TECHNISCHE UNIVERSITÄT DARMSTADT

Interaction and representation challenges of sustainability related information – **The quest for usable sustainability**

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Telecooperation Lab; Computer Science Department

Telecooperation Lab

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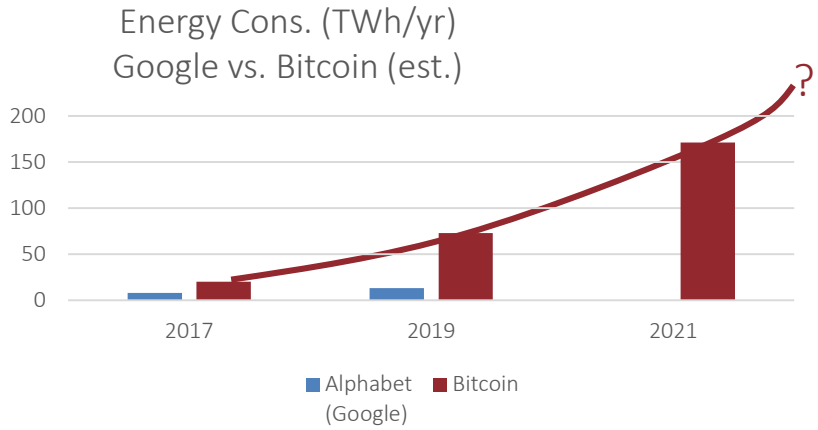
Sustainability

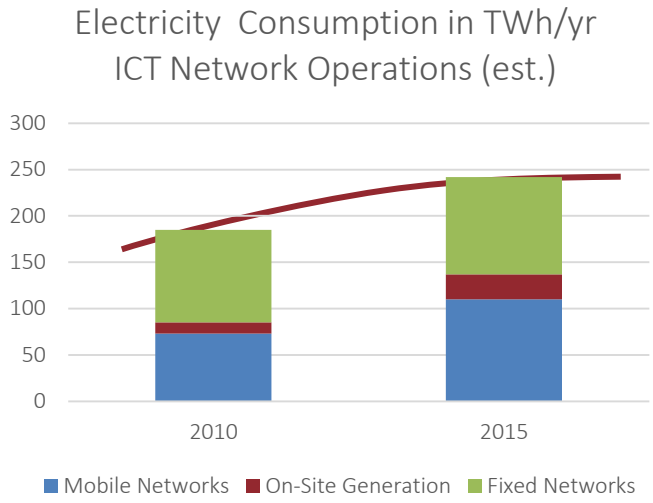
"green"

https://pixabay.com/photos/grass-green-meadow-juicy-fresh-2228960, Pixaby License, FelixMittermeier)



data from:
https://digiconomist.net/bitcoin-energy-consumption
https://www.statista.com/statistics/788540/energy-consumption-of-google/

Informatics needs "green" needs Informatics



data from: J. Malmodin & D. Lundén.
The electricity consumption and operational carbon emissions of ICT network operators 2010-2015
Report from KTH Centre for Sustainable Communications
ISBN: 978-91-7729-679-9

"green"

needs

informatics

effects

causes

root causes

effect sizes

[1]

1: https://pixabay.com/illustrations/danger-skull-vector-clipart-sign-2324940 (Pixabay lic., Mohamed Hassan)
2: https://www.piqsels.com/en/public-domain-photo-fsity (free under CC0 PD license)

effects

causes

root causes

effect sizes

£ $ € ¥

§

1

2

materials

production

Ressources, e.g. water footprint

packaging

…

…

…

logistics

consumption / waste

…

…

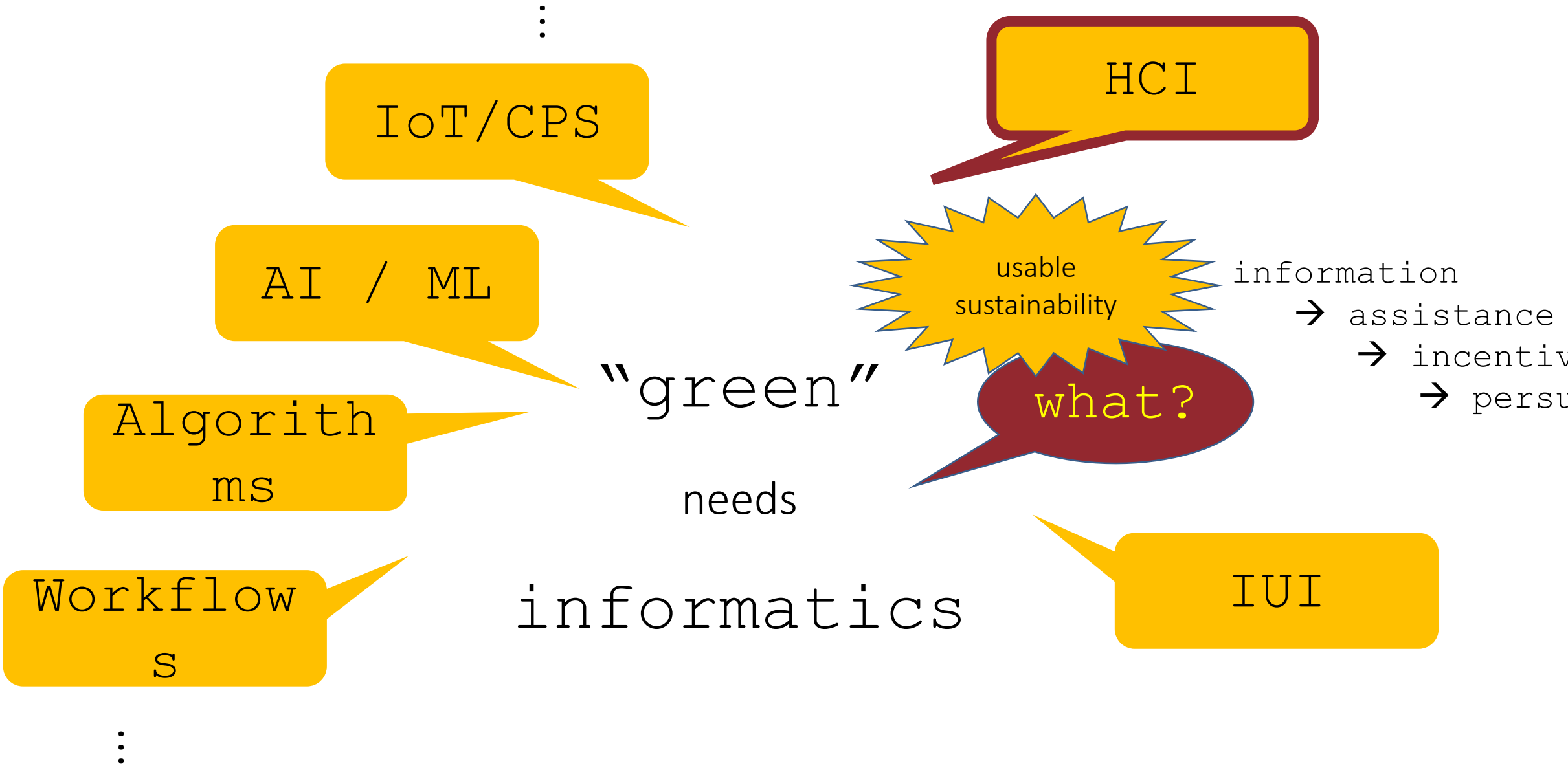
recycling

stake-holders

alternatives

existing

potential

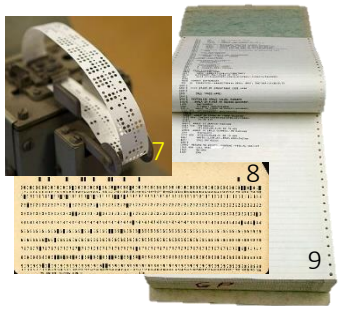

...
IoT/CPS
HCI
AI / ML
usable sustainability
information
→ assistance
→ incentiv
→ persu
"green"
what?
Algorithms
needs
informatics
IUI
Workflows
...

Challenge: Cyber↔Physical Integration *in the Wild*

Permission by CEiiA, www.ceiia.com, Helena Silva

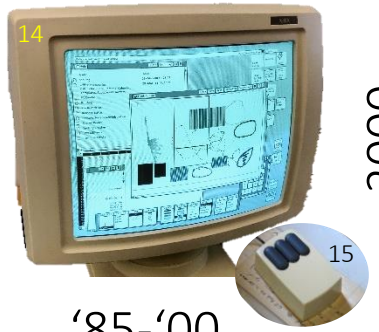
HCI Evolution

For 50 years: glass walls separate analog (human) from digital!



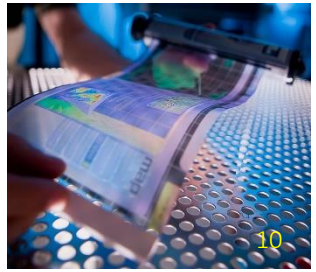
‘45-‘70

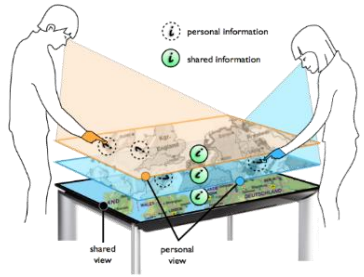
‘70-‘85



‘85-‘00

2000





2020 → ?

