

# Augmented Reality - Towards a New Generation of User Support System in Maintenance Operation (IARMO)

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# Paper Instructions and Documentation



From SBB



From SBB

# Augmented Reality-based User Guidance

«Right information at the right place and time.»

- ✓ Significantly reduced errors
  - ✓ Reduced task completion time
  - ? Simplified documentation
  - ? User acceptance
  - ? Enabling employees
- } [1,2]



[1] J. Blattgerste et al. Comparing conventional and augmented reality instructions for manual assembly tasks. In Proceedings of the 10th international conference on pervasive technologies related to assistive environments, pp. 75–82, 2017.

[2] M. Hoover et al. Measuring the performance impact of using the microsoft hololens 1 to provide guided assembly work instructions. Journal of Computing and Information Science in Engineering, 20(6), 2020.

# Clutch Inspection and Repair at SBB facilities

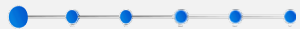


# Project IARMO - Overview

## WP1: Knowledge Transfer with Augmented Reality (AR)

### Processes

Digital Checklists  
(Preventive Maintenance)



Decision Trees  
(Curative Maintenance)



### Devices



Realwear HMT-1



Microsoft HoloLens 2

## WP2: Process Monitoring

- Real-time analysis of operators' actions based on hand tracking and smartwatch IMU



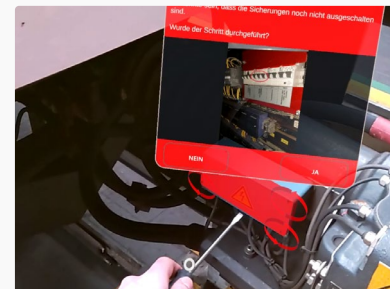
Smartwatch IMU



Hand tracking

## WP3: Context-Aware AR Support | 2023

- Real-time feedback for expected mistakes




# WP1: AR user guidance & knowledge transfer


**RQ1:** What is the **preferred instruction type** among paper documents, a monocular display, and a sophisticated AR head-mounted display?

**RQ2:** How effective is AR in guiding inexperienced technicians through clutch failure diagnosis?

## User Study 1

 preemptive clutch checkup


 digital checklist

 technicians (n=6)  
1/3 of task per instruction type

## User Study 2

 clutch failure diagnosis

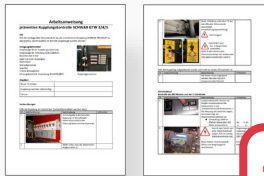
 decision tree

 expert technicians (n=2)  
Novice technicians with Hololens app (n=6)

# Results

## Study 1

Document



Usability

Preferences

4.05 / 5

2 / 6

Realwear



3.80 / 5

1.5 / 6

HoloLens 2



4.24 / 5

3.5 / 6

## Study 2

Technicians (n=6)

- 100% success rate
- positive experience: enabled for a new task
- lack in understanding of why tasks are performed

