

# Extended Reality in Ergonomics: Training with your own Avatar

6th PEROSH Research Conference

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Manchester, 09.10.2025



# Ergonomics inquiries

Use cases from all industries





# Digital technologies in use

Workplace design- and simulation



ComputerMyoGraphy



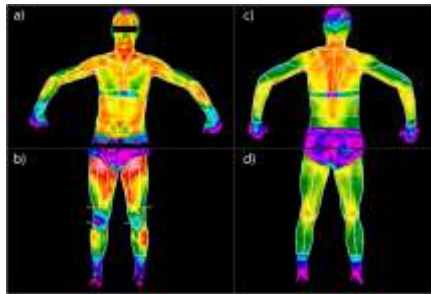
Eye Tracking



Force measuring systems



Thermography



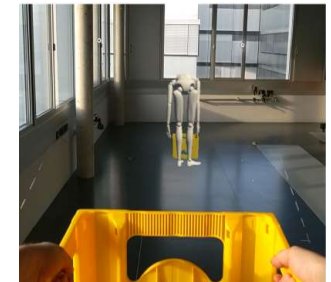
Motion capturing



Virtual Reality



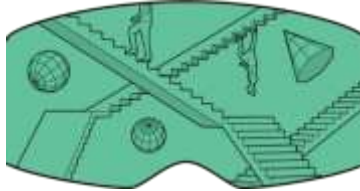
Augmented Reality





# eXtended Reality(XR)

generic term for Virtual(VR)- Augmented(AR)- and Mixed Reality(MR)



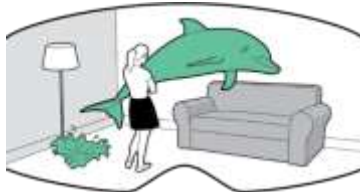
## Virtual Reality

Artificially generated environment, fully immersive, virtual reality is displayed in a Head-Mounted Display(HMD)



## Augmented Reality

Computer-assisted extension of reality perception (graphics, animations, videos, overlaid virtual objects...)



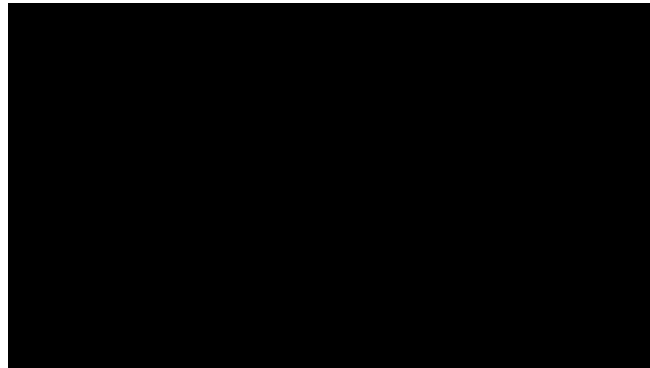
## Mixed Reality

Virtual objects are inserted into reality, or vice versa; real and virtual objects interact



# eXtended Reality(XR)

applications for occupational safety and health





# Xtended Reality in Ergonomics?



## Questions before the development of XR-applications

*How can XR be used for consulting and training (of employees) in ergonomics?*

*Which applications can be used to reach the broadest possible target audience?*

*Extended Reality for workplace design (addressee employers) is not the main focus of VeRgonomiX*

# first idea of VR-trainings in ergonomics: VeRgonomiX

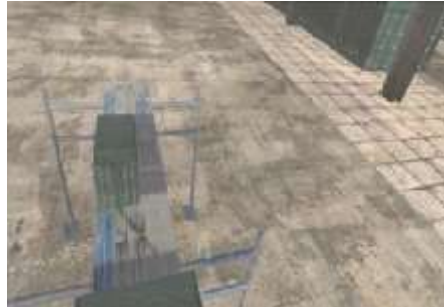


Project with institutes of Creative\Media\Technologies,  
Health Sciences  
and Center for Digital Health of University of Applied  
Sciences St.Pölten

First developments of VR-rooms:

- Training manual load handling
- Workplace design
- Prevention of slip and/or fall

Programmed to be compatible with  
Motion Capture-systems





# Training room warehouse

manual load handling – lifting boxes from shelf to pallet



<u>Kisten heben</u>	<u>Bohrer</u>	<u>Balance</u>	<u>Willkommen</u>	<u>Kisten heben</u>	<u>Abchluss</u>
<u>Alle Kisten resetten</u>		<u>Letzte Kiste resetten</u>	<u>Nächster Schritt</u>	<u>Vorheriger Schritt</u>	



**BUT**



## Problems with immersion in the Virtual Reality

Reality content?!?