1-4: Pics w/ Pixabay license by: 1 Stocksnap, 2 Firmbee 3 Maxim Kazachkov 4 Mediamodifier 5 Manish Dhawan; 6: https://commons.wikimedia.org/wiki/File:IBM1442.corestore.jpg (gnu.org/licenses/gfdl.html, Mike Ross); 7-15: under https://creativecommons.org/licenses
7 https://commons.wikimedia.org/wiki/File:Harwell-dekatron-witch-10.jpg (CC BY-SA 3.0, Bad Germ) 8: https://commons.wikimedia.org/wiki/File:Used_Punchcard_(5151286161).jpg (CC BY 2.0, Pete Birkinshaw) 9: https://commons.wikimedia.org/wiki/File:Bound_computer_printout.agr.jpg (CC BY-SA 3.0, ArnoldReinhold) 10: https://commons.wikimedia.org/wiki/File:Flexible_display.jpg (CC BY 2.0, U.S. Army RDECOM) 11: https://commons.wikimedia.org/wiki/File:Teletype_with_papertape_punch_and_reader.jpg (CC BY-SA 3.0, Alison Wheeler)
12: https://commons.wikimedia.org/wiki/File:IBM-3279.jpg (CC BY 2.0 Shieldforyoureyes) 13: https://en.wikipedia.org/wiki/VT100#/media/File:DEC_VT100_terminal.jpg (CC BY 2.0, Jason Scott) 14: https://www.flickr.com/photos/leighklotz/48465463446 (CC BY 2.0, Leigh Klotz)
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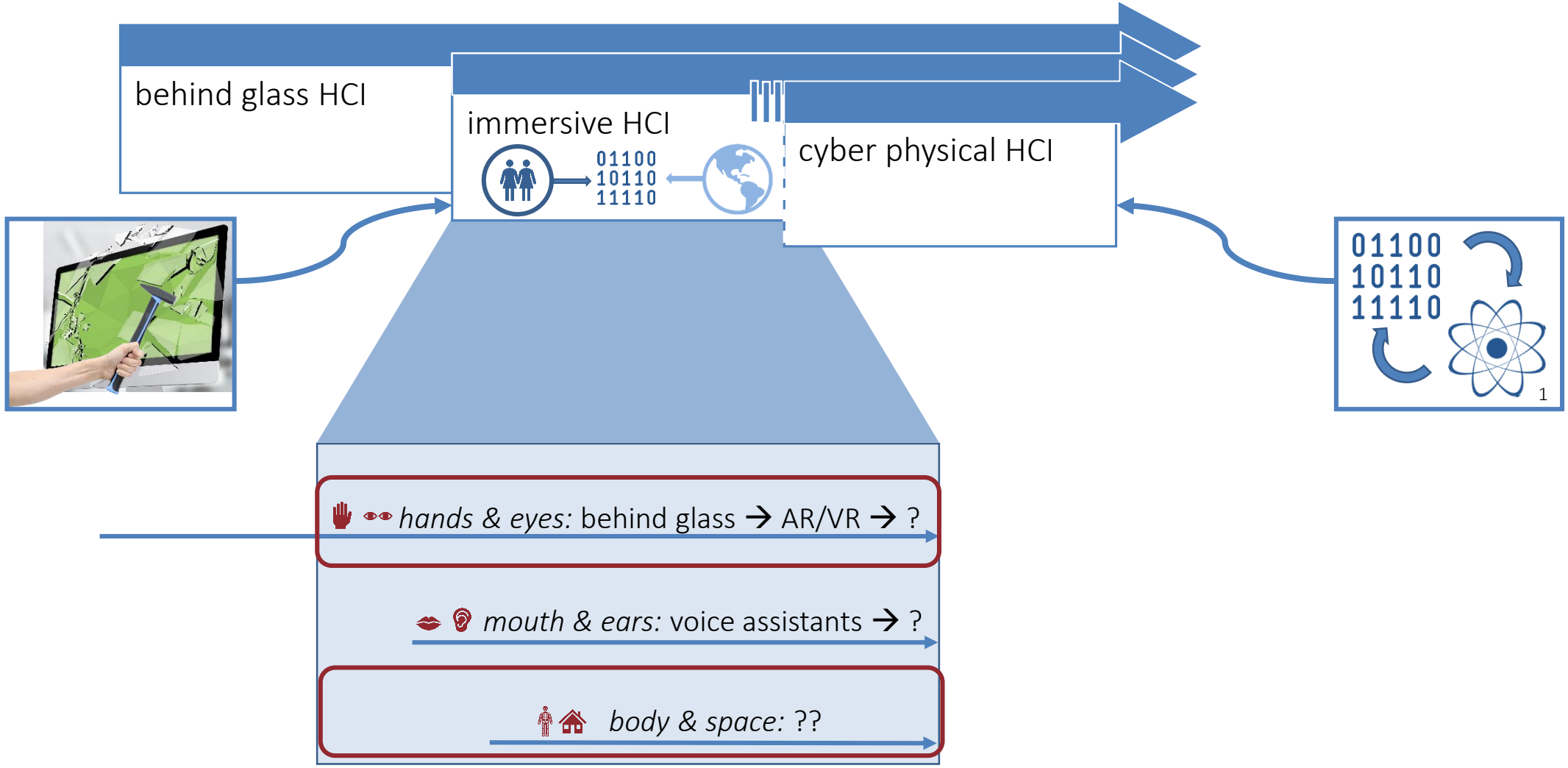
HCI Evolution



1: https://pixabay.com/de/vectors/kern-physik-atom-protonen-35000/ (Pixabay license, Clker-Free-Vector-Images

Optional Material : Ongoing Research

Technische Universität Darmstadt

A Note Up Front

- Don‘t get distracted by clumsy lab prototypes
- Remember Ivan Sutherland‘s „Sword of Damokles“

1: https://commons.wikimedia.org/wiki/File:Head-mounted_display_and_wired_gloves,_Ames_Research_Center.jpg (Public Domain, NASA)
2: https://www.piqsels.com/en/public-domain-photo-isugj (free under CC0 PD license)
3. https://www.piqsels.com/en/public-domain-photo-jtvqa (free under CC0 PD license)
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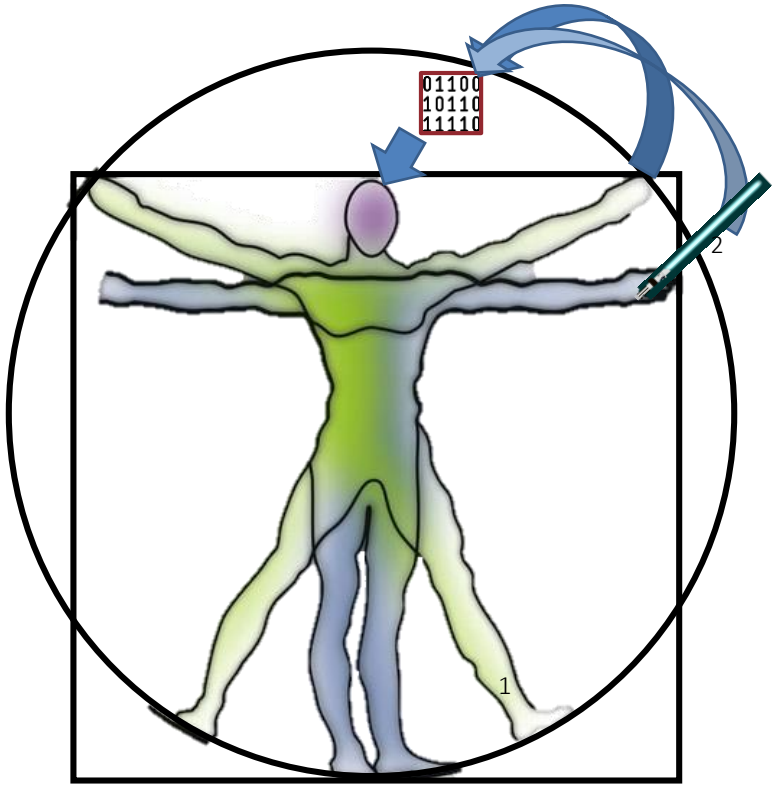
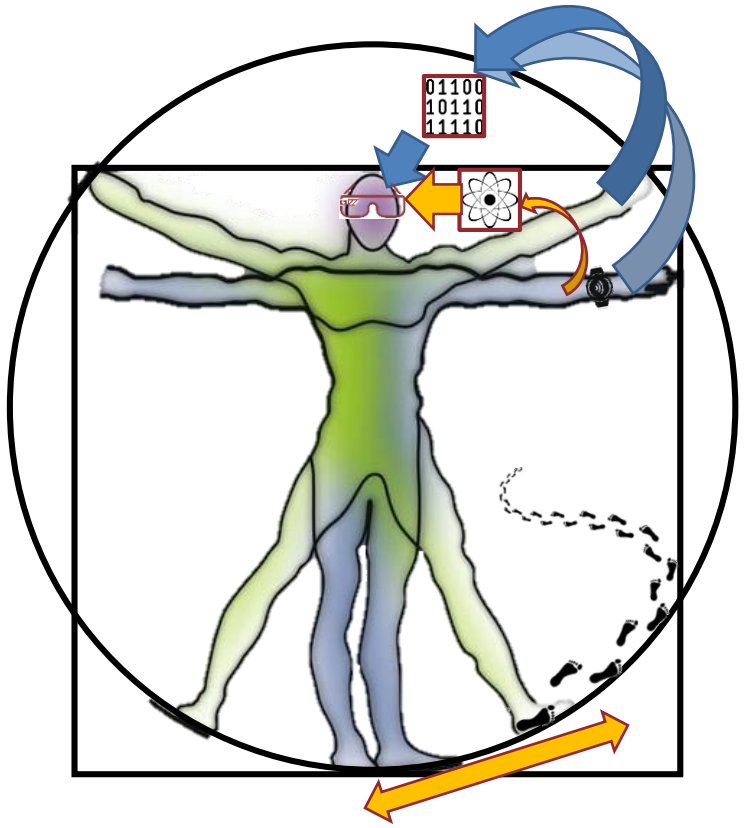
Today: Visual Immersion + Simple Hand Input

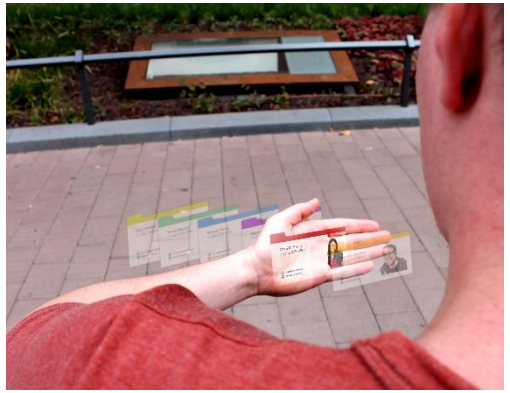


- AR/VR today: **Cyber Touch / Cyber Gestures**
  - (eyes and) hands …
    - … + optional: controller
    - … navigate **in** cyber model
    - … perform touch/gesture **on** cyber model

1: https://pixabay.com/de/vectors/vitruvian-man-anatomie-wissenschaft-151866 (Pixabay license, OpenClipart-Vectors)
2: https://pixabay.com/de/vectors/lichtschwert-star-wars-george-lucas-1980162 (Pixabay license, Ricarda Mölck)
3: https://unsplash.com/photos/NN9HQkDgguc (Unsplash license, Stephan Sorkin)

1st Step: From Hands to Arms, AR-to-Go





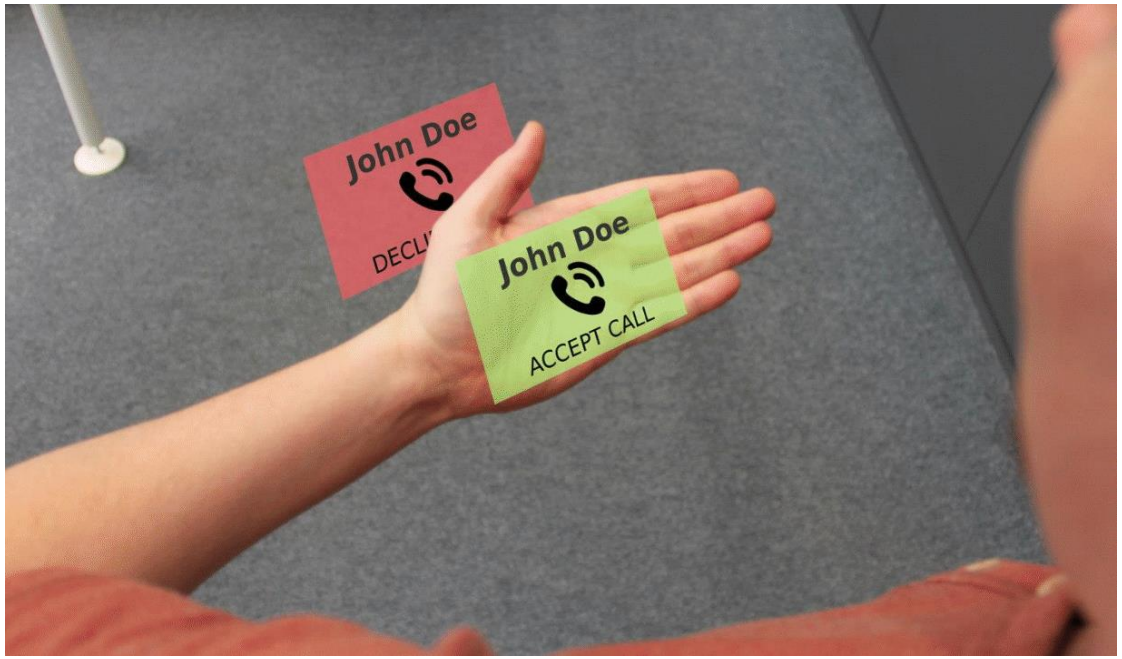
- **Cyber-Physical Upper-Limb Interaction**
  - perception → motion of upper limbs …
    - (+optional: Smartwatch or similar)
    - … *immediately & continuously interacts* with cyber model
    - … *location independent* → enables interaction *on the go*


