Various AR components

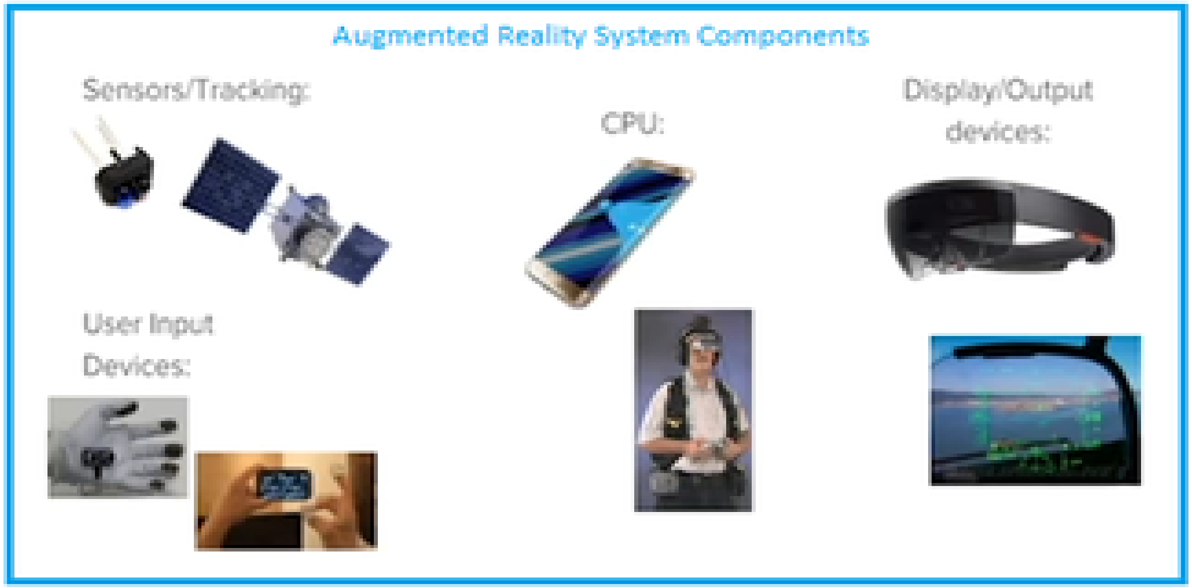

Fig 1: Components of AR

Augmented reality (AR) is an interactive experience that combines the real world and computer-generated content. The content can span multiple sensory modalities, including visual, auditory, haptic, somatosensory, and olfactory. AR can be defined as a system that incorporates three basic features: a combination of real and virtual worlds, real-time interaction, and accurate 3D registration of virtual and real objects. The primary value of augmented reality is the manner in which components of the digital world blend into a person's perception of the real world, not as a simple display of data, but through the integration of immersive sensations, which are perceived as natural parts of an environment.

The hardware components for augmented reality are a **processor, display, sensors, and input devices**. There are also five significant software components of AR: Artificial intelligence, AR software, and Processing.

The processor is responsible for running the AR software and processing the data from the sensors. The display is used to present the AR content to the user. Sensors such as cameras, accelerometers, and gyroscopes are used to track the user's movements and the environment. Input devices such as touchscreens or controllers allow the user to interact with the AR content.

Artificial intelligence is used in AR to recognize objects and patterns in the real world. This allows the AR software to accurately place virtual objects in the real world. The AR software is responsible for generating and rendering the virtual content. Processing is used to manipulate and analyze data from sensors.

