Intellectual Output_O1:
EMERALD e-book for developing of biomimetic mechatronic systems

MODULE 4
VR/AR

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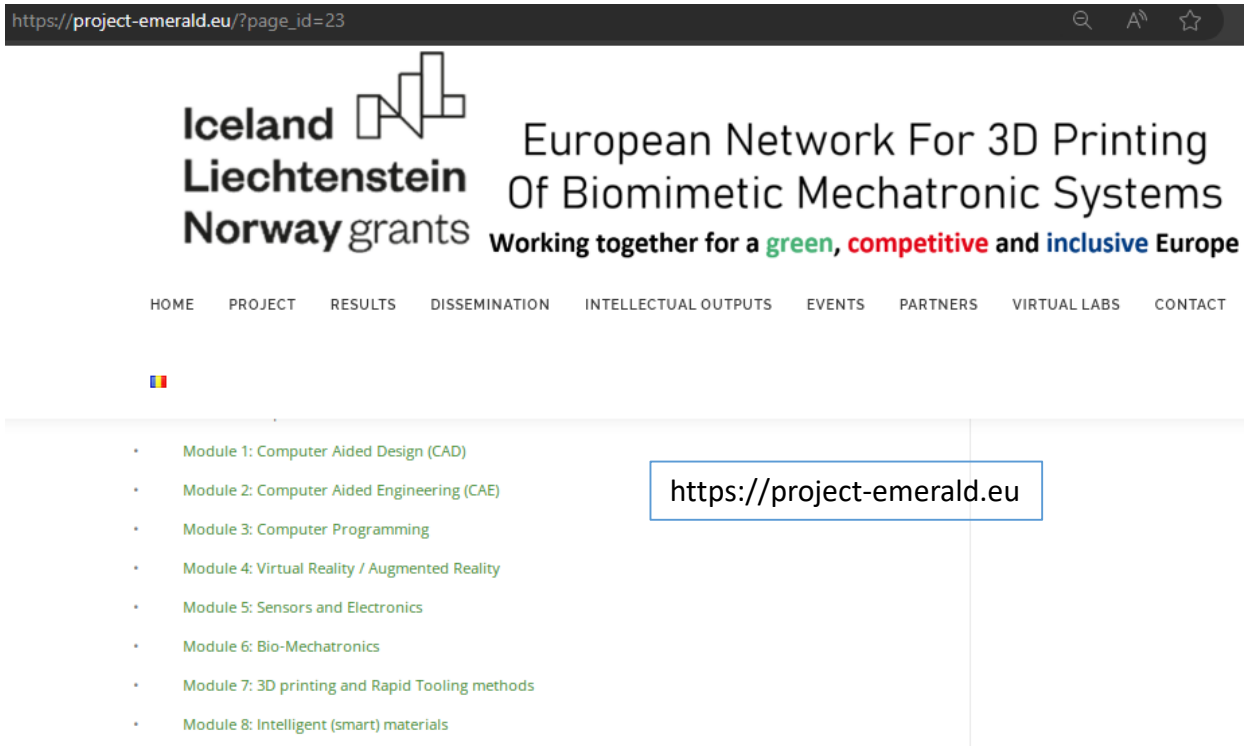

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EUROPEAN NETWORK FOR 3D PRINTING OF BIOMIMETIC MECHATRONIC SYSTEMS

MODULE 4: VR/AR

Project Title	**European Network for 3D Printing of Biomimetic Mechatronic Systems 21-COP-0019**
Output	**IO1 - EMERALD e-book for developing of biomimetic mechatronic systems**
Module	**Module 4 – Virtual Reality & Augmented Reality**
Date of Delivery	**July 2022**
Authors	**Filip GÓRSKI**
Version	**V1.1**

