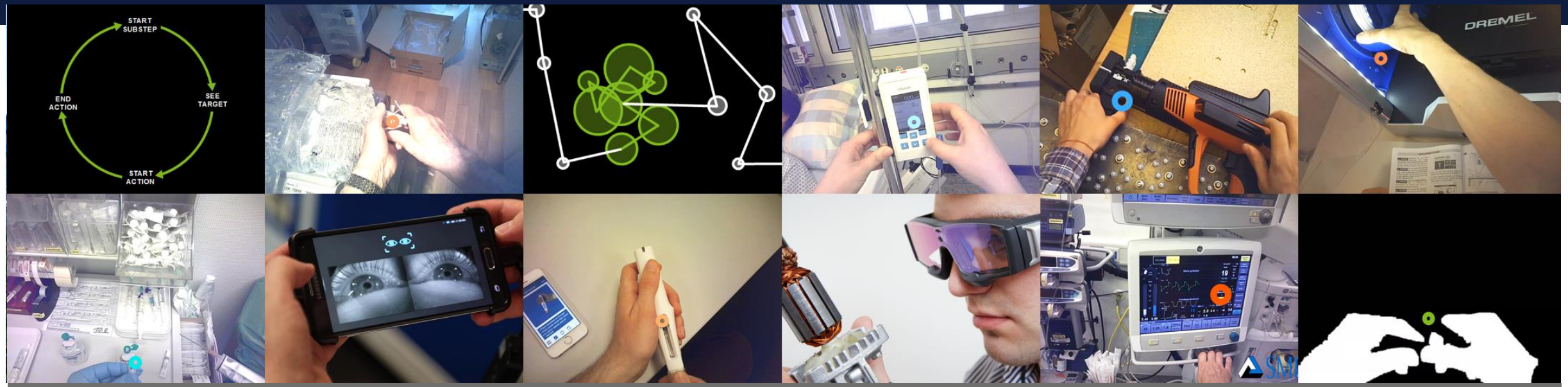


Eye Tracking – the Key to Computational Understanding of Human Behavior and Cognition

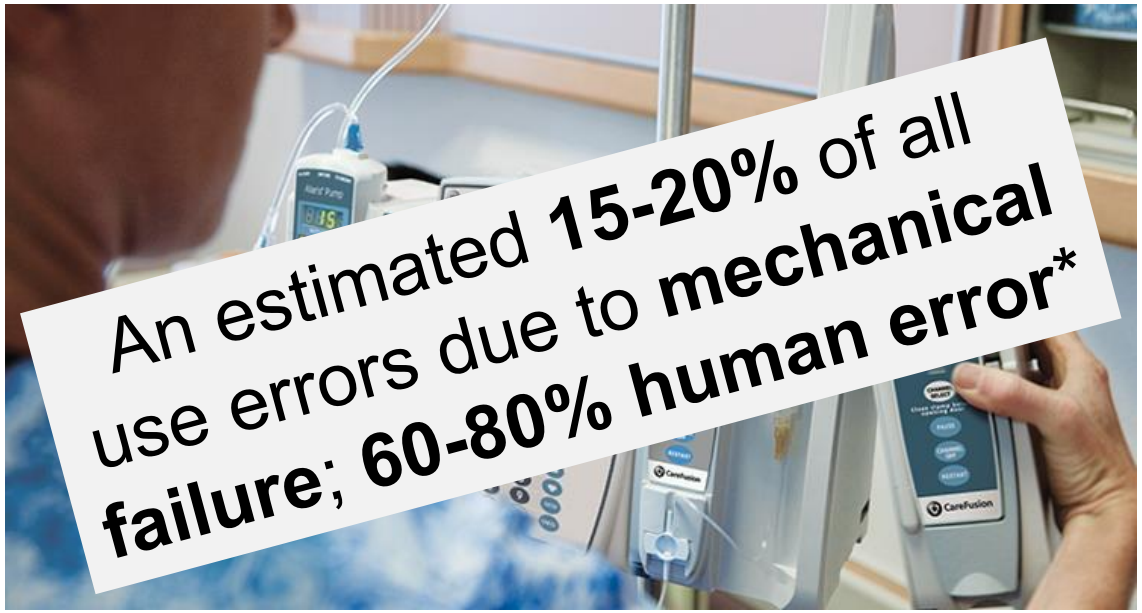
Prof. Dr. Mirko Meboldt

Dr. Quentin Lohmeyer, Stephan Hess, Julian Wolf, Felix Wang, Kerrin Weiss

“A user interface is like a Joke.
If you have to explain is, it’s not that good” Martin LeBlanc

Consumer products

Safety related products



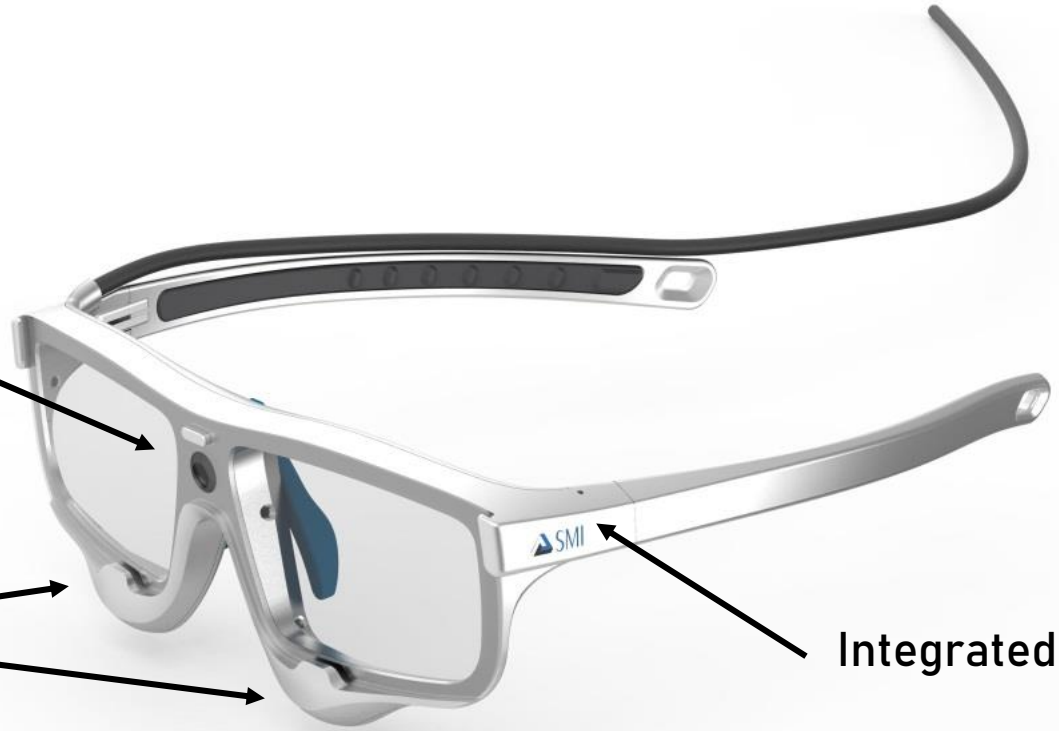
Our research goal:

Algorithms for data driven usability and expertise assessment!

