Virtual Reality

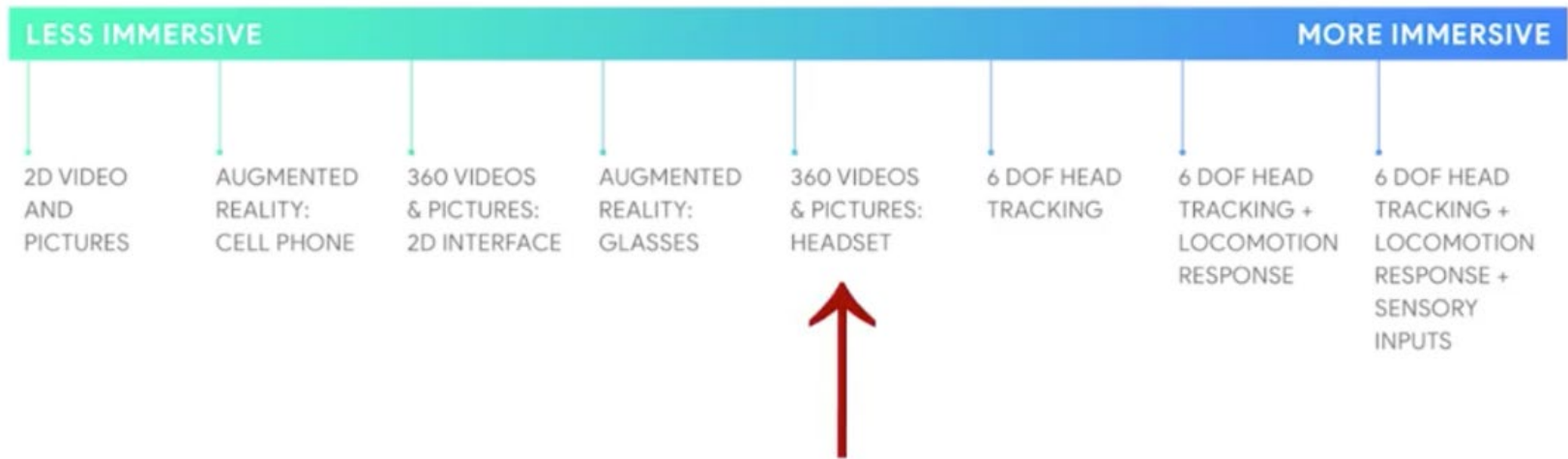From the basics of VR to complex medical applications

Iulia-Cristina Stănică, PhD

Definition

- Virtual Reality (VR) is an **emerging technology** that creates a realistic environment through **computer means.**

- Virtual reality has continued to evolve over time, focusing on stimulating the user's senses: **sight**, **hearing** and sometimes even **haptic perception**.

- Focusing on the authenticity of immersion, modern virtual reality can bring many benefits when used in many areas, such as accessibility, flexibility, creating diverse environments, permanent feedback