No haptic, no physical feedback

Abstract interaction with environment

Body missing



# VeRgonomiX II – focus on manual load handling

integration of real objects into the VR



- Scanning a real object via 3D-lidar technology
- Defining and tracking the real physical object with HTC vive tracker
- Matching the coordinates of the scanned object with the real physical object



## VeRgonomiX II



Pre-recorded and implemented into the training-software:

Different training-relevant movements were recorded with the Rokoko Motion Capture-Suit, 19 IMUs integrated

→ Visualisation via avatar



## VeRgonomiX II – execution



- exercise: lifting a load
- individual feedback via recorded avatar
- additionally either auditory or written feedback
- repeat the exercise task at will



# ARgonomiX

Implementation of the VergonomiX-tools into the Augmented Reality(AR) during another project called **IMPACT-sXR**



Training manual load handling via AR(HoloLens)



Displaying life-sized avatars in the real world as feedback



## Introduction evaluation study

evaluation study accomplished of TU Wien - UAS St.Pölten - AUVA

Virtual & Augmented Reality-tool compared

in an Austrian supermarket(Spar) with warehouse-workers



# Methods

18 subjects: lifting a 15kg box frontal and 90° offset:

- Without assistance system and with VR
- Without assistance system and with AR

Objective movement analysis with digital aids,  
video recording and subsequent software-based evaluation

In ErgoMaps

Then subjective survey for user acceptance evaluation  
via Net Promoter Score



ErgoMaps: Copyright Foto David Kostolani

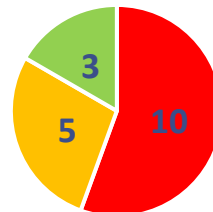


## Results – Quantitative Analysis

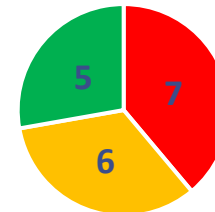
n=18

Net Promoter Score	AR	VR
Promoter (Pr)	3 / 16.67 %	5 / 27.78 %
Passive (Pa)	5 / 27.78 %	6 / 33.33 %
Detractors (De)	10 / 55.56 %	7 / 38.89 %
NPS score (Pr-De [%])	-38.89 %	-11.11 %
Standard Deviation	3.02	2.8