*Institute of Medicine Report

Eye Tracking Glasses

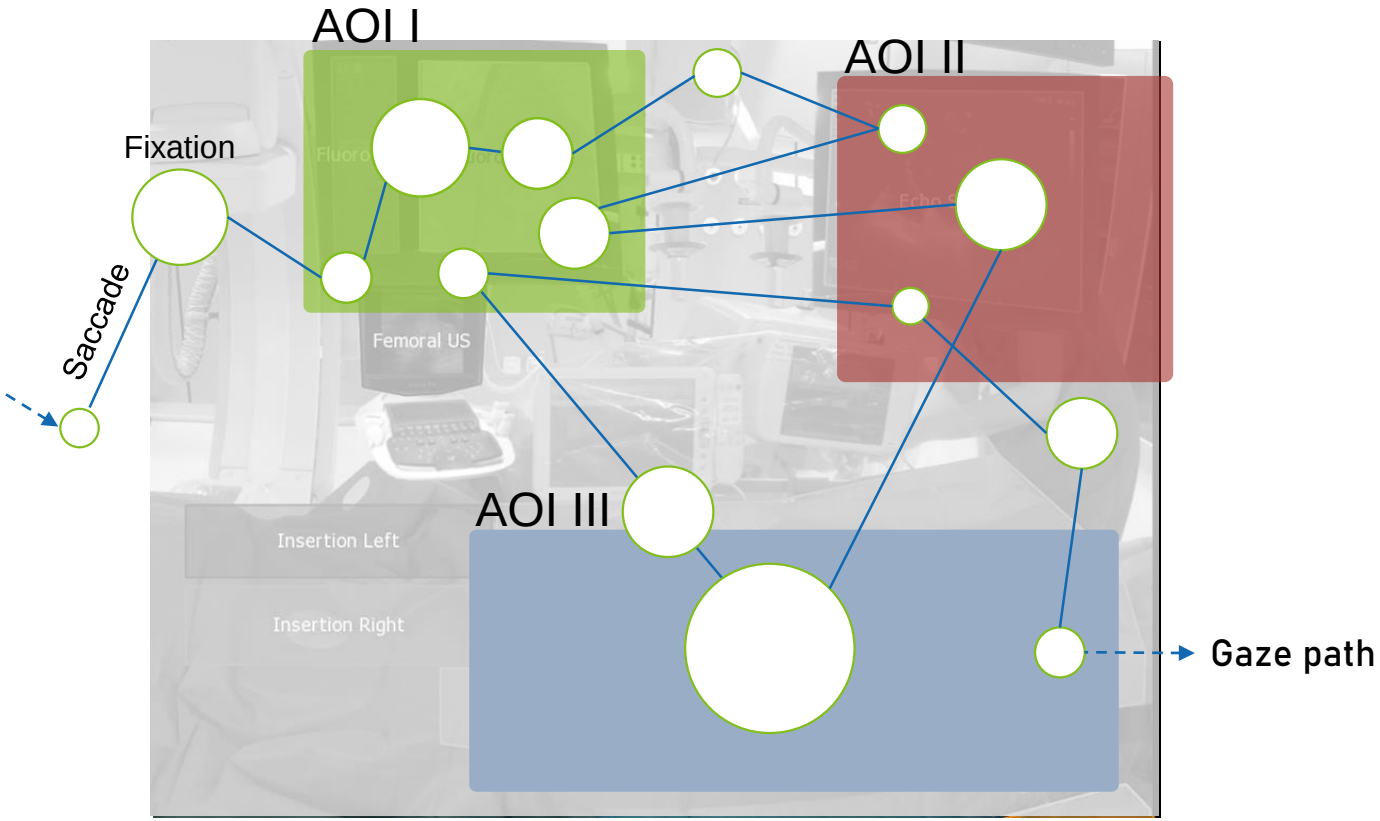
Scene Camera
Resolution
1280x960px @24 fps

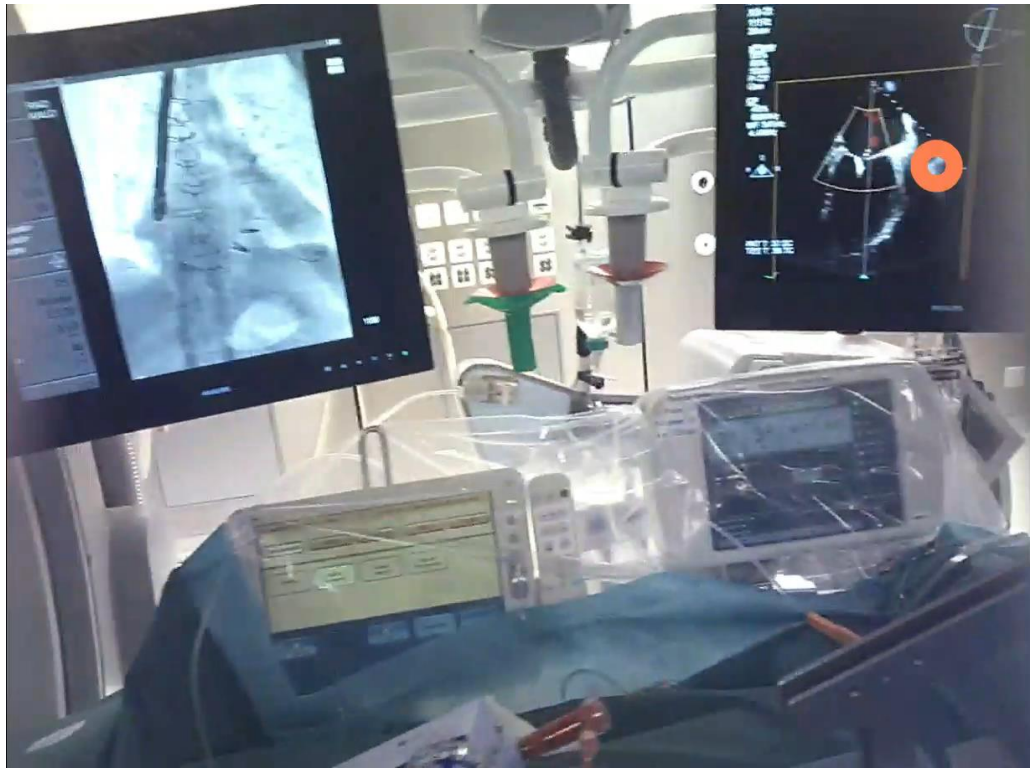


Gaze Tracking
Sampling Rate: 60Hz
Accuracy: 0.5°

Integrated **Microphone**

Eye Tracking Analysis – Short Introduction.

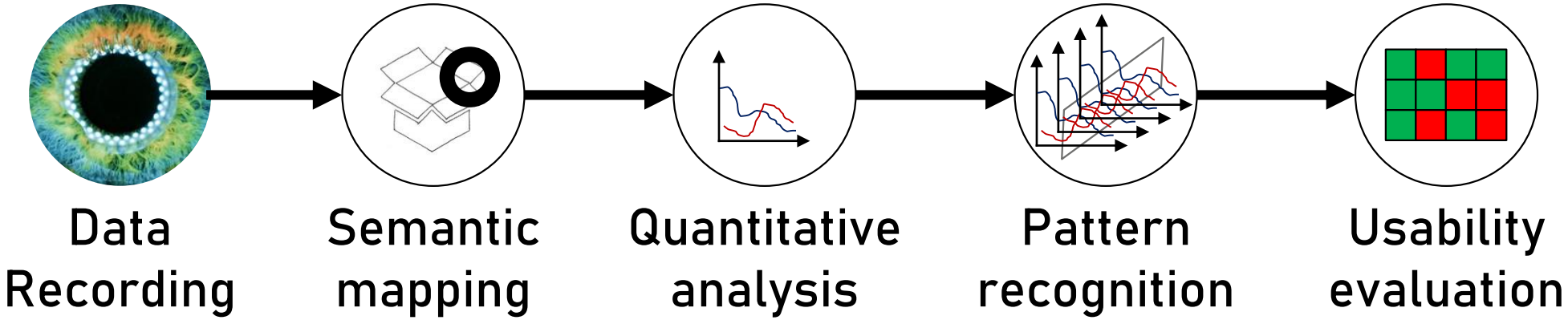




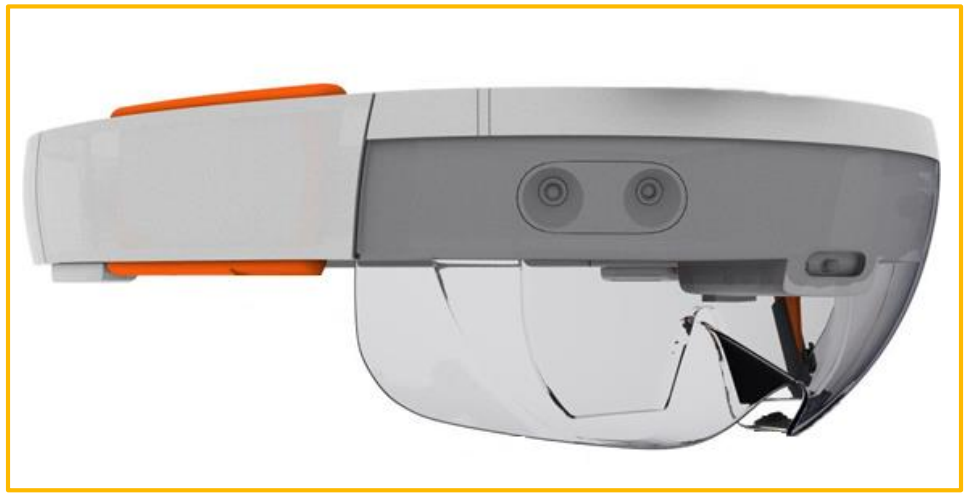
Fixation: The eye is relatively still and extracts visual information.

Saccade Fast movement of the eye between two fixations, without extracting information.

