Realtà Virtuale e Aumentata nelle PMI.

Definizione tematica, ambiti applicativi e metodologia di lavoro

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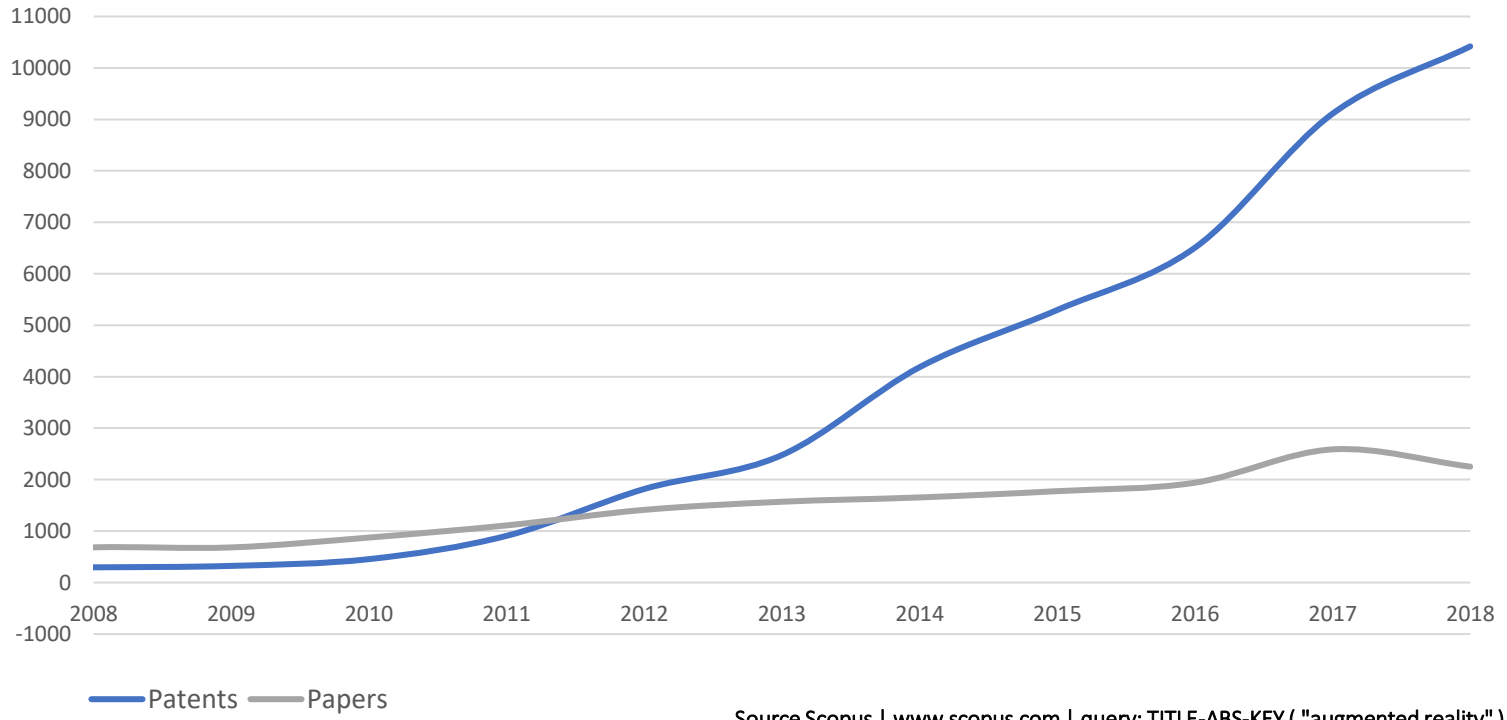
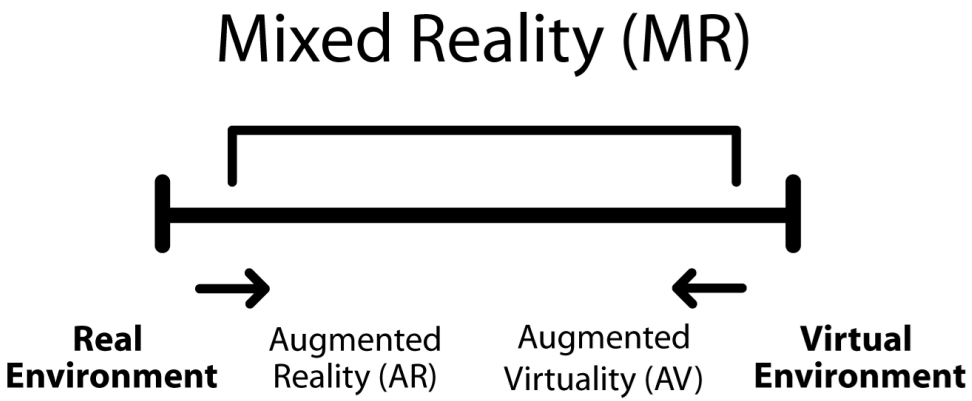
Augmented Reality Trend