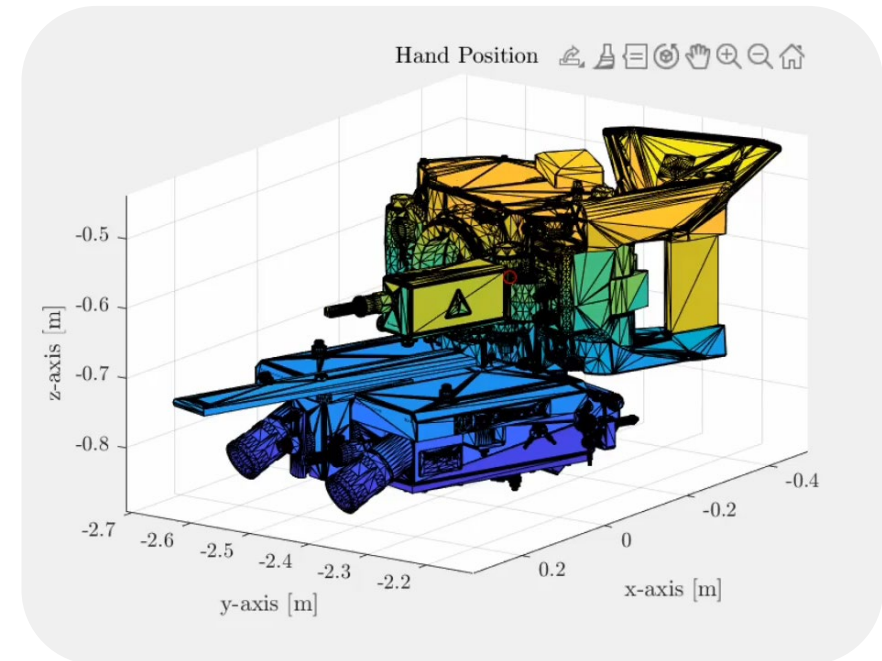
Experts

- faster
- less structured

Further insights

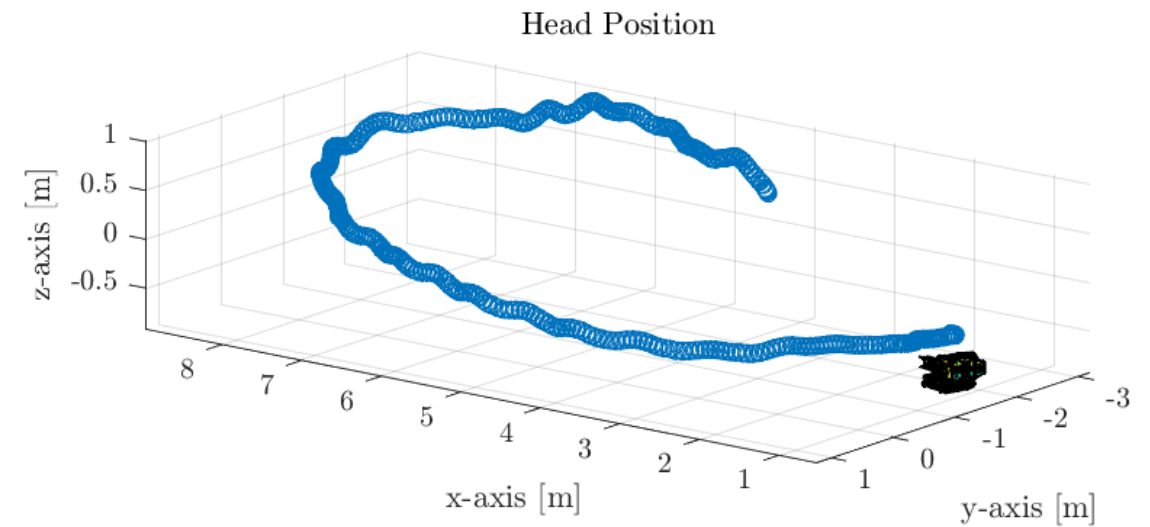
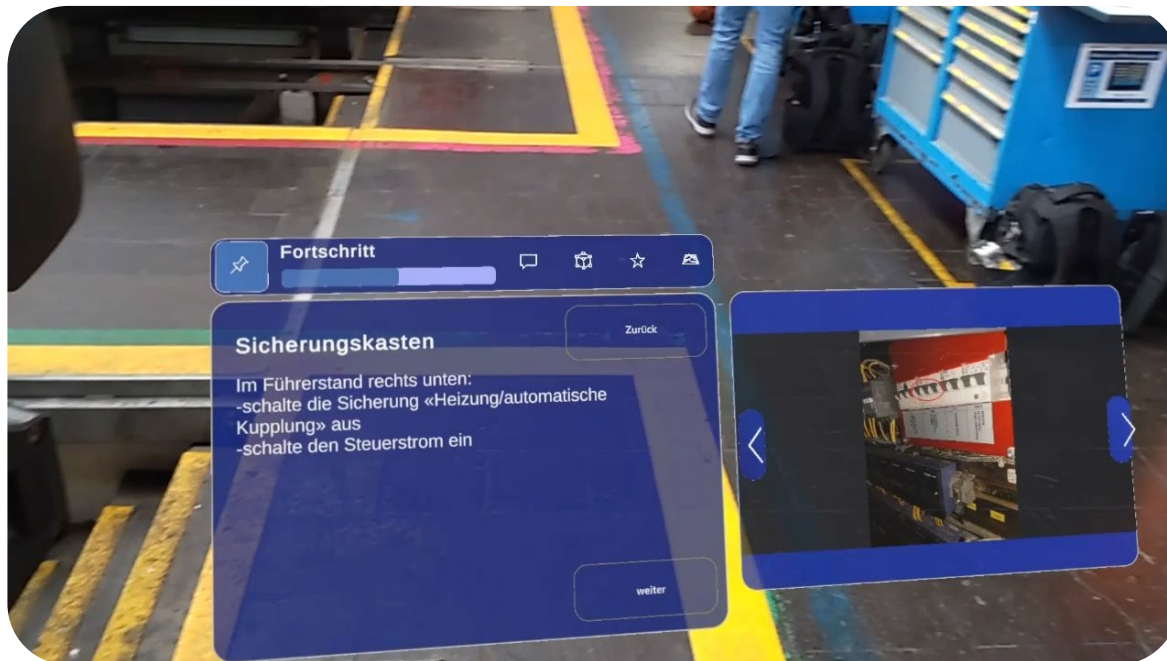
- good for standardizing the process
- small inconsistencies can fail the process
- promising for training failure diagnosis