Virtual Reality

The Virtual Reality Spectrum

LESS IMMERSIVE — MORE IMMERSIVE

2D VIDEO AND PICTURES

AUGMENTED REALITY: CELL PHONE

360 VIDEOS & PICTURES: 2D INTERFACE

AUGMENTED REALITY: GLASSES

360 VIDEOS & PICTURES: HEADSET

6 DOF HEAD TRACKING

6 DOF HEAD TRACKING + LOCOMOTION RESPONSE

6 DOF HEAD TRACKING + LOCOMOTION RESPONSE + SENSORY INPUTS

Virtual Reality - concepts

- Virtual environments
- Avatar
- Immersion
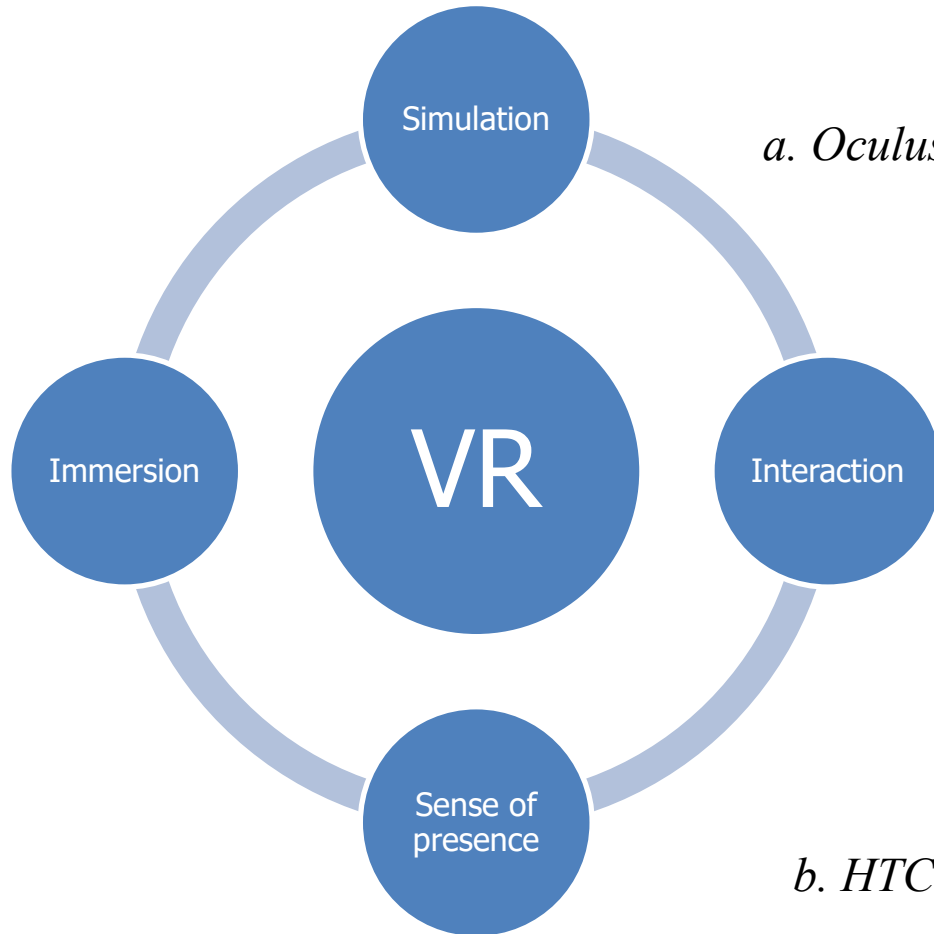- Telepresence
- Virtual economies
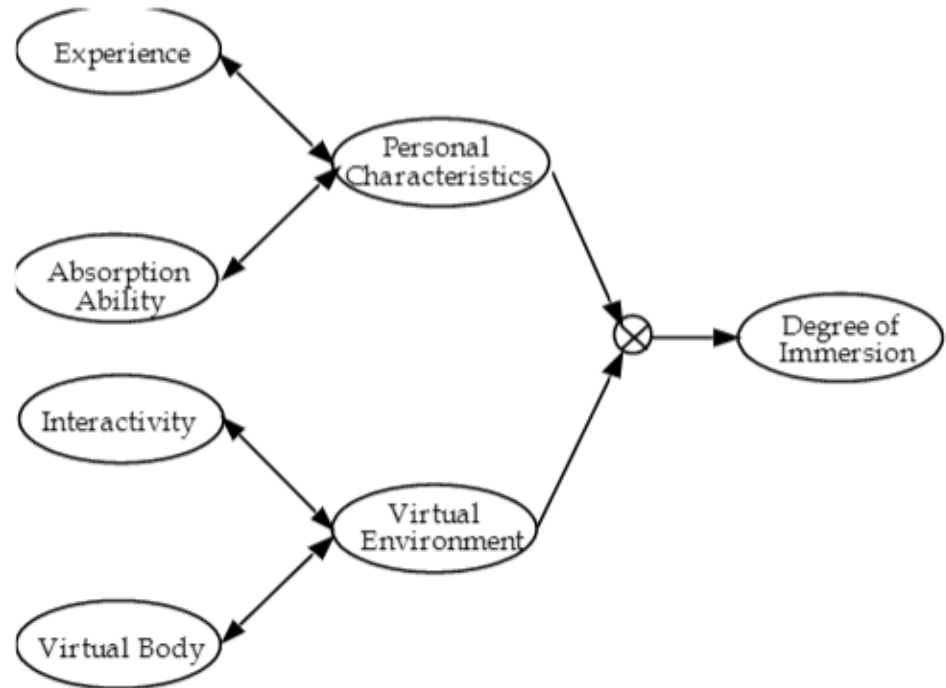
The Theory of Cognitive Immersion.
The Cognitive Factors of Embodiment and Interaction in Virtual Environments.
Jolanda G. Tromp