Source Scopus | www.scopus.com | query: TITLE-ABS-KEY ("augmented reality")

What is Augmented Reality?

- 1994 - Milgram's definition: "An AR system supplements the real world with virtual (computer – generated) object that appear to coexist in the same space as the real world."



Milgram, P., & Kishino, F. (1994). A Taxonomy of Mixed Reality Visual Displays. *IEICE Transactions on Information Systems*, *E77-D*(12), 1321–1321.

What are the technologies behind AR?

- 1997 - Azuma's definition: "Augmented Reality is a technology which:

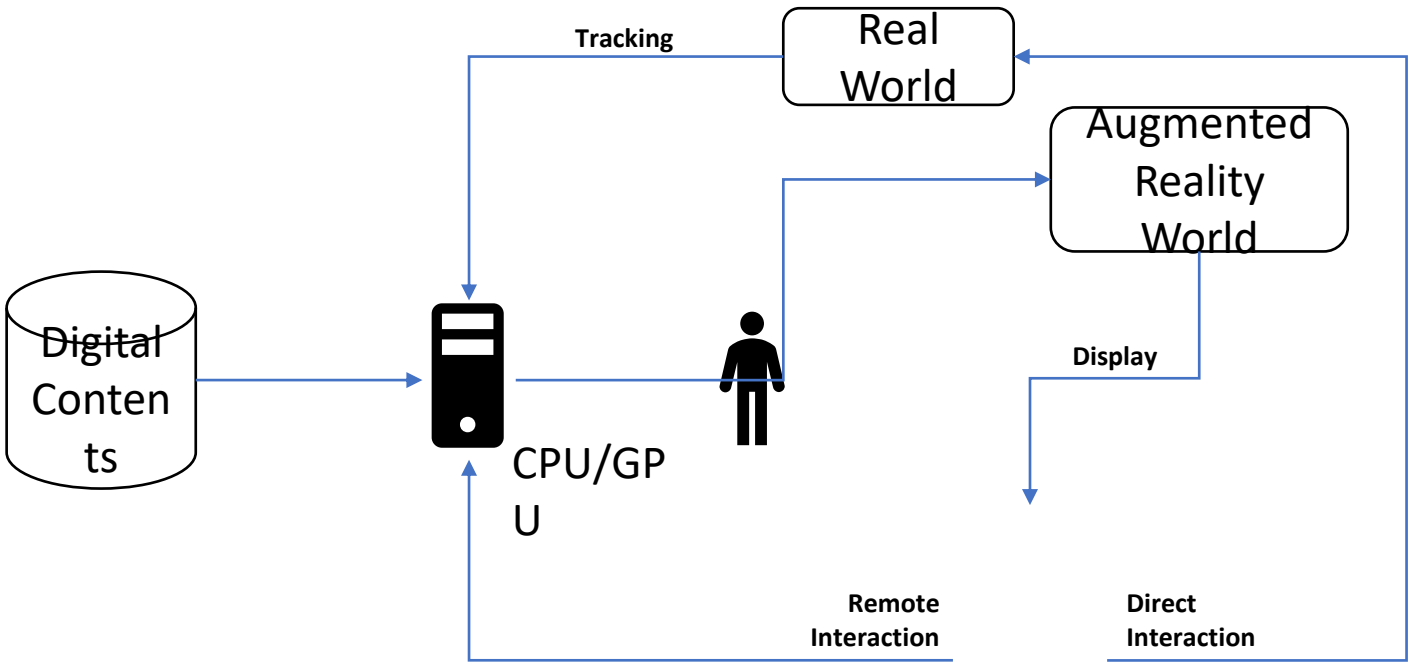
- Combines real and virtual imagery → Display
- Is interactive in real time → Interaction
- Registers the virtual imagery with the real world" → Tracking

