

VIRTUAL REALITY PAPER PRESENTATION

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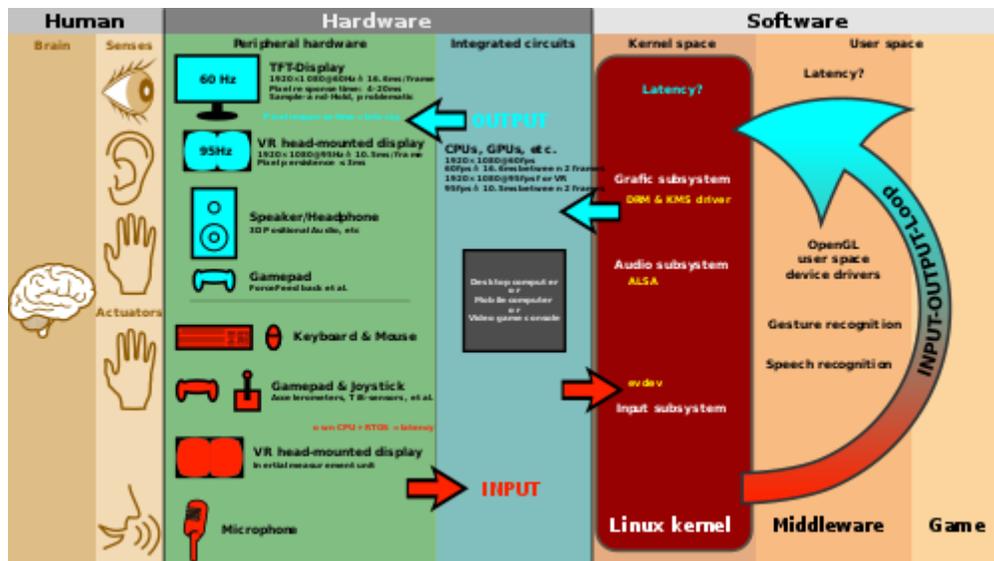
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Virtual reality (VR) typically refers to [computer](#) technologies that use [software](#) to generate the realistic images, sounds and other sensations that replicate a real environment (or create an imaginary setting), and simulate a user's physical presence in this environment. VR has been defined as "...a realistic and immersive simulation of a [three-dimensional](#) environment, created using interactive software and [hardware](#), and experienced or controlled by movement of the body"^[1] or as an "immersive, interactive experience generated by a computer".^[2]

A person using virtual reality equipment is typically able to "look around" the artificial world, move about in it and interact with features or items that are depicted on a [screen](#) or in goggles. Most 2016-era virtual realities are displayed either on a [computer monitor](#), a [projector screen](#), or with a [virtual reality headset](#) (also called [head-mounted display](#) or HMD). HMDs typically take the form of head-mounted goggles with a screen in front of the eyes. Programs may include audio and sounds through speakers or headphones.

Advanced [haptic](#) systems in the 2010s may include tactile information, generally known as [force feedback](#) in medical, [video gaming](#) and military training applications. Some VR systems used in video games can transmit vibrations and other sensations to the user via the [game controller](#). Virtual reality also refers to remote communication environments which provide a virtual presence of users with through [telepresence](#) and [telexistence](#) or the use of a [virtual artifact](#) (VA). The immersive environment can be similar to the real world in order to create a [lifelike experience](#) or it can differ significantly from reality where gamers can use fictional powers.

Etymology and terminology



Paramount for the sensation of [immersion](#) into virtual reality are a high [frame rate](#) (at least 95 fps), as well as a low [latency](#). Furthermore, a pixel persistence lower than 3 [ms](#) is required, because if not, users will feel sick when moving their head around.