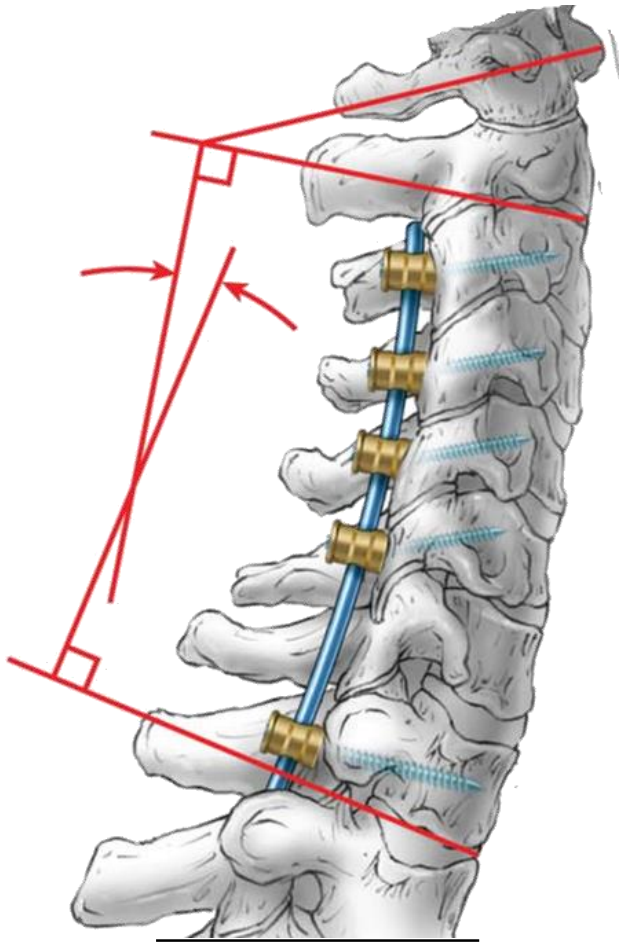
Workflow of Usability Testing with Eye Tracking

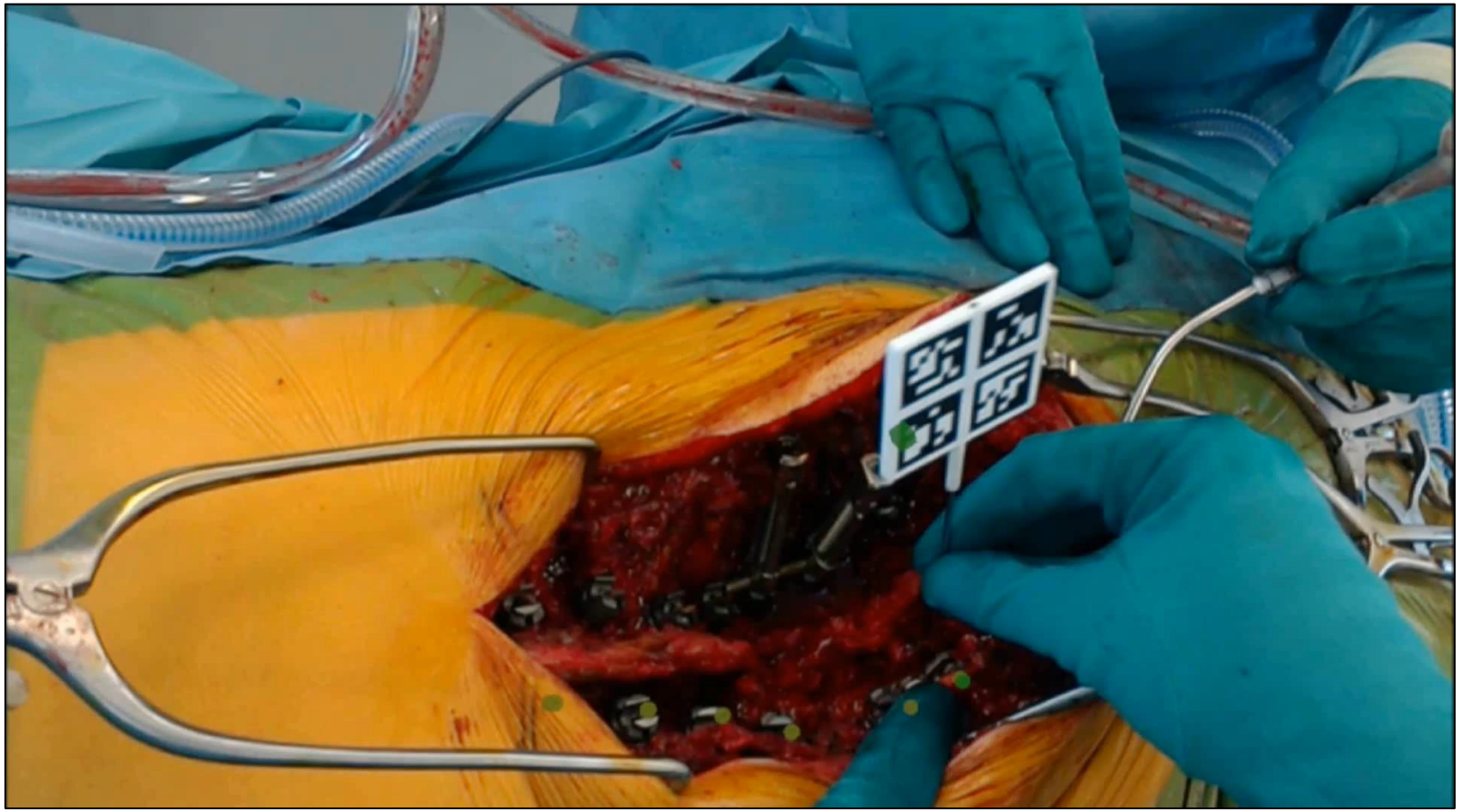


HMZ Flagship Project "*SURGENT*"



Rod Bending in Spinal Fusion Surgery





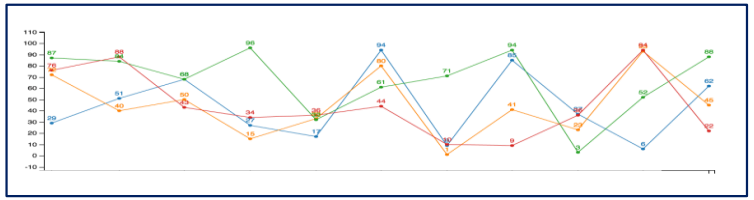
Balgrist CARD-Team, Prof. Mazda Farshad

What is the Essence of Good Support in Surgery?

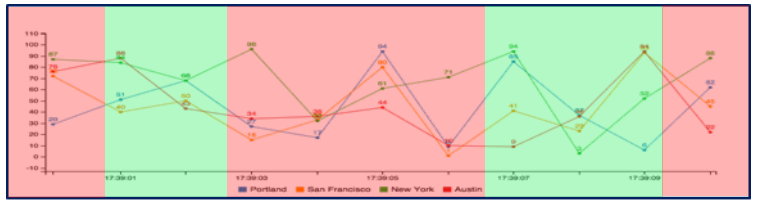
Observing the operator, **understanding** his actions and **anticipating** his next move.

How Can We Successfully Integrate Support Technology?

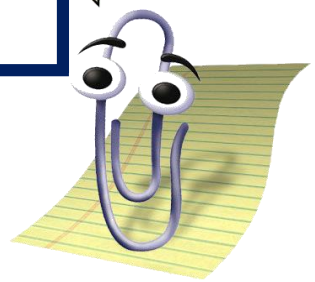
1. Data Recording



2. Evaluate Data



Hi there,
how can I help you?