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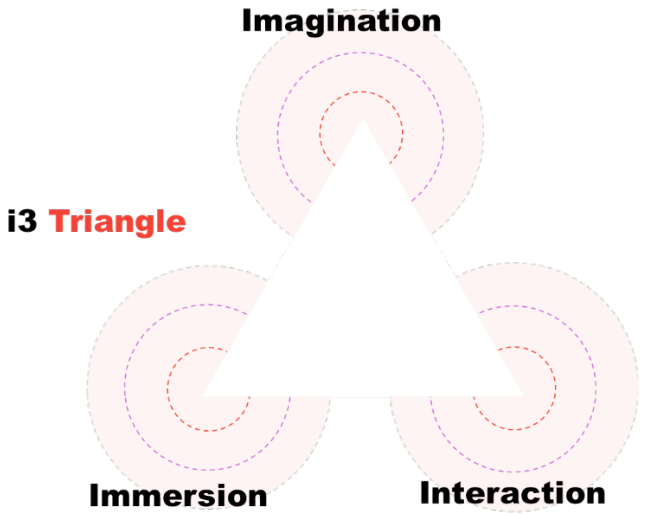
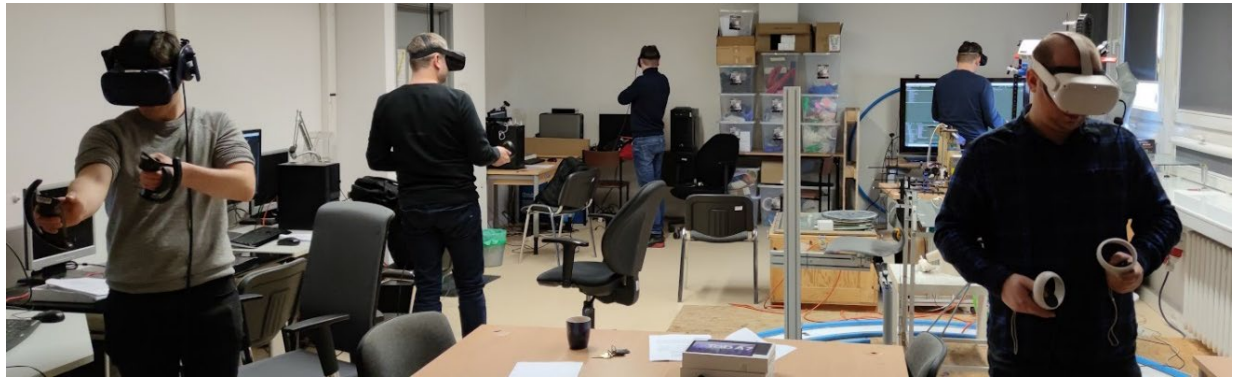


I3 Triangle, on the basis of [Burdea & Langrana 1993]



Immersive interactive VR system users

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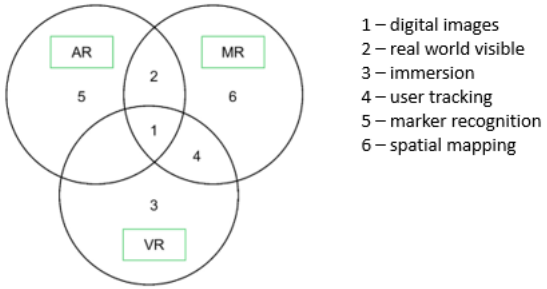
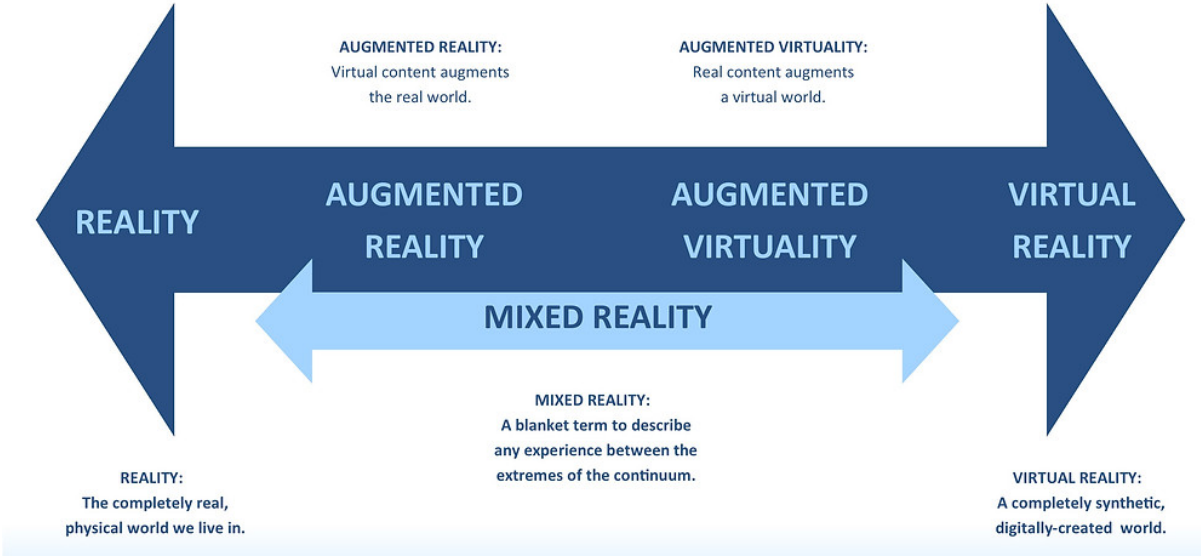
Difference between AR (left, [Meredith 2017]) and MR (right, [wired.co.uk])



