Magic Leap Product Guidelines

Sensor Data Access & Control

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The content in this document is not intended to serve as professional advice and should not be used as a substitute for consultation with professional, technical or other competent advisors.

The use cases and statements provided in this document are intended to demonstrate the potential of Magic Leap 2 in various scenarios and may be provided by third parties regarding their specific applications. They should not be taken as guarantees or promises regarding the performance of Magic Leap 2 in similar situations. The images shown are for illustration purposes only and may not be an exact representation. Actual experiences and/or results may vary.

Content

Sensor Data Access & Control

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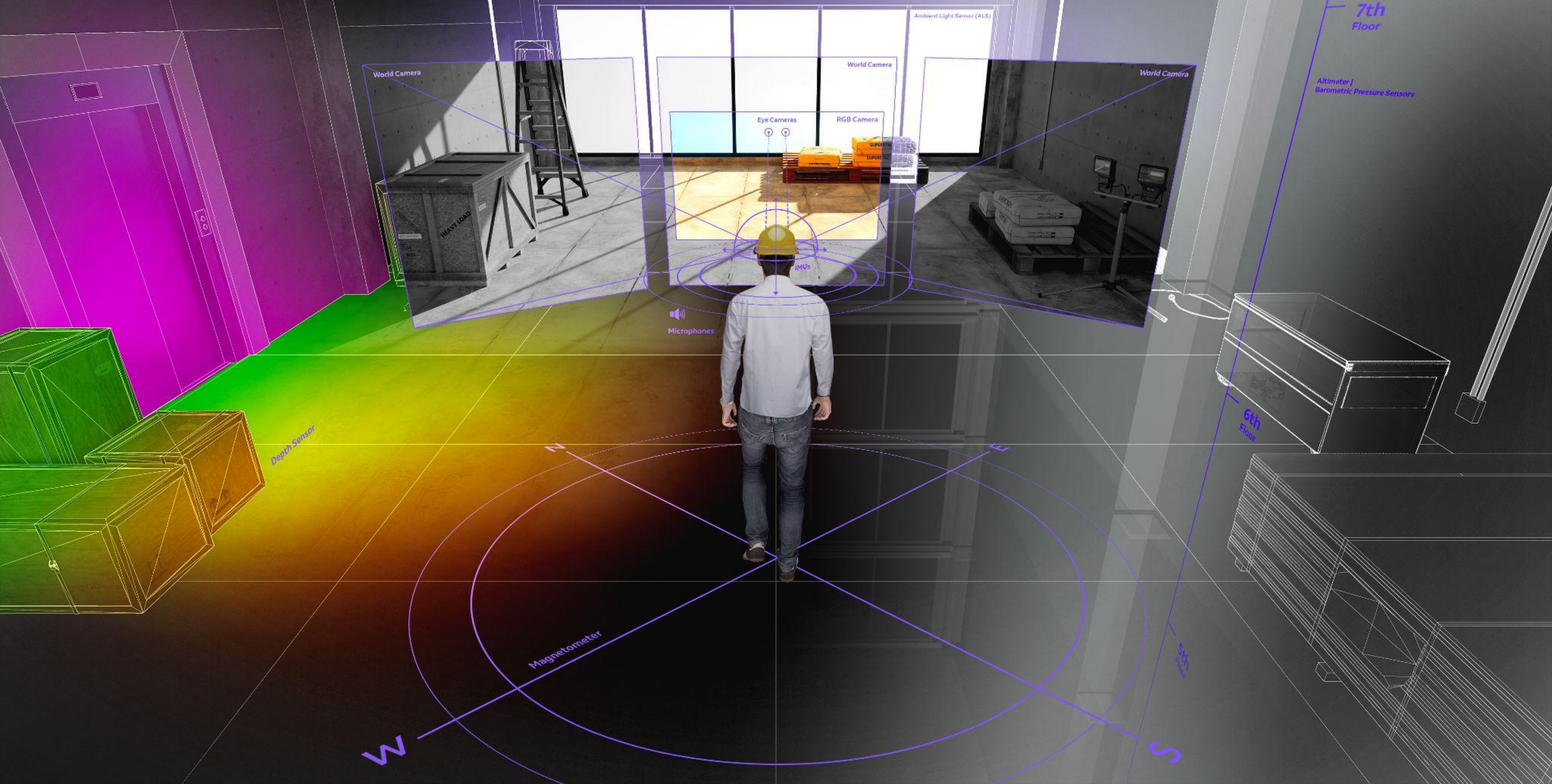
1. Sensor Data Access & Control