Azuma, R. T. (1997). A Survey of Augmented Reality. Presence: Teleoperators and Virtual Environments, 6(4), 355–385.

Taxonomy of Augmented Reality Technologies

Technologies	Types	Techniques
Display	Wearable	Video see-through | Optical see-through
	Handled	Video see-through | Optical see-through | Direct augmentation
	Spatial	Video see-through | Optical see-through | Direct augmentation
Interaction	Direct	Remote controller | Gesture recognition | Tangible interfaces
	Remote	Remote controller | Gesture recognition | Speech recognition
	Hybrid	Combination of different interaction techniques
Tracking	Computer Vision	Marker based | Motion capture | 3D Model | Point cloud | SLAM
	Sensors	Accelerometers | Gyroscopes | Magnetometers | Hybrid
	Hybrid	Combination of different tracking techniques

How it works?

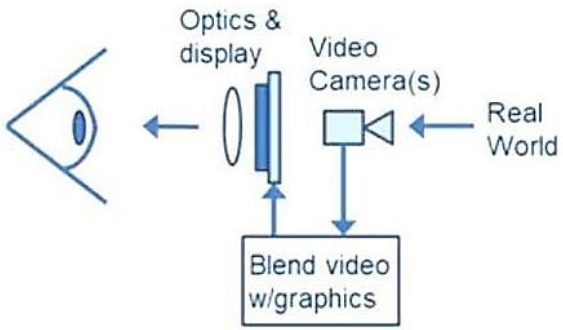

Tracking
Real World
Augmented Reality World
Digital Contents
CPU/GPU
Display
Remote Interaction
Direct Interaction

Display Types

- **Wearable**: the user wears the display device (head-mounted displays, helmets, glasses). Private visualisation
- **Handled**: the user holds in his/her hands the display device (tablets, smartphones, projectors). Private or shared visualisation
- **Spatial**: the display device is located somewhere in the real world (monitors, head-up displays, projectors). Shared visualisation
- **NB:** Display devices can completely or partially include the computational unit.

Video see-through displays

- Digital contents are combined with a video stream of the real world



Advantages:

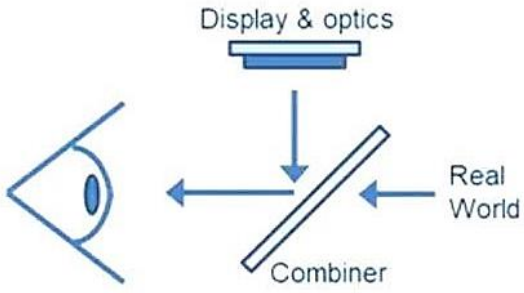
- Photorealistic rendering of the digital contents
- Synchronization of real and virtual images