# Eye & Hand tracking

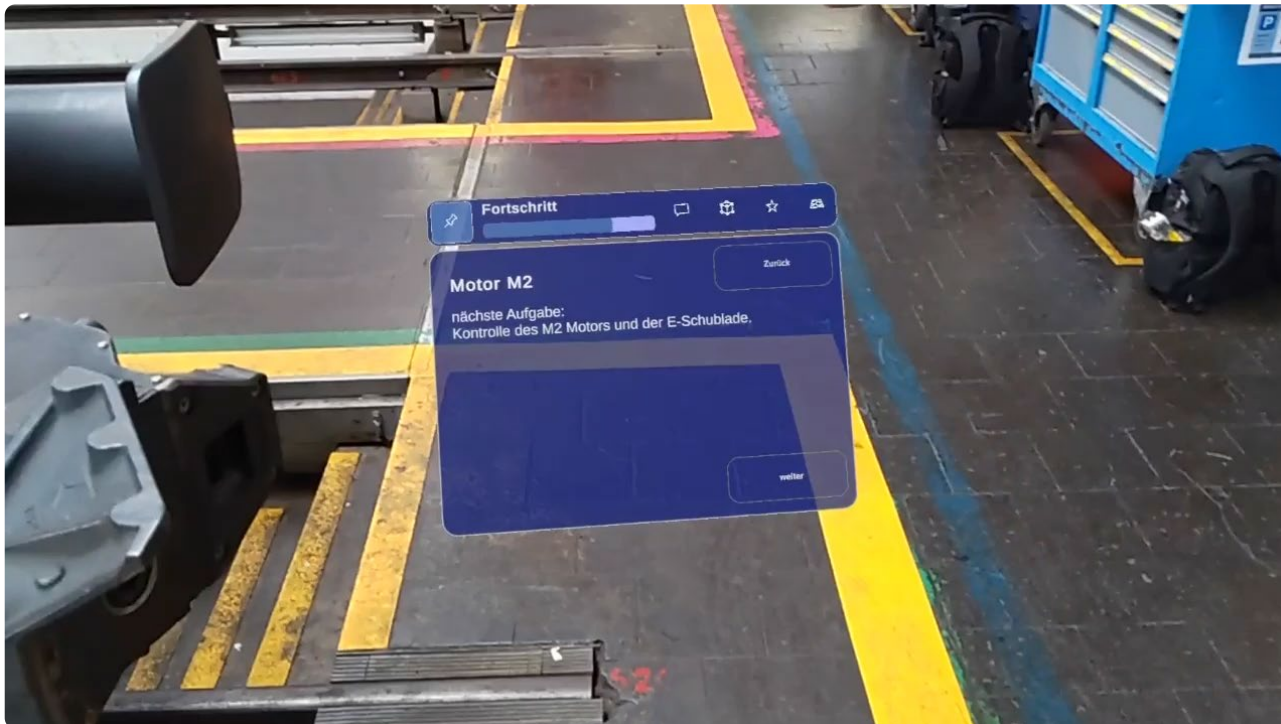




# Head tracking



# Context Awareness: Safety Warnings



## Warnung!

Es könnte sein, dass die Sicherungen noch nicht ausgeschaltet sind.

