Artificial Intelligence in Interactive Systems
~~Practical Machine Learning~~

Organization

Sven Mayer

Team

Sven Mayer

Jesse Grootjen

Jan Leusmann

Organization

- **Lecture**: Thursday 10-12 c.t., in-person only
- **Tutorials:** Fridays 10-12 c.t., in-person only
- **Location:** Pettenkoferstr. 14, Kl. HS Physiologie (F1.08)

- ~~**Practical projects**: one (iteration of a) practical project over the course of the lecture, intermediate presentations in the tutorials, and a final presentation at the end of the lecture.~~

Organization

- **Moodle course** (organization & material)
- https://moodle.lmu.de/course/view.php?id=38595
- **Website** https://www.medien.ifi.lmu.de/lehre/ss25/pml/
- **Old Recordings & Old Slides** https://sven-mayer.com/pml
- Updated slides will come out just before every lecture.
- **Email** pml@medien.ifi.lmu.de

Old Recorded Lecture

- Content will change, but gives a impression
- Online available at https://sven-mayer.com/pml/
- No need to watch the lecture recording before the lecture
- Videos 20min to 1h

- In the lecture slot (Thursdays, 10-12)
  - Lecture & Discussion

Organization

Hands-On Sessions

You will get all the information in the first tutorial.

- Examples will be based on
  - Python 3.9+
  - Keras + TensorFlow
  - Jupyter Notebooks recommended

- Get started:
  - https://www.python.org/
  - https://www.tensorflow.org/install
  - https://jupyter.org/
  - For Windows users: https://www.lfd.uci.edu/~gohlke/pythonlibs/

Exam

- Written exam
  - 90-minute
  - Closed book
  - Content of the lectures, tutorials, and exercises.

- Date: TDA
  - The announcement will happen via Moodle
  - https://studiengangskoordination.ifi.lmu.de/misc/klausuren.html

- This lecture has 6 ETCS, which is equivalent to 180h of work

Lectures

- 01.05.2025 Public holiday
- 08.05.2025 Lecture 01: Organization & Introduction
- 15.04.2025 Lecture 02: Supervised vs. Unsupervised Learning
- 22.05.2025 Lecture 04: Introduction Neural Networks
- 29.05.2024 Public holiday
- 05.06.2025 Lecture 05: Advanced Neural Networks & Lecture 06: Evaluating Neural Networks & …
- 12.06.2025 … & Lecture 07: Trainings Strategies
- 19.06.2025 Public holiday
- 26.06.2025 Lecture: Online Machine Learning by Jan Leusmann
- 03.07.2025 Lecture 09: Generative Adversarial Networks (GANs), and Lecture 08: Recurrent Neural Network (RNN) & Long Short-Term Memory (LSTM)
- 10.07.2025 Lecture: Large Language Models by Thomas Weber
- 17.07.2025 Lecture 10: Reinforcement Learning
- 24.07.2025 Lecture: Applications
- Open Discussion
- Q'n'A: Exam preparation

Tutorials

- 09.05.2025 Canceled
- 16.05.2025 Organization & Lecture 03: Full Practical Neural Network Walkthrough
- 23.05.2025 Exercise 01
- 30.05.2025 Public holiday
- 06.06.2025 TBD
- 13.06.2025 Exercise 01 Results & Exercise 02
- 20.06.2025 Public holiday
- 27.06.2025 TBD
- 04.07.2025 TBD
- 11.07.2025 TBD
- 18.07.2025 TBD
- 25.07.2025 TBD

The Next Generation of Computing Systems: Artificial Intelligence meets Humans

Sven Mayer

Ubiquitous Computing

Mark Weiser, 1991

“The most profound technologies are those that disappear. They weave themselves into the fabric of everyday life until they are indistinguishable from it”

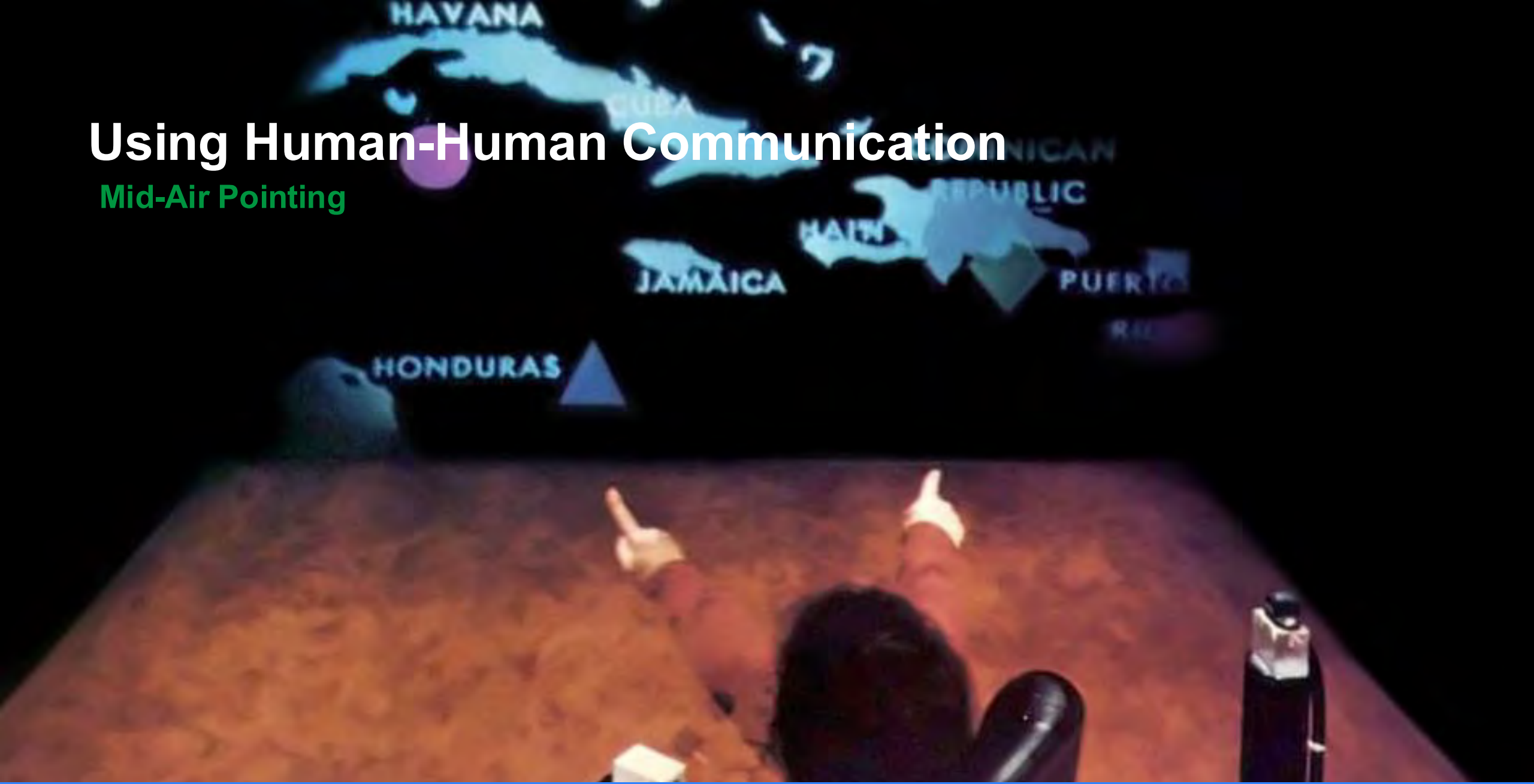
“…Hundreds of computers in a room could seem intimidating at first, […] these hundreds of computers will come to be invisible to common awareness. People will simply use them unconsciously to accomplish everyday tasks.”

Mark Weiser (1991) The Computer for the 21 st Century. Scientific american, 265(3). https://www.jstor.org/stable/24938718

„Just Walk Out“ shopping experience at Amazon Go

Using Human-Human Communication

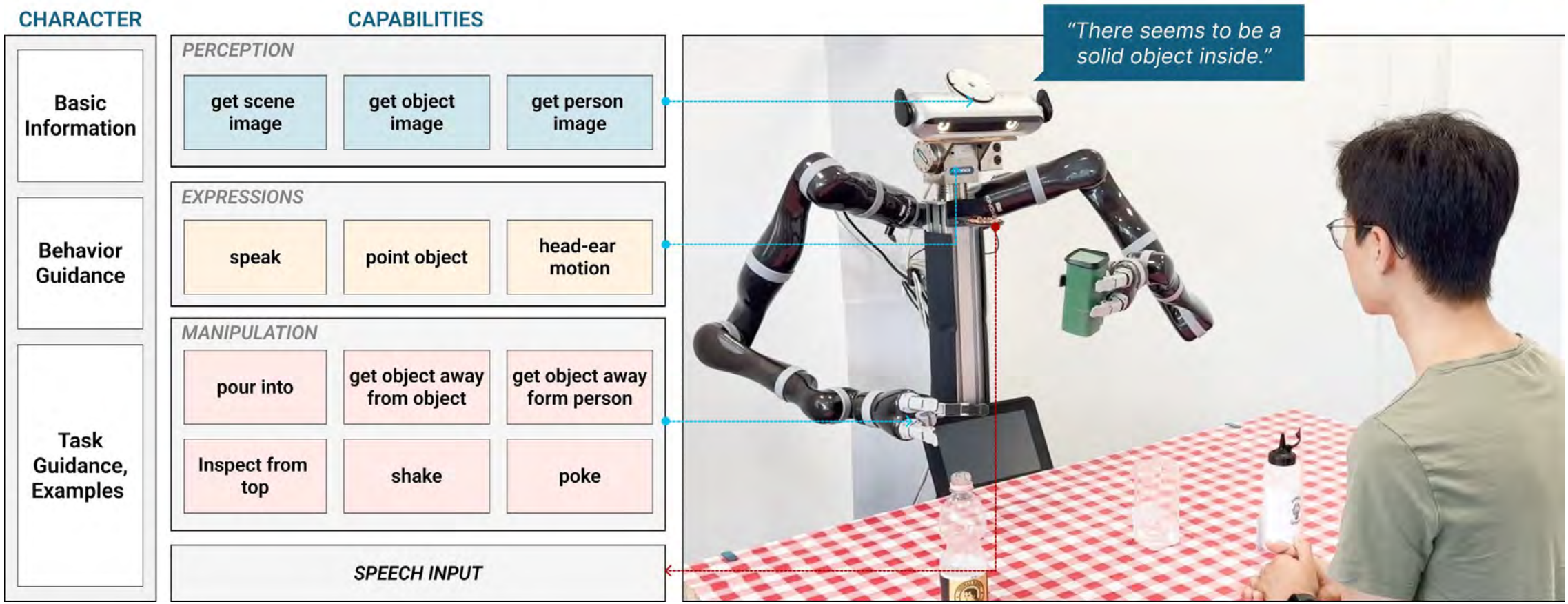
Mid-Air Pointing



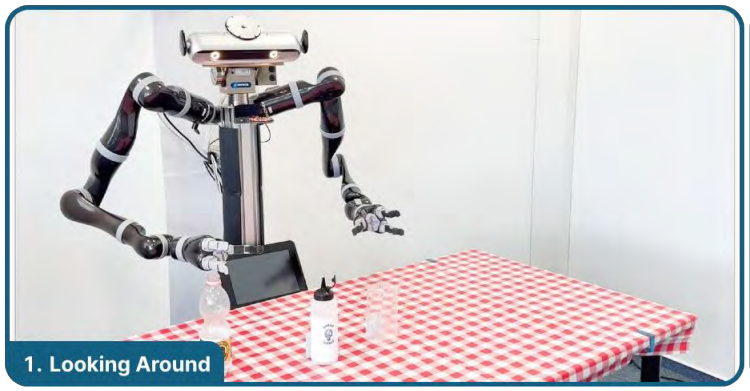
R. A. Bolt (1980) “Put-that-there”: Voice and gesture at the graphics interface. SIGGRAPH ‘80 DOI: http://doi.org/10.1145/800250.807503

S. Mayer, L. Lischke, J. E. Grønbæk, Z. Sarsenbayeva, J. Vogelsang, P. W. Woźniak, N. Henze, G. Jacucci (2018) Pac-Many: Movement Behavior when Playing Collaborative and Competitive Games on Large Displays. In Proc. of CHI. DOI: https://doi.org/10.1145/3173574.3174113

MM-LLM Robotic Agent

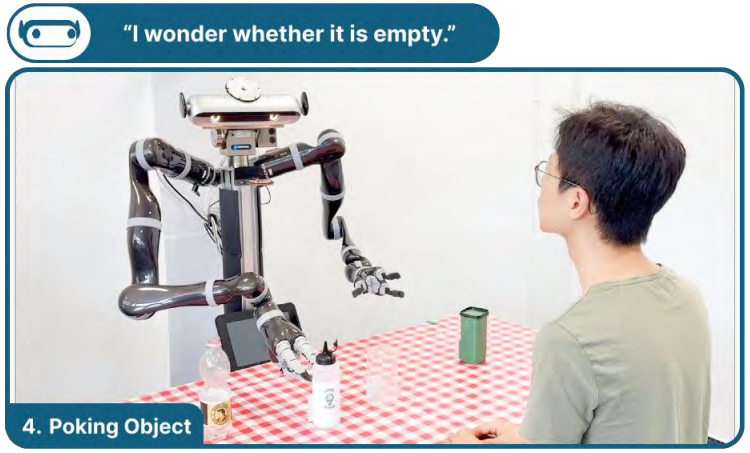


Jan Leusmann, Anna Belardinelli, Luke Haliburton, Stephan Hasler, Albrecht Schmidt, **Sven Mayer**, Michael Gienger, Chao Wang (2025) Investigating LLM-Driven Curiosity in Human-Robot Interaction. In: Proceedings of the 2025 CHI Conference on Human Factors in Computing Systems, Association for Computing Machinery DOI: https://doi.org/10.1145/3706598.3713923


1. Looking Around

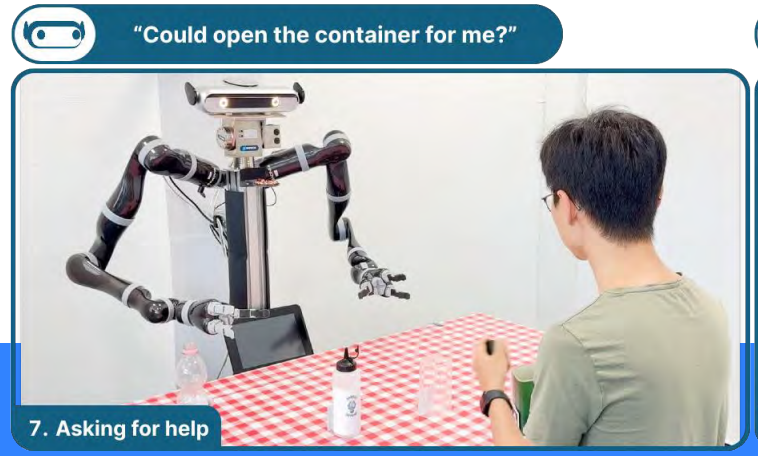

"What is your name?"
2. Asking Name

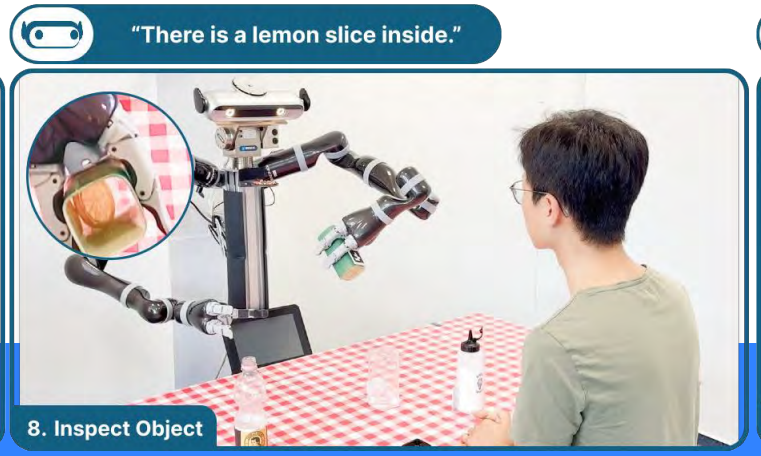

"Are we going to prepare a cocktail?"
3. Asking About Task


"I wonder whether it is empty."
4. Poking Object


5. Pouring Liquor


"There seems to be a solid object inside."
6. Shake Object


"Could open the container for me?"
7. Asking for help

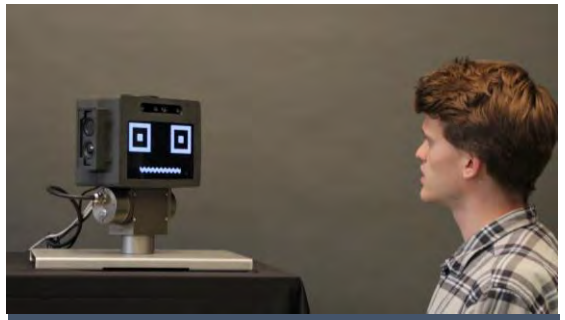

"There is a lemon slice inside."
8. Inspect Object


"Do you usually like lemon in your gin and tonic?"
9. Asking Preference

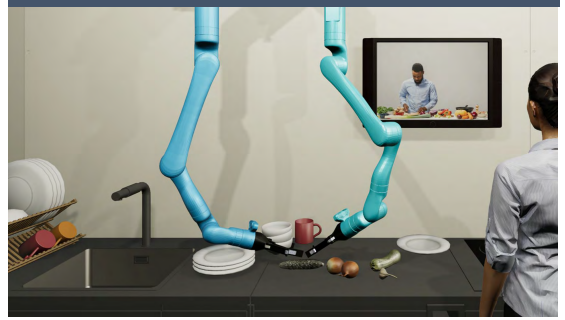
Investigating LLM-Driven Curiosity in Human-Robot Interaction

User Sensing

Context Awareness

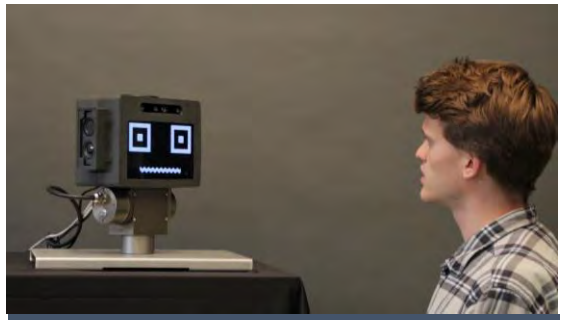


Embodied Agents

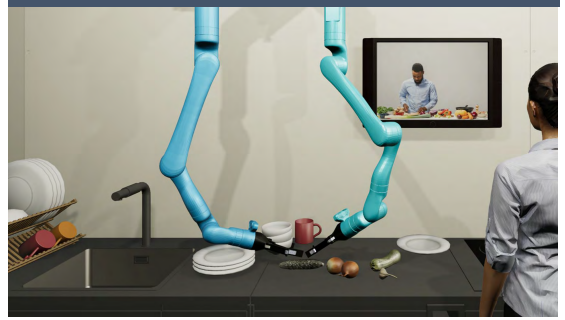


User Sensing

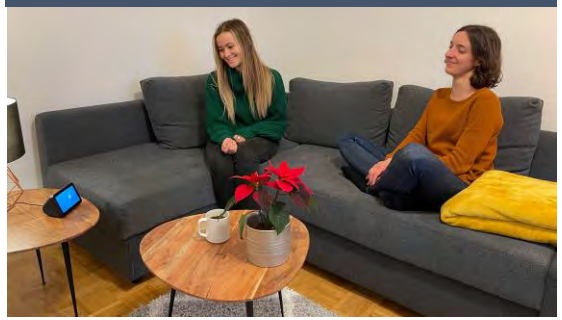
Context Awareness



Embodied Agents



Privacy & Security

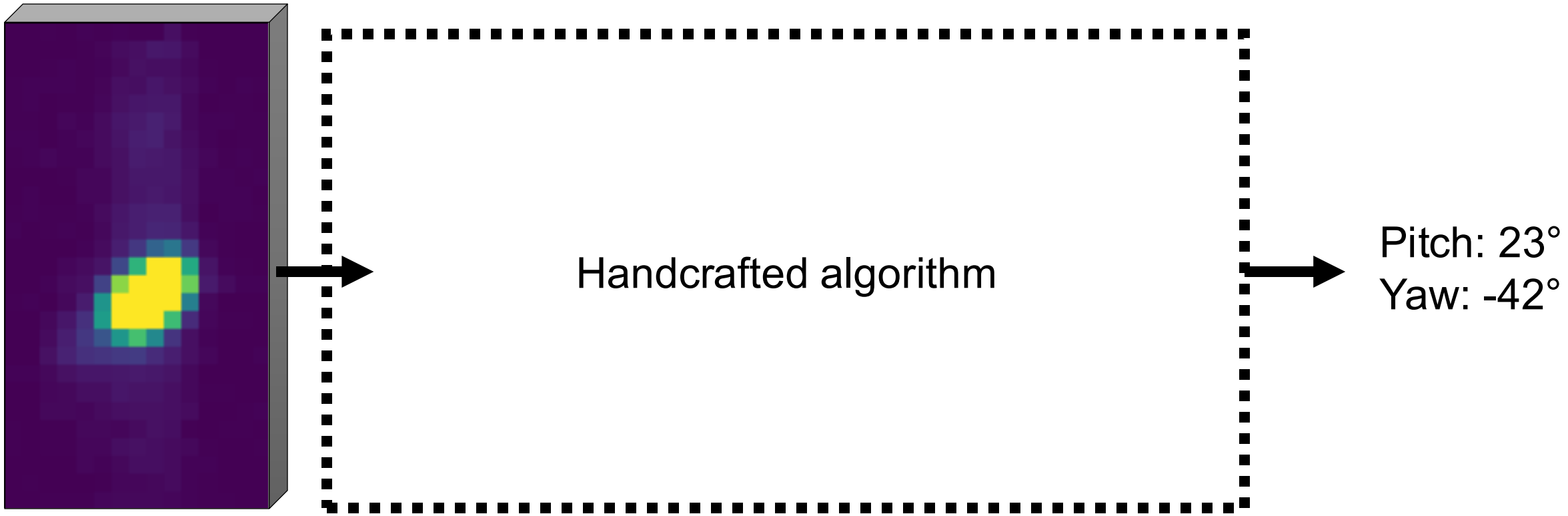


Understanding the Context of the Human

Finger Orientation as Context or Input

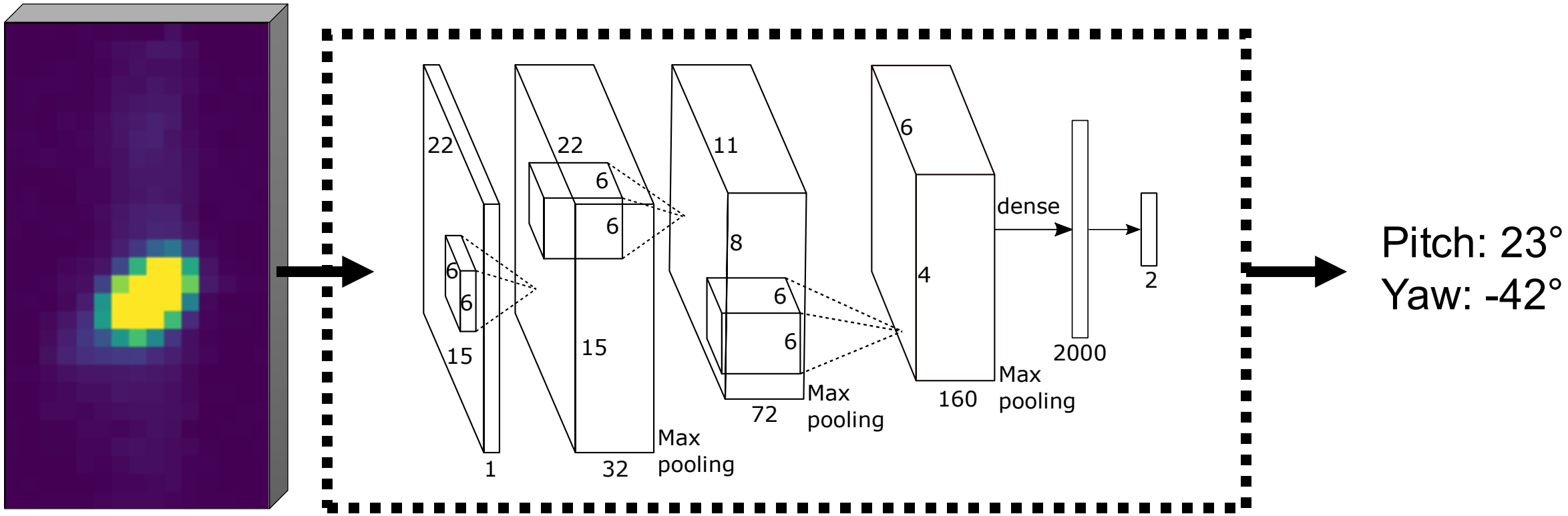
R. Xiao, J. Schwarz, C. Harrison (2015) Estimating 3D Finger Angle on Commodity Touchscreens. In Prof. of ISS. DOI: https:// doi.org/10.1145/2817721.2817737

