



Department of Engineering for Innovation  
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Augmented and Virtual Reality Laboratory  
(AVR Lab)



## New Trends in Virtual Reality and Augmented Visualization

*Lucio Tommaso De Paolis*

## Overview

- Virtual Reality and Augmented Reality technologies
- VR and AR applications
- visualization and interaction systems

## Virtual Reality

Environment

Computer

Senses

User



“A high-end user interface that involves real-time simulation and interaction through multiple sensorial channels (vision, sound, touch, smell, taste)”

Simulation

Interaction

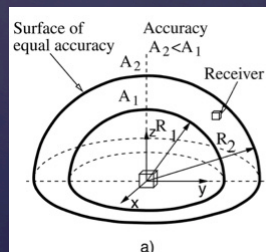
Immersion

Presence

## Input Devices

**Trackers** measure the motion of “objects” such as user’s wrist or his head vs. a fixed system of coordinates

- ✓ magnetic trackers
- ✓ mechanical trackers
- ✓ optical trackers





## Input Devices

### Optical Trackers

*non-contact position measurement devices that use optical sensing to determine the real-time position/orientation of an object*

- Passive
- active

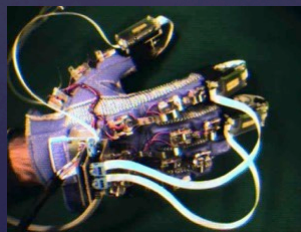


## Input Devices

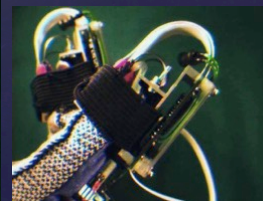
5DT Data Glove



The CyberGlove



PERCRO Glove



## Output Devices

The human senses need specialized interfaces

- ✓ graphics displays for visual feedback
- ✓ 3-D audio hardware for localized sound
- ✓ haptic interfaces for force and touch feedback
- ✓ low interest in smell feedback

## Output Devices

Sensics piSight HMD



5DT SenszTech HMD



Olympus Eye Trek Face Mounted Display Optics

## Output Devices

### Active glasses



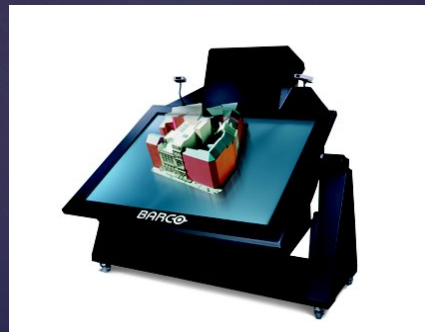
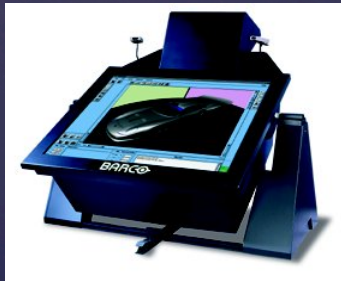
wireless



wired

## Output Devices

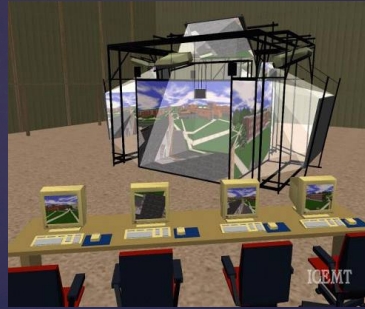
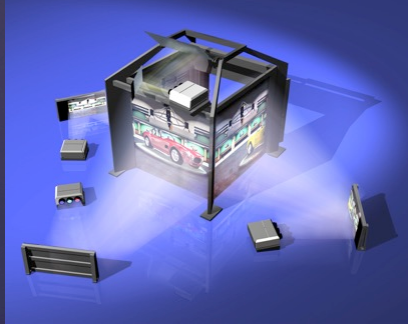
### Projector-based Large-Volume Displays



Baron workbench (courtesy of BARCO Co.)



## Output Devices



CAVE 3D large volume display (courtesy of Fakespace Co.)

