

EXTENDED REALITY (XR)

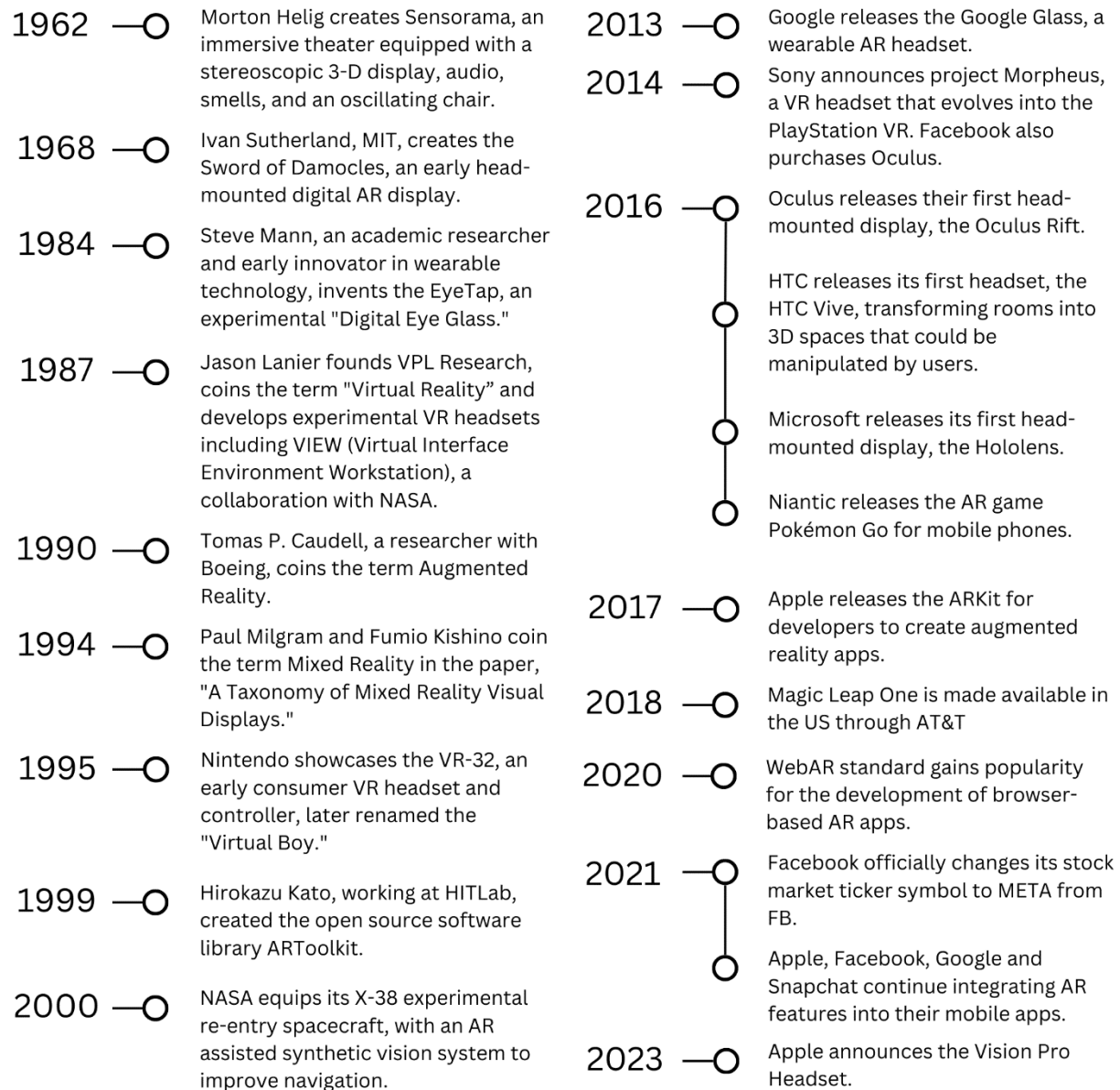
INTRODUCTION

In 2016, Niantic released Pokémon Go, an augmented (AR) reality video game for mobile devices. By overlaying creatures and game mechanics on top of the live camera feed from the mobile device, and connecting devices to each other, Pokémon Go gave many people their first commercial experience of extended reality (XR), highlighting its social, interactive, and artistic potentials. XR also includes Virtual Reality (VR) and Mixed Reality (MR).