Cyndia
Not so awesome
Domey
What what what
Esther
BFF
Bob
Most awesome guy
+49 6151 31337 123
Awesomestr. 69
64289 D-Town

Proximity-based Interaction

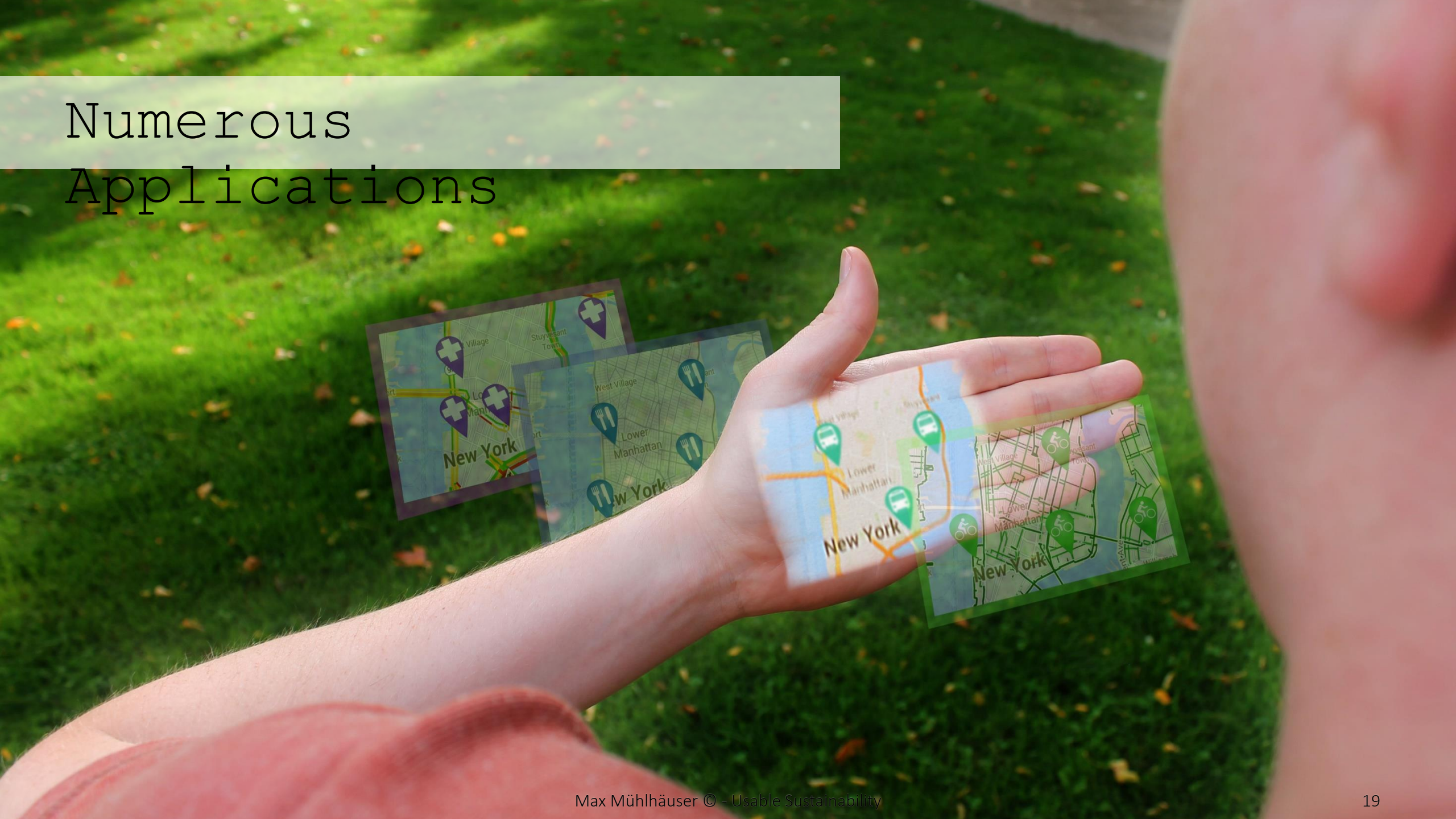
Immediate & Continuous Interaction …

… with continuous model



… with discrete model

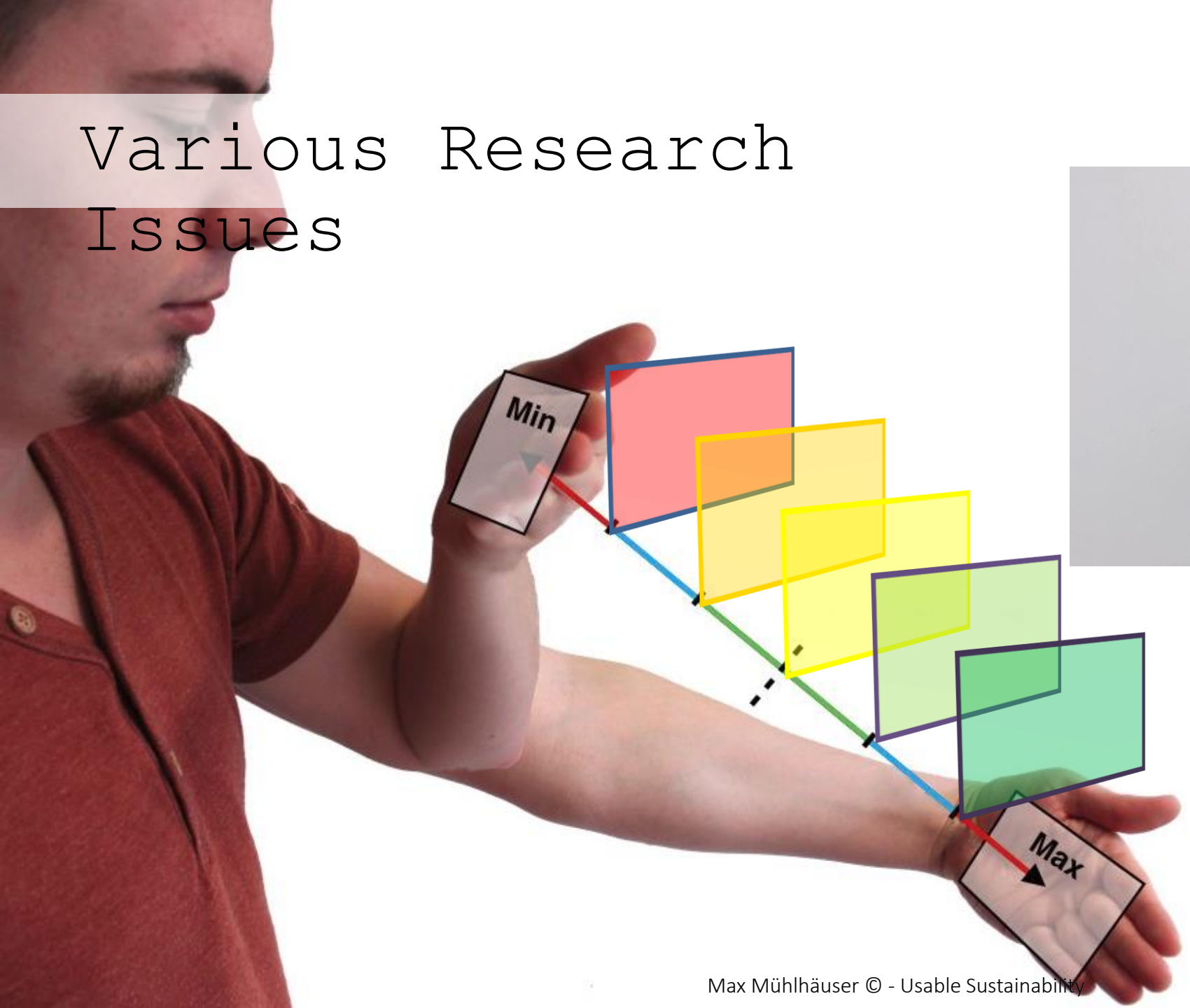
Numerous Applications

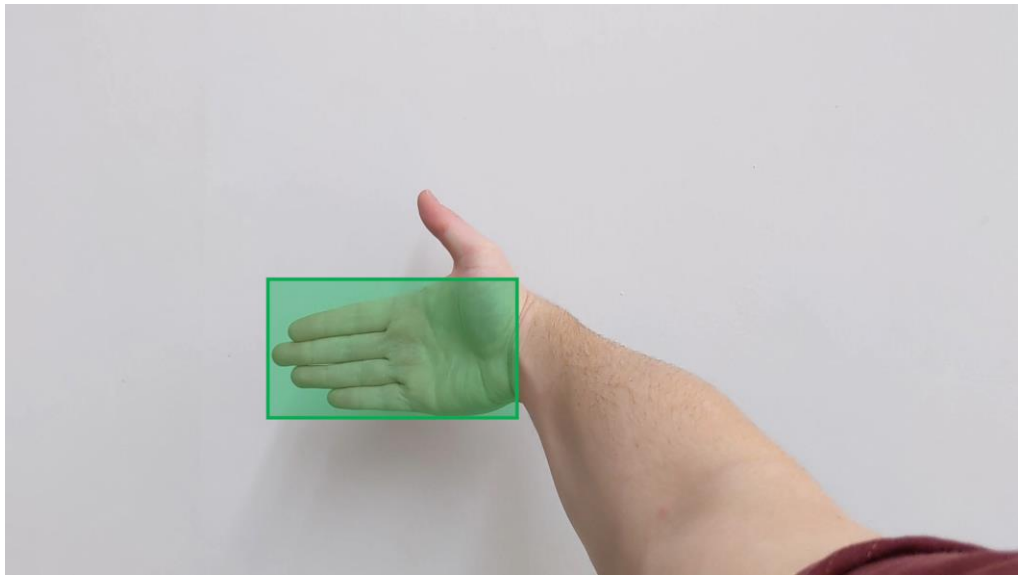


Numerous Applications

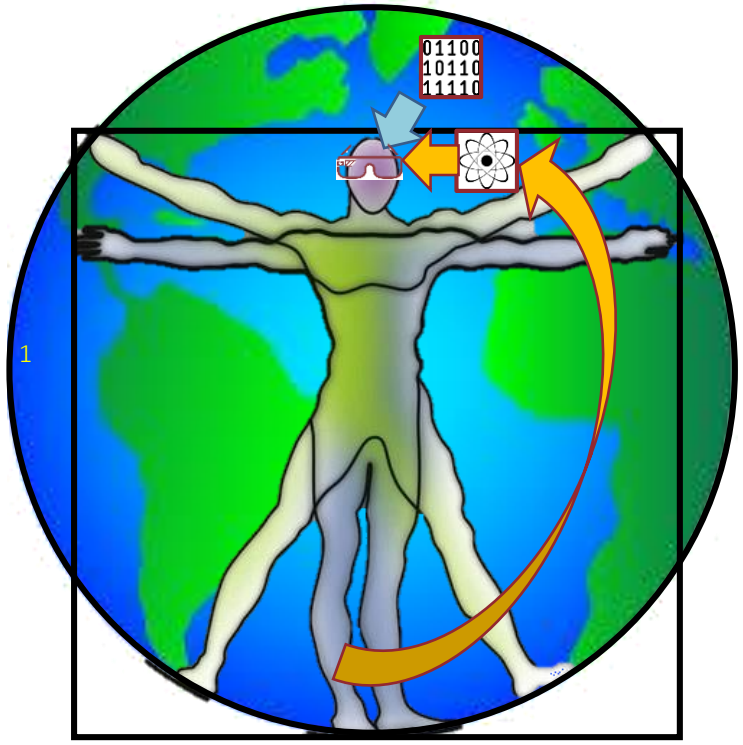
Use Case *Smartwatch Interaction*

Various Research Issues





Next Step: Lower Limbs, True Outdoor Immersion



1

- **Outdoor Cyber-Physical Interaction**
  - immediate interaction at large scope (city → global) …
    - … leveraging the *lower limbs*
    - … keeping hands free for physical world

