Extended Reality in Industry 4.0 (ERI)

Lecture 1: Introduction

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Department of Human Centered Design,
IIIT Delhi

Key Information

- **Google classroom link:** https://classroom.google.com/c/NzkxMzY2MDQyNDgw?cjc=egnlvkyb
- **Class code:** egnlvkyb
- **Instructor:** Dr. Kalpana Shankhwar
- **Email id:** kalpana@iiitd.ac.in
- **Office:** A-403 (R&D Block)
- **Office hours:** Monday 1:30-3:30 pm
- **Class:** Monday and Thursday 11:00-12:30 pm

About me

Kalpana Shankhwar

Education
- PhD in Mechanical Engineering, **National Taiwan University (NTU)**
- M.Tech in Mechanical Engineering, **IIT Guwahati**
- B.E. in Mechanical Engineering, **SGSITS Indore**

Work Experience
- Engineer at **MAN Trucks India Pvt. Ltd.**
- Assistant Professor at **KIIT University**, Bhubaneswar
- Assistant Professor at **IIIT Delhi** (From July 2023 – Present)

Lab
- Emerging Technology Integrated Design & Manufacturing (https://etidm.iiitd.edu.i

Lab Information

The Emerging Technology Integrated Design & Manufacturing lab (ETiDM) at HCD focuses on exploring and investigating emerging technologies including Extended reality (XR)/ (AR, VR, MR), Artificial Intelligence (AI), Digital Twin, Internet Of Things (IoT) and Haptic Technology. The ongoing research projects employ emerging technologies to develop smart training, tutorial and evaluation systems in the context of Industry 4.0 and Education 4.0. The lab aims to explore emerging technologies and conduct interdisciplinary research to overcome existing challenges in diverse fields for example, education, healthcare, manufacturing, teleoperation, guidance for safety and so forth.

Extended Reality

Haptic Technology

Digital Twin

Artificial Intelligence

Finite Element Method

User Centered Design

Ongoing research

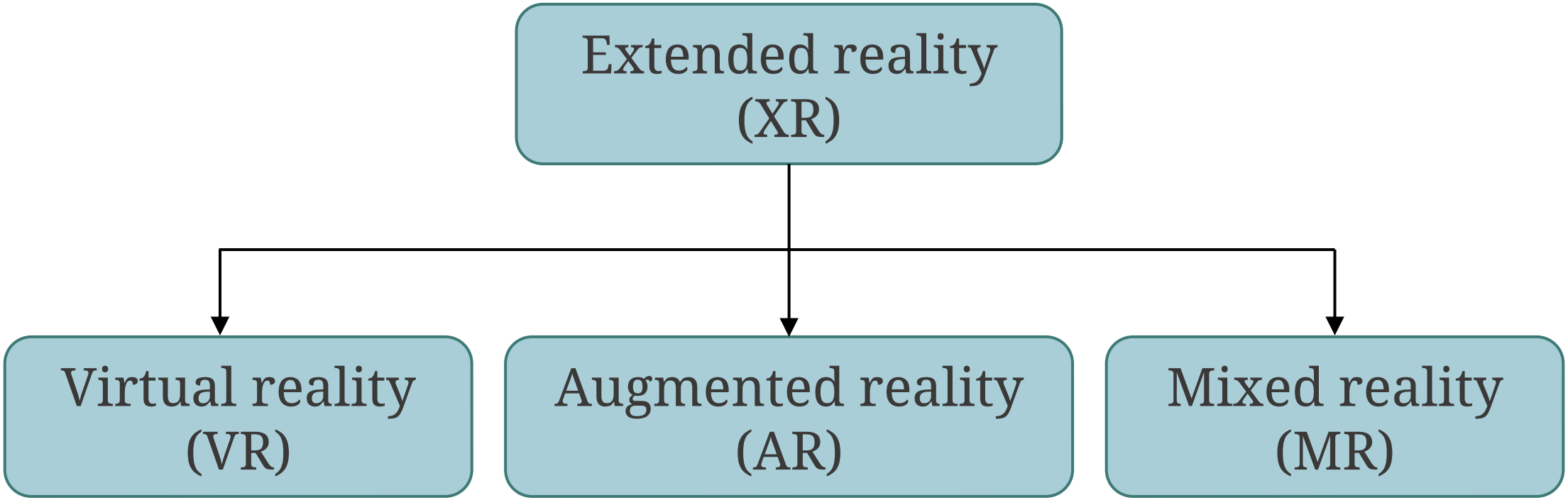
1. VR simulation of 3D path optimization for food delivery through drones.
2. Real-time 3D reconstruction using SLAM technology in VR environment to control a robotic arm remotely
3. Gesture-based interactive game design using mixed reality (MR).
4. VR-based 3D modeling software development.
5. Haptic device for surgical training in MR.
6. Visualization Of Customized Architectural Floor Plans Generated By GenAI In VR

Grading Policy

Type of Evaluation	% Contribution in Grade
Class exercise	10 [participation in class activities]
Assignment	30 [4 Assignments]
Final project (group/individual)	20 [1 or 2 individuals depending on class strength]
Mid term	15
End term	25

Resources

- CAD/CAM Theory and Practice (by Ibrahim Zeid and R. Sivasubramaniam)
- S.N. Lal, Engineering Drawing with an Introduction to AutoCAD, Cengage India Private Limited, 1st Edition, 2017.
- Computer Aided Design: A Conceptual Approach (By Jayanta Sarkar)


Extended reality
(XR)
Virtual reality
(VR)
Augmented reality
(AR)
Mixed reality
(MR)

Virtual reality (VR)

- VR is an artificial environment which is experienced through sensory stimuli (such as sights and sounds) provided by a computer and in which one's actions partially determine what happens in the environment
- Provides an immersive experience, enabling users to interact with objects and navigate in 3D space
- Creates highly-engaging user experiences

Virtual reality (VR)

	AR	VR	MR
Virtual Object	O	O	O
Real Object	O	X	O
Environment	Real world	Virtual environment	Real world
Objective	Provide additional information	Immerse in the virtual environment	Interact with virtual objects in the real world


Teleport

Destructive
Disassembly
Training System

History of Virtual Reality (VR)

- Panoramic paintings

1838 – Stereoscopic photos & viewers

- In 1838 Charles Wheatstone's research demonstrated that the brain processes the different two-dimensional images from each eye into a single object of three dimensions.
- Viewing two side by side stereoscopic images through a stereoscope gave the user a sense of depth and immersion.