1 – digital images
2 – real world visible
3 – immersion
4 – user tracking
5 – marker recognition
6 – spatial mapping

Common and distinctive features of main XR technologies



Milgram's XR continuum [Milgram et al. 1994]

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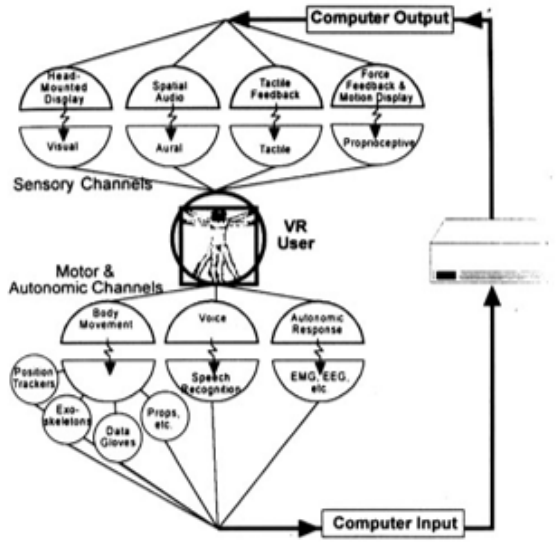
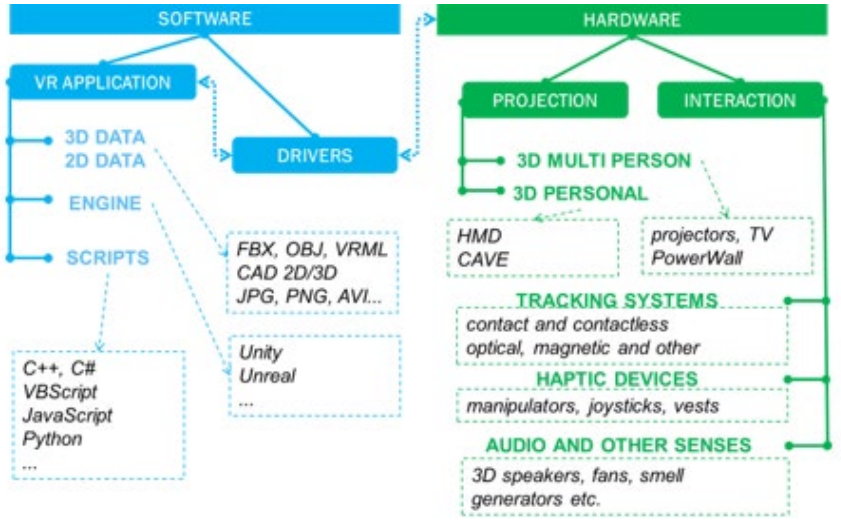
XR systems



Basic input/output channels of VR system [Biocca & Delaney 1995]



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Hardware

Example of a VR headset – HTC Vive Pro – with controllers and base stations [vive.com]

VR controller example, with its virtual representation [oculus.com]

Examples of mixed reality devices – holographic goggles [microsoft.com] and a holographic diplay [3dholodisplay.com]