In 1938, [Antonin Artaud](#) described the illusory nature of characters and objects in the [theatre](#) as "[la réalité virtuelle](#)" in a collection of essays, [Le Théâtre et son double](#). The English translation of this book, published in 1958 as [The Theater and its Double](#),^[3] is the earliest published use of the term "virtual reality". The term "[artificial reality](#)", coined by [Myron Krueger](#), has been in use since the 1970s. The term "virtual reality" was used in [The Judas Mandala](#), a 1982 science fiction novel by [Damien Broderick](#). "[Virtual](#)" has had the meaning "being something in essence or effect, though not actually or in fact" since the mid-1400s, "...probably via sense of "capable of producing a certain effect" (early 1400s)".^[4] The term "virtual" has been used in the computer sense of "not physically existing but made to appear by software" since 1959.^[4]

Virtual reality is also called "virtual realities", "immersive multimedia", "artificial reality"^[5] or "computer-simulated reality". A dictionary definition for "[cyberspace](#)" states that this word is a synonym for "virtual reality", but the two terms are fundamentally different (something that is "virtual" does not necessarily need to rely on a network, for instance).^[6]

Virtual reality shares some elements with "augmented reality" (or AR). AR is a type of virtual reality technology that blends what the user sees in their *real* surroundings with digital content generated by computer software. The additional software-generated images with the virtual scene typically enhance way the real surroundings look in some way. Some AR systems use a camera to capture the user's surroundings or some type of display screen which the user looks at (e.g., Microsoft's [HoloLens](#), [Magic Leap](#)).

Before the 1950s



The Sensorama was released in the 1950s.



[View-Master](#), a stereoscopic visual simulator, was introduced in 1939.

The first references to the concept of virtual reality came from [science fiction](#). [Stanley G. Weinbaum](#)'s 1935 short story "Pygmalion's Spectacles"^[7] describes a goggle-based virtual reality system with holographic recording of fictional experiences, including smell and touch.

1950-1970

[Morton Heilig](#) wrote in the 1950s of an "Experience Theatre" that could encompass all the senses in an effective manner, thus drawing the viewer into the onscreen activity. He built a prototype of his vision dubbed the [Sensorama](#) in 1962, along with five short films to be displayed in it while engaging multiple senses (sight, sound, smell, and touch). Predating digital computing, the Sensorama was a [mechanical device](#). Around the same time, [Douglas Engelbart](#) used computer screens as both input and output devices. In 1968, [Ivan Sutherland](#), with the help of his student [Bob Sproull](#), created what is widely considered to be the first virtual reality and [augmented reality](#) (AR) [head-mounted display](#) (HMD) system. It was primitive both in terms of [user](#)

[interface](#) and [realism](#), and the HMD to be worn by the user was so heavy that it had to be suspended from the ceiling. The graphics comprising the virtual environment were simple [wire-frame model](#) rooms. The formidable appearance of the device inspired its name, [The Sword of Damocles](#)1970–1990



[Battlezone](#), an arcade video game from 1980, used 3D vector graphics to immerse the player in a VR world.(Atari).

Also notable among the earlier [hypermedia](#) and virtual reality systems was the [Aspen Movie Map](#), which was created at [MIT](#) in 1978. The program was a crude virtual simulation of [Aspen, Colorado](#) in which users could wander the streets in one of three modes: summer, winter, and polygons. The first two were based on photographs—the researchers actually photographed every possible movement through the city's street grid in both seasons—and the third was a basic 3-D model of the city. Atari founded a research lab for virtual reality in 1982, but the lab was closed after two years due to Atari Shock ([North American video game crash of 1983](#)). However, its hired employees, such as Tom Zimmerman, Scott Fisher, Jaron Lanier and Brenda Laurel, kept their research and development on VR-related technologies. By the 1980s the term "virtual reality" was popularized by [Jaron Lanier](#), one of the modern pioneers of the field. Lanier had founded the company [VPL Research](#) in 1985. VPL Research has developed several VR devices like the Data Glove, the Eye Phone, and the Audio Sphere. VPL licensed the Data Glove technology to Mattel, which used it to make an accessory known as the Power Glove. While the Power Glove was hard to use and not popular, at US\$75, it was early affordable VR device.

