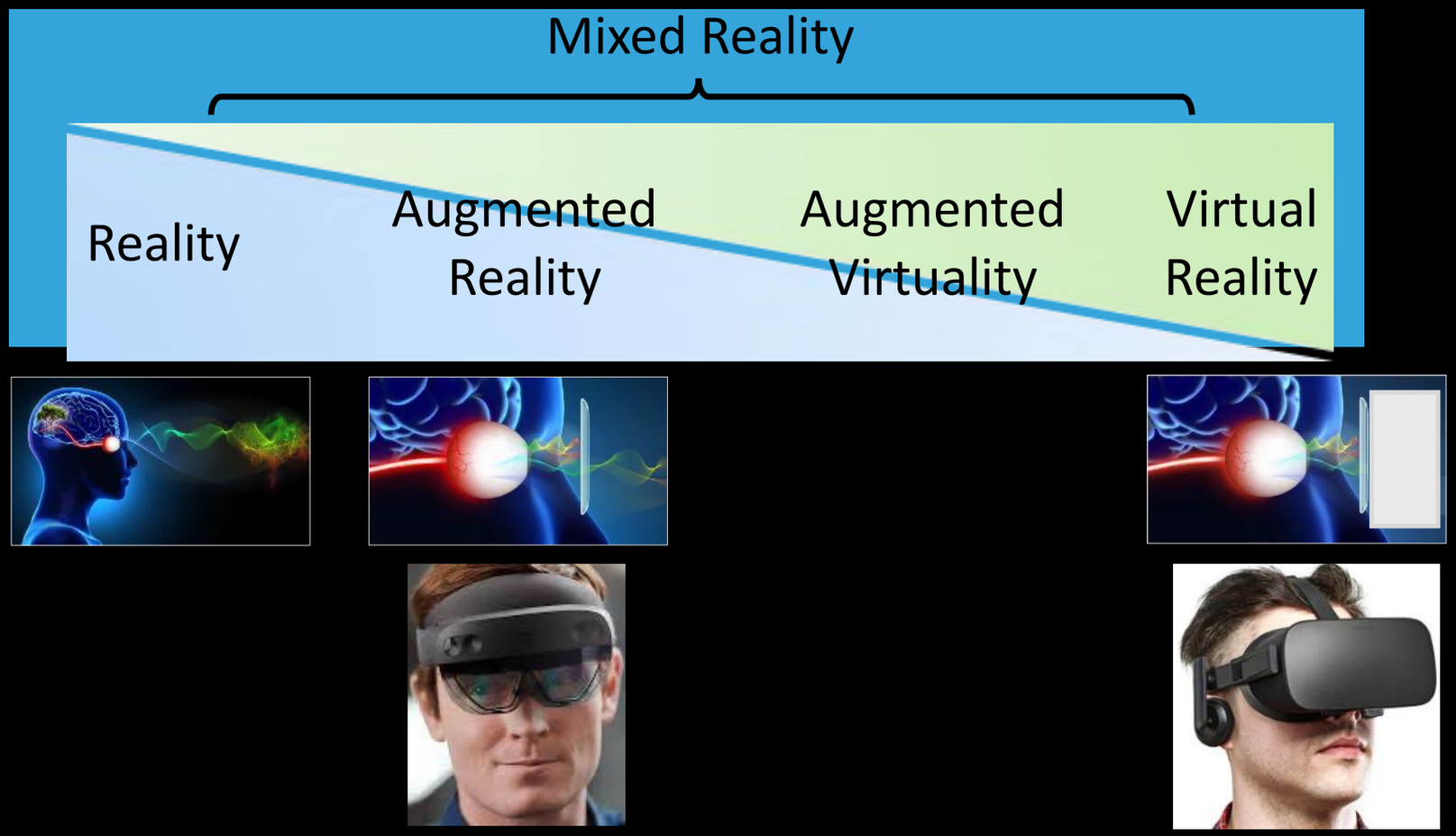
20% of Facebook employees involved

MIXED REALITY (MR)



Paul Milgram and Fumio Kishino. A Taxonomy of Mixed Reality Visual Displays. *IEICE Transactions on Information Systems*, E77-D(12):1321–1329, December 1994

EXTENDED REALITY (XR) = MR + VR



Paul Milgram and Fumio Kishino. A Taxonomy of Mixed Reality Visual Displays. *IEICE Transactions on Information Systems*, E77-D(12):1321–1329, December 1994

MY GUIDING RESEARCH QUESTIONS

1. How to create an AR display that can display *virtual objects that are indistinguishable from real objects*?

2. How does the human Eye-Brain system react to AR?

3. Aftereffects of using AR?

https://www.magicleap.com/en-us/news/op-ed/spatial-computing-an-overview-for-our-techie-friends

RELEVANT RESEARCH AREAS FOR ADDRESSING THESE QUESTIONS

Human Perception

Psychology, Neuroscience

Technology

Computer Graphics, Computer Vision, Optics, Embedded Computing, Deep Learning, Software Engineering