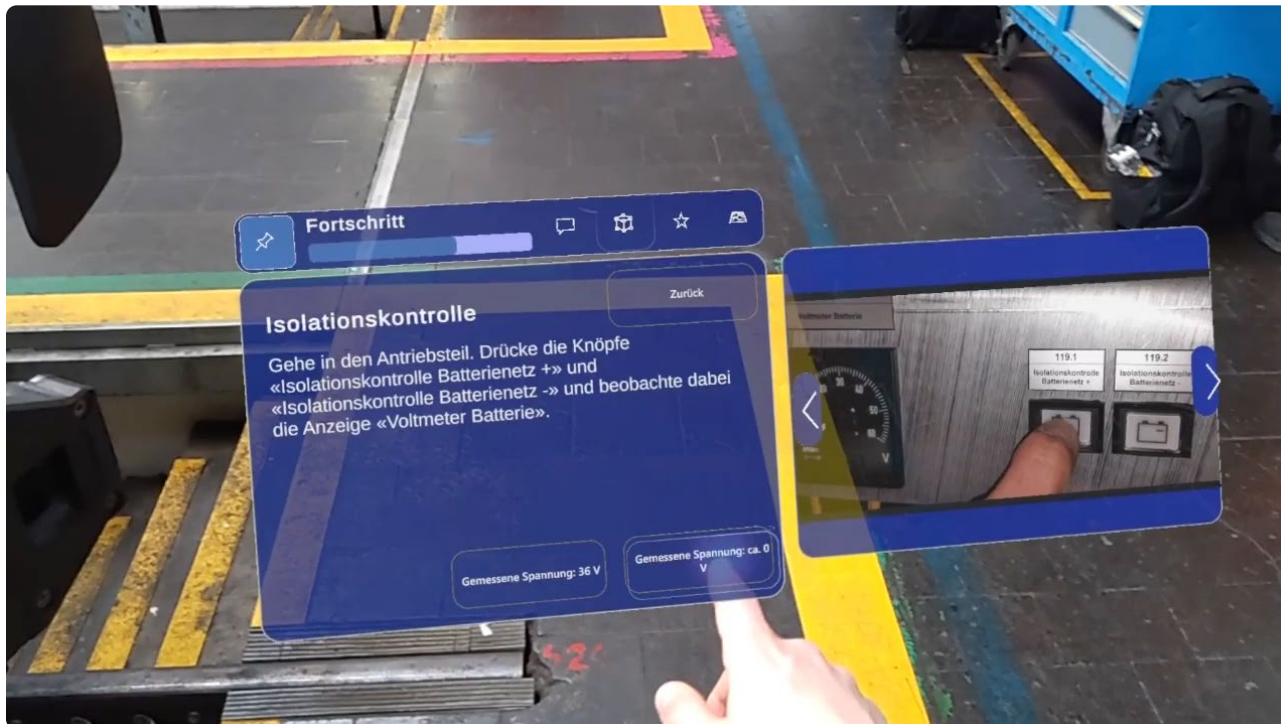
Wurde der Schritt durchgeführt?



NEIN

JA

# Context Awareness: Process Reliability Hints



## Hinweis

Es könnte sein, dass die Isolationskontrolle nicht richtig durchgeführt wurde.

Wurde der Schritt durchgeführt?



NEIN

JA

# WP3: Context-aware Augmented Reality Support

**RQ1:** How do operators **perceive real-time feedback** provided on safety- or process-critical steps?

**RQ2:** What is the **accuracy** of spatial checkboxes for step detection?

## User Study 1



Digital checklist



AR instructions (**no feedback**)



Technicians (n=13)

## User Study 2



Digital checklist



AR instructions (**with feedback**)



Technicians (n=17)

# Results

## Study 1: AR instructions (no feedback)

- Excellent usability score 89/100 (SD=7)
- 100% stated that instructions are clear, detailed and with great visuals
- 62% prefer AR over paper instructions

## Study 2: AR instructions with feedback

- 100% felt increased safety
- 80% saw a possible increase in reliability
- 18% would be bothered by false warnings
- 100% prefer AR over paper instructions

**System Accuracy = 98.2%**

# Conclusion & Outlook

## WP1

- Sophisticated AR device was preferred
- Proof-of-concept for curative maintenance task was successful

## WP3

- Today's AR devices are full of sensors for understanding human behavior
- Allows for accurate real-time feedback
- Real-time feedback significantly increases user acceptance

## Limitations & Outlook

- Test decision tree app for training diagnosis tasks
- Investigate long-term effects of working with AR with feedback
- Extend technical capabilities of feedback system

Thank you