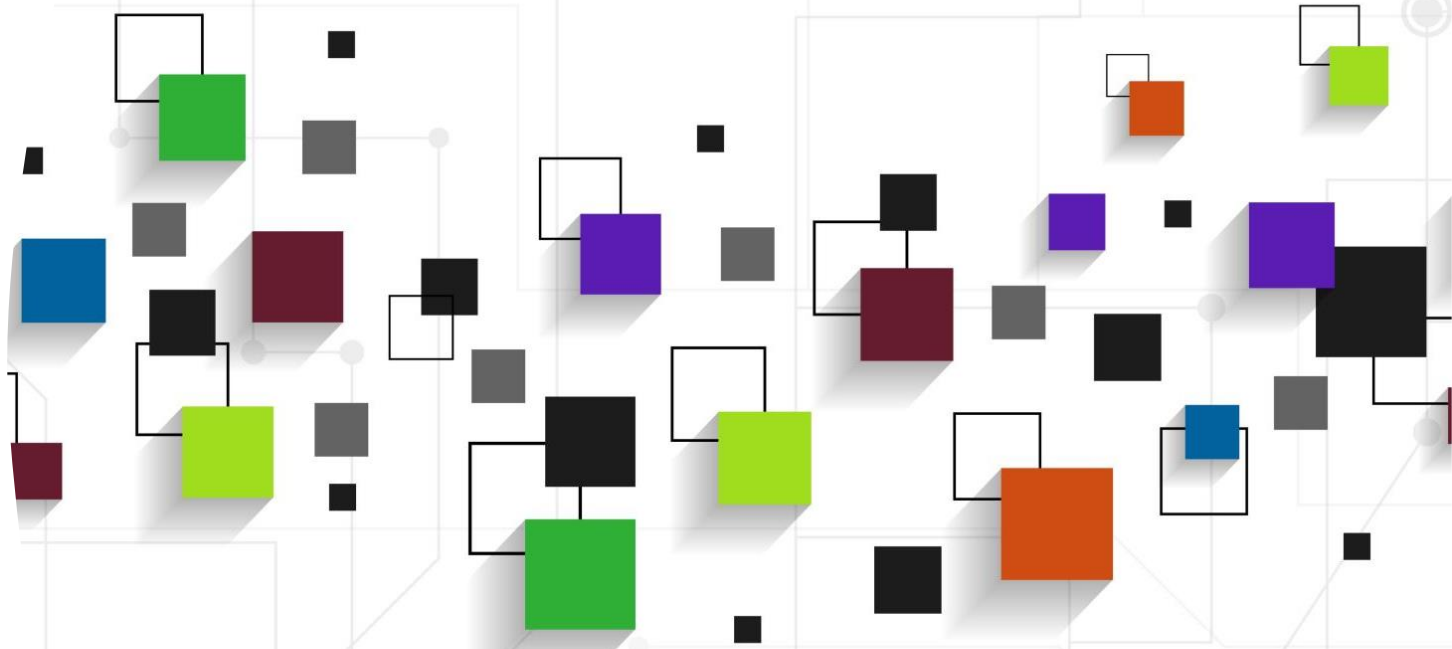
증강현실

(2023. 9. 13.)

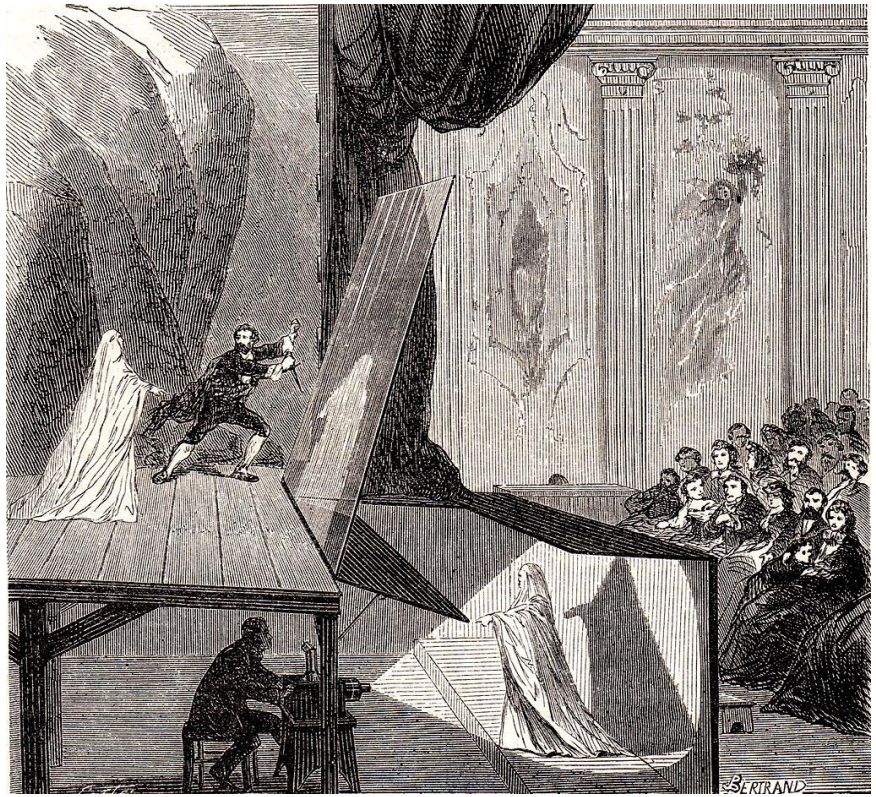
이 종 원
(jwlee@sejong.ac.kr)



Brief History of AR

Pepper’s Ghost (1862)

- ✓Projection onto glass to make ghost image appear on stage
- ✓Named after the English scientist John Henry Pepper
- ✓Popularizing the effect with a theatre demonstration in 1862



https://en.wikipedia.org/wiki/Pepper%27s_ghost

Early HUD (1958)

✓Showing flight information over the real world

F-16 Head-Up Display

Sutherland HMD

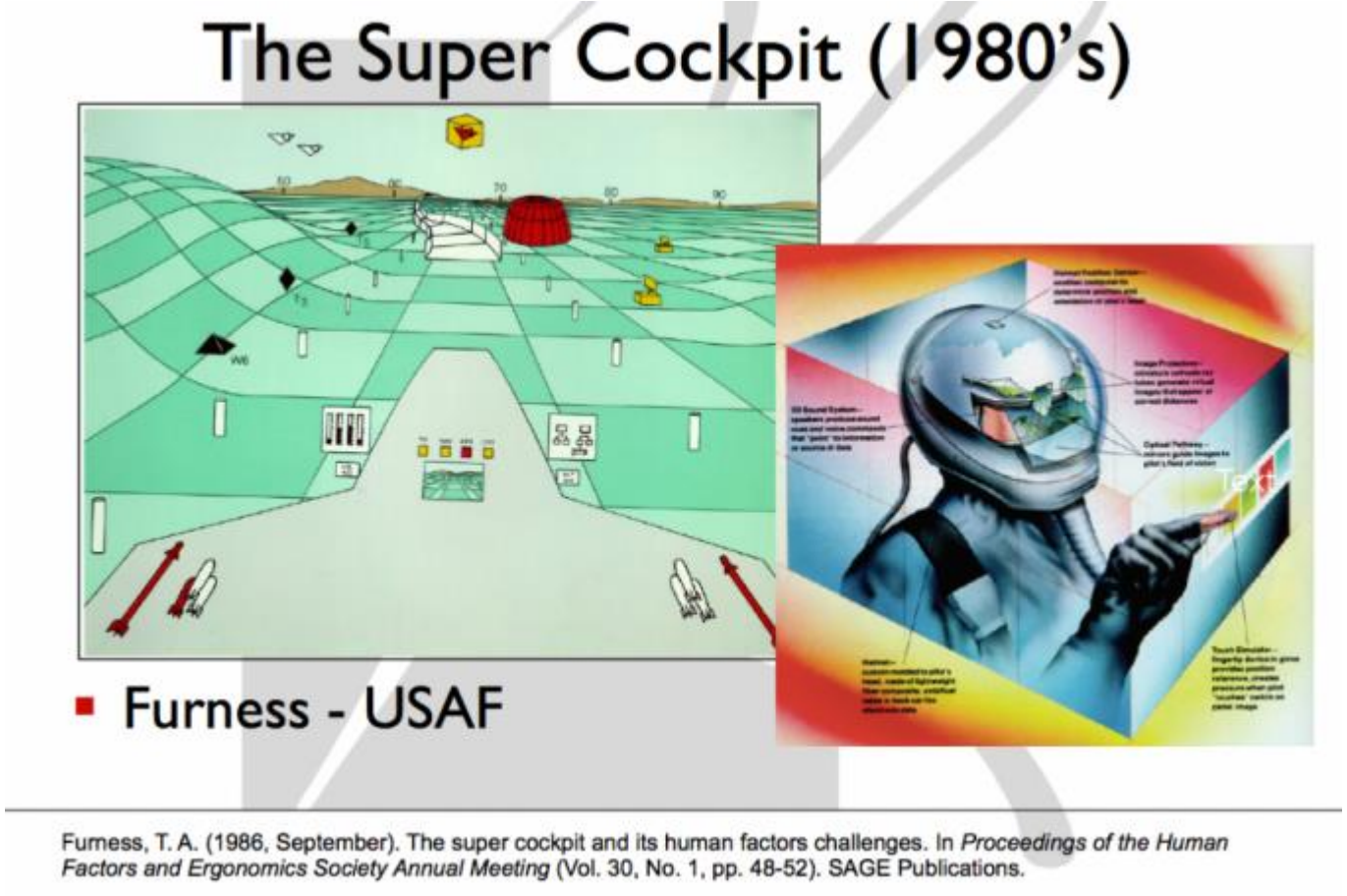
- ✓Sutherland / Sproull's first HMD system (1968)
- ✓See-through, with ultrasonic/mechanical tracking