During this time, virtual reality was not well known, though it did receive media coverage in the late 1980s. Most of its popularity came from marginal cultures, like [cyberpunks](#), who viewed the

technology as a potential means for social change, and the [recreational drug](#) subculture, who praised virtual reality not only as a new art form, but as an entirely new frontier.^[8] Some drug users consume drugs while using VR technologies.^[9] The concept of virtual reality was popularized in mass media by movies such as *Brainstorm* (1983) and *The Lawnmower Man*. The VR research boom of the 1990s was accompanied by the non-fiction book *Virtual Reality* (1991) by [Howard Rheingold](#).^[10] The book served to demystify the subject, making it more accessible to researchers outside of the computer sphere and sci-fi enthusiasts.

Once the industry began to attract media coverage, some even compared the innovations in virtual reality to the Wright Brothers' pioneering invention of the airplane.^[11] In 1990, Jonathan Waldern, a VR Ph.D, demonstrates "[Virtuality](#)" at the Computer Graphics 90 exhibition staged at London's Alexandra Palace. This new system was an arcade machine that would use a [virtual reality headset](#) to immerse players. *CyberEdge* and *PCVR*, two VR industry magazines, started to publish in the early 1990s. However, most ideas about VR remained theoretical due to the limited computing power available at the time. The extremely high cost of the technology made it impossible for consumers to adopt. When the Internet became widely available, this became the technology focus for most people. The VR industry mainly provided VR devices for medical, flight simulation, automobile industry design, and military training purposes from 1970 to 1990.^[citation needed]

1990-2000

In 1991, [Sega](#) announced the [Sega VR](#) headset for [arcade games](#) and the [Mega Drive](#) console. It used [LCD](#) screens in the visor, stereo headphones, and inertial sensors that allowed the system to [track](#) and react to the movements of the user's head.^[12] In the same year, [Virtuality](#) launched and went on to become the first mass-produced, networked, multiplayer VR entertainment system. It was released in many countries, including a dedicated VR arcade at [Embarcadero Center](#) in [San Francisco](#). Costing up to \$73,000 per multi-pod Virtuality system, they featured headsets and exoskeleton gloves that gave one of the first "immersive" VR experiences.^[13] Antonio Medina, a MIT graduate and NASA scientist, designed a virtual reality system to "drive" Mars rovers from Earth in apparent real time despite the substantial delay of Mars-Earth-Mars signals. The system, termed "Computer-Simulated Teleoperation" as published by Rand, is an extension of virtual reality.^[14]

In 1991, [Carolina Cruz-Neira](#), [Daniel J. Sandin](#) and [Thomas A. DeFanti](#) from the [Electronic Visualization Laboratory](#) created the [first cubic immersive room](#), replacing goggles by a multi-projected environment where people can see their body and other people around. In that same year, *Computer Gaming World* predicted "Affordable VR by 1994".^[15] By 1994, Sega released the [Sega VR-1](#) motion simulator [arcade attraction](#),^{[16][17]} in [SegaWorld amusement arcades](#). It was able to track head movement and featured [3D polygon graphics](#) in [stereoscopic 3D](#), powered by the [Sega Model 1 arcade system board](#).^[18] Also in 1994 Apple released QuickTime VR, which, despite using the term "VR", was unable to represent virtual reality, and instead displayed 360 photographic panoramas.

A year later, the artist [Maurice Benayoun](#) created the first VR artwork connecting in real time 2 continents: the "Tunnel under the Atlantic" between the [Pompidou Centre](#) in Paris and the

Museum of Contemporary Art in [Montreal](#). The installation included dynamic real time 3d modeling, video chat, spatialized sound and AI content management. A non-VR system called the [Virtual Boy](#) was created by [Nintendo](#) and was released in Japan on July 21, 1995 and in North America on August 15, 1995.^[19] Also in 1995, a group in Seattle created public demonstrations of a "[CAVE-like](#)" 270 degree immersive projection room called the Virtual Environment Theater, produced by entrepreneurs Chet Dagit and Bob Jacobson.^[20] Then in 1996 the same system was shown in tradeshow exhibits sponsored by [Netscape](#) Communications, and championed by Jim Barksdale, for the first time showing VR connected to the Internet with World Wide Web content feeds embedded in [VRML](#) 3D virtual world models. Forte released the [VFX1](#), a PC-powered virtual reality headset in 1995, which was supported by games including [Descent](#), [Star Wars: Dark Forces](#), [System Shock](#) and [Quake](#). In 1999, entrepreneur [Philip Rosedale](#) formed [Linden Lab](#) with an initial focus on the development of hardware that would enable computer users to be fully immersed in a 360 degree virtual reality experience. In its earliest form, the company struggled to produce a commercial version of "The Rig", which was realized in prototype form as a clunky steel contraption with several computer monitors that users could wear on their shoulders.^[21] That vision soon morphed into the software-based, 3D virtual world [Second Life](#).