Stereoscope

- Stereoscopes are optical devices that help to view the two images separately.
- When adjacent photos (a stereo pair) are viewed with a stereoscope, a three-dimensional view of the ground and objects in the photo is seen.
- Stereoscopy creates the illusion of three-dimensional depth from a pair of two-dimensional images.
- Stereoscopy is the **production of the illusion of depth** in a photograph, movie, or other two-dimensional image by the presentation of a slightly different image to each eye.

Stereoscope

1929 – Link Trainer The First Flight Simulator

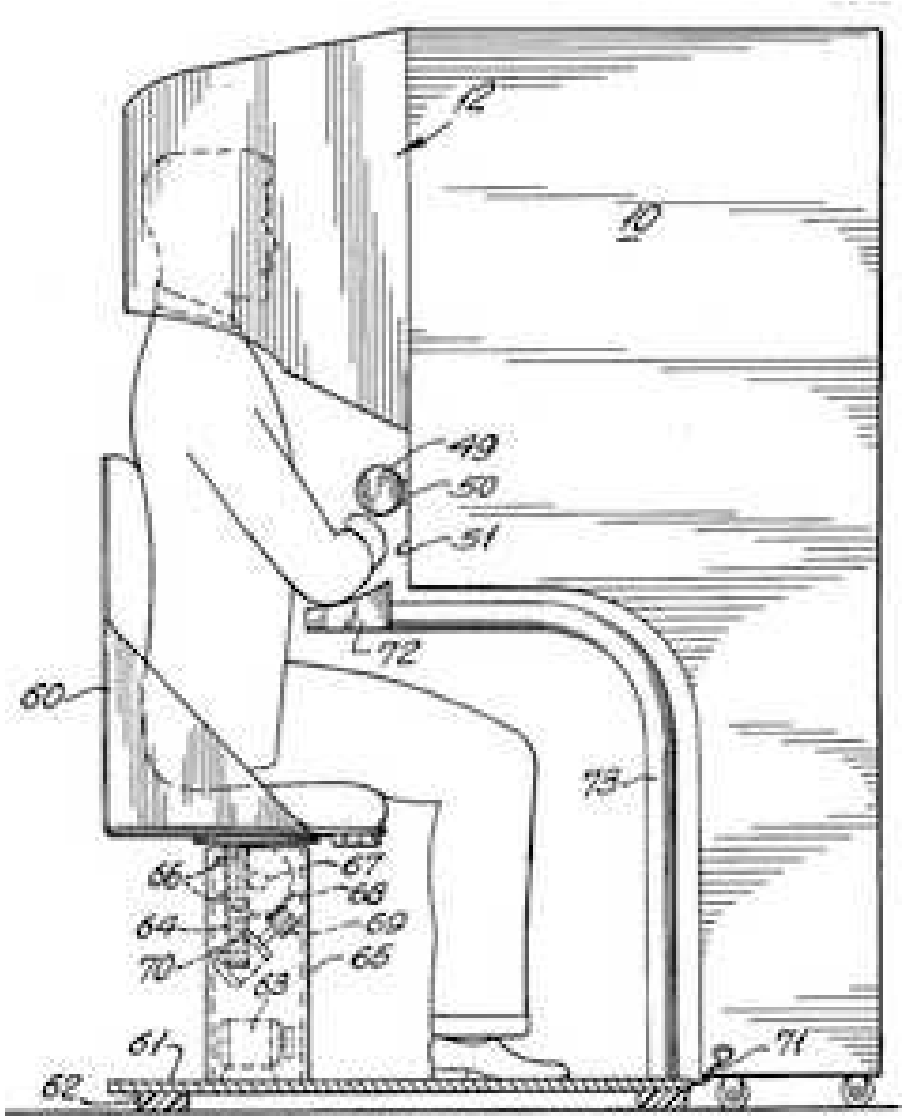
- In 1929 Edward Link created the “Link trainer” an example of a commercial flight simulator, which was entirely electromechanical.
- It was controlled by motors that linked to the rudder and steering column to modify the pitch and roll.
- A small motor-driven device mimicked turbulence

1929 – Link Trainer The First Flight Simulator

1950s – Morton Heilig's Sensorama

- In the mid 1950s cinematographer Morton Heilig developed the **Sensorama** which was an arcade-style theatre cabinet that would stimulate all the senses, not just sight and sound.
- It featured stereo speakers, a stereoscopic 3D display, fans, smell generators and a vibrating chair.

1950s – Morton Heilig's Sensorama



1960 – The first VR Head Mounted Display

- Morton Heilig's next invention was the Telesphere Mask and was the first example of a head-mounted display (HMD), albeit for the non-interactive film medium without any motion tracking.
- The headset provided stereoscopic 3D and wide vision with stereo sound.

