

1st Tutorial HEALTHXR XR FOR HEALTHCARE: IMMERSIVE AND INTERACTIVE TECHNOLOGIES FOR SERIOUS GAMES

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Motivation

• The interest towards XR in the field of health is growing

- Many research projects are addressing the use of XR for health
- Many research papers
- (Many) practical uses?
- Which are the open challenges?





Main goal of the tutorial – part 1

- To analyze the state of the art of XR for health
 - Visualization devices
 - Tracking devices
 - Hardware
 - Software techniques
 - Software development
 - Use in health context







Main goal of the tutorial – part 2

- To analyze which perceptual aspects are important to build effective XR solutions
 - Perception-interaction loop
 - Depth of field; Vergence-accommodation conflict;
 - Computational neural models to improve XR applications
 - Use cases: XR applications
 - Teleconsultations







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Main goal of the tutorial – part 3

- XR techniques must be contextualized in a wider context
- Data collection, usage, and sharing
- XR as medical devices and instruments
- The Fit4MedRob (Fit4MedicalRobotics) project example
- Personalization and adaptation







Health and XR

Different health applications

- Rehabilitation
 - Cognitive
 - Physical
- Exposure therapy
- Assessment and recovery
- Medical training











XR technologies as Digital Allied

- Medicine and health technologies are made of
 - Humans (patients, doctors, therapists)
 - Hardware components (instruments, prosthesis, robots)
 - XR technologies may play the role of a "Digital Allied"







PILab@DIBRIS – Perception & Interaction Lab

Perception&Interaction Lab @DIBRIS Università di Genova pilab.unige.it











Binocular Disparity

Blur plus Disparity











The presenters

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XR AND

REHABILITATION

Applications and future developments of VR, AR and XR for rehabilitation

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EXTENDED REALITY (XR)

REAL ENVIRONMENT AUGMENTED REALITY (AR) AUGMENTED VIRTUALITY (AV)



AV) VIRTUAL REALITY (VR)



Milgram continuum, 1994

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virtual

Slide: 14 **VELO**













EXTENDED REALITY (XR)

NON-IMMERSIVE VR (DISPLAYS/TABLETS)



SEMI-IMMERSIVE VR (CAVE)



IMMERSIVE VR (HMD)



immersivity and sense of presence

acceptability















XR AND REHABILITATION Immersivity and sense of presence

[...] presence in virtual reality as the extent to which **people respond realistically within a virtual environment**, where response is taken at every level from low-level physiological to high-level emotional and behavioural responses.

We suggest, for the sake of clarity, an alternative terminology. We have called PI the 'being there' qualia that was referred to as 'presence' in the original literature: it is **the feeling of being in the place depicted by the virtual environment** (even though you know that you are not there). We call the **Psi the illusion that what is happening is real** (even though you know that it is not real).

M. Slater, M. Usoh, & A. Steed. Depth of presence in virtual environments. Presence: Teleoperators & Virtual Environments, 1994 M. Chessa, G. Maiello, A. Borsari, & PJ Bex . The perceptual quality of the Oculus Rift for immersive Virtual Reality. Human–computer interaction, 2019. THE 31** IEEE CONFERENCE ON VIRTUAL REALITY AND 3D USER INTERFACES











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XR AND REHABILITATION Immersivity and sense of presence





M. Chessa, G. Maiello, A. Borsari, & PJ Bex . The perceptual quality of the Oculus Rift for immersive Virtual Reality. Human–computer interaction, 2019. THE 31st IEEE CONFERENCE ON VIRTUAL REALITY AND 3D USER INTERFACES Slide: 17 **Slide:** 17











XR AND REHABILITATION Which visualization technologies?





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C. Bassano, M. Chessa and F. Solari, "Visualization and Interaction Technologies in Serious and Exergames for Cognitive Assessment and Training: A Survey on Available Solutions and Their Validation," IEEE Access, 2022 THE 31st IEEE CONFERENCE ON VIRTUAL REALITY AND 3D USER INTERFACES Slide: 18 Seciety











XR AND REHABILITATION The role of interaction

Virtual Reality: the computer-generated simulation of a threedimensional image or environment **that can be interacted with in a seemingly real or physical way by a person** using special electronic equipment, such as a helmet with a screen inside or gloves fitted with sensors.