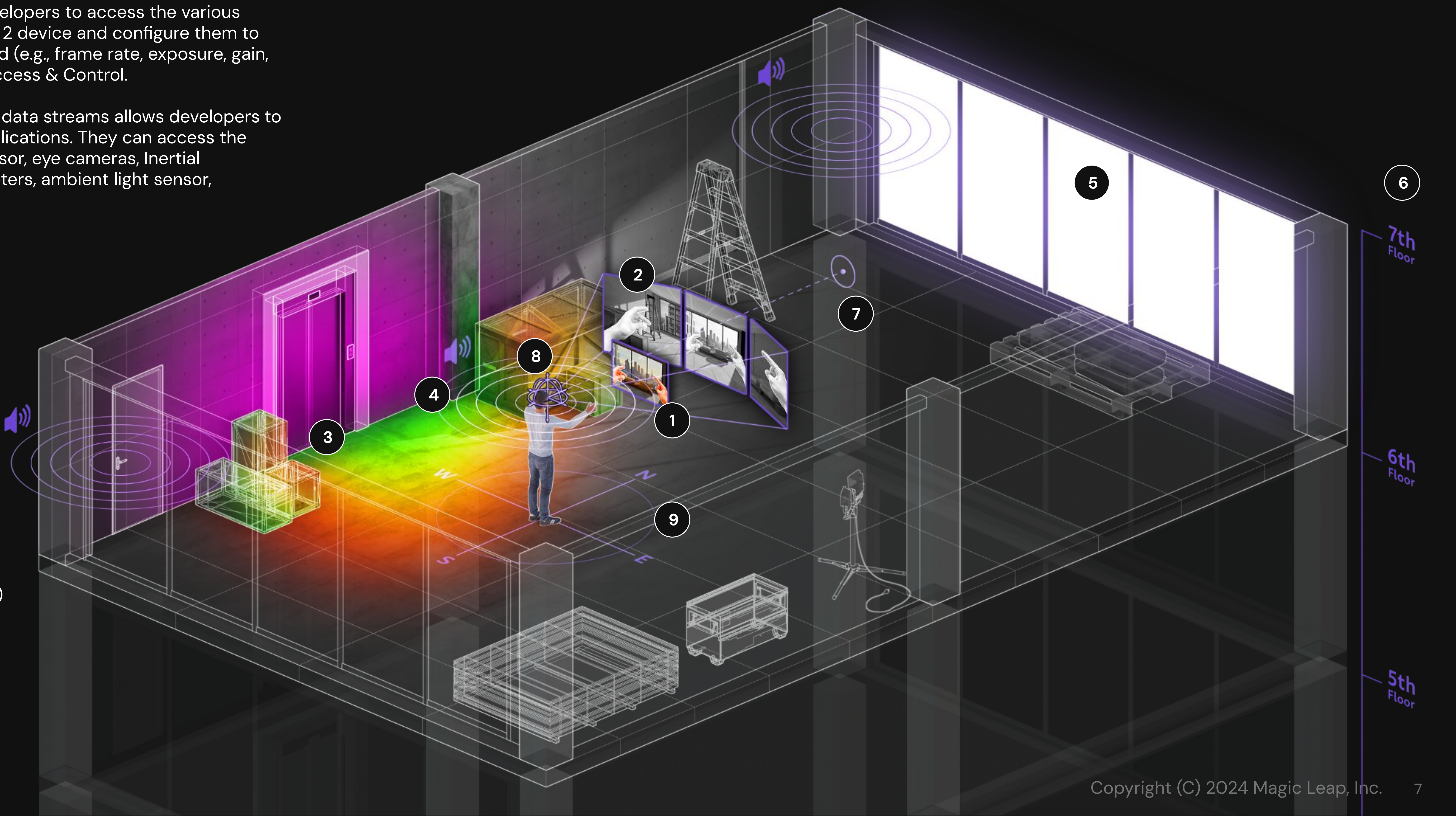
1.1 What is it?