XR changes how we perceive and interact with the world around us. It has made an impact in construction, medical, entertainment and exploration industries, amongst many others. The latest cycle of research and devices, from the metaverse to Apple's latest Vision Pro headset, has attracted substantial investments and equally creative engineers. But where do these tools come from, and how can we engage with them from a critical perspective?

WHAT IS XR?

XR or "Extended Reality" is an umbrella term used to describe technologies that blend digital experiences with physical reality. While many innovative XR technologies are becoming increasingly mainstream, some of the ideas underlying VR and AR technologies can be traced back to the 1800s and stereoscopic displays, which play with vision. These early devices made it possible to capture and represent the world in 3D images using mirrors and refracting prisms. The Crash Course: Future of VR episode has a more detailed look at the history of VR (video includes transcript).



Caption: A timeline for immersive technologies from 1962 to today.

Image text:

A timeline of immersive technologies:

1962: Morton Helig creates Sensorama, an immersive theater equipped with a stereoscopic 3-D display, audio, smells, and an oscillating chair.

1968: Ivan Sutherland, MIT, creates the Sword of Damocles, an early head-mounted digital AR display.

1984: Steve Mann, an academic researcher and early innovator in wearable technology, invents the EyeTap, an experimental "Digital Eye Glass."

1987: Jason Lanier founds VPL Research, coins the term "Virtual Reality" and develops experimental VR headsets including VIEW (Virtual Interface Environment Workstation), a collaboration with NASA.

1990: Tomas P. Caudell, a researcher with Boeing, coins the term Augmented Reality.

1994: Paul Milgram and Fumio Kishino coin the term Mixed Reality in the paper, "A Taxonomy of Mixed Reality Visual Displays."

1995: Nintendo showcases the VR-32, an early consumer VR headset and controller, later renamed the "Virtual Boy."

1999: Hirokazu Kato, working at HITLab, created the open source software library ARToolkit.

2000: NASA equips its X-38 experimental re-entry spacecraft, with an AR assisted synthetic vision system to improve navigation.

2013: Google releases the Google Glass, a wearable AR headset.

2014: Sony announces project Morpheus, a VR headset that evolves into the PlayStation VR. Facebook also purchases Oculus.

2016: Oculus releases their first head-mounted display, the Oculus Rift. HTC releases its first headset, the HTC Vive, transforming rooms into 3D spaces that could be manipulated by users. Microsoft releases its first head-mounted display, the HoloLens. Niantic releases the AR game Pokémon Go for mobile phones.

2017: Apple releases the ARKit for developers to create augmented reality apps.

2018: Magic Leap One is made available in the US through AT&T.

2020: WebAR standard gains popularity for the development of browser-based AR apps.

2021: Facebook officially changes its stock market ticker symbol to META from FB.

Apple, Facebook, Google and Snapchat continue integrating AR features into their mobile apps.

2023: Apple announces the Vision Pro Headset.

WHAT'S THE DIFFERENCE BETWEEN AR, VR AND MR?

Technologies that fall under the term XR provide us with a more immersive way to interact with digital objects. What do AR, VR, and MR mean?

Virtual Reality (VR) usually relies on a head mounted display with screens for each eye. This allows content creators to generate “stereoscopic” video which translates into a three-dimensional experience. VR devices can immerse a user in real-world 360 video, computer-generated content, or a combination of both; these are usually controlled by handheld remotes. Examples of VR include the video game Second Life, the Mozilla Hubs platform of virtual rooms, or, in fiction, the Star Trek Holodeck.

With Augmented Reality (AR) experiences, digital content is layered on top of the physical world using headsets, smartphones or wearables. With AR, the wearer’s environment can be augmented with text, images, video, sound, and other forms of haptic feedback – just like in Pokémon Go. Other examples include Tiktok’s animated overlays, or Ikea’s app which helps you visualize furniture in a room before buying it.

The defining feature of Mixed Reality (MR), and what differentiates it from AR, is that objects in the physical world and digital content coexist and interact with each other, and with you! For example, Google Translate can overlay translated text over real life script. If you change what is written, the translation will update.

Generally, XR can be thought of as any system which blurs the lines between what is real and what is computationally simulated by making the latter interactive and immersive.