Sutherland Display

https://youtu.be/NtwZXGprxag

Super Cockpit Program

✓1970 – 80's: US Air Force Super Cockpit (T. Furness III)



Furness, T. A. (1986, September). The super cockpit and its human factors challenges. In *Proceedings of the Human Factors and Ergonomics Society Annual Meeting* (Vol. 30, No. 1, pp. 48-52). SAGE Publications.

https://www.roadtovr.com/50-years-vr-tom-furness-super-cockpit-virtual-retinal-display-hit-lab-virtual-world-society/

Modern Airforce HMDs

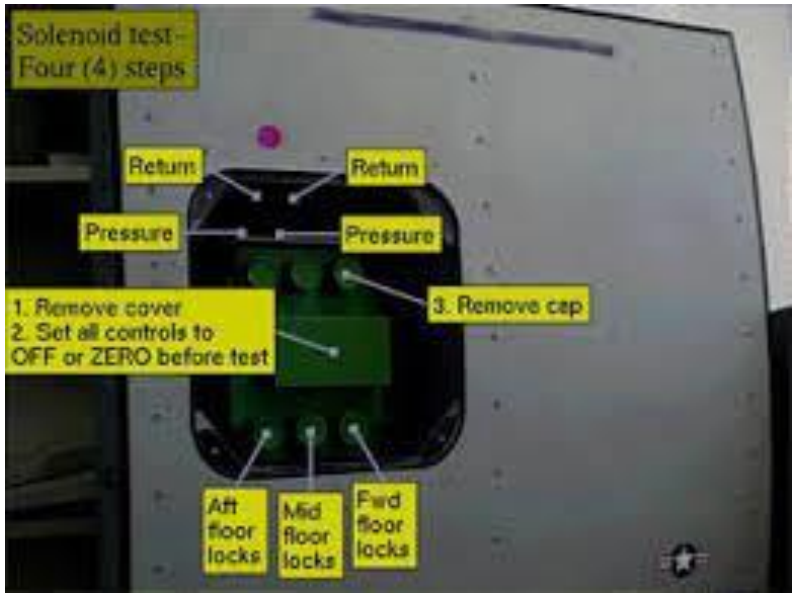
Get a Pilot's Eye View of the F-35 HUD – AINtv (2014. 7. 16.): https://www.youtube.com/watch?v=Ay6g66FbkmQ

First Industrial Use of AR

✓Early 1990's, Boeing coined the term "AR"

✓Wire harness assembly application begun

- Lead by Tom Caudell, and David Mizell

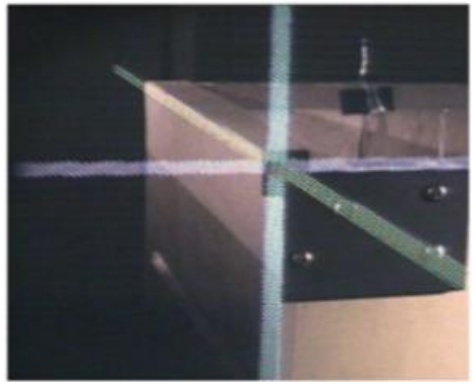


U. Neumann and A. Majoros, "Cognitive, performance, and system issues for augmented reality application in manufacturing and maintenance," Proceedings. IEEE 1998 Virtual Reality Annual International Symposium

Academic Research Beginning

✓University research begun at UNC and others

- 1994: Motion stabilized display [Azuma]
- 1995: Fiducial tracking in video [Bajura / Neumann]
- 1996: UNC hybrid magnetic-vision tracker



Development of the Field

- ✓1996: MIT Wearable Computing efforts
- ✓1998: Dedicated conference begin (ISMAR)
- ✓Late 90's: Collaboration, outdoor, and interaction

  Augmented sports broadcasts

https://atomicdigital.design/blog-post/1998-augmented-reality-football

The Glowing Puck (1995)

https://atomicdigital.design/blog-post/1998-augmented-reality-football

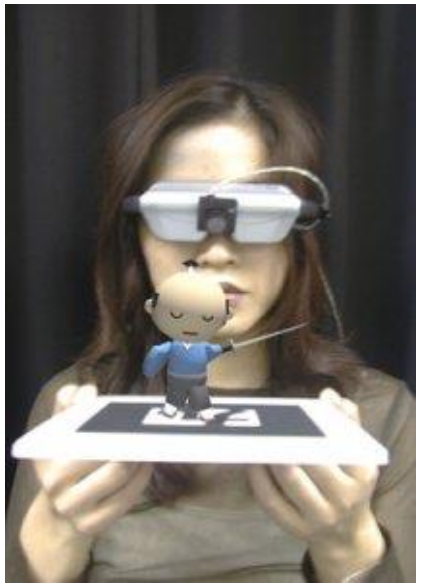
Development of Tools

✓1996: CyberCode (Rekimoto)