Processor

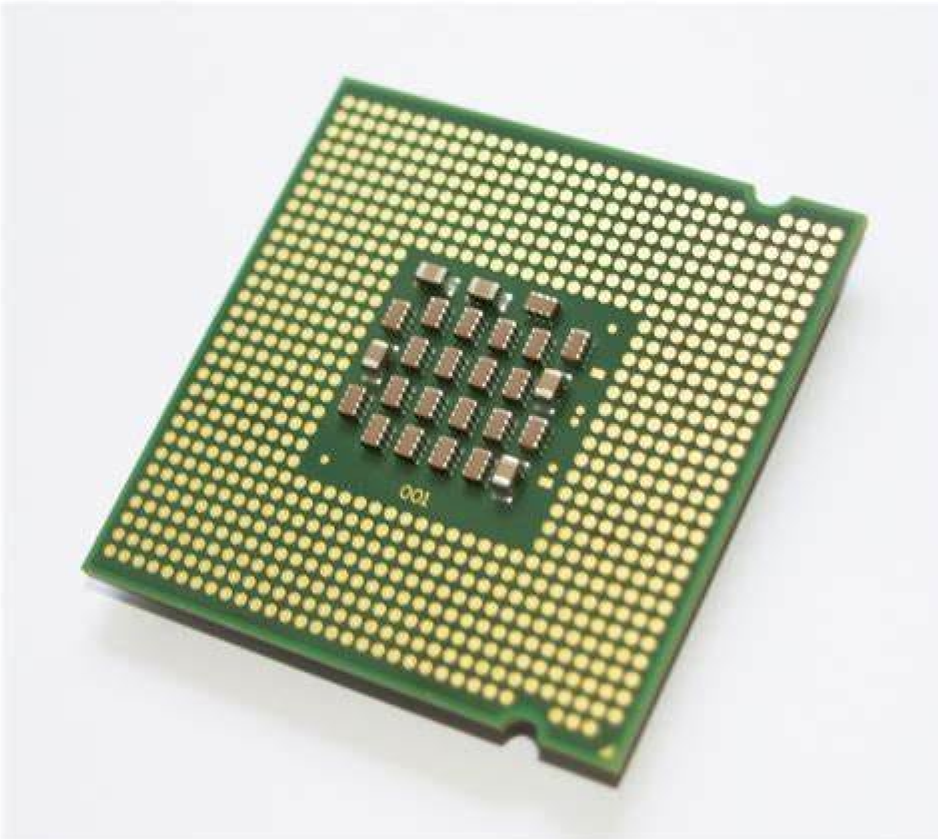

Fig 2: Processor

There is no specific processor used for AR, but the device needs to have a powerful CPU that integrates with the hardware design to ensure good performance and effective real-time calculations. ***Eg: Apple hardware and software are designed together for the best AR experience.***

ARM's Leadership in high-performance, low-power specialized processors is ideal for future experiences on AR smart glasses that will transform everyday lives in the future, from more immersive entertainment and gaming to navigation and translation.

According to Google, ARCore *(AR environment developed by Google) is designed to work on a wide variety of qualified android phones running Android 7.0 (Nougat) and later.*

Display

Fig 3: Display of AR

There are several types of displays available for AR. Head-mounted devices for virtual and augmented reality come in different shapes and sizes from the minimal Google Glass to the fully immersive HTC vive. At its core, head-mounted displays (HMDs) consist of two primary structural elements: **optics and image displays**. Augmenting displays can be broadly classified into two types: Optical See-through and Video see-through.

Fig 4: Optical See - through

In optical See-though glasses, the user views reality directly through optical elements such as holographic waveguides and other systems that enable graphical overlay on the real world.

