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AUGMENTED REALITY

HISTORY, CHALLENGES AND APPLICATIONS

WHAT IS AUGMENTED REALITY?

- We define Augmented Reality (AR) as a real-time direct or indirect view of a physical real-world environment that has been enhanced / augmented by adding virtual computer-generated information to it [14].
- AR is both interactive and registered in 3D as well as combines real and virtual objects

HISTORY

- First appearance of AR dates back to the 1950s
  - Morton Heilig, a cinematographer, thought of cinema is an activity that would have the ability to draw the viewer into the onscreen activity by taking in all the senses in an effective manner (1956)
- In 1962, Heilig built a prototype of his vision, which he described in 1955 in “The Cinema of the Future”, named Sensorama, which predated digital computing [15]

HISTORY

https://www.wareable.com/media/images/2016/04/sensorama-full-1459515007-sz7p-column-width-inline.jpg

HISTORY

- 1966 invention of the Head Mounted Display (HMD) by Ivan Sutherland
- In 1968, Sutherland was the first one to create an augmented reality system using an optical see-through head-mounted display [16]
- „our objective in this project is to surround the user with displayed three-dimensional information“

HISTORICAL BACKGROUND

The world’s first head-mounted display with the “Sword of Damocles” [1][2]

HISTORY

- In 1975, Myron Krueger creates the Videoplace, a room that allows the users to interact with virtual objects for the first time
- 1984 realisation of his idea „artificial reality“ with the help of a computer system

CAT'S CRADLE

HISTORY

- 1990 Tom Caudell and David Mizell coin the phrase Augmented Reality while helping workers assemble wires and cable for an aircraft [14]
- They also started discussing the advantages of Augmented Reality versus Virtual Reality (VR), such as requiring less power since fewer pixels are needed [16].
- 1990 L.B Rosenberg developed one of the first functioning AR systems, called Virtual Fixtures and demonstrated its benefit on human performance
- Steven Feiner, Blair MacIntyre and Doree Seligmann presented the first major paper on an AR system prototype named KARMA [14]

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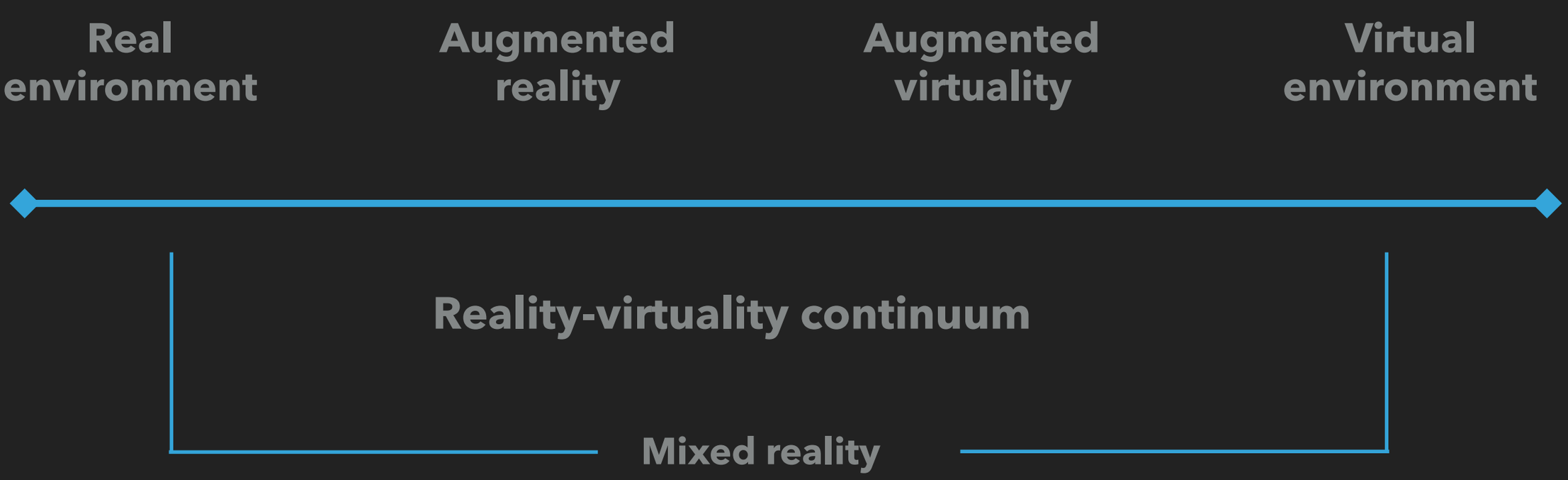
AUGMENTED REALITY



Reality-virtuality continuum [8]

AUGMENTED REALITY

- combines real and virtual objects in a real environment
- registers (aligns) real and virtual objects with each other
- runs interactively, in three dimensions, and in real time.