Machine Learning to Enhance Sensing



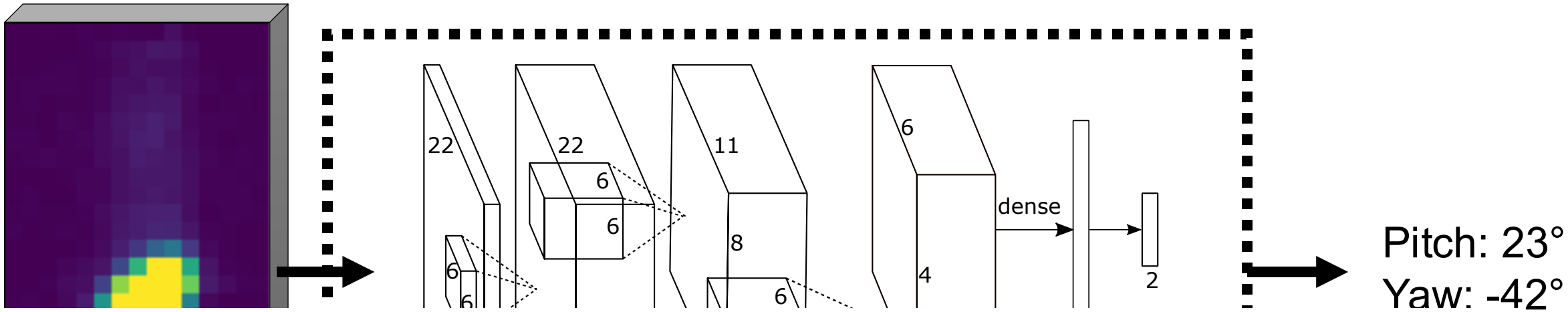
Often used for: Support vector machine (SVM), k-nearest neighbors algorithm (kNN), Decision Trees, Random forest, Gaussian process

Machine Learning to Enhance Sensing



S. Mayer, H. V. Le, & N. Henze (2017) Estimating the Finger Orientation on Capacitive Touchscreens Using Convolutional Neural Networks. In Proc. of ISS.
DOI: https://doi.org/10.1145/3132272.3134130

Machine Learning to Enhance Sensing



Method	Pitch			Yaw		
	RMSE	MAE	SD	RMSE	MAE	SD
GP reimplementation of Xiao et al. [41]*	14.74	11.78	14.38	56.58	40.51	39.51
pseudo implementation of Xiao et al. [41]**	14.19	11.58	8.21	44.53	33.39	29.46
CNN + L2	12.8	10.09	7.88	24.19	17.62	16.58

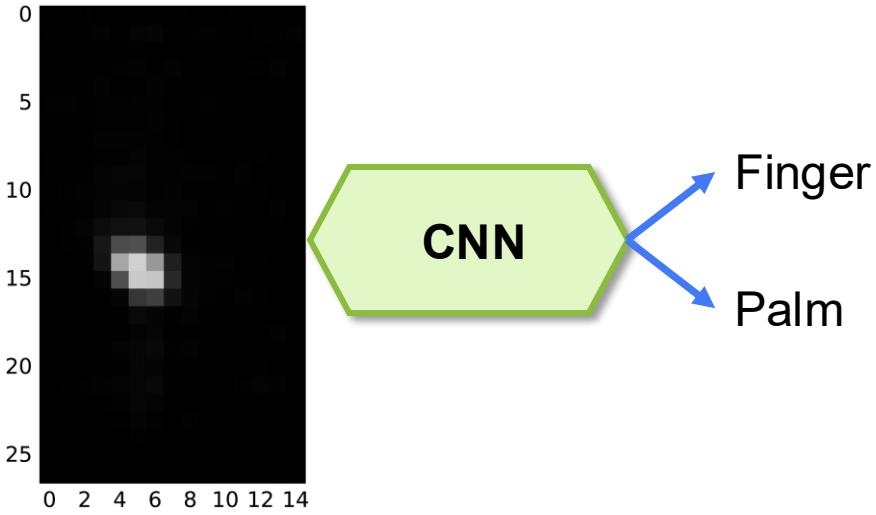
8.9%

45.7%

S. Mayer, H. V. Le, & N. Henze (2017) Estimating the Finger Orientation on Capacitive Touchscreens Using Convolutional Neural Networks. In Proc. of ISS.
DOI: https://doi.org/10.1145/3132272.3134130

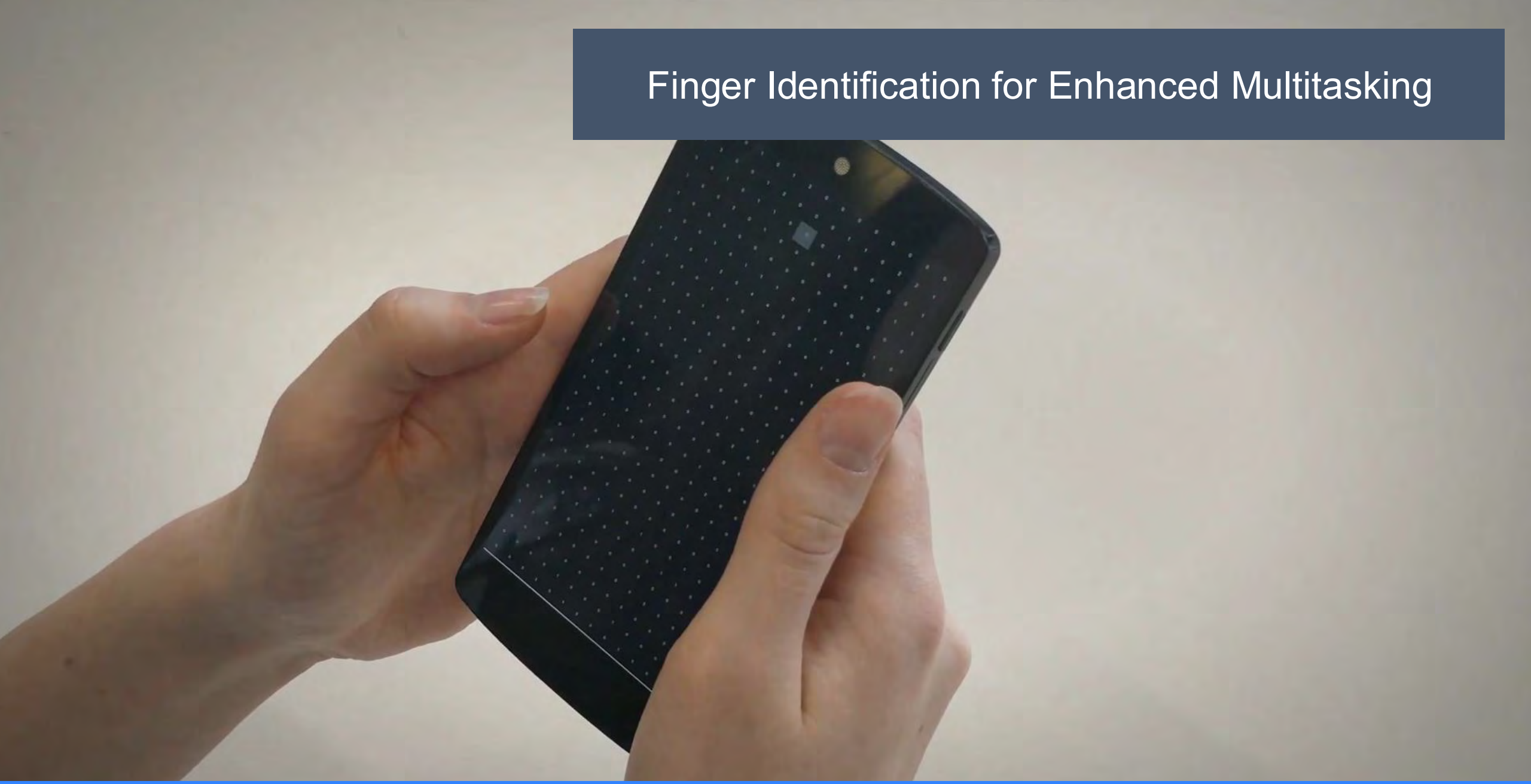
Palm Detection

- Convolutional Neural Network
- Classification
- Representation Learning



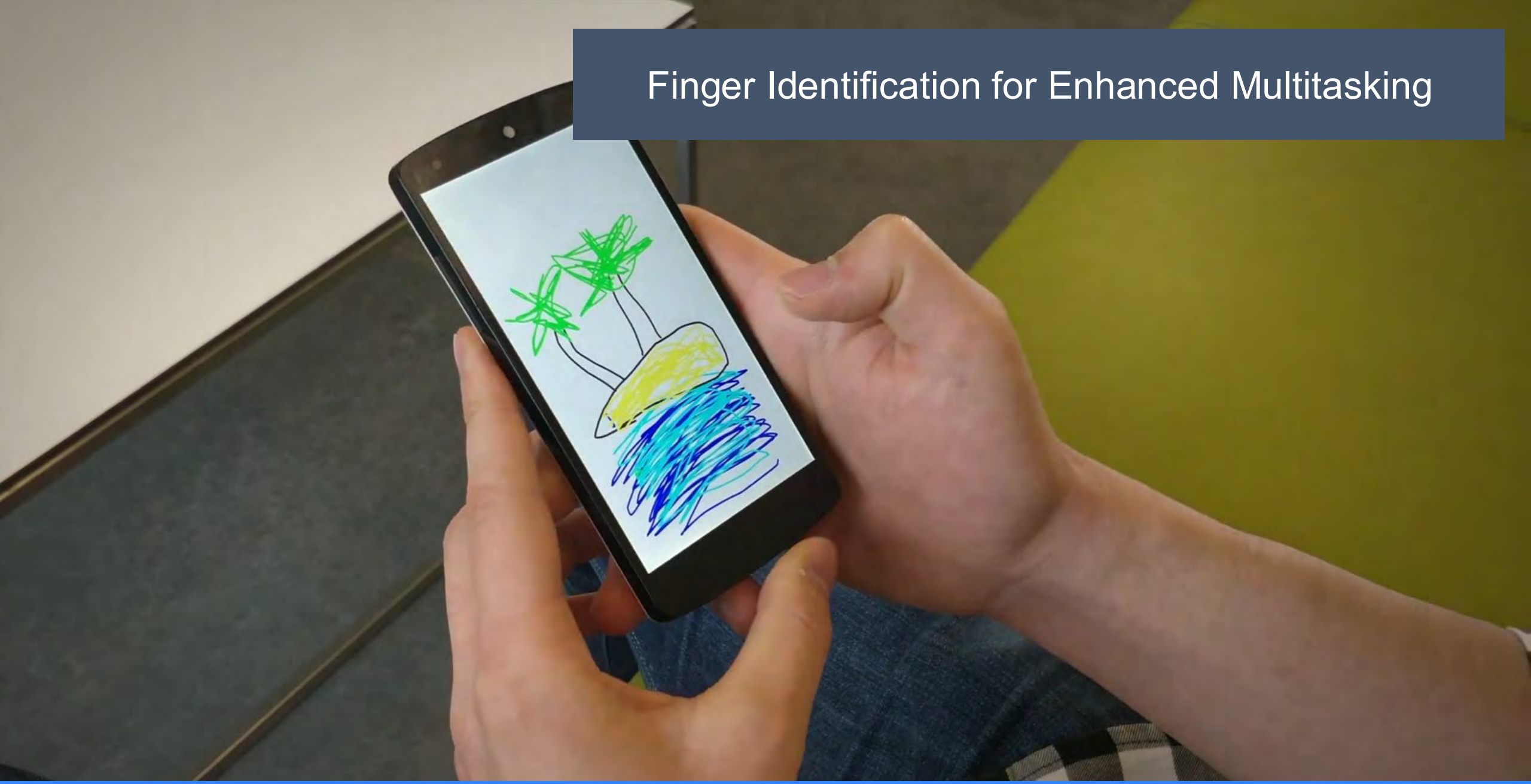
Huy Viet Le, Thomas Kosch, Patrick Bader, **Sven Mayer**, and Niels Henze. 2018. PalmTouch: Using the Palm as an Additional Input Modality on Commodity Smartphones. In Proc. of CHI '18. ACM. DOI: https://doi.org/10.1145/3173574.3173934

Finger Identification for Enhanced Multitasking



H. V. Le, **S. Mayer** & N. Henze (2019) Investigating the Feasibility of Finger Identification on Capacitive Touchscreens using Deep Learning. In Proc. of IUI.
DOI: https://doi.org/10.1145/3301275.3302295

Finger Identification for Enhanced Multitasking

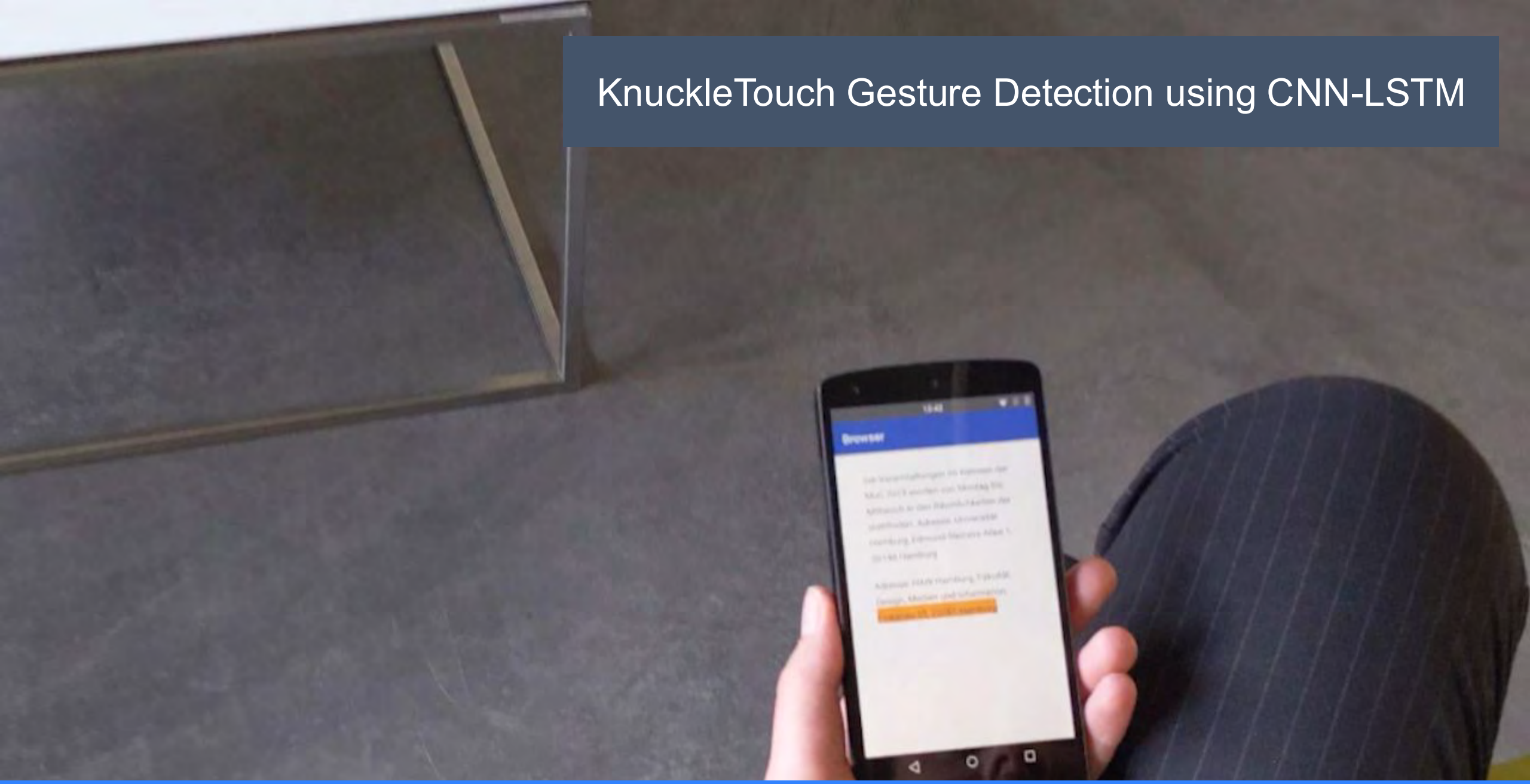


H. V. Le, **S. Mayer** & N. Henze (2019) Investigating the Feasibility of Finger Identification on Capacitive Touchscreens using Deep Learning. In Proc. of IUI.
DOI: https://doi.org/10.1145/3301275.3302295

KnuckleTouch Gesture Detection using CNN-LSTM

R. Schweigert, J. Leusmann, S. Hagenmayer, M. Weiß, H.V. Le, **S. Mayer**, A. Bulling. KnuckleTouch: Enabling Knuckle Gestures on Capacitive Touchscreens using Deep Learning. MuC 2019

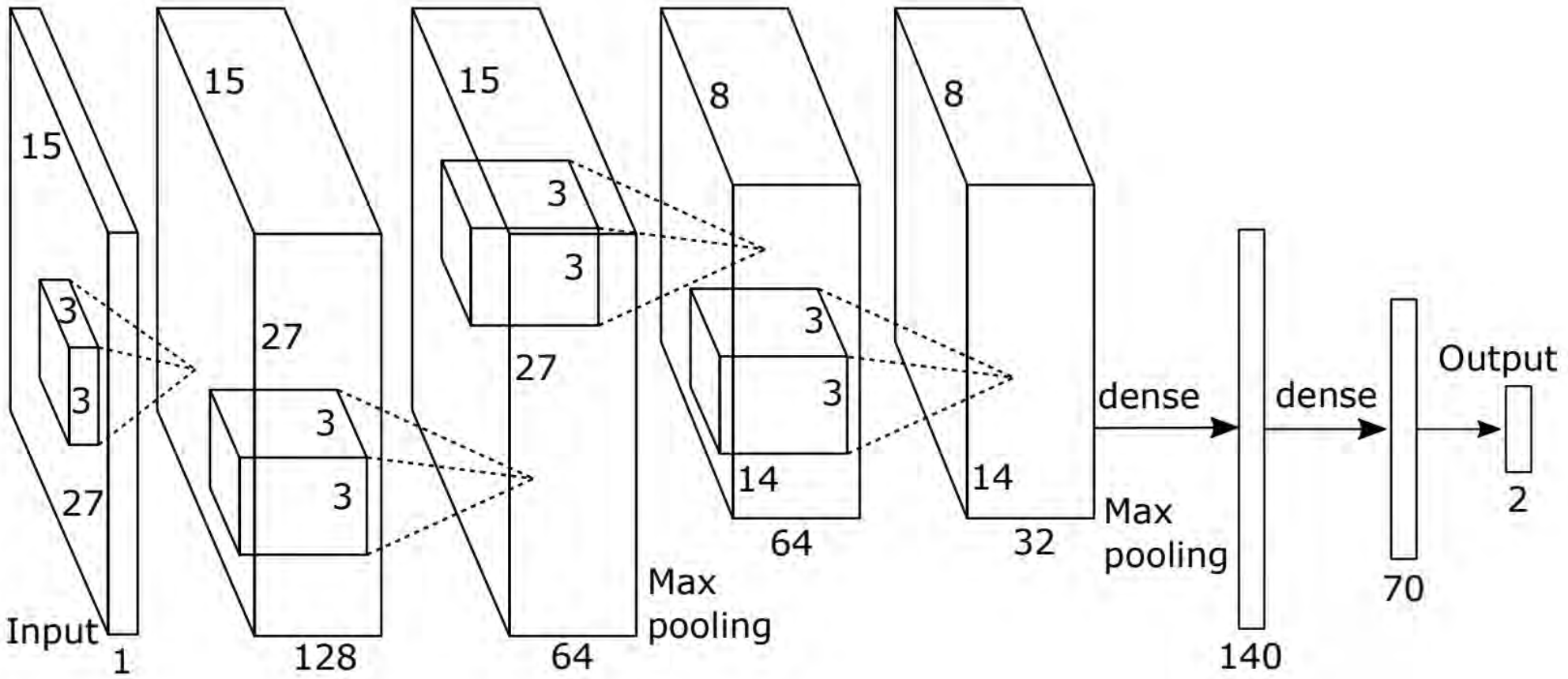
KnuckleTouch Gesture Detection using CNN-LSTM



R. Schweigert, J. Leusmann, S. Hagenmayer, M. Weiß, H.V. Le, **S. Mayer**, A. Bulling (2019) KnuckleTouch: Enabling Knuckle Gestures on Capacitive Touchscreens using Deep Learning. In Prof of. MuC. DOI: https://doi.org/10.1145/3340764.3340767