Kinds of Extended Reality

Augmented Reality



Digital designs get displayed over a user's environment, but aren't interactive. AR is a way to show digital information about an environment.

Virtual Reality



A user's environment is replaced by a digitally rendered space. VR is generally intended to be an immersive experience using sight and hearing.

Mixed Reality



In MR, rendered objects and physical objects can interact in real time. User action on the physical can trigger changes with digital objects and vice-versa.

Caption: Graphics license CC-BY for the Noun Project, by Arafat Uddin, Path Lord, and Smashicons.

Image text: A graphic with text summarizing the differences between the technologies designated as XR: Augmented Reality (with a graphic showing how a cup rendered through a tablet is displayed with a digital speech bubble) is when digital designs get displayed over a user's environment but aren't interactive. AR is a way to show digital information about an environment.

Virtual Reality is when a user's environment is replaced by a digitally rendered environment. VR is generally intended to be an immersive experience using sight and hearing. This text is accompanied by a graphic of a person with short hair in a black shirt with a head mounted display and a stylized rendering of a 360 environment around them.

Mixed Reality is when rendered objects and physical objects can interact in real time. User action on the physical can trigger changes with digital objects and vice versa.

HOW WILL XR AFFECT OUR EVERY DAY LIVES?

For some people, XR is already affecting the way they work or live. As mentioned above, translation apps use AR to translate text. Digital maps often let you overlay information over a satellite representation of the terrain surrounding you. Book scanning apps detect the edges of a page and display those in real time on your mobile device to make sure you will get the output you want.

In healthcare, VR helps people get in the shoes of people who perceive the world in different ways or to prepare patients for medical procedures. In retail, brands have, like Ikea, used AR or VR to let curious customers “try out” products before purchasing. In digital arts, some people have reoriented their career towards exploring the artistic potential of these tools, creating immersive experiences, compositions, games, etc.

At research centers, XR technologies are also being used to visualize and explore large datasets. For example, NASA’s [PointCloudsVR](#) is used to map and explore star system information gathered by orbital satellites. Finally, various museums provide high resolution tours of their collections in immersive formats, making their collection remotely accessible.



Image caption: NASA engineer Tom Grubb manipulates a 3D simulation that animates the speed and direction of four million stars in the local Milky Way neighborhood using the PointsCloudVR system. CC-By Wikimedia Commons.

Image text: A bald person wearing a blue button down long sleeve shirt wearing headphones, a head mounted display, and holding a VR hand controllers in each hand. The person is standing in front of a large rendering of a galaxy, which is mostly green and yellow and white. The person is looking up through the head mounted display.

SINGLE AND MULTI-PLAYER ENVIRONMENTS

In the 1990's, VR environments tended to be single-player worlds. Projects such as Second Life (released 2003) popularized the possibility of interacting with other users via avatars in a virtual world, which have since become the norm, and allow for further integration with AR / MR experiences.

In 2021, Facebook changed its name to Meta and publicized its version of a Virtual Reality platform. Learn more from the [Web 3.0 and the metaverse Quick Thing](#).



Image caption: A Meeting in Second Life, one of the original multi-player commercial online meeting environments. CC-BY Wikiversity.

Image text: Over a dozen characters in the game Second Life are standing around a green oval with a red dot in it for a virtual meeting. They are in a digital environment that looks like a desert, with dark brown sand and grey rock hills. There are a few structures in the background and a Welsh flag on one of the hills. All the characters have various designs but are hard to distinguish.

OTHER SENSES AND ACCESSIBILITY

Although head mounted displays are often the technological focus of XR development, various devices have for decades worked with other senses than the visual to provide immersive experiences. For example, there is a whole subset of immersive audio games which replace video environments with purely auditory ones, through which you play using only headphones.

This highlights that XR, although it can provide a very wide range of new experiences for audiences, has accessibility barriers. What would XR designed for d/Deaf and hard of hearing people look like? For people with different mobility needs? For people with low vision or who are blind? These are still areas of active experimentation and research. If you are interested in making immersive experiences accessible and worthwhile, how would you work to include marginalized perspectives?

A NOTE ON WEARABLES

Wearables are electronics designed to be worn on a variety of human bodies. As XR expands immersion from seeing and hearing to feeling, smelling, and perhaps eventually tasting, wearables will in large part determine how comfortable future technology will be. Correspondingly, wearables are an active field of research.