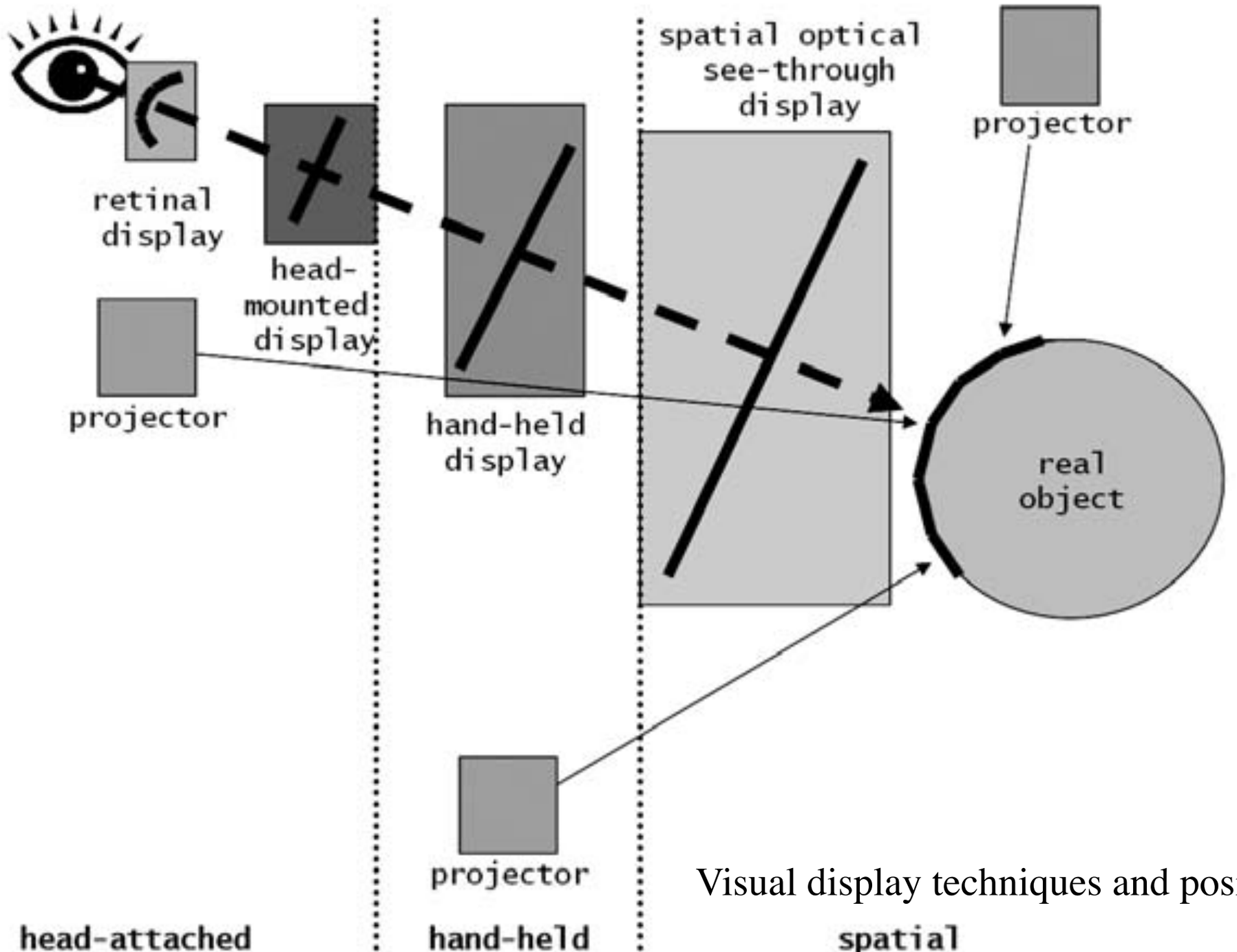
http://blogs.solidworks.com/solidworksblog/wp-content/uploads/sites/2/6a00d83451706569e2017ee8115a91970d.jpg

http://mashable.com/2012/11/21/augmented-reality-advertising-privacy-law//#d9jbNWLqMOqx

AR DEVICES

- Main devices for AR are
  - displays,
  - input devices,
  - tracking,
  - and computers.