Applications

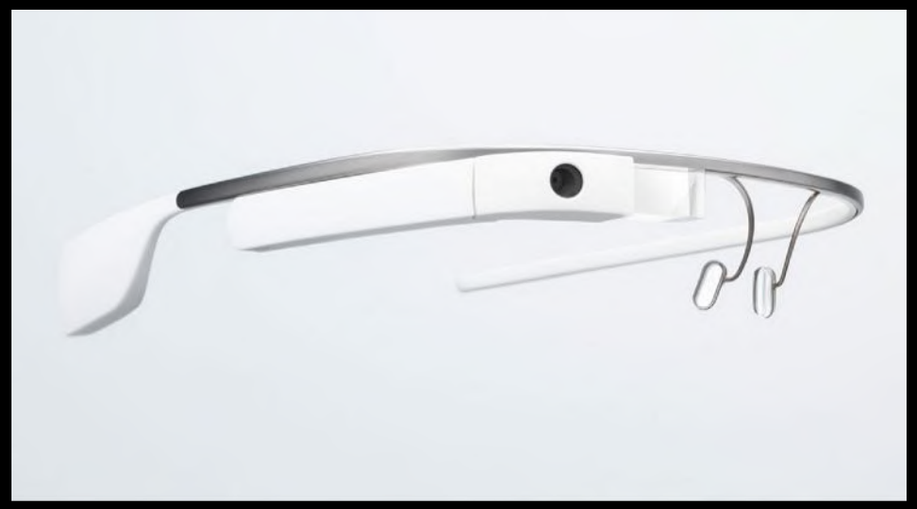
UX Design

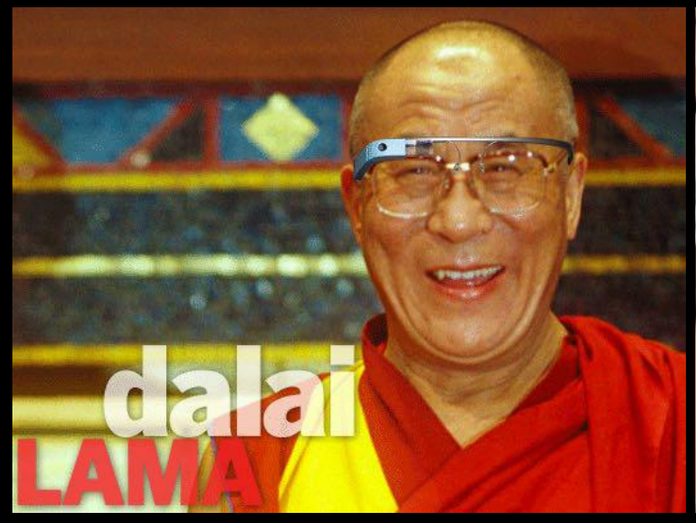
MY FIRST 22 YEARS OF AR RESEARCH

EDGE-BASED X-RAY

Benjamin Avery, Christian Sandor, Bruce H. Thomas. Improving Spatial Perception for Augmented Reality X-Ray Vision. In *Proceedings of the IEEE Virtual Reality Conference*, pages 79–82. IEEE, March 2009. Lafayette, Louisiana, USA.

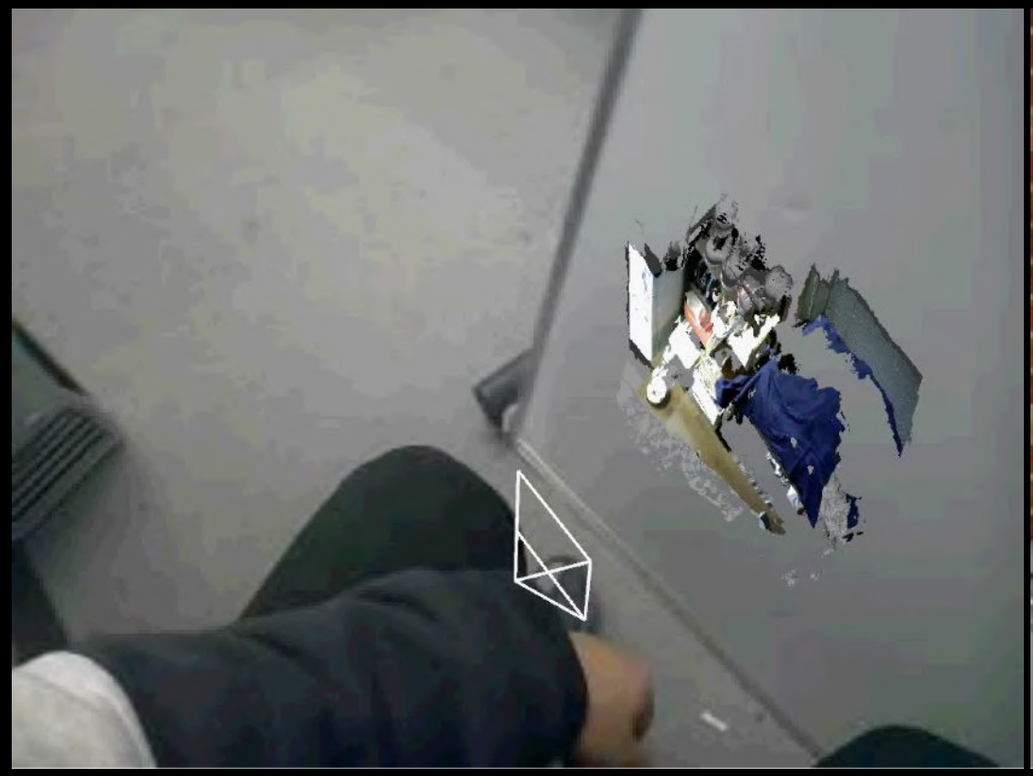
AR X-RAY FOR GOOGLE GLASS





Google Faculty Award (2014)

FINAL DEMO (4/2015)



CURRENT WORK: MEDICAL APPLICATIONS

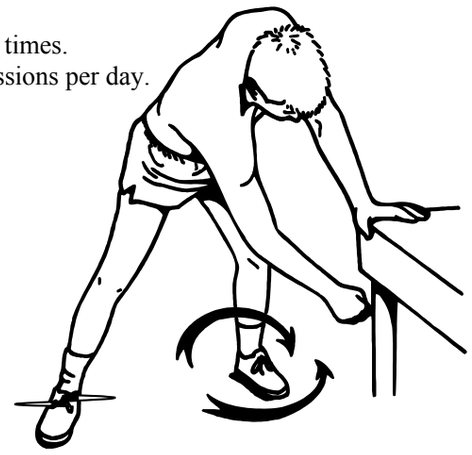
FallonClinic
Treating you well.

Rehabilitation & Sports Medicine
Frozen Shoulder

SHOULDER - 26
Range of Motion Exercises:
Pendulum (Circular)

Let arm move in a circle clockwise, then counter-clockwise, by rocking body weight in a circular pattern.

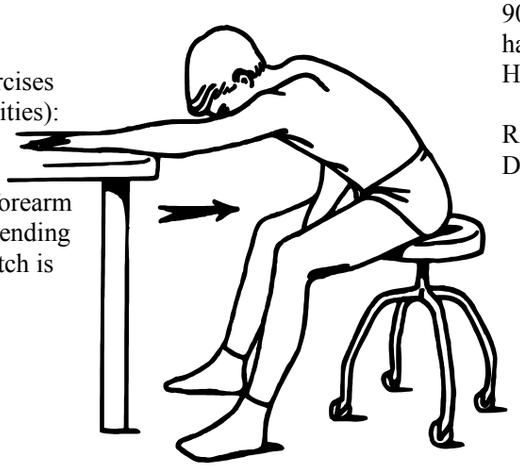
Repeat 10 times.
Do 3-5 sessions per day.



SHOULDER - 7
Range of Motion Exercises (Self-Stretching Activities): Flexion

Sitting upright, slide forearm forward along table, bending from waist until a stretch is felt. Hold 30 seconds.

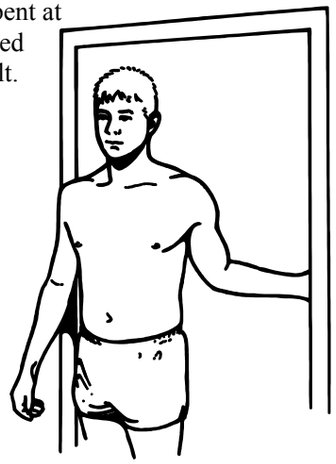
Repeat 1-4 times
Do 1 session per day.