1961 Headsight – First motion tracking HMD

- In 1961, two Philco Corporation engineers (Comeau & Bryan) developed the first precursor to the HMD.
- It incorporated a video screen for each eye and a magnetic motion tracking system, which was linked to a closed circuit camera.
- The Headsight was not actually developed for virtual reality applications (the term didn't exist then), but to allow for immersive remote viewing of dangerous situations by the

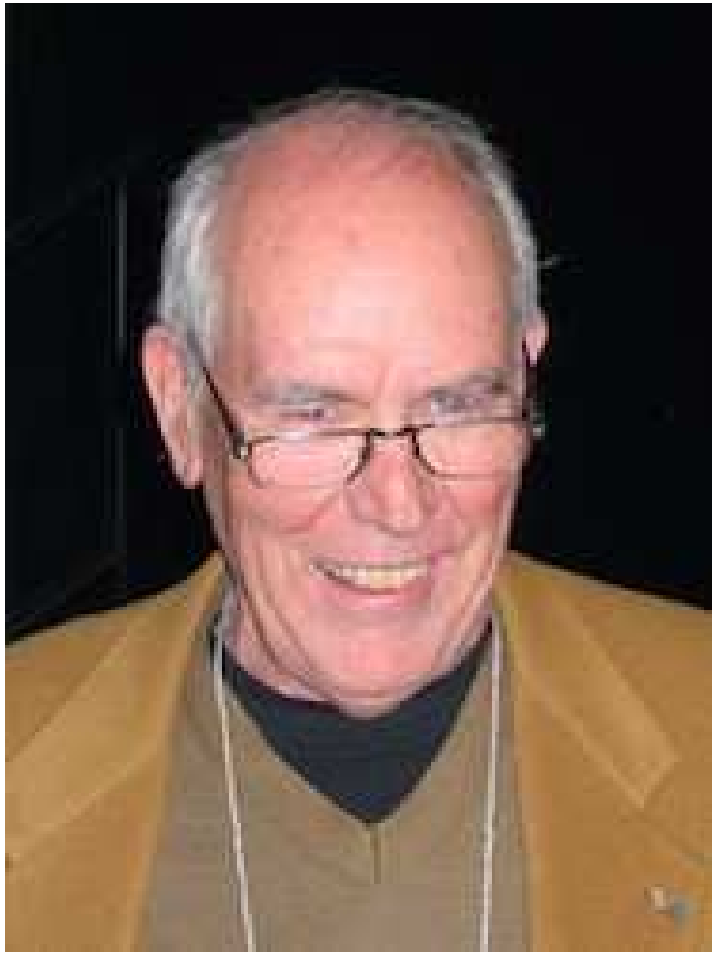
1961 Headsight – First motion tracking HMD

- Head movements would move a remote camera, allowing the user to naturally look around the environment.
- It lacked the integration of computer and image generation.

1968 – Sword of Damocles

- In 1968 Ivan Sutherland and his student Bob Sproull created the first VR / AR head mounted display (Sword of Damocles) that was connected to a computer and not a camera.
- It was a large and too heavy for any user to comfortably wear and was suspended from the ceiling.
- The computer generated graphics were very primitive wireframe rooms and objects.

1968 – Sword of Damocles



1987 – Virtual reality the name was born

- In 1987, Jaron Lanier, founder of the visual programming lab (VPL), coined the term “virtual reality”.
- Through his company VPL research Jaron developed a range of virtual reality gear including the Dataglove and the EyePhone head mounted display.

1997 – Landmark VR PTSD Treatment

- Georgia Tech and Emory University collaborated to use VR for the treatment of PTSD in war veterans.
- VR technology gave therapists unrivaled control over what the patients sees and experiences

2007 – Google Brings Us Street View

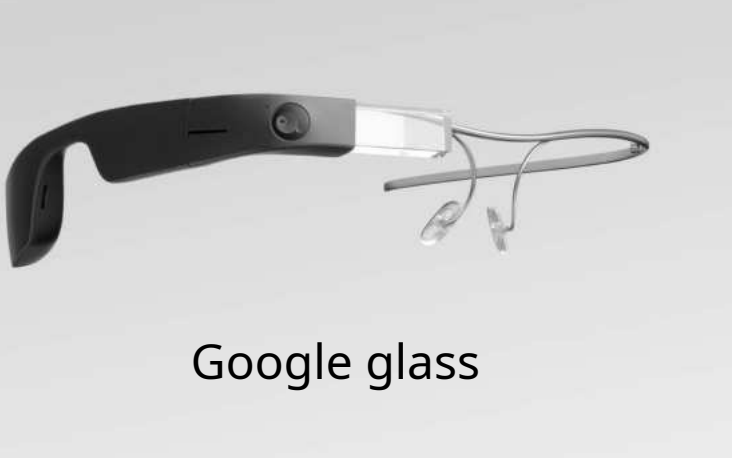
- Google enhanced its Maps service with street-level 360-degree images, captured by special cars fitted with custom camera equipment.
- Today you can “stand” in just about any part of the world and look around.

2010 - present

- 2010 - Oculus prototyped
- 2012 - Oculus Rift Kickstarter
- 2014 - Google cardboard, Samsung Gear VR
- 2016 - HTC Vive
- 2019 - Oculus Quest
- Presently - Vision Pro, HoloLens 2, Meta Quest, HTC Vive Pro, HTC Vive Cosmos, Google glass