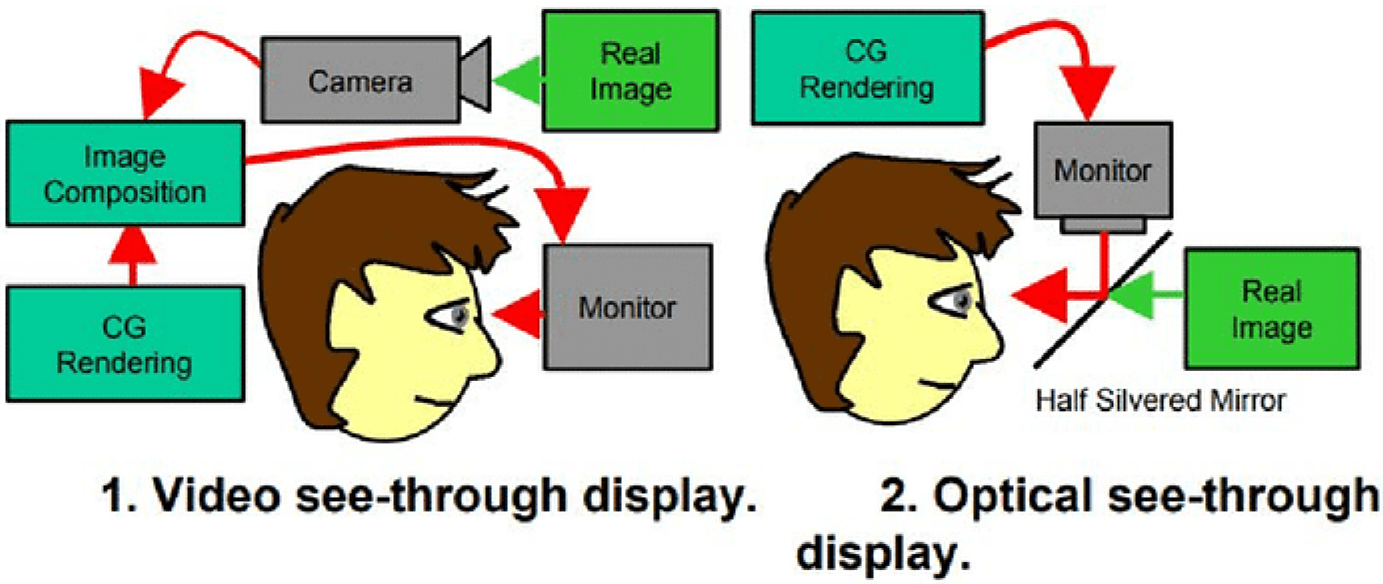

Fig 5: Video see-though

Video see-through is a type of augmented reality (AR) display that presents video feeds from cameras inside head-mounted devices. This is the standard method that phones use AR with. This can be useful when you need to experience something remotely: a robot which you send to fix a leak inside a chemical plant; a vacation destination that you're thinking about. This is also useful when using an image enhancement system: thermal imagery, night-vision devices, etc.

Sensors

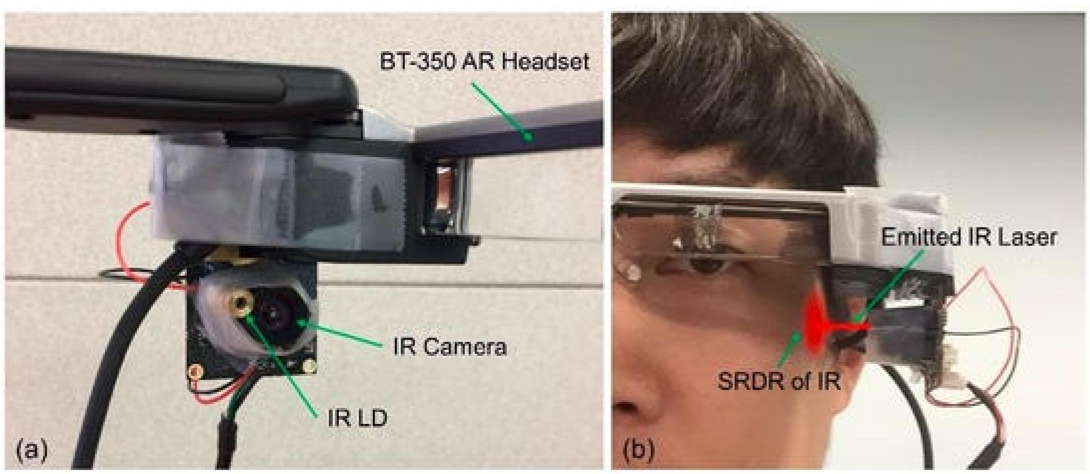

Fig 6: Sensors

A wide range of sensor technologies is required to support augmented reality (AR) systems. Today's AR implementations are mostly focused on visual and audio interfaces and rely on motion tracking and listening/voice recognition sensors. AR involves the creation of an environment that integrates the existing surroundings with virtual elements. As a result, AR uses more complex sensing, beginning with an IMU and adding time-of-flight sensors, heat mapping, structured light sensors, etc.

Most AR headsets rely on one or more special types of imaging sensors including; time of flight (ToF) cameras, vertical-cavity surface-emitting laser (VCSEL) based light detection and ranging (LiDAR), binocular depth sensing, or structured-light sensors.

Input Devices

Input devices are used to record user interactions using sensors, as well as other objects and the environment. The data obtained in this way are summarized, if necessary, semantically interpreted and forwarded to the world simulation. The data obtained in this way are summarized, if necessary, semantically interpreted and forwarded to the world simulation. There is a wide range of VR/AR input devices available and a classification of these can be done in different ways. The distinction can be made based on accuracy (fine or coarse) or range (from an area that can be reached with an outstretched arm, to an area where one can walk or look around). It is also possible to distinguish between discrete input devices that generate one-time events, such as a mouse button or pinch glove (a glove with contacts on the fingertips) and continuous input devices that generate continuous streams of events (e.g., to continuously transmit the position of a moving object).

Audio Displays and Haptic Displays

Haptic display:

Haptic technology transmits tactile information using sensations such as vibration, touch, and force feedback. Virtual reality systems and real-worth technologies use haptics to enhance interactions with humans.

One of the goals of haptics is to allow a virtual reality system to make humans feel as if the experiences it portrays are ‘real’. A commonplace haptic technology is mobile phone vibrations during gaming to boost immersion.

Haptics leverage force and tactile feedback to enable users and computers to interface with each other. The former simulates certain physical features of the object being virtualized, such as pressure and weight. The latter portrays the object’s texture (for instance, smoothness or roughness).