Sensor Data Access is a system for developers to access the various sensors integrated into the Magic Leap 2 device and configure them to gather data in a specific manner desired (e.g., frame rate, exposure, gain, etc.). We refer to this as Sensor Data Access & Control.

The ability to access and control these data streams allows developers to build more valuable algorithms and applications. They can access the RGB camera, world cameras, depth sensor, eye cameras, Inertial Measurement Units (IMUs), magnetometers, ambient light sensor, altimeters and microphones.

Sensors:

1. RGB Camera
2. World Cameras
3. Depth Sensor
4. Microphones
5. Ambient Light Sensor (ALS)
6. Altimeter
7. Eye Cameras
8. Inertial Measurement Units (IMUs)
9. Magnetometer



1.2 Why is this important?

Third-party developers are able to access raw sensor data (with user permission) for two key reasons:

1. We can’t predict all use cases

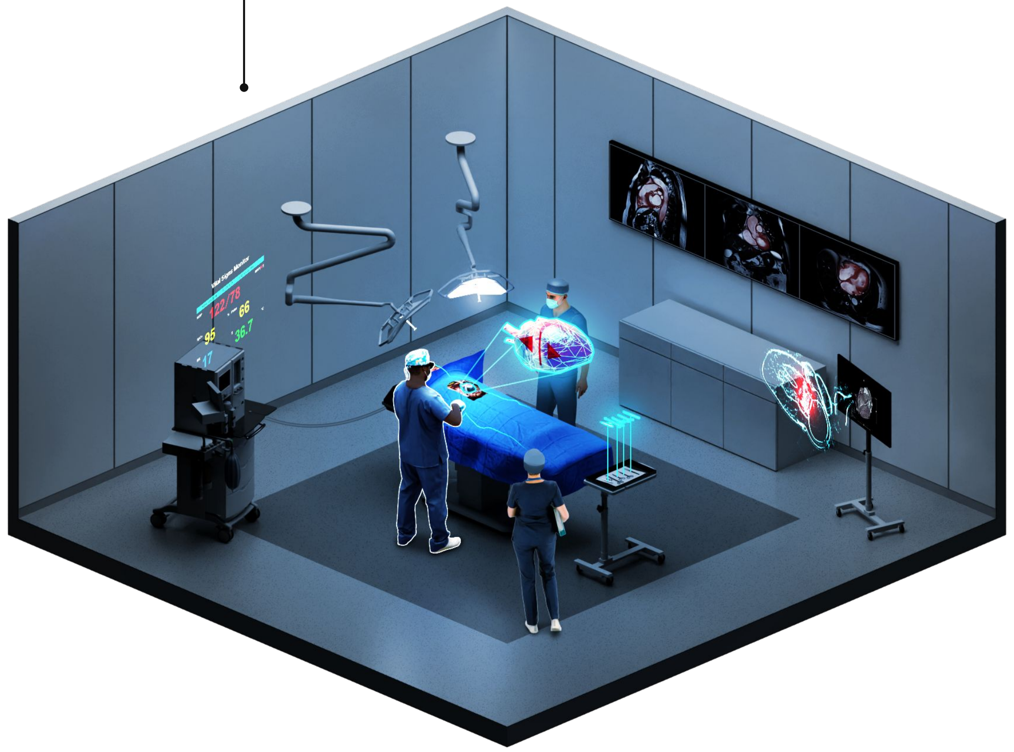
We can’t anticipate all the use cases and the data processing required for unique scenarios. By allowing developers to configure the sensors and access the raw data streams, they can build their own optimally suited algorithms to their specific needs, and create high-value AR solutions for the market.