RESOURCES AT THE CONCORDIA LIBRARY

The Webster Library Technology Sandbox has VR, AR, and MR equipment such as headsets, scanners, and design software as well as a variety of related workshops and assistance. The Webster Library Visualization Studio also offers VR headsets and an immersive multichannel sound system (full technical specifications).

QUIZ

What is the difference between AR and VR?

- A. AR is more real than VR
- B. VR is more real than AR
- C. AR allows the user to interact with surroundings while VR tends to separate users from immediate physical objects
- D. VR usually has smells as part of the experience

Correct answer: C

Feedback: AR and VR are both complex technologically and culturally, so qualifying one as "more real" is context dependent. Although some immersive systems have used smell, it is not a standard controlled element in most VR environments at the moment. The correct answer is therefore C, as AR does allow users to interact with their surroundings while VR tends to try to isolate someone from their surroundings.

What are people doing with XR?

- Doctors are operating on patients remotely using specialized robotic equipment and sophisticated telepresence systems.
- Museums are offering virtual tours of their collections.
- Space agencies are testing control interfaces and mapping out large datasets relating to celestial bodies and their interactions.
- Artists are performing shows using virtual representations of themselves.

Correct answer: All of the above

Feedback: XR is indeed used in all these ways!

ACTIVITY



How do extended reality technologies make real life look like a game, and how can gaming affect our everyday experiences through XR? This activity gives you a chance to think about how XR has made great progress because of its promises in a gaming context, and as a result the boundaries between ludic (playful) activities and practical activities has been blurred.



Watch this Pokémon Go [demo](#).

- What does the app do?
- Is it interactive?
- Can multiple people interact with each other through the app?

Then, watch [this TikTok](#) showing an AR furniture store. Think of these questions:

- What are the app's XR capacities?
- Are the visual mechanics comparable to Pokémon Go?

- Is it interactive?
- Can it be used socially like Pokémon Go?

If you haven't already, you can try out the Pokémon Go game on your own, with a [guide to help you get started](#).



It should take about 10 minutes to view the videos and consider the questions.

Are you an undergraduate student participating in the FutureBound program?

After reviewing the content and completing the activities for one of the Things, you can complete a [reflection form](#) to have it count as one activity towards your **Communication and Digital Capabilities certificate!**

RESOURCES

Crash Course: Games ep. 21

In this Crash Course: Games episode, Andre Meadows offers a detailed review of VR's history up to 2017. Video: <https://youtu.be/BfcBjJ3c9lg>

Mozilla Hubs: Spoke

The Mozilla Hubs platform is an example of a project which lets users build their own VR meeting or event rooms, which can then be hosted publicly.

Web Page: <https://hubs.mozilla.com/spoke>

Accessibility of VR experiences

In this article from 2020, the authors discuss the result of their survey of people with limited mobility using VR technology.

Journal Article: <https://dl.acm.org/doi/10.1145/3373625.3416998>

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VIDEO TRANSCRIPT

Slide: The Concordia University Library logo, under the title: Quick Things for Digital Knowledge. The slide also has hand drawn little symbols of pens, speech bubbles, play symbols, on a textured background.

Interviewer: [Text displayed on slide] What is XR?

Ezra J. Teboul: In recent years people have been very excited about immersive video games you can play with head mounted displays, or that show digital objects on top of real things as part of the gameplay. These games allow us to interact with digital information visually and auditorily, but there's a wide variety of hardware and software they're built with. XR, or extended reality, is an umbrella term to designate all those technologies that make the virtual accessible. XR technologies have seen waves of interest and investment, but they seem to remain primarily used for specialized applications as in gaming, training, some medical treatments, or construction.

Interslide: a stock photo of a parent and a child on their lap with VR headset, in a cartoon forest with a dragon and a goat.

Interviewer: [Text displayed on slide] So, what kinds of technologies does XR encompass?

Ezra J. Teboul: For now, the two main categories are AR and VR.

Interslide: displays a computer monitor with an icon of someone holding a phone up to a cup and the cup being shown on the phone as having a speech bubble. Text reads: In AT, digital information is displayed over a user's environment but isn't interactive. AR is a way to make digital information accessible in some environments.

Ezra J. Teboul: AR stands for augmented reality, and it is already a relatively popular way of doing something. Pokémon Go, Google Glass, and TikTok are all products which allow people without vision impairments to “see” computer generated items, things or information on top of their usual environment.