SHOULDER - 11
Range of Motion Exercises (Self-Stretching Activities): External Rotation (alternate)

Keep palm of hand against door frame, and elbow bent at 90°. Turn body from fixed hand until a stretch is felt. Hold 30 seconds.

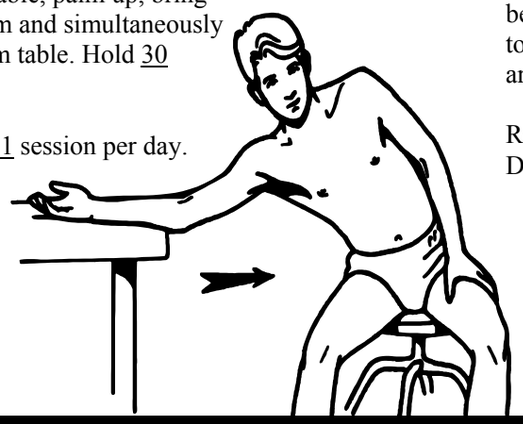
Repeat 1-4 times
Do 1 session per day.



SHOULDER - 9
Range of Motion Exercises (Self-Stretching Activities): Abduction

With arm resting on table, palm up, bring head down toward arm and simultaneously move trunk away from table. Hold 30 seconds.

Repeat 1-4 times Do 1 session per day.



SHOULDER - 73
Towel Stretch for Internal Rotation

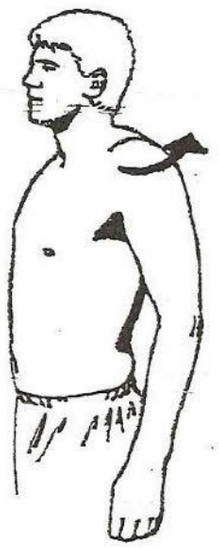
Pull involved arm up behind back by pulling towel upward with other arm. Hold 30 seconds.

Repeat 1-4 times
Do 1 session per day.

SCAP SETS

Pull your shoulders back, pinching the shoulder blades together. Do not let the shoulders come forward. Hold 5-10 seconds.

Repeat 10 times
Do 1 session per day.