300

250

200

150

100

50

Completion time [s]







All states



SHAPERSORTER EXERGAME



C. Bassano, M. Chessa, F. Solari (2020) A Study on the Role of Feedback and Interface Modalities for Natural Interaction in Virtual Reality Environments. HUCAPP













XR AND REHABILITATION Which interaction technologies?



VS





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XR AND REHABILITATION The role of passive haptics







L. Gerini, F. Solari, M. Chessa. A cup of coffee in Mixed Reality: analysis of movements' smoothness from real to virtual. IEEE ISMAR22 THE 31st IEEE CONFERENCE ON VIRTUAL REALITY AND 3D USER INTERFACES Slide: 23 Slide: 23 Slide: 23 Slide: 23 Slide: 24 S













XR AND REHABILITATION

To extend the reality!

Virtual Environment (context, gamification)

Real Environment (robot, objects, interaction)



real chair









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clustered chair







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XR AND REHABILITATION Validation and User Studies





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XR AND REHABILITATION A big gap...







Workshops

Workshops
Multi-modal Affective and Social Behavior Analysis and Synthesis in Extended Reality (MASSXR)
First Workshop on VR for Exergaming (VR4Exergame)
KELVAR Workshop: K-12+ Embodied Learning through Virtual and Augmented Reality
4th Annual Workshop on 3D Content Creation for Simulated Training in eXtended Reality (TrainingXR)
Workshop on Emerging Novel Prototyping Techniques for XR (ENPT XR)
2nd International Workshop on eXtended Reality for Industrial and Occupational Support (XRIOS)
2nd XR Health workshop - XR Technologies for Healthcare and Wellbeing (XR Health)



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XR AND REHABILITATION A big gap...







HMDs or displays?



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HMDs may cause problems

- Many categories of patients cannot use HMDs
- Sickness and undesired effects
- But also
 - Cannot be excluded from the real world
 - Must maintain the visual contact with parents or caregivers
 - Do not accept wereables











Designing a VR exergame

Of course, your patients could wear the last generation helmet, and with controllers could simulate a real experience! r

We would like an exergame to make rehabilitation effective and fun!



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We were thinking more about catching a red ball while sitting in front of the TV. The exergme must be delivered at home, patients do not like VR, and the hospital has no money to buy devices! NAME AND A DESCRIPTION OF





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Use case: VR for the RETT syndrome

- Rett syndrome is a rare genetic neurological disorder that occurs almost exclusively in girls,
- It leads to severe impairments, affecting nearly every aspect of the child's life: their ability to speak, walk, eat, and even breathe easily.
- The hallmark of Rett syndrome is near constant repetitive hand movements.
- Rett syndrome is usually recognized in children between 6 to 18 months as they begin to miss developmental milestones or lose abilities they had gained.
- At the moment, it is impossible to use HMDs with girls affected by the RETT

https://www.rettsyndrome.org/ https://www.airett.it/











- Application to propose reaching task and actions to prevent stereotyped movements
 - A VR environment seems promising!











- Girls like special effects and reward is important to motivate them.
 - Again, a VR environment seems promising!











State of the state states

- Girls cannot wear HMDs
 - A big display may be a good solution!







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- Girls cannot use controllers (we will discuss later about tracking)
 - We track them with a ZED camera (but...)







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VR for RETT syndrome: goals and requirements

- Girls need a tactile feedback
 - A physical proxy triggering the action may solve the problem







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VR for RETT syndrome: open issues

- Solutions to take care of all the constraints may hamper:
 - Sense of presence in the VR
 - Sense of agency
 - Visuo motor coherency
 - Am I really touching the object I am seeing?
 - What is triggering the reward?



Tracking the user (and // the real environment)

Pose estimation







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Full body tracking (motion capture systems)

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[OPTITRACK]

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Full body tracking (motion capture systems)

PROs and CONs

- Very good accuracy
- Full body tracking
- For CG animations (videogames, movies,...)
- Very expensive
- Dedicated rooms, calibration, technicians
- Tracking hands' movements needs dedicated solutions (but hands are important for interaction)







Hands tracking (motion capture systems)













Hands tracking (Vision – Leap Motion)













Hands tracking (Vision – Standard cameras)

[CVPR,2019]











Hands tracking (Vision – Oculus Quest cameras)















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Pose estimation

- 2D human pose estimation is used to estimate the 2D position or spatial location of human body keypoints from visuals such as images and videos.
- 3D Human Pose Estimation is used to predict the locations of body joints in 3D space. Besides the 3D pose, some methods also recover 3D human mesh from images or videos.
- Human Pose modeling





Pose estimation

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Pose estimation – markerless techniques

OPENPOSE









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DEEPLABCUT











Pose estimation – markerless techniques













In rehabilitation...