1: https://pixabay.com/de/vectors/erde-globus-welt-amerika-23593 (Pixabay license, Clker-Free-Vector-Images)

Today's interaction with HMDs

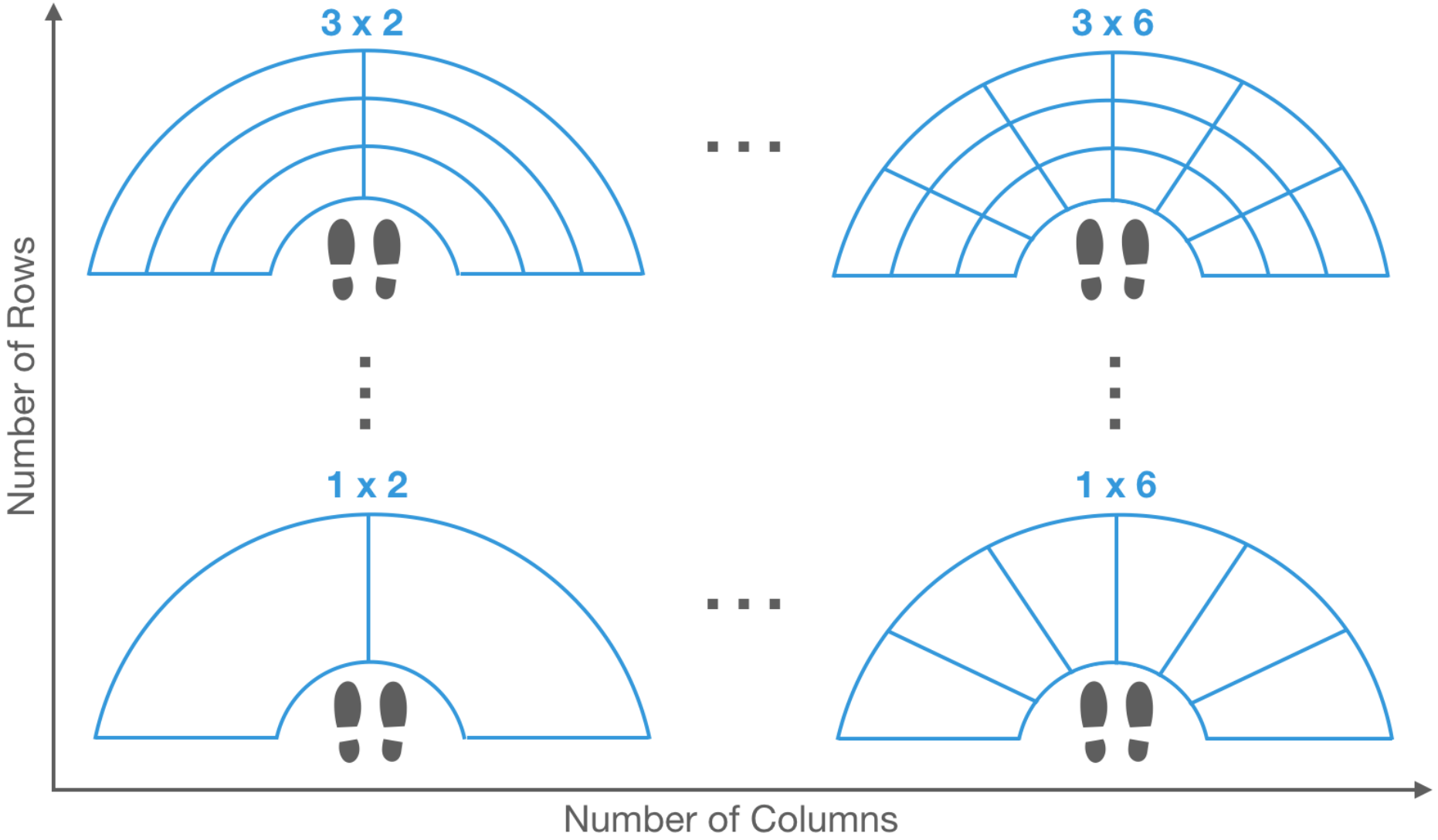
Mind The Tap: Concept

Hypothesis: Proprioception allows users to operate indirect interfaces.

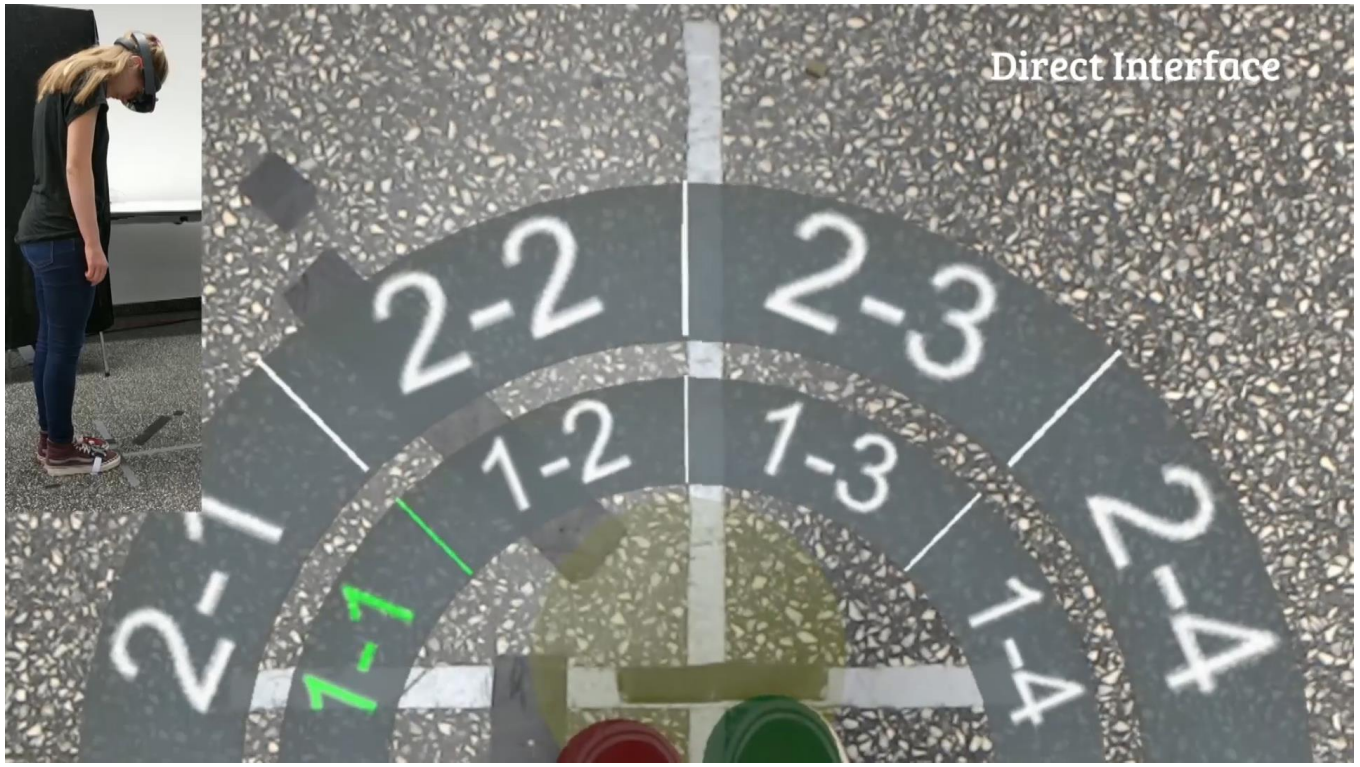
direct interaction

indirect interaction

Rows and Columns



Controlled Experiment: Direct Interaction



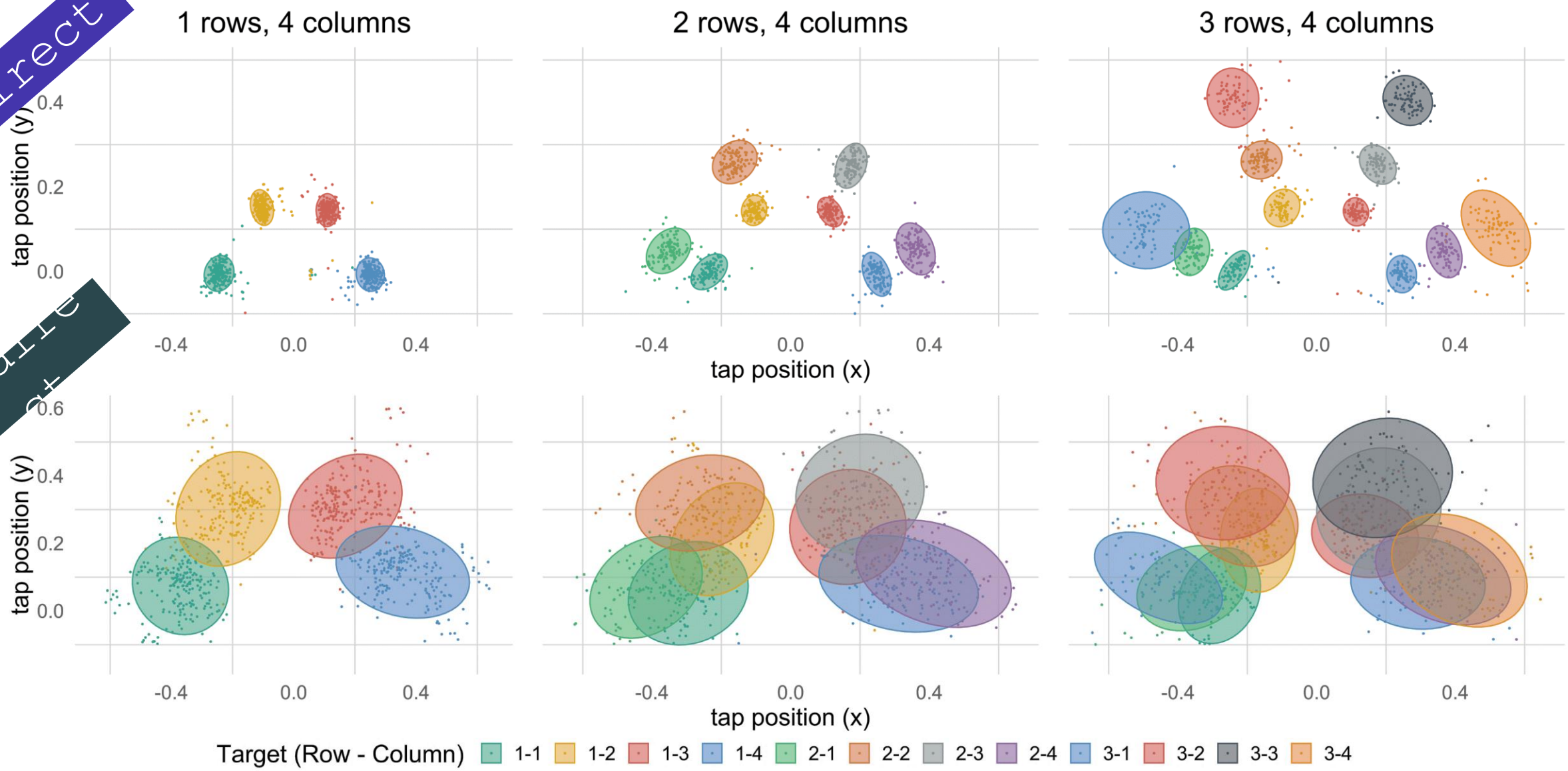
direct interaction

All measurements in meters.