VR - Characteristics

Simulation

Immersion

VR

Interaction

Sense of presence

a. Oculus Rift

b. HTC Vive

Virtual Reality
Information and Communications Technology based Innovation

5

VR - Characteristics

- **Simulation** = creation of a logical model of a real or imaginary element, taking into account the reproduction of the components through which the element is perceived at sensory level (e.g. animations).

- **Interaction** is generally specific to computers, not necessarily virtual reality - it refers to the transmission of commands using input devices and the real-time observation of their effects, calculated in virtual space.

- The **sense of presence** is defined as the psychic perception of "being present" or "existing" in the virtual environment in which the subject is immersed.

- **Immersion** - probably the most complex component - it contains *sensory immersion* (HMDs or other additional devices), *mental immersion* (how to perceive the world mentally) and *emotional immersion* (feelings caused by the virtual environment).

VR History

- 1950s – the concept of VR in SF movies

- 1962 - Morton Heilig patented a prototype called **Sensorama**, a machine that offered users a multi-sensory cinematic experience, stimulating sight, hearing, smell and haptic sense.

- 1960s – first HMDs including head motion tracking

- 1965 - "The ultimate display" – revolutionary concept: world seen through an HMD, including sounds and haptics (= ancestor of modern VR)

Sensorama device

VR History

- 1987 – the term "virtual reality" is created

- 1990s – Arcade companies become interested by VR, creating innovative machines or consoles

- 21st century: rapid development of VR, technology becomes available for mobile phones; great support from the game industry

VR – History vs Present

History

- Relatively old technologies (>50 years)

- But, until recently, very expensive

- Limitations in capabilities

- Limitations in computing power

➢ few application, only in "rich" areas: military, medical training.

➢ few scenarios, slow growth

Present

- Boom of powerful yet cheap devices   (Oculus/Vive ~ 500$, Kinect 100$, LeapMotion 80$ etc.)

- Nice computing power (GPUs !)

- Mobile computing as well

- Plenty of scenarios become feasible

- Application market expected to boom in a few years

VR Devices

- Head mounted displays (HMDs) e.g. HTC Vive, Oculus, Playstation VR
- Tracking devices (body, hands, head)
- Haptic gloves, vests, force feedback
- Joysticks, wheels, treadmills, CAVEs etc.
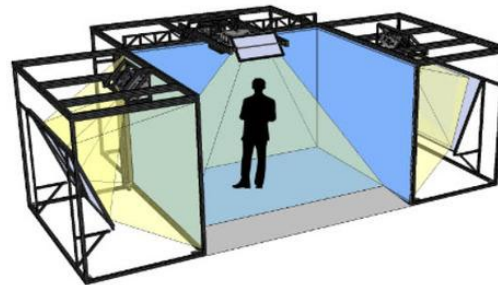
Virtual Reality - applications

- **Games**
- **Training simulators**
- **Scientific simulations**
- **Various domains**:
  - Army (see https://www.americasarmy.com/)
  - Medicine (surgery simulators, therapy etc.) see https://youtu.be/p4vO64Y27JE
  - Education (training, explorations, experiments)
  - Psychology (therapy)
  - Arts (3D museums)
  - Industry, constructions etc.