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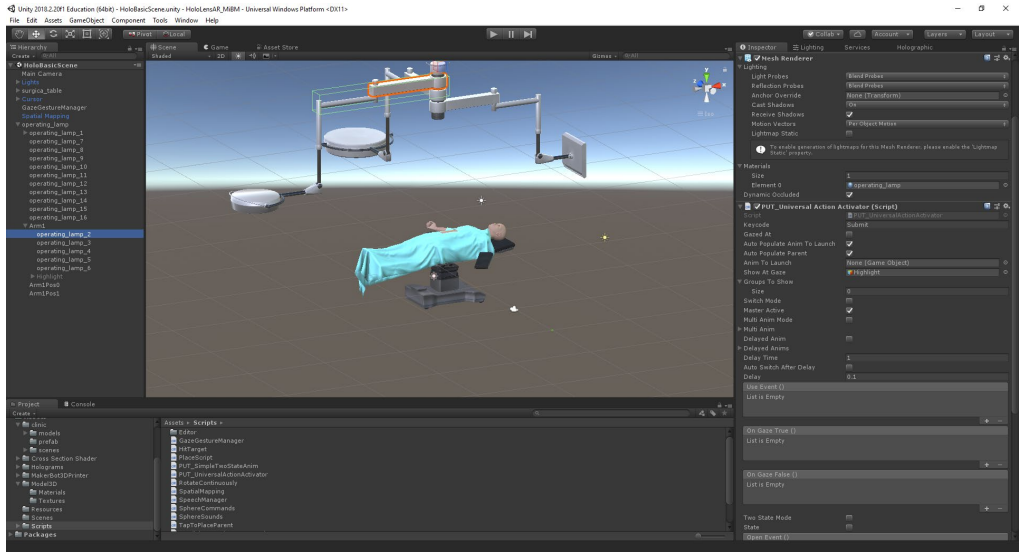
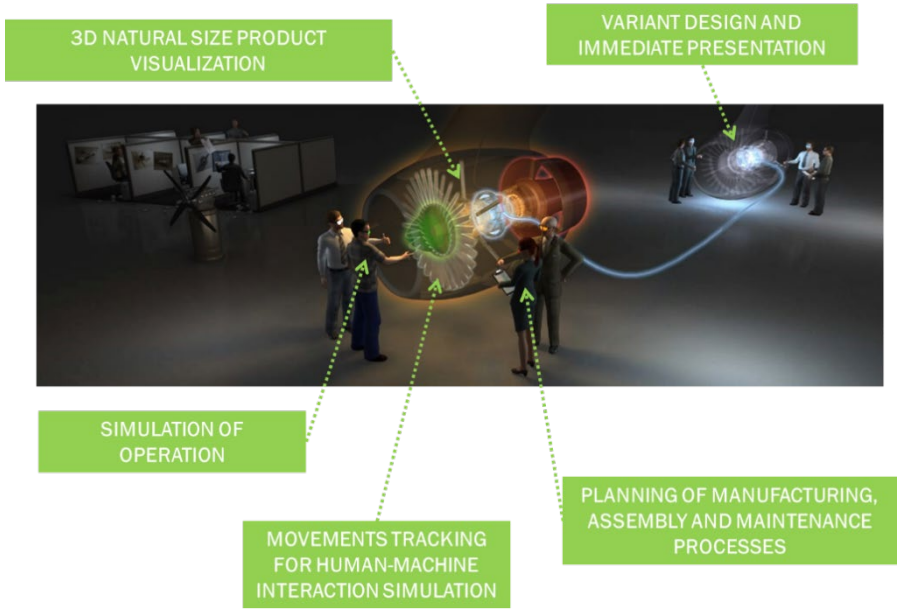
Software and Applications of XR technologies



Unity game engine



Applications of VR in engineering, based on [Górski 2019]

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Applications of XR technologies

Examples of VR use in medicine [medscape.com] and military [James 2015]

AR and MR applications [skanska.pl] [Downey 2016] [Kaminsky 2019] [fashionbi.com]