A 2013 developer version of [Oculus Rift](#) from [Oculus VR](#), the company [Facebook](#) acquired in 2014 for \$2 billion

2000–present



The affordable and accessible [Google Cardboard](#) standard.

In 2001, SAS3 or SAS Cube became the first PC based cubic room, developed by Z-A Production ([Maurice Benayoun](#), David Nahon), Barco, Clarté, installed in Laval France in April

2001. The SAS library gave birth to Virtools VRPack. By 2007, [Google](#) introduced [Street View](#), a service that shows panoramic views of an increasing number of worldwide positions such as roads, indoor buildings and rural areas. It also features a stereoscopic 3D mode, introduced in 2010.^[22] In 2010, [Palmer Luckey](#), who later went on to found [Oculus VR](#), designed the first prototype of the [Oculus Rift](#). This prototype, built on a shell of another virtual reality headset, was only capable of rotational tracking. However, it boasted a 90-degree field of vision that was previously unseen in the consumer market at the time. This initial design would later serve as a basis from which the later designs came.^[23]

In 2013, Valve discovered and freely shared the breakthrough of low-persistence displays which make lag-free and smear-free display of VR content possible.^[24] This was adopted by Oculus and was used in all their future headsets.

In July 2013, Guild Software's [Vendetta Online](#) was widely reported as the first [MMORPG](#) to support the Oculus Rift,^{[25][26]} making it potentially the first persistent online world with native support for a consumer virtual reality headset. Since 2013, there have been several virtual reality devices that seek to enter the market to complement Oculus Rift to enhance the game experience. One, [Virtuix Omni](#), is based on the ability to move in a three dimensional environment through an [omnidirectional treadmill](#).

In early 2014, Valve showed off their SteamSight prototype, the precursor to both consumer headsets released in 2016. It shared major features with the consumer headsets including separate 1K displays per eye, low persistence, positional tracking over a large area, and [fresnel lenses](#).^{[27][28]}

On March 25, 2014, [Facebook](#) purchased Oculus VR for \$2 billion.^[29] In that same month, [Sony](#) announced Project Morpheus (its code name for [PlayStation VR](#)), a virtual reality headset for the [PlayStation 4](#) video game console.^[30] Google announces [Cardboard](#), a do-it-yourself stereoscopic viewer for smartphones. The user places their smartphone in the cardboard holder, which they wear on their head. In 2015, the Kickstarter campaign for Gloveone, a pair of gloves providing motion tracking and haptic feedback, was successfully funded, with over \$150,000 in contributions.^[31]

In February–March 2015, [HTC](#) partnered with [Valve Corporation](#) announced their virtual reality headset [HTC Vive](#) and controllers, along with their tracking technology called Lighthouse, which utilizes "base stations" mounted to the wall above the user's head in the corners of a room for positional tracking of the Vive headset and its motion controllers using infrared light.^{[32][33][34][35]} The company announced its plans to release the Vive to the public in April 2016 on December 8, 2015.^{[36][37]} Units began shipping on April 5, 2016.^[38]

In July 2015, [OnePlus](#) became the first company to launch a product using virtual reality.^[39] They used VR as the platform to launch their second flagship device the OnePlus 2, first viewable using an app on the Google Play Store,^[40] then on YouTube.^[41] The launch was viewable using OnePlus Cardboard, based on the Google's own Cardboard platform. The whole VR launch had a runtime of 33 minutes, and was viewable in all countries. Also in 2015, [Jaunt](#), a startup company developing cameras and a [cloud](#) distribution platform, whose content will be

accessible using an [app](#), reached \$100 million in funding from such sources as [Disney](#) and [Madison Square Garden](#).^[42] On April 27, 2016, [Mojang](#) announced that [Minecraft](#) is now playable on the [Gear VR](#).^[43] Minecraft is still being developed for the Oculus Rift headset but a separate version was released to the Oculus Store for use with the Gear VR. This version is similar to the Pocket Edition of Minecraft.