CURRENT WORK: MEDICAL APPLICATIONS

Courtesy of http://campar.in.tum.de/Main/FelixBork

AR X-RAY FOR VETERINARY HEALTH CARE

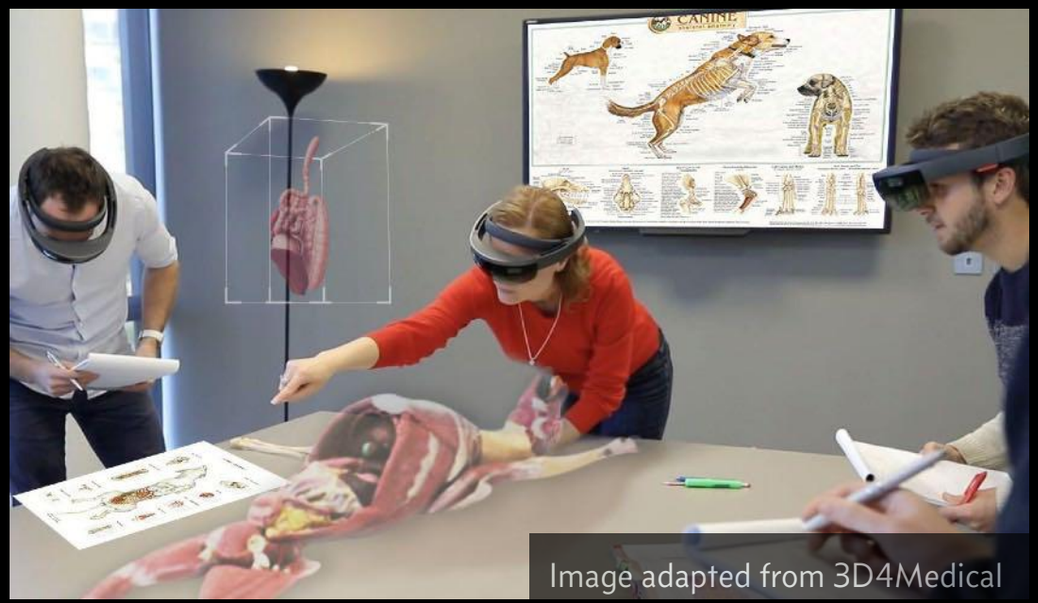


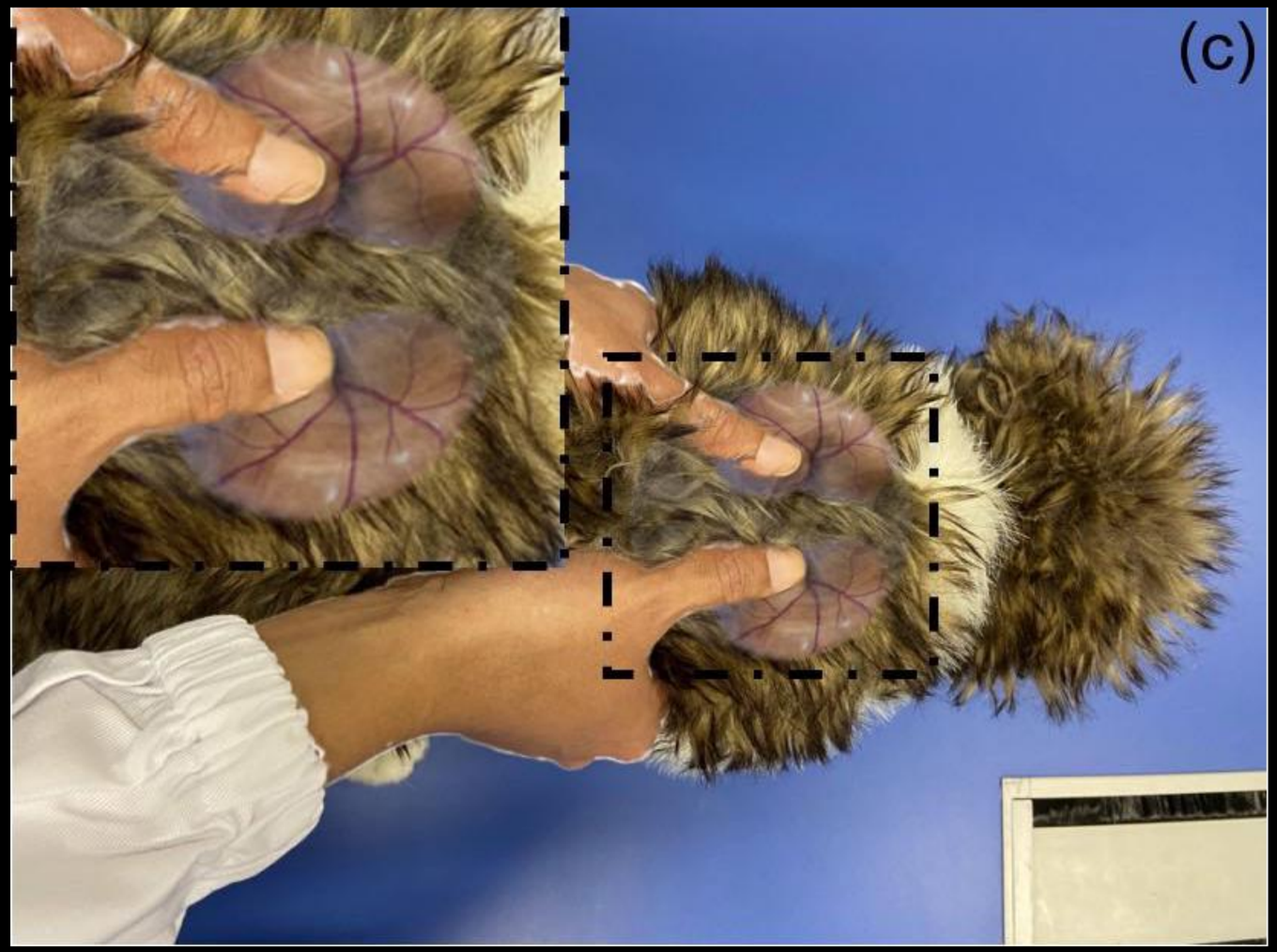
Image adapted from 3D4Medical

Image adapted from Shutterstock

Prof. Vanessa Barrs
Jockey Club College of Veterinary Medicine (Hong Kong)

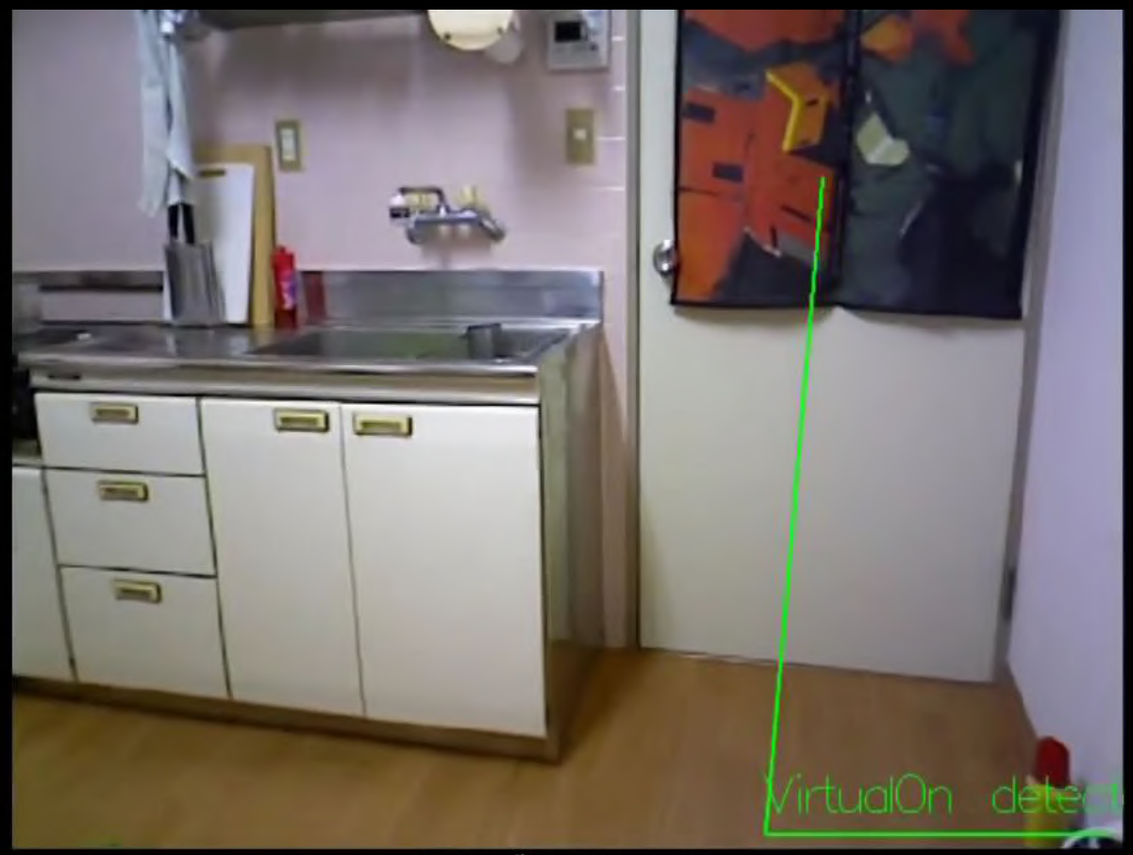
Prof. Nassir Navab
Johns Hopkins University (USA)
TU Munich (Germany)

AR X-RAY FOR VETERINARY HEALTH CARE



AR X-RAY FOR VETERINARY HEALTH CARE

Qiaochu Wang
(1st year PhD)



いかがでしたか？

. . . . .