KnuckleTouch Gesture Detection

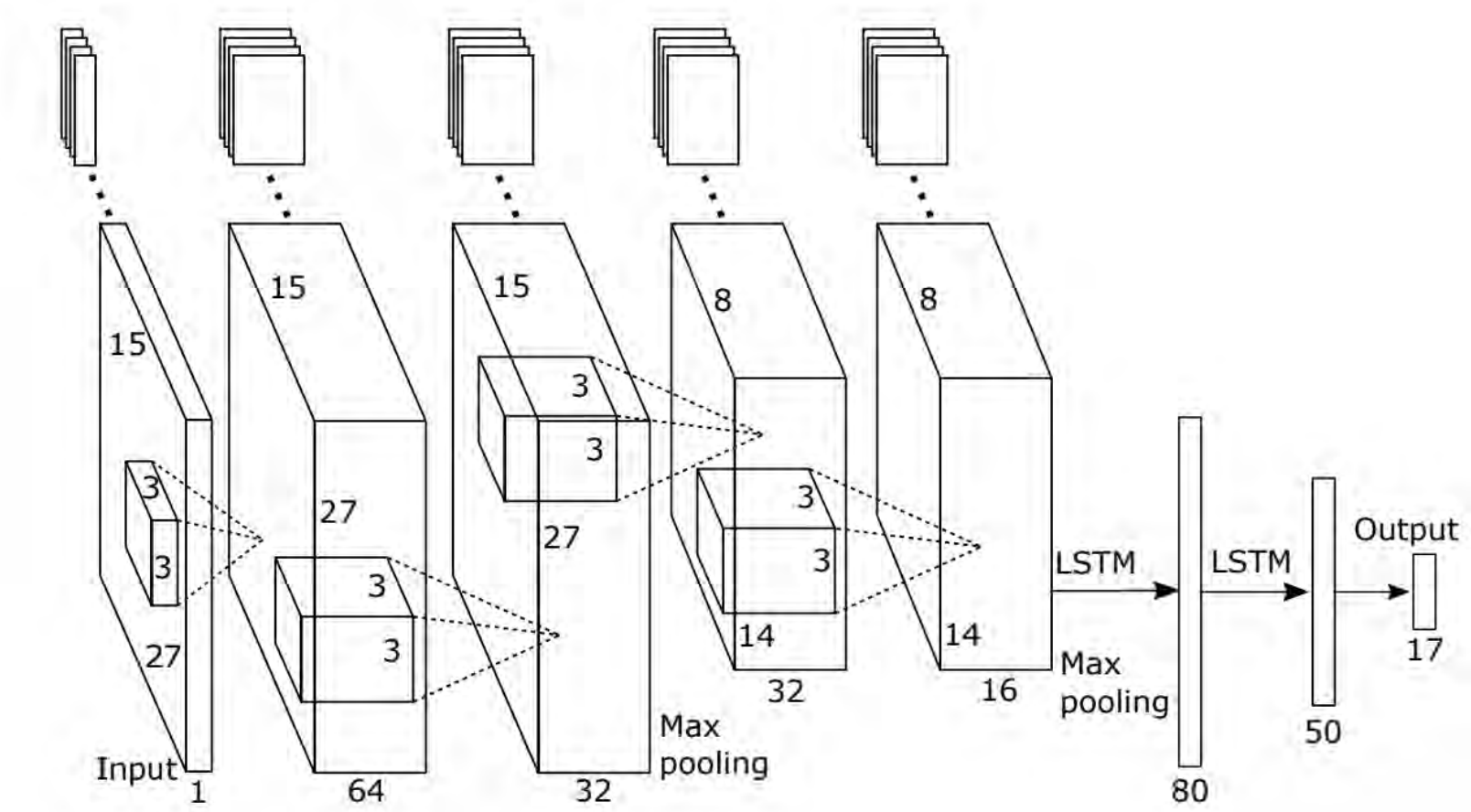
CNN for Finger vs. Knuckle Detection



R. Schweigert, J. Leusmann, S. Hagenmayer, M. Weiß, H.V. Le, **S. Mayer**, A. Bulling (2019) KnuckleTouch: Enabling Knuckle Gestures on Capacitive Touchscreens using Deep Learning. In Prof of. MuC. DOI: https://doi.org/10.1145/3340764.3340767

KnuckleTouch Gesture Detection

CNN-LSTM for Gesture Detection



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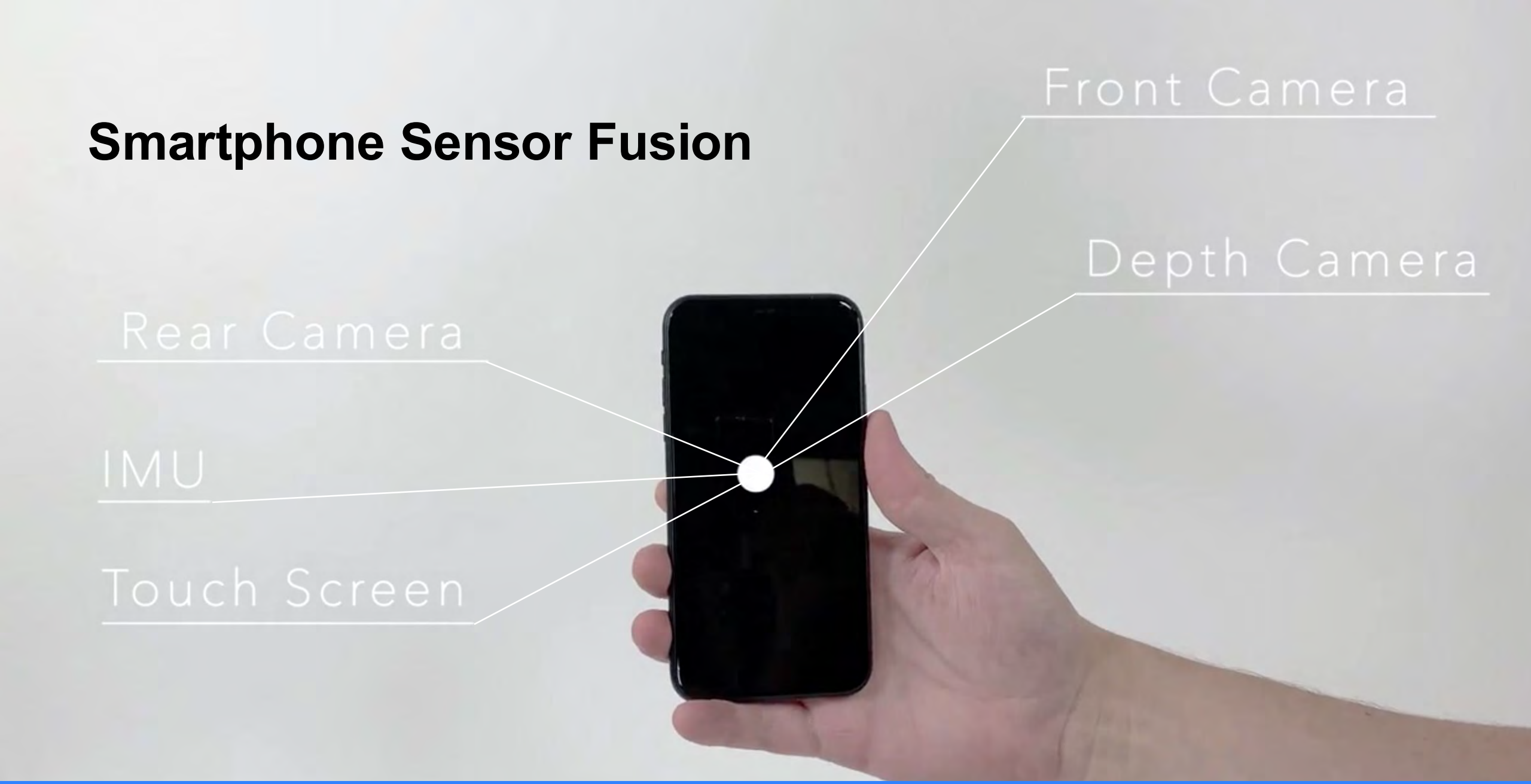
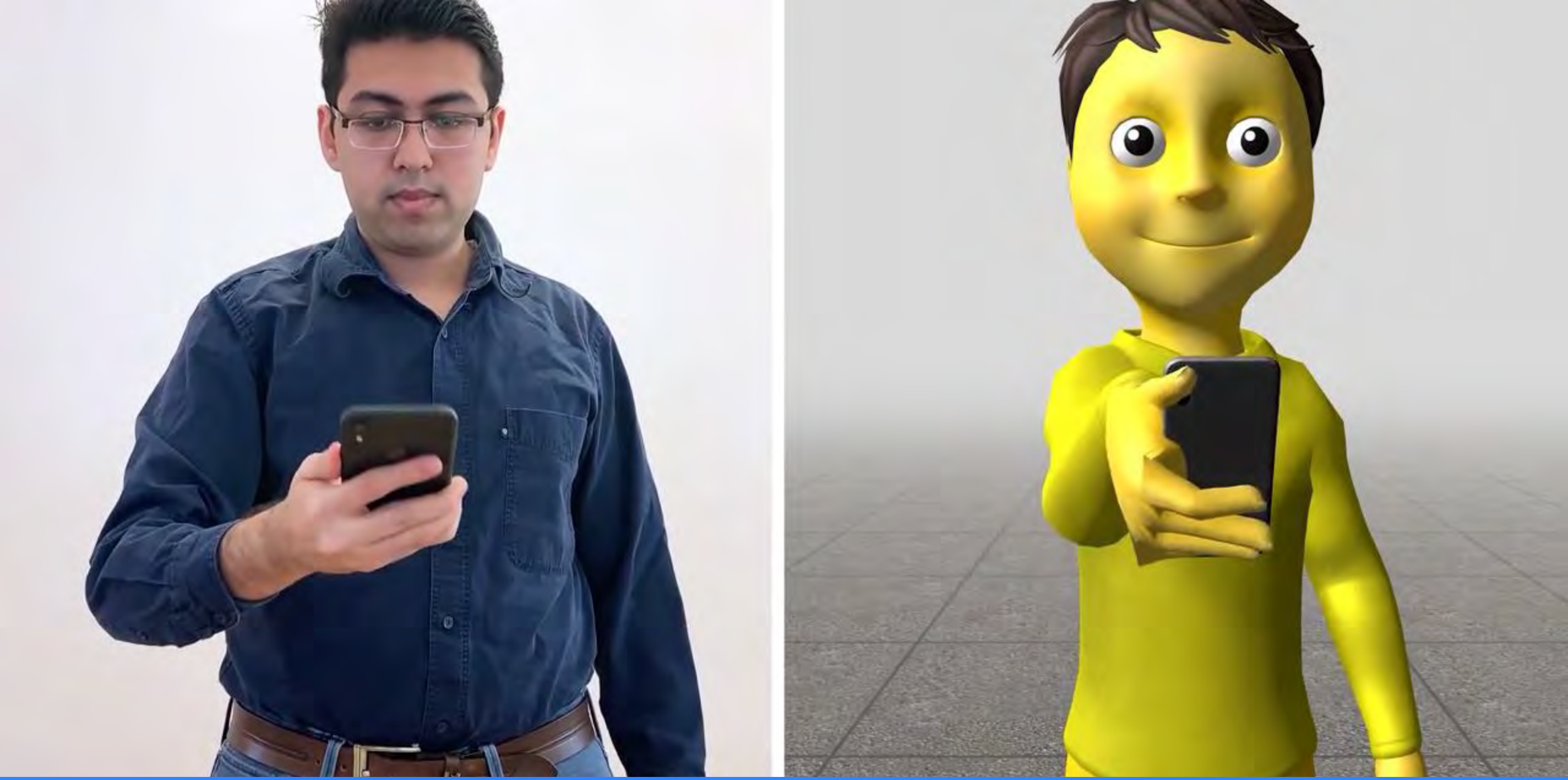
Smartphone Sensor Fusion

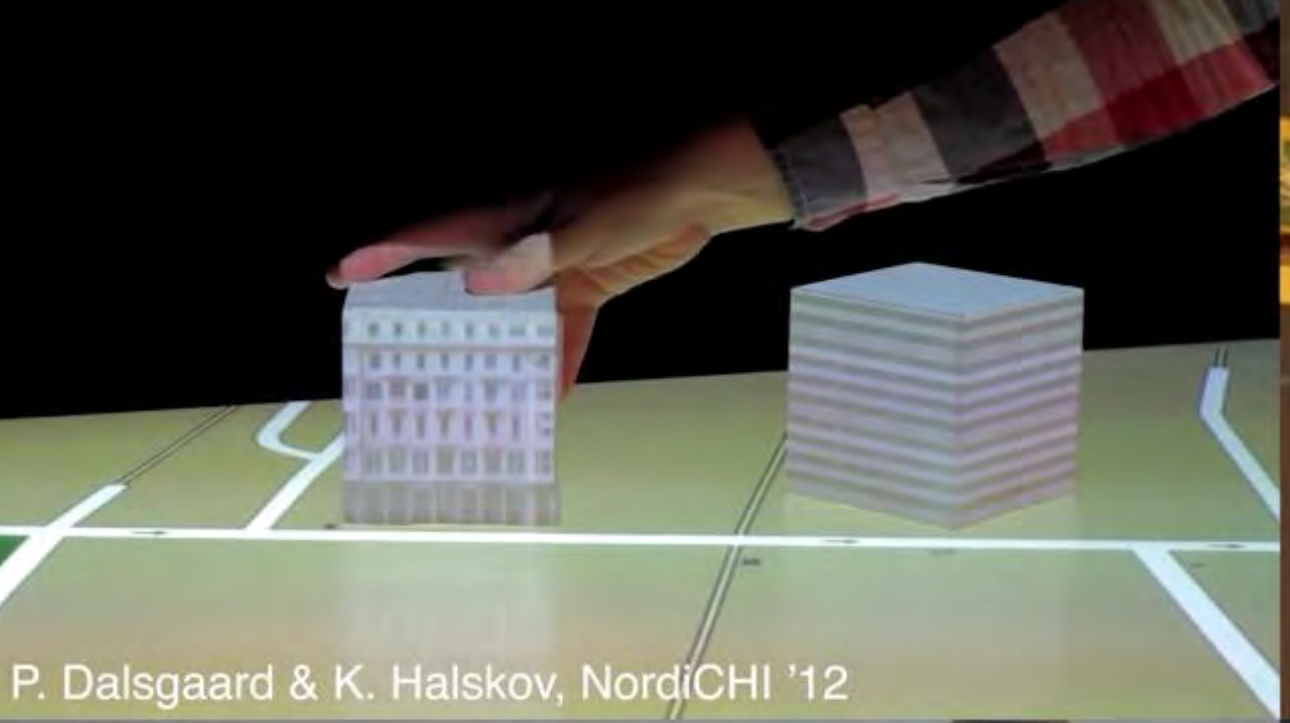


Karan Ahuja, **Sven Mayer**, Mayank Goel, Chris Harrison (2021) Pose-on-the-Go: Approximating User Pose with Smartphone Sensor Fusion and Inverse Kinematics.
In Proc. of CHI. DOI: https://doi.org/10.1145/3411764.3445582



Karan Ahuja, **Sven Mayer**, Mayank Goel, Chris Harrison (2021) Pose-on-the-Go: Approximating User Pose with Smartphone Sensor Fusion and Inverse Kinematics.
In Proc. of CHI. DOI: https://doi.org/10.1145/3411764.3445582

Understanding the World around Humans

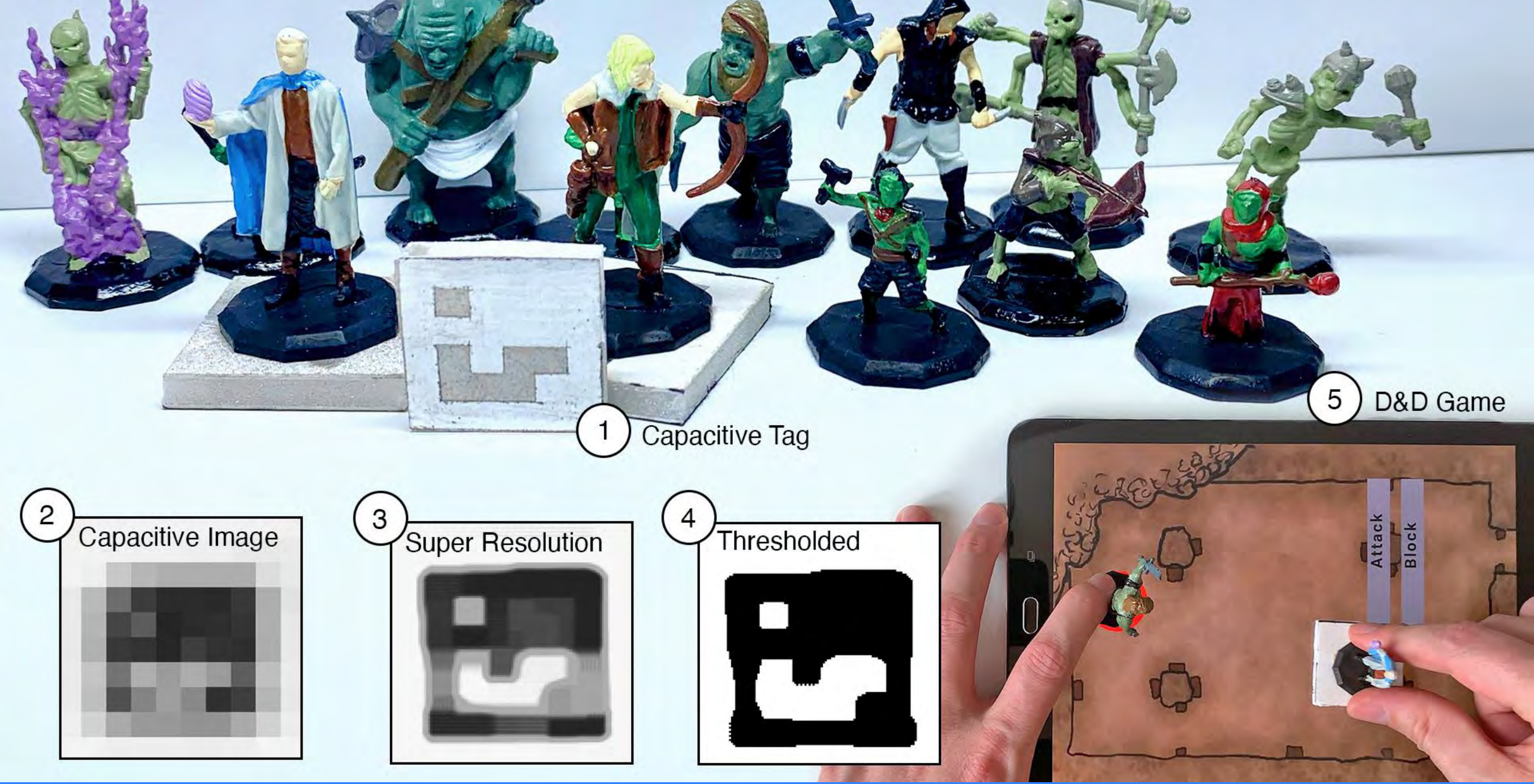


P. Dalsgaard & K. Halskov, NordiCHI '12

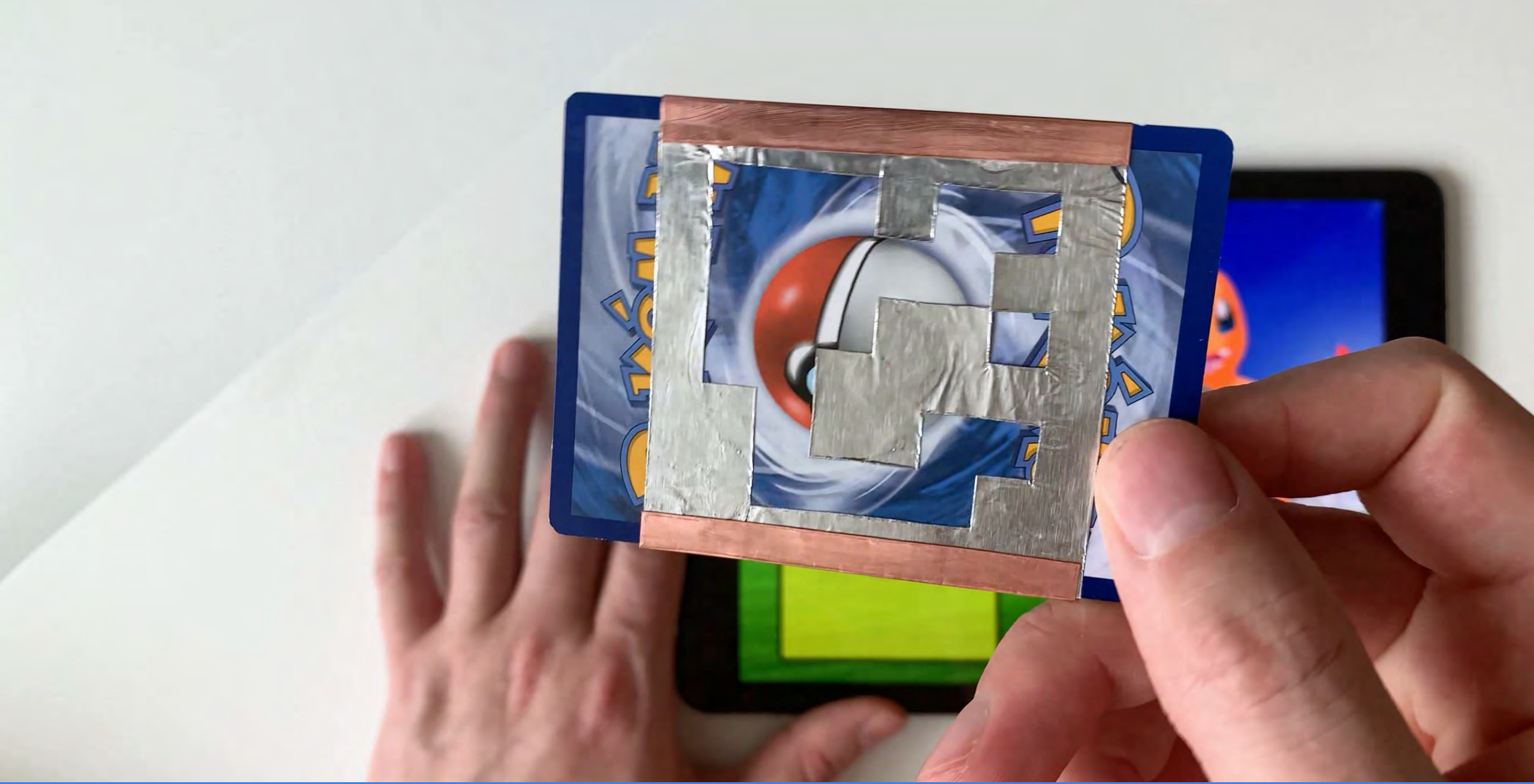
A. Olwal & A. Wilson, GI '08

J. Underkoffler & H. Ishii, CHI '99

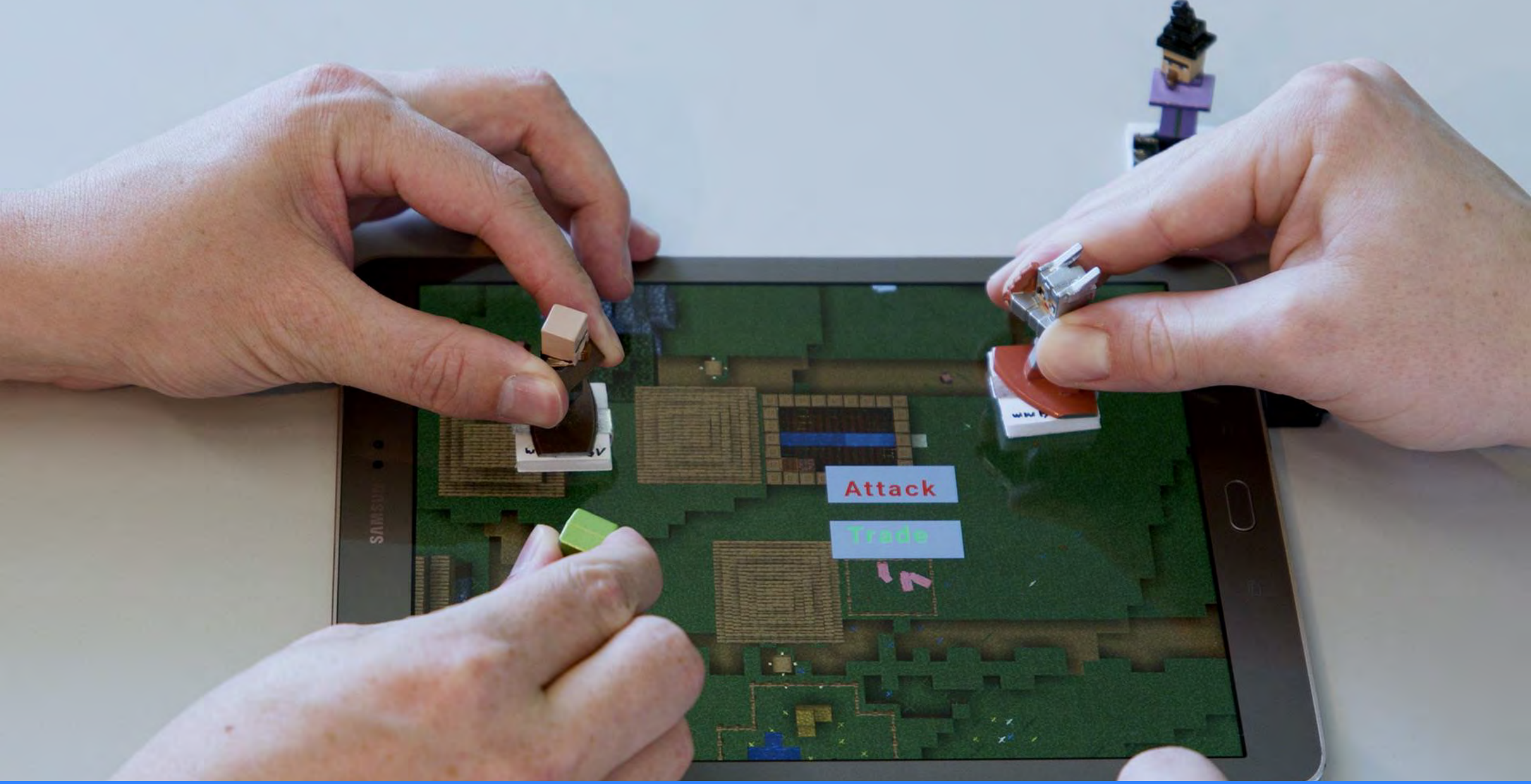
E. W. Pedersen & K. Hornbæk, CHI '11



Sven Mayer, Xiangyu Xu, Chris Harrison (2021) Super-Resolution Capacitive Touchscreens. In Prof. of CHI. DOI: https://doi.org/10.1145/3411764.3445703