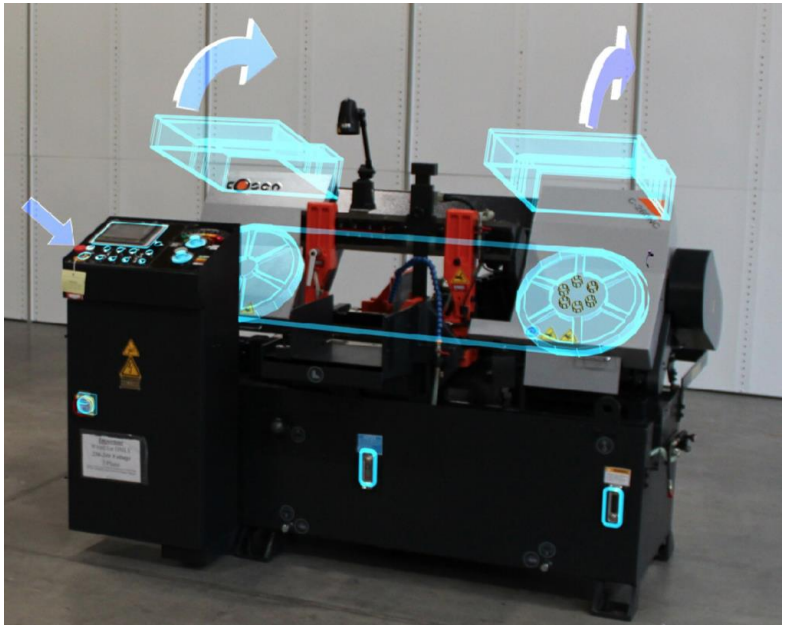
Disadvantages:

- Unnatural perception of the real environment

Optical see-through display

- Half-silver mirrors optically combines digital contents rendered by monitors or projectors.





Advantages:

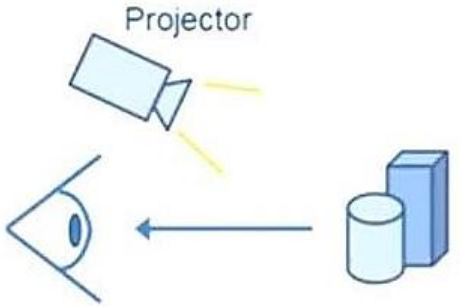
- Natural perception of the real environment

Disadvantages:

- Opacity of the digital contents
- Time lag, jittering of the virtual images

Direct augmentation

- Digital contents are directly projected to physical object.



Advantages:

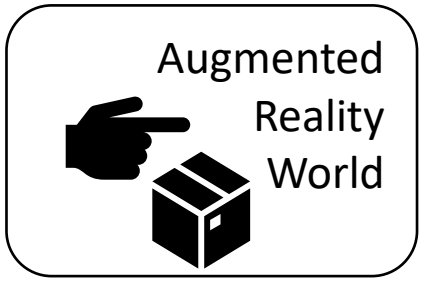
- No medium between user's eyes and the real world

Disadvantages:

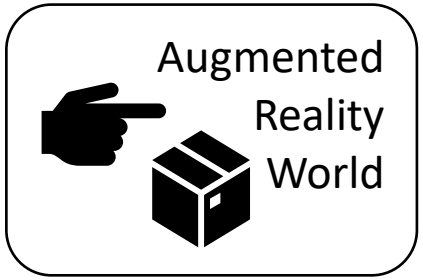
- Complex setup and calibration
- Influence of ambient light

Interaction Types

- **Direct**: users interact with digital objects consistently with their position within the real world



- **Remote**: users do not directly interact with digital objects but externally.



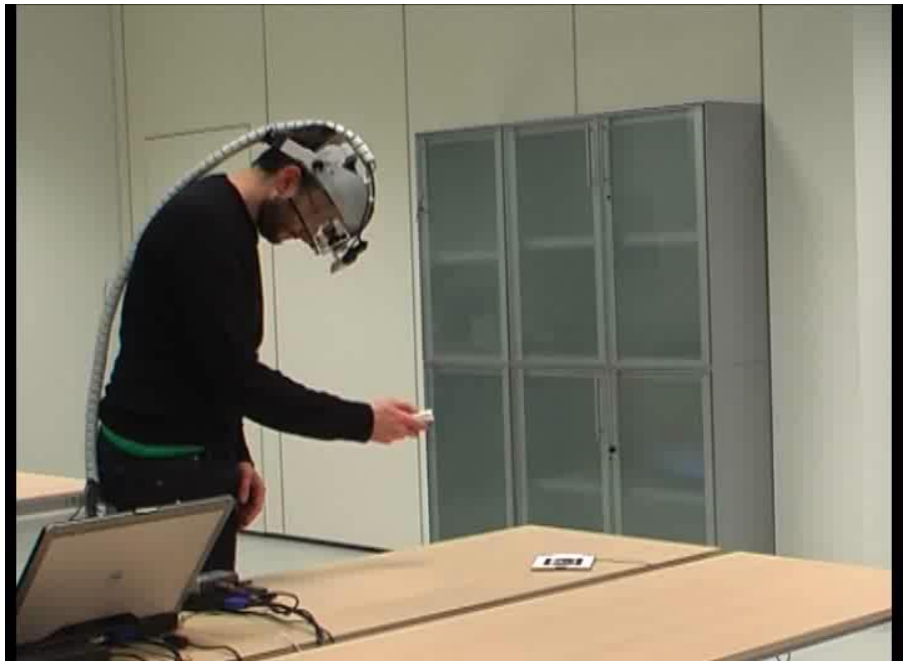
- **Hybrid**: Combination of different interaction techniques.