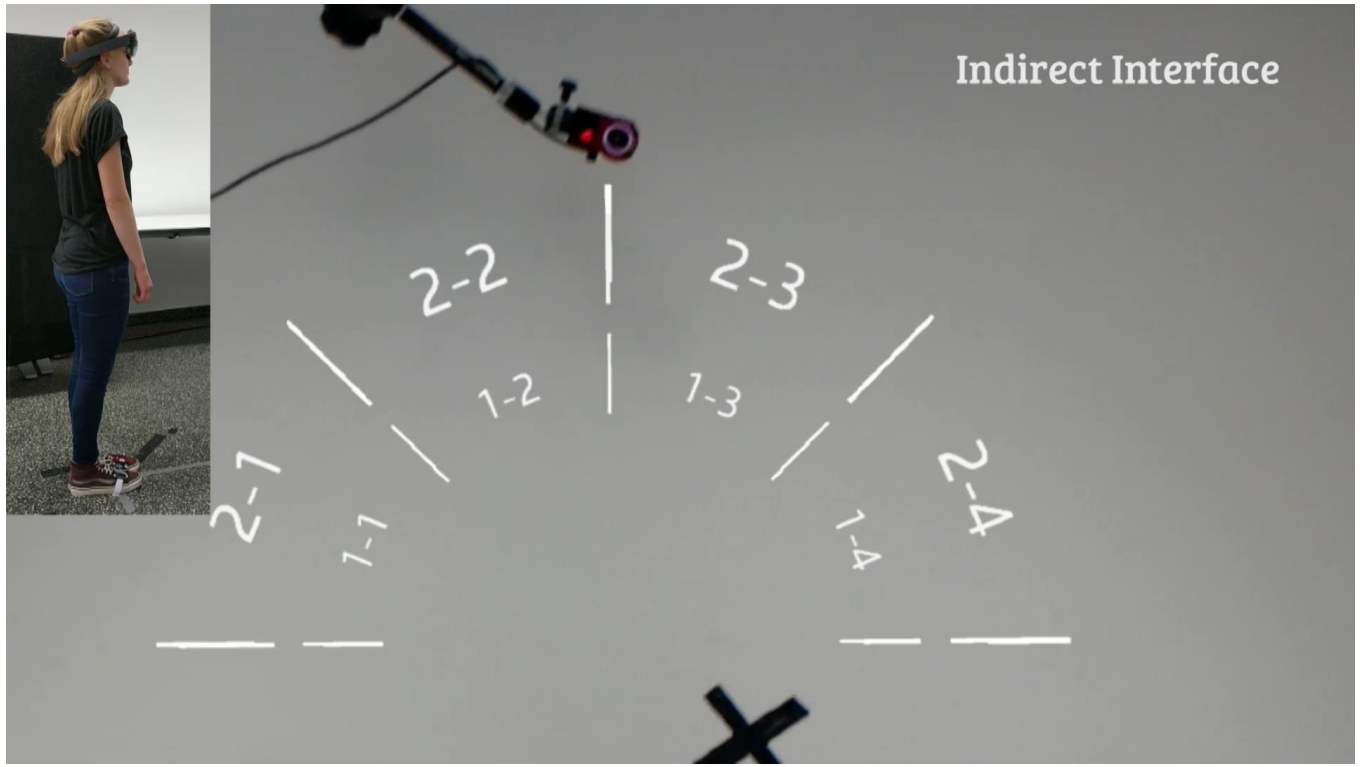
Initial Results: Accuracy and Area

direct

indirect



Controlled Experiment: Indirect Interaction



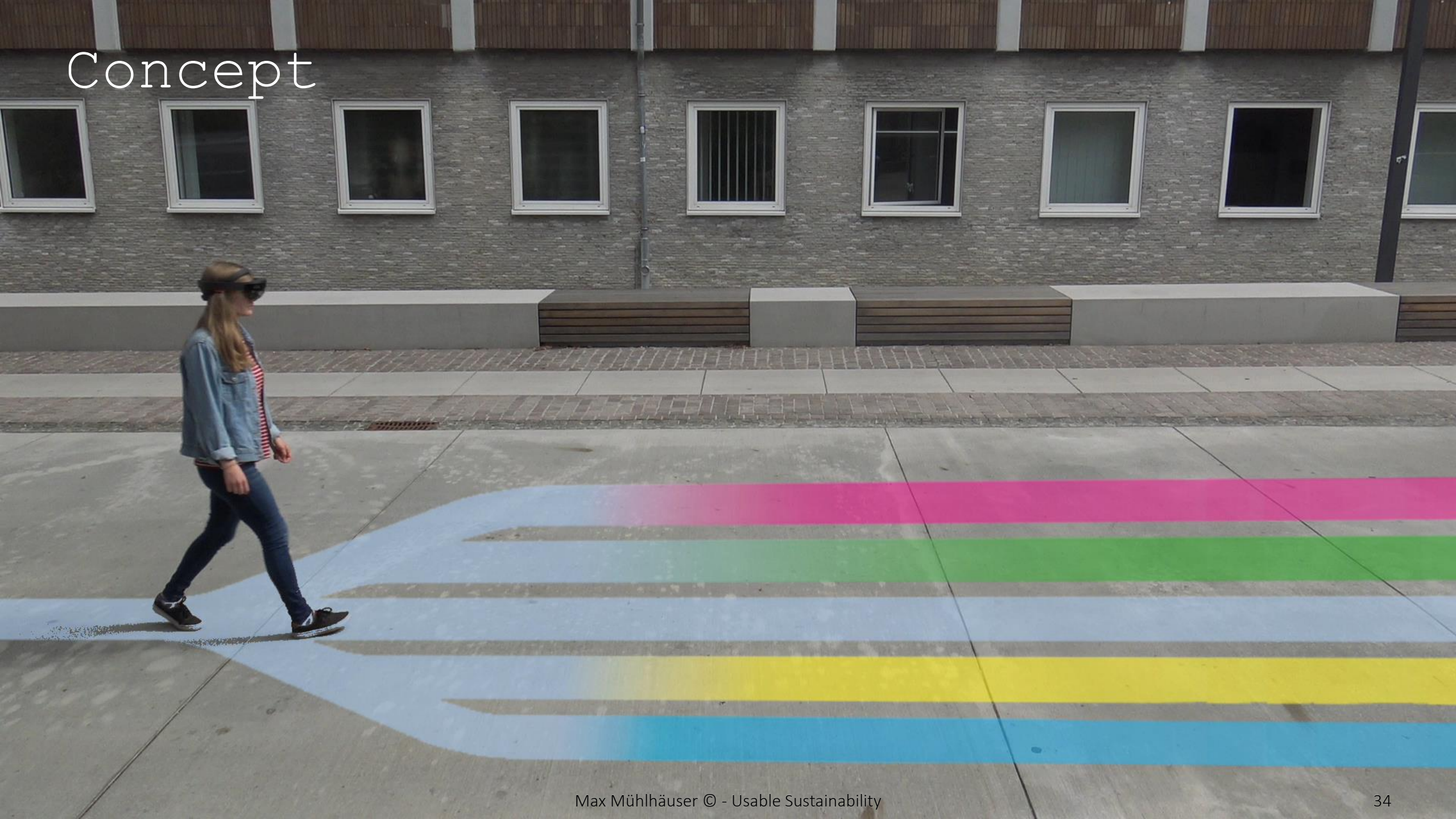
on indirect interaction

Walk the Line

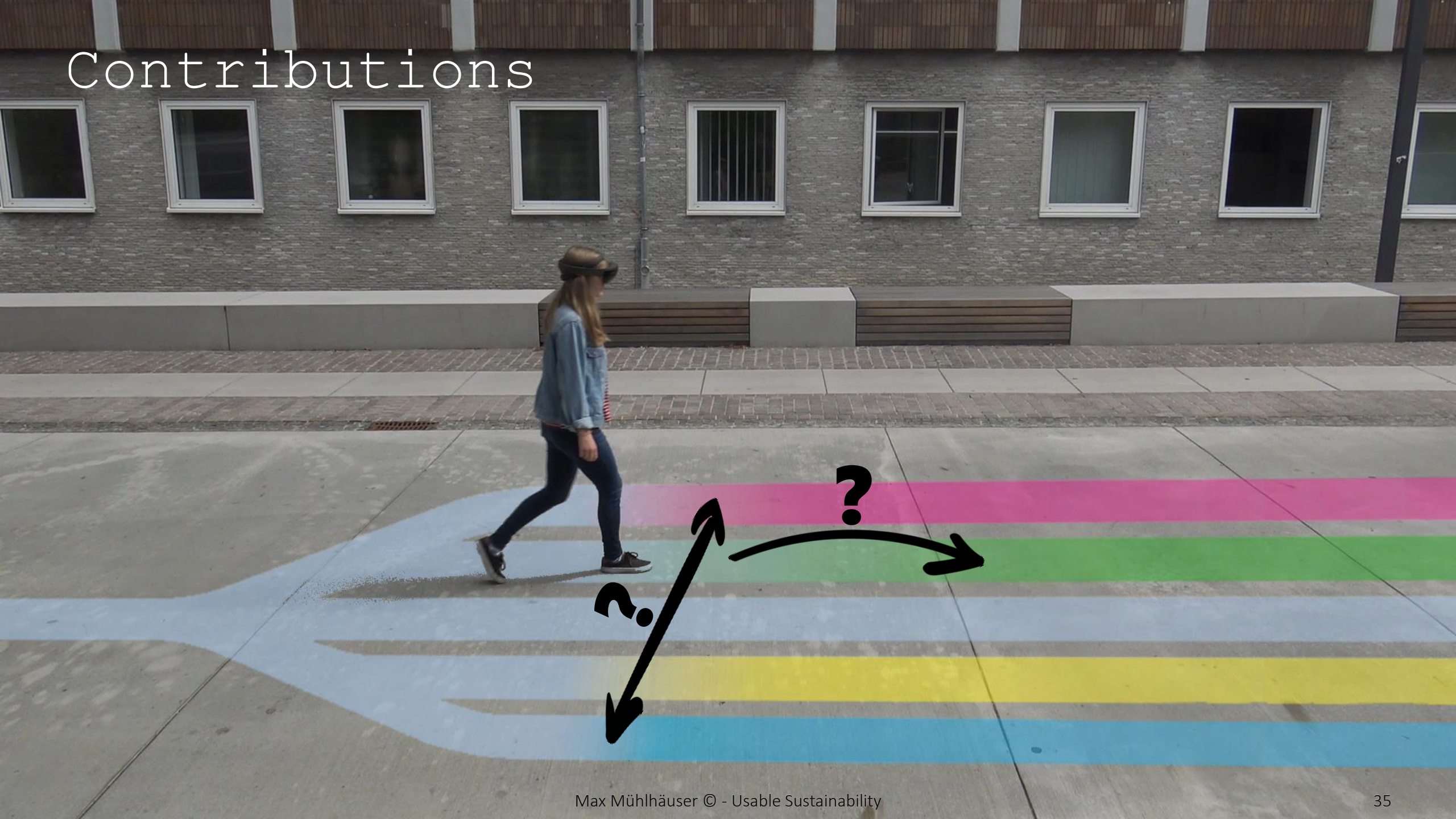
Concept

Concept

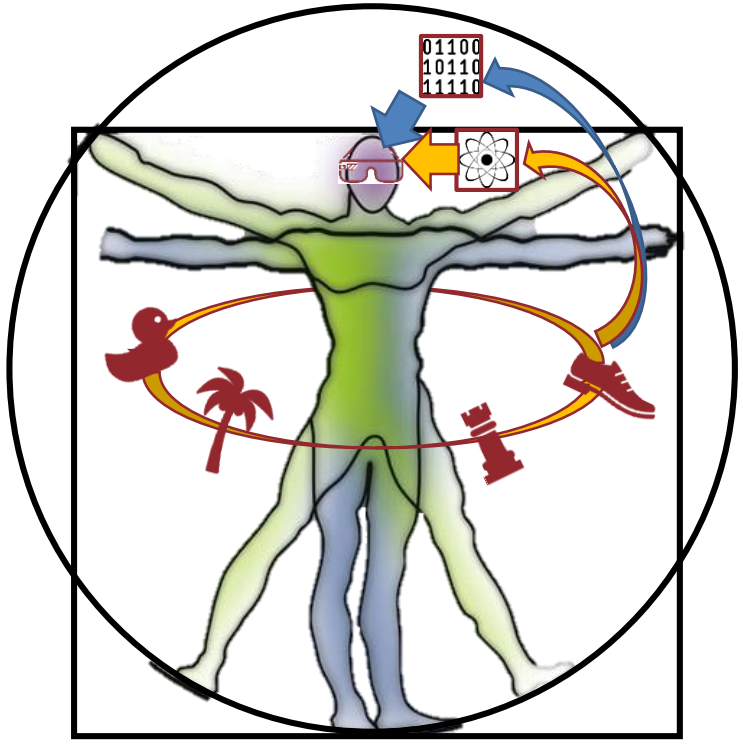
Concept

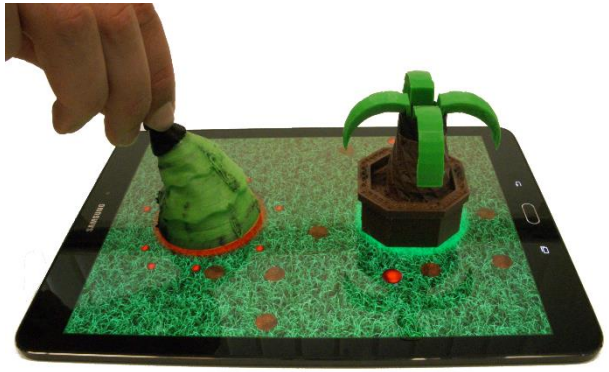


Contributions



Big Step: Turning The Physical World Interactive





- **Interaction with Cyber-Physical Objects**
  - Physical world becomes part of the system
    - AR up to now: digital world only overlaid on physical world
    - issue here: how to fabricate interactive objects with ease
    - (Lead Researcher: Dr. Martin Schmitz)

CheckMate: 3D-print & AR

Demo App: **combines** AR and 3D printed cyber-physical objects

- scenario: check across two distant locations
- check board: tabletop or tablet PC
- own figures: 3D printed, interactive
- remote figures: AR based

CheckMate

Exploring a Tangible Augmented Reality Interface for Remote Interaction

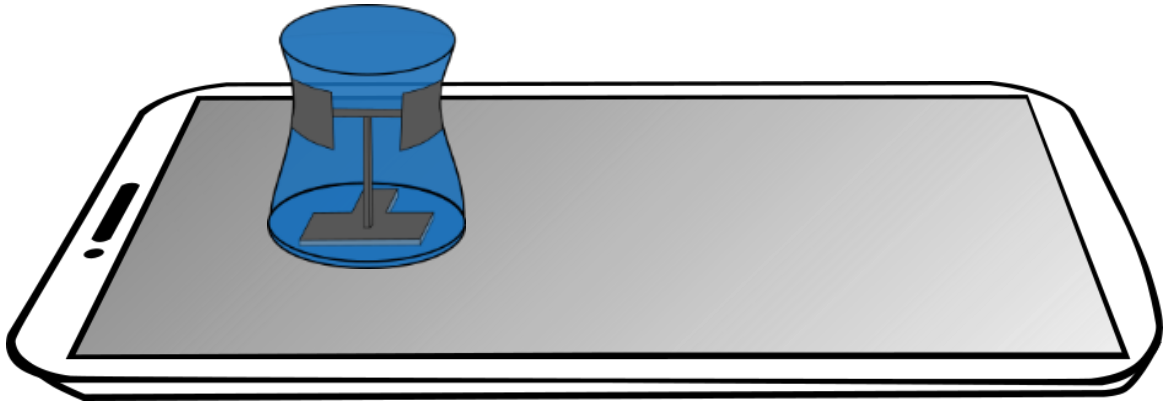
Sebastian Günther Florian Müller Martin Schmitz Jan Riemann
Niloofar Dezfuli Markus Funk Dominik Schön Max Mühlhäuser