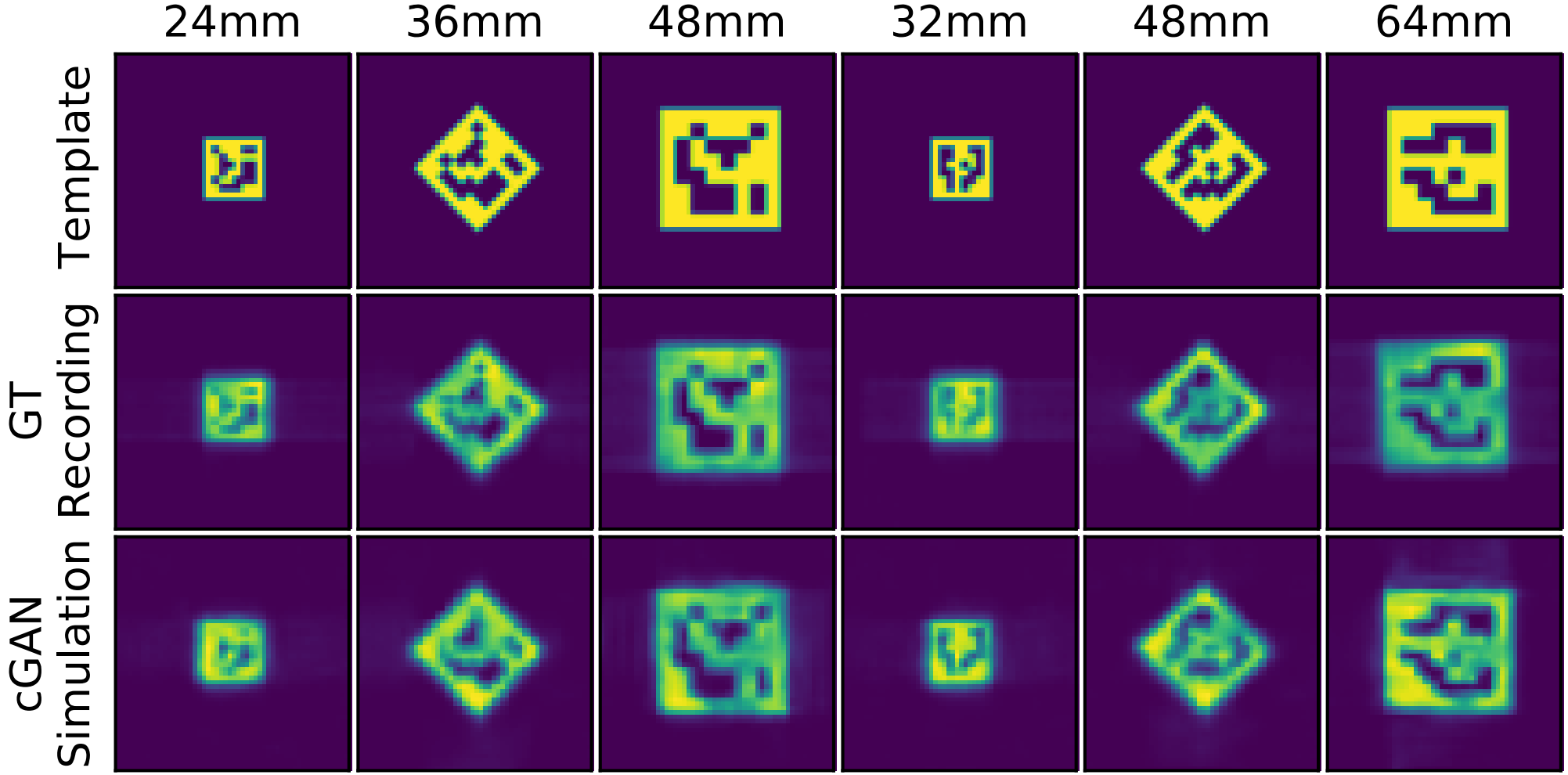


Sven Mayer, Xiangyu Xu, Chris Harrison (2021) Super-Resolution Capacitive Touchscreens. In Prof. of CHI. DOI: https://doi.org/10.1145/3411764.3445703



Benedict Steuerlein, **Sven Mayer** (2022) Conductive Fiducial Tangibles for Everyone: A Data Simulation-Based Toolkit using Deep Learning. Proceedings of the ACM on Human-Computer Interaction 6, no. MHCII. DOI: https://doi.org/10.1145/3546718

General Adversarial Network Simulations



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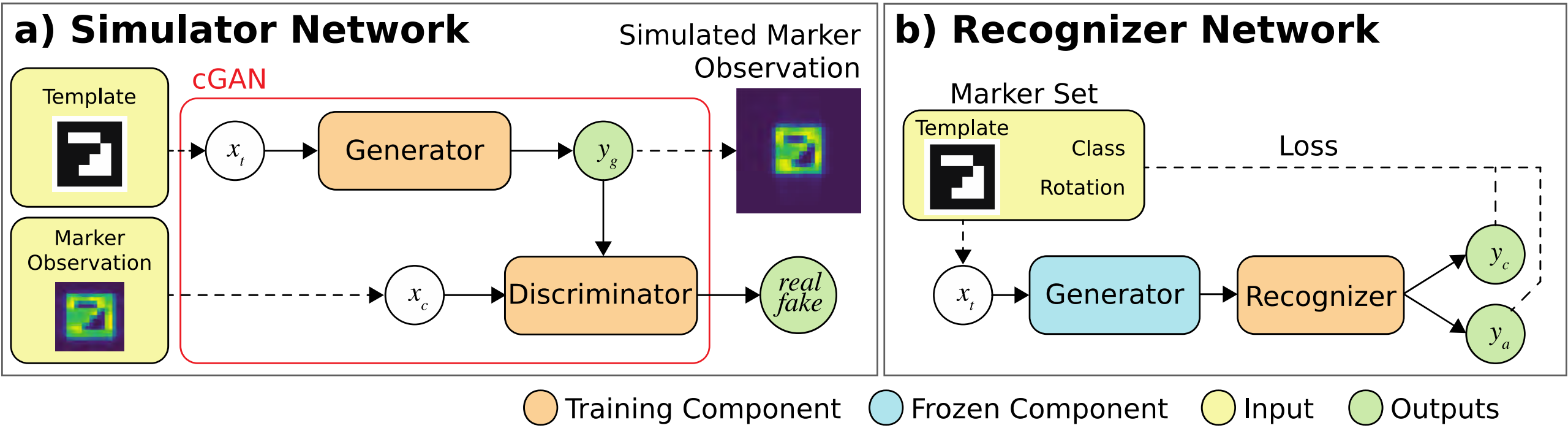
General Adversarial Network Idea



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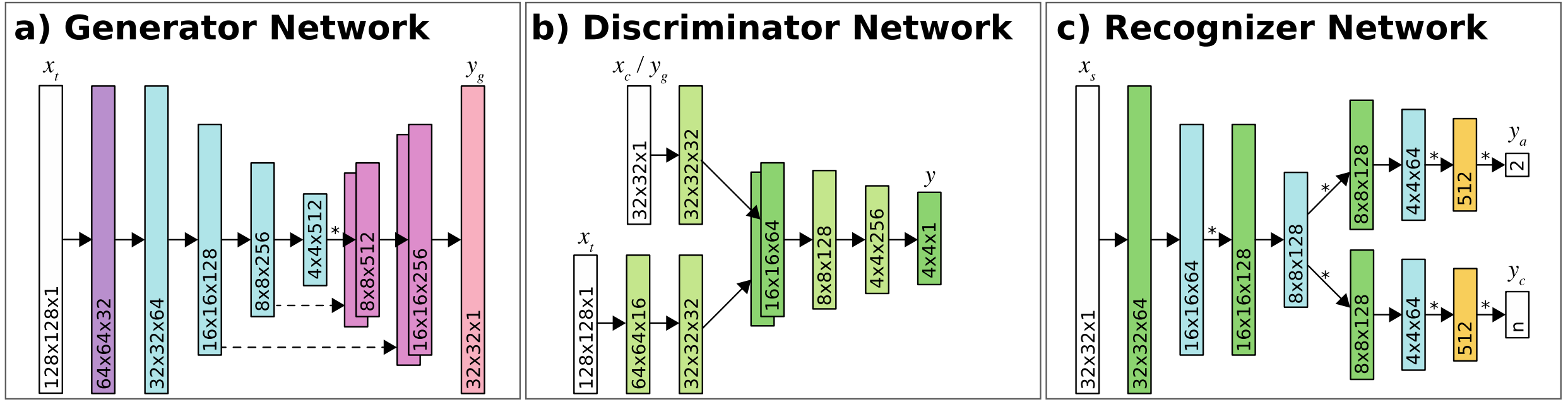
Internal GAN Structure



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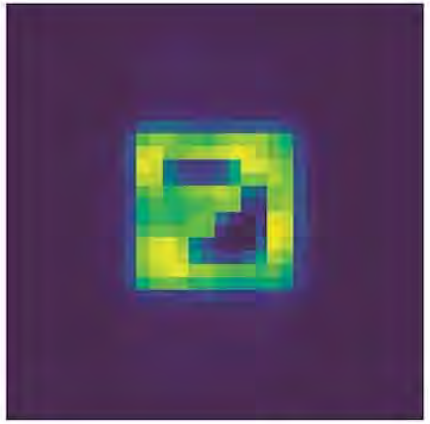
Our Approach

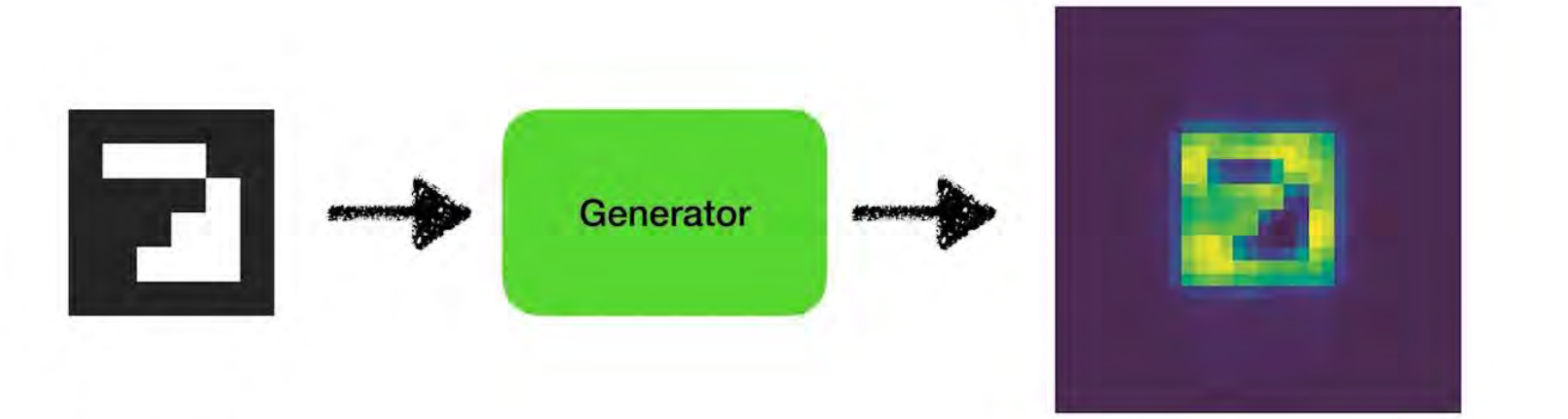
Fiducial Marker



Capacitive Image

Benedict Steuerlein, **Sven Mayer** (2022) Conductive Fiducial Tangibles for Everyone: A Data Simulation-Based Toolkit using Deep Learning. Proceedings of the ACM on Human-Computer Interaction 6, no. MHCII. DOI: https://doi.org/10.1145/3546718

Our Approach



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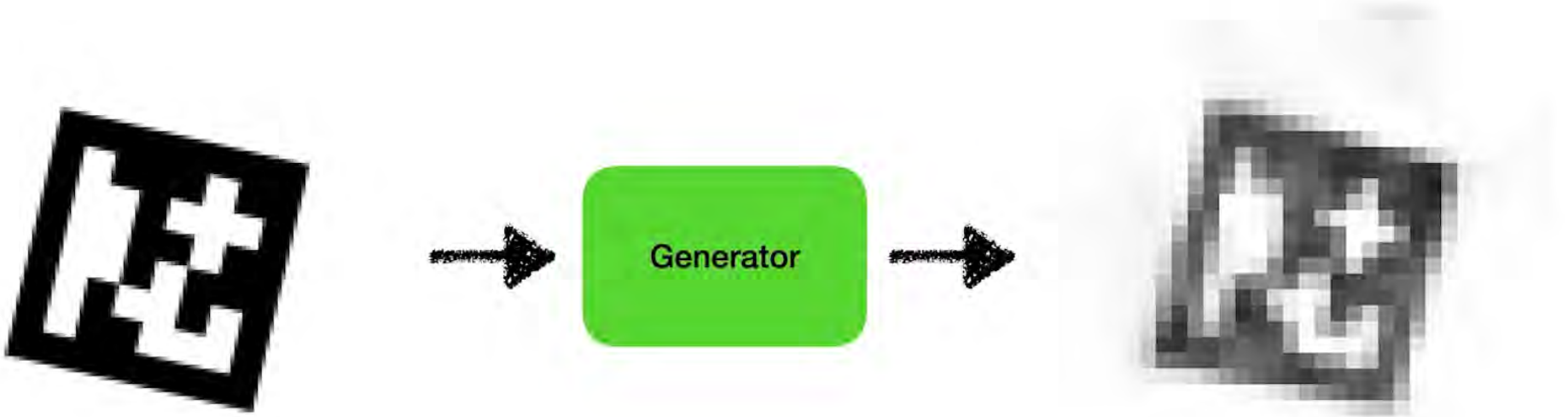
Our Approach



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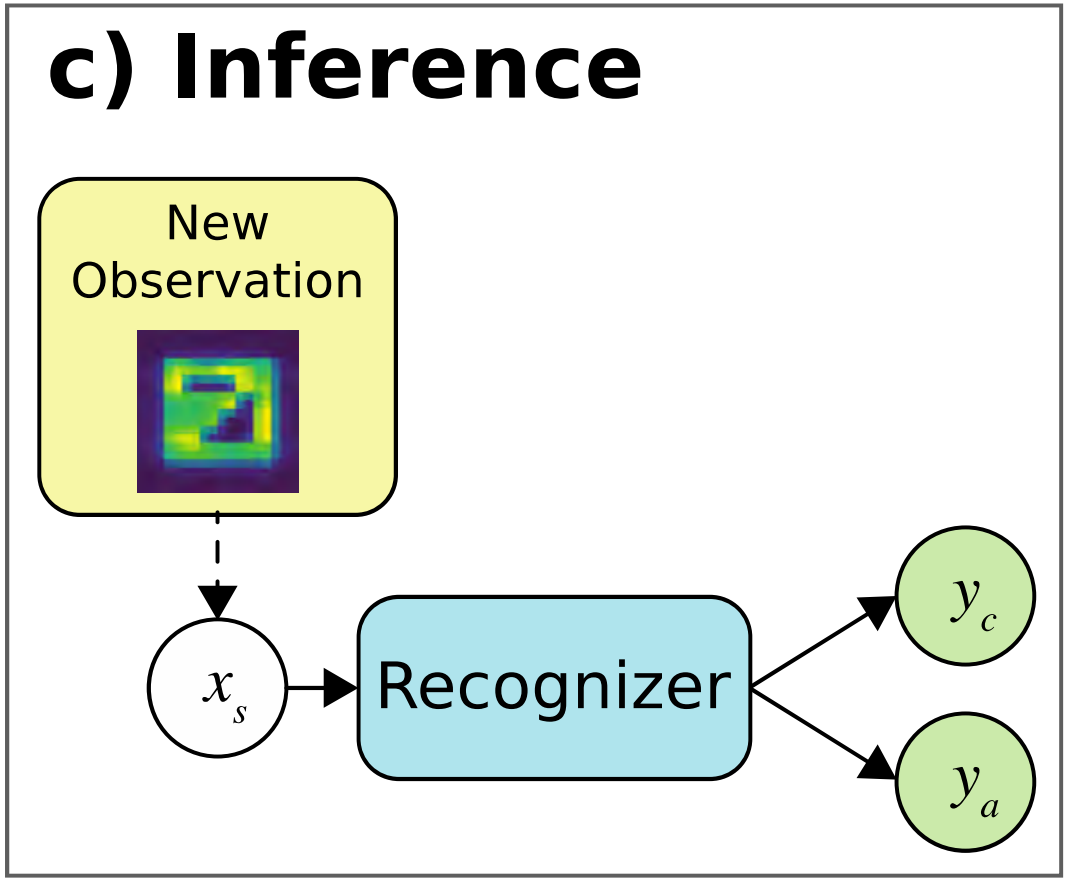
Deployment (no GAN)



