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An Overview of Augmented Reality (AR): How AR Works, AR Devices and its Future Trends

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Abstract: Augmented reality (AR) adds digital content onto a live camera feed**,** making that digital content look as if it is part of the physical world around you.
In practice, this could be anything from making your face look like a giraffe to overlaying digital directions onto the physical streets around you. Augmented reality can let you see how furniture would look in your living room, or play a digital board game on a cereal box. All these examples require understanding the physical world from the camera feed, i.e. the AR system must understand what is where in the world before adding relevant digital content at the right place. This is achieved using computer vision, which is what differentiates AR from VR, where users get transported into completely digital worlds.
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Introduction

Augmented Reality(AR) is defined as a a direct or indirect view of a physical, real-world environment whose elements are augmented by computer-generated sensory input. Simply put, AR is digital content onto a live camera feed which makes it a part of the physical world.

Augmented reality (AR) is an interactive experience of a real-world environment where the objects that reside in the real world are enhanced by computer-generated perceptual information, sometimes across multiple sensory modalities, including visual, auditory, haptic, somatosensory and olfactory.
The three main elements that define augmented reality:

1. It connects real and virtual worlds,
2. It's interactive in real time,
3. It allows movement in 3D.

Types of Augmented Reality

AR is divided into two main types:

1. **Trigger based:** They are stimuli that initiate the augmentation. They can be papers, object markers as well as GPS locations.
   In **trigger based,** we have **three types:**
   a. Marker-based: This requires a marker to achieve an augmentation. These markers can be paper based or as physical objects of the real world. These augmentations related to the marker enhance the object or the image using digital enhanced 360 degrees model/images.
   b. Location-based: This utilises GPS location as a trigger to pair the current location with dynamic information stored as a point of interest. For example: In the following map application, you view dynamically relevant information as per your location.
   c. Dynamic Augmentation: This is responsive to the view of the object as it changes. This type of AR also utilises motion tracking with the scale of the model to identify the right degree of augmentation for the object. For example: Sephora has developed an AR application which tracks your face and allows you to "apply" various types and degrees of cosmetics.

2. View based: These digitised objects do not require a reference field to be overlaid, where their location can be manipulated dynamically.
View based can be divided into **two types:**
a. Superimposition-based : This type of marker-less augmentation uses a static view of the world where external digital models/images can enhance the original environment. Here object recognition is key. For example: During a hands-free maintenance operation, an AR-based glass can detects the hardware equipment and identifies its sub-parts and its relevant information.

b. Generic Digital Augmentation: This digitises an object or an asset in the real world without any heed or any reference to the real world environment. For example, SketchFab is an application where you can visualise multiple 3D models in the real world.

Some examples of augmented reality:

- Enhanced navigation systems use augmented reality to superimpose a route over the live view of the road.
- During football games, broadcasters use AR to draw lines on the field to illustrate and analyze plays.
- Furniture and housewares giant IKEA offers an AR app (called IKEA Place) that lets you see how a piece of furniture will look and fit in your space.
- Military fighter pilots see an AR projection of their altitude, speed, and other data on their helmet visor, which means they don't need to waste focus by glancing down to see them.
- Neurosurgeons sometimes use an AR projection of a 3-D brain to aid them in surgeries.

How Augmented Reality(AR) Work

It is a integrated combination of the following technologies:

a. S.L.A.M: As per Wikipedia, "Simultaneous Localisation and Mapping is the computational problem of constructing and updating a map of an unknown environment while keeping track of the agent's location with it". Imagine a virtual graph where your 3D object is uploaded, which is dynamic enough to change its position as per the user.

b. Depth Tracking: A sensor which measures the distance of the object from the AR device.

AND the following **Components**:

- **Cameras and sensors.** Collecting data about user's interactions and sending it for processing. Cameras on devices are scanning the surroundings and with this info, a device locates physical objects and generates 3D models. It may be special duty cameras, like in Microsoft Hololens, or common smartphone cameras to take pictures/videos.
- **Processing.** AR devices eventually should act like little computers, something modern smartphones already do. In the same manner, they require a CPU, a GPU, flash memory, RAM, Bluetooth/WiFi, a GPS, etc. to be able to measure speed, angle, direction, orientation in space, and so on.
- **Projection.** This refers to a miniature projector on AR headsets, which takes data from sensors and projects digital content (result of processing) onto a surface to view. In fact, the use of projections in AR has not been fully invented yet to use it in commercial products or services.
- **Reflection.** Some AR devices have mirrors to assist human eyes to view virtual images. Some have an "array of small curved mirrors" and some have a double-sided mirror to reflect light to a camera and to a user's eye. The goal of such reflection paths is to perform a proper image alignment.