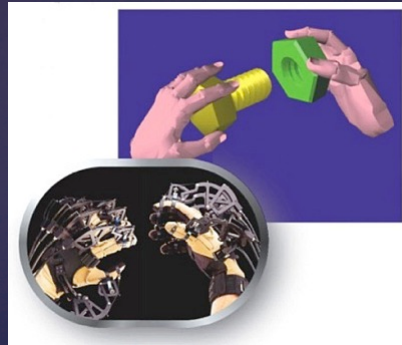
## Output Devices – Oculus Rift

The Oculus Rift combines a low-latency tracking system that enables the sensation of presence in the virtual environment and the Oculus Touch



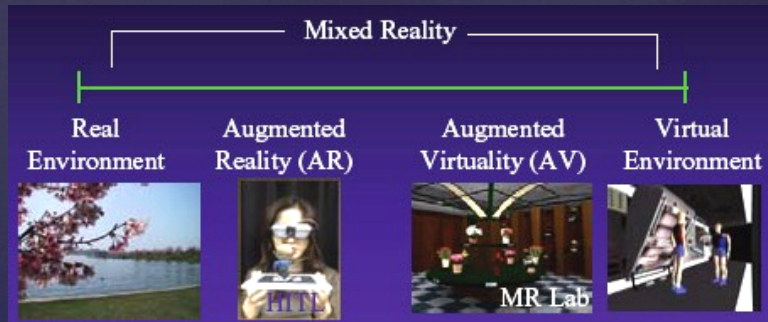
## Output Devices – Haptic Interfaces

Comes from Greek *Hapthai* meaning the sense of touch



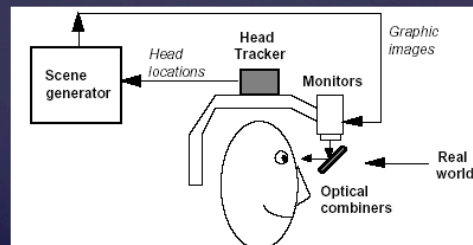
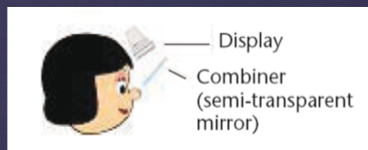
Augmented Reality Technology

# Virtual and Augmented Reality



# Augmented Reality Technology

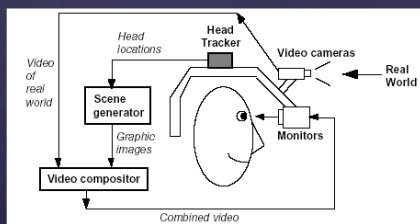
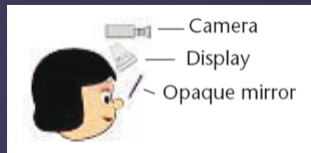
optical see-through





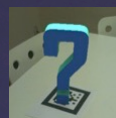
# Augmented Reality Technology

video see-through

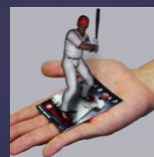


# Augmented Reality

✓ Marker detection



✓ Markerless detection



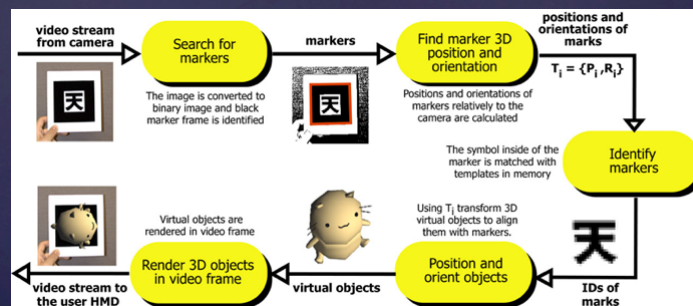
✓ GPS + compass



## AR Toolkit

- ✓ Library for the building of AR applications
- ✓ Use of computer vision algorithms based on marker (pattern of black squares)

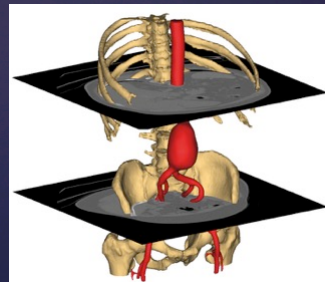
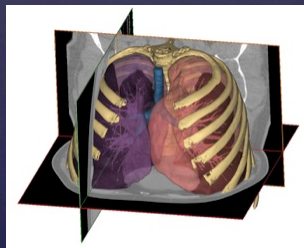
<http://www.hitl.washington.edu/artoolkit/>



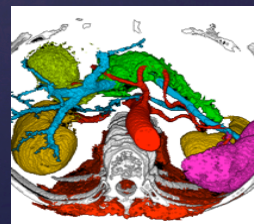
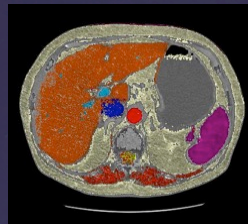
## Virtual Reality in Medicine and Surgery