Interviewer: [Text displayed on slide] What about VR?

Ezra J. Teboul: VR stands for virtual reality.

Interslide: a phone with an icon of someone with a VR headset surrounded by an abstracted version of a VR world (looks like a cylinder). There is also an image of child with long hair in a yellow jacket with a VR headset , with a hand up trying to grasp something in the VR world.

Ezra J. Teboul: This is generally an immersive experience meant to replace the user’s environment with a completely computer-generated one. often, other people are also immersed in the same space and interacting with each other. For example, Facebook rebranded as Meta and tried to push a new version of its platform that people would meet on using virtual avatars.

Interslide: a graphic of a person wearing a suit and a VR headset over a blue background.

Interviewer: [Text displayed on slide] Is MR a mixture of AR and VR?

Ezra J. Teboul: Yes.

Interslide: has an icon of a tablet with a hand interacting with the representation of a landscape digitally as it is captured by the tablet camera. Text reads: MR: In Mixed Reality, rendered objects and physical objects can interact in real time. User action of the physical can trigger changes with digital objects and vice-versa.

Ezra J. Teboul: Mixed Reality, or MR, is a crossover category where actions on digital objects have noticeable consequences in real life, and vice versa. In that sense it may combine hardware and software from both forms of extended reality technologies into a new mixed environment. This is a more recent term, and examples have not quite yet come to the mainstream for now.

Interslide: A graphic of two people in a workshop looking at a digital object through a phone. The object is rendered in the image as if it was on the workbench in front of them. It looks like a circular turbine on its side.

Interviewer: [Text displayed on slide] And so, these ideas have been of interest to inventors and researchers for a long time?

Ezra J. Teboul: Yes!

Interslide: reads: XR through time: the ideas underlying VR and AR technologies can be traced back to the 1800's and stereoscopic displays.

Ezra J. Teboul: Panorama rooms and early stereoscopes, which use different techniques to create the illusion of immersive, 3D environments, were introduced in Europe as early as the late 18th century.

Interslide: a fragment from a panoramic painted scroll, Gu Hongzhong's Night Revels of Han Xizai, dated 980 AD. There are figures in dark robes standing amongst people in brighter clothing playing flutes.

Ezra J. Teboul: In China, panoramic handscrolls had been painted since at least the 12th century.

Interslide: a caption from US patent 3,050,870 by M. L. Helig, page 3: includes a portion of figure 5, a diagram of the sensorama showing a figure sitting in the machine torso and up. From Jan 10 1961.

Ezra J. Teboul: Skip to the 1950's, when Morton Heilig's Sensorama combined stereoscopy with fans, smell generators, stereo audio and a mechanical chair to immerse his audience in short multisensory films.

Interslide: a rendering of a person wearing a VR headset. The lines of their outfit and headset are highlighted in purple neon lines.

Ezra J. Teboul: It took some time for electronics to enable immersive, interactive video of some kind, but in 1987 the term virtual reality was coined and things like "VR Pods" started appearing in some north American malls. By 1993, Sega was attempting to market a VR headset for the Genesis console. In 2022, the global VR market is sometimes estimated to represent roughly 60 billion dollars, so who knows what will be next with this level of interest!

Interviewer: [Text displayed on slide] What can I do with XR at the Concordia Library?

Interslide: Concordia Library Resources: reads: Technology Sandbox: 3D Scanners, VR Headsets... for loan; Try out Tools like A-Frame or Tiltbrush; Visualization Studio: VR Stations, Multichannel Audio System, Extended Display

Ezra J. Teboul: The technology Sandbox, on the second floor of the Webster library, has equipment like 3D scanners and headsets, as well as instruction on things like A-Frame or Tiltbrush. The Visualization Studio also offers VR stations as well as an extended linear display and a multichannel audio system. As these technologies become more culturally relevant, these topics and tools will also become bigger parts of the media, film, arts, or education curriculums, so check the Concordia course catalog regularly and ask your faculty about these topics!

Slide: Ezra J. Teboul, Student librarian. CREDITS: This presentation template was created in Slidego including icons by Flaticons or from Noun Project and infographics and images by Freepik. Music is Lofi Summer Background by Vladislav Kurnikov on Pixabay.