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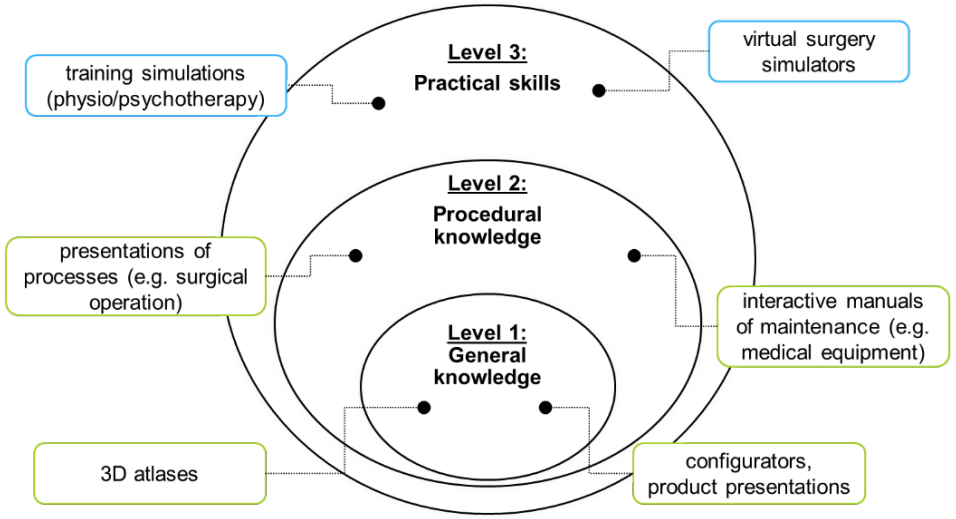
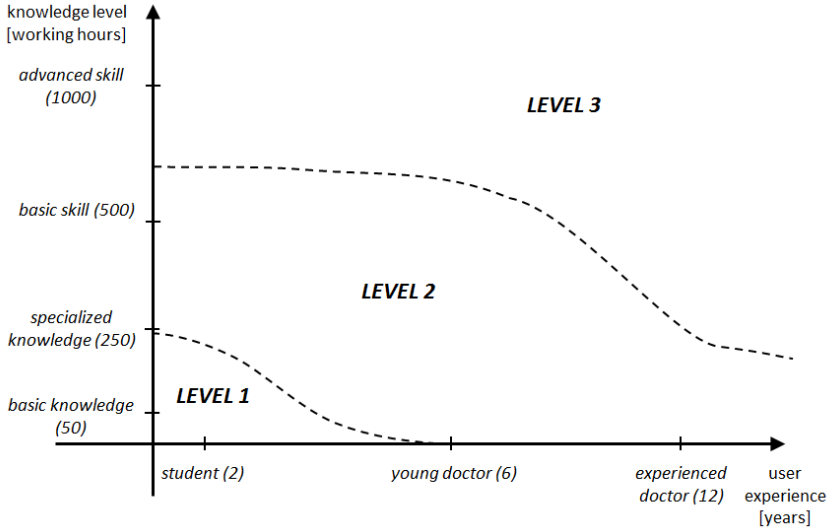
XR technologies in biomedical applications



Levels of XR applications by knowledge [Górski et al. 2017]



Levels of XR applications and mapping to specific user classes [Górski et al. 2017]

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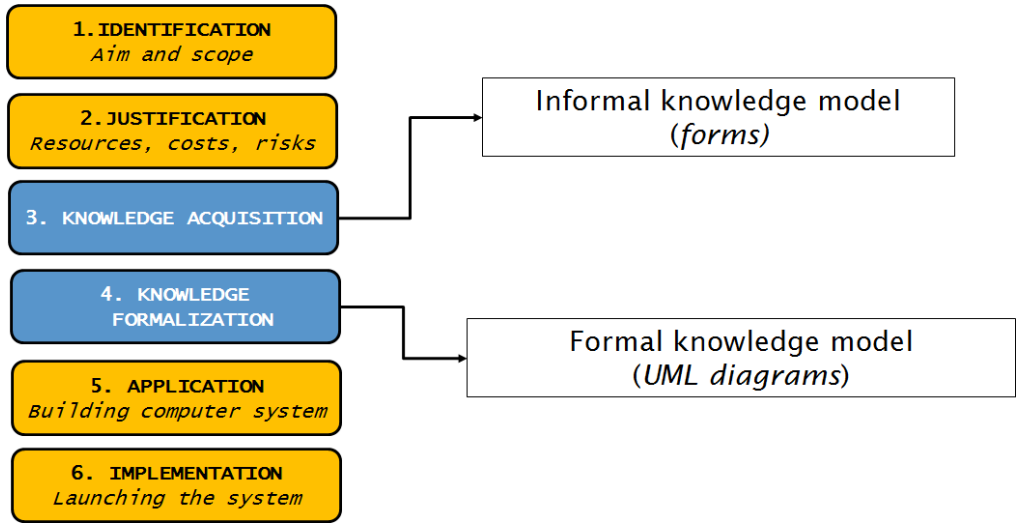
Table 3.1. Requirements of applications of different knowledge levels [Górski et al. 2017]