Google Cardboard

Oculus Kickstart



Google glass

HTC Vive

Vision Pro

Samsung Gear VR

HTC Vive Cosmos

Meta Quest 3

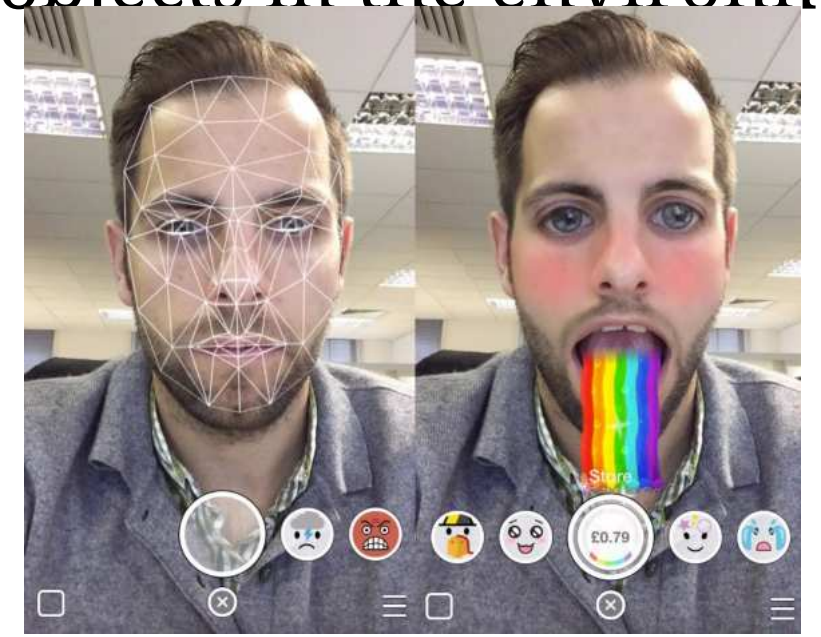
HTC Vive Pro

HoloLens 2

Oculus quest 2019

Augmented Reality (AR)

- Enhanced version of virtual reality in which digital information is overlaid on an image of a physical object being viewed through a device for example, smartphone camera.
- Used smartphone camera to place virtual characters onto objects in the environment as if they really are there



Augmented Reality (AR)

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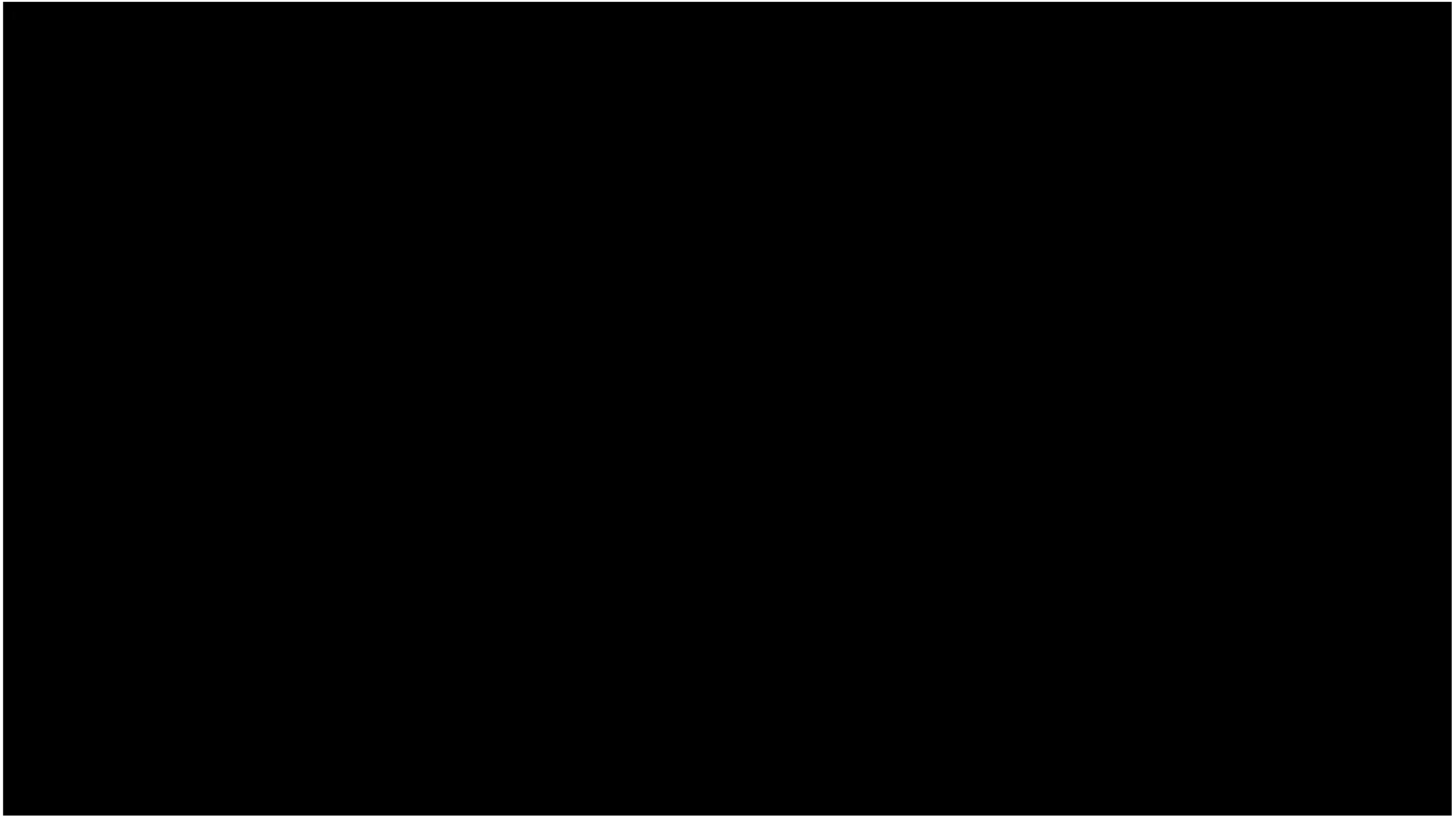
Augmented Reality (AR)



Mixed Reality

- Mixed realty is similar to AR, combining digital information with the real world. Physical objects and virtual objects can interact with each other. Users can interact and manipulate the physical and virtual obj