Tangible interfaces

Tangible interfaces are powerful because the physical objects have familiar properties, physical constraints, and affordances, making them easy to use.

Remote controller

- User directly or remotely interacts by using a remote controller



https://youtu.be/YW-mMd9GhuM

Caruso, G., & Re, G. M. (2010). AR-Mote: A wireless device for Augmented Reality environment. In *in Proceedings of 2010 IEEE Symposium on 3D User Interfaces (3DUI)* (pp. 99–102). IEEE. https://doi.org/10.1109/3DUI.2010.5444714

Gesture recognition

User’s hands to directly or remotely interact with digital contents

Speech recognition

- Use of the voice to remotely interact with the digital contents

Tracking Types

- **Computer vision**: algorithms elaborating video stream of the real world and use elements inside it for tracking. **Commonly used with video see-trough displays.**
  - Marker
  - Motion capture system
  - 3D model
  - Point cloud
  - SLAM

- **Sensors**: measurements of physical properties to evaluate position and orientation of sensors.

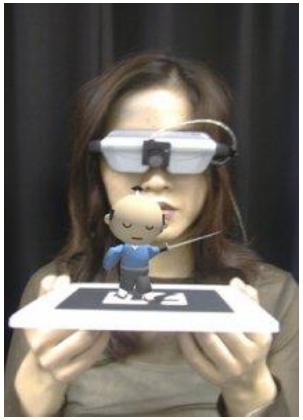
- **Hybrid**: combination of different tracking technologies and techniques to improve the tracking quality.

Marker-based tracking

- Well-known 2D objects inside the real world are used as references for the digital contents.

☺ Simple setup
☺ Inexpensive

☹ Tracking limitations
☹ Affected by light conditions



Squared b/w marker

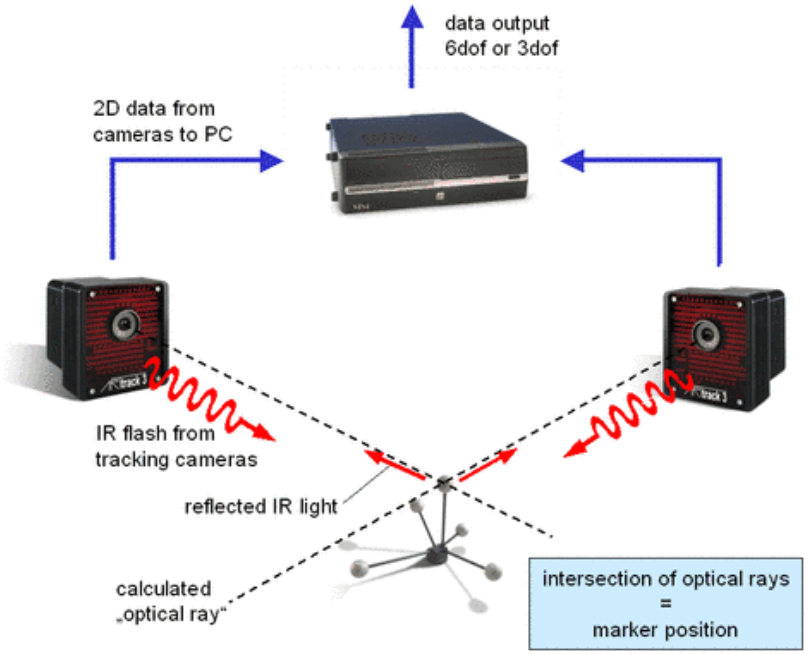
Image target

Motion capture system

- Use of a cluster (marker-set) of spherical reflective markers and multiple IR cameras. Particularly effective for direct augmentation.

