# Applications of Augmented Reality

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# Introduction

Augmented Reality, or AR, is a form of virtual reality where the real world is retained as part of the experience, and computer generated 3-D content is overlaid on top of the environment and can be interacted with as though it was an actual object placed in the real world. Augmented Reality can range from many different categories, such as constructive AR, where the information and content added is additive to the real world, or destructive AR, where the real world is less of a factor and is more covered up. As such, there are thousands of applications for Augmented Reality, and this article will do its best to explain the existing technologies, and how they can be used in the future.

# Background

Augmented Reality, while a relatively new technology, was first envisioned to a wider audience back in 1901 by the famous author, L. Frank Baum. In his short story “The Master Key”, Baum mentions a “Demon of Electricity” who produces a device called a Character Marker. These spectacles would project a letter onto everyone they meet, marking their true character. The glasses idea would prove to be precognisant, as one of the first mainstream technologies that brought AR to the wider world would be the Google Glass. The Google Glass was one of the first modern examples of Wearable AR, where the technology was directly displayed via a headset shaped and weighing around the same as a pair of eyeglasses (in fact, prescription frames could be made for those that required glasses). Many people at the time

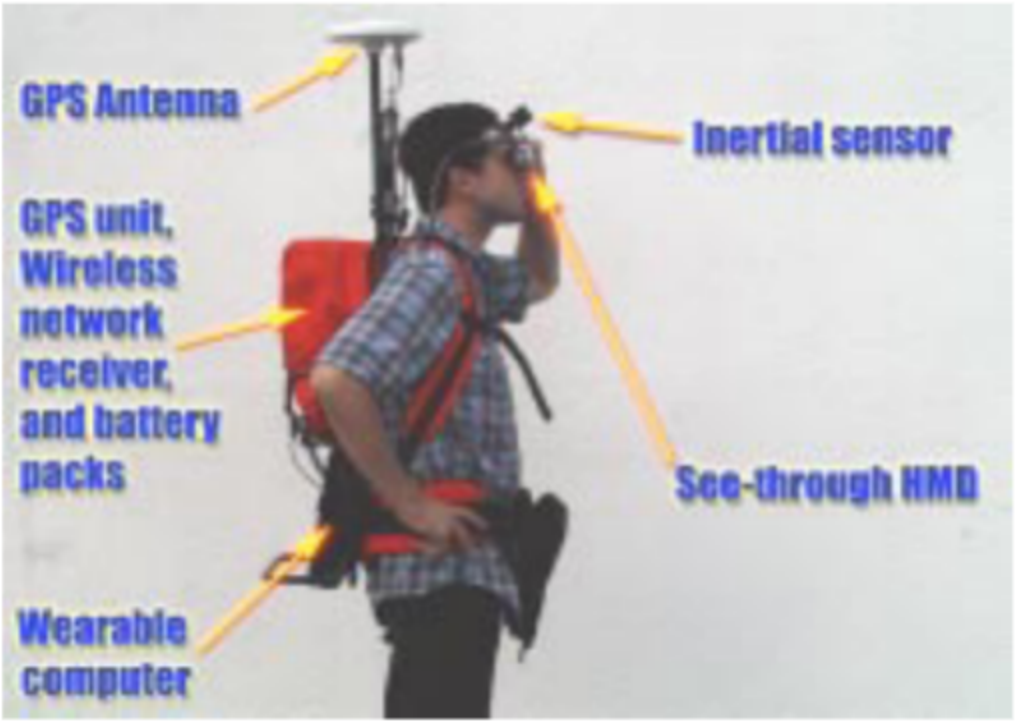
predicted that we would do away with phones altogether, and we would instead have wearable headsets that would completely replace all other computers and electronic devices. However, the technology wasn't ready and was often too clunky, restrictive, and expensive. However, as smartphones began to gain popularity and improve in technology, AR became a part of technologies that we use daily, even without thinking about it, included in our smartphones and apps that are a part of everyday life.