DISPLAY TECHNOLOGIES



Visual display techniques and positioning [4]

DISPLAY POSITIONING

- Head-mounted (Head-worn) [9]
  - Cakmakci and Rolland [9] give a recent detailed review of head-mounted display technology
- video/optical see-through head-mounted display (HMD)
- virtual retinal display (VRD)
- head-mounted projectors or projective displays (HMPD)

ACTUAL DISPLAY DEVICES

ACTUAL DISPLAY DEVICES

ACTUAL DISPLAY DEVICES

https://upload.wikimedia.org/wikipedia/commons/d/dd/Google_Glass_Main.jpg

ACTUAL DISPLAY DEVICES

https://www.microsoft.com/microsoft-hololens/en-us

DISPLAY POSITIONING

- Hand-held
  - video/optical see-through displays

http://static511.layar.com.s3.amazonaws.com/old/2010/09/10x0902samsung75nh10.jpg

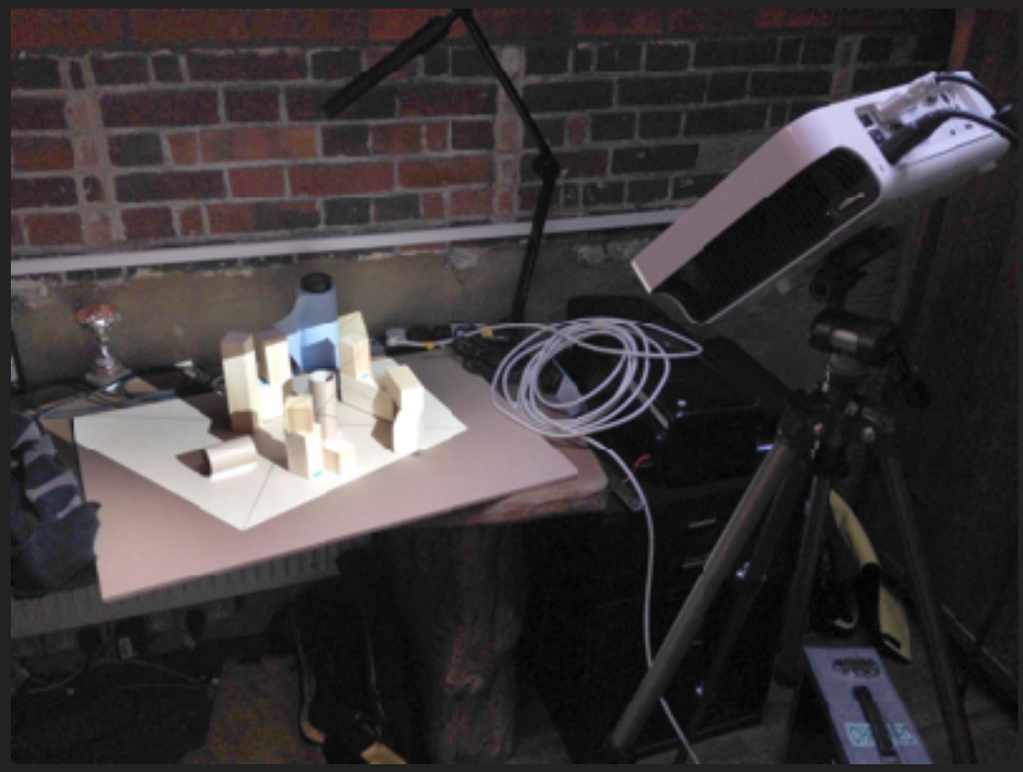
- hand-held projectors

http://i.imgur.com/PZRD5xl.jpg?1

DISPLAY POSITIONING

- Spatial Displays
  - placed statically within the environment
    - screen-based video see-through
    - spatial optical see-through displays
    - projectors