https://www.youtube.com/watch?v=9jpWiTVR0GA

河童

美勇水滸傳
木曽駒若丸義仲

目目連
もくもくれん

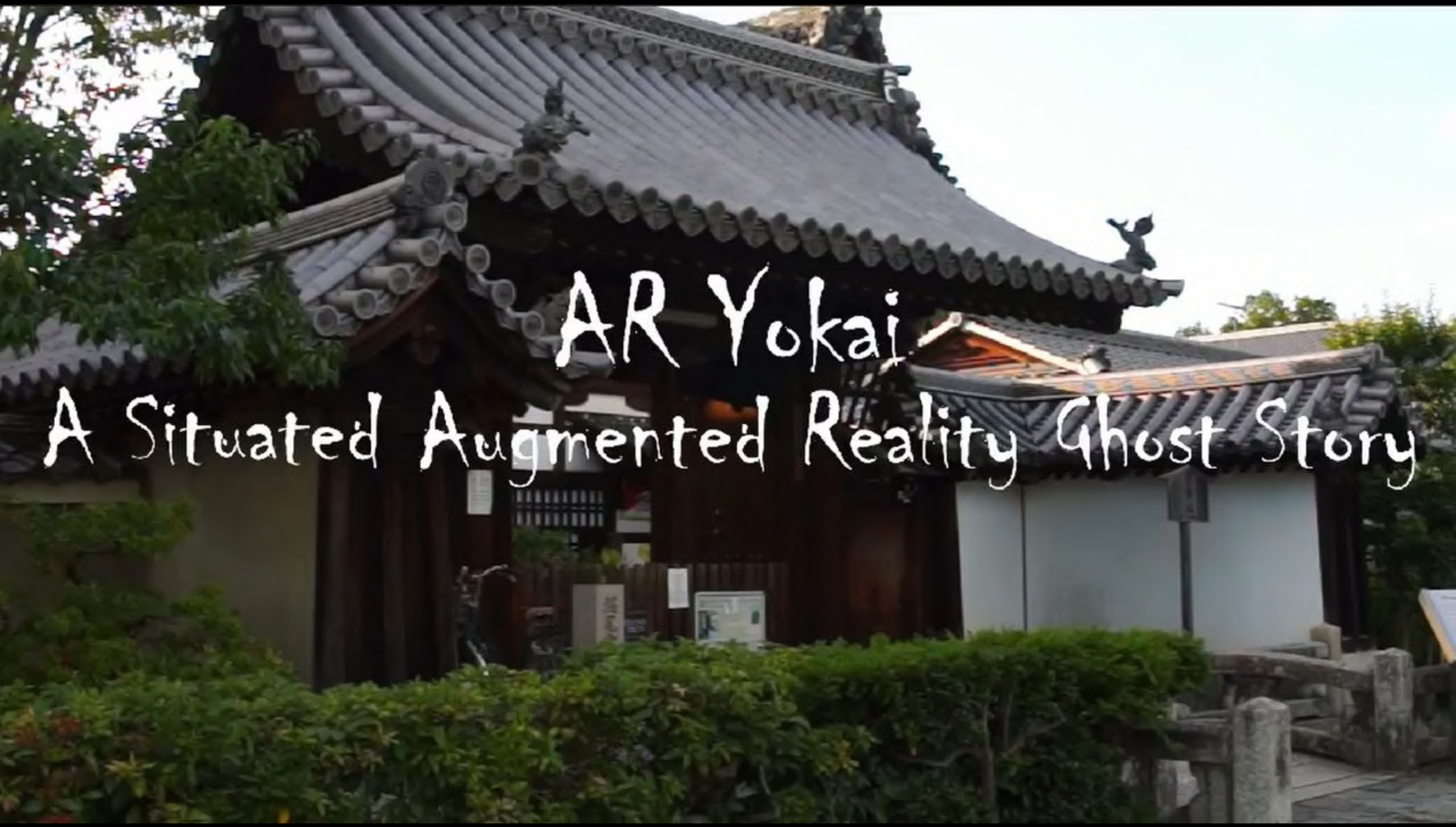
ぬらりひょん

Yōkai (妖怪) are supernatural monsters, spirits, and demons that range from the malevolent to the mischievous and occasionally bring good fortune; in Japanese folklore, they go back as far as AD 700. In this unique Augmented Reality experience we enable multiple users to encounter them together in a unique story, situated in Shunkoin, an ancient temple in Kyoto.

Left: Katsushika Hokusai (葛飾 北斎). Paper lantern ghost (提灯お化け), 1830

Right: Shunkoin temple (春光院), Kyoto.

http://www.aryoukai.com


AR Yokai
A Situated Augmented Reality Ghost Story

Damien Constantine Rompapas, **Christian Sandor**, Alexander Plopski, Daniel Saakes, Dong Hyeok Yun, Takafumi Taketomi, and Hirokazu Kato. HoloRoyale: A Large Scale High Fidelity Augmented Reality Game. Demo at *IEEE International Symposium on Mixed and Augmented Reality*, Munich, Germany, October 2018.

HoloRoyale: A Large Scale High Fidelity Augmented Reality Game

Damien Constantine Rompapas* Christian Sandor* Alexander Plopski* Daniel Saakes†
Yun Dong Hyeok† Takafumi Taketomi* Hirokazu Kato*

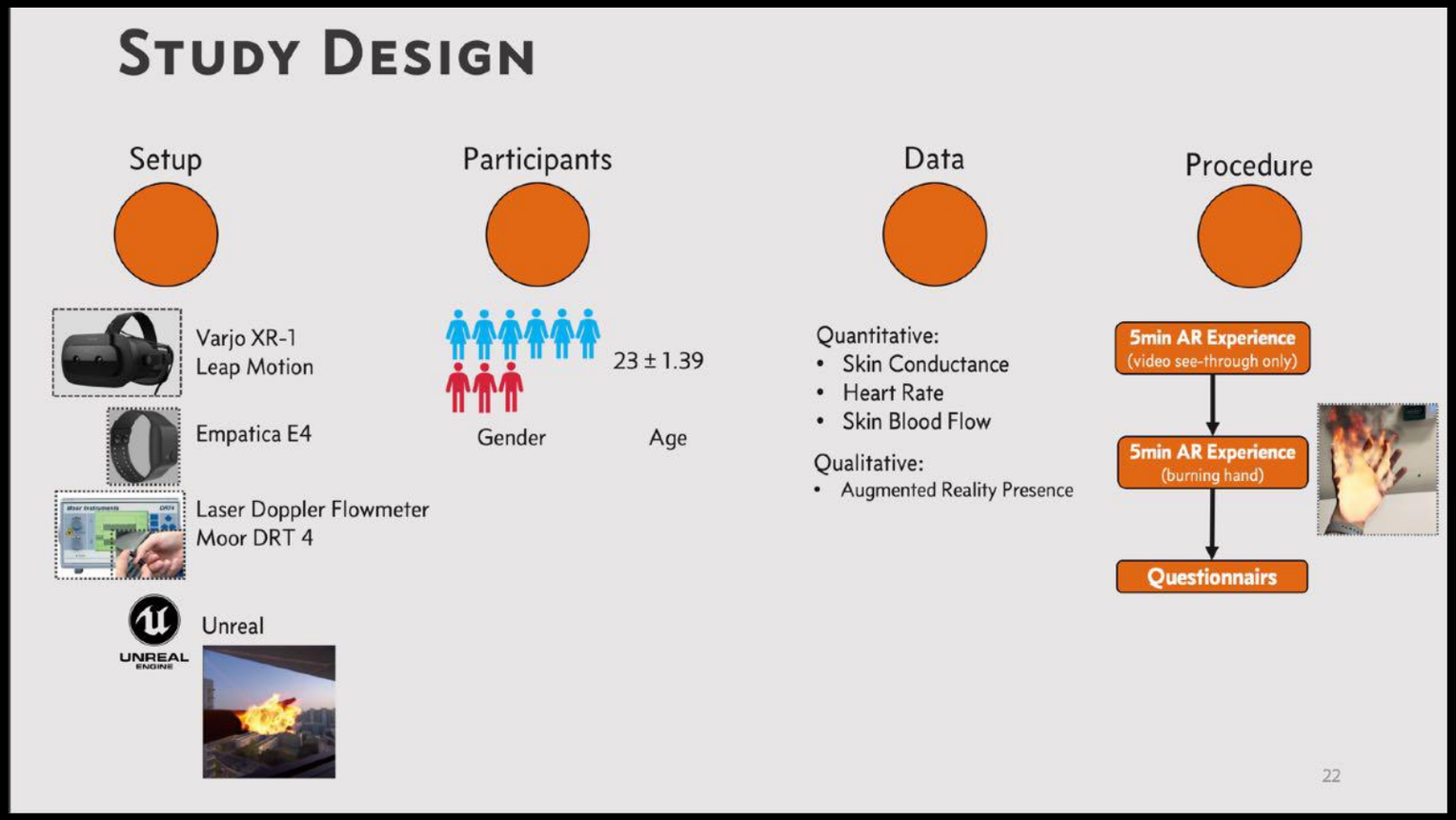
Interactive Media Design Lab*
Nara Institute of Science and Technology