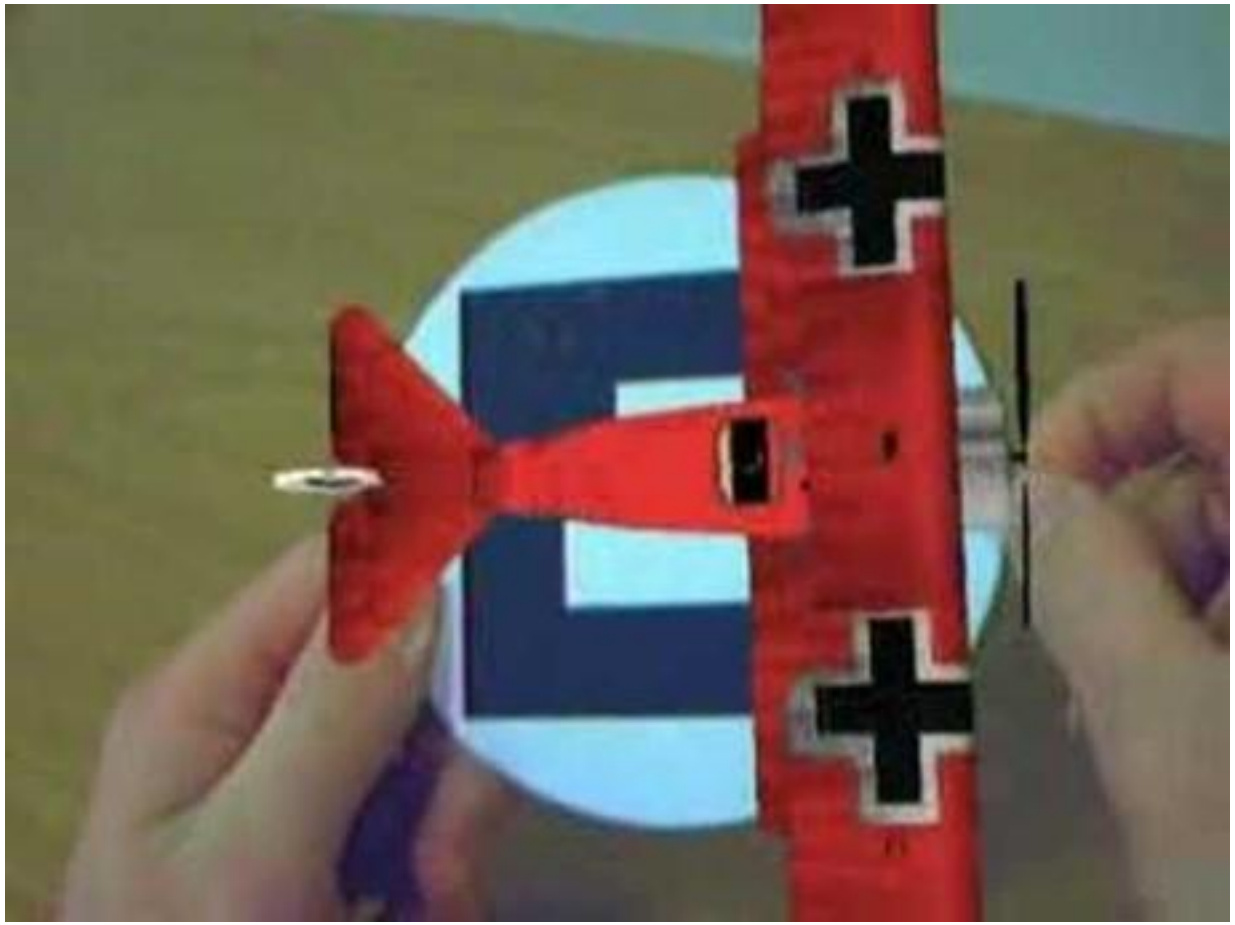
- First matrix code tracking

✓1999: ARToolKit (Kato & Billinghurst)

- Open-source tracking library



ARToolKit Demo



ARToolKit demonstration (07. 6. 18.): https://www.youtube.com/watch?v=TqGAqAFlGg0

Mobile/Wearable Systems

✓1995: Navicam (Rekimoto)

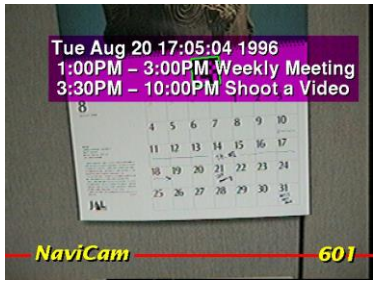
- Handheld AR

✓1997: Touring Machine (Feiner)

- Backpack AR, GPS, see-through display

✓1998: Tinmith (Univ. of South Australia)

- Outdoor gaming, CAD



2005 – Mobile Phone AR

✓Mobile phones

- Camera
- Processor
- Display

✓AR on mobile phones

- Simple graphics
- Optimized computer vision
- Collaborative interaction

Anders Henrysson, Mark Billinghurst, and Mark Ollila, “Augmented Reality on Mobile Phones,” 2005 The Annual SIGRAD Conference Special Theme – Mobile Graphics

AR Advertising (HIT Lab NZ 2007)

- ✓Text message to download AR application (200K)
- ✓See virtual content popping out of real paper advertisement
- ✓Tested May 2007 by Saatchi and Saatchi

2007 – AR Research Mainstream

✓MIT Technology Review

- March 2007
- One of the ten most exciting technologies

✓Economist

- Dec 6th, 2007
- Reality, only better

https://www.technologyreview.com/10-breakthrough-technologies/2007/

2008 – Browser Based AR

- ✓Flash + camera + 3D graphics: ARToolKit ported to Flash
- ✓High impact: High marketing value
- ✓Large potential install base: 1.6 billion web users
- ✓Ease of development: Lots of developers, mature tools
- ✓Low cost of entry: Browser, web camera

GE Smart Grid

GE Augmented Reality (09. 2. 13.): https://www.youtube.com/watch?v=vJO_AZkCL9U

2009 – AR in Magazines

✓Esquire magazine

- Dec. 2009 issue
- 12 pages AR content

✓Many others

- Wired
- Colors
- Red Bull
- …

Esquire Magazine

Esquire's AR Issue: A Tour (12. 3. 27.): https://www.youtube.com/watch?v=LGwHQwgBzSI&t=1s

Wired Magazine

https://youtu.be/y3EXE608hMg?si=3F9G9iCU4P5byfbK

2009 – Outdoor Information Overlay

- ✓Mobile phone based
- ✓Tag real-world locations
  - GPS + Compass input
  - Overlay graphics on live video
- ✓Applications
  - Travel guide, advertising, etc.
- ✓Wikitude, Layar, …
  - iOS/Android, Public API released

Layar

Layar, wolrds first mobile AR browser (09. 6. 15.) https://www.youtube.com/watch?v=b64_16K2e08

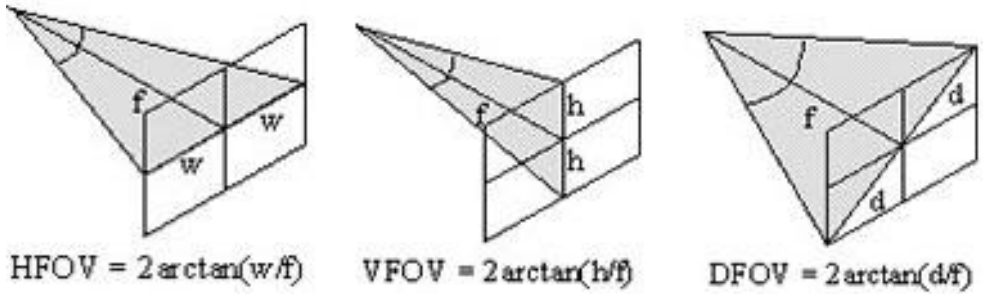
Google Glass (2011)

Google Glass (2011)

How It Really Feels [through Google Glass] (13. 2. 25.) https://www.youtube.com/watch?v=fNATuCkRWFE

Google Glass Enterprise Edition 2 (2019)

- ✓Small, lightweight wearable computer with transparent display
- ✓640 x 360 Display
- ✓80 DFOV
- ✓Multi-touch gesture touchpad
- ✓Single 6-axis Accelerometer/Gyroscope, single 3-axis Magnetometer
- ✓46g



Google Glass Enterprise Edition 2

https://youtu.be/5IK-zU51MU4 (2:36)

Epson Moverio BT-300 (2016)

- ✓Stereo see-through display ($700)
- ✓1280 RGB x 720 pixels, 23 degrees FOV, 30Hz, 69g
- ✓Android powered, separate controller
- ✓VGA camera, GPS, gyro, accelerometer

Other Smart Glasses

Solos (2016)

Raptor (2018)

Blade Smart Glasses (2018)

M300 (2016)

dynaEdge AR100 Viewer (2018)