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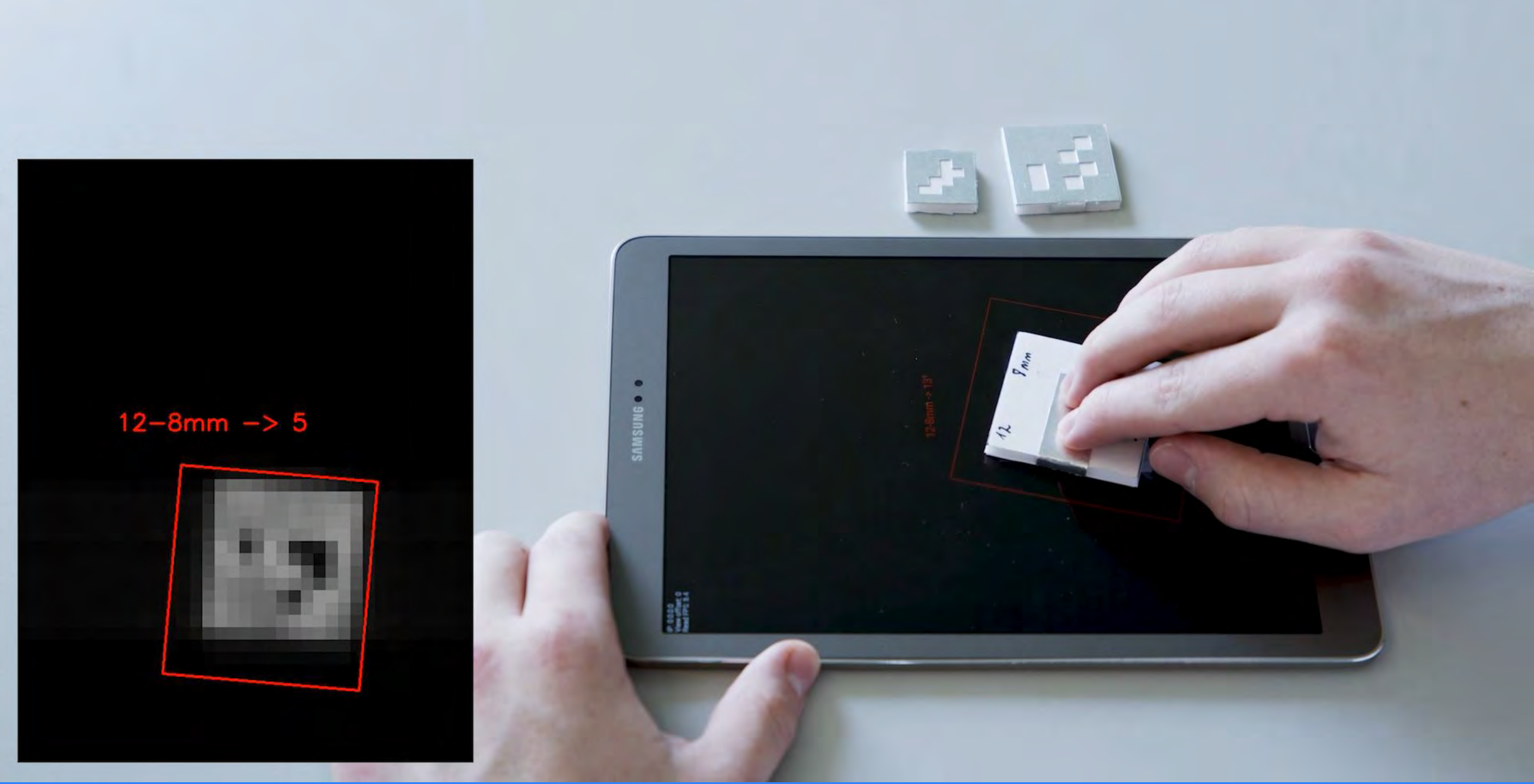
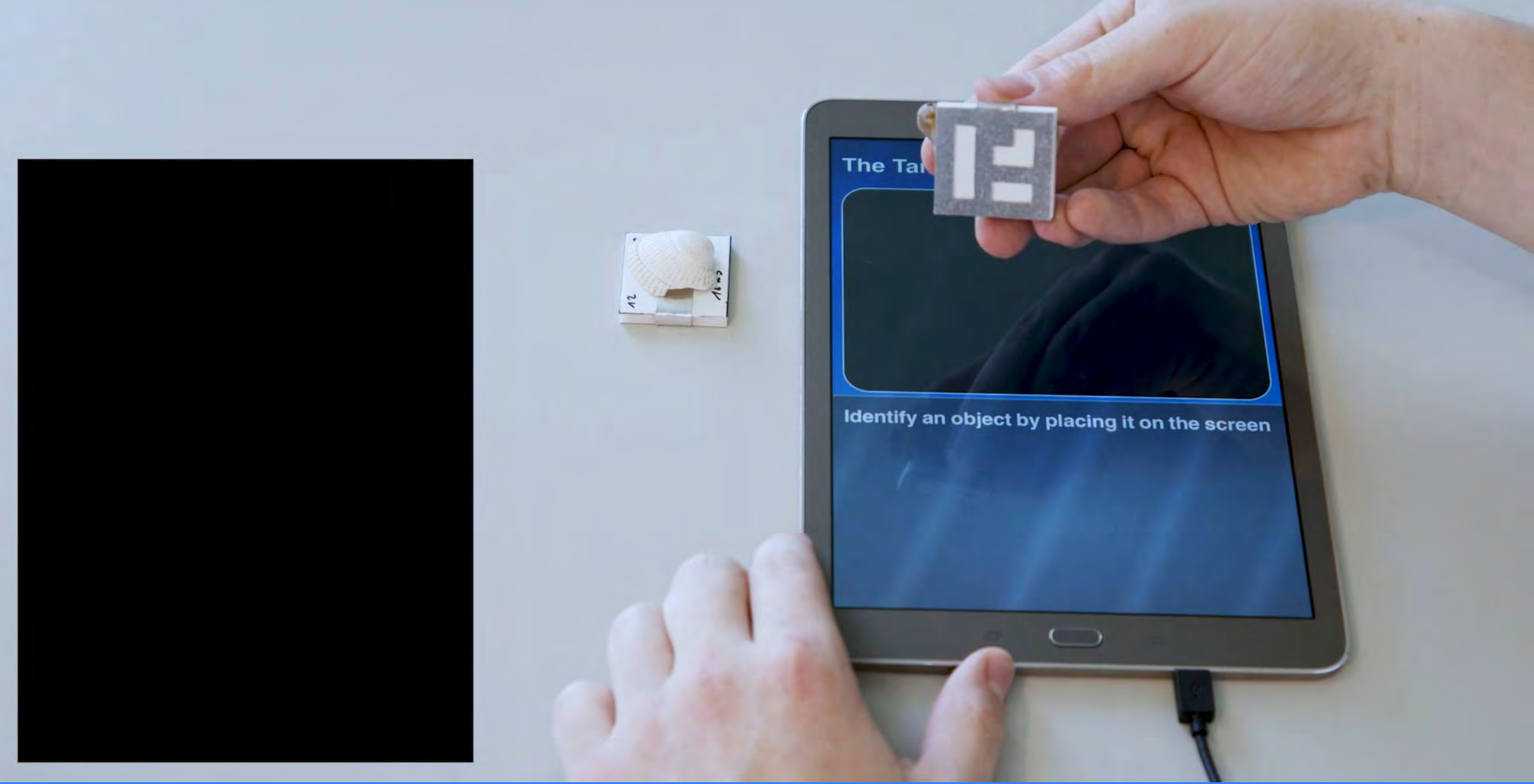
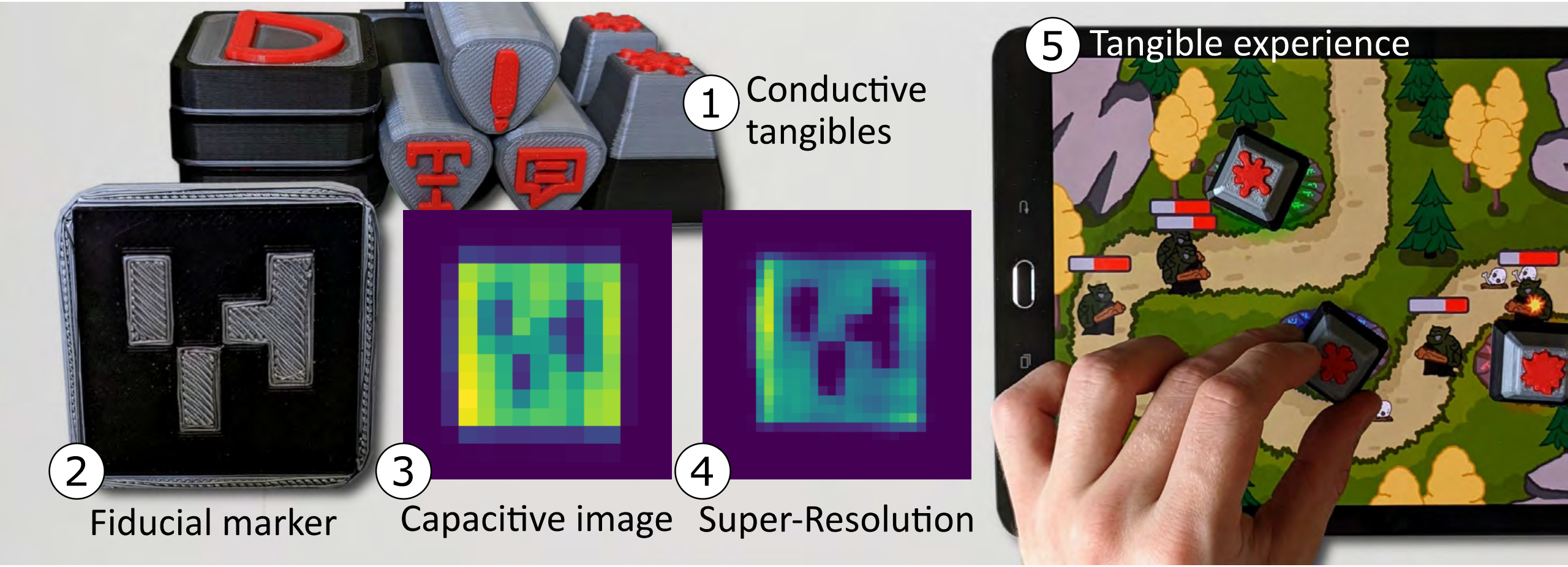


Benedict Steuerlein, **Sven Mayer** (2022) Conductive Fiducial Tangibles for Everyone: A Data Simulation-Based Toolkit using Deep Learning. Proceedings of the ACM on Human-Computer Interaction 6, no. MHCII. DOI: https://doi.org/10.1145/3546718



Benedict Steuerlein, **Sven Mayer** (2022) Conductive Fiducial Tangibles for Everyone: A Data Simulation-Based Toolkit using Deep Learning. Proceedings of the ACM on Human-Computer Interaction 6, no. MHCII. DOI: https://doi.org/10.1145/3546718

Super Resolution + GAN



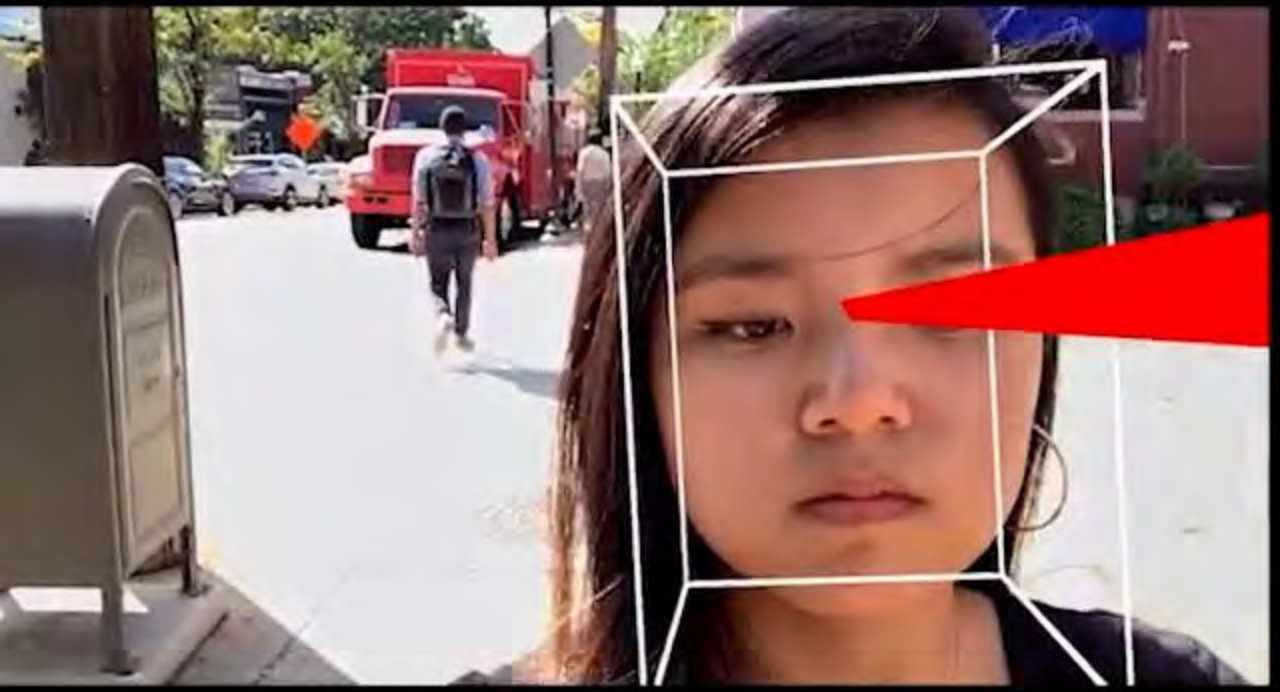
Marius Rusu, **Sven Mayer** (2023) Deep Learning Super-Resolution Network Facilitating Fiducial Tangibles on Capacitive Touchscreens. In: Proceedings of the 42nd ACM Conference on Human Factors in Computing Systems (CHI'23), Association for Computing Machinery, Hamburg, Germany.

Artificial Intelligence Powered User Interfaces

Gaze Aware Voice Assistant

Sven Mayer, Gierad Laput, Chris Harrison (2020) Enhancing Mobile Voice Assistants with WorldGaze. In Proc. of CHI. DOI: https://doi.org/10.1145/3313831.3376479

Gaze Aware Voice Assistant



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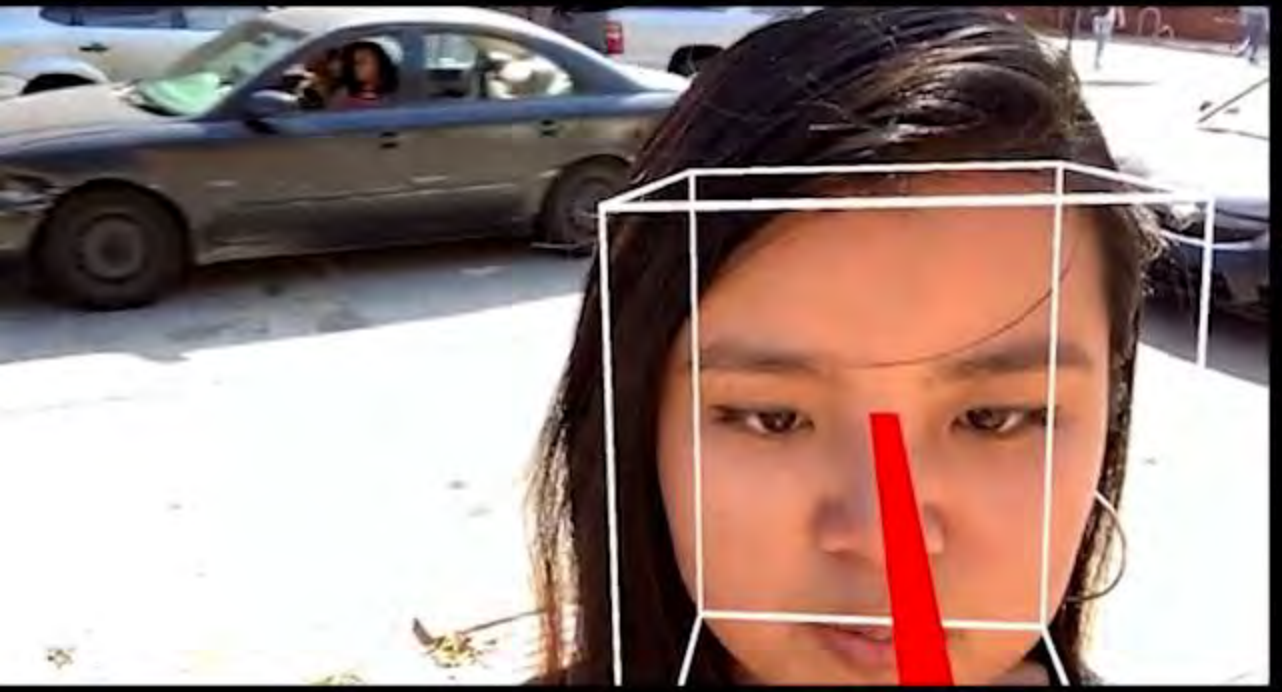
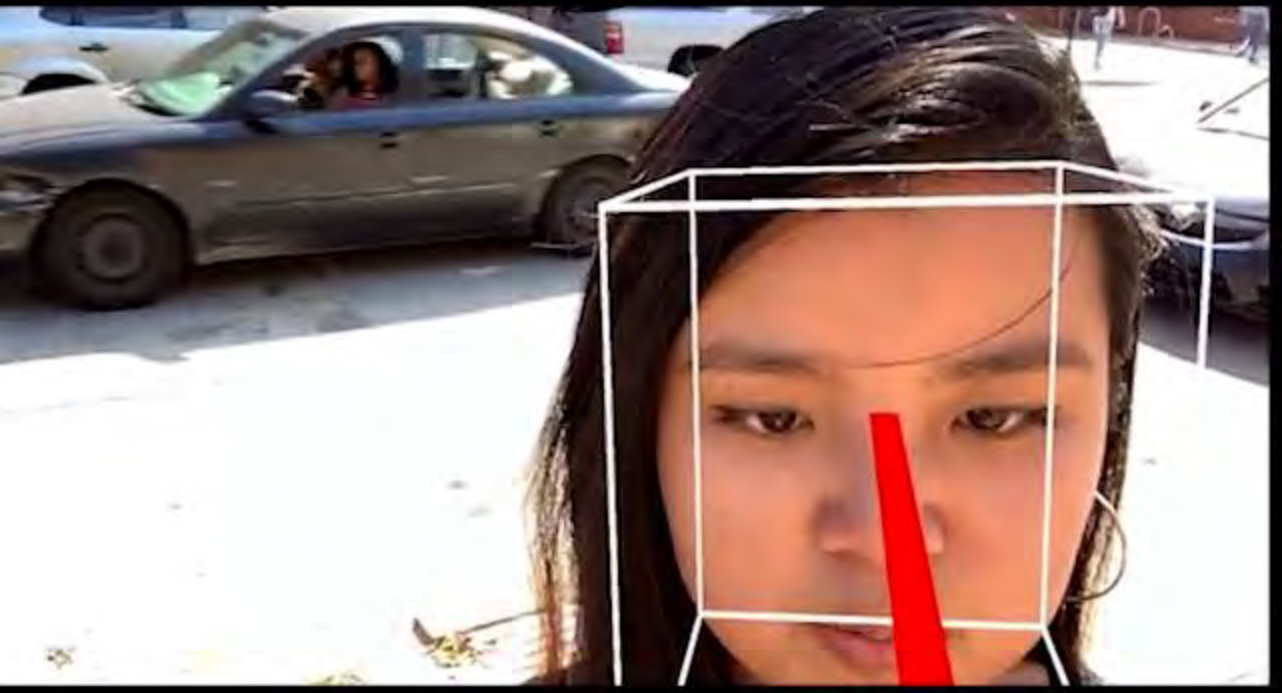
Gaze Aware Voice Assistant



When does ***this*** open?

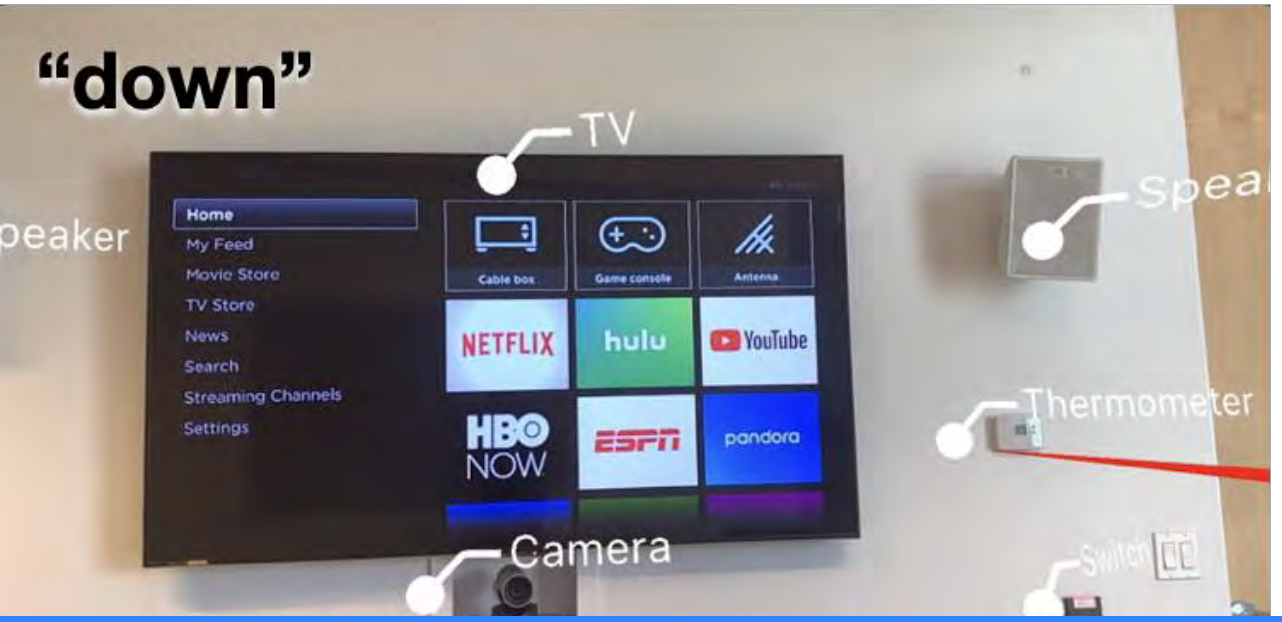
Gaze Aware Voice Assistant

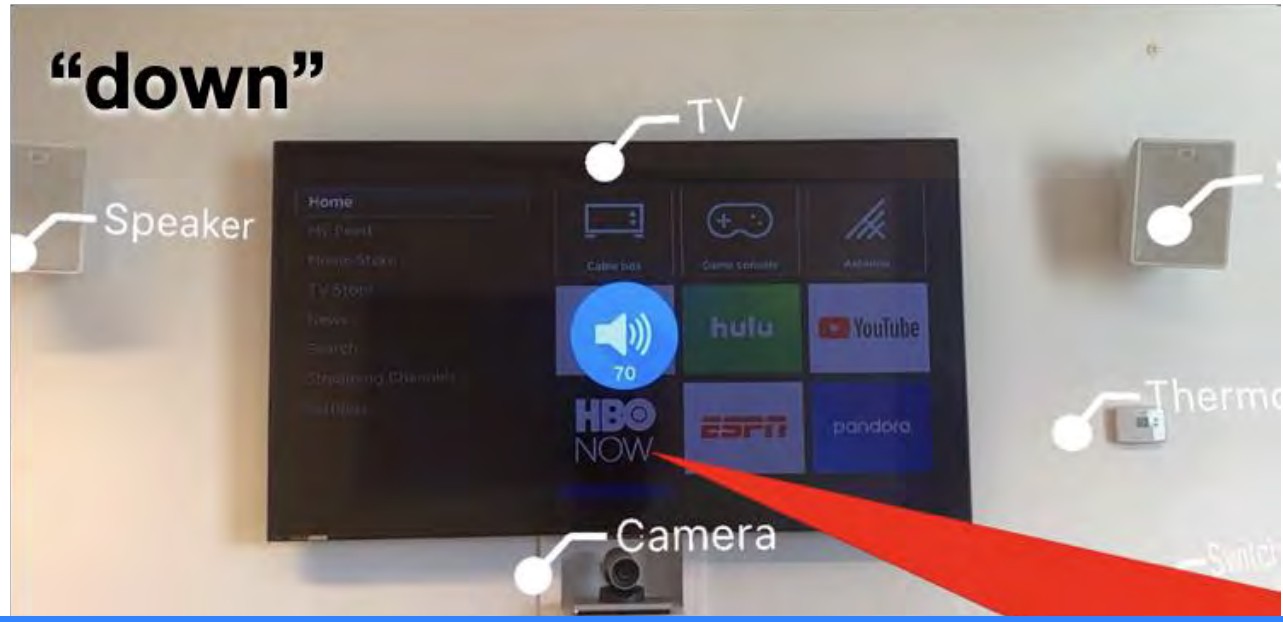


The Oakland Fashion Optical

When does ***this*** open?