Virtual Reality in Education

- Advantages such as:
  - creating new learning methods (non-traditional)
  - improve analytical and exploratory capacity of students
  - present educational content in an original manner
  - present past or inaccessible facts, notions or processes

- Examples:
  - Presenting events from the Antic Greece
  - Virtual journeys inside the human body
  - Applications with virtual teachers / supervisors
  - Creating collaborative learning environments

Virtual Reality in Education
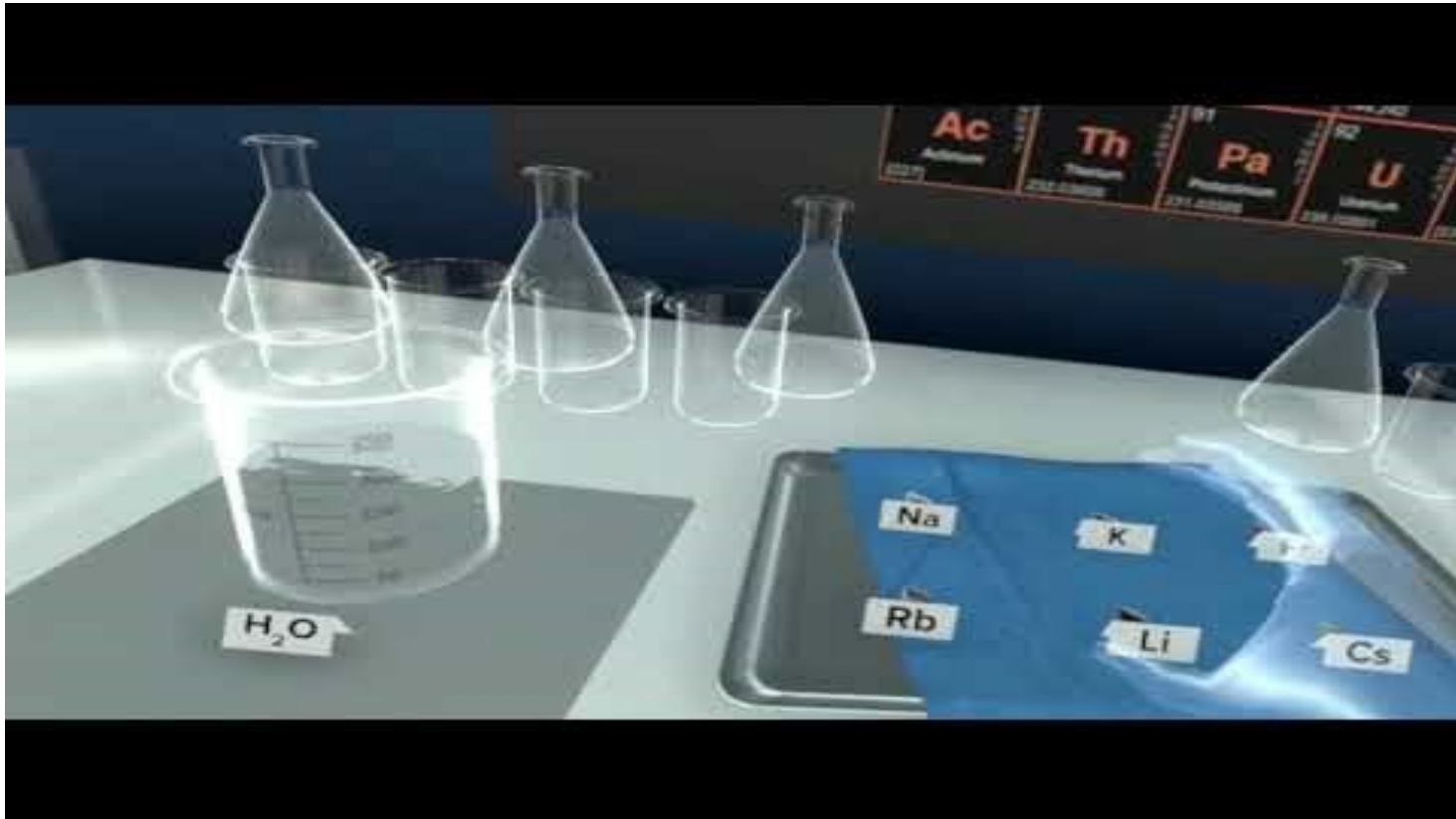
Virtual Reality in Army

- One of the first domains to use VR

- Advantages such as:
  - Costs reduction of the training
  - Increasing safety and accessibility

- Examples:
  - Flight simulators
  - SIMNET - training program for teamwork
  - Training of military doctors for medical triage

Virtual Reality in Games

- By far the most popular category of virtual reality applications

- An integral part of today's "culture" and entertainment (the gaming industry surpasses the cumulative film and music industry)

- Various genres: shooter, adventure, role-playing (RPG), simulations, strategy, sports, racing etc.