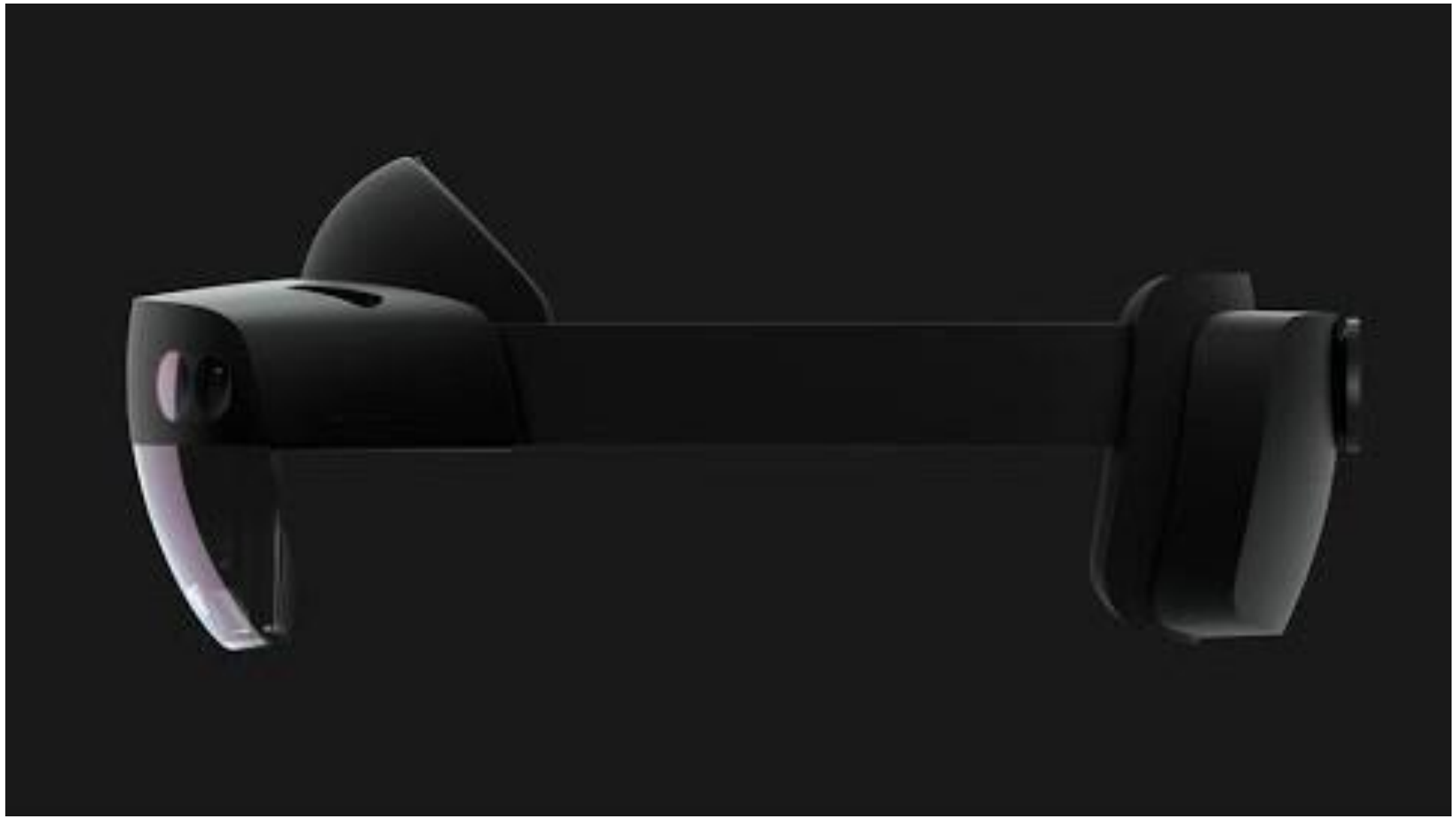
X2 (2019)

HoloLens 2 (2019)

- ✓ HoloLens: 2016
- ✓ $3,500 per device or $99/month
- ✓ Display
  - See-through holographic lenses
  - Resolution: 2k 3:2 light engines
  - Diagonal field of view: 52 degrees (previous 34 degrees)
  - Eye-based rendering

- ✓ Human understanding
  - Head and eye tracking
  - Voice
- ✓ Environment understanding
  - World-scale positional tracking
  - Spatial mapping (real-time environment mesh)
  - Mixed reality capture

HoloLens 2 (2019)



Introduction Microsoft HoloLens 2 https://www.youtube.com/watch?v=eqFqtAJMtYE

HoloLens 2 (2019)

HoloLens 2: inside Microsoft's new headset (19. 2. 24.) https://www.youtube.com/watch?v=6IxGU66w0NM

Magic Leap ML-1 (2018)

✓$2,300

✓Bi-Focal Display – two focus planes

- Horizontal FOV of 40°, vertical FOV of 30°, diagonal value of 50°
- 1280 x 960 resolution, eye-tracking

✓Separate display and computer

- Nvidia “Parker” Tegra X2 CPU, 8GB RAM, 128 GB storage
- 6 DOF handheld controller, magnetic tracking

Magic Leap ML-1 (2018)

Magic Leap Studios | Project Create (18. 8. 8.) https://www.youtube.com/watch?v=K5246156rcQ

Magic Leap 2 (2022)

https://youtu.be/3riUny4XWSg (1:15, 2022)

Magic Leap 2

https://youtu.be/7MxXtqTYLF4?si=xv4ilyZnyyL7kh4A (0:26)

Oculus Quest Pro (2022)

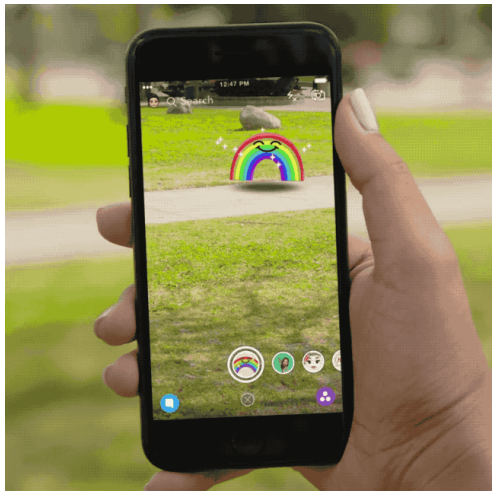
- ✓ Weight: 722g
- ✓ Real-time expression tracking
  - 5 infrared eye and face tracking sensors capable of a 120-degree FOV each
  - Capture upper and lower facial movements
- ✓ Controllers
  - 3 cameras and a Snapdragon mobile processor per controller
  - 360-degree range of motion in your virtual space
  - TruTouch haptic feedback
- ✓ Display
  - 22 pixels per degree, 1800 x 1920 pixels per eye
  - 106 degrees Horizontal x 96 degrees Vertical FOV

Oculus Quest Pro

https://youtu.be/Vh6dVgBDmAM (1:46)

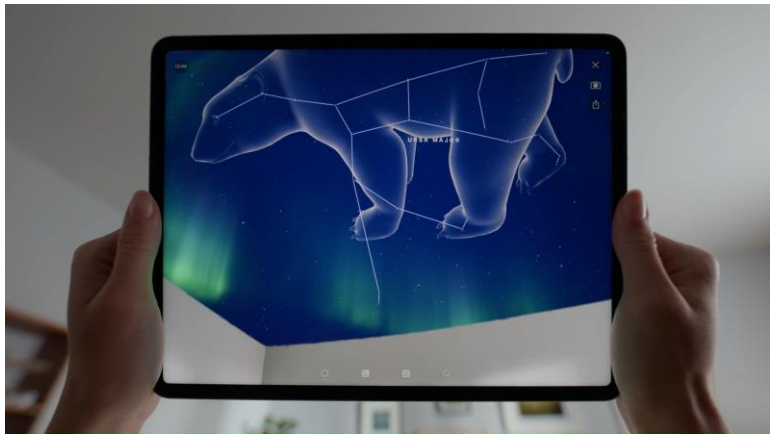
Mobile Camera AR Apps (2015-)