Modern Augmented Reality first works by creating a map of the environment around the device. Technologies like LIDAR and Cameras on the device create a 3D model of everything in the field of view, and algorithms use technologies such as corner detection and interest points to detect features. These are normally used to then create a canvas from which to affix the AR experience that will be projected onto that environment. By keeping track of those points of interest, as well as using external sensors such as gyroscopes, accelerometers, and GPS data, the device will detect movement, and will be able to adjust the project of the object accordingly, whether it is making it smaller if it is "moved away from", or by showing it from another angle as the device is moved around the point where it has "placed" this virtual object. Techniques such as SLAM (Simultaneous Localization and Mapping) are also used in the event that some of the environment is unknown and the perspective changes. Through these processes, devices can use Augmented Reality to project realistic images that can appear to exist in, and even interact with. the real world.

# Types and Uses of Augmented Reality

## Wearable Augmented Reality

As mentioned before, the public's first experience with Augmented Reality came at the hands of the Google Glass. However, that wasn't the first piece of wearable technology to be created. Like many technologies, the first applications for augmented reality were developed for military forces. The Battlefield Augmented Reality System (or BARS) was developed by the US Naval Research Laboratory in the late 1990s and early 2000s as a way to assist soldiers going into low visibility environments. The system had a way of highlighting the walls of rooms, important waypoints, other humans, and even routes of entrance and escape. It required a full backpack that contained a GPS unit, a large network receiver, and even a GPS antenna. These would all be connected to a heads-up display worn like a pair of goggles. While this technology was revolutionary, it was ruled too clunky to be used in a battlefield, and was never widely used until it was made much smaller.




*1. The hardware for the prototype BARS system*

The Google Glass was the next major foray into Augmented Reality. As mentioned before, the Google Glass was developed as a way of wearing around your computer or smartphone. The Google Glass had a single camera, a touchpad for controlling the computer (much like the one on a laptop), and a small heads up display. While far from immersive, it allowed a small window into the world of augmented reality. For example, when at the airport, you would immediately see details regarding your specific flight. Once again, the Google Glass was considered clunky, niche, and extremely expensive, boasting a price tag of $1,500 when it was released in 2013.

*2. A User Wears the Google Glass. Ariel Zambelich for Wired*

Wearable technology isn't entirely a thing of the past, however. One of the major features of the brand new F-35 planes being rolled out to militaries around the globe by Lockheed Martin is its Helmet Mounted Display System (or HMDS). This system provides pilots with up to the second data such as air speed, temperature, position, and even error data in the event of a malfunction. However, the coolest features come from its AR capabilities in improving vision. For ages, pilots would be required to wear separate night vision goggles to fly night missions, increasing cost and operational complexity. With the HMDS, the night vision is implemented directly into the helmet, and can take advantage of the thousands of sensors the F-35 has to get an even better picture of the world around them. That capability extends to removing blind spots

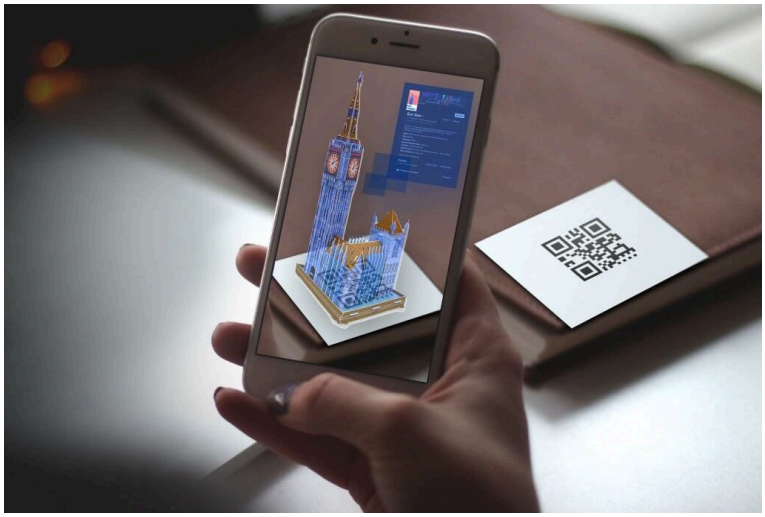
as well. The biggest blindspot for a pilot is below the plane. With the new HMDS, pilots can simply look down, and the fuselage will simply be removed as sensors below the plane send data to the heads up display, where a complete picture is projected onto the screen. With these innovations in Augmented Reality, pilots can improve their own safety, as well as their mission success rate.