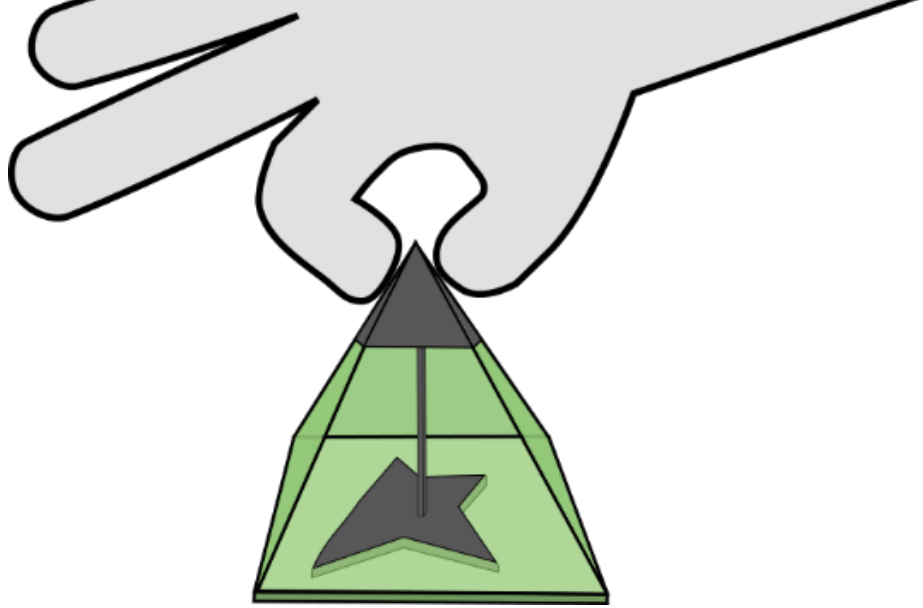
TECHNISCHE UNIVERSITÄT DARMSTADT

Telecooperation Lab

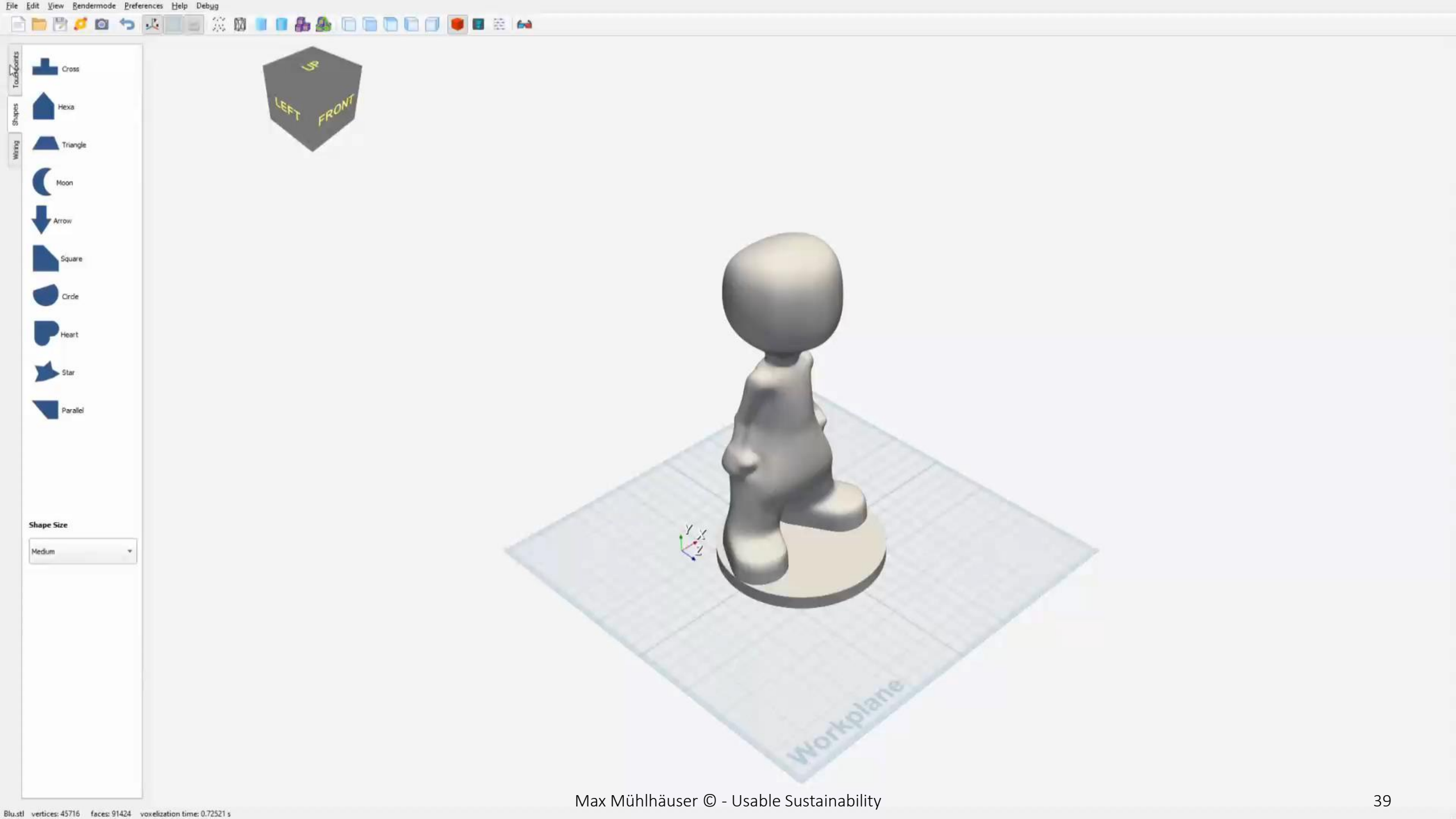
CHI 2018 Engage with CHI

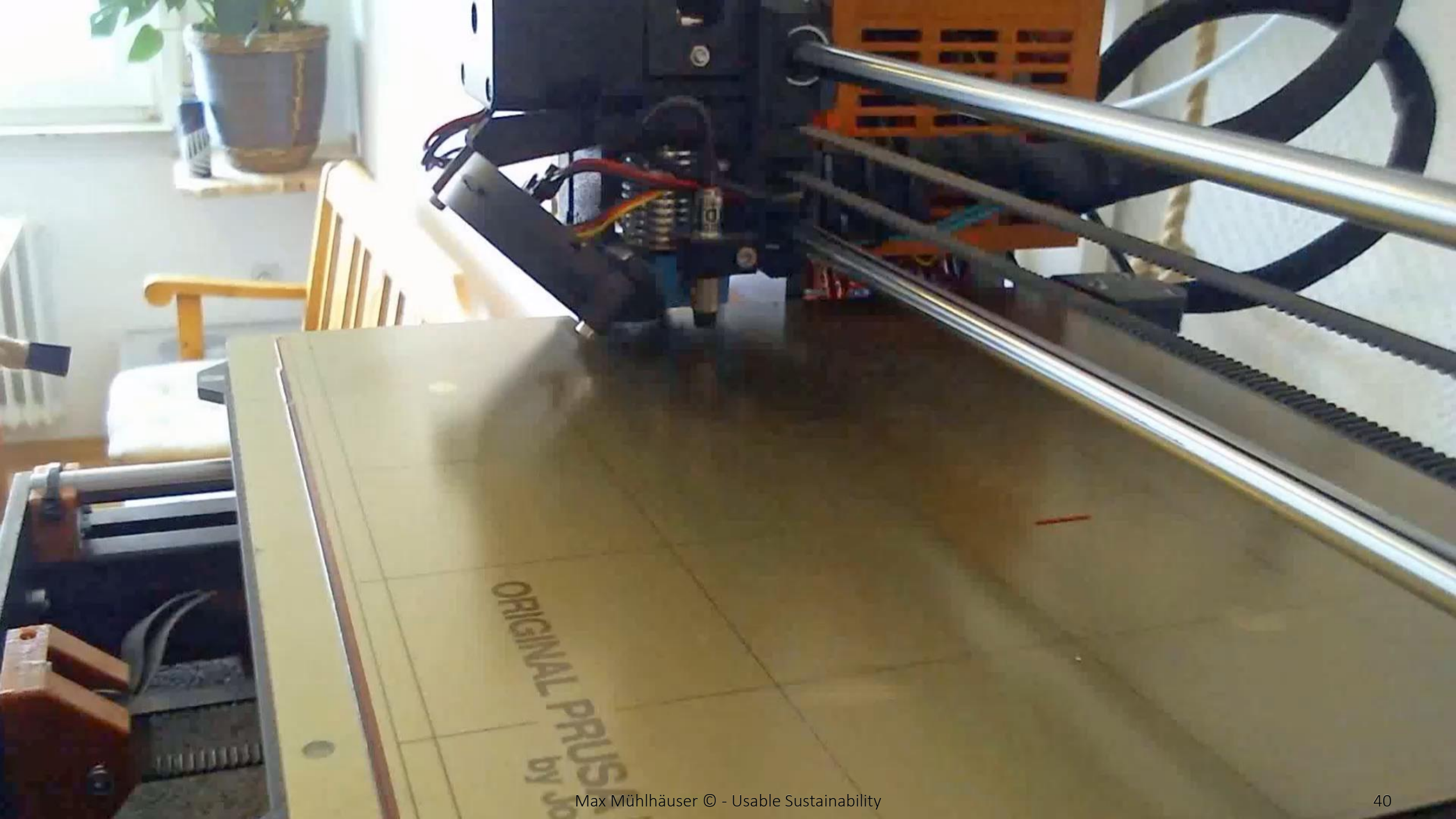
Itsy-Bits



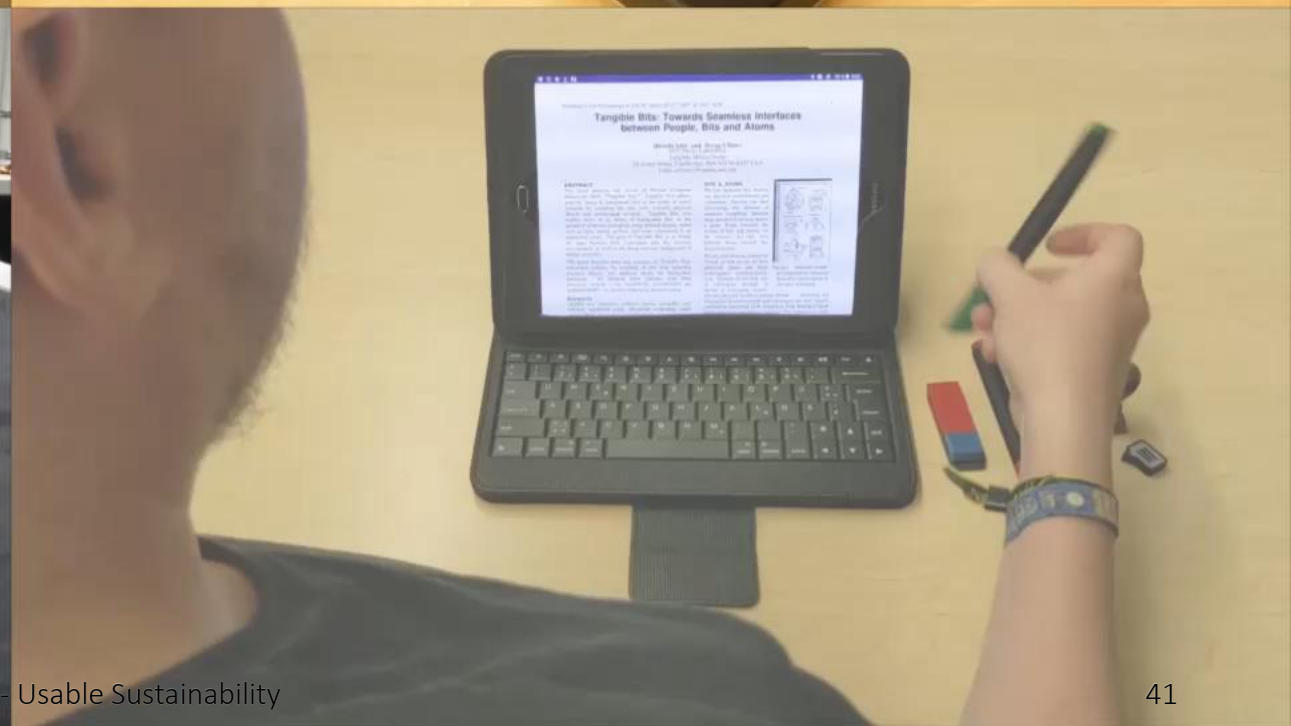


- Identify
- Position & Rotation