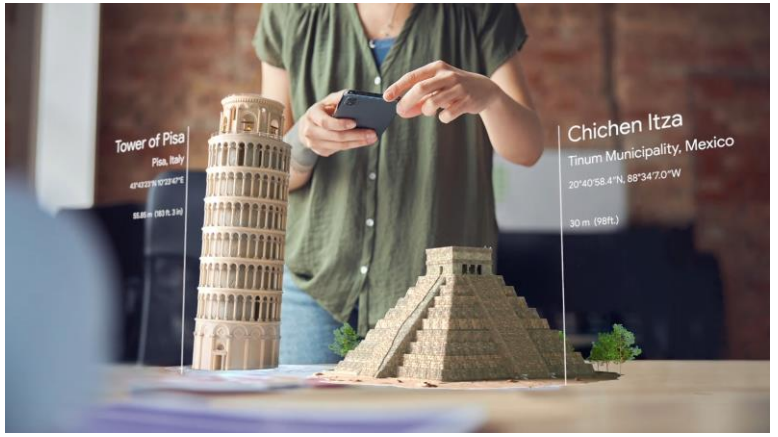
- ✓SnapChat – Lenses, World Lenses
  - Cinco de Mayo lens > 225 million views
- ✓Facebook – Camera Effects
- ✓Google – Word Lens/Translate



ARKit/ARCore (2017)

- ✓Visual Inertial Odometry (VIO) systems
- ✓Mobile phone pose tracked by Camera (Visual), Accelerometer and Gyroscope (Inertial)
- ✓Features: Plane detection, lighting detection, hardware optimization
- ✓Links
  - https://developer.apple.com/arkit/
  - https://developer.google.com/ar/





ARKit Example

Examples of work currently being done by developers with Apple's new ARKit (17. 6. 27.) https://www.youtube.com/watch?v=6xDyVBsBtX8