Sven Mayer, Gierad Laput, Chris Harrison (2020) Enhancing Mobile Voice Assistants with WorldGaze. In Proc. of CHI. DOI: https://doi.org/10.1145/3313831.3376479

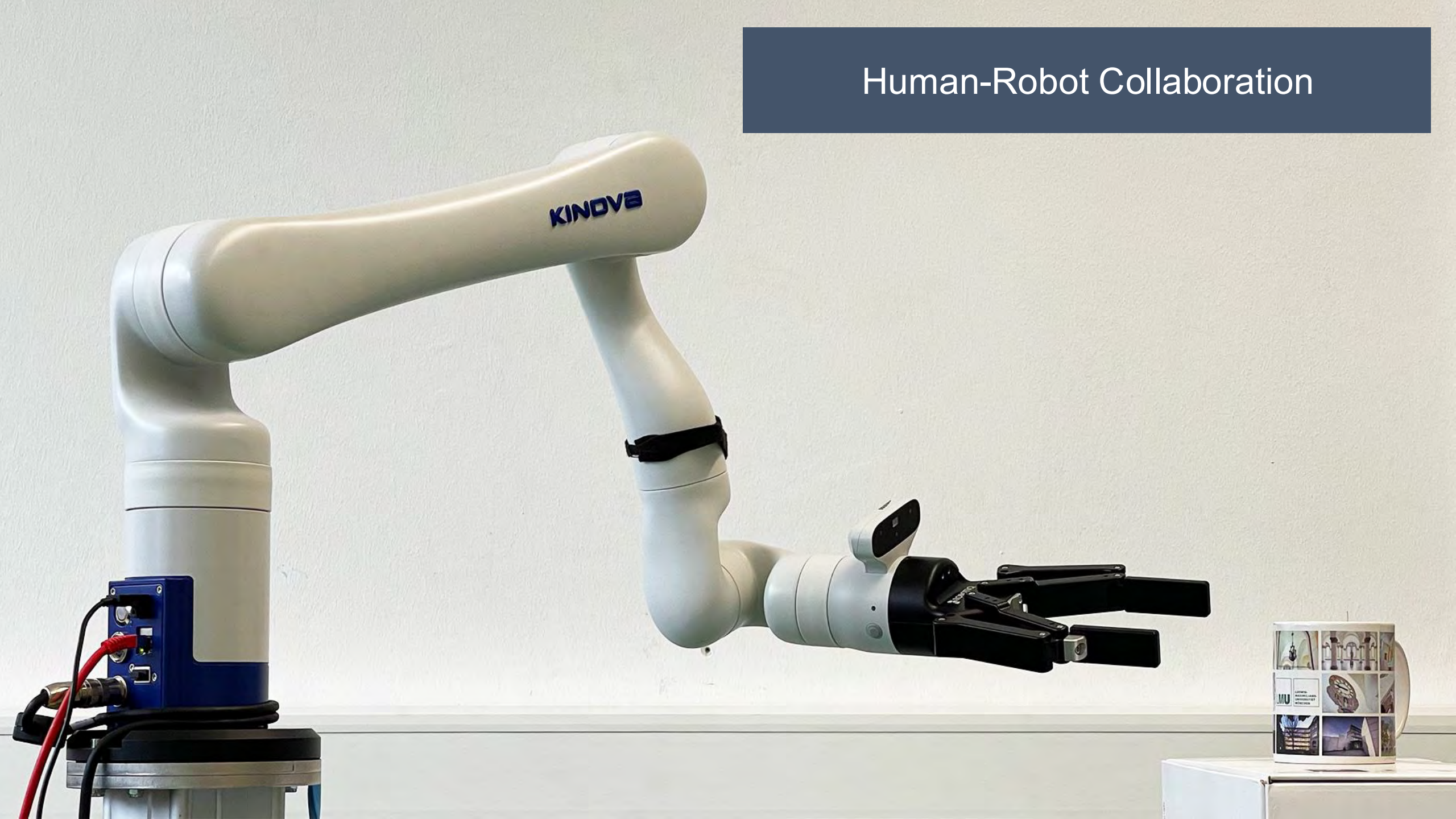




Sven Mayer, Gierad Laput, Chris Harrison (2020) Enhancing Mobile Voice Assistants with WorldGaze. In Proc. of CHI. DOI: https://doi.org/10.1145/3313831.3376479

Embodied Agents as the Future Challenges in Human-Machine Collaboration

Human-Robot Collaboration

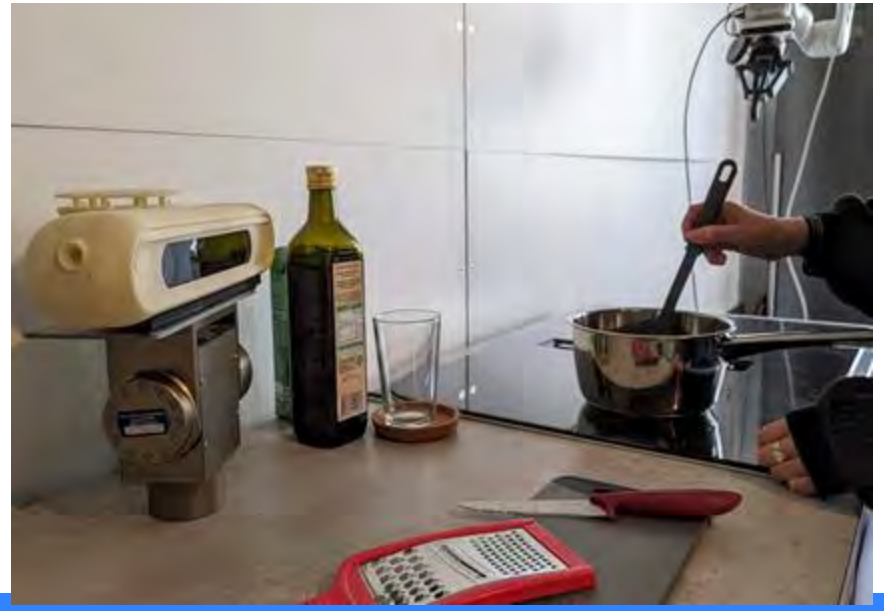


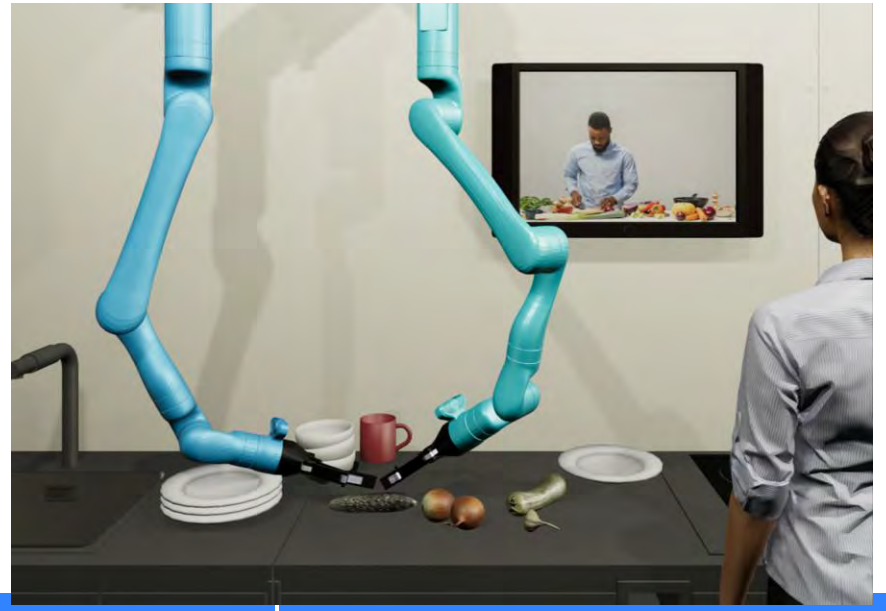
Steeven Villa, **Sven Mayer**, Jess Hartcher-O'Brien, Albrecht Schmidt, Tonja-Katrin Machulla (2022) Extended Mid-air Ultrasound Haptics for Virtual Reality. Proceedings of the ACM on Human-Computer Interaction 7, no. ISS.

Carl Oechsner, Sven Mayer, Andreas Butz (2022) Challenges and Opportunities of Cooperative Robots as Cooking Appliances. In: Proceedings of the 2022 Workshop on Engaging with Automation.

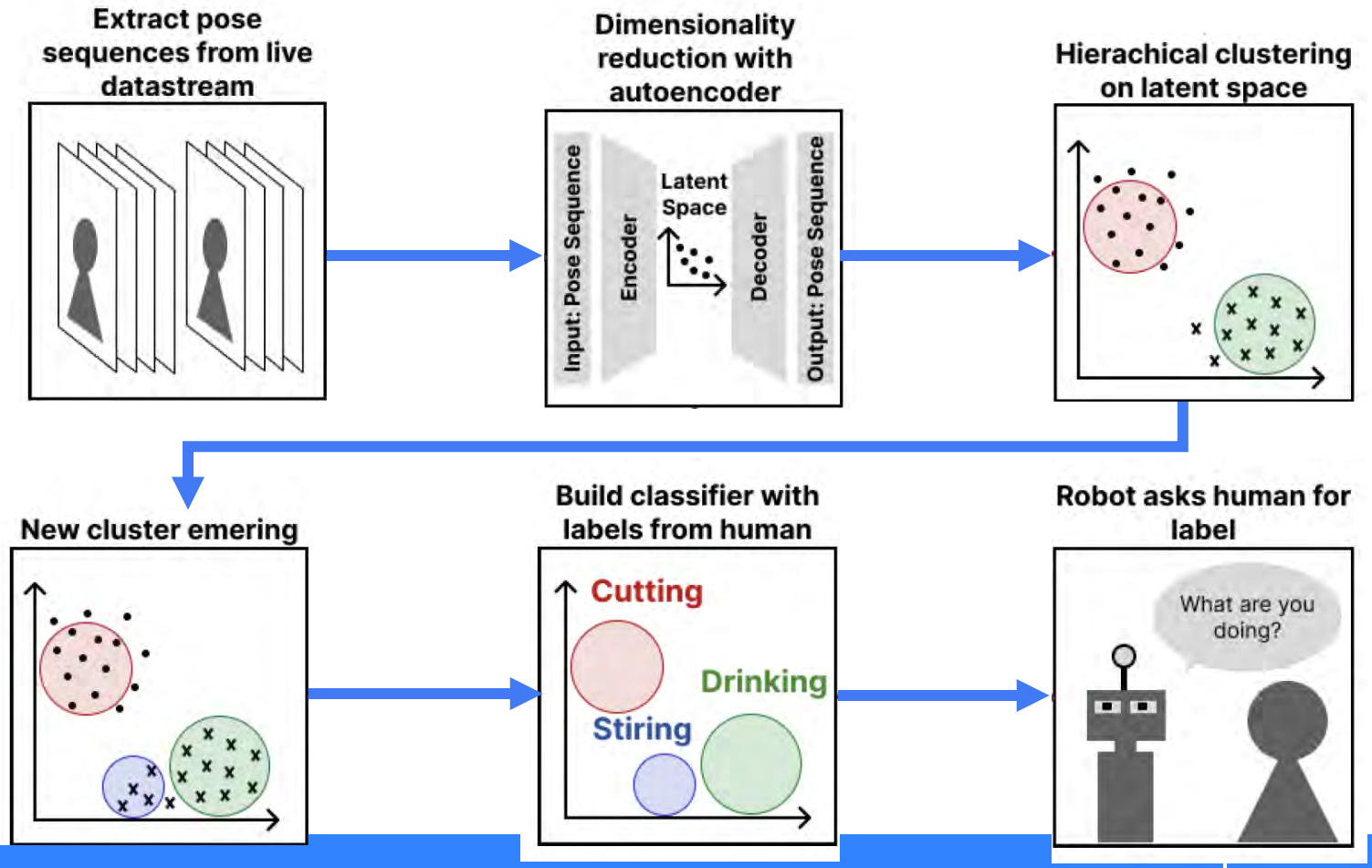
Dialog Systems

- Working together with a system having shared control
- Negotiation process



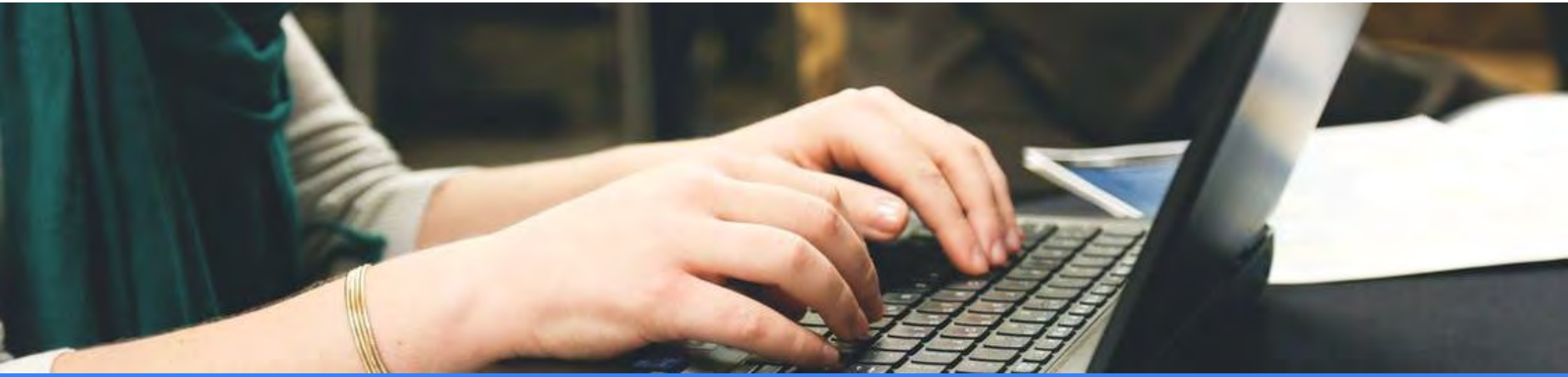


Human-In-The-Loop Labels



The Next Generation of Computing Systems: Artificial Intelligence meets Humans

1. Understanding the Context of the Human
2. Understanding the World around Humans
3. Artificial Intelligence Powered User Interfaces
4. Future Challenges in Human-Machine Collaboration



Practical Machine Learning

Introduction

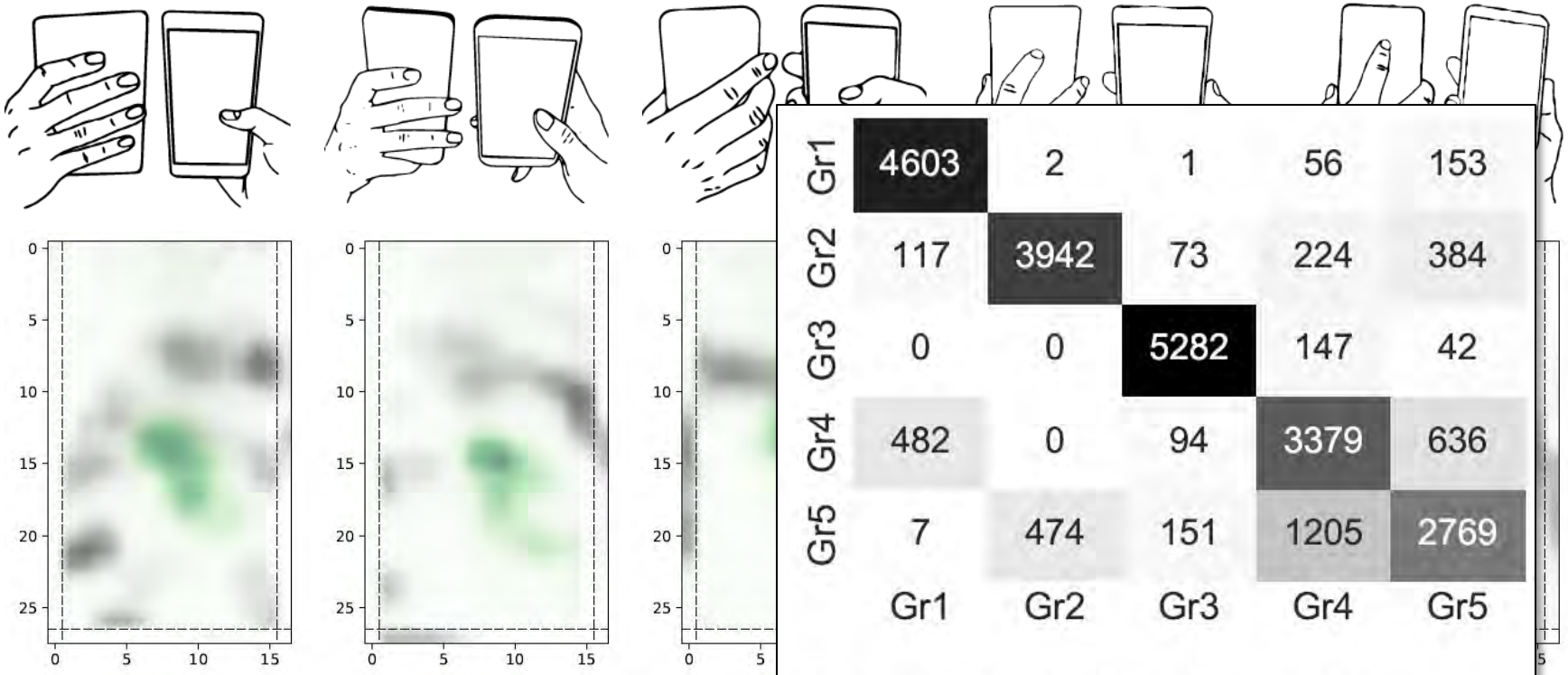
Sven Mayer

Where can we find ML used?

- Self driving cars (Tesla)
- Voice interfaces (Alexa, Siri)
- Face recogntion (Google Photos)
- Recomender systems (Netflix, Amazon)
- Games (AlphaGo)
- Character recognition (Post offices)
- Banking systems
- Medical diagnosis
- ML for Human-Computer Interaction  **Focus**

Introduction into Machine Learning

Examples



	Gr1	Gr2	Gr3	Gr4	Gr5
Gr1	4603	2	1	56	153
Gr2	117	3942	73	224	384
Gr3	0	0	5282	147	42
Gr4	482	0	94	3379	636
Gr5	7	474	151	1205	2769

Figure 7: Confusion matrix showing the classification results for the exemplary grip classifier.

Huy Viet Le, Sven Mayer, Patrick Bader, and Niels He
the whole device surface. In Proceedings of MobileHCI

Introduction into Machine Learning

Examples

Huy Viet Le, Sven Mayer, Maximilian Weiß, Jonas Vogelsang, Henrike Weingärtner, and Niels Henze. 2020. Shortcut Gestures for Mobile Text Editing on Fully Touch Sensitive Smartphones. ACM ToCHI. DOI: https://doi.org/10.1145/3396233

Introduction into Machine Learning

Examples

Huy Viet Le, Thomas Kosch, Patrick Bader, Sven Mayer, and Niels Henze. 2018. PalmTouch: Using the Palm as an Additional Input Modality on Commodity Smartphones. In Proceedings of CHI '18. Association for Computing Machinery, New York, NY, USA, Paper 360, 1–13. DOI: https://doi.org/10.1145/3173574.3173934

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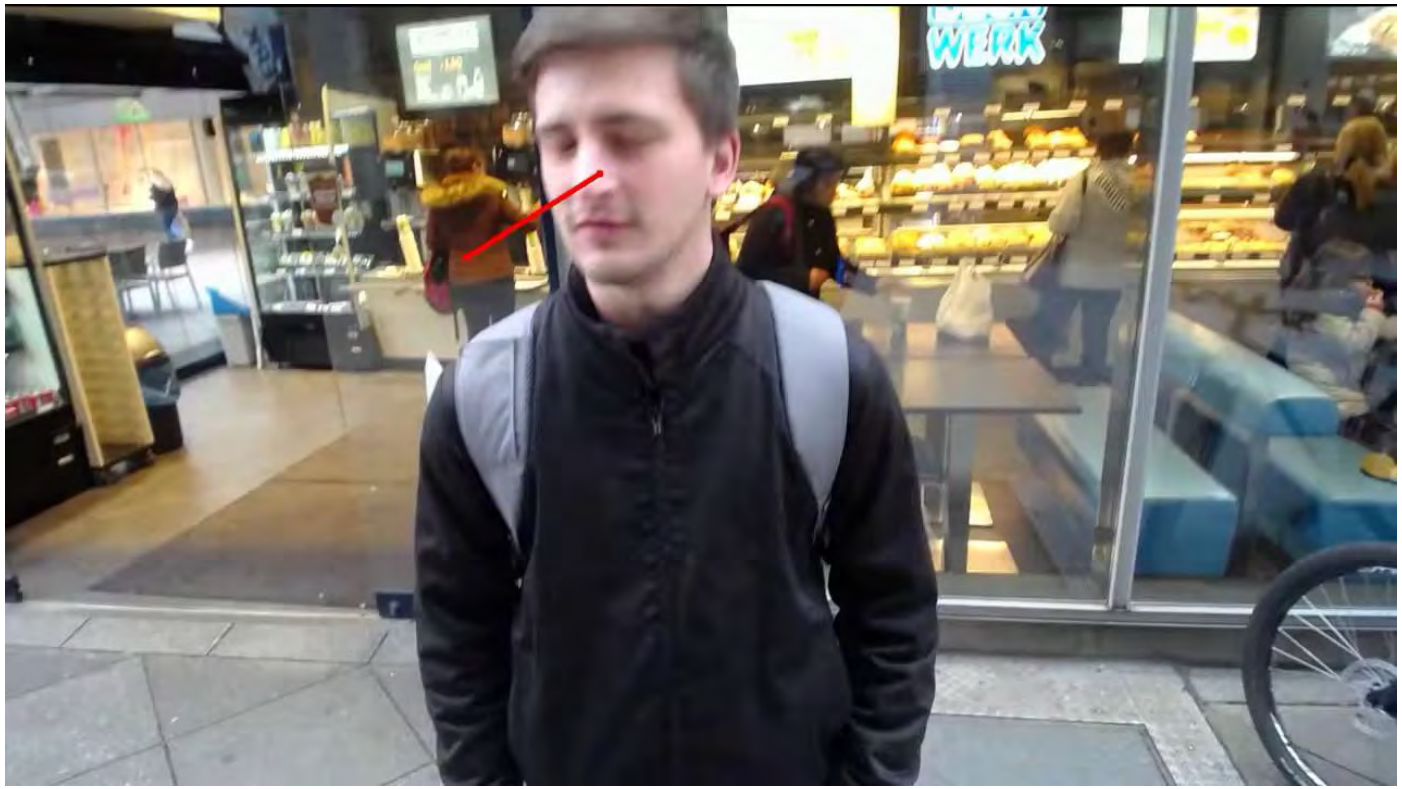
Adaptive Keyboards

Introduction into Machine Learning

Examples



Xucong Zhang, Yusuke Sugano, and Andreas Bulling. 2019. Evaluation of Appearance-Based Methods and Implications for Gaze-Based Applications. In Proc. Of CHI '19. ACM. DOI: https://doi.org/10.1145/3290605.3300646

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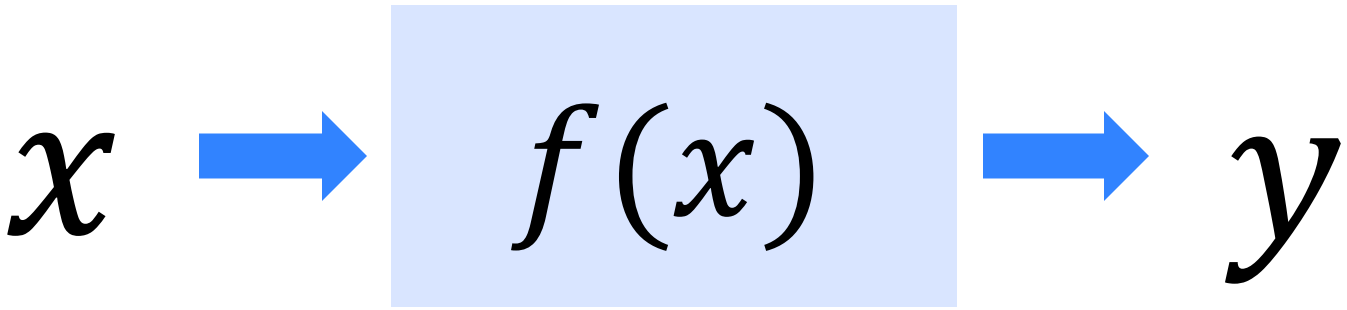
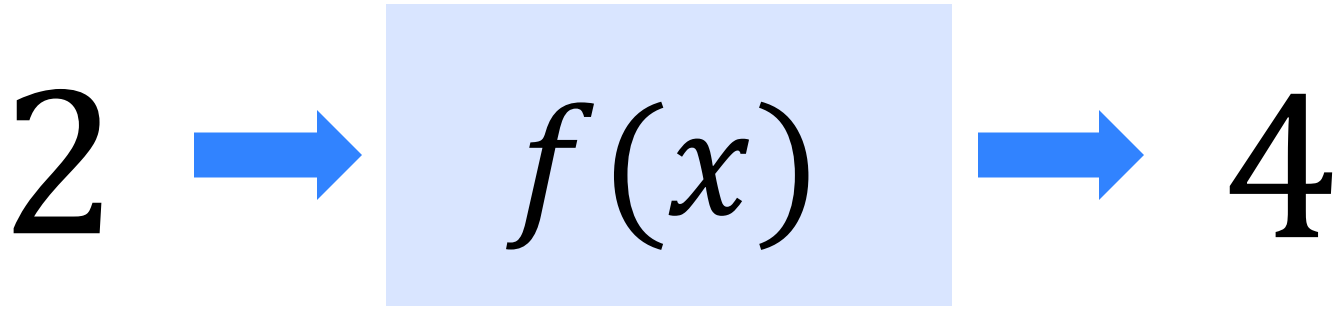
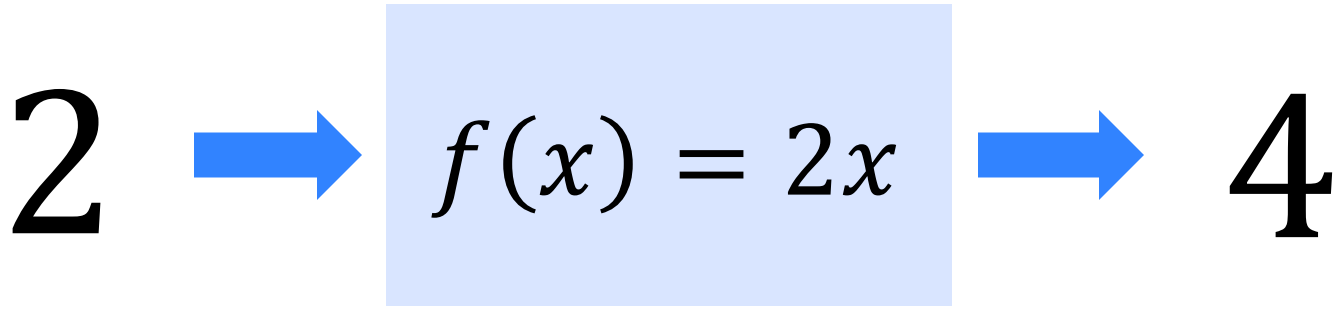