Why Does AR Need Computer Vision

While our brain is extremely good at understanding images, this remains a very difficult problem for computers. There is a whole branch of Computer Science dedicated to it called computer vision. Augmented reality requires understanding the world around the user in terms of both semantics and 3D geometry. Semantics answers the "what?" question, for example recognizing the cereal box, or that there is a face in the image. Geometry answers the "where?" question, and infers where the cereal box or the face are in the 3D world, and which way they are facing. Without geometry, AR content cannot be displayed at the right place and angle, which is essential to make it feel part of the physical world. Often, we need to develop new techniques for each domain. For example, computer vision methods that work for a cereal box are quite different from those used for a face.

Augmented Reality Devices

Many modern devices already support Augmented reality. From smartphones and tablets to gadgets like Google Glass or handheld devices, and these technologies continue to evolve. For processing and projection, AR devices and hardware, first of all, have requirements such as **sensors, cameras, accelerometer, gyroscope, digital compass, GPS, CPU, displays,** and things we've already mentioned.

Devices suitable for Augmented reality fall into the following categories:

- **Mobile devices** (smartphones and tablets) – the most available and best fit for AR mobile apps, ranging from pure gaming and entertainment to business analytics, sports, and social networking.
- **Special AR devices**, designed primarily and solely for augmented reality experiences. One example is head-up displays (HUD), sending data to a transparent display directly into user's view. Originally introduced to train military fighters pilots, now such devices have applications in aviation, automotive industry, manufacturing, sports, etc.

- **AR glasses (or smart glasses)** – Google Glasses, Meta 2 Glasses, Laster See-Thru, Laforge AR eyewear, etc. These units are capable of displaying notifications from your smartphone, assisting assembly line workers, access content hands-free, etc.
- **AR contact lenses (or smart lenses),** taking Augmented Reality one step even farther. Manufacturers like Samsung and Sony have announced the development of AR lenses. Respectively, Samsung is working on lenses as the accessory to smartphones, while Sony is designing lenses as separate AR devices (with features like taking photos or storing data).
- **Virtual retinal displays (VRD)**, creating images by projecting laser light into the human eye. Aiming at bright, high contrast and high-resolution images, such systems yet remain to be made for a practical use.

Future Trends Of Augmented Reality

Augmented reality saw its record growth in 2019. Commercial support for AR is positioned to be strong, with big tech names like Microsoft, Amazon, Apple, Facebook and Google making serious commitments. As of May 2019, the installed user base for AR-supporting mobile devices reached 1.5 billion. Industry players in the augmented reality world expect 2020 to be a year marked by an uptick in the pace of industry growth.

1: Mobile AR: Apple announced ARKit 3.0, Google's ARCore is rapidly growing its installed base

The 2017 introduction of Apple's ARKit and Google's ARCore software development kits (SDKs) has standardized the development tools and democratized mobile AR app creation which has brought about more than double the amount of mobile AR-enabled devices and tripled the number of active users during 1.5 years. Having once brought AR to the mass audience of mobile users, Apple secured its AR market leadership as it unveiled ARKit 2.0 at WWDC 2018, and then ARKit 3.0 at WWDC 2019. In terms of technology, the introduced advances placed mobile AR in the same line with headset-based AR, if not above it. We still can see a significant ARKit's dominance over ARCore, however the latter has grown almost 10 times in absolute figures. The installed base of ARCore-compatible Android devices grew from 250 million devices in December 2018 to 400 million in May 2019.

2: Augmented Reality as a novel way of shopping

Based on a report from Gartner, at least 100 million users were expected to utilize AR-enabled shopping technologies by 2020, which is one of the hottest retail trends of this year. The boom in mobile devices that employ AR means the sector is now occupied by robust and mature technologies. Developers, retailers and customers are now comfortably using them as part of their daily experience.

A BRP report indicated that 48% of consumers said that they'd be more likely to buy from a retailer that provided AR experiences. Unfortunately, only 15% of retailers currently put AR to use. Only a further 32% of retailers stated they plan to deploy virtual or augmented reality applications over the next three years.

3: AR for navigation solutions

One of the most obvious use cases for AR technologies is indoor navigation, and 2020 is expected to be the year that the average consumer gets their first real taste of its potential. People already lean heavily on maps services from both Google and Apple to get around outside, but indoor navigation stands to be the use case that blows the public away.

ARKit and ARCore based applications for indoor navigation can provide directions in airports, malls, hospital and office campuses. Gatwick Airport has already deployed its own smartphone solution that provides routes to terminals and gates based on a user's flight number.

In August 2019, Google launched a beta of its augmented reality walking directions feature for Google Maps that will be available to all AR-compatible iOS and Android mobile devices. Users can simply whip out their phones, point their cameras and see information about surrounding features in real time. Google's software is likely to move beyond the smartphone space and include integration with smart glasses.

Working from an installed base of maps users, AR-powered navigation is expected to move into new territory.

4: AR-powered solutions for the enterprise

Smart glasses are currently at a stage where consumer solutions are likely a few years off. Military, medical and enterprise solutions, however, are beginning to prove the value of combining AR with headsets and smart glasses.