☺ High tracking quality
☺ Not affected by light conditions

☹ Complex setup
☹ Expensive

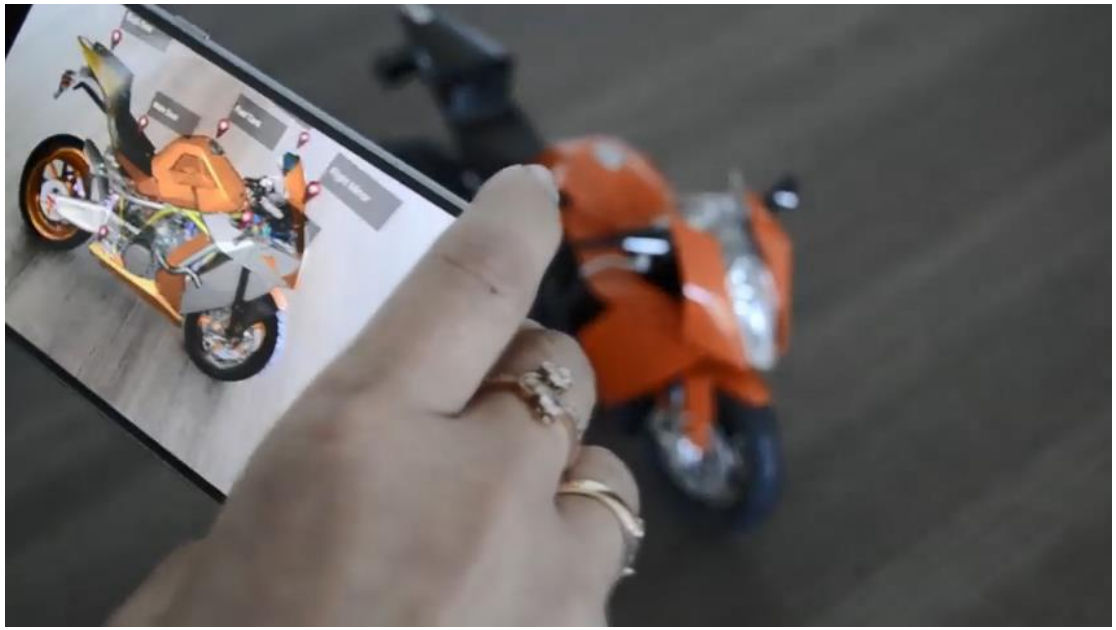


3D model tracking

- Digital 3D models of real objects are used as references for the digital contents.