- Track

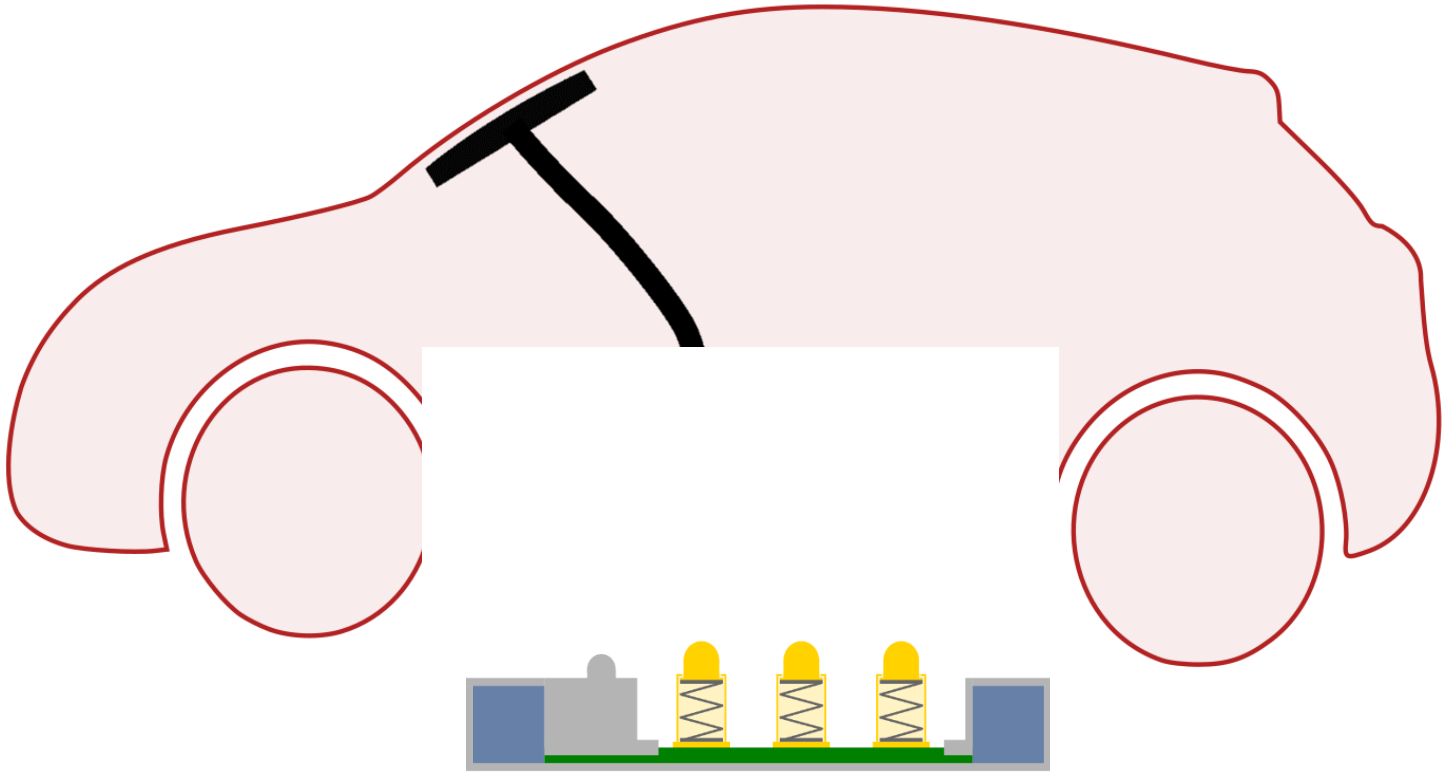

File Edit View Rendermode Preferences Help Debug
Cross
Hexa
Triangle
Moon
Arrow
Square
Circle
Heart
Star
Parallel
Shape Size
Medium
UP
LEFT
FRONT
Workplane
Blu.stl vertices: 45716 faces: 91424 voxelization time: 0.72521 s