Features/requirements	Level 1	Level 2	Level 3
Visualization	Static – pre-rendering (possible static images and pre-rendered sequences)	Kinematic – real-time rendering (3D engine, live animation)	Dynamic – real-time rendering with object deformations
Human tissue data form	Illustrative (3D modeled by graphic designer with no medical imaging)	Selected cases (modeled on the basis of pre-selected patient data from medical imaging)	Real data (data from CT scans or other medical imaging, processed for better visualization)
Animations	Simple, pre-rendered	Rigid bodies – real-time, deformations – pre-rendered	Both rigid and deformable bodies in real time
Object manipulation and interaction methods	Mouse, keyboard, graphical user interface, gestures	Graphical user interface, gestures, tracking	Graphical user interface, gestures, tracking, haptic manipulation with force feedback
Collisions and force feedback	Unnecessary	Beneficial	Mandatory if no physical props
Full immersion (HMD)	Beneficial	Needed but not mandatory	Mandatory if no physical props
Required tracking and force accuracy	Low or N/A	medium/low	high
Required computing power	low/medium	medium/high	high
Participation of specialists - medical doctors	Planning stage - definition of requirements	Planning and building stage – sharing procedural knowledge	Planning, building and verification – recording of procedure



Stages of XR application design and preparation process [Górski 2019]