- Based on number of players: singleplayer, multiplayer, MMORPG

Virtual Reality in Games (Popular titles)

Half-Life Alyx

Beat Saber

No Man's Sky

Minecraft VR

Skyrim VR

Superhot VR

Virtual Reality in Medicine

- VR becomes more and more popular in medicine, including:
  - Educational application in the medical field (anatomy lessons for children, students etc.)
  - Medical simulator (e.g. surgery)
  - Treatment of neurological disorders (e.g. phobias, autism, post-traumatic stress, pain management – for example after burns -, dementia, depression, ADHD)
  - Training in the medical field (physical or psychological rehabilitation)
  - Addiction treatment
  - Psychological reconciliation
  - Socialization or social reintegration for disadvantaged categories (e.g. people with disabilities, sick etc.)

Medical education

- Virtual worlds are an interesting area for the medical field, offering opportunities in both the teaching of anatomy and clinical interventions.

- By viewing large volumes of information in 3D, residents and students can understand important **physiological principles** or **basic anatomy**.

- In addition to anatomical training, VR has been used to teach the ability to perform various non-surgical tasks, such as electrocardiogram, application of first aid techniques, or specific ophthalmology procedures.

Medical education - Examples

- **Second Life** - an online virtual world, similar to an MMORPG game; it has been used for disaster simulation, nurse training, nutrition

- **Stanford and Cambridge Universities** – use Virtual Reality simulators which help study the anatomy of the human body (including the study of cancerous tumours).

Surgery simulators

- In surgical simulators that use virtual reality, **complex procedures and difficult tasks** can be trained and practiced so that residents become familiar with stressful situations and environments.

- Some surgeries cannot be seen live by a large number of people, while others are rare in real life, so the training process can be difficult without the help of virtual reality.

- Idea exists from **1995**

- Virtual reality models can be **customized** for each patient, depending on the results of x-rays or other clinical investigations.

Treatment of neurological disorders

- Nowadays, there is a worrying increase in the number of people suffering from mental disorders, which is very serious given that these types of diseases are very difficult to treat.

Compared to other mental disorders, anxiety disorders are much more common, although they often do not receive the attention they deserve.
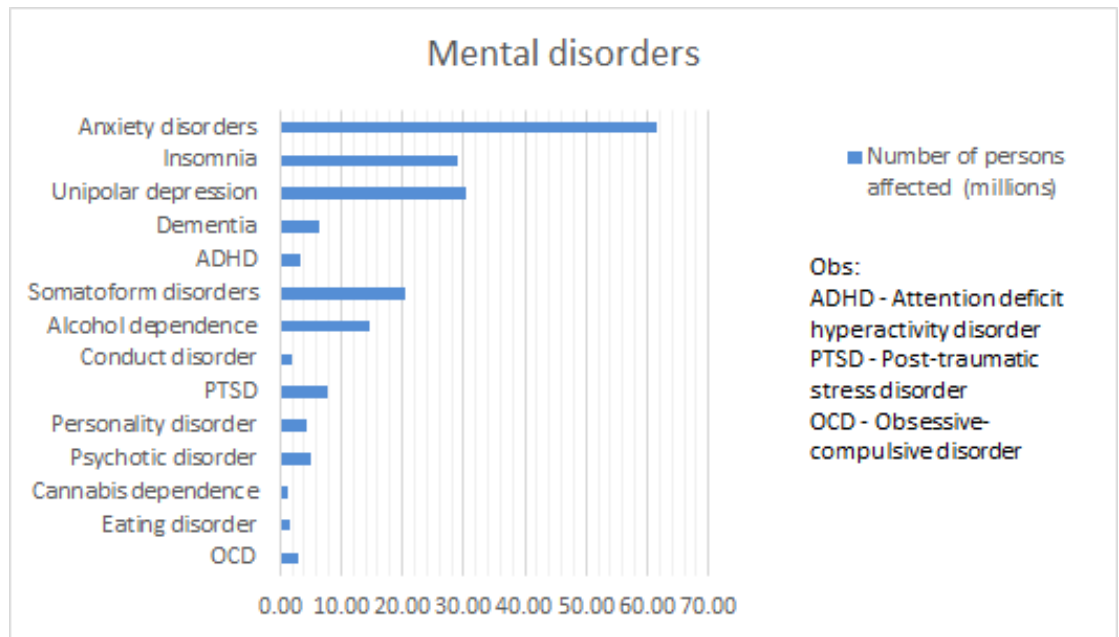
Mental disorders in Europe (2016)