Use

Media

Media companies such as [Paramount Pictures](#), and [Disney](#) have applied VR into marketing campaigns creating interactive forms of media. In October 2014 Paramount Pictures, in collaboration with the media production company [Framestore](#), created a VR experience utilizing the [Oculus](#) DK2. The experience was dubbed a "time sensitive adventure in space" that took place in a portion of the Endurance space ship from the film "Interstellar." The experience was available to the public at limited AMC theater locations.^{[44][45]} In May 2016, Disney released a VR experience titled Disney Movies VR on Valve Corporation's [Steam](#) software, free for download. The experience allows users to interact with the characters and worlds from the Disney, Marvel, and Lucasfilm universes.^[46]

Many companies, including [GoPro](#), [Nokia](#), [Samsung](#), [Ricoh](#) and [Nikon](#), develop [omnidirectional cameras](#), also known as 360-degree cameras or VR cameras, that have the ability to record in all directions.^[47] These cameras are used to create images and videos that can be viewed in VR. (See [VR photography](#).) Films produced for VR permit the audience to view the entire environment in every scene, creating an interactive viewing experience. Production companies, such as [Fox Searchlight Pictures](#) and [Skybound](#), utilize VR cameras to produce films that are interactive in VR. Fox Searchlight, Oculus and Samsung Gear VR collaborated on a project titled "Wild – The Experience", starring Reese Witherspoon. The VR film was presented at the [Consumer Electronics Show](#) as well as the [Sundance Film Festival](#) in January 2015.^[48] On December 8, 2015, the production company [Skybound](#) announced their VR thriller titled "Gone". In collaboration with the VR production company WEVR, and Samsung Gear VR, the 360-degree video series was released on January 20, 2016.^{[49][50]}

Non-profit organisations such as [Amnesty International](#), [UNICEF](#), and [World Wide Fund for Nature](#) (WWF) have started using virtual reality to bring potential supporters closer to their work, effectively bringing distant social, political and environmental issues and projects to members of the public in immersive ways not possible with traditional media. Panoramic 360 views of conflict in Syria^[51] and face to face encounters with CGI tigers in Nepal^[52] have been used in experiential activations and shared online to both educate and gain financial support for such charitable work.

Pornographic studios such as [Naughty America](#), [BaDoinkVR](#) and [Kink](#) have applied VR into their products since late 2015 or early 2016. The clips and videos are shot from an angle that resembles POV-style porn.^{[53][54]}

In September 2016, Agon announced that the upcoming [World Chess Championship](#) match between [Magnus Carlsen](#) and [Sergey Karjakin](#), scheduled for that November, would be "the first in any sport to be broadcast in 360-degree virtual reality."^[55]

[Fox Sports](#) unveiled *Fox Sports VR*, a series of virtual reality broadcasts consisting mainly of [Fox College Football](#) broadcasts, in September 2016. The telecasts (which use roughly 180 degrees of rotation) were made available through smartphone apps and head-mounted displays, with [TV Everywhere](#) authentication required. The first VR telecast, which featured [Oklahoma](#) hosting [Ohio State](#), took place September 17.^{[56][57]}

Education and training



[U.S. Navy](#) personnel using a VR parachute training simulator.

