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Integrating Haptic Interaction into a Virtual Training System for Manual Procedures in Industrial Environments

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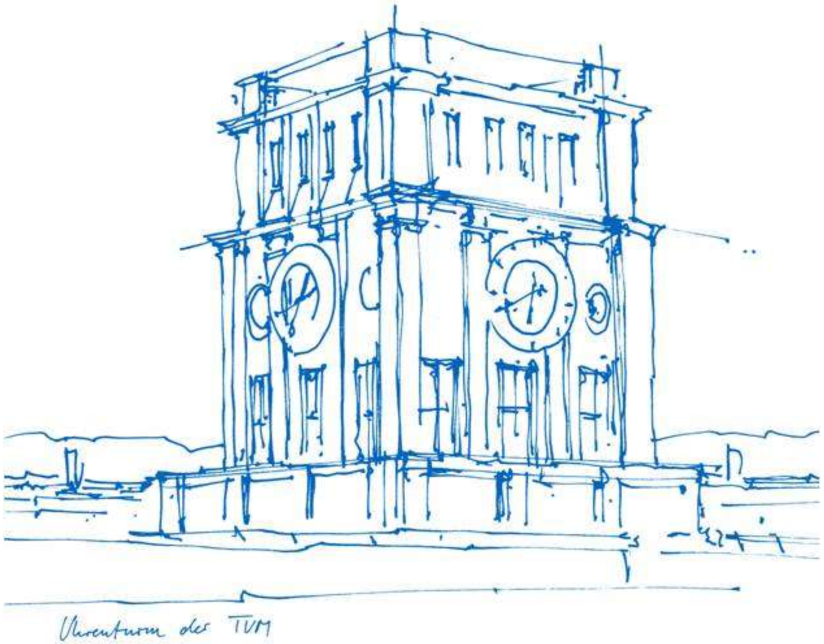

Situation in Manufacturing

Trends

- Increasing pace of technological change
- Increasing product variability
- Globalization and increased competition
- Demographic change

Effects on Manufacturing

- Increasingly flexible and autonomous manufacturing equipment
- Increasingly complex manufacturing processes and equipment
- Human work remains a vital component
- Workers with diverse skills will be increasingly present in the workforce

Virtual training systems to train human workers for industrial procedures.

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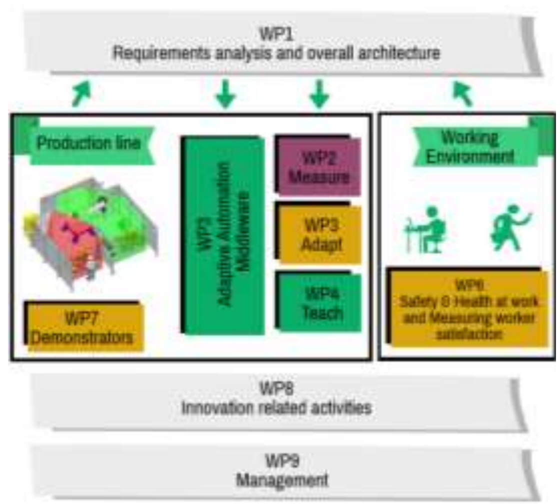
INCLUSIVE

Smart and adaptive training systems for INCLUSIVE work environments.

Bridge the gap between human capabilities and the demands of industrial machines using adaptive interfaces and teaching systems.

Development of off- and on-line training systems that adapt to the needs and capabilities of human operators.



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Virtual Training Systems

User trains industrial procedures in a fully virtual environment.

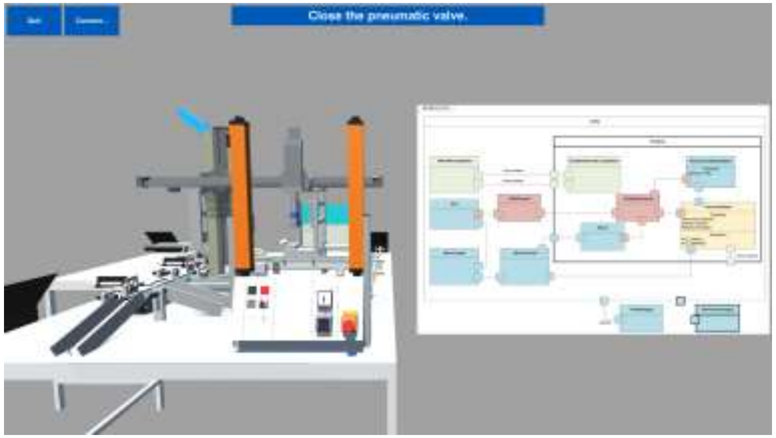
Virtual representations of machines, components, and tools.

Motivation

Cost-efficient training.

Safe training environment without risks for user or machine.

Flexibility of visualization and interaction techniques.



Loch et al. (2018)

Ordaz et al. (2015)

Types of Knowledge

Declarative Knowledge

Know that something is the case

What to do in a given situation (Williams & Davids (1995))

Procedural Knowledge

Goal-oriented knowledge (Corbett & Anderson (1995)

Applied during the execution of a task

Knowing that vs. Knowing how

Use haptic interaction to teach “knowing how” in a virtual training system.