Strong vs. Weak AR

Strong AR

✓Very accurate tracking

✓Seamless integration into real world

✓Natural interaction

✓Head mounted AR

Weak AR

✓Imprecise tracking

✓No knowledge of the environment

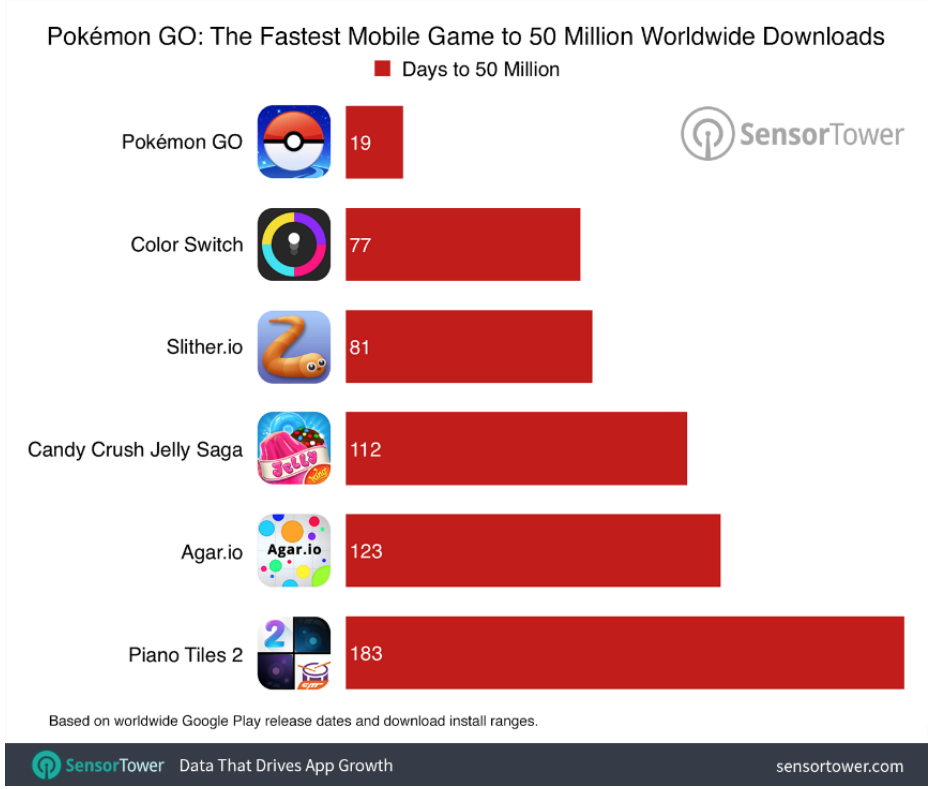
✓Limited interactivity

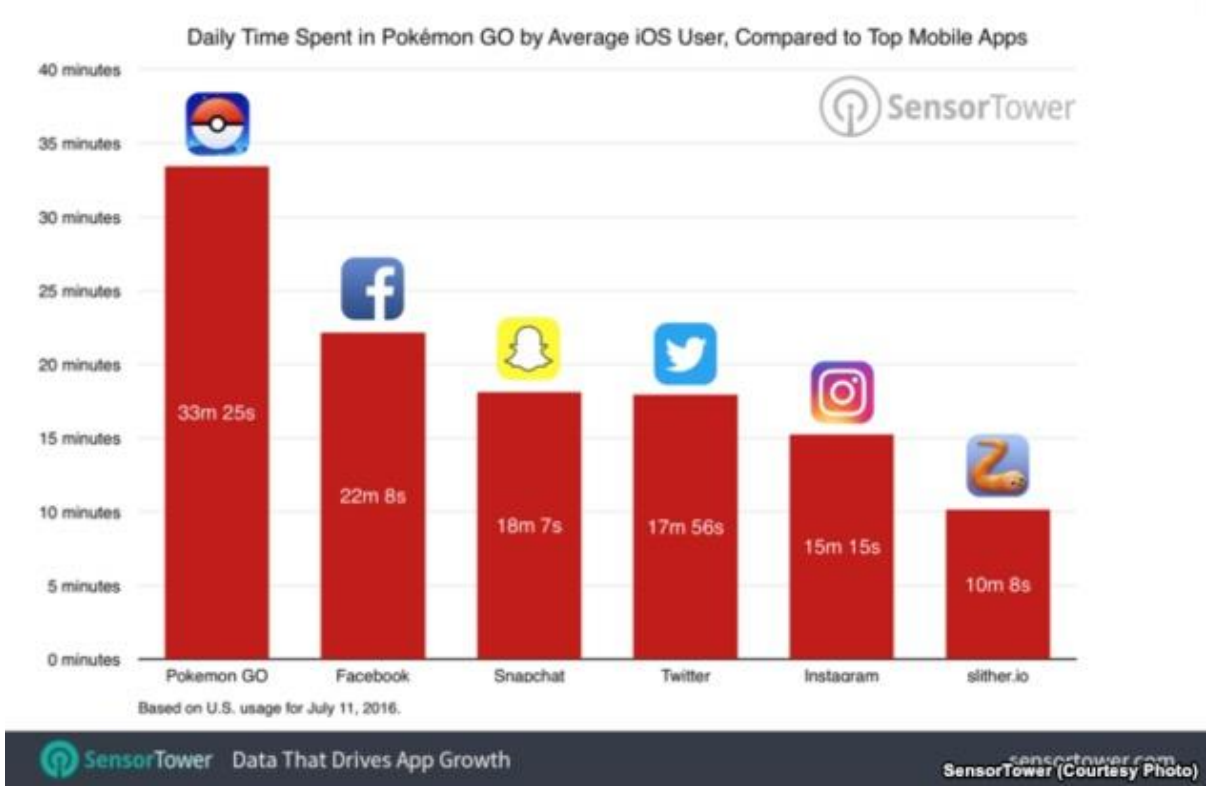
✓Handheld AR

Pokémon GO

✓Killer Combo: brand + social + mobile + geo-location + AR

Pokémon Go Effect





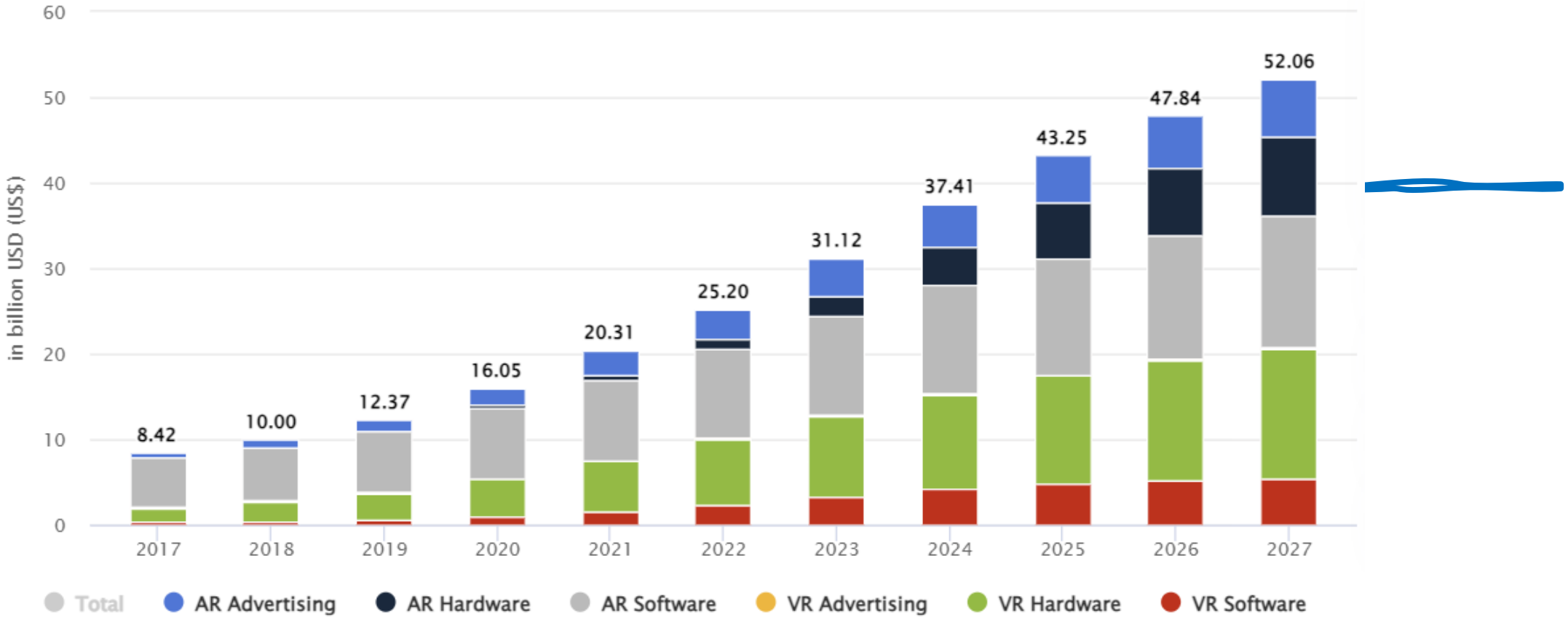
Augmented Reality Today

✓Key Technologies Available

- Robust tracking (Computer Vision, GPS/sensors)
- Display (Handheld, HMDs)
- Input devices (Kinect, etc)
- Developer tools (Vuforia, ARKit, ARCore, Unity, Unreal Engine)

✓AR/VR Market

- $31.12 Billion in 2023



Notes: Data shown is using current exchange rates and reflects market impacts of the Russia-Ukraine war. Data represents only the B2C revenue covered in the market.