Mixed Reality

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A Realistic Visuo-Haptic-Based Manual Milling Training Simulator with a Milling Machine Mockup

Visuo-haptic XR-based manual metal arc welding training system

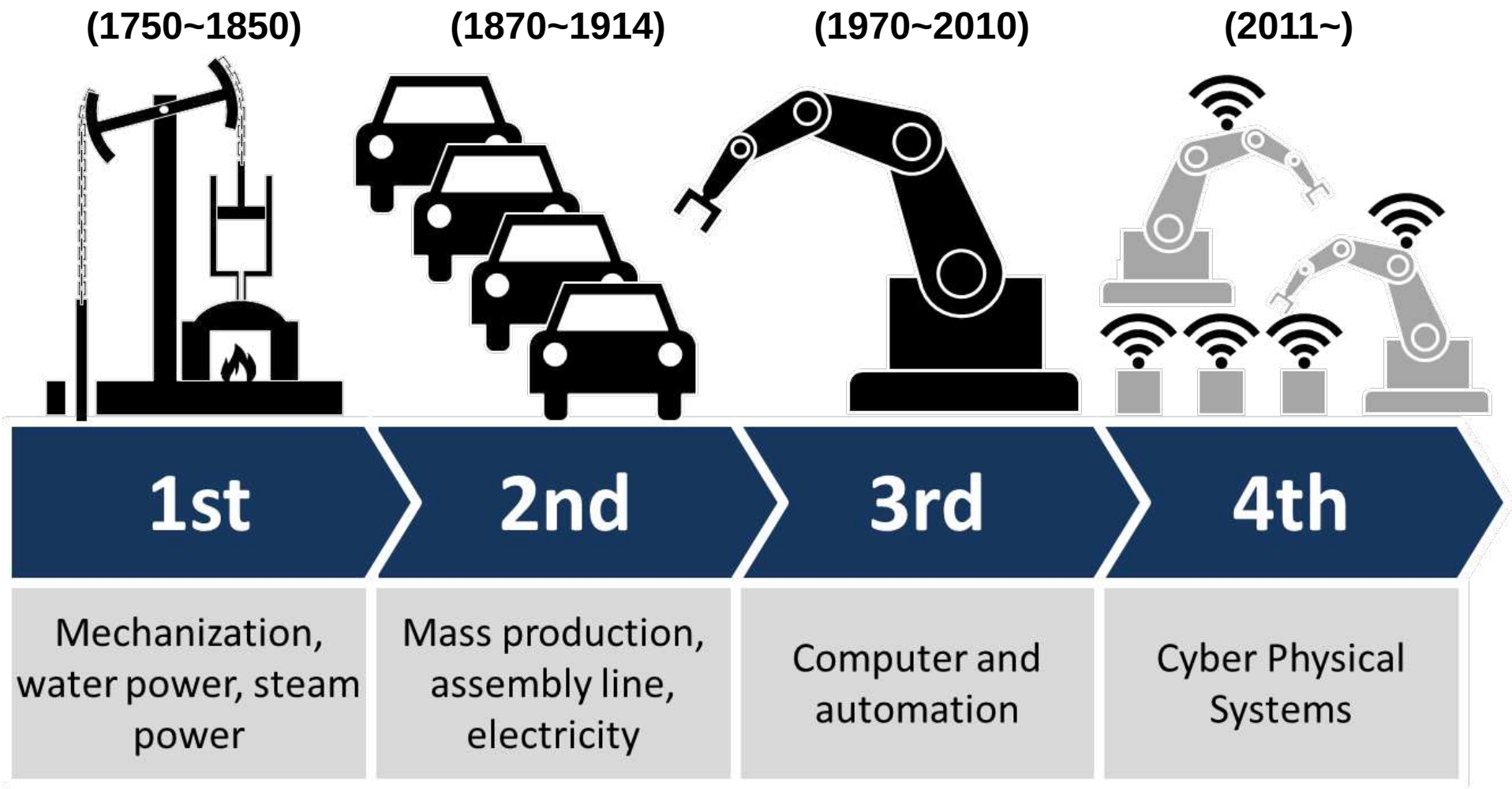
Presented by

Department of Mechanical Engineering
National Taiwain University
Kalpana Shankhwar and Shana Smith

XR Applications

- Assembly process
- Maintenance
- Teleoperation
- Welding training
- Human-Robot collaboration
- Finite element analysis results visualization
- Medical and healthcare
- Skill evaluation
- Manual Milling simulation
- Gaming
- Safety training
- Architecture
- Tourism
- Education

Industrial revolutions



Industry 4.0

- Industry 4.0 is the integration of intelligent digital technologies into manufacturing and industrial processes. It encompasses a set of technologies such as industrial Internet of Things (IoT) networks, AI, Big Data, robotics, and automation. It allows smart manufacturing and the creation of intelligent factories, aiming to enhance **productivity, efficiency**, and **flexibility** in manufacturing.
- In the Industry 4.0 environment, the **interconnected computers**, **smart materials**, and **intelligent machines** communicate with one another, interact with the environment, and eventually make decisions with **minimal human involvement**.

Industrial revolutions

First industrial revolution

- Starting in the late 18th century in Britain, the **first industrial revolution** helped enable **mass production** by using **water** and **steam power** instead of purely **human** and **animal power**.

Second industrial revolution

- A century later, the **second industrial revolution** introduced **assembly lines** and the use of **oil, gas** and **electric power**. These new power sources, along with more advanced communications via **telephone** and **telegraph**, brought mass production and some degree of automation to manufacturing processes.