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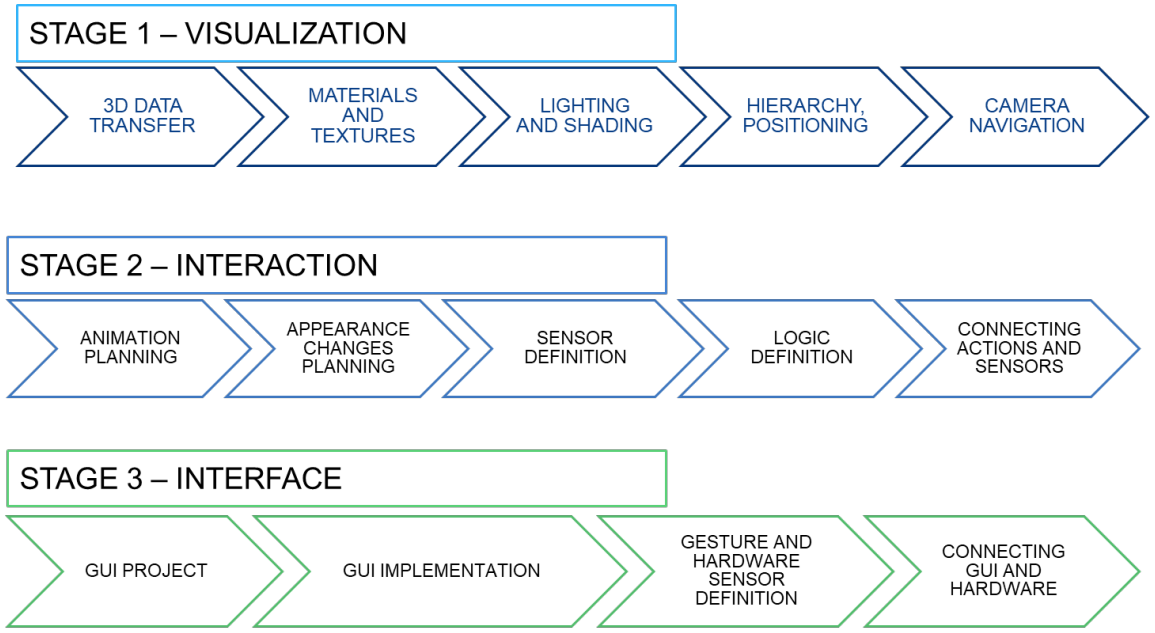
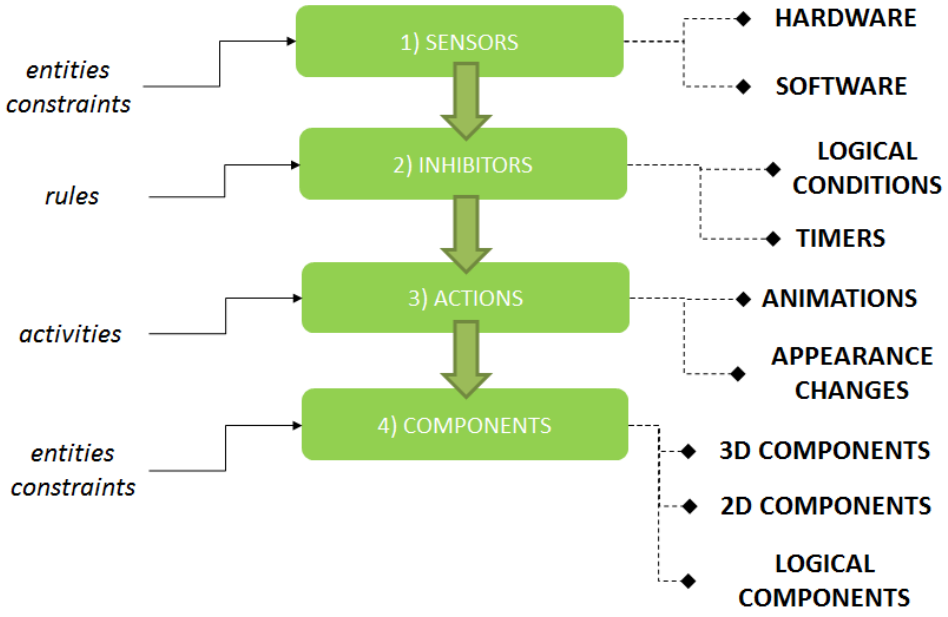
Building medical VR/AR applications



Phases of XR application development process



Main concepts in creating interactions in XR applications

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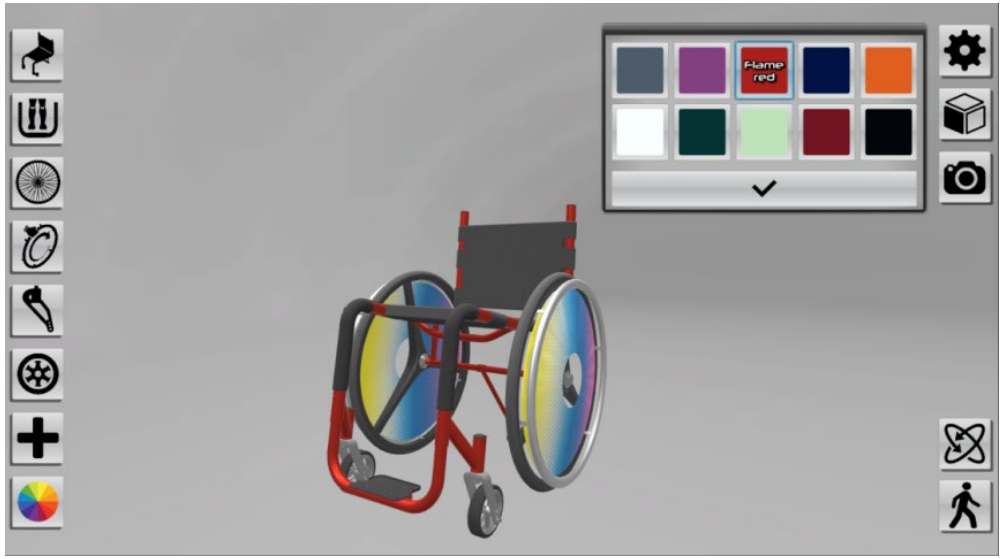
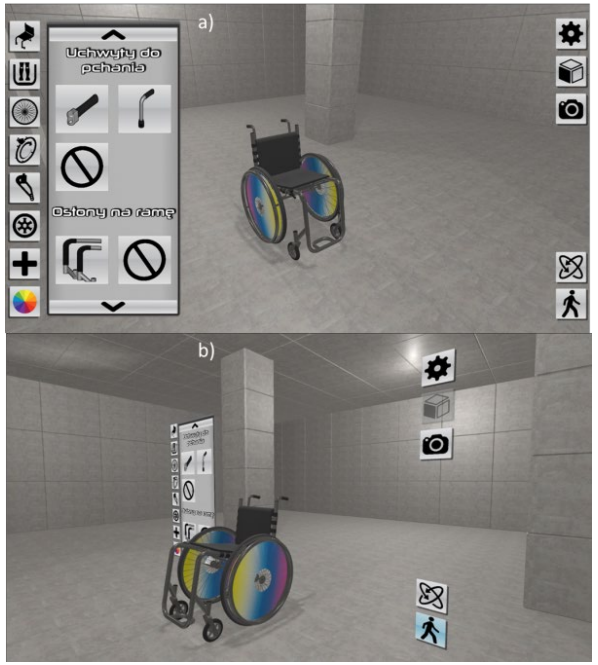
Examples of VR/AR applications for medicine and biomedical engineering