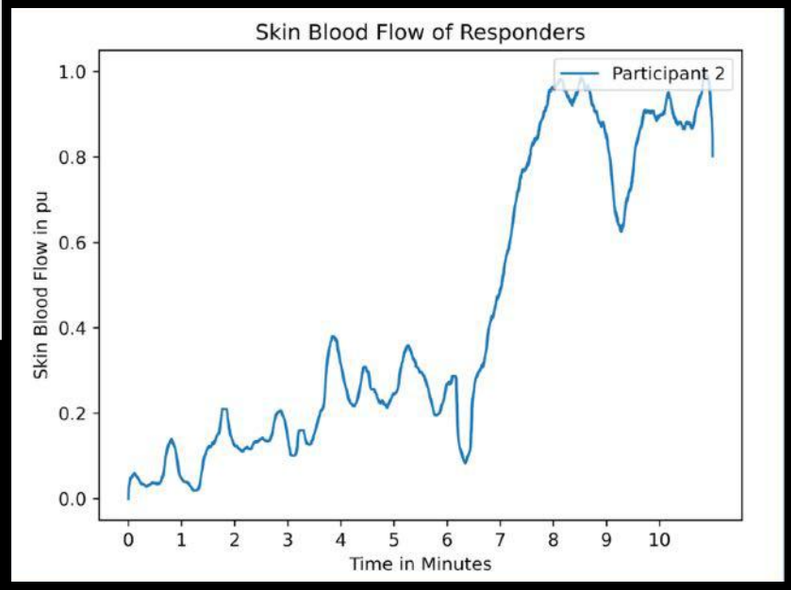
Department of Industrial Design†
KAIST

Note: video contains narration

Damien Constantine Rompapas, **Christian Sandor**, Alexander Plopski, Daniel Saakes, Dong Hyeok Yun, Takafumi Taketomi, and Hirokazu Kato. HoloRoyale: A Large Scale High Fidelity Augmented Reality Game. Demo at *IEEE International Symposium on Mixed and Augmented Reality*, Munich, Germany, October 2018.

REVISITING THE BURNING HAND





Daniel Eckhoff, Cecilia Li, Gladys Cheing, Alvaro Cassinelli, Christian Sandor. Investigation of Microcirculatory Effects of Experiencing Burning Hands in Augmented Reality. *IEEE Conference on Virtual Reality and 3D User Interfaces Abstracts and Workshops,* pages 569-570, March 2021

SUMMARY: 22 YEARS OF AR RESEARCH

Application domains

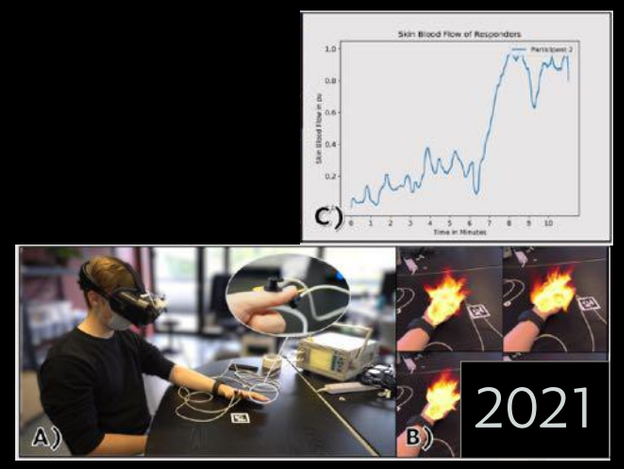
- Consumer, medical
- (Automotive, industrial, military)

Fundamental science

- Perception
- Technology

Overarching question: Content creation

- e.g. Situated Storytelling & Games



MY NEXT 22 YEARS OF AR RESEARCH

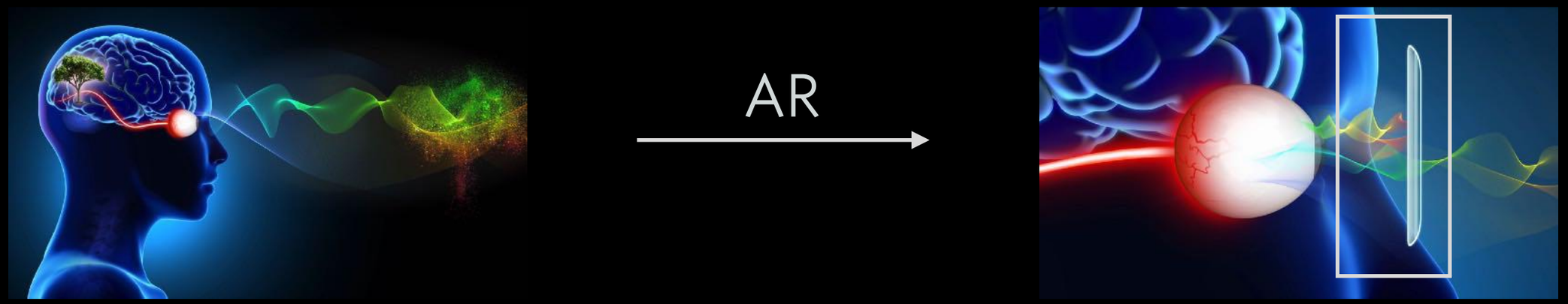
INCREDIBLE CHALLENGES

Technology

1. How to create a head-worn light field display?

2. How to localize the display in space?

Content production



https://www.magicleap.com/en-us/news/op-ed/spatial-computing-an-overview-for-our-techie-friends