Treatment of neurological disorders
Anxiety disorders

- There are many anxiety disorders, such as **phobias, panic disorder, or generalized anxiety disorder.**

- A number of methods are commonly used to treat anxiety disorders, such as **medical treatment** or **cognitive-behavioral psychotherapy**.

- Instead, **exposure therapy** is considered the most effective. Therapy consists of gradually exposing the patient to his fear, without any real danger.

Treatment of neurological disorders
# Phobias - examples

- **SpiderWorld** - Probably one of the first applications of virtual reality to treat phobias was to treat arachnophobia (fear of spiders). It was developed in 1998 by a group of researchers and psychologists from the International Laboratory of Technology and the Human-Computer Interface in the USA.

Treatment of neurological disorders
Phobias - examples

- **Anti-PHOBIES** - an application that uses virtual reality to treat phobias (claustrophobia and acrophobia), developed in FILS, UPB, as a bachelor project. It is an application that develops a flexible and interactive environment, oriented towards self-treatment and self-training.
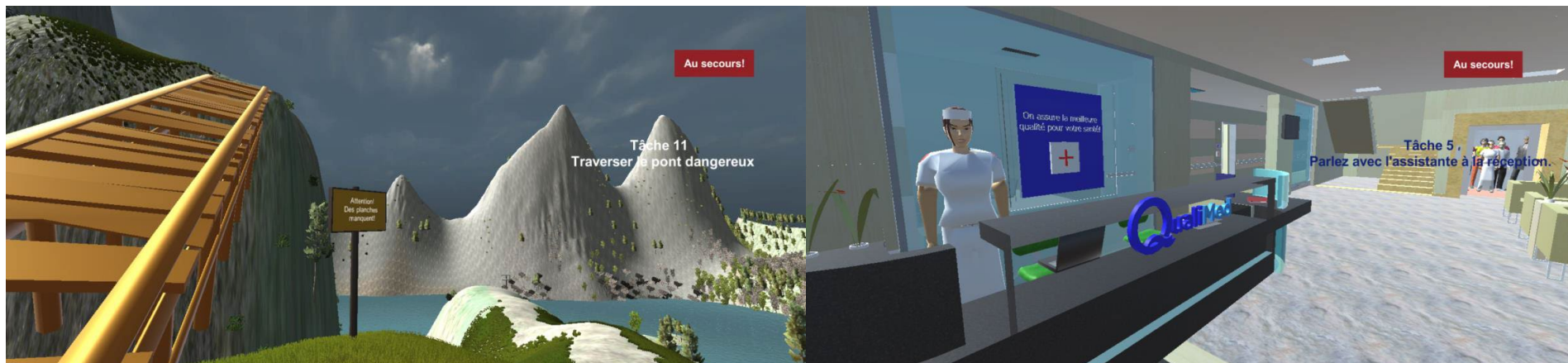
Treatment of neurological disorders
PTSD

- **Post-traumatic stress disorder** (PTSD) is a mental illness that develops in some people who have experienced or witnessed a shocking, frightening, or dangerous event.

- PTSD symptoms are generally grouped into four categories: intrusive memories, avoidance, negative changes in thinking and mood, and changes in physical and emotional reactions.