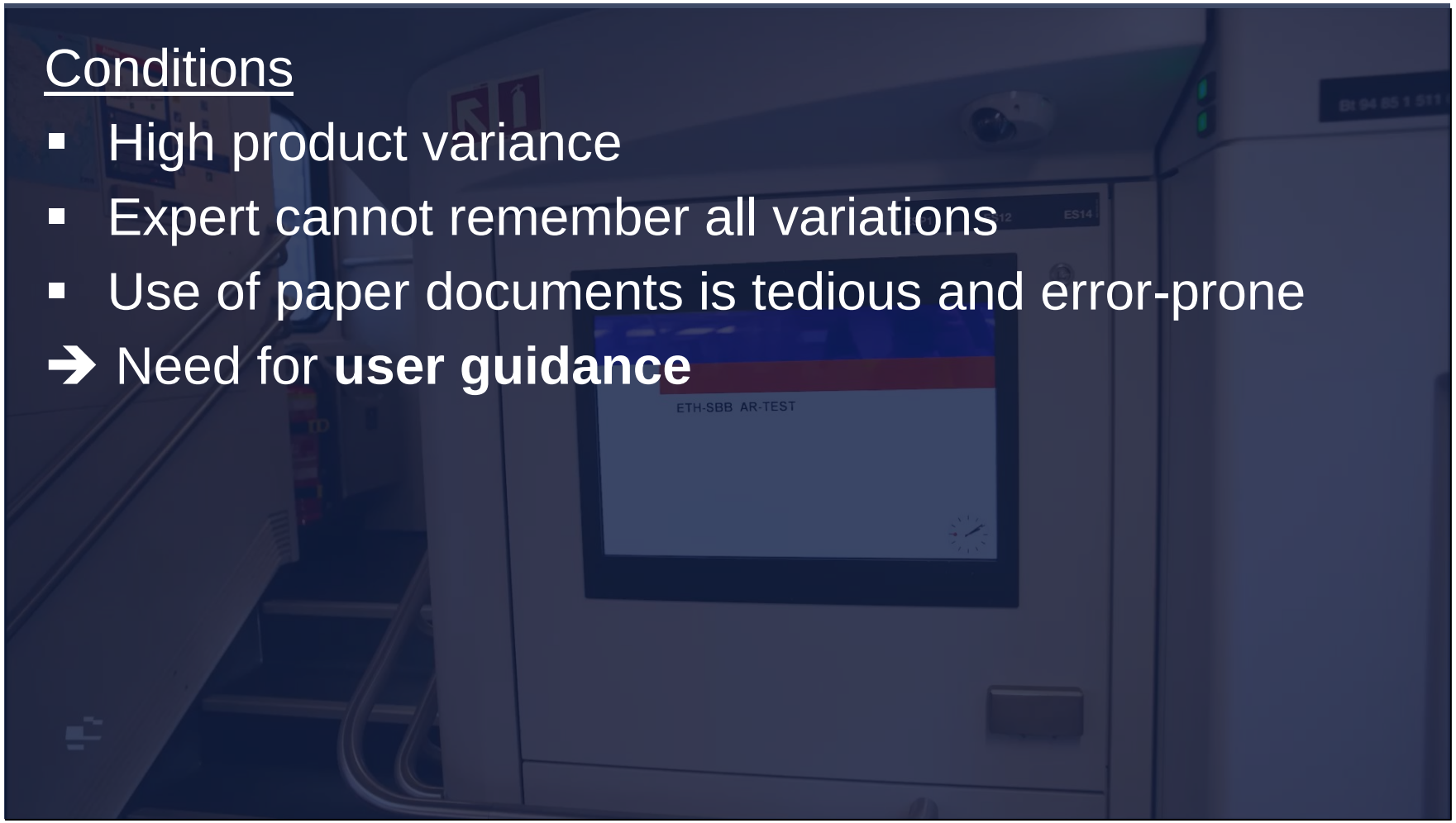
3. Closed Loop

Real-time support during the procedure

- Situation-specific
- Skill-dependent

Predict errors before they happen

Maintenance of Emergency Brake System

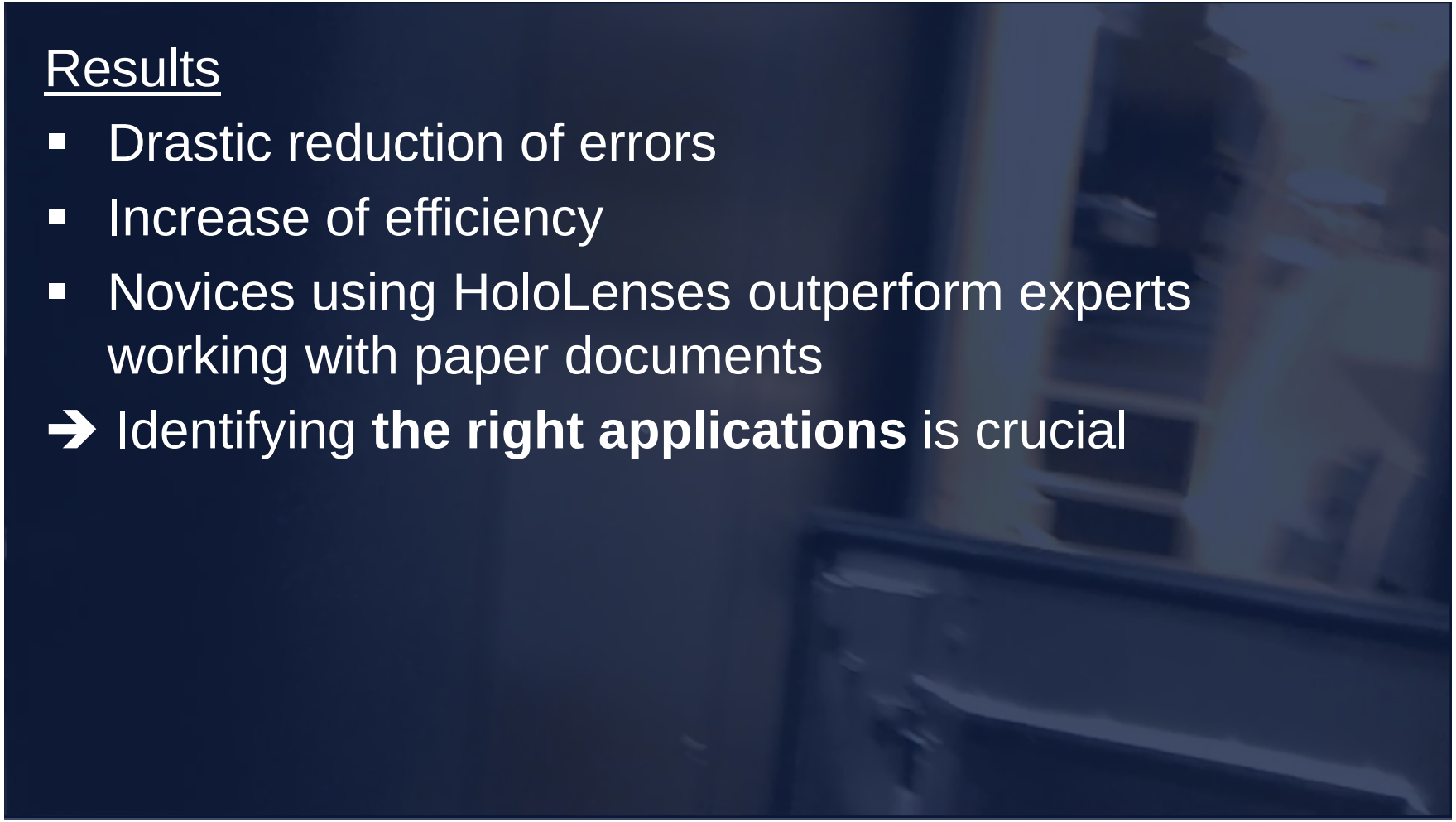


Conditions

- High product variance
- Expert cannot remember all variations
- Use of paper documents is tedious and error-prone

➔ Need for **user guidance**

AR Prototype: Maintenance of Emergency Brake System



Results

- Drastic reduction of errors
- Increase of efficiency
- Novices using HoloLenses outperform experts working with paper documents

➔ Identifying **the right applications** is crucial

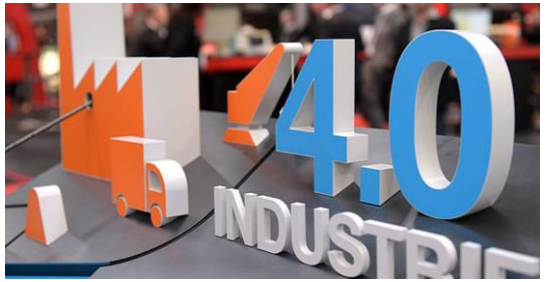
Mixed reality: Merging the real and the digital world