## Building of the Virtual Environment

- the real patients' images are processed in order to distinguish the anatomical structures and to associate different chromatic scales to the organs
- the **segmentation** and **classification** phases are carried out in order to obtain information about the size and the shape of the organs



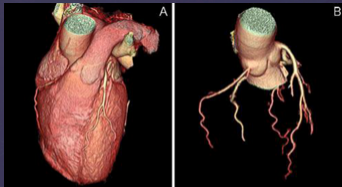
## Building of the Virtual Environment





## Why 3D?

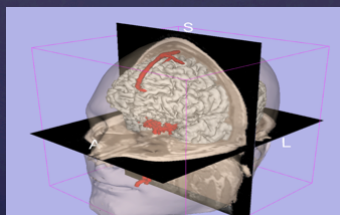
avoiding invasive procedures



surgical preoperative planning



improving diagnosis



surgical training



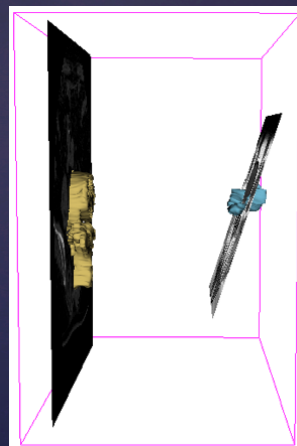
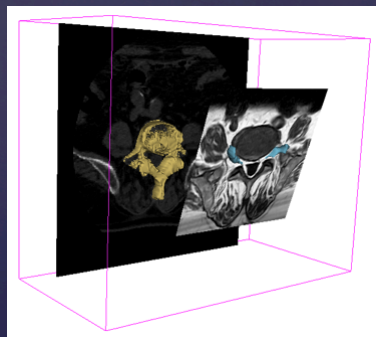
## Segmentation, what is?

- subdivision of an image into regions or constituent objects
- subdivision level driven by the complexity of the problem to be solved
- the process ends when the items have been isolated
  
- by hand: partitioning process of the components through *manual editing*
- semi-automatic: recognition of structures of interest based on some parameters

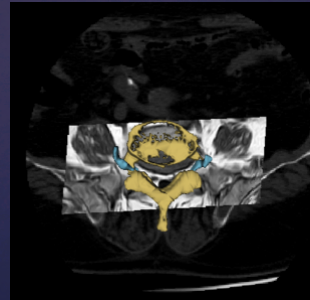
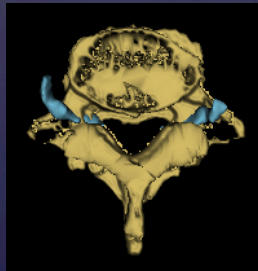
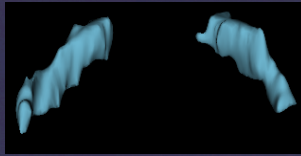
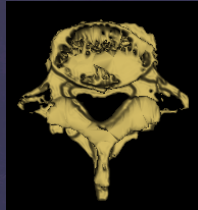
## Registration, what is?

- comparison of information contained in images, thanks to their alignment
- choosing an anatomical area of interest, registration involves a series of CT and MRI images
- this step corresponds to a transformation matrix (phases of rotation and translation)

## Data fusion - Vertebroplasty

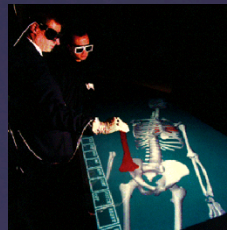


## Data fusion - Vertebroplasty



## Virtual Reality in Medicine

- Computer Aided Surgery
- **Diagnosis**
- Pre-operative Planning
- **Training**
- Telesurgery
- **Rehabilitation**





## Why simulation?

The training on virtual patients met the growing need for training in Minimally Invasive Surgery

Many of these procedures need to be learned by repetition; new and unusual surgical procedures can be practiced in a safe manner

A simulator incorporates both realistic graphics and the sense of touch (force feedback)



- ✓ to increase experience
- ✓ to increase patient safety
- ✓ to practice medical skills
- ✓ to plan the operative strategy

Simulations will be part of the new system of graduate medical education

## NeuroTouch: A Virtual Simulator for Cranial Microneurosurgery Training

**NeuroTouch** is a virtual simulator with haptic feedback designed for the acquisition and assessment of technical skills involved in craniotomy-based procedures