INCREDIBLE CHALLENGES

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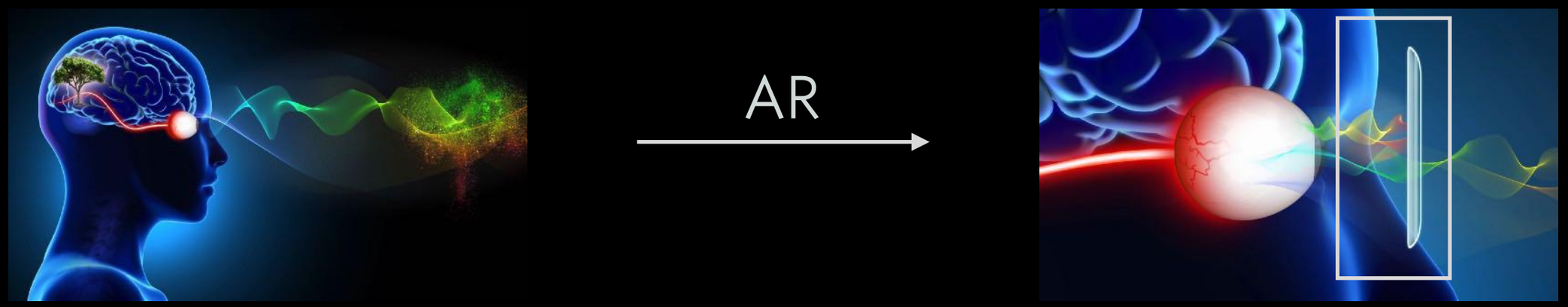

https://www.magicleap.com/en-us/news/op-ed/spatial-computing-an-overview-for-our-techie-friends

MAJOR BREAKTHROUGHS: LOCALIZATION FOR AR

[1996] Jun Rekimoto: Cybercode

First AR marker tracker

[1999] Hirokazu Kato: ARToolkit

Open source Cybercode

[2007] Georg Klein: PTAM

First SLAM system suitable for AR

[2011] Richard Newcombe: KinectFusion

First volumetric capturing system suitable for AR

[2015] Georg Klein: Hololens

First convincing optical see-through AR HMD

<10 ms motion-to-photon latency

jitter < 1mm @ 1m distance

CYBERCODE

Jun Rekimoto and Yuji Ayatsuka. CyberCode: Designing Augmented Reality Environments with Visual Tags. In *Proceedings of DARE: Designing augmented reality environments,* pages 1-10, 2000

PTAM

Georg Klein and David Murray. Parallel Tracking and Mapping for Small AR Workspaces. In *Proceedings of the IEEE and ACM International Symposium on Mixed and Augmented Reality*, pages 225-234, 2007.

SIGGRAPH Talks 2011

KinectFusion:

Real-Time Dynamic 3D Surface Reconstruction and Interaction

Shahram Izadi 1, Richard Newcombe 2, David Kim 1,3, Otmar Hilliges 1,
David Molyneaux 1,4, Pushmeet Kohli 1, Jamie Shotton 1,
Steve Hodges 1, Dustin Freeman 5, Andrew Davison 2, Andrew Fitzgibbon 1

1 Microsoft Research Cambridge 2 Imperial College London
3 Newcastle University 4 Lancaster University
5 University of Toronto

MAJOR BREAKTHROUGHS: LOCALIZATION FOR AR

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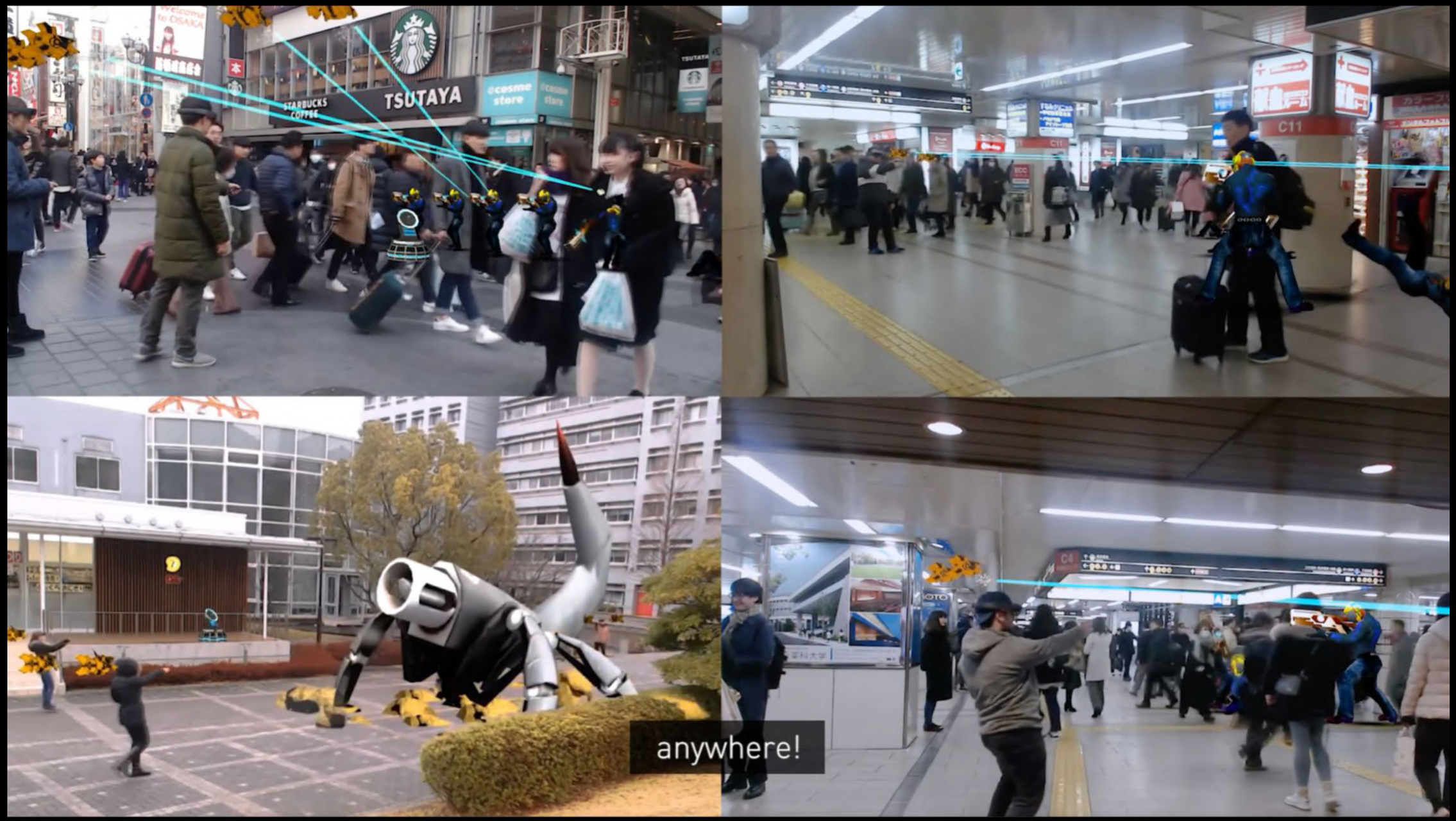
SO, WHAT'S MISSING?