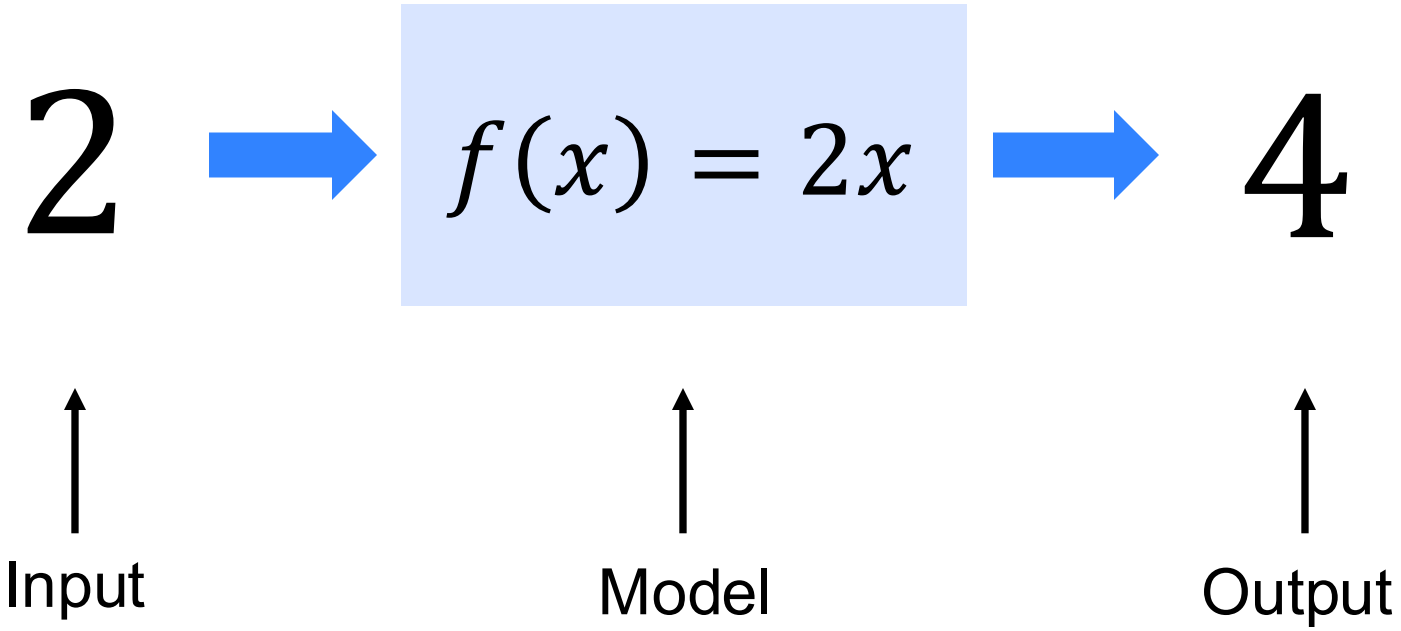
Introduction into Machine Learning



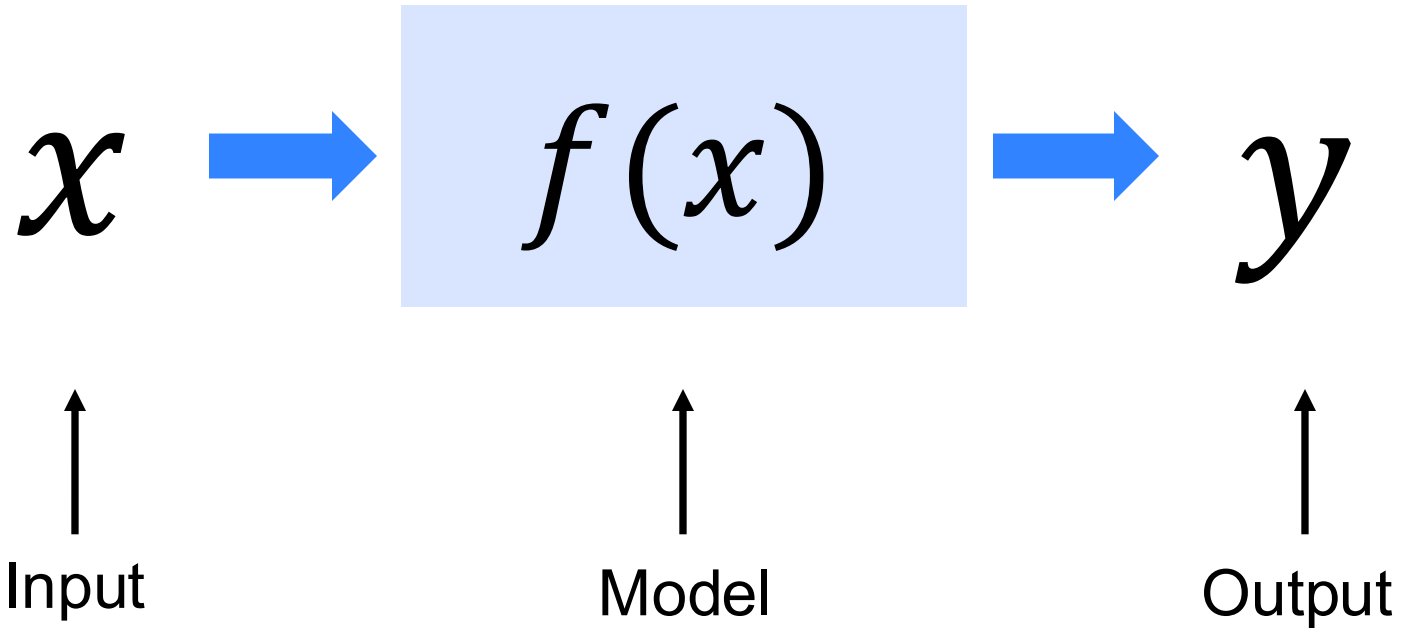
Introduction into Machine Learning



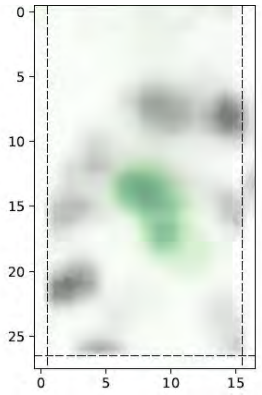
Introduction into Machine Learning



Introduction into Machine Learning



Introduction into Machine Learning



$f(x)$

Input

Model?

Output

Introduction into Machine Learning

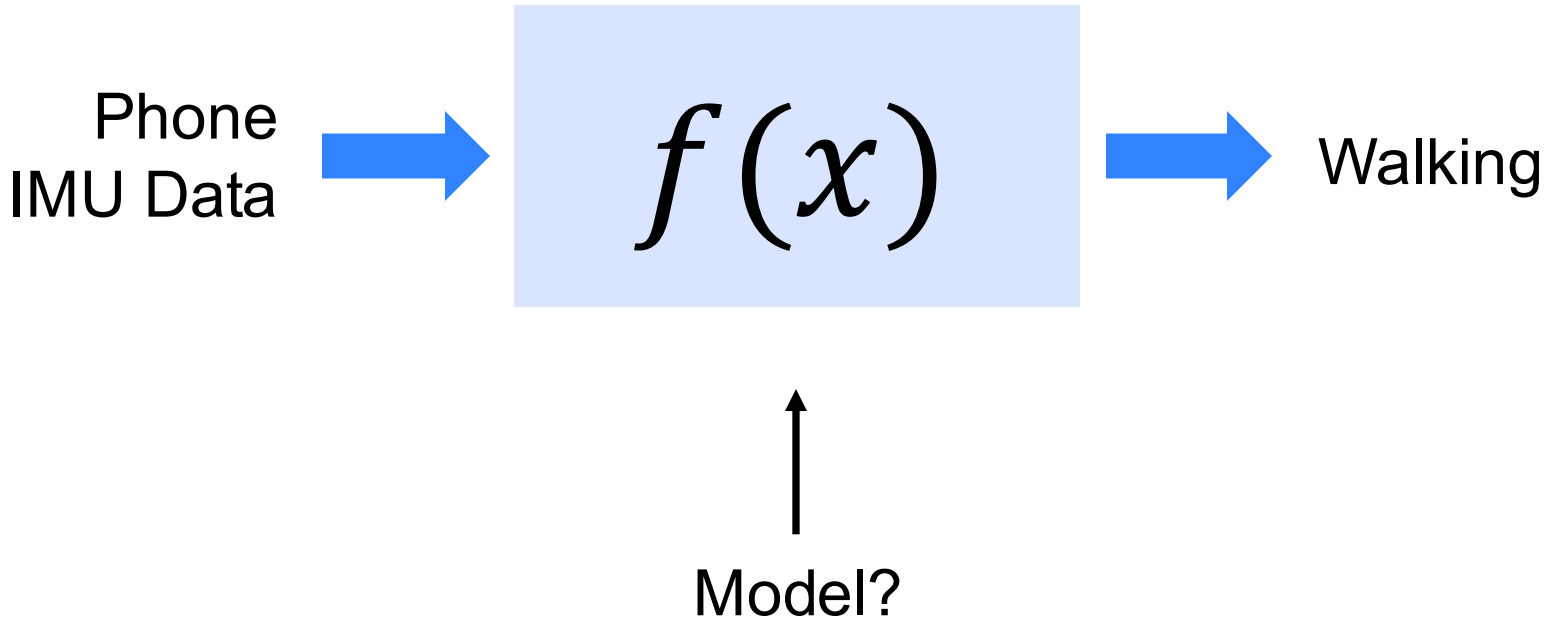
$f(x)$

Walking

Model?

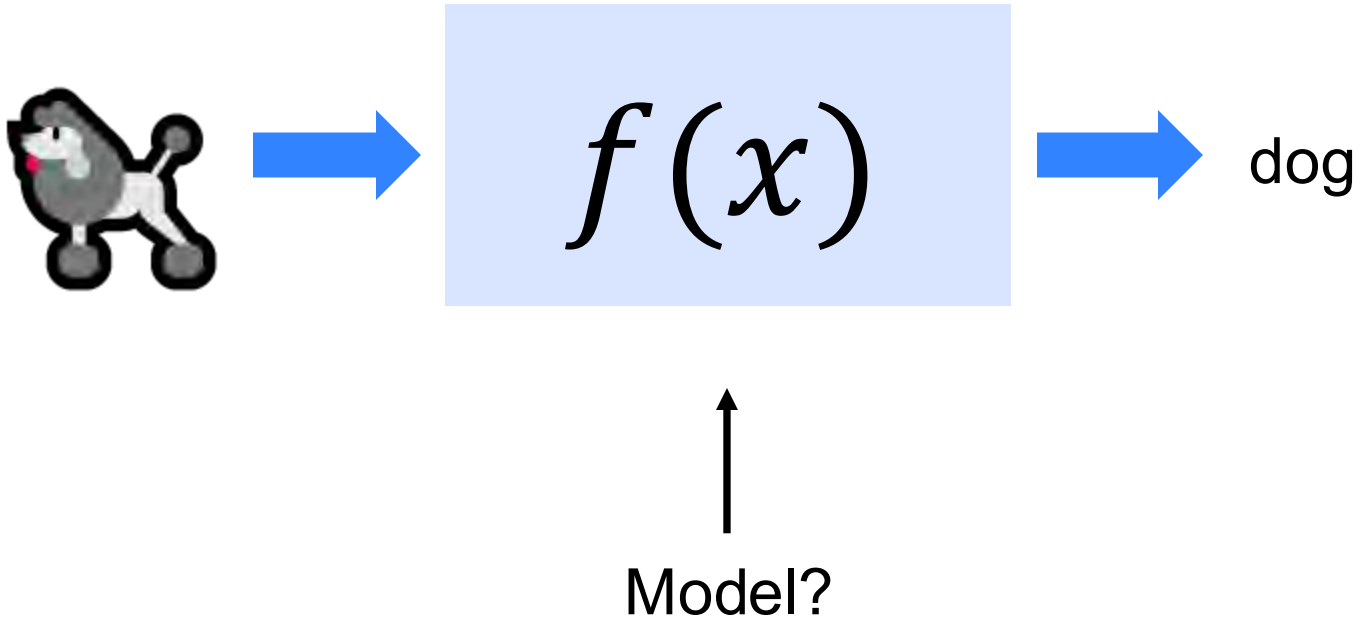
*human activity recognition

Introduction into Machine Learning



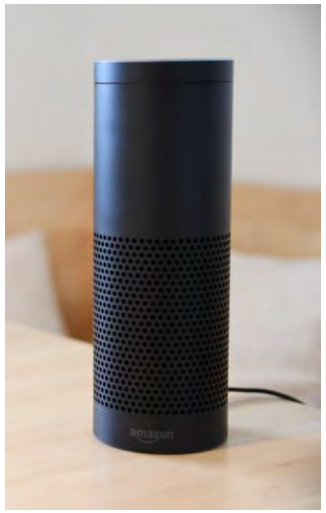
*human activity recognition

Introduction into Machine Learning



*object recognition

Introduction into Machine Learning



$f(x)$

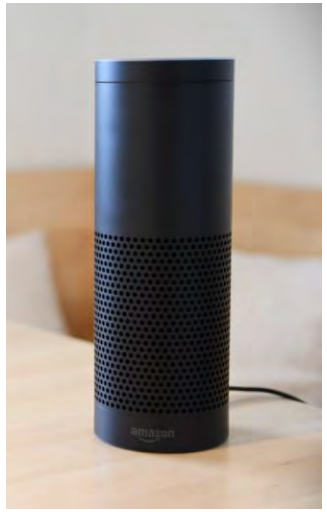
speaker

Model?

*object recognition

Introduction into Machine Learning

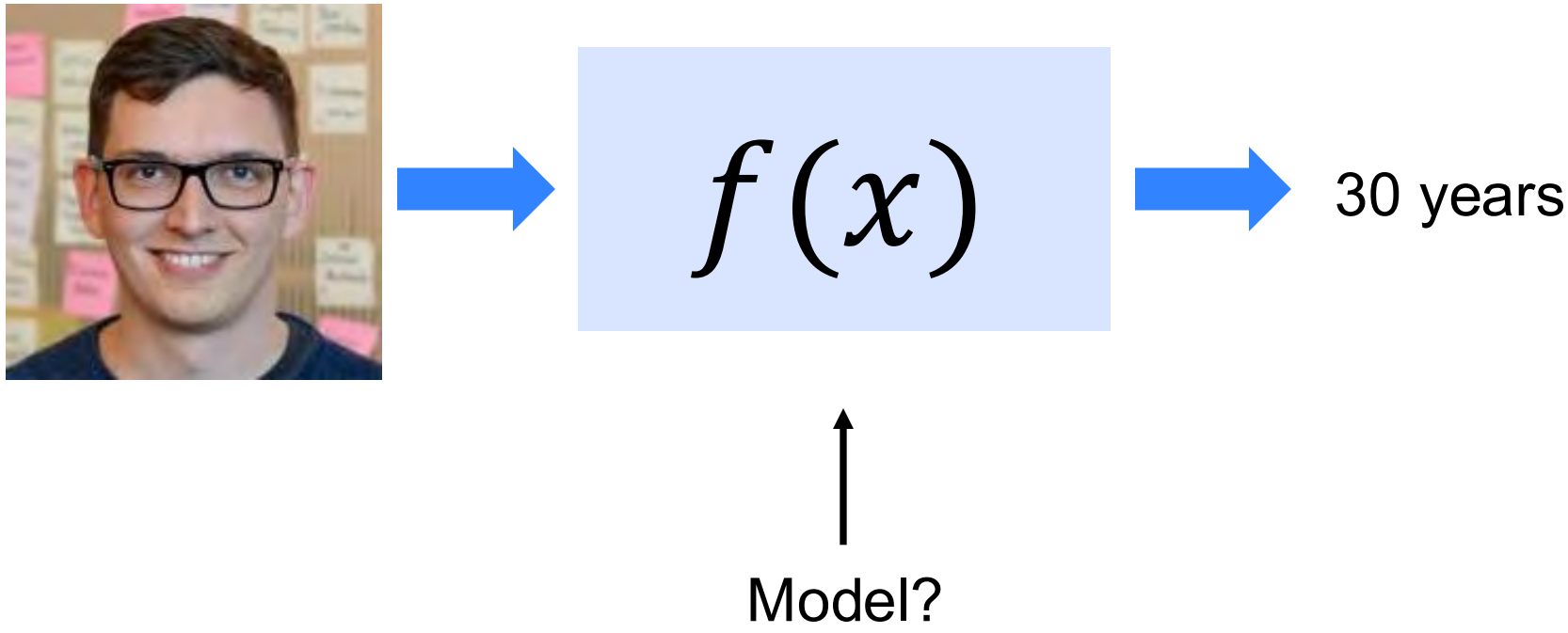
speaker → $f(x)$ →



Model?

*Generative Adversarial Network (GAN)

Introduction into Machine Learning



Gil Levi, and Tal Hassner. "Age and gender classification using convolutional neural networks." In Proceedings of the CVPR workshops. 2015. IEEE: https://doi.org/10.1109/CVPRW.2015.7301352

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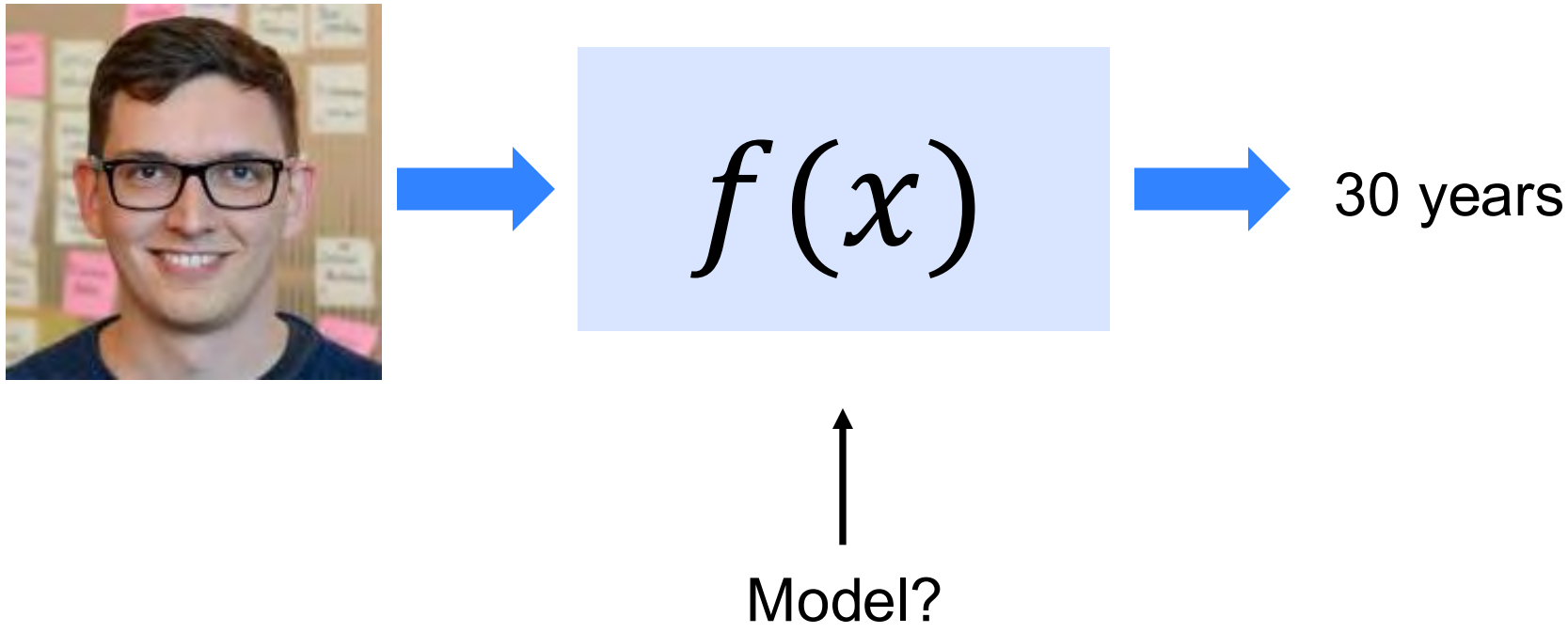

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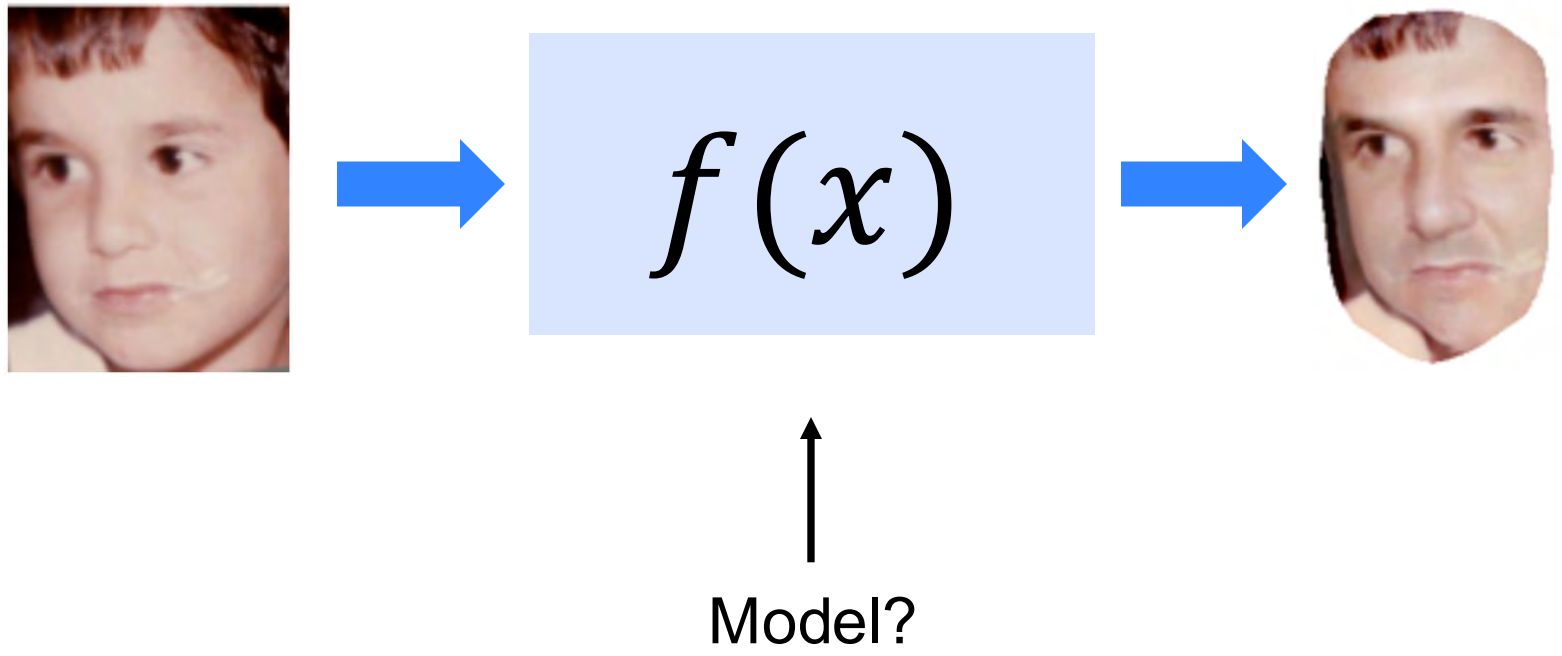
Introduction into Machine Learning