One of the major current headwinds for AR is battery life. Announced in February 2019, Microsoft HoloLens 2 was likely the most anticipated product in this space in 2019. The company hopes to roll out its technology to great fanfare by demonstrating improvements in raw processing power, battery life and wearability. The U.S. Army has awarded a $480 contract to Microsoft, and the company is also working with the industrial IoT firm PTC to streamline the development of both augmented and mixed reality products.

5: Augmented Reality enhanced by Artificial Intelligence

Artificial intelligence and machine learning are fast-growing sectors in tech. Bringing them together with Augmented and Mixed Reality systems is a natural extension of many of the things that are best suited to AI and ML, particularly computer vision. Likewise, the ability to create human-machine processes that handle problems like disease diagnosis has immense potential to improve outcomes.

35% of sales on Amazon are derived from its recommendation engine, which leans heavily on data science and machine learning to deliver search results and match advertisers with customers. Moving out of the web browser and into the real world has immense commercial potential. By pairing consumer profiles with AR and ML, retailers can identify customer needs based on their environments and provide them with recommendations.

Point-and-shoot retail AR solutions will also be major drivers of innovation. A shopper in a store can get AI-based customer support while walking around. If they have questions about pricing, features or current offers, answers can be supplied by a chatbot based on natural language processing (NLP) technologies. Responses can even be tailored to the customer's unique profile, allowing greater personalization on the fly.

Robust AI and ML solutions can be extended to the AR and MR spaces to provide value to everyday users of mobile devices.

6: WebAR

In the web space, Chrome AR is a highly anticipated product of 2020. Instead of needing to use specialized apps, users can simply log on to AR-enabled websites to access the same level of functionality. In order to foster adoption, an unofficial and unsupported version of the WebAR code is made available to developers on GitHub, too.

Mozilla is also engaged with WebAR and trying to bring AR solutions to Firefox. The goal is to make AR adoption significantly more friction-free by using the installed user bases of web browser audiences. Apple, Samsung and Microsoft web browser offerings are also rapidly adopting the WebAR standards.

Although these standards have yet to be established, the implementation of AR in browsers is under active development, by means of either porting existing libraries (e.g. AR.js) or developing new ones (e.g. A-Frame, React 360). 2020 is the year that WebAR may become available on virtually every up-to-date web browser in the world.

7: Remote assistance via shared Augmented Reality

Collaborative efforts, such as conference calls, are often undermined by the lack of a direct personal presence. AR, however, can create mixed-reality settings where everyone on a conference call can see each other in a more socially conducive environment. Microsoft is moving forward with a beta of a video-calling system that employs augmented reality to create holographic-style representations of participants. Cisco Systems is also working on a project called Musion that brings together its networking products with AR technologies.

AR-based remote assistance sessions is a use case that may promote innovation. A combination of WebRTC and AR makes it possible to conduct real-time maintenance work and troubleshooting. By leveraging concurrent data streaming, assistance providers can join more directly in the maintenance, configuration and repair processes.

8: AR in the automotive industry

During 2019, a number of car manufacturers were showing off on-the-road AR solutions, too. For example, Genesis G80 utilizes a number of features to ensure accuracy, including tracking the driver's line of sight to ensure that holographic overlays are always in the right spot. Instead of having to look down at a GPS panel in the dashboard, the driver will see arrows on a heads-up display providing live directions. Porsche is also making major investments in similar technologies.

One major advantage of automotive AR is that many of the problems that are present in other use cases are easily overcome. Cars already have alternators to generate electrical power for use on the fly, largely eliminating battery

concerns. Likewise, the windshield serves as a ready stand-in for cumbersome headsets. Multiple generations of drivers have also been acclimated to onscreen data and instructions by means of car-themed video games.

9: The market evolves and remains open to innovative business-driven solutions

2017 heralded the Cambrian explosion of the AR world, the introduction of easy-to-use software development kits from both Apple (called ARKit) and Google (called ARCore). Brands, development companies, agencies, and startups rapidly followed, taking advantage of their potential. ARKit 2 landed at WWDC 18, with Apple introducing the USDZ format that makes adding models, data and animations to AR landscapes simple. 3D object recognition, environment texturing and face tracking were also introduced.

- Tracking multiple faces
- Motion capture
- Detecting when people are occluded
- Concurrent use of both the back and front cameras on the phone.

The so-called ARCloud also stands out as something to watch. The ARCloud is a concept built around cross-platform compatibility, persistence and sharing. It is intended to provide a seamless experience with the real world, too.2019 wasn't a year of revolutionary changes in the Augmented Reality technology. However, evolutionary improvements of software and hardware, like ARKit 3.0 and Apple's A13 chip in iPhone 11, will contribute to the future of augmented reality technology maturity in 2020.

Conclusion

AR is a very active field, and in the future we expect to see many exciting new developments. As computer vision gets better at understanding the world around us, AR experiences will become more immersive and exciting. Moreover, augmented reality today lives mostly on smartphones, but it can happen on any device with a camera. When enough computational power will be available on AR glasses, we expect this medium to make AR mainstream - enhancing the way we live, work, shop and play.

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