*3. The Heads-Up Display of the F-35 Helmet. K2 Communications for National Defense*

## Marker Based Augmented Reality

Marker Based Augmented Reality requires a designated Marker or Symbol to begin and place the Augmented Reality Experience. These are often used as part of a museum or other educational experience, or as part of a product promotion. By scanning a QR code (that is presumably a set size, at an easy to detect orientation, and usually is one of only a couple of

options(, Users can see a set 3D model that, while they cannot fully interact with it, can be looked around, and expanded upon via a few preset options. In the example below, this technology is showing a miniature model of Big Ben being projected onto a set QR code. The model is colorized so as to highlight its different components and main features. There are even options to expand informational boxes that elaborate on the history and architecture of the structure. This technology was, and is common in educational attractions, such as Museums and Zoos, in order to augment their existing physical attractions, and engage younger tourists and attendees. It is a fun, cheap, and interesting way to ensure that people fully get to experience exhibits, and learn about intricacies that could be harder to promote solely in a traditional exhibit. This technology was once groundbreaking, however, it has since been eclipsed by Markerless Augmented reality.



*4. A phone scans a QR code and displays an annotated model of Big Ben on top of it*

# Markerless Augmented Reality

Markerless Augmented Reality comes in two major categories.

The first are filters, where the augmented reality must still be put on a specific object, but that specific object isn't standardized like the QR codes or Symbols present in Marker Based Augmented Reality. An example of this are the Snapchat AR face filters. These filters still require that a face is in the frame to place the filter on. However, the filter can be used on any and all faces, and will work, regardless of the differences between them. Using a data set based on thousands of pictures of different faces from throughout the world, Snapchat marked out where a person's eyes, ears, mouth, and nose are on the pictures, and the algorithm learned to recognize them on other images as well. When you open your camera within Snapchat, it immediately makes a 3D map of your face, and tracks where specific points on your face, such as your eyes and mouth, are. It then takes the specific filter, and adjusts it to fit your face before matching it with the points on your face it was designed to fit next to. For example, a beard filter might take into account where your ears and base of your chin are, or a glasses filter might take into account where your eyes and nose are. These points can even be adjusted to fit filters that change when you move your face in specific ways, such as a filter that makes you vomit rainbows when you open your mouth. By measuring the distance between points on your upper and lower lip, and detecting when your teeth and the inside of your mouth are visible, the filter can then activate, placing the experience in the right place on your face.

*5. The Author of this paper uses a "Minion Filter" on Snapchat, showcasing how the filter can find his skin and turn it yellow, as well as surrounding his eyes with goggles.*

Another type of Markerless Augmented Reality is the kind that can be placed anywhere, and isn't reliant on a consistent structure, such as a face. The applications of this are vast, and all it requires is a wide open empty flat space. Possibly the most famous example of this would be the viral mobile game, Pokémon GO. Pokémon GO is by far the most popular game from game developer Niantic, who combines location and camera data to turn the real world into game boards. While their games range in subjects from Transformers, to Harry Potter, to even the NBA, Pokémon GO remains their most popular and influential game. It also is a great example of how Augmented Reality technology has evolved over time. When the game first came out, the Pokémon on the screen were little more than stickers. Occasionally, they could be moved around, but they felt isolated from the world, and could not be significantly interacted with. However, as technology evolved more over time, the Pokémon could be much better placed in the real world, even circled around, and petted. This culminated in the "reality blending" feature, where, once a Pokémon was placed in the real world, should an object pass in front of it, such as a passing pedestrian, the device would recognize it, and stop generating parts of the model, much as

though the model was actually in the real world. This feature was revolutionary, and the fact that it is being rolled out to the masses is a testament to how much the technology has advanced over time.

*6. Two AR snapshots from Pokemon Go showing how an AR based object can be walked "around" as perspective changes*

Markerless Augmented Reality technology can have other uses, however. One that can save lives are medical applications. Oftentimes, it can be hard for surgeons to find a specific point in the body, and getting a full, unobstructed picture of the problem directly can be difficult. Augmented reality is being used to overlay medical images, techniques, and labels onto patients in the Operating Room, assisting doctors in treating and performing surgery on patients. For patients with a more specific problem, CT scans can even be overlaid, allowing doctors a template to properly ensure they are more precise than ever before.