SO, WHAT'S MISSING? ABSOLUTE POSITIONING

[1996] Jun Rekimoto: Cybercode

First AR marker tracker

We can't stick markers all over the world

[1999] Hirokazu Kato: ARToolkit

Open source Cybercode

[2007] Georg Klein: PTAM

First SLAM system suitable for AR

[2011] Richard Newcombe: KinectFusion

First volumetric capturing system suitable for AR

only *relative* positioning

[2015] Georg Klein: Hololens

First convincing optical see-through AR HMD

<10 ms motion-to-photon latency

jitter < **1mm** @ 1m distance

very hard requirement (forget GPS!)

ABSOLUTE POSITIONING

Definition:

> Determination of the 6 degrees of freedom of an object in the world (rotation & translation)

Desirable properties of an implementation:

- instant-on
- minimal environmental preparation effort
- high accuracy (0.1 mrad)

Other fields have different names for the same problem:

- Kidnapped robot problem (Robotics)
- Relocalization (Computer Vision)

IN 2015, WE UNSUCCESSFULLY TRIED POSENET

(b) Relocalization under difficult dusk and night lighting conditions. In the dusk sequences, the landmark is silhouetted against the backdrop however again the convnet seems to recognize the contours and estimate pose.

Alex Kendall, Matthew Grimes, and Roberto Cipolla. PoseNet: A Convolutional Network for Real-Time 6-DOF Camera Relocalization. *http://arxiv.org/abs/1505.07427*, 2015.

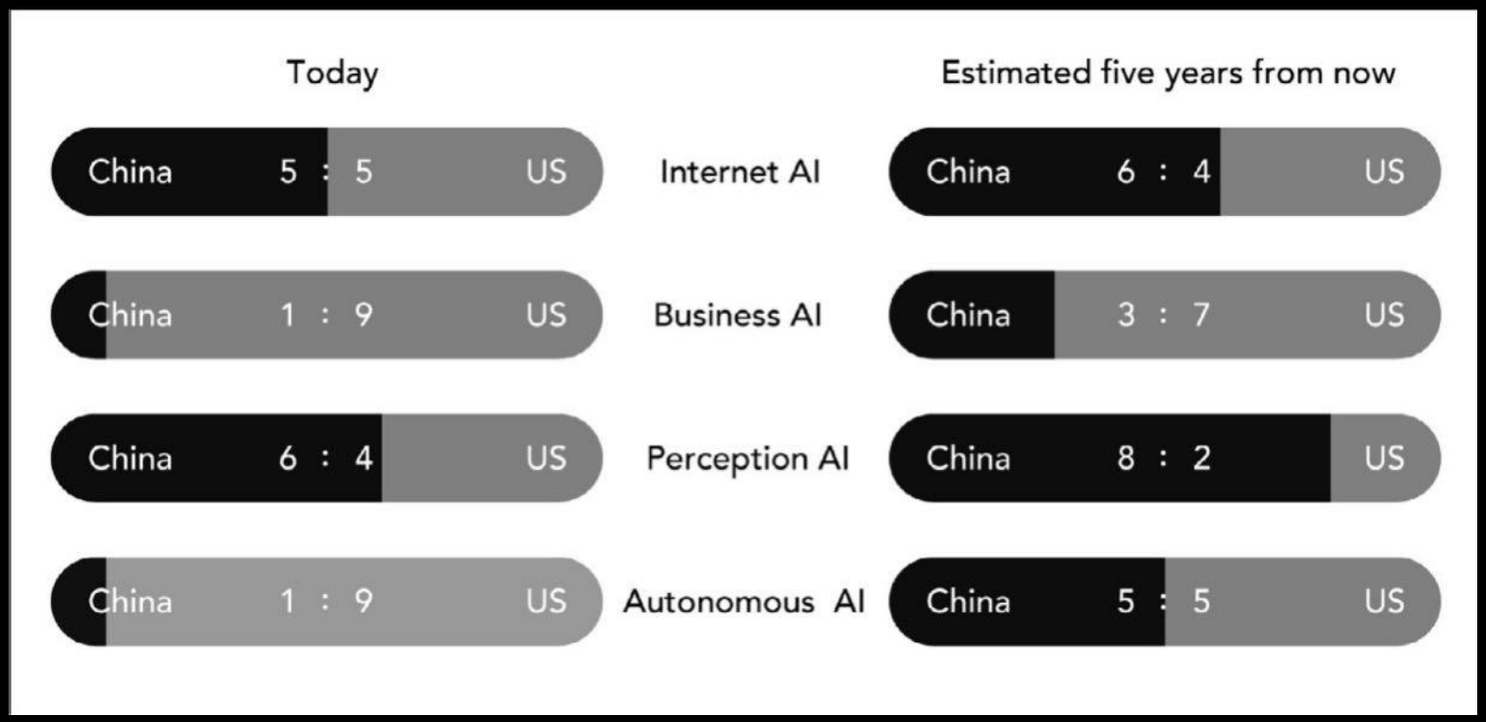
IN 2020, I SAW A WORKING SOLUTION (!)

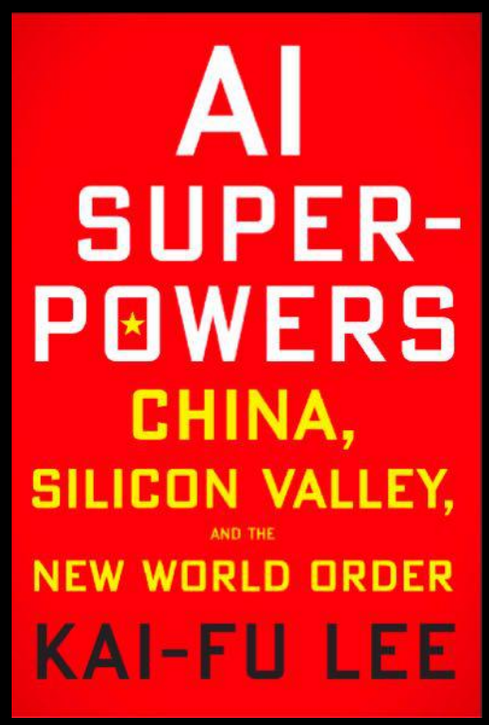
Visit to one of the biggest Chinese IT companies

They had a demo of a working solution to Absolute Positioning!

My guess how they did it: Immense video data

1 year of non-stop video of all streets of a major city

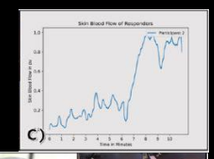




CONCLUSIONS

Past Works

- Application domains
  - Consumer, medical
  - (Automotive, industrial, military)
- Fundamental science
  - Perception
  - Technology
- Overarching question: Content creation
  - e.g. Situated Storytelling & Games



The Future

Europe is too far behind 😢

- Technology
  - 1. How to create a head-worn light field display?
  - 2. How to localize the display in space?
- Content creation

Europe's chance