Application - wheelchair configurator [Myślewska 2017]



Wheelchair configurator – standard and immersive mode

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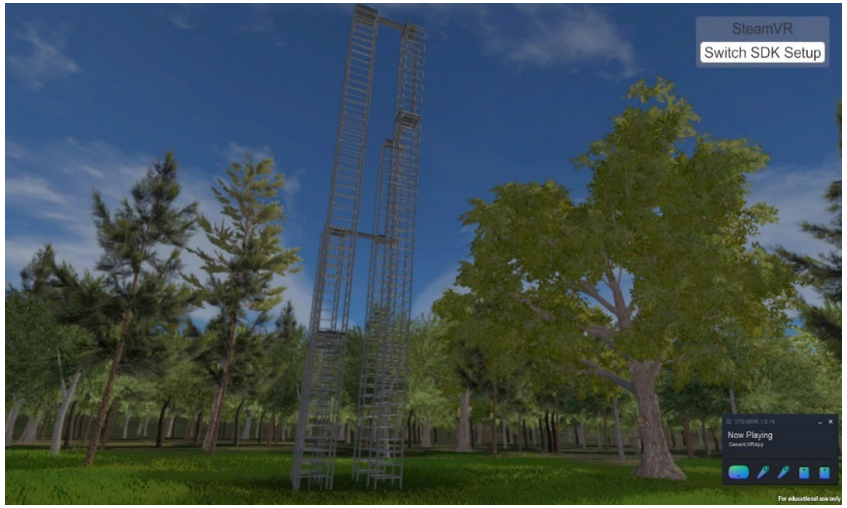
Fear of heights therapy



Fear of heights therapy – ground view [Połczyńska 2020]

Fear of heights therapy – top view [Połczyńska 2020]

Test user making the “swallow” posture [Połczyńska 2020]

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Summary

In this course module, basic information about virtual, augmented and mixed reality techniques were presented. The reader was familiarized with basic concepts and definitions, XR system structure and possible components, as well as applications. Also, a methodology of building XR applications was presented, in form of a development process proposal and description of its particular stages, illustrated with examples of specific applications. Below, effects that should be achieved after familiarizing with the chapter are specified.

1. Reader is able to define, distinguish and classify concepts of Virtual Reality, Augmented and Mixed Reality.
2. Reader has knowledge about Virtual, Augmented and Mixed Reality systems: projection, tracking, gesture recognition and haptics, as well as available software classes for XR application creation.
3. Reader should know about possibilities and examples of application of Virtual Reality systems in product lifecycle for medicine and biomedical engineering.
4. Reader should know how to design an interactive VR application for presentation of properties of a specific product, activity or workplace.

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