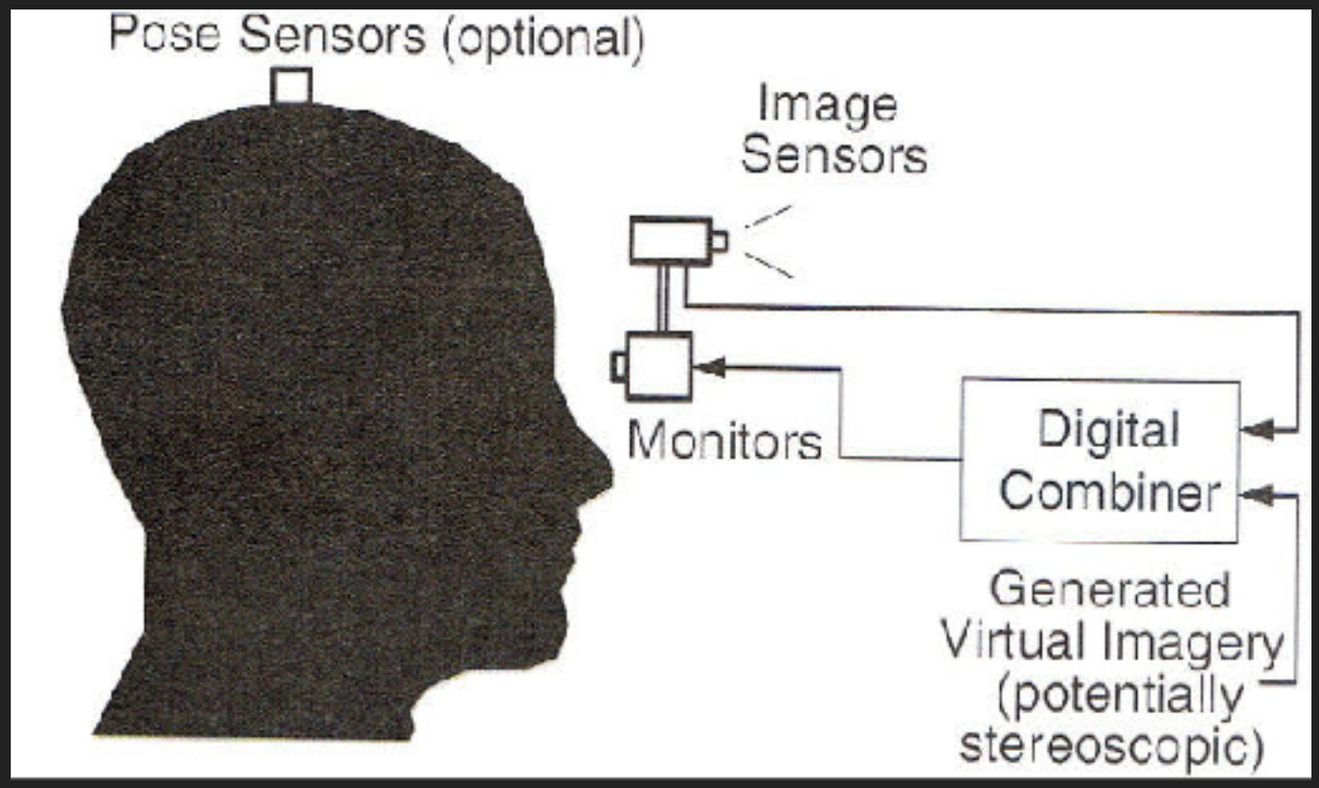
http://korala.lt/file/2012/02/HoloScreen-21.jpg