Industrial revolutions

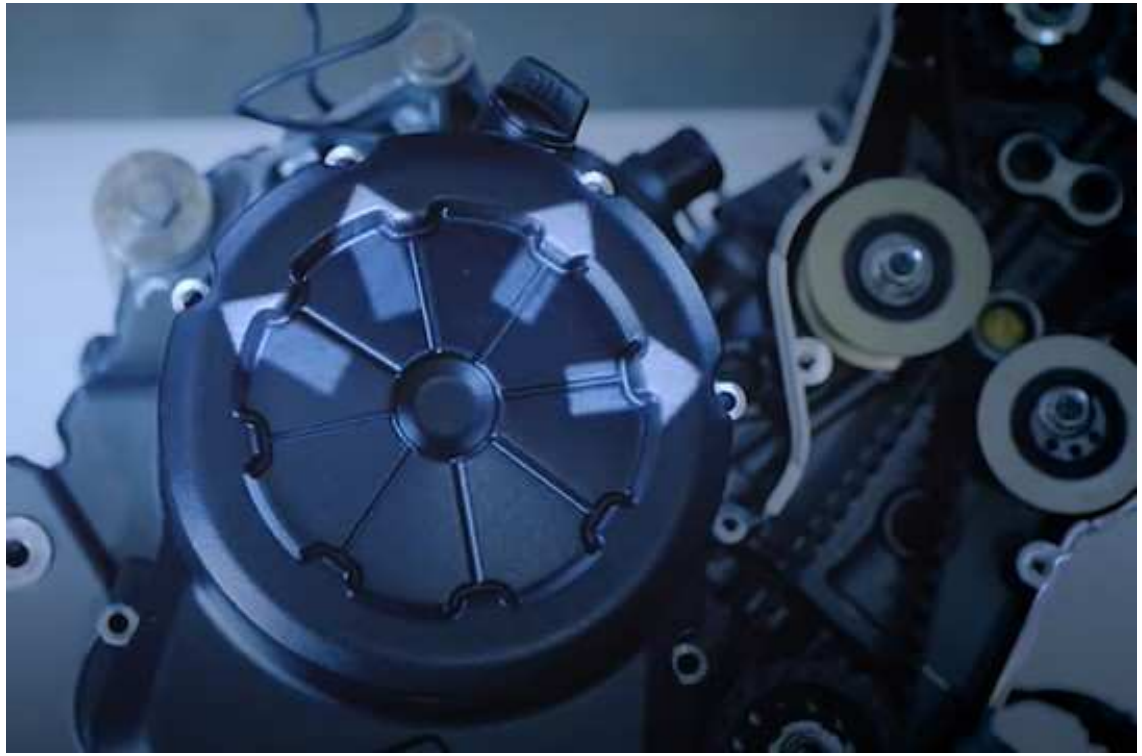
Third industrial revolution

- The third industrial revolution, which began in the middle of the 20th century, added **computers**, **advanced telecommunications** and **data analysis** to manufacturing processes. The digitization of factories began by embedding programmable logic controllers (PLCs) into machinery to help automate some processes and collect and share data.

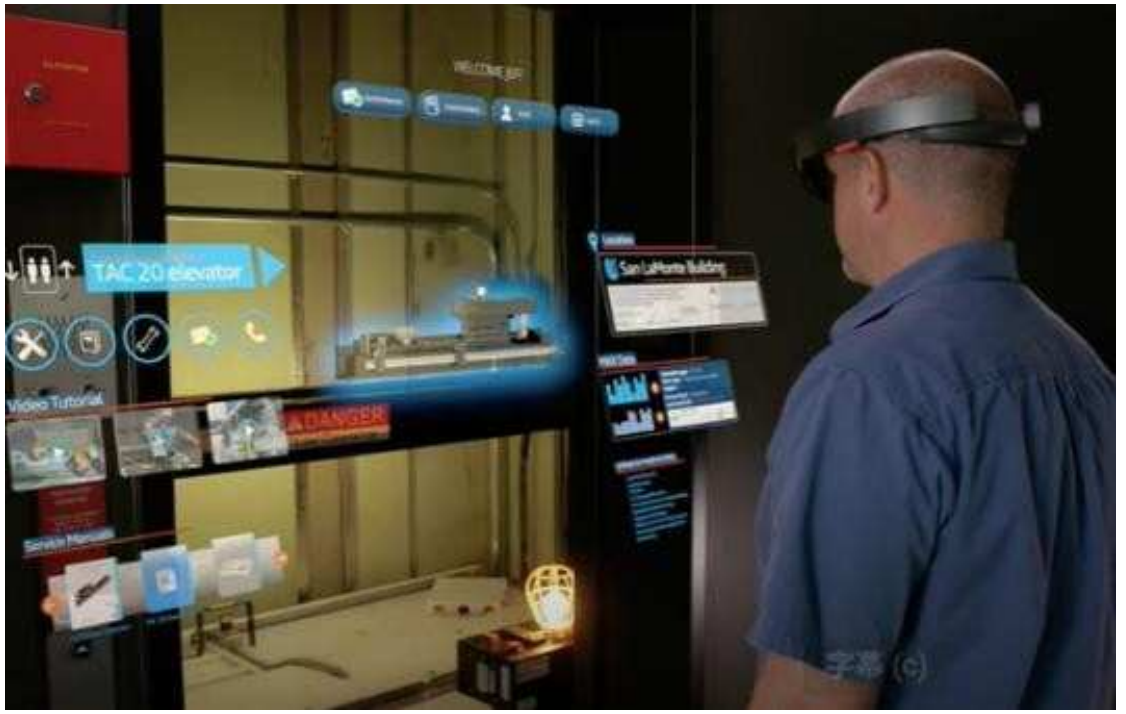
Fourth industrial revolution

- We are now in the fourth industrial revolution, also referred to as Industry 4.0. Characterized by **increasing automation** and the employment of **smart machines** and **smart factories**, informed data helps to produce goods more efficiently and productively.