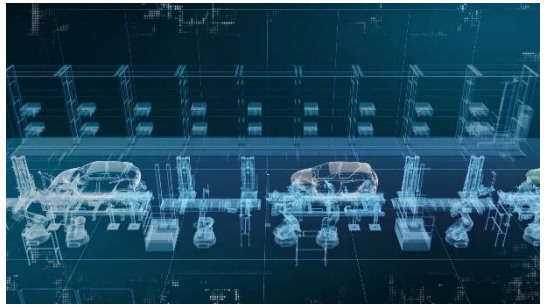
Real-World Applications

Eye Tracking

Digital World

User



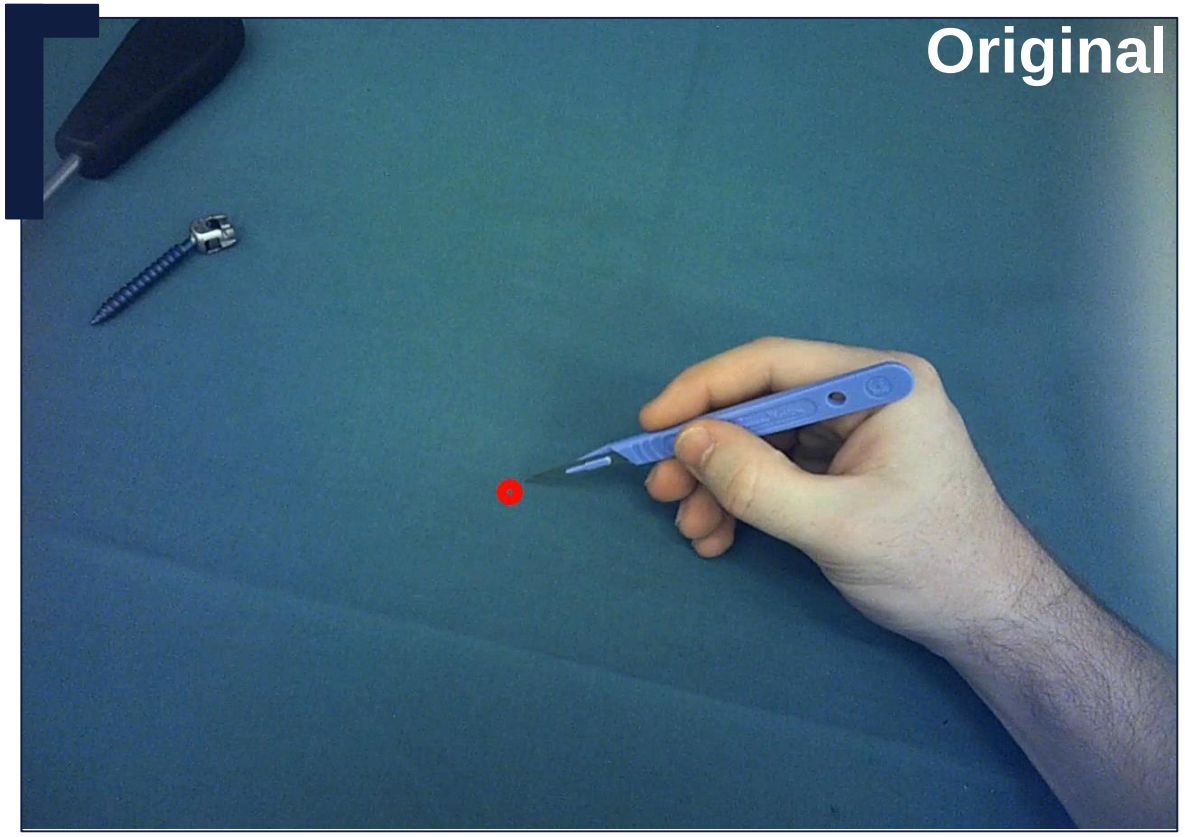


Augmented Reality

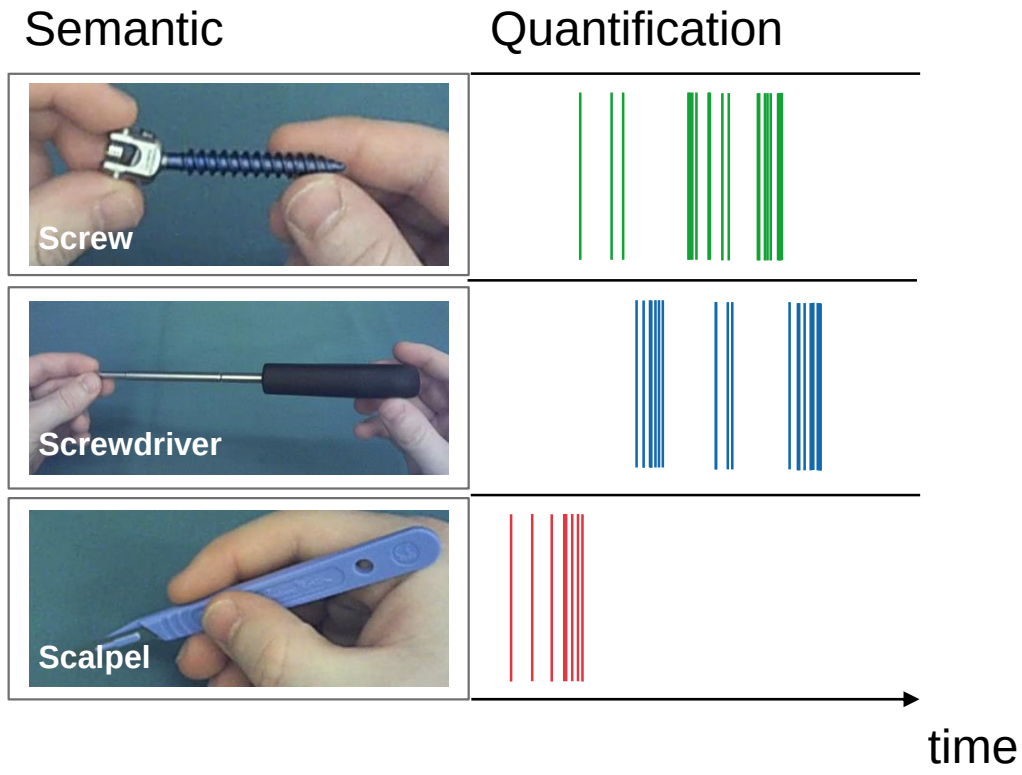
Source: stadt-zuerich.ch, fairpower.ch, bystronic.ch, sbb.ch

Source: conrad.ch, audimax.de, swisscrafting.ch, siemens.ch

Measuring Visual Patterns on Tangible Objects

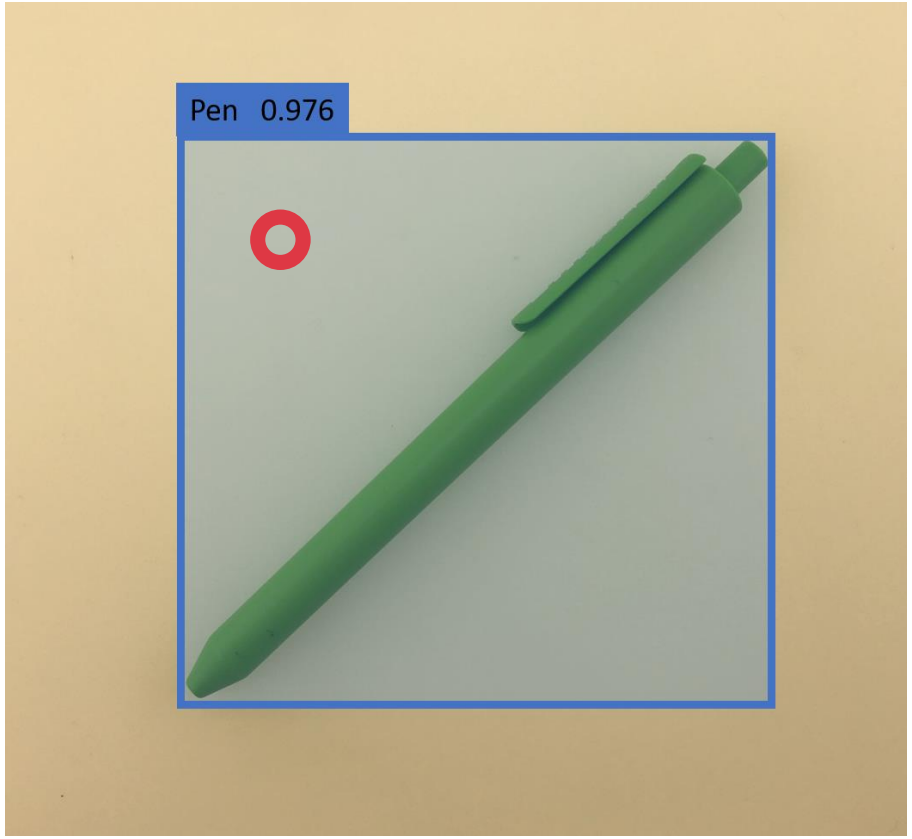


AOI (Area of Interest) sequence chart:

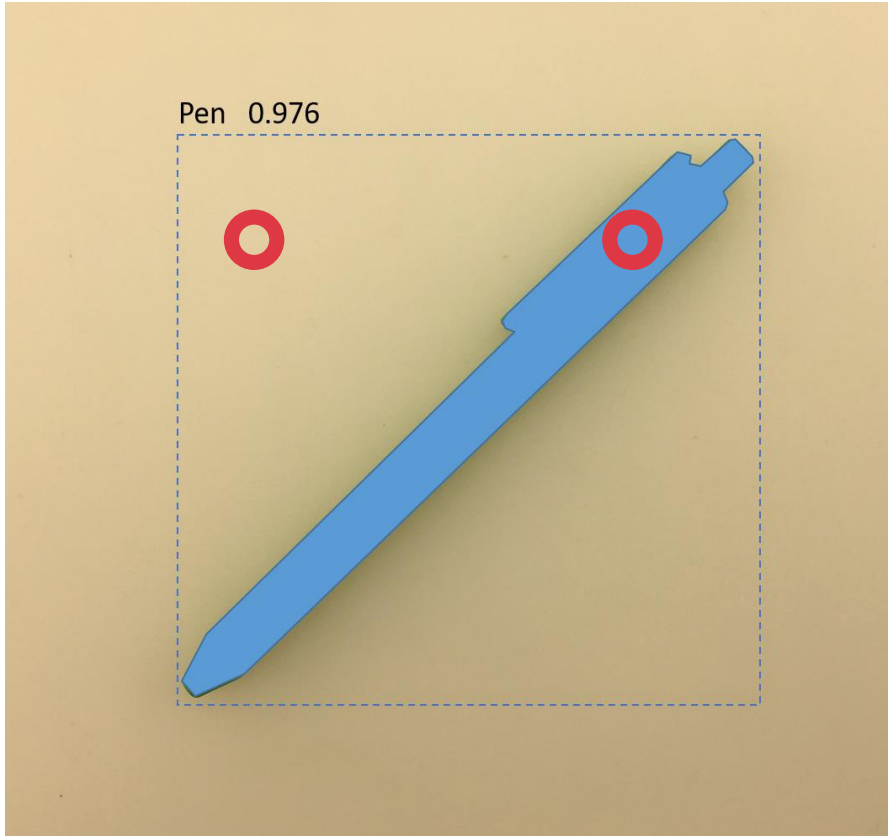


Concept for Automated Semantic Mapping of Gaze Data

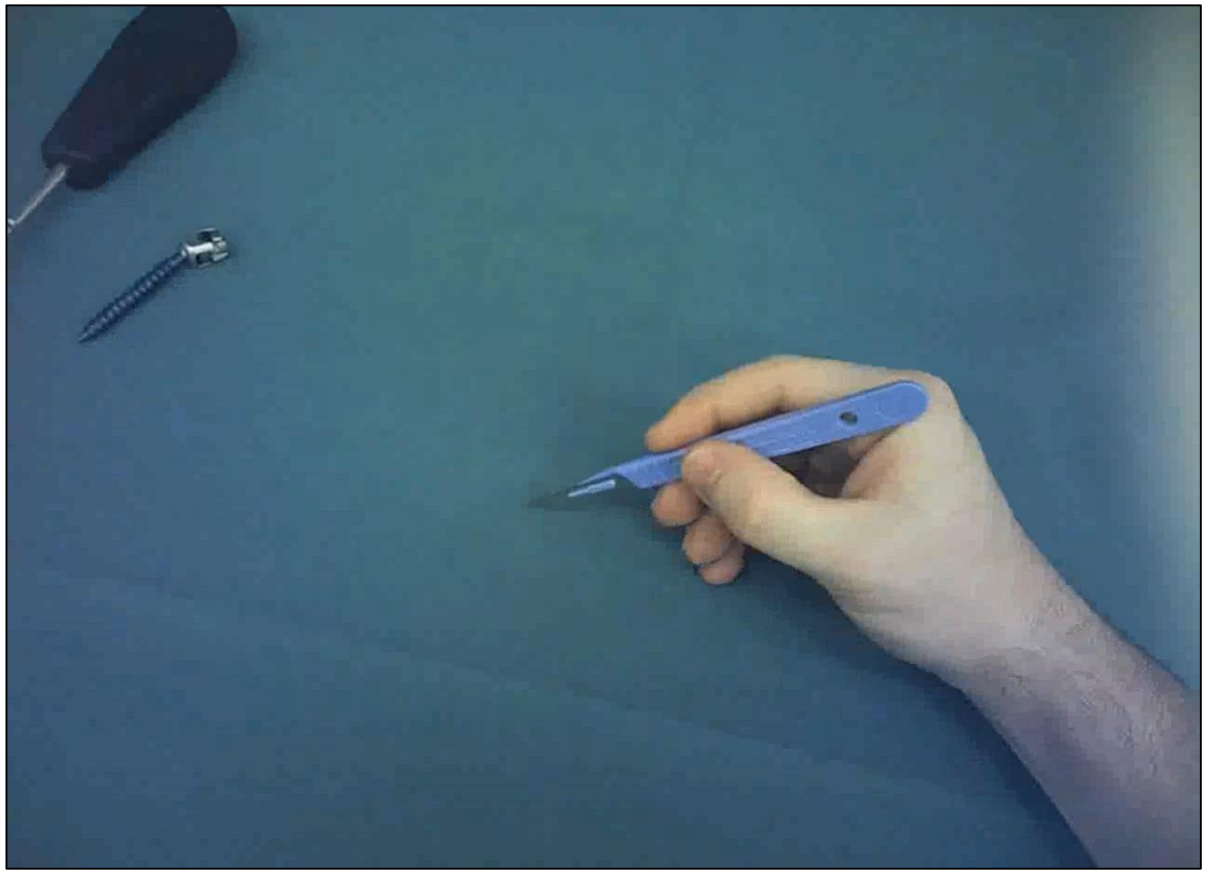
Conventional deep CNN

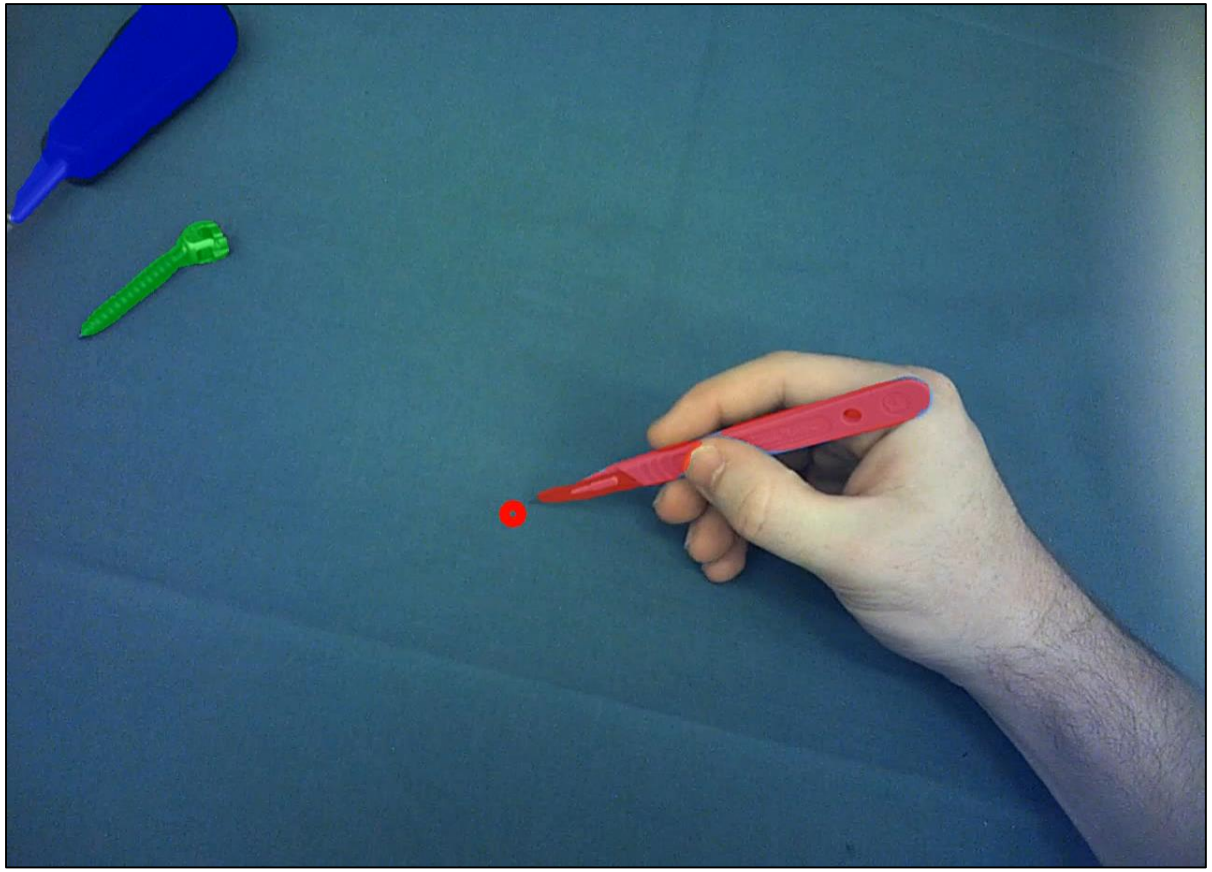


Mask R-CNN (He at al. 2017)



Automated Semantic Mapping - cGOM.