How exactly do haptics work?

Before we dive into the workings of this technology, let’s first understand the role of the human skin. This complex organ is full of touch receptors and nerve endings called the **somatosensory system**. This system notifies the brain of heat, cold, pain, and other sensations that humans feel.

Touch receptors transmit sensations by conveying signals to the closest neuron, which then signals the next closest neuron until the brain receives the signal. The brain then determines the response to the sensation. This entire process takes under a second.

Audio and graphics stimulate our sense of sound and sight to transmit information. Similarly, haptics stimulates our somatosensory system to pass on information and provide context.

For instance, when a user holds down an application icon on the app tray of an Apple iPhone, their finger experiences a ‘pull’ sensation. The haptic motors of the iPhone generate this sensation to communicate that the app is ready to be moved, deleted, or categorized.

The vibrations, forces, and other movements of haptic systems are created mechanically using different methods. The most common method is an eccentric rotating mass (ERM) actuator. The rapid spinning of the ERM causes instability in the force from the weight, leading to movements in the motor and, subsequently, haptic feedback.

Linear resonant actuators (LRA) are another method to create haptic feedback. In this method, a magnet joined with a spring is bound by a coil and secured using an outer layer. The coil is electromagnetically energized to drive the magnetic mass to vibrate, creating a feedback sensation.

Apart from LRA and ERM, other emerging technologies are also being used to provide haptic feedback in more accessible and realistic ways. Experts use Haptics for functions such as teaching, training, entertainment, and remote hands-on operations.

Types of Haptic Technologies:

1. **Graspable:**

Graspable devices (think joysticks) are a standard haptic technology that generates kinesthetic feedback. The tactical vibrations, movements, and resistance caused by these devices enable users to increase immersion in gaming and even operate robots more effectively in remote or virtual conditions.

Interesting examples of this technology in action include bomb disposal and space exploration. In the latter use case, astronauts or on-ground personnel use haptics-controlled robots to repair equipment (such as spacecraft parts or satellites) without leaving the vessel or even Earth.

2. **Touchable:**

Touchable haptic technology is prevalent in consumer applications; think smartphones that respond to taps, rotations, and other user movements. Advances in the touchable haptics space will soon enable the technology to replicate object movements and textures (known as haptography).

For instance, companies could leverage programmable textures to allow customers to feel clothing materials such as cotton or silk before purchasing, all from the comfort of their homes.

3. **Wearable:**

Wearable haptic technology simulates a sensation of contact by leveraging tactile stimuli,including pressure, vibration, and even temperature.

A fast-emerging use case of wearable haptics is virtual reality (VR) gloves that mimic real-world sensations and transmit and receive inputs from users controlling their virtual avatars or remote robots.

A common example is a glove fitted with some form of tactile display, such as small vibrators.

Audio Display Device:

In March 2018, Bose did something unexpected. They released a new wearable prototype at SXSW: 3D printed, augmented reality audio sunglasses. Instead of adding artificial visuals, they focus on sound-based augmented reality (AR), using motion sensors with GPS information from the user's smartphone to trigger audio cues. This is a new take on what we've come to expect from AR.

Sound has always been a fundamental part of our lives. It adds more texture, context and meaning to our daily interactions and immerses us. Yet, while sound serves as one of the dimensions we look for in today's movies and video games, virtual and augmented reality sound it is often overlooked.

Why is Virtual and Augmented Reality Audio Overlooked?

The development of AR/VR begins in optics. Visual immersion is priority for developers as they work toward overcoming field of view (FOV) limitations with existing devices. After all, visuals typically serve as the main branch of the AR/VR experience.

Then there are technical design challenges. Our eyes are away from our ears, which presents unique obstacles to tackling device design. Today's wearables typically have a horizontal fit over the eyes and come in bulky form factors.

Extending them to fit the ears would expand the vertical reach, thereby adding to the bulkiness of the device.

When we shift the focus from wearables to smartphones, we run into a new set of challenges. In their current form, smartphones only provide a 'flavor' of AR/VR. In either case, sound is experienced directly through the device speakers or through an additional set of headphones. In the case of virtual reality, the user could be looking at three different form factors to immerse themselves: the smartphone, headset and headphones. And even then, the experience can still be somewhat clunky.

Finally, there are battery concerns with untethered devices. The processing power required for AR/VR visuals considerably impacts the battery life of the device. Adding acoustics that match the visuals can further affect battery life, leading to less-than-desirable user experiences. Combined with the high cost of manufacturing today's gadgets, it is easy to see why virtual and augmented reality audio may not be a priority in development.