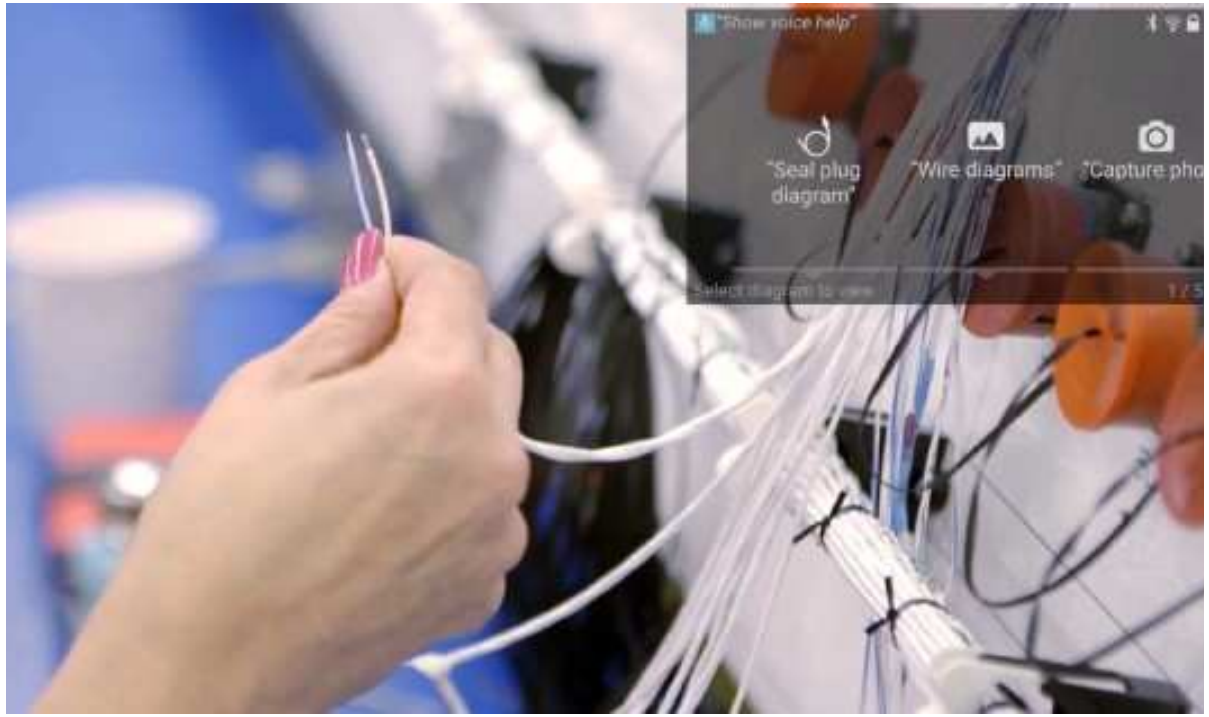
Training



Operation



Manufacturing



Marketing

Tampere University

AR-based interaction for human-robot collaborative manufacturing

Antti Hietanen[1], Jyrki Latokartano[2], Roel Pieters[3], Minna Lanz[2], Joni-Kristian Kämäräinen[1]

Laboratories of Signal Processing[1] , Mechanical Engineering and Industrial Systems[2] and Automation and Hydraulic Engineering[3], Tampere University of Technology, Finland

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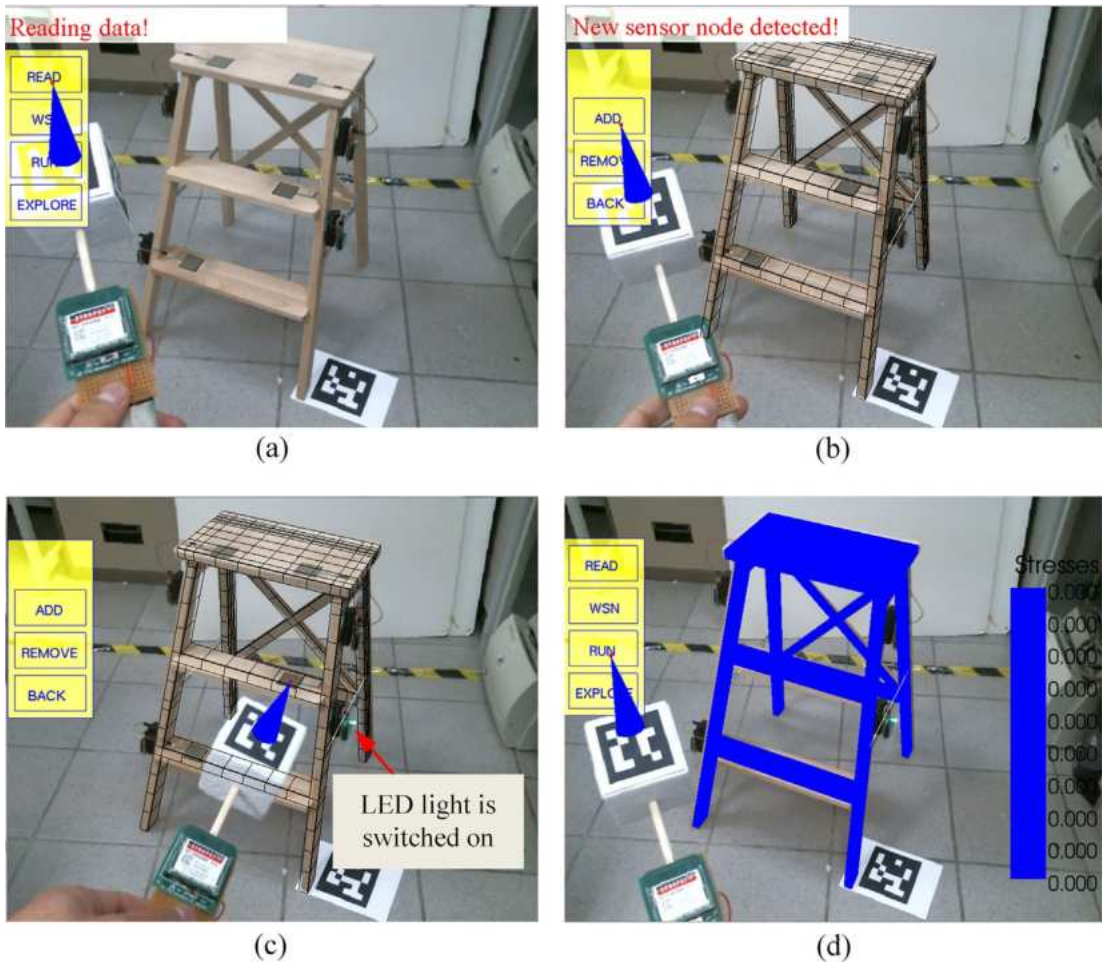
INSTITUTE OF COMMUNICATION INFORMATION AND PERCEPTION TECHNOLOGIES