J. Wolf, S. Hess, D. Bachmann, Q. Lohmeyer, **M. Meboldt,**

Automating areas of interest analysis in mobile eye tracking experiments based on machine learning, Journal of Eye Movement Research (**2018**)

Pattern recognition for usability assessment

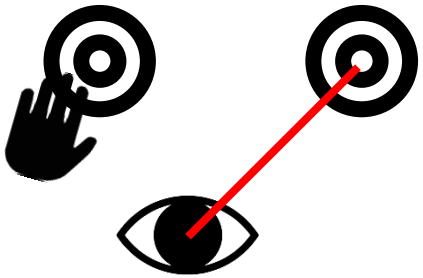
Pattern 1

Action requires
strict monitoring

hand and gaze
on the same target

Pattern 2

No monitoring
is required



attentional system looks
ahead on a different target

Algorithms to Give the Data Meaning: Hand-Gaze Distance

Long phases of **constant hand-gaze distance**
indicate problems or time-consuming / demanding tasks

Gaze point

Hand

Project: Usability Optimization of the DREMEL 3D Printer

56 participants

no training

lab environment

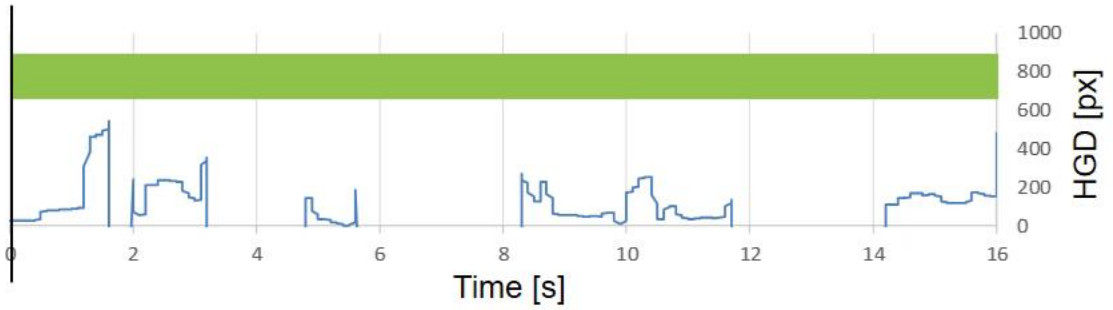
questionnaires afterwards

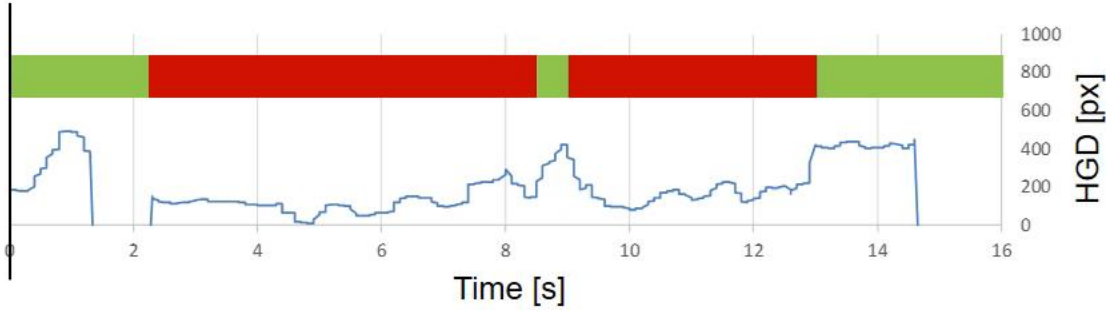
DREMEL®

We proved that we can detect 97% of the usability issues automatically by an algorithm compared to manual observation*

no problem

problem detected

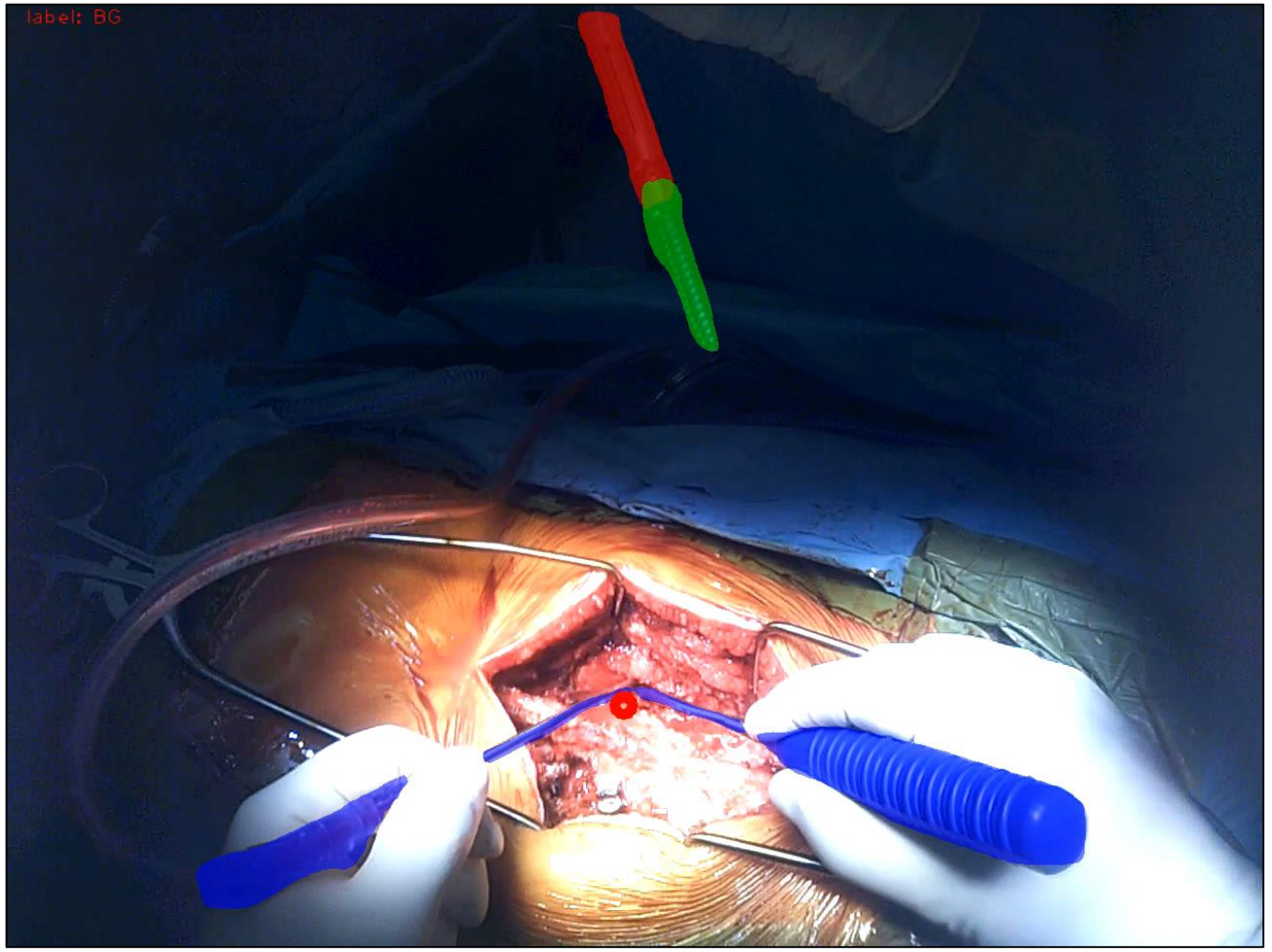




M. Mussgnug, D. Singer, Q. Lohmeyer, **M. Meboldt,** *Automated interpretation of eye–hand coordination in mobile eye tracking recordings.* Künstliche Intelligenz (**2017**) 337

