# Goodyear Project

# Microsoft HoloLens Research

## 1. What is the Microsoft HoloLens?

The Microsoft HoloLens is a pair of **mixed reality smartglasses** that belongs to a technology called **Augmented Reality**.

The Microsoft HoloLens is a **head-mounted display** unit which is connected to an adjustable inner headband. The HoloLens can be adjusted by tilting it up and down, as wells as forward and backward.

The HoloLens is running the **Windows Mixed Reality** platform under the Windows 10 computer operating system. Its tracking technology comes from the Kinect.

The **major improvement** which sets the HoloLens aside from every key player in the market is that unlike the Oculus Rift or HTC Vive VR headsets, the **Microsoft HoloLens is completely untethered** and doesn't need to be communicate with a PC or smartphone in order to project holograms into the space around you. That is because the HoloLens itself has a **self-contained holographic computer**.

The HoloLens 1 was released in 2016 and is currently being sold at a hefty price of $3000.
The HoloLens 2 was released in 2019 and is currently being sold at a hefty price of $3500.

## 2. What can the HoloLens do?

Obvious applications for the HoloLens include **content consumption** and **communication** these can be things such as floating videos or a more immersive Skype session.

The "**Holograms**" application consists of a catalogue of a variety of 3D objects that the user can place around them.
HoloLens headset can scan the environment in the real time and do things such as aid in the guidance of robots or create on-the-fly semi accurate wire meshes of objects that exists in real life.

Digital objects can also interact with their real environment. For example, if you throw a ball on the floor it would bounce around just like you would expect.

All of this is possible thanks to multiple cameras stationed inside the headset.

HoloLens also handles the sound incredibly well. This is done through the **Unity engine** where developers can pin **audio** to specific objects then as people wearing the HoloLens walk through a specific area the sound changes based on your proximity to the objects just like it would in the real world and reports say that it's good enough to trick your brain. The audio is actually delivered through two small speakers in the headset not headphones this is so you can still hear the real environment around you.

Furthermore, to this **full Windows 10 integration**, when wearing a headset, you can drag items from a PC desktop and pull them off the screen into the air and still control them with your mouse.

**Voice inputs** are also very well done. No address command needed like Alexa or Heyy Sirii

**HoloTour** might be interesting for us. Audiovisual 3D Virtual tourism apllication

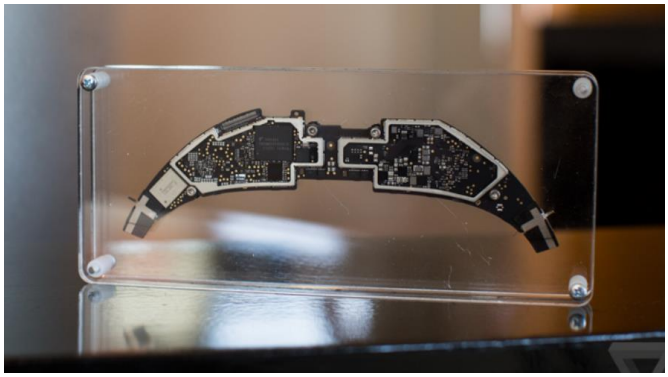
## 3. How does it work? (Hardware)

A lot what HoloLens is capable of is made possible by an **array of cameras and sensors**. These include more than **five cameras**, **accelerometers** and **gyroscopes** to sense where your head is, and house positioned at all times. In addition to the HoloLens mapping out your real-world environment, it combines these data inputs by flooding the device with terabytes of data captured every second by the sensors.
The HoloLens features:

- **Inertial Measurement Unit (IMU)**, which include:
  - Accelerometer
  - Gyroscope
  - Magnetometer
- 4 “environment understanding” sensors (two on each side)
- Energy-efficient depth camera with a 120°x120° angle of view (Miniature version of the Kinect)
- 2,4-megapixel photographic video camera
- 4 microphone arrays
- Ambient light sensor