ORIGINAL PRUS


Please memorize the following terms
Person
Woman
Man
Camera
TV
NEXT
MoCA


Tangible Bits: Towards Seamless Interfaces
between People, Bits and Atoms

Oh Snap! -- *Self-Contained* 3D-printed objects

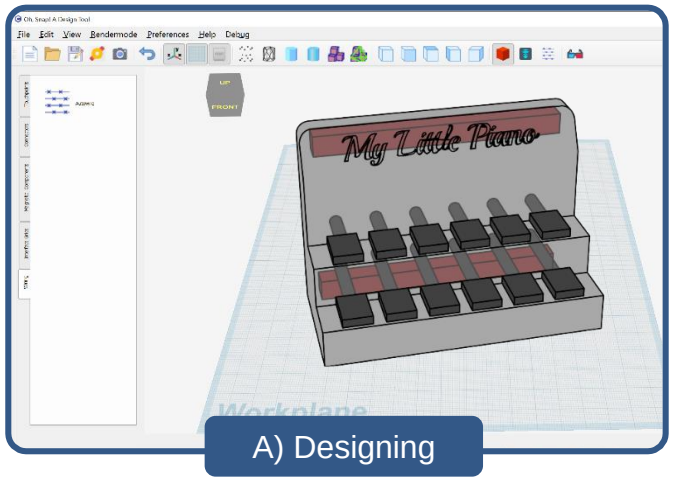


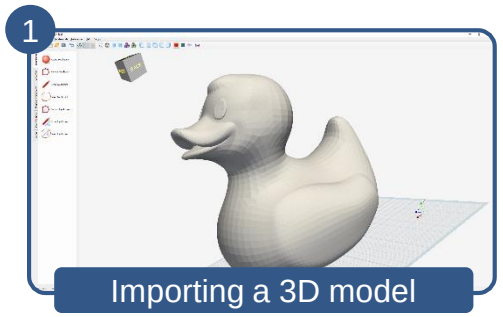
Printed Sensor

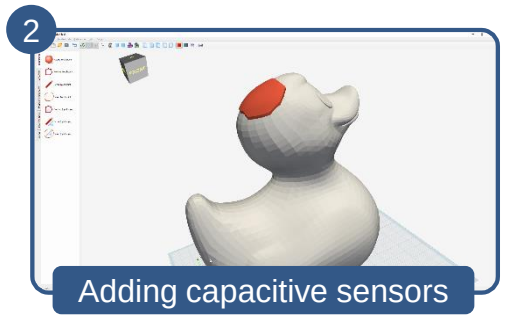
3D-Printed Por

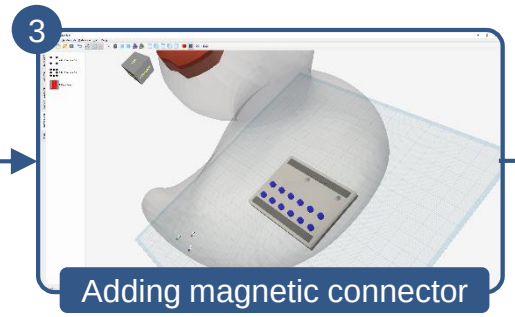
Magnetic Board

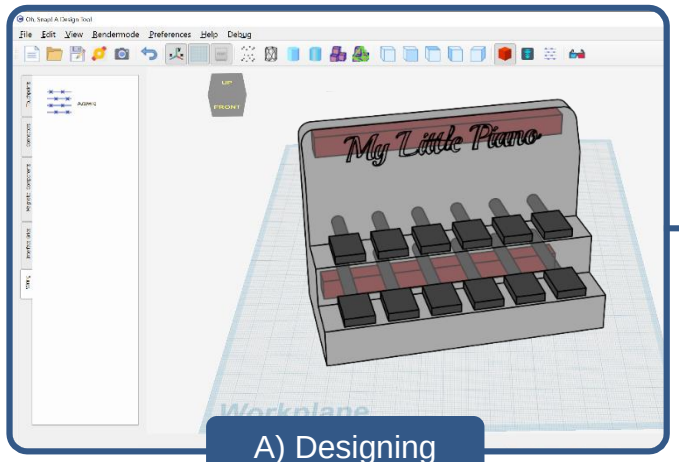
Process for Step A: Design



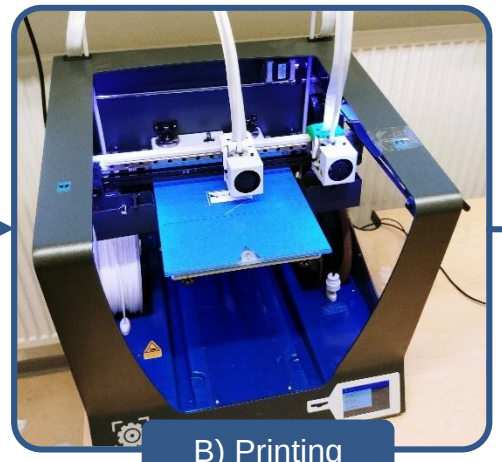








A) Designing



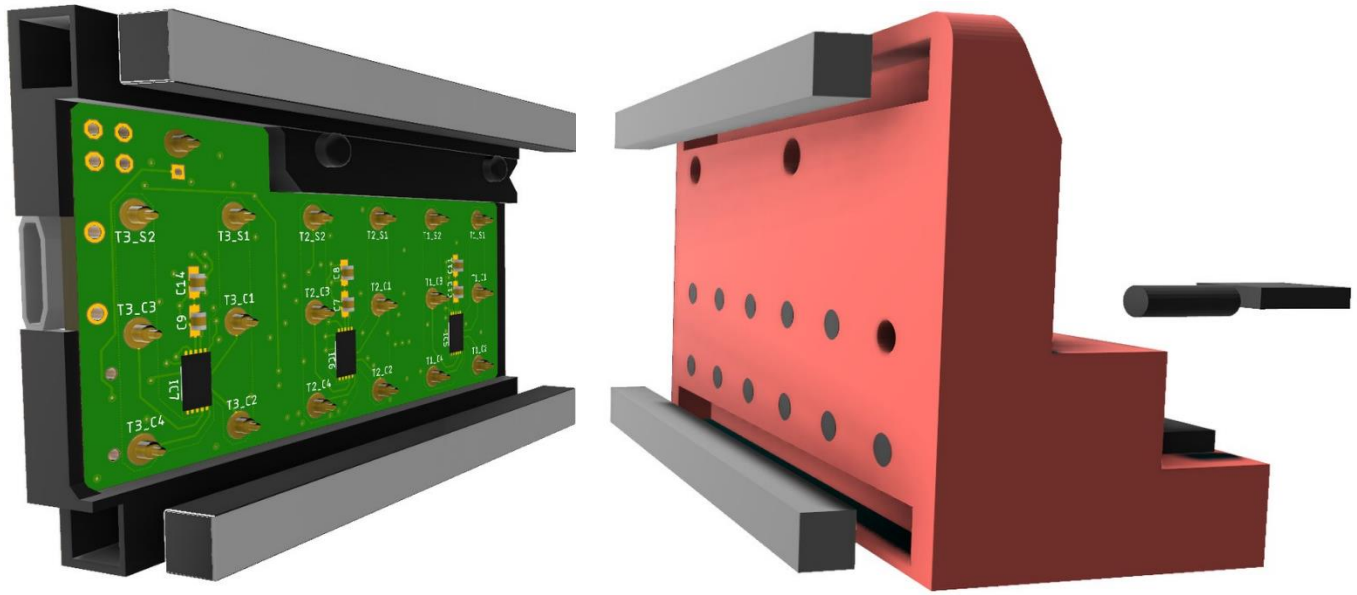
B) Printing

Printed Object with Magnetic Interface

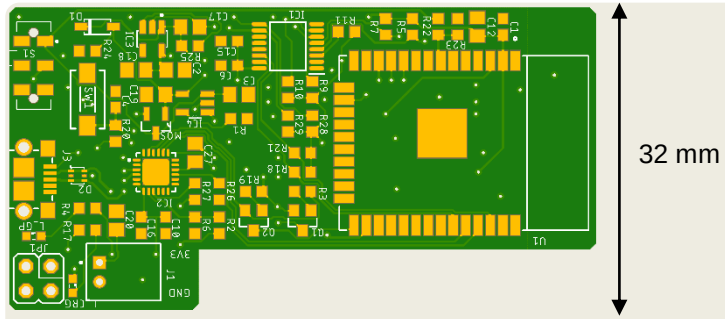
Oh Snap Board

C) Snapping

D) Interacting



- 12 sensing channels
- WiFi & BLE
- Battery on board
- WebSocket & MQTT



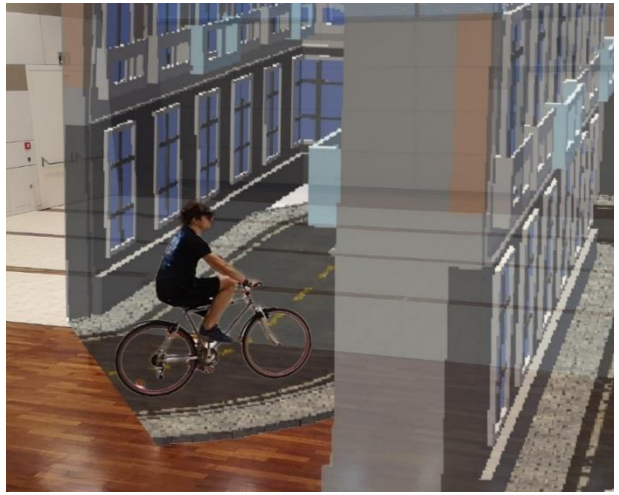
Credit Card (86 x 54 mm)

Applied Research: Sustainable-Mobility HCI

- Sustainable mobility is very dangerous
  - Large safety gap: cars ↔ sustainable individual mobility (bike, eScooter …)

- Research challenge: digital assistance → HCI in the wild

Cyclists‘ Assistance Systems



Training & Evaluation Methods

Autonomous Cycling ☺

1 https://commons.wikimedia.org/wiki/File:Berlin_ghostbike.jpg (license free, Bukk)
2 https://pixabay.com/photos/augmented-reality-bicycle-girl-bike-1853592 (Pixabay license, Pexels)

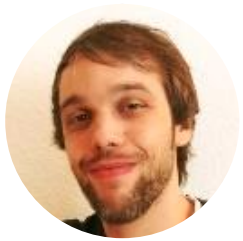
Summary

- **Usable sustainability** informatics is *the* enabling technology → consider HCI!
  - Remember usable security: took *decades* to get recognized as key enabler
- HCI has „departed from“ behind-glass interaction …
  - … and embarked on **immersive** interaction: AR, VR → **cyber-physical** interaction
  - Challenge: interaction in the wild / on the go
  - Challenge: integration with physical world
    - E.g., with the help of 3D printing: custom-fabricated objects
- SWO**T** Threat: timeframe for acceptable devices
- SW**O**T Opportunity: key element of digitization in industry & life

Credit Goes to TK Lab's HCI group

- … postdocs,


Jan Riemann


Martin Schmitz


Andrii Matviienko


Thomas Kosch

- current PhD researchers,


Dominik Schön

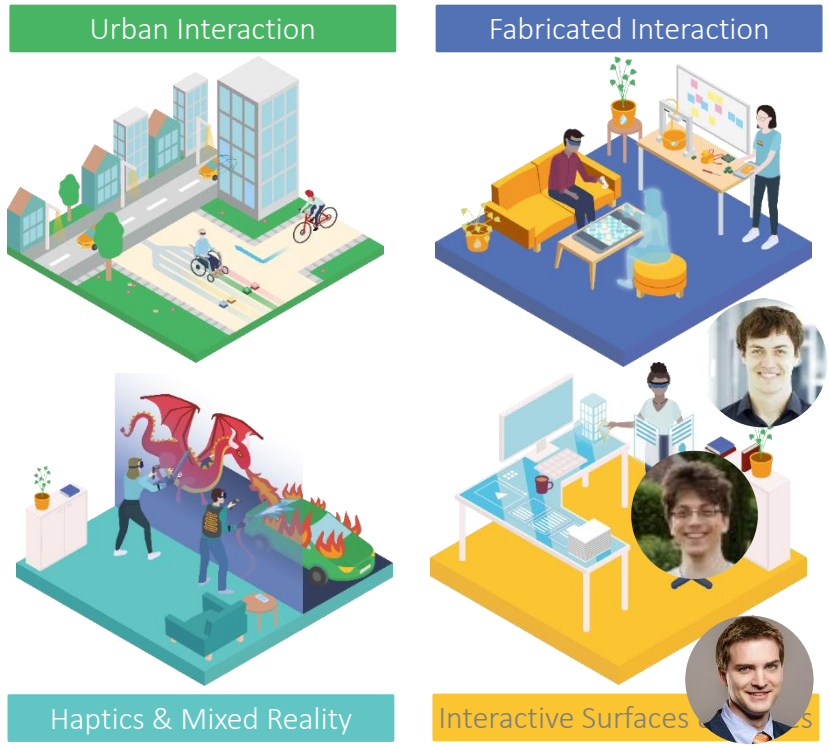

Sebastian Günther


Hesham Elsayed


Julius von Willich

- former postdocs and researchers, including …

Dr. Florian Müller Dr. Markus Funk Dr. Niloo Dezfuli Dr. Mo Khalilbeigi
Dr. Karola Marky Prof. Dr. Jürgen Steimle Prof. Dr. Jochen Huber



our collaborators from around the world,

and many excellent Master's students

The End

Thank you for listing!

Questions?