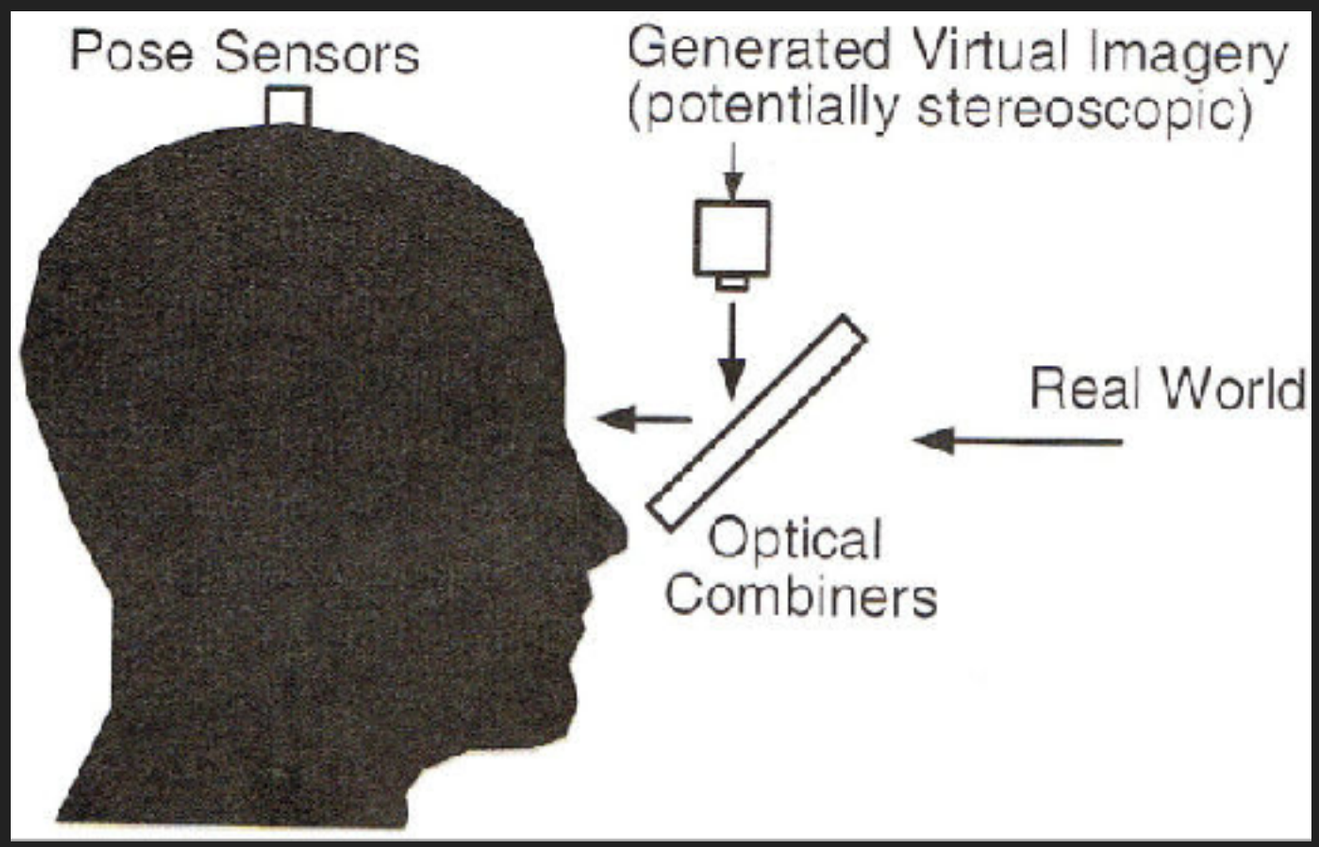


https://i1.creativecow.net/u/278136/0_photo.jpg

VISUAL DISPLAYS

- basically three ways to visually present an augmented reality
- video-see-through
- optical see-through
- projective displays





VIDEO SEE-THROUGH

- **advantages**
  - Since reality is digitised, it is easier to mediate or remove objects from reality
  - includes removing or replacing of markers or placeholders with virtual objects
  - brightness and contrast of virtual objects are matched easily with the real environment
  - techniques of video production are usable, but needed in real time
  - digitised images allow tracking of head movement
- **disadvantages**
  - see-through include a low resolution of reality
  - a limited field-of-view (although this can easily be increased)

OPTICAL SEE THROUGH

- possible for head-worn displays, hand-held displays, and spatial setups
- **advantages**
  - leave the real-world resolution intact
  - parallax-free(no eye-offset due to camera positioning) [8]
  - users can still see when power fails [8]
- **disadvantages**
  - transparent mirrors and lenses reduces brightness and contrast
    - of images and
    - real-world perception

PROJECTIVE DISPLAYS

- **advantages**
  - (do not require special eye-wear)
  - can cover large surfaces for a wide field-of-view
    - Projection surfaces may range from flat, plain coloured walls to complex scale models [3]
- **disadvantages**
  - additional interaction devices needed (indirect interaction)
  - need to be calibrated
  - limited to indoor use only (or by night also outdoor)
  - due to low brightness and contrast

CHARACTERISTICS OF VISUAL AR DISPLAYS

CHARACTERISTICS OF SURVEYED VISUAL AR DISPLAYS

Positioning	Head-worn				Hand-held	Spatial		
Technology	**Retinal**	**Optical**	**Video**	**Projective**	**All**	**Video**	**Optical**	**Projective**
Mobile	+	+	+	+	+	−	−	−
Outdoor use	+	±	±	+	±	−	−	−
Interaction	+	+	+	+	+	Remote	−	−
Multi-user	+	+	+	+	+	+	Limited	Limited
Brightness	+	−	+	+	Limited	+	Limited	Limited
Contrast	+	−	+	+	Limited	+	Limited	Limited
Resolution	Growing	Growing	Growing	Growing	Limited	Limited	+	+
Field-of-view	Growing	Limited	Limited	Growing	Limited	Limited	+	+
Full-colour	+	+	+	+	+	+	+	+
Stereoscopic	+	+	+	+	−	−	+	+
Dynamic refocus (eye strain)	+	−	−	+	−	−	+	+
Occlusion	±	±	+	Limited	±	+	Limited	Limited
Power economy	+	−	−	−	−	−	−	−
Opportunities	Future dominance	Current dominance			Realistic, mass-market	Cheap, off-the-shelf	Tuning, ergonomics	
Drawbacks		Tuning, tracking	Delays	Retro-reflective material	Processor, Memory limits	No see-through metaphor	Clipping	Clipping, shadows