Research has been done on learning in virtual reality, as its immersive qualities may enhance learning. VR is used by trainers to provide learners with a virtual environment where they can develop their skills without the real-world consequences of failing. [Thomas A. Furness III](#) was one of the first to develop the use of VR for military training when, in 1982, he presented the Air Force with his first working model of a virtual flight simulator he called the Visually Coupled Airborne Systems Simulator (VCASS). The second phase of his project, which he called the "Super Cockpit", was even more advanced, with high resolution graphics (for the time) and a responsive display. Furness is often credited as a pioneer in virtual reality for this research.^[8] VR plays an important role in combat training for the military. It allows the recruits to train under a controlled environment where they are to respond to different types of combat situations. A fully immersive virtual reality that uses [head-mounted display](#) (HMD), data suits, [data glove](#), and VR weapon are used to train for combat. This setup allows the training's reset time to be cut down, and allows more repetition in a shorter amount of time. The fully immersive training environment allows the soldiers to train through a wide variety of terrains, situations and scenarios.^[58]

A headsreen-wearing soldier sits at a gunner station while learning in a Virtual Training Suite.

VR is also used in flight simulation for the Air Force where people are trained to be pilots. The simulator would sit on top of a hydraulic lift system that reacts to the user inputs and events. When the pilot steer the aircraft, the module would turn and tilt accordingly to provide [haptic feedback](#). The flight simulator can range from a fully enclosed module to a series of computer monitors providing the pilot's point of view. The most important reasons on using simulators over learning with a real aircraft are the reduction of transference time between land training and

real flight, the safety, economy and absence of pollution.^[59] By the same token, virtual driving simulations are used to train tank drivers on the basics before allowing them to operate the real vehicle.^[60] Finally, the same goes for truck driving simulators, in which Belgian firemen are for example trained to drive in a way that prevents as much damage as possible. As these drivers often have less experience than other truck drivers, virtual reality training allows them to compensate this. In the near future, similar projects are expected for all drivers of priority vehicles, including the police.^[61]

Medical personnel are able to train through VR to deal with a wider variety of injuries.^[62] An experiment was performed by sixteen surgical residents where eight of them went through [laparoscopic cholecystectomy](#) through VR training. They then came out 29% faster at [gallbladder](#) dissection than the controlled group.^[63] With the increased commercial availability of certified training programs for basic skills training in VR environments, students have the ability to familiarize themselves with necessary skills in a corrective and repetitive environment; VR is also proven to help students familiarize themselves with skills not specific to any particular procedure.^[64] Hard skills are not the only educational application for medical personnel. In an experiment conducted by Pr. [Schmid Mast](#), virtual medical visit were simulated to identify efficient communication styles and train doctors accordingly.^[65] VR application was used to train road crossing skills in children. It proved to be rather successful. However some students with autistic spectrum disorders after such training might be unable to distinguish virtual from real. As a result, they may attempt quite dangerous road crossings.^[66]

Video games



[PlayStation VR](#) headset used in video games



A person wearing haptic feedback devices, which enable him to feel elements in the virtual world.

The use of graphics, sound and input technology in [video games](#) can be incorporated into VR. Several Virtual Reality head mounted displays (HMD) were released for gaming during the early-mid 1990s. These included the [Virtual Boy](#) developed by [Nintendo](#), the iGlasses developed by Virtual I-O, the Cybermaxx developed by Victormaxx and the [VFX1 Headgear](#) developed by [Forte Technologies](#). Other modern examples of narrow VR for gaming include the [Wii Remote](#), the [Kinect](#), and the [PlayStation Move/PlayStation Eye](#), all of which track and send motion input of the players to the game console somewhat accurately.

Several companies were working on a new generation of VR headsets, which were released on March 28, 2016: [Oculus Rift](#) is a head-mounted display for gaming purposes developed by Oculus VR, an American technology company that was acquired for US\$2 billion by [Facebook](#) in 2014. One of its rivals was named by Sony as PlayStation VR (codenamed Morpheus), which requires a PS4 instead of a PC to run. In 2015, [Valve Corporation](#) announced their partnership with [HTC](#) to make a VR headset capable of tracking the exact position of its user in a 4.5 by 4.5 meters area, the [HTC Vive](#).^[67] All these virtual reality headsets are tethered headsets that use special lenses to magnify and stretch a 5.7-inch screen (in the case of Morpheus) across the field of vision. There are more gaming VR headsets in development, each with its own special abilities. [StarVR](#) offers a 210° field of view, whereas [FOVE](#) tracks the position of human eyes as an input method.^[68]