☺ Simple setup
☺ Inexpensive

☹ Preparation of the 3D model
☹ Affected by light conditions

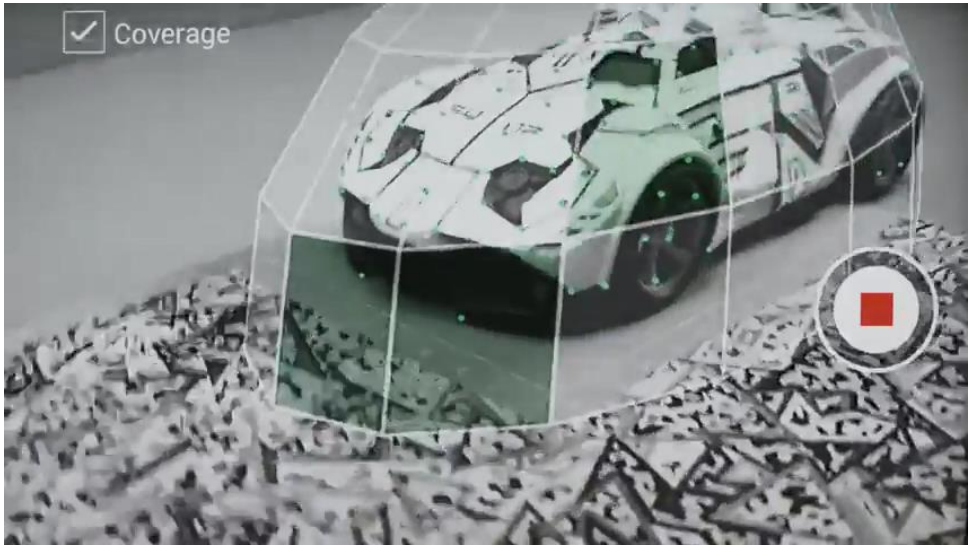


Point Cloud tracking

- Track the camera motion using an offline reconstructed 3D point cloud of a real object.

☺ Good tracking quality
☺ Inexpensive

☹ Preparation of the point cloud
☹ Affected by light conditions



Current Hardware

- Tablets and smartphones

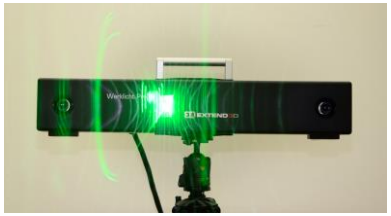
- Optical see-through Headset or glasses

Microsoft HoloLens

Meta 2

DAQRI Smart Glasses

- Projectors and smart projectors



extend3d

Lightform

Current Software

vuforia™

INFINITY
augmented reality

ALVAR

kudan
COMPUTER VISION

EasyAR

AUGMENT

ARTOOLKIT

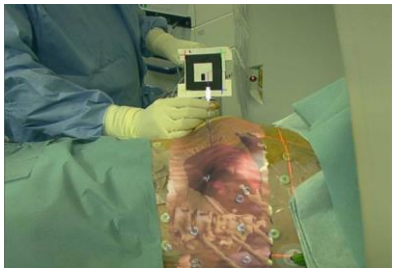
Augmented Reality application fields

Data visualization

Cultural Heritage

Automotive

Industry



Medical

Military

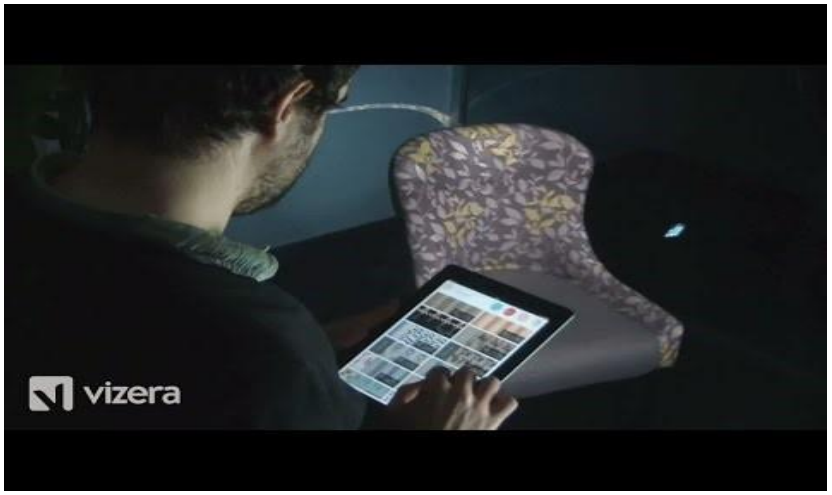
Real estate

Advertising

Space planning

Remote assistance

Mixed prototyping



APPROFONDIMENTI

- link di siti web.
  - https://www.ptc.com/en/products/augmented-reality/vuforia-studio
  - https://www.ptc.com/en/products/augmented-reality/vuforia-spatial-toolbox
  - https://breakingvr.it/2019/01/04/cinque-grandi-domande-sulla-realta-virtuale-per-il-2019/
  - http://www.polo-lecco.polimi.it/it/fare-ricerca-a-lecco/laboratori-sperimentali/laboratorio-di-prototipazione-virtuale-e-realta-aumentata/

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