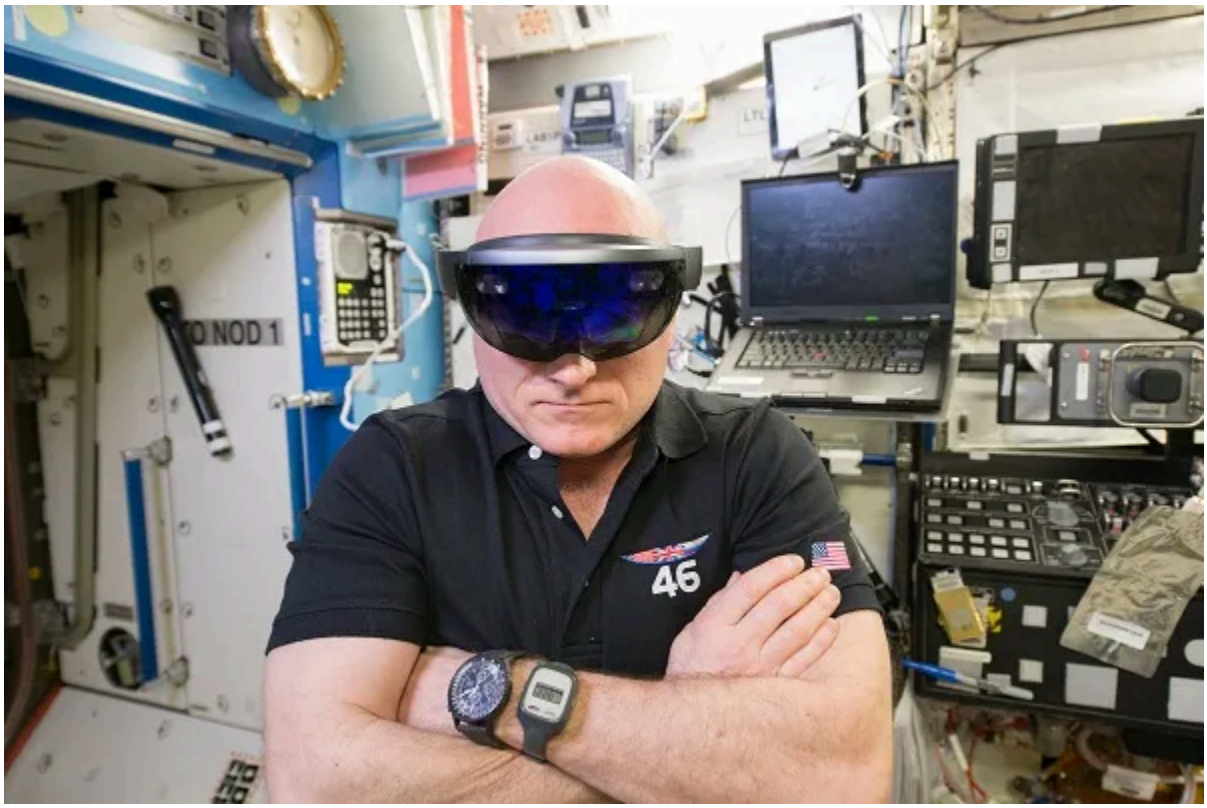
*7. Doctors use AR to get a better picture of a patient's brain before surgery*

In addition, Augmented Reality can be used in products and sales. It can be hard to get proper measurements for a space for a major piece of equipment or furniture, and oftentimes, a client would like to see how an object looks in a space before fully committing to purchasing it. However, offering to drag objects and set them fully up in a space without a guaranteed payoff or purchase is risky and expensive to sellers. However, AR allows a customer to place a piece of furniture in their own homes and fully see how it looks without having to risk bringing it in or out of their residence. Retailers like IKEA and Amazon pioneered this feature, and now it is an expected feature of every store that sells bigger purchases, such as furniture and appliances.