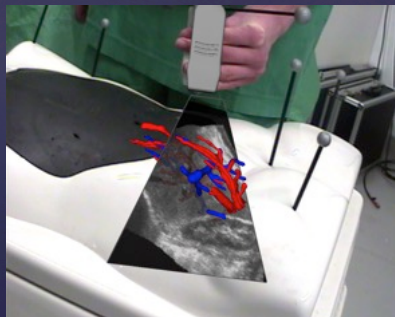


Prototypes have been set up in 7 teaching hospitals across Canada for beta testing and validation and to evaluate integration of NeuroTouch into a neurosurgery training curriculum

## Augmented Reality in Medicine and Surgery

### Augmented Reality in Surgery

- Augmented Reality blends virtual and real in the real environment
- the basic idea is to provide a “X-ray vision”
- to use the high accuracy of medical images not only for diagnostics, but for the operation itself overlaying an image to the surgical field

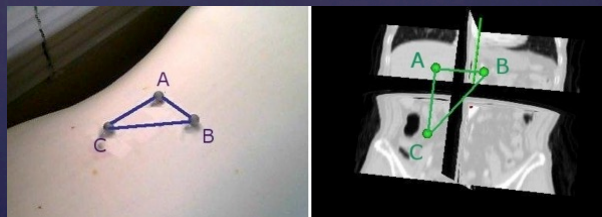


## Augmented Reality in Surgery

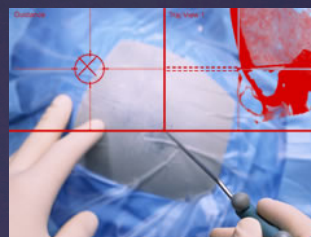
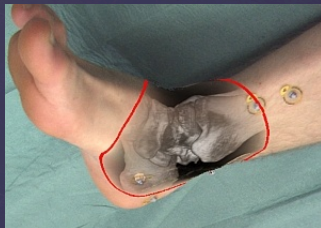
In order to have a perfect correspondence between virtual and real organs it is necessary to carry out an accurate **registration** phase that provides as result the overlapping of the virtual 3D model of the organs on the real patient

The registration phase is carried out just once at the beginning of the surgical procedure

the registration algorithm is based **fiducial points**



## Augmented Reality in Surgery

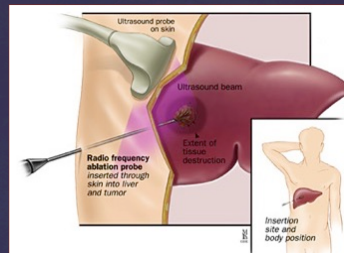




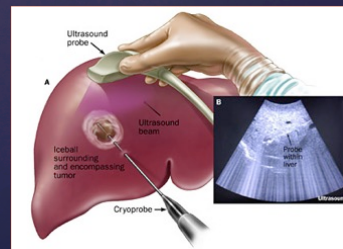
## RFA Ablation of the Liver Tumours

### Hepatic Cancer

The Liver Radiofrequency Ablation (RFA) consists in the placement of a needle inside the liver parenchyma to reach the centre of the tumour



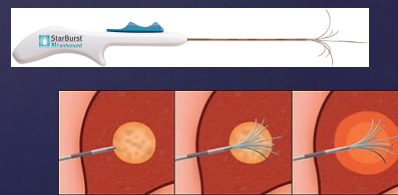
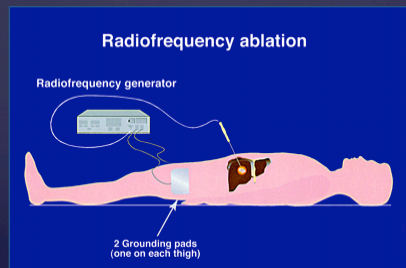
When the lesion is reached, an array of electrodes is extracted from the tip of the needle and a RF current is injected in the tumour tissue in order to cause the tumour cell necrosis for hyperthermia



## RFA Ablation of the Liver Tumour

With the superimposition of the virtual models of the patient's anatomy (liver, cancer, etc) exactly where are the real ones, it is possible to make the needle placement less difficult