Fine arts

[David Em](#) was the first fine artist to create navigable virtual worlds in the 1970s.^[69] His early work was done on mainframes at [Information International, Inc.](#), [Jet Propulsion Laboratory](#), and [California Institute of Technology](#). [Jeffrey Shaw](#) explored the potential of VR in fine arts with early works like *Legible City* (1989), *Virtual Museum* (1991), and *Golden Calf* (1994). Canadian artist [Char Davies](#) created immersive VR art pieces *Osmose* (1995) and *Ephémère* (1998). [Maurice Benayoun](#)'s work introduced metaphorical, philosophical or political content, combining VR, network, generation and intelligent agents, in works like *Is God Flat?* (1994), "Is the Devil Curved?" (1995), *The Tunnel under the Atlantic* (1995), and *World Skin, a Photo Safari in the Land of War* (1997). Other pioneering artists working in VR have include [Knowbotic Research](#), [Rebecca Allen](#) and [Perry Hoberman](#).^[70] In 2016, the first project in Poland called *The Abakanowicz Art Room* was realized – it was documentation of the art office professor [Magdalena Abakanowicz](#) made by [Jarosław Pijarowski](#) and Paweł Komorowski.^[71]

Engineering

The use of 3D [computer-aided design](#) (CAD) data was limited by 2D monitors and paper printouts until the mid-to-late 1990s, when video projectors, 3D tracking, and computer technology enabled a renaissance in the use 3D CAD data in virtual reality environments. With the use of active shutter glasses and multi-surface projection units immersive engineering was made possible by companies like VRcom and [IC.IDO](#). Virtual reality has been used in automotive, aerospace, and ground transportation original equipment manufacturers (OEMs) in their product engineering and manufacturing engineering . Virtual reality adds more dimensions to [virtual prototyping](#), product building, assembly, service, performance use-cases. This enables engineers from different disciplines to view their design as its final product. Engineers can view the virtual bridge, building or other structure from any angle. As well, some computer models allow engineers to test their structure's resistance to winds, weight, and other elements. Immersive VR engineering systems enable engineers, management and investors to see virtual prototypes prior to the availability of any physical prototypes.

Heritage and archaeology

The first use of a VR presentation in a heritage application was in 1994, when a museum visitor interpretation provided an interactive "walk-through" of a 3D reconstruction of [Dudley Castle](#) in England as it was in 1550. This consisted of a computer controlled laserdisc-based system designed by British-based engineer Colin Johnson. The system was featured in a conference held by the British Museum in November 1994, and in the subsequent technical paper, *Imaging the Past – Electronic Imaging and Computer Graphics in Museums and Archaeology*.^[72] Virtual reality enables heritage sites to be recreated extremely accurately, so that the recreations can be published in various media.^[73] The original sites are often inaccessible to the public or, due to the poor state of their preservation, hard to picture.^[74] This technology can be used to develop virtual replicas of caves, natural environment, old towns, monuments, sculptures and archaeological elements.^[75]

Architectural design



A visitor at Mozilla Berlin Hackshibition trying Oculus Rift virtual reality experience on Firefox.

One of the first recorded uses of virtual reality in architecture was in the late 1980s when the University of North Carolina modeled its Sitterman Hall, home of its computer science department, in a virtual environment.^[11] Several companies, including IrisVR and Floored, Inc., provide software or services that allow architectural design firms and various clients in the real estate industry to tour virtual models of proposed building designs. IrisVR currently provides software that allows users to convert design files created in CAD programs like SketchUp and Revit into files viewable with an Oculus Rift, HTC Vive, or a smartphone "in one click", without the need for complex tiered workflows or knowledge of game engines such as Unity3D.^[76] Floored, meanwhile, manually constructs and refines Rift-viewable 3D models in-house from either CAD files for un-built designs or physical scans of already built, brick-and-mortar buildings, and provides clients with access to its own viewing software, which can be used with either an Oculus Rift or a standard 2D web browser, afterward.^[77]