Training Systems with Haptic Interaction

The inclusion of haptic elements benefits virtual training systems.

Devices for in- and output of haptic information or gesture-based interaction simulate manual components of industrial procedures.

Shortcoming: Physical properties of the components (e.g., weight, dimensions) are not transported.

Introduce haptic interaction with real industrial components to virtual training systems.

Bhatti et al. (2009)

Stork et al. (2012)

Haptic Virtual Training Systems

Combination of physical components and projected instructions.

Training of the establishment of a screw connection.

Motivation for the Introduction of Haptic Interaction

Human being are physical creatures (Saffer 2009).

Creation of an active learning environment that provides possibilities for experimentation and experience.

Experience with the handling of the tools before training in the real working environment.

Suitable for limited user groups such as

Users with vision declines (e.g., older workers).

Low-experienced/low-literate users.

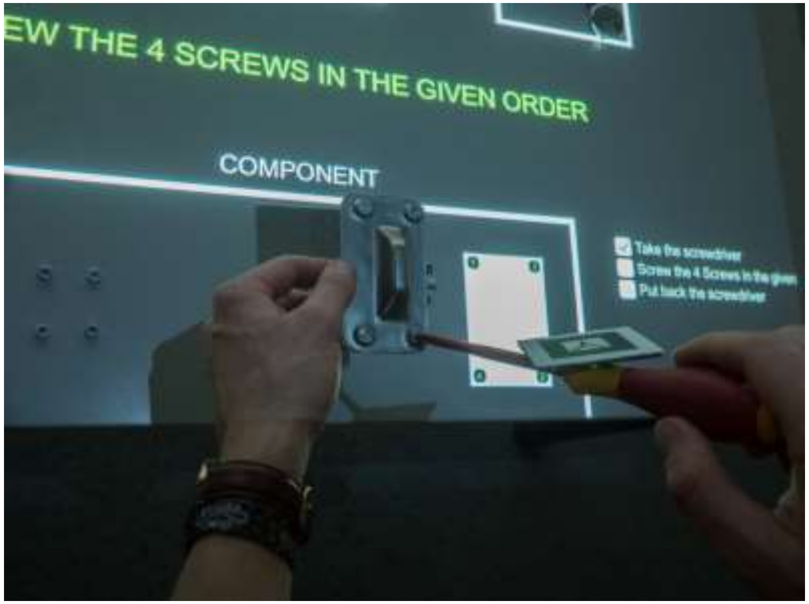
Dynamic Instructions

System detects whether the user follows training process based on markers.

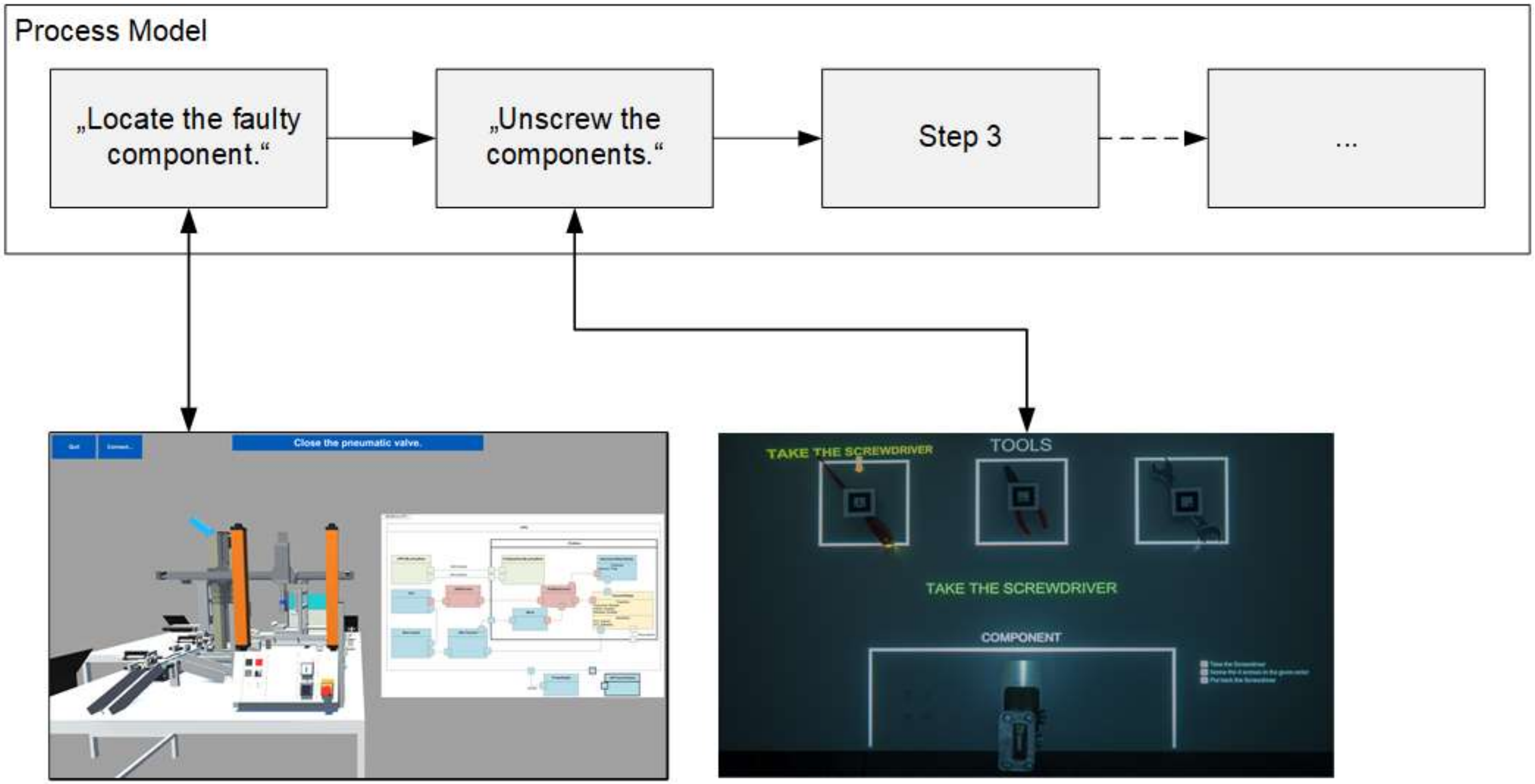
Instructions are automatically changed based on the progress of the user.