AR Training



VR Training

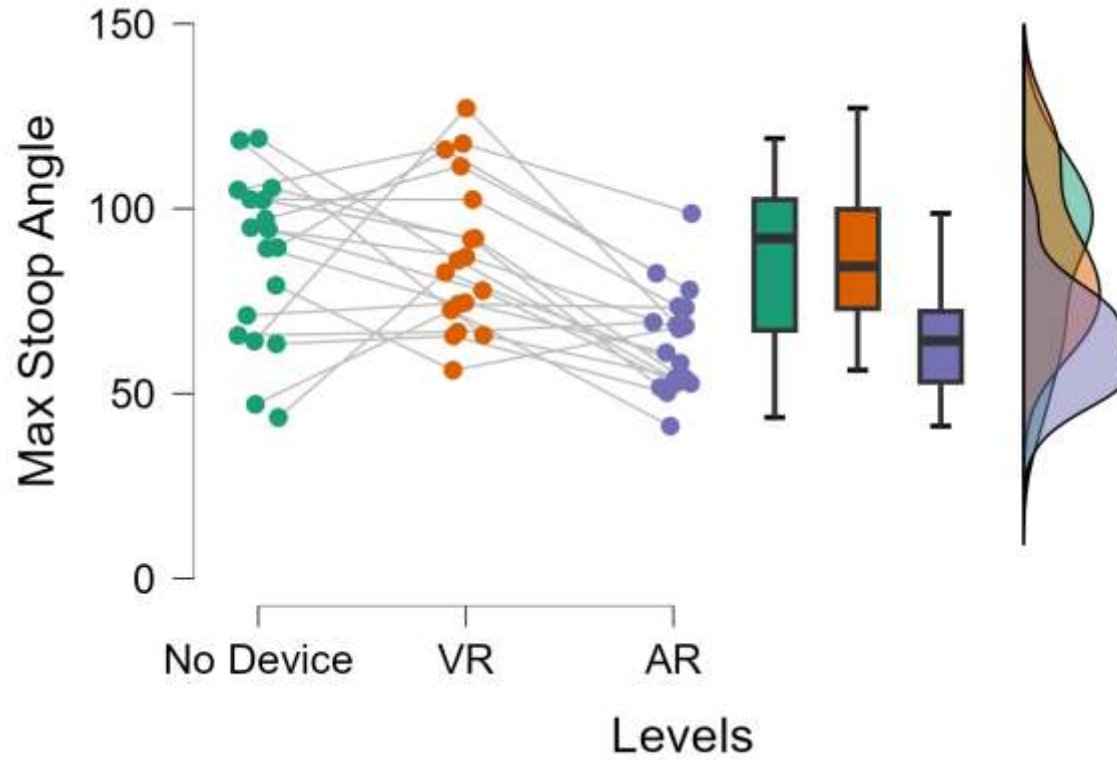




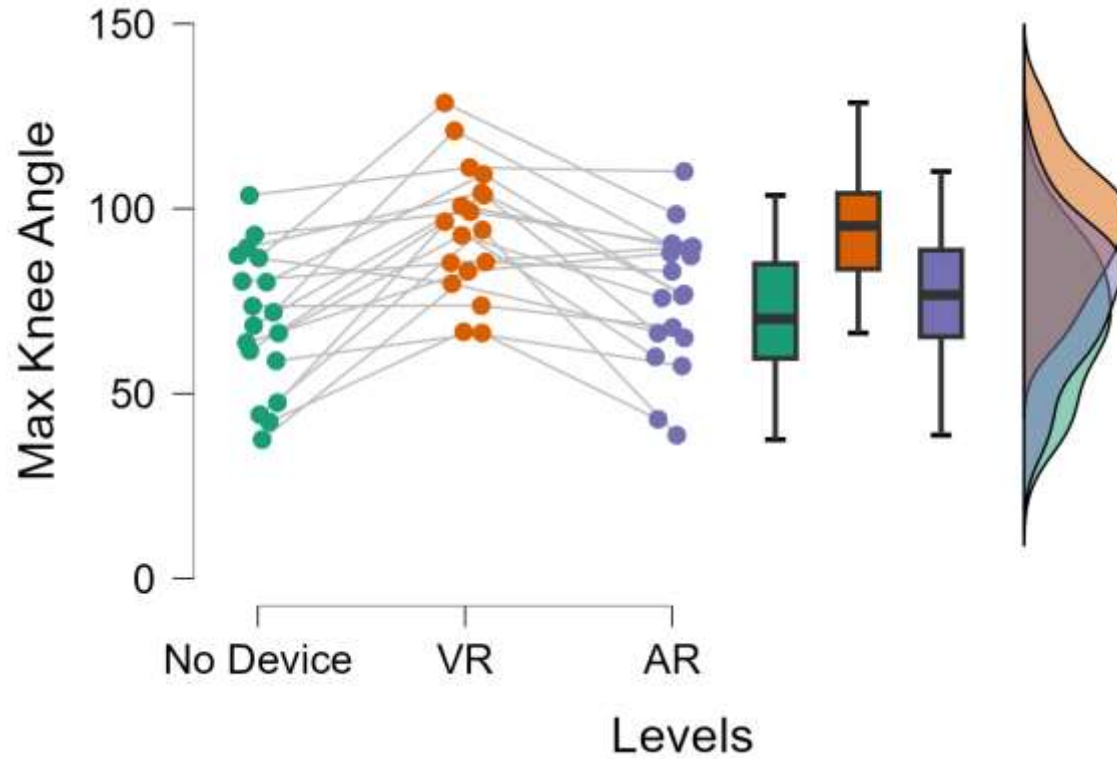
## Results – Ergomaps Analysis

Condition	Front Lifting (n=18)	Percentage	Lateral Lifting (n=18)	Percentage
Control trial & VR & AR equally good	4	22.2%	4	22.2%
Control trial best	2	11.1%	2	11.1%
AR best	1	5.6%	2	11.1%
VR best	2	11.1%	3	16.7%
VR or AR better than control trial	9	50.0%	6	33.3%
Control trial worst	8	44.4%	3	16.7%
AR worst	1	5.6%	5	27.8%
VR worst	4	22.2%	4	22.2%

# Results



## Results





## Discussion

- Quantitative Analysis
  - NPS results were poor for both scenarios: -38.89% for AR and -11.11% for VR, indicating a low likelihood of training recommendation.
  - Negative NPS values suggest both scenarios need improvement; enhanced training settings with more time and participant focus could improve XR system ratings.
- Analysis Ergomaps
  - Frontal lifting analysis showed 50% immediate improvement, with 44.4% rating the control trial worst, indicating immediate training effects.
  - Lateral lifting results were mixed; 33.3% improved, but 25.7% performed worst post-AR, suggesting it requires longer training.
- Coaches Feedback
  - Both systems can already be deployed and can assist AUVA trainers in courses.
  - Both systems have their respective advantages and disadvantages, with potential for further improvements.



## Discussion

- Max Stoop Angle
  - Individuals exhibit the highest stoop angles in the VR condition, suggesting that the VR environment might encourage more pronounced stooping.
  - The AR condition results in lower stoop angles compared to both VR and No Device conditions, potentially indicating a lesser tendency to stoop in AR.
- Max Knee Angle
  - VR Condition: Participants exhibit higher and more consistent knee angles, indicating that VR may promote a more standardized posture during the activity.
  - AR Condition: The AR condition shows lower variability and a slightly lower median knee angle, suggesting that AR might not be as effective as VR but still offers some consistency.
  - Comparison: Overall, the data suggests that while VR tends to encourage a higher knee angle, AR may still provide benefits with a more consistent performance compared to having no device. #

**Both VR and AR systems show promise but also indicate areas for potential improvement.**



**Thank you very much for your attention!**

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