Most recent update: Aug 2023

Source: Statista Market Insights

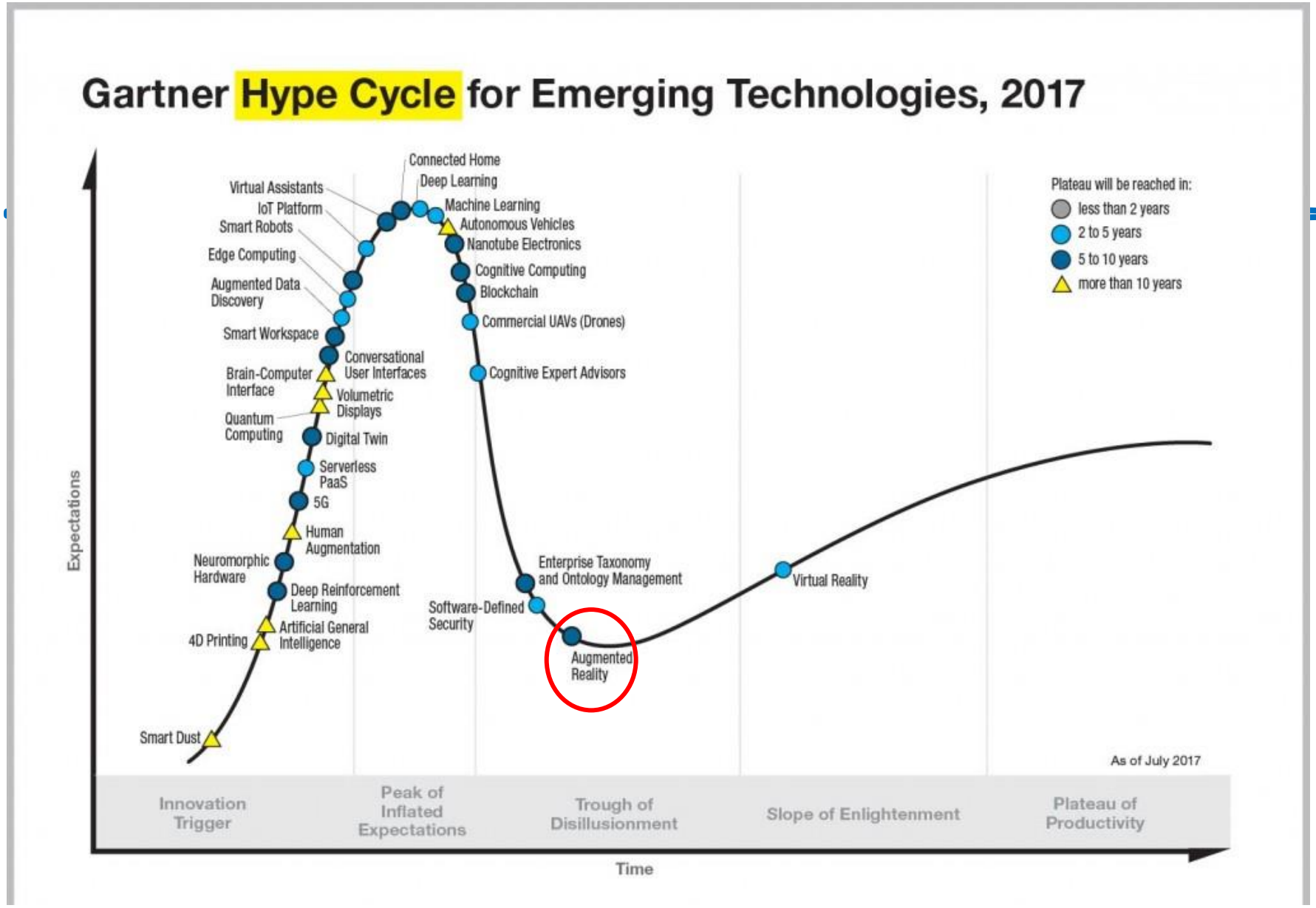
Recap of Key Points

✓Augmented Reality has a long history going back to the 1960's

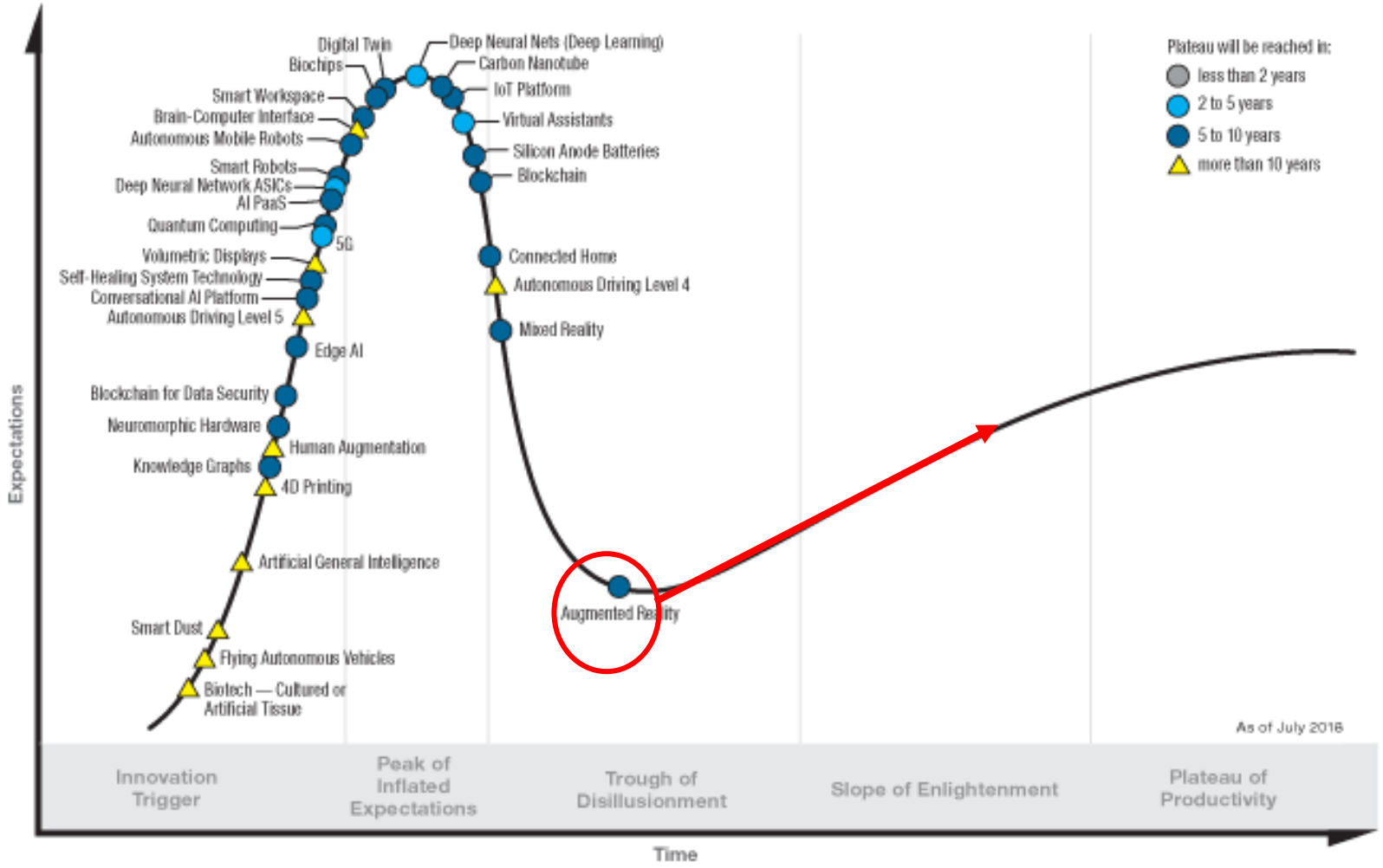
✓Interest in AR has exploded over the last few years and is being commercialized quickly

✓AR is growing in several areas

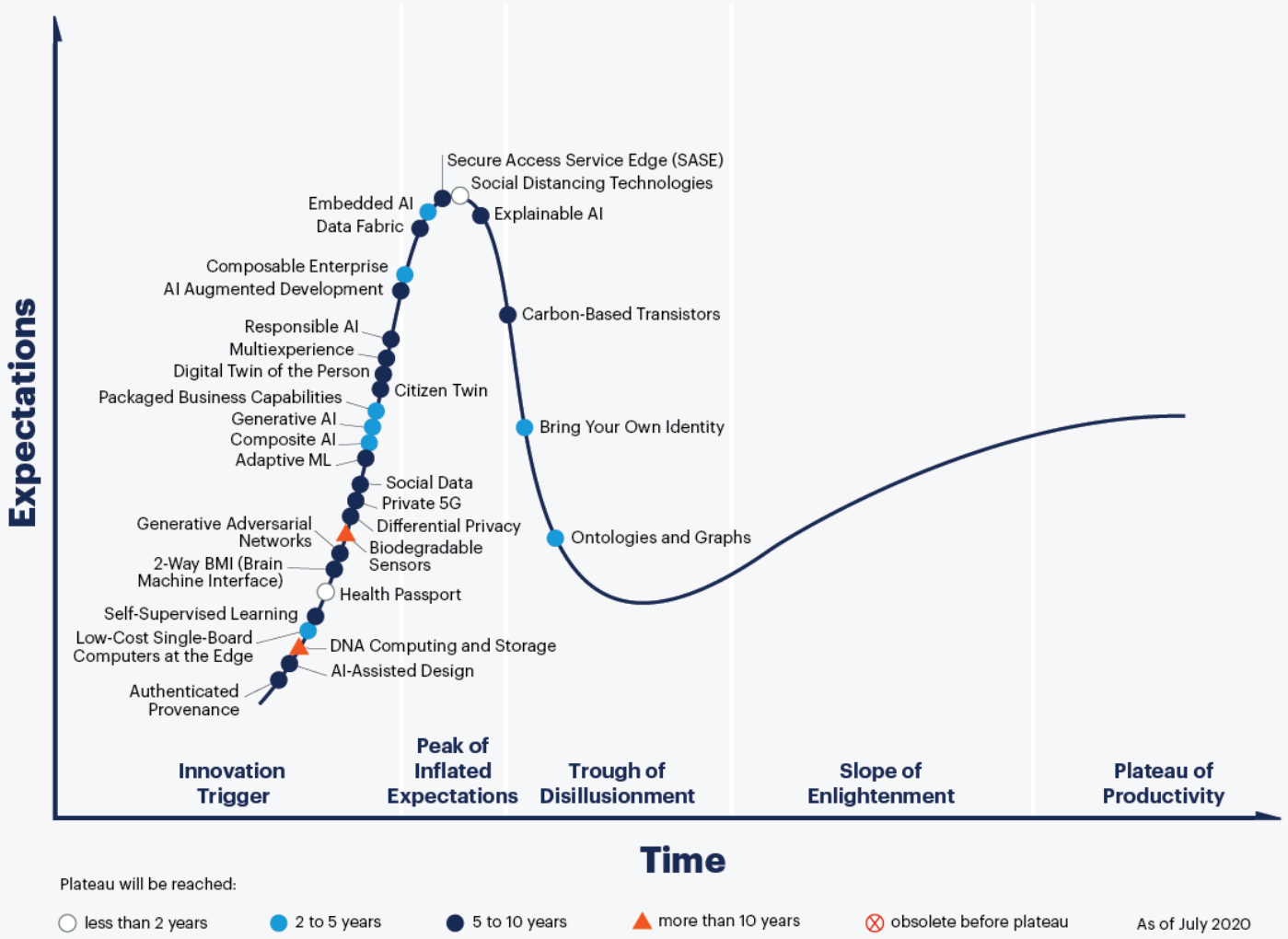
- Mobile AR
- Web based AR
- Marketing experiences


Gartner Hype Cycle for Emerging Technologies, 2017
Connected Home
Deep Learning
Virtual Assistants
IoT Platform
Machine Learning
Smart Robots
Autonomous Vehicles
Edge Computing
Nanotube Electronics
Augmented Data Discovery
Cognitive Computing
Blockchain
Smart Workspace
Commercial UAVs (Drones)
Conversational User Interfaces
Brain-Computer Interface
Cognitive Expert Advisors
Volumetric Displays
Quantum Computing
Digital Twin
Serverless PaaS
5G
Human Augmentation
Neuromorphic Hardware
Enterprise Taxonomy and Ontology Management
Deep Reinforcement Learning
Software-Defined Security
Virtual Reality
Artificial General Intelligence
4D Printing
Augmented Reality
Smart Dust
Plateau will be reached in:
less than 2 years
2 to 5 years
5 to 10 years
more than 10 years
As of July 2017
Expectations
Innovation Trigger
Peak of Inflated Expectations
Trough of Disillusionment
Slope of Enlightenment
Plateau of Productivity
Time