CHARACTERISTICS OF SURVEYED VISUAL AR DISPLAYS [8]

TRACKING SENSORS AND APPROACHES

- User Movement Tracking & interaction tracking
- Mechanical, ultrasonic, and magnetic
- Global positioning systems
- Radio
- Inertial
- Optical
- Hybrid (Sensor Fusion)

TRACKING

Technology	Range (m)	Setup time (hr)	Precision (mm)	Time (s)	Environment
Optical: marker-based	10	0	10	∞	in/out
Optical: markerless	50	0–1	10	∞	in/out
Optical: outside-in	10	10	10	∞	in
Optical: inside-out	50	0–1	10	∞	in/out
GPS	∞	0	5000	∞	out
WiFi	100	10	1000	∞	in/out
Accelerometer	1000	0	100	1000	in/out
Magnetic	1	1	1	∞	in/out
Ultrasound	10	1	10	∞	in
Inertial	1	0	1	10	in/out
Hybrid	30	10	1	∞	in/out
UWB	10–300	10	500	∞	in
RFID: active	20–100	when needed	500	∞	in/out
RFID: passive	0.05–5	when needed	500	∞	in/out

INPUT DEVICES

- large variety of input devices for AR (also VR)
  - Gloves
  - wristband
  - smartphone
  - phone as pointing device (see Google Sky Map)
  - Chosen input device depend on the application
  - big aim: hand free interaction

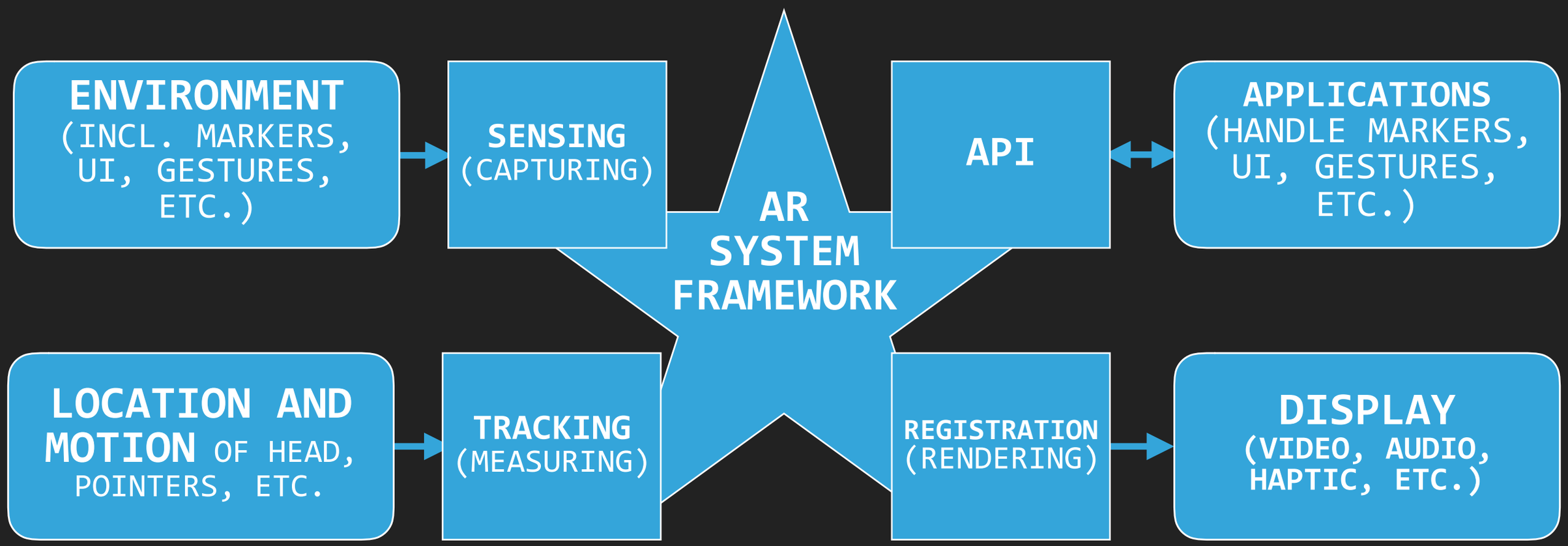
USER INTERFACE AND INTERACTION

- New UI paradigm
- Tangible UI and 3D pointing
- Natural UI
  - Haptic UI and gesture recognition
  - Visual UI and gesture recognition
  - Aural UI and speech recognition
- Multimodal AR interfaces

MORE AR REQUIREMENTS

- Höllerer and Feiner [5][6] mention three more requirements for a mobile AR system:
  - computational framework,
  - wireless networking,
  - and data storage and access technology.
- Content is of course also required, so some authoring tools are mentioned here as well.