*8. The IKEA app placing an AR version of the ADDE chair (left) in the author's living room next to the real thing (right).*

Finally, AR can be used to help us expand our dominion as a species and traverse the stars. NASA's use of Augmented Reality (AR) aboard the International Space Station (ISS) has already proven to be a game-changer, and its potential for future missions is even more exciting. AR is helping astronauts operate more independently, providing hands-free, step-by-step guidance for repairs and experiments through devices like HoloLens. This capability is critical in space, where traditional support from Earth can be delayed by communication lags. In the future, NASA plans to expand AR's role in training, allowing astronauts to prepare for complex tasks in simulated environments that mirror the challenges of space. AR could also revolutionize scientific research, overlaying real-time data directly onto equipment or specimens, enabling faster and more accurate analyses. As NASA sets its sights on deep-space missions to the Moon and Mars, AR will be indispensable for navigation, habitat construction, and managing life-support systems in

harsh and unfamiliar environments. These tools will empower astronauts to troubleshoot and innovate on the fly, ensuring mission success even when Earth is millions of miles away. Through these advancements, AR is not just enhancing daily life on the ISS but also shaping the future of human space exploration.




*9. NASA Astronaut, Scott Kelly uses the HoloLens device to increase efficiency aboard the ISS*

# Conclusion

Technology for Augmented Reality (AR) has not only evolved remarkably over time but continues to display incredible diversity in its applications today. This diversity is not a limitation but rather an opportunity, as it enables AR to be tailored to countless uses that enhance

and enrich our daily lives. Through the integration of AR into various facets of modern living, the way we work, shop, learn, and play is being fundamentally transformed. Jobs can be performed with greater precision and efficiency, consumers are empowered with better access to information, and entertainment has become more interactive, engaging, and immersive. The journey of AR from a futuristic concept to an integral part of our lives is a testament to its transformative potential. For instance, early visions of AR, like L. Frank Baum's speculative "Character Marker" in 1901, were fantastical yet oddly prescient, foretelling devices like Google Glass. Google Glass, while not perfect, introduced wearable AR to the mainstream and demonstrated the promise of having information accessible at a glance. Though its initial form was bulky and expensive, its legacy laid the groundwork for wearable AR systems like the advanced Helmet Mounted Display Systems used in modern F-35 fighter jets, which not only improve pilot safety but also enhance mission effectiveness. The leap from a $1,500 experimental headset to a military-grade tool underscores how AR has evolved to meet diverse needs, from convenience to critical functionality. On a more accessible level, AR has seamlessly integrated into our daily routines through smartphones and apps. Marker-based AR, for example, allows for interactive educational experiences in museums or augmented promotional campaigns by projecting 3D models onto predefined symbols. Meanwhile, markerless AR, as seen in Snapchat filters and Pokémon GO, has brought the technology to our fingertips in fun and engaging ways. These innovations have grown from simple overlays to dynamic, context-aware projections, with advanced techniques like SLAM enabling realistic and interactive virtual objects to coexist with real-world environments. Such advancements highlight AR's progression from novelty to a reliable and versatile tool. The practical benefits of AR are equally impressive. In healthcare, AR assists surgeons with overlays of critical medical data during procedures,

improving precision and outcomes. Retailers have embraced AR to help customers visualize furniture or appliances in their own homes, removing barriers to purchase decisions and enhancing customer confidence. These applications showcase AR's ability to address real-world challenges, whether it's saving lives in the operating room or making home renovations easier. In entertainment, AR continues to redefine how we engage with content. Pokémon GO, for instance, began as a simple game but evolved into a platform that blends digital creatures seamlessly into our environment, utilizing advanced "reality blending" techniques. By allowing virtual elements to interact with real-world objects, AR has bridged the gap between digital and physical experiences, creating a sense of presence and interactivity that was previously unimaginable. As AR technology continues to evolve, the possibilities are boundless. It's reshaping industries, revolutionizing everyday tasks, and opening up new avenues for creativity and productivity. The innovations we see today are just the tip of the iceberg, promising a future where AR isn't just an enhancement to our reality but a fundamental part of it. Through AR, we are not only augmenting our environments but also enriching our lives in ways that were once confined to the realm of science fiction.

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