In order to process the huge amount of the data the HoloLens includes:

- **Intel Cherry Trail SoC**, which contains the:
  - CPU
  - GPU
- **Holographic Processing Unit (HPU)**



The HPU does a lot of the heavy tasks here so that the CPU and GPU can just focus to launch apps and display holograms.
**The HPU handles all of the data from the cameras and sensors and process it in real-time**, so that the user can use gestures accurately

The HPU a **coprocessor** which has been developed and manufactured especially for use of the Microsoft HoloLens.
According to the developer of the HoloLens Alex Kipman, this is what the HPU does:

Realistic Holograms work by tricking your brain into seeing light as matter. Ultimately, you perceive the world because of light. If I could magically turn on the debugger, we would see photons bouncing throughout the world eventually they hit the back of your eyes and through that you reason out what the world is. You essentially hallucinate the world, or you see what your minds wants you to see. To create project HoloLens images, light particles bounce around millions of times in a light engine within the device. These photons enter the goggles two lenses where they are ricochet between layers of blue, green and red glasses before they reach the back of your eye and when you get the light at the exact angle, there is where the magic comes in. Unlike most screen technologies before, it's not pixels but **actual photons that are being generated making the digital elements extremely lifelike**.


Microsoft refers to them as “waveguides” → Optical projection System to beam holograms into the user’s eye

Microsoft is counting **light points** to boost HoloLens’ resolution and the number of light points per radian for density. More radiants and light points mean that the holograms are brighter and richer. These bright and rich holograms are projected and bounced around as particles of light (photons) through the waveguide and into your eyes

The Soc and the HPU each have 1GB **LPDDR3** and share 8MB **SRAM**
The SoC runs the **Windows 10 Operating System** and controls 64GB **eMMC**

28 custom **DSPs** from **Tensilica** are used of the HPU in order to:

- Process and integrate data from the sensors
- Spatial Mapping
- Gesture Recognition
- Voice & Speech Recognition

Other features are:

- **IEEE 802.11ac Wi-Fi**
- **Bluetooth 4.1 Low Energy (LE)** wireless connectivity

Bluetooth is being used to pair the HoloLens with the included **Clicker,** which is a thumb-sized finger-operating input device used for interface scrolling and selecting. The Clicker also includes a clickable surface for selecting and an **orientation sensor** which is responsible for the scrolling functions via tilting and panning of the unit. There’s an elastic finger loop on the Clicker for the user to hold it with their finger and a USB 2.0 micro-B receptable for charging purposes.

The depth sensing camera works simultaneously with two “environment understanding” cameras which are responsible for capturing the real world around you to help the HoloLens recognize where obstacles or objects are. In addition to that exists a 2-megapixel video camera at the front which can record exactly what you see with the holograms included. That’s what Microsoft calls **mixed reality capture.**

The visor of the device is tinted, equipped inside with a pair of transparent combiner lenses also known as **HUD (Head-up Display)**, in which the projected images are displayed in the lower half of the visor. Additionally, the HoloLens visor must be calibrated to the **interpupillary distance (IPD)** to adjust the vision of the user.

The HoloLens also include a pair of small, red **3D Audio speakers**, which are located near the user’s ears, along the bottom edges of the side of the goggles. These speakers will not obstruct the external sounds. The **Head-related Transfer Functions (HRTF)** enables the HoloLens to generate **binaural audio**, which can simulate spatial effects. That means that the user can virtually perceive and locate where the sound coming from a virtual pinpoint or location.
(Spatial Sound)

Furthermore, on the top edge of the goggles are located two pairs of buttons which are responsible to adjust the display brightness and the volume for the speakers. A row of five LED nodes on the left side is used to indicate the battery level and setting power/standby mode. The internal rechargeable battery has an average life of 2-3 hours. The HoloLens can also be operated while charging. The glasses include a **USB 2.0 micro-B** receptable and a **3.5 mm audio jack.**

## 4. Interface

The HPU uses **GGV inputs** which are sensual and natural interface commands such as gaze, gesture and voice.