Inverse kinematics

- Forward kinematics: compute the end-effector position from joint angles
- Inverse kinematics: compute the (possible) joint angles from the position of the end-effector











Inverse kinematics























- <u>http://root-motion.com/2016/06/inverse-kinematics-in-dead-and-buried/</u>
- <u>https://assetstore.unity.com/packages/tools/animation/final-ik-</u>

Solvers	Solutions
Aim IK	Baker - recording Humanoid/Generic/Legacy animation
Arm IK	Grounder - foot placement correction for all creatures
Biped IK	Interaction System - procedural IK interactions
CCD IK	Rotation Limits - angular, polygonal, spline and hinge constraints
FABRIK	Hit Reaction - procedural IK reactions to bullet hits
Finger Rig	Aiming guns, bows and melee weapons
Full Body Biped IK	Animation warping
Leg IK	Driving rigs
Limb IK	Mapping full body avatars to VR anchors
Look-At IK	
Trigonometric IK	+65 demos about all kinds of use cases
VR IK	



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Pose estimation and user tracking

- Different solutions
- The need of having flexible solutions
- Same application, different pose estimator or tracking solutions depending on the requirements











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[IMMERSE Viola et al., IEEE GEM24]







Users representation

Self-avatar and others' avatars











Fit for Medical Robotics

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Interaction in XR

Controllers? Cameras? Others?



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Interaction in Virtual Reality – free hands vs controller





C. Bassano, M. Chessa, F. Solari (2020) A Study on the Role of Feedback and Interface Modalities for Natural Interaction in Virtual Reality Environments. HUCAPP











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Self Representation and Interaction in Immersive Virtual Reality

Submitted to

HUCAPP 2021 – 5th International Conference on Human Computer Interaction Theory and Applications



E. Viola, F. Solari, M. Chessa (2021) Self Representation and Interaction in Immersive Virtual Reality HUCAPP21















Not affected by occlusions

Not dependent on a hand model















Computer Vision algorithms (illumination, noise)



Affected by occlusions and limited field of view



Dependent on a hand model















C. Bassano, M. Chessa, F. Solari (2020) A Study on the Role of Feedback and Interface Modalities for Natural Interaction in Virtual Reality Environments. HUCAPP

Gusai et al (2017) ICIAP







Bare hand interaction (fitting problems?)

Robust tracking of the palm

Drift of the fingers











Use case: medical simulation and training with passive haptics

Physical mannequins



Virtual Reality













Ricci, S., Mobilio, G. A., Calandrino, A., Pescio, M., Issa, E., Rossi, P., ... & Casadio, M. (2021, November). RiNeo MR: A mixedreality tool for newborn life support training. In 2021 43rd Annual International Conference of the IEEE Engineering in Medicine & Biology Society (EMBC) (pp. 5043-5046).

Girau, E., Mura, F., Bazurro, S., Casadio, M., Chirico, M., Solari, F., & Chessa, M. (2019, July). A mixed reality system for the simulation of emergency and first-aid scenarios. In 2019 41st Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC) (pp. 5690-5695).

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- Familiarization with the system
- 4 questionnaires (background, RAQ, SSSQ, IPQ)²

subjects (30 ± 12 years, 24 females)

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ORLANDO, FL USA

2. Realism Assessment Questionnaire (RAQ), Short Stress State Questionnaire (SSSQ), Igroup Presence Questionnaire (IPQ)







NTNU Norwegian University of Science and Technology

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XR as a Digital Allied

The Fit 4 Medical Robotics experience









The Fit4MedRob ICT infrastructure



Robotic platform Telemedicine systems XR environments

Are all part of the Delivery

Main goal: Robots and XR will become medical devices

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The Fit4MedRob ICT infrastructure (exergames)

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Exergames integrated with Homing and D-Wall (Tecnobody)











Thanks to

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FIT4 MED ROB

Fit for Medical Robotics