TYPICAL AR FRAMEWORK TASK



Typical AR system framework tasks (adopted from [8])

APPLICATIONS

- wide range of applications possible with AR
  - Personal information systems
    - [10] „biggest potential markets for AR“
  - Personal Assistance and Advertisement
  - Navigation
  - Touring

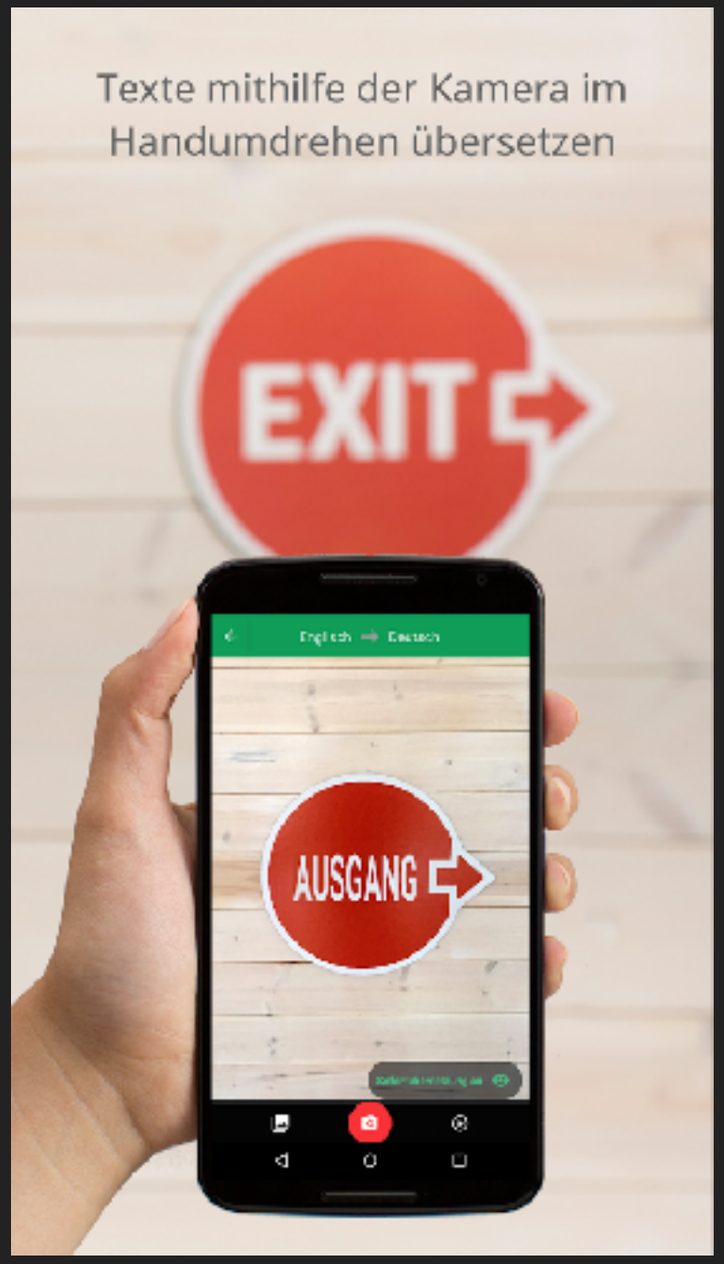
APPLICATIONS

- Industrial applications
  - Design
  - Assembly
  - Maintenance
  - Training and Simulation

APPLICATIONS

- AR for entertainment
  - Sports broadcasting
  - Event broadcasting
  - Games
  - Edutainment
- AR for Office
- AR for collaboration

APPLICATION – PERSONAL ASSISTANCE



https://play.google.com/store/apps/details?id=com.google.android.apps.translate&hl=de

APPLICATION – NAVIGATION

http://www.wearear.de/augmented-reality-bei-mercedes-benz/

APPLICATION – NAVIGATION

http://0.design-milk.com/images/2013/08/IKEA-augmented-reality-app-catalogue-01.jpg