Gaze commands, such as head-tracking, are being used for the application to focus to whatever the user is seeing.

The air tapping method, similar to clicking an imaginary computer mouse, is being used to select elements or any virtual application or button. Besides the tap can be held in order to drag the simulation to move an element.

Voice commands are also being used to execute commands and actions.

## 5. Limitations

Currently you can only control HoloLens with your gaze and by hovering your finger in the air to tap on a cursor? It works fine, is extremely intuitive and everyone could get it at the first time, but **HoloLens needs more sophisticated gestures that mimic real-life movements.**

The biggest limitation is the small viewing area so really all the holograms and the digital environments are only visible through a small square area, so if you go close to digital objects, you can't see the entirety of it. It cuts them off. This was one of the most common complaints among reviewers. (**Limited field of view**, Optical limitation won't change much)


It's still a challenge for the HoloLens to cover the entire eye as the pupil is moving around.

## 6. Developing Applications for HoloLens

The **Integrated Development Environment IDE** known as **Microsoft Visual Studios** can be used to create 2D & 3D applications for HoloLens. These applications can be tested using the **HoloLens Emulator** (included into Visual Studio 2015 IDE) or **HoloLens Development Edition.**

For 3D holographic applications it is recommended to use **Windows Holographic APIs.** Microsoft recommends using the **Unity Engine** & **Vuforia** to create our own 3D apps for the device. Other possible apps to use are **DirectX** and **Windows APIs.**

Microsoft | unity

## 7. HoloLens 1 vs HoloLens 2 Comparison

| Specs | HoloLens 1 | HoloLens 2 |
|---|---|---|
| Price (release day) | $3000 (for dev) $5000 (Commercial Suite) | $3500 or $125/mo for Enterprise or $99/mo for Developer |
| Display resolution | 1280×720 (per eye) | 2048 × 1080 px (per eye) |
| Holographic density | >2.5K radiants (light points per radian) | >2.5K radiants (light points per radian) |
| Field of view (FOV) | 34° | 52° |
| Weight | 579 grams | 566 grams |
| IPD adjustment | yes | yes |
| Eye-based rendering | Automatic pupillary distance calibration | Display optimization for 3D eye position |
| Eye-tracking | no | yes |
| Processor | Intel 32-bit (1GHz) | Qualcomm Snapdragon 850 |
| Camera | 2.4 MP, HD video | 8MP stills, 1080p video |
| Audio | Built-in speakers 3.5mm jack; | Built-in spatial sound; 3.5mm jack |
| Built-in microphone | four-microphone array | five-microphone array |
| Flip-up visor | no | yes |
| Voice command | yes | yes |
| Biometric Security (Iris Scanning) | no | yes |
| Hand tracking | one hand | both hands full tracking |
| Gestures: Bloom, Air Tap, Tap and Hold | yes | yes |
| Gestures: Press, Grab, Direct manipulation, Touch interaction, Scroll with wave | no | yes |
| USB | micro USB 2.0 | USB Type-C |

## 8. Weblinks used for research


- https://4experience.co/hololens-2-vs-hololens-1-whats-new/
- https://www.theverge.com/2016/4/6/11376442/microsoft-hololens-holograms-parts-teardown-photos-hands-on#:~:text=The%20magic%20of%20HoloLens%20is,and%20the%20environment%20around%20you.&text=This%20headset%20understands%20the%20objects,that%20don't%20jerk%20around.
- https://www.youtube.com/watch?v=NwY-6sQDYnk&ab_channel=ColdFusion
- https://www.gvsu.edu/cms4/asset/7E70FBB5-0BBC-EF4C-A56CBB9121AECA7F/7_things_about_microsoft_hololens.pdf
- https://en.wikipedia.org/wiki/Microsoft_HoloLens