Hype Cycle for Emerging Technologies, 2018



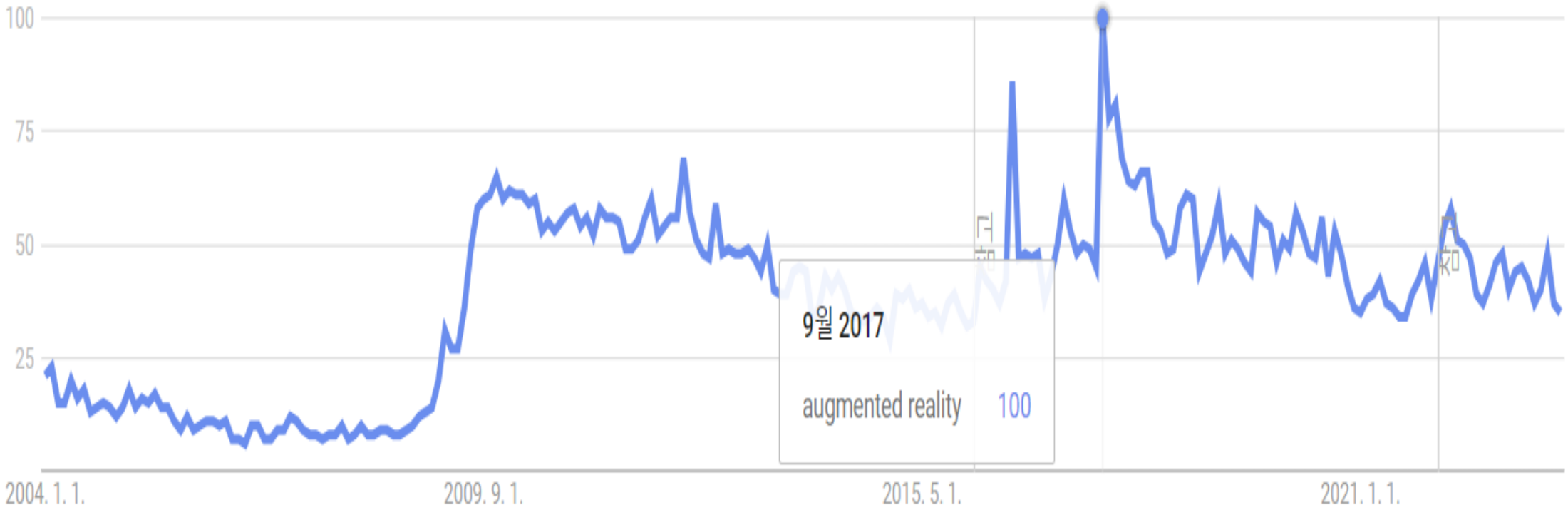
Hype Cycle for Emerging Technologies, 2020



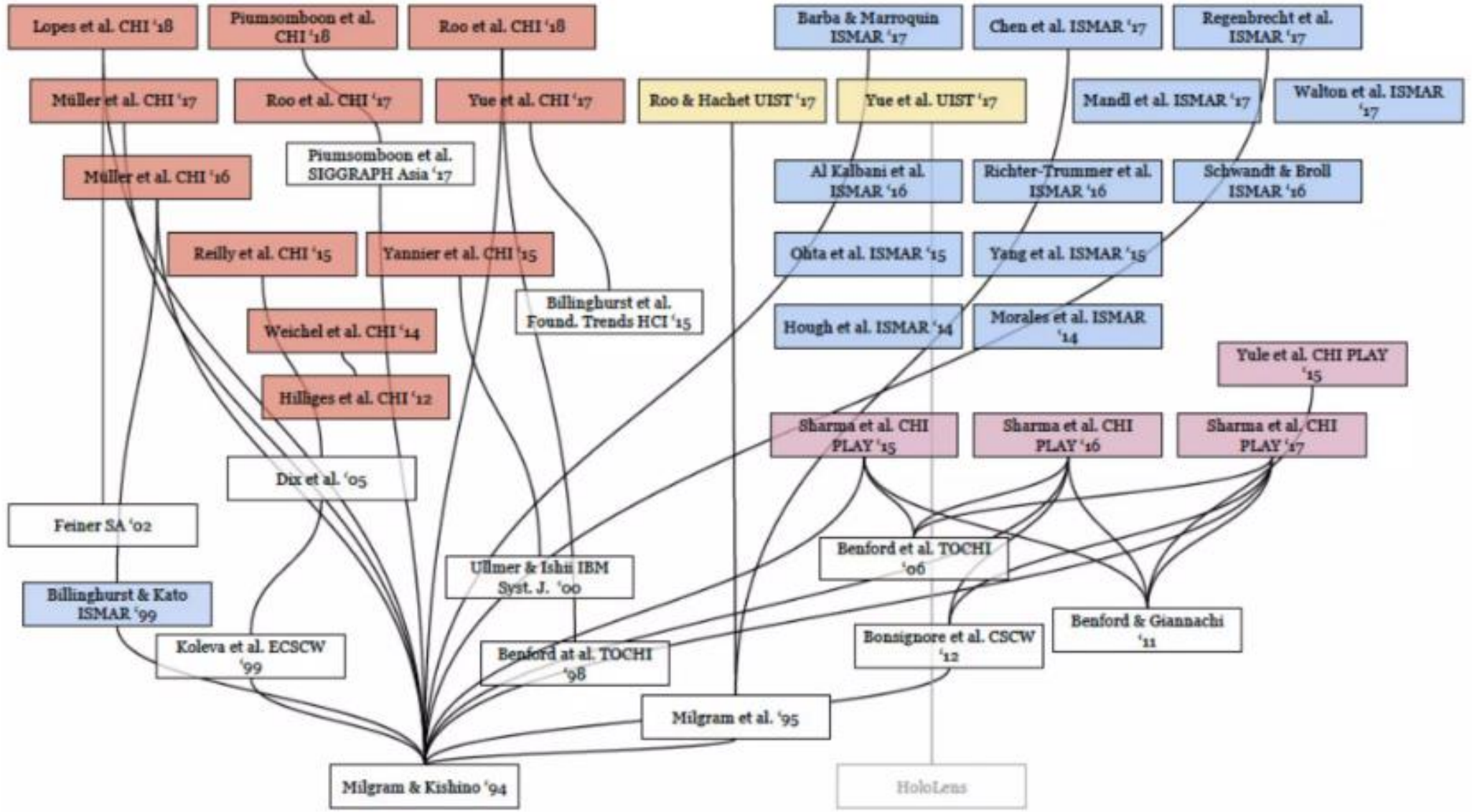
gartner.com/SmarterWithGartner

Gartner

Google Searches for AR



Google Searches for AR vs. VR


Lopes et al. CHI '18
Piumsomboon et al. CHI '18
Roo et al. CHI '18
Barba & Marroquin ISMAR '17
Chen et al. ISMAR '17
Regenbrecht et al. ISMAR '17
Müller et al. CHI '17
Roo et al. CHI '17
Yue et al. CHI '17
Roo & Hachet UIST '17
Yue et al. UIST '17
Mandl et al. ISMAR '17
Walton et al. ISMAR '17
Piumsomboon et al. SIGGRAPH Asia '17
Müller et al. CHI '16
Al Kalbani et al. ISMAR '16
Richter-Trummer et al. ISMAR '16
Schwandt & Broll ISMAR '16
Reilly et al. CHI '15
Yannier et al. CHI '15
Ohta et al. ISMAR '15
Yang et al. ISMAR '15
Billinghurst et al. Found. Trends HCI '15
Weichel et al. CHI '14
Hough et al. ISMAR '14
Morales et al. ISMAR '14
Yule et al. CHI PLAY '15
Hilliges et al. CHI '12
Sharma et al. CHI PLAY '15
Sharma et al. CHI PLAY '16
Sharma et al. CHI PLAY '17
Dix et al. '05
Feiner SA '02
Benford et al. TOCHI '06
Ullmer & Ishii IBM Syst. J. '00
Billinghurst & Kato ISMAR '99
Benford & Giannachi '11
Koleva et al. ECSCW '99
Bonsignore et al. CSCW '12
Benford at al. TOCHI '98
Milgram et al. '95
Milgram & Kishino '94
HoloLens

Q/A