HGD = Hand-Gaze Distance

Object Segmentation in a Surgical Procedure

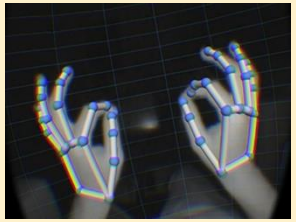


Microsoft Hololens 2

Input Channels

Camera /
Depth Camera

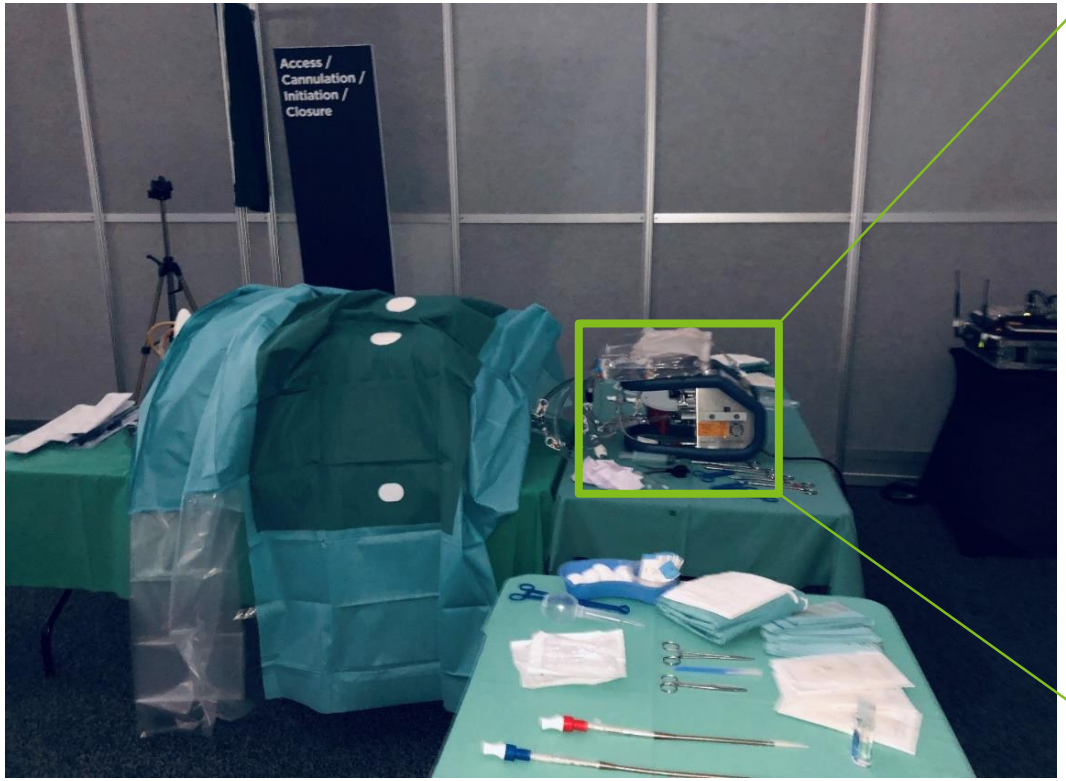
Eye Tracking

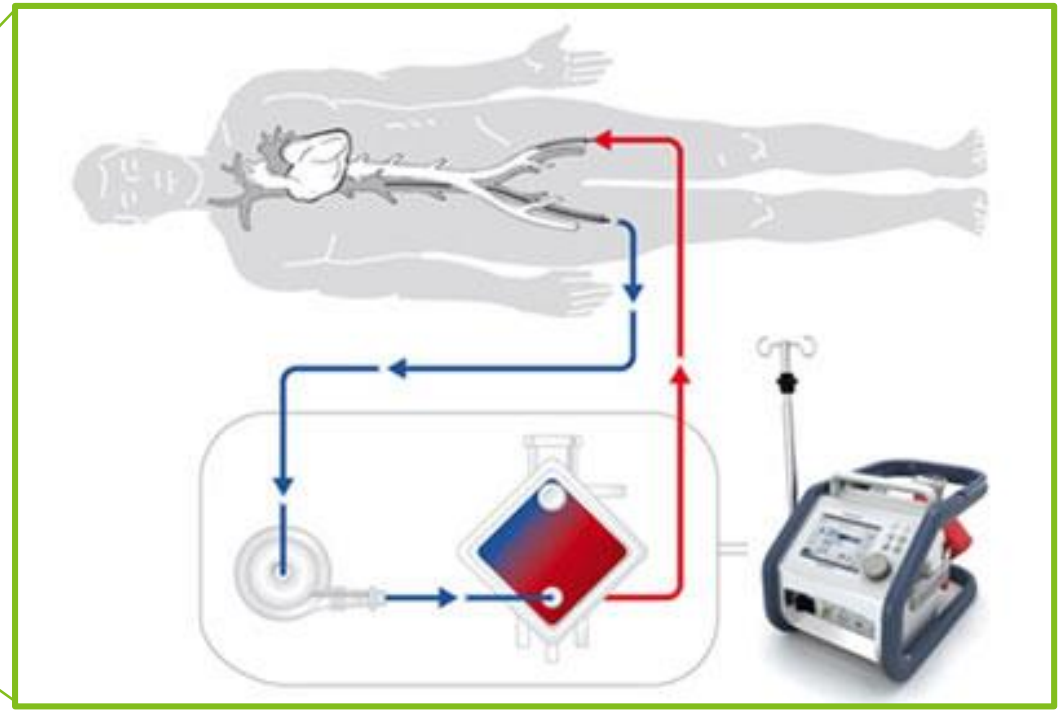


Hand Tracking

Full of sensors that can **measure human behavior** to **display appropriate information**

ECMO - Extracorporeal membrane oxygenation

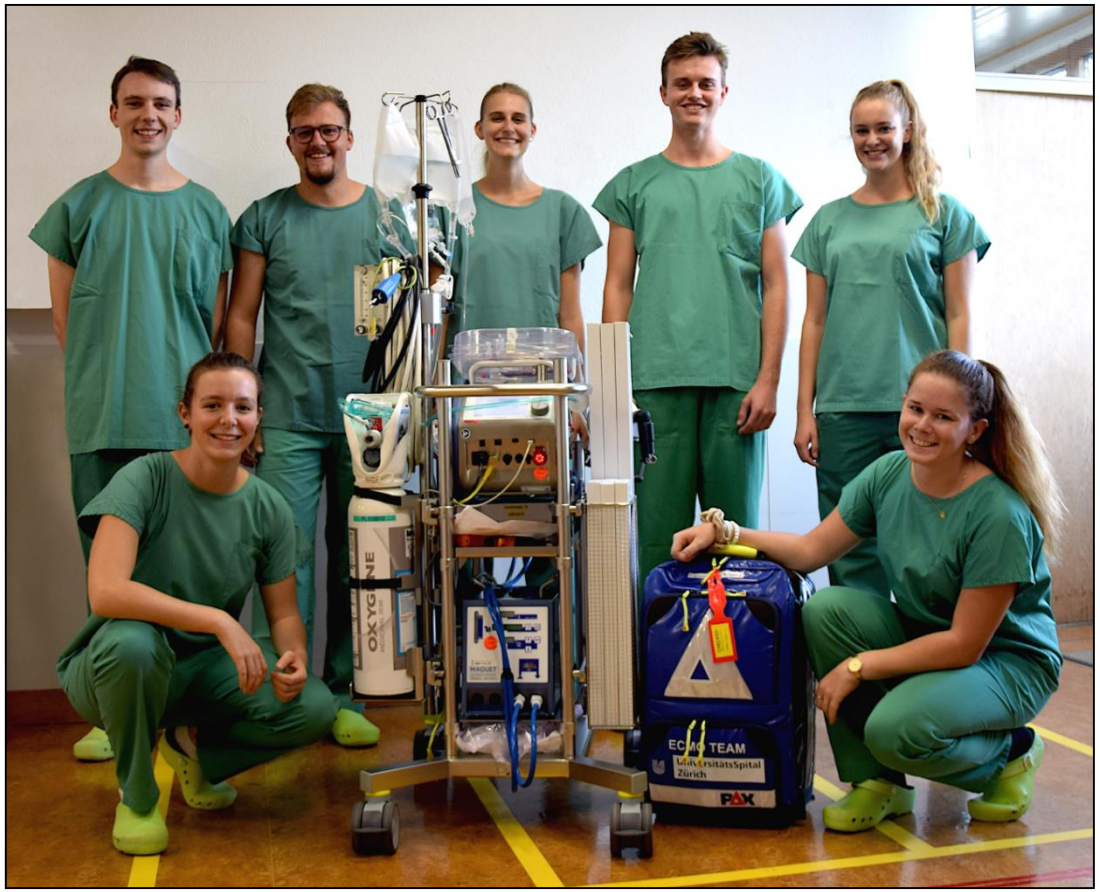




ECMO can greatly **increase survival rate** but is **challenging** to use properly due to the **complexity of the human body**.

Development of ECMO AR user guidance with HoloLens

Team ARORA

Goal: Simplifying the use of ECMO, **increasing patient safety**

- Implement **user manual** and **decision tree** for trouble shooting
- Constantly **read patient parameters**
- Implement **context-aware user guidance**