Ira Kemelmacher-Shlizerman, Supasorn Suwajanakorn, and Steven M. Seitz. 2014. Illumination-aware age progression. In Proceedings of the CVPR 2024. IEEE. DOI: https://doi.org/10.1109/CVPR.2014.426

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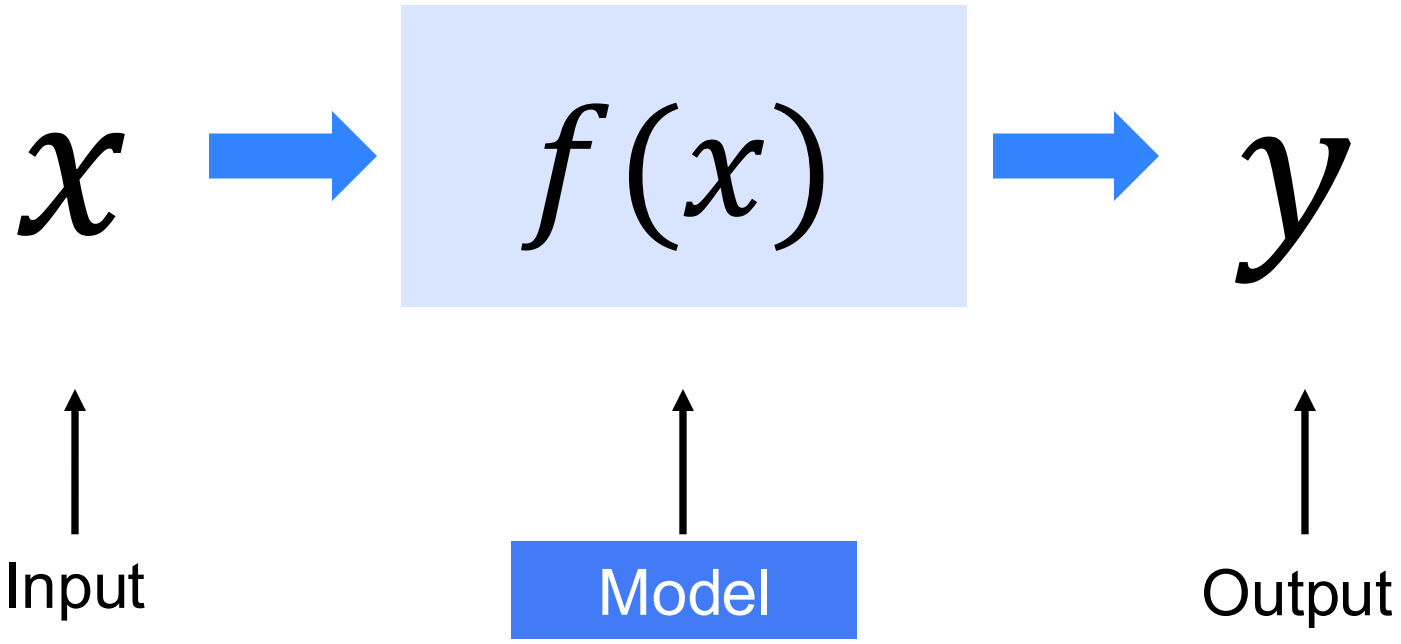

Models

- “Traditional” Machine Learning
  - Support Vector Machines
  - Decision Trees
  - Random Forest
  - …
- “Deep” Learning Methods
  - Neuronal Networks
  - Convolutional Neuronal Networks
  - Recurrent Neural Network (RNN)
  - Generative Adversarial Network (GAN)
  - …

Models

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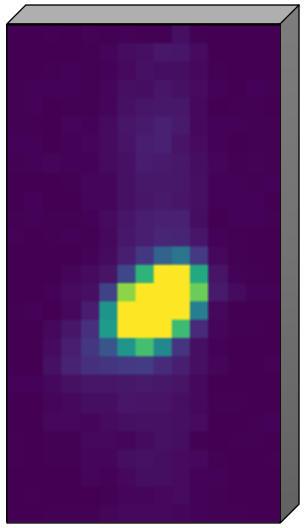
  - Recurrent Neural Network (RNN)
  - Generative Adversarial Network (GAN)
  - …

We will look at some of them in this lecture.

We will focus mainly on Deep Learning Methods.

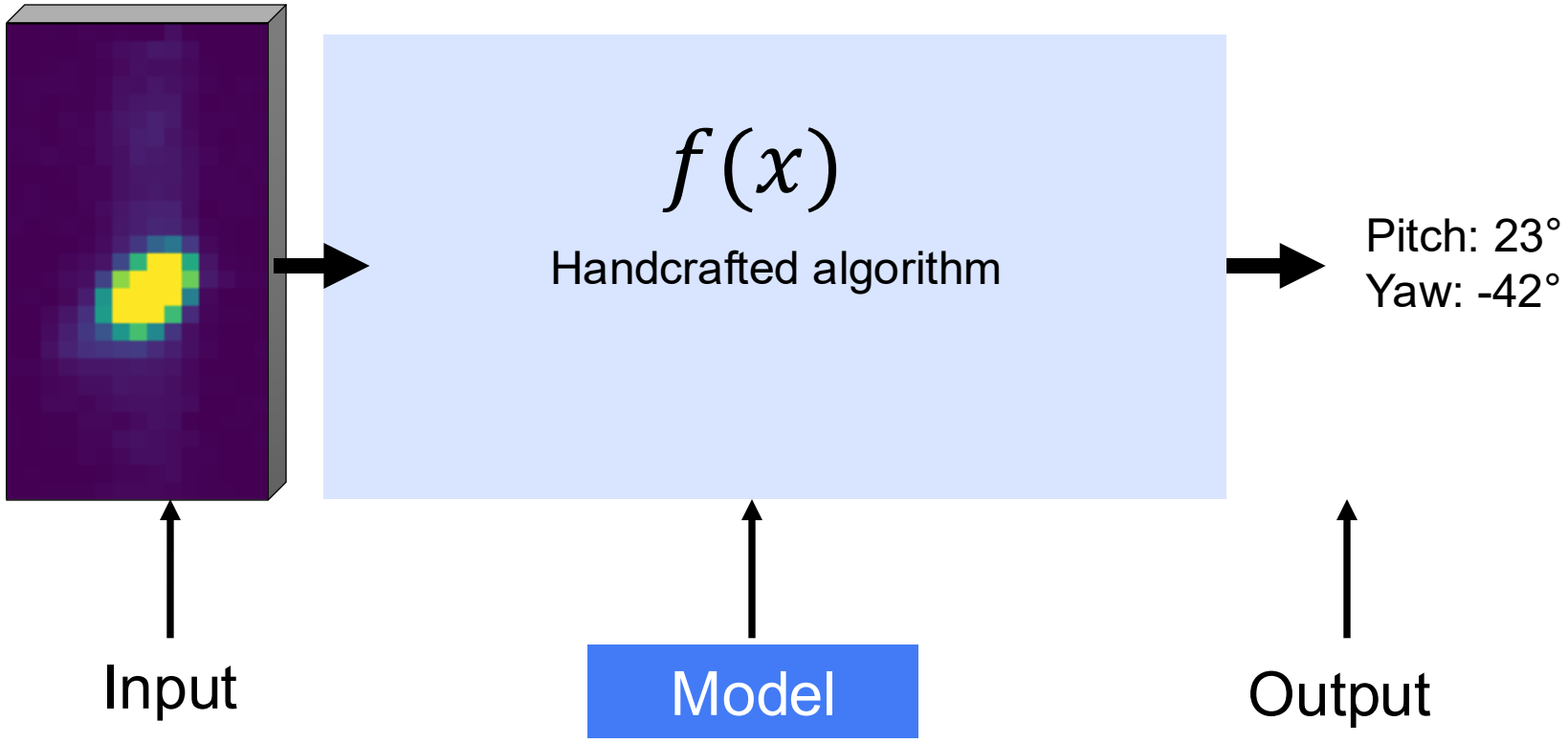
Example

Human-Computer Interaction



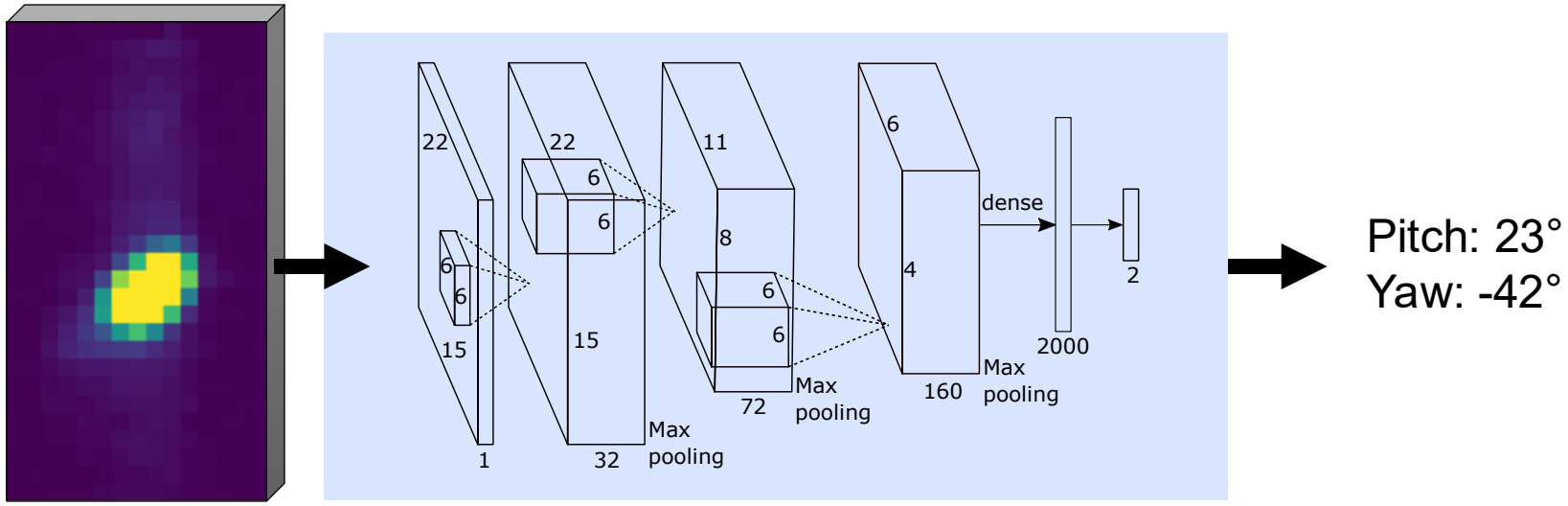
Example

Human-Computer Interaction



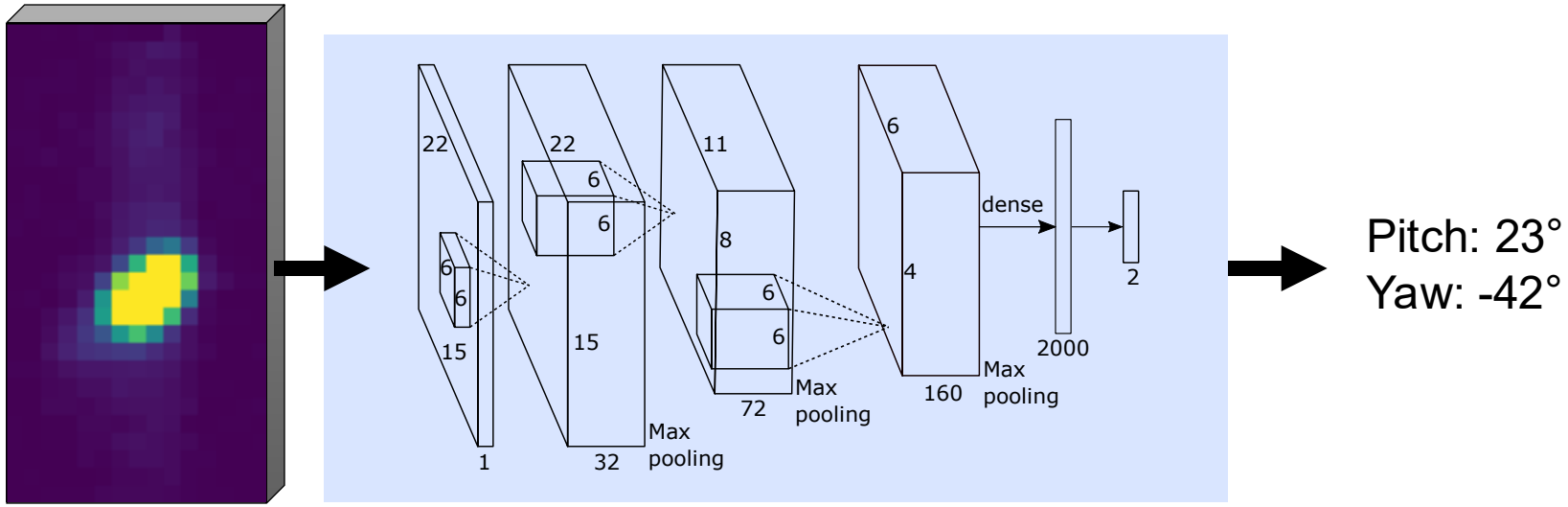
Example

Human-Computer Interaction



Example

Human-Computer Interaction



Pitch: 23°
Yaw: -42°

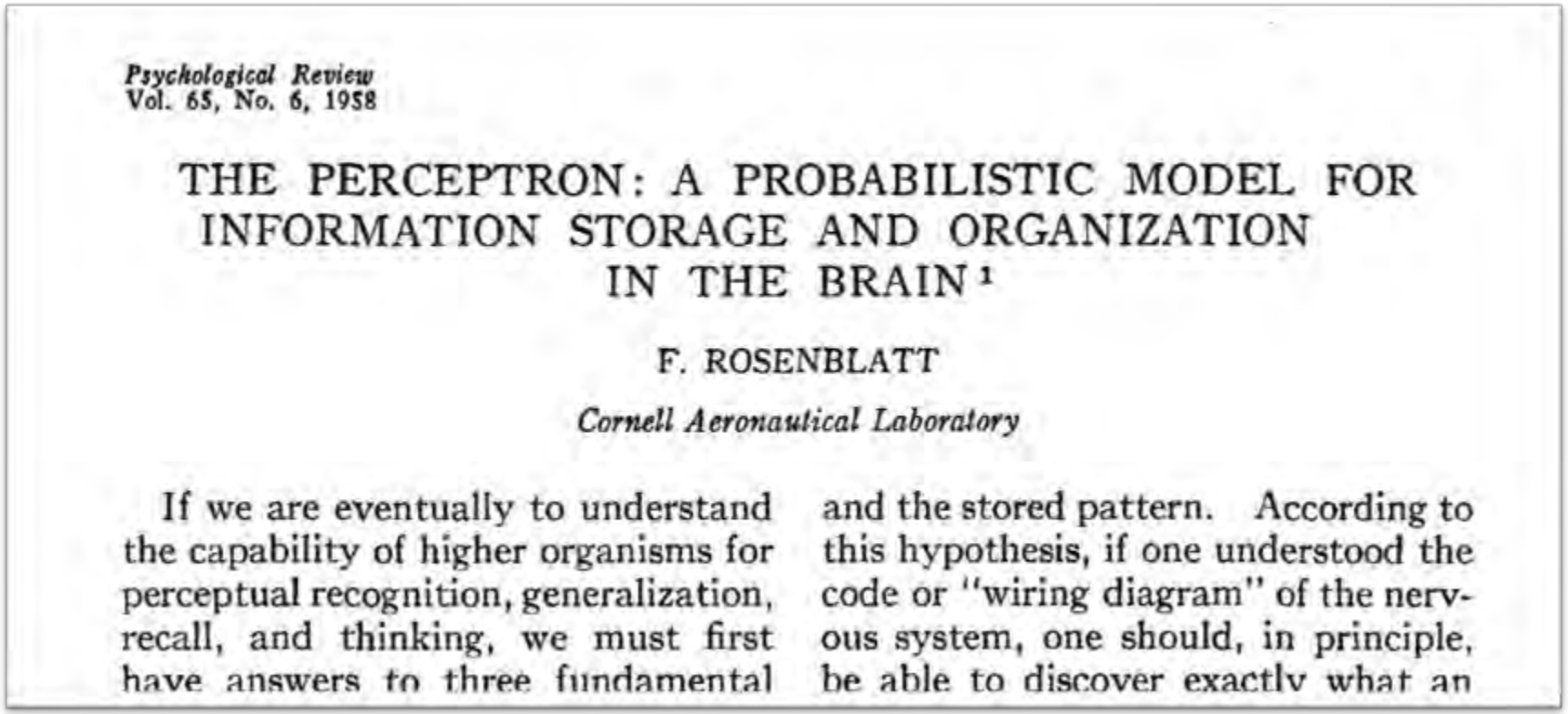
Method	Pitch			Yaw		
	RMSE	MAE	SD	RMSE	MAE	SD
GP reimplementation of Xiao et al. [41]*	14.74	11.78	14.38	56.58	40.51	39.51
pseudo implementation of Xiao et al. [41]**	14.19	11.58	8.21	44.53	33.39	29.46
CNN + L2	12.8	10.09	7.88	24.19	17.62	16.58

8.9%

45.7%

Neuronal Networks

What can be trained?



Psychological Review
Vol. 65, No. 6, 1958

THE PERCEPTRON: A PROBABILISTIC MODEL FOR INFORMATION STORAGE AND ORGANIZATION IN THE BRAIN[1]

F. ROSENBLATT

Cornell Aeronautical Laboratory

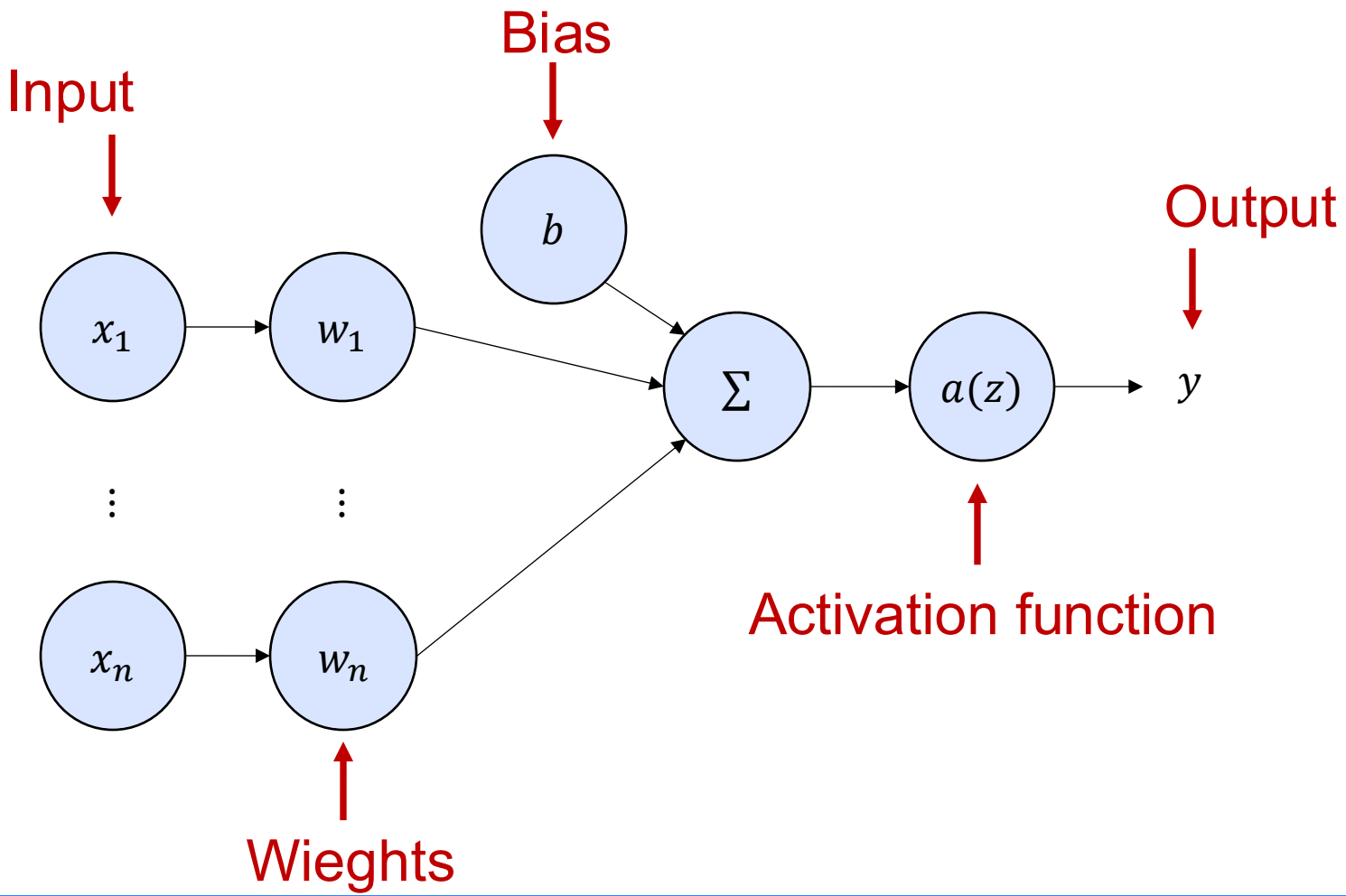
If we are eventually to understand the capability of higher organisms for perceptual recognition, generalization, recall, and thinking, we must first have answers to three fundamental

and the stored pattern. According to this hypothesis, if one understood the code or "wiring diagram" of the nervous system, one should, in principle, be able to discover exactly what an

Frank Rosenblatt. "The perceptron: a probabilistic model for information storage and organization in the brain." *Psychological review* 65, no. 6 (1958): 386. DOI: https://psycnet.apa.org/doi/10.1037/h0042519

What is a Perceptron?

Single-Layer Perceptron



Conclusion

Introduction to Machine Learning

- Practical Examples
- General understanding of the model f(x)
- Deep Learning Approaches
  - Perceptron
  - Weights & biases can be trained
  - Activation function

Questions?

License