In this way the surgery patient's risks and the surgery time should be reduced

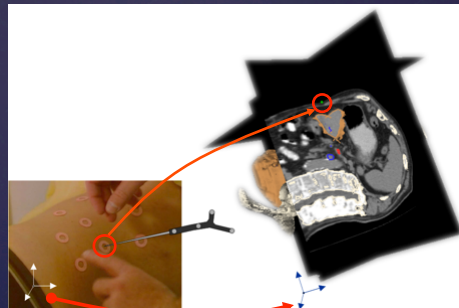


## AR in RFA Ablation of the Liver Tumour

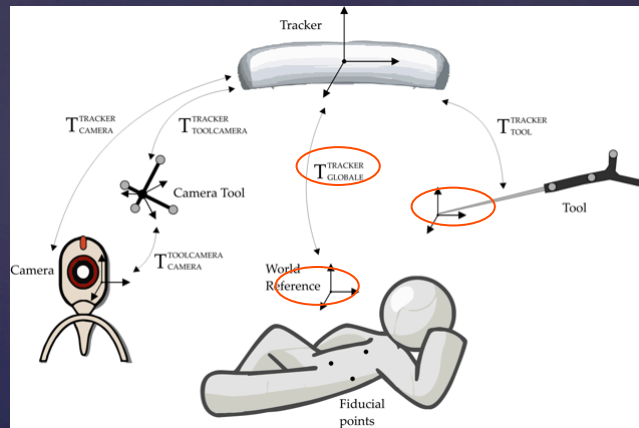
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## AR in RFA Ablation of the Liver Tumour



## Visualization and Interaction



## Gestural Touchless Interface

### Bacterial Contamination of Computer Keyboards in a Teaching Hospital

Maureen Schultz, MSN, CIC; Janet Gill, BSN, CIC; Sabiha Zubairi, MT; Ruth Huber, MS, CIC; Fred Gordin, MD

#### ABSTRACT

We tested 100 keyboards in 29 clinical areas for bacterial contamination. Ninety five were positive for microorganisms. *Staphylococcus*, *Clostridium perfringens*, *Enterococcus* (including one *faecalis*)

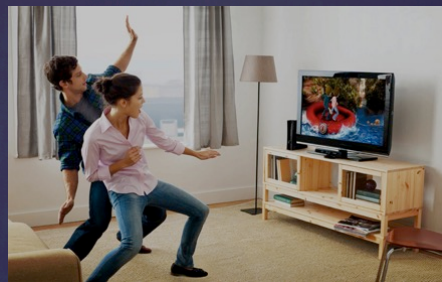
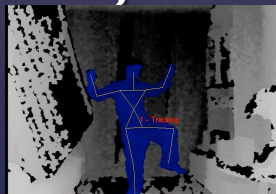
### COMPUTER KEYBOARD AND MOUSE AS A RESERVOIR OF PATHOGENS IN AN INTENSIVE CARE UNIT

Bernd Hartmann, Dr med.,<sup>1</sup> Matthias Benson, Dr med.,<sup>1</sup> Axel Junger, Dr med. habil,<sup>1</sup> Lorenzo Quinzio,<sup>1</sup> Rainer Röhrig, Dr med.,<sup>1</sup> Bernhard Fengler,<sup>1</sup> Udo W. Färber, Dr rer. nat.,<sup>2</sup> Burkhard Wille, Prof Dr med.,<sup>2</sup> and Gunter Hempelmann, Prof Dr med. Dr h.c.

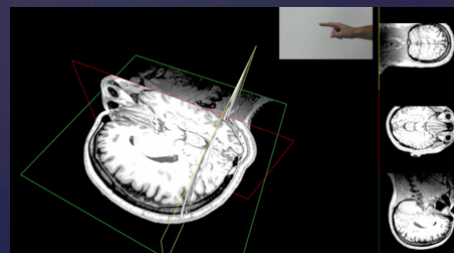
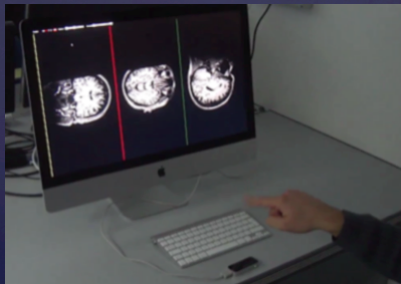
Hartmann B, Benson M, Junger A, Quinzio L, Röhrig R, Fengler B, Färber UW, Wille B, Hempelmann G. Computer keyboard and mouse as a reservoir of pathogens in an intensive care unit. J Clin Monit 2004; 18: 7-12

**ABSTRACT. Objective.** User interfaces of patient data management systems (PDMS) in intensive care units (ICU), like computer keyboard and mouse, may serve as reservoirs for the transmission of microorganisms. Pathogens may be transferred via the hands of personnel to the patient causing nosocomial infections. The purpose of this study was to examine the microbial contamination of computer user inter-

## Gestural Touchless Interface



## Gestural Touchless Interface



## Wearable Touch-Free Control

*Myo - Wearable Gesture Control from @thalmic Labs*

The Myo gesture control armband reads your muscle activity so you can have a touch-free control with gestures and motion

- hand gestures are detected by proprietary EMG muscle sensors containing three-axis gyroscope, three-axis accelerometer, three-axis magnetometer
- communication via bluetooth





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