Visual and verbal instructions are provided next to the work area.

Instruction get gradually reduced to increase the complexity of the training.



Integration with Virtual Training System



Visual Training System

Haptic Training System

System Architecture

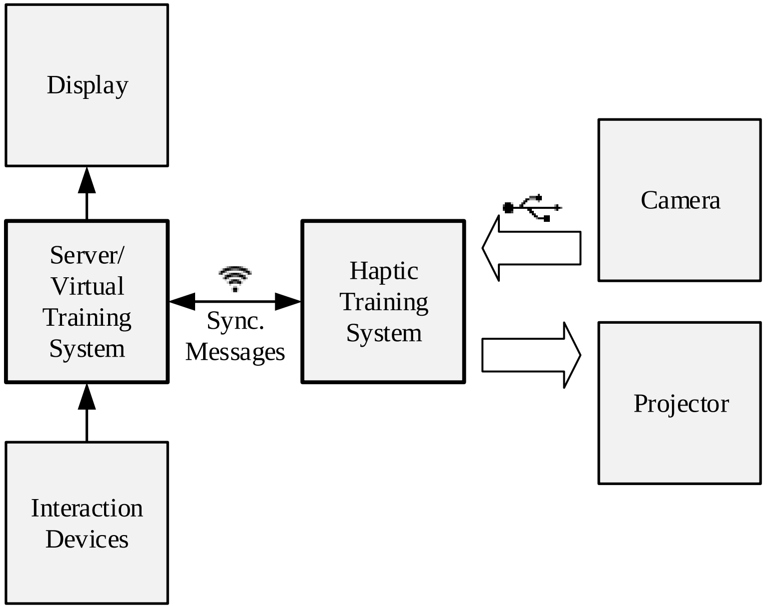
Distributed architecture with central server component that controls training system.

Haptic training system is implemented as an independent component.

Synchronization using text messages over WiFi connection.

Application of consumer-grade equipment (e.g., webcam, projector).

Implementation of training system based on ARToolkit and Unity.



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Conclusion

Enhanced acquisition of motor skills and abilities for tool operation.

Trainee gets familiarized with physical characteristics of components and tools.

Intuitive and simple training system.

Education of inexperienced and low skilled workers.

Training in real scenarios gets facilitated since user already worked with the real tools.

Minimization of errors and work disruptions after training.

Outlook

Introduce real-time feedback using force-sensing resistors. ✓

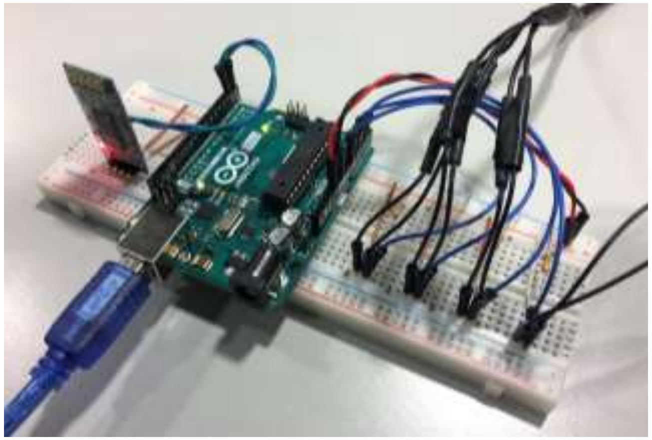
Empirical evaluation against baseline system without haptic components. ✓

Introduce additional feedback modalities (e.g., haptic or auditory feedback). ✓

Evaluate marker-less tracking for augmented instructions.

Integration of wearable devices for additional visualization possibilities and collaborative training approaches.

Ziegler (2018)


Ziegler (2018)