APPLICATION – MAINTENANCE

https://artcom.de/project/augmentierte-3d-exponate/

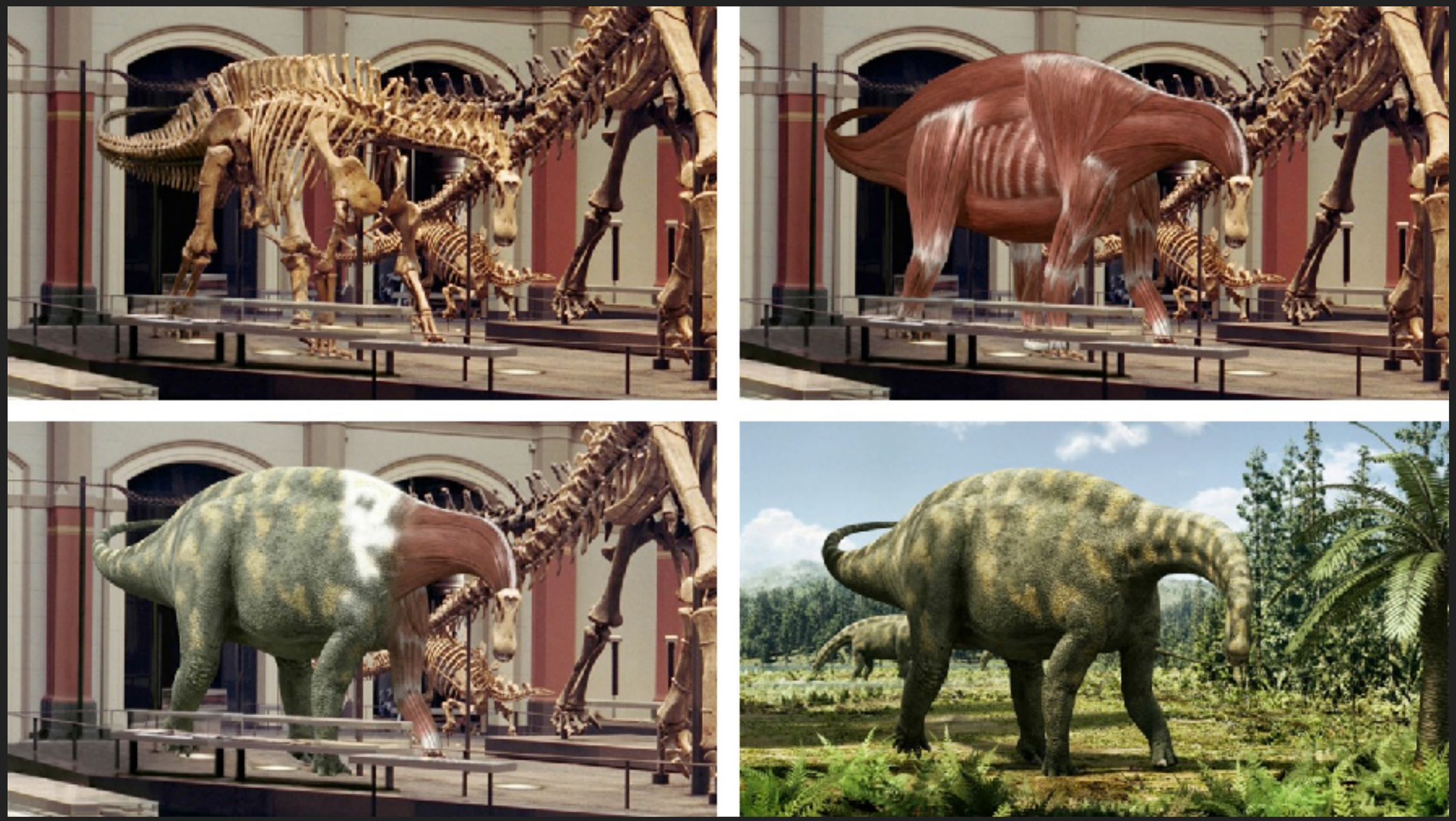
APPLICATION – DESIGN

https://www.jvrb.org/past-issues/1.2004/34

APPLICATION – EDUTAINMENT

https://artcom.de/project/museum-fuer-naturkunde/

APPLICATION – EDUTAINMENT



https://artcom.de/project/museum-fuer-naturkunde/

ACCEPTANCE

- Social acceptance issues
  - Interaction with AR systems implemented in mobile applications need to be subtle, discrete and unobtrusive, so to not disrupt the user if s/he is under a high load of work and the disruption is not of priority level
- Natural Interaction
- Fashion acceptance
- Personal and private systems

FUTURE OF AR

- AR is still in infancy state
- future possible applications are infinite
- also brings the possibility of enhancing missing senses for some users
- Even the future is not far from challenges for augmented reality. We
- social acceptance issues, privacy concerns, and ethical concern arising with the future of augmented reality applications in the industry.

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