Scuola Superiore Sant'Anna

Effects of augmented reality on the performance of teleoperated industrial assembly tasks in a robotic embodiment

PERCRO Perceptual Robotics Laboratory


Reading data!
READ
EXPLORE
New sensor node detected!
ADD
BACK
ADD
REMOVE
BACK
LED light is switched on
READ
WSN
RUN
Stresses
(a)
(b)
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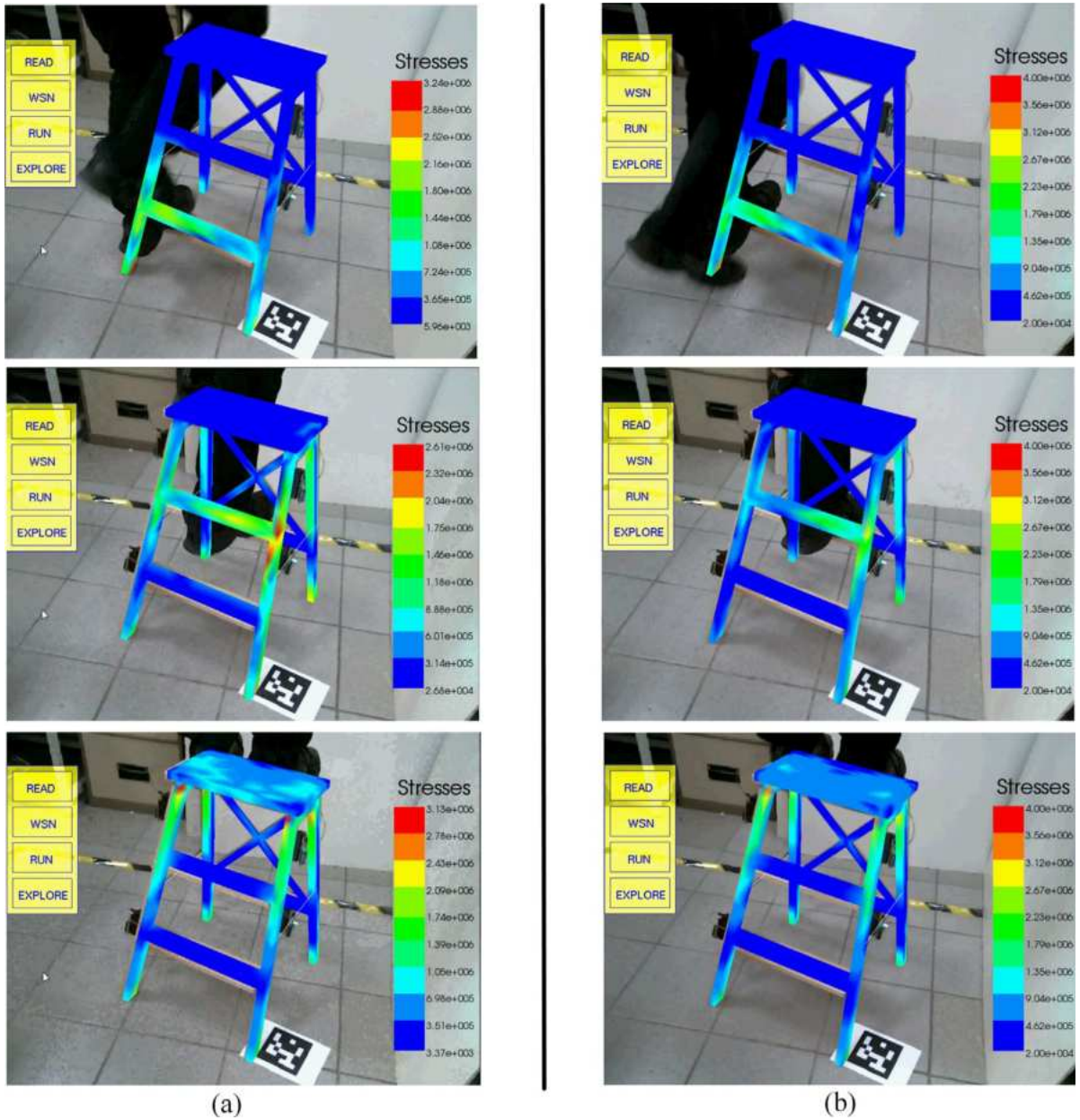
READ
WSN
RUN
EXPLORE
Stresses
(a)
(b)

Thankyou!