- Examples: Virtually Better (company that created VR-based mobile apps for treating anxiety disorders), Bravemind (University of Southern California Institute for Creative Technologies, treating soldiers from Vietnam or Irak)

Treatment of neurological disorders
# Autism, addictions

- Recent studies highlight the benefits of using virtual reality-based interventions, in which people with **autism spectrum disorders** can practice difficult **social interactions** in a platform that causes them less anxiety.

- Vocational training in VR offers several advantages compared to traditional methods of developing social skills, such as **simple tasks of recognizing emotions or role-playing games.**

- Virtual reality is increasingly being used to treat **addictions**, including **alcohol, tobacco, drugs**, and even **computer games**. Therapy is based on exposure, participants are constantly monitored by specialists to monitor their psychological reactions and response to stimuli. Patients are trained to resist addiction, so the realism of VR scenes is extremely important.

Medical rehabilitation

- Medical rehabilitation is the process necessary for recovery from **physical**, **physiological** or **mental illness**.

- Virtual reality and augmented reality can be used for neuro-motor rehabilitation, to assess a number of parameters of the individual: **posture, joint mobility, muscle strength, balance or gait**

- An **example** of this is the **ePHoRt project**, which proposes a telerehabilitation system for rehabilitation after **hip replacement surger**y. It includes a web application based on a client-server architecture, usable by the patient, physiotherapist and doctor. The application has both videos with demonstrations of the exercises to be reproduced by the patient, as well as a 3D avatar that reproduces in real time the patient's movements captured through an Xbox Kinect device.

Medical rehabilitation INREX-VR

- PhD project developed in UPB
- Neurorehabilitation system with virtual reality
- Upper and lower limb exercises (classics + games)
- Animation therapist + user avatars, in real time
- Telemedicine (remote configuration of the therapist using a mobile application)
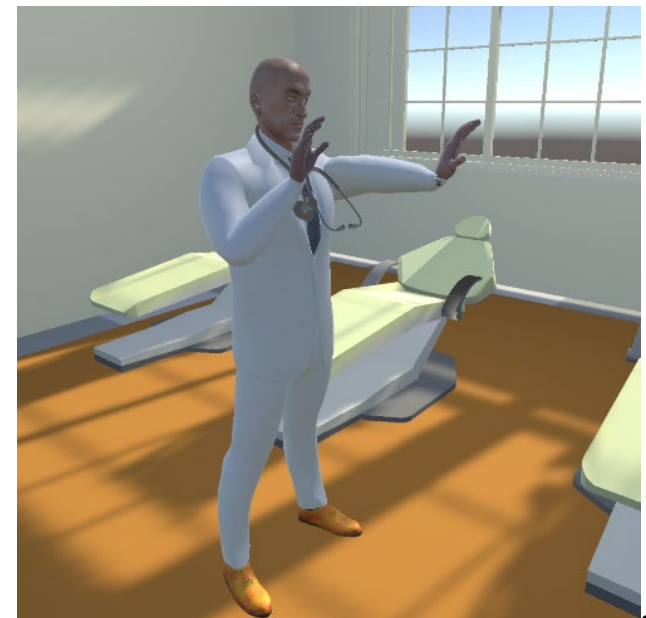
Advantages and disadvantages of VR for medical training

Advantages	Disadvantages
- wide variety of environments	- safety of use (possible side effects: malaise, nausea, headache, dizziness, inappropriate body response or eye fatigue)
- great accessibility (large numbers of people, different rentals)	
- flexibility to the needs of the user	
- reduction of the duration of the implementation of the training	- must fight skepticism
- training in perilous or risky situations	- necessary advanced technological equipment
- an extremely visual and interactive approach	- there are people who suffer from technology phobias: technophobia or cyberphobia
- training process becomes more enjoyable and sometimes fun	
- complex situations broken down into smaller pieces	
- continuous feedback and evaluation	

Conclusions

- Virtual reality is an **emerging technology**, a useful and innovative tool for various fields.

- The **military**, **education**, **medicine** or **entertainment** are just a few examples where virtual reality can offer useful solutions for training or for combating current problems.

- The technology used to be very expensive, but things are getting better and better with the increase of computational power of mobile devices.

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