VR software products like these can provide a number of benefits to architects and their clients. During the design process, architects can use VR to experience the designs they are working on before they are built. Seeing a design in VR can give architect a correct sense of scale and proportion.^[78] Having an interactive VR model also eliminates the need to make physical miniatures to demonstrate a design to clients or the public. Later on, after a building is constructed, developers and owners can create a VR model of a space that allows potential buyers or tenants to tour a space in VR, even if real-life circumstances make a physical tour unfeasible. For instance, if the owner of an apartment building has a VR model of a space while the building is under construction, she can begin showing and renting the units before they are even ready to be occupied. Furthermore, this sort of showing can be conducted over any distance, as long as the potential customer has access to a VR setup (or, even, with the help of [Google Cardboard](#) or a similar phone-based VR headset, nothing but a smartphone.)

Urban design



A land development plan using Prefurbia, a 4th generation design system.

In 2010, 3D virtual reality was beginning to be used for urban regeneration, planning and transportation projects.^[79] In 2007, development began on a virtual reality software which took design coordinate geometry used by land surveyors and civil engineers and incorporated precision spatial information created automatically by the lines and curves typically shown on subdivision plats and land surveying plans. The item list contained a set of controls for [3D rendering](#), such as water reflective surfaces or building height. The land surface in software to create a contour map uses a digital terrain model (DTM). By 2010, prototype software was developed for LandMentor, a technology to automate the process leading from design to virtualization.



A streetscape with homes, showing architectural shaping and blending

Therapy

Main article: [Virtual reality therapy](#)

The primary use of VR in a therapeutic role is its application to various forms of exposure therapy, including [phobia](#) treatments.

Furthermore, the use of VR as a distraction during medical procedures has been studied as well, mostly in children. The reasoning behind this is inspired by the [gate control theory of pain](#).

Theme parks

Since 2015, virtual reality has been installed onto a number of roller coasters, including [Galactica](#) at [Alton Towers](#), [The New Revolution](#) at [Six Flags Magic Mountain](#) and [Alpenexpress](#) at [Europapark](#), amongst others. [The Void](#) is a virtual reality theme park in [Pleasant Grove, Utah](#) that has attractions where, by using virtual reality and other new technologies that haven't yet hit the market, you can play the game as if you were inside it. An illusion created by more than one of our senses, in this park, you can see, smell and even touch what is happening in the game.

Concerts



Assembled Google Cardboard VR

In [Oslo Spektrum](#) on May the 3rd 2016, Norwegian pop band [a-ha](#) cleared away their normal stage-production to give room for a very different concert performance in collaboration with Void, a [Norwegian computational](#) design studio working in the intersection between [design](#), [architecture](#), [art](#) and [technology](#). The collaboration resulted in a unique one-of-a-kind concert with advanced [scenography](#) using 360 virtual reality technology. [3D cameras](#), 20000 lines of codes, 1000 square meters of projection film and massive projectors was set up into a visual show that made the [Oslo Spektrum](#) arena in [Oslo](#), [Norway](#) into a light installation and visual experience that unfolded live for the audience instead of a pre programmed sequence. The stereoscopic VR-experience was made available for Android users directly through a YouTube app and also made available for iPhone users and other platforms.^{[80][81][82]}

Retail

[Lowe's](#), [IKEA](#) and [Wayfair](#) and other retailers have developed systems that allow their products to be seen in virtual reality, to give consumers a better idea of how the product will fit into their home, or to allow the consumer to get a better look at the product from home.^[83] Consumers looking at digital photos of the products can "turn" the product around virtually, and see it from the side or the back. The retail travel industry such as Cruise About and [Flight Centre](#) have been adopting VR to enable customer in their stores to view cruise cabins, tourism content, and hotel rooms prior to booking.

Exercise and fitness

Certain companies are using VR to target the fitness industry by using [gamification](#) concepts from video games to distract from the tedium of exercise.^[84]

Marketing

Virtual Reality has the potential to completely replace many forms of digital marketing.^[85] Marketing strategies in small and middle sized enterprises, ever more frequently include virtual reality in their ad concepts, POS material and budgets. Virtual Reality presents a unique opportunity for advertisers to reach a completely immersed audience.^[86]