2. We believe in complementary efforts to build better algorithms

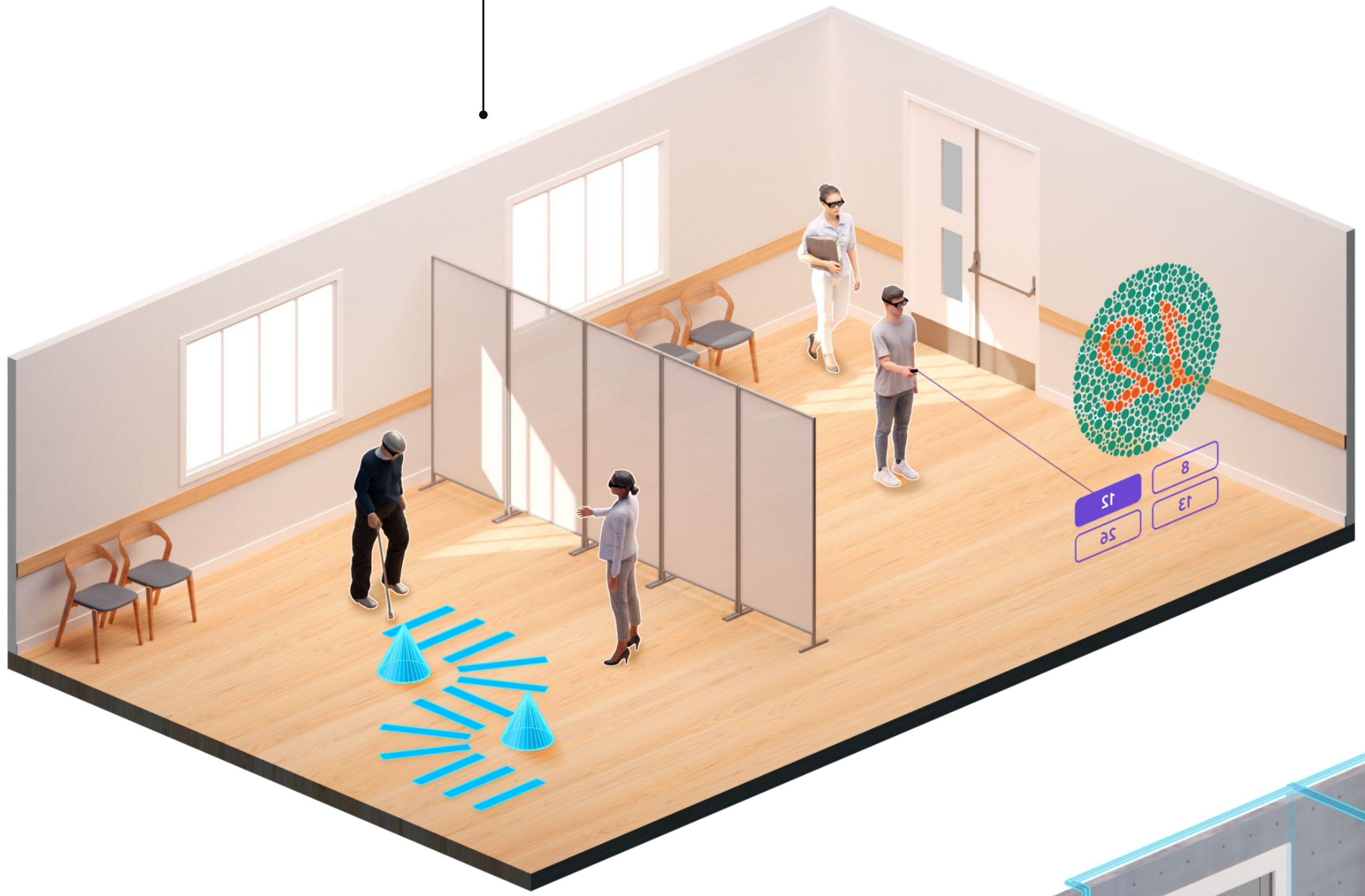
Companies in certain specialty fields can create algorithms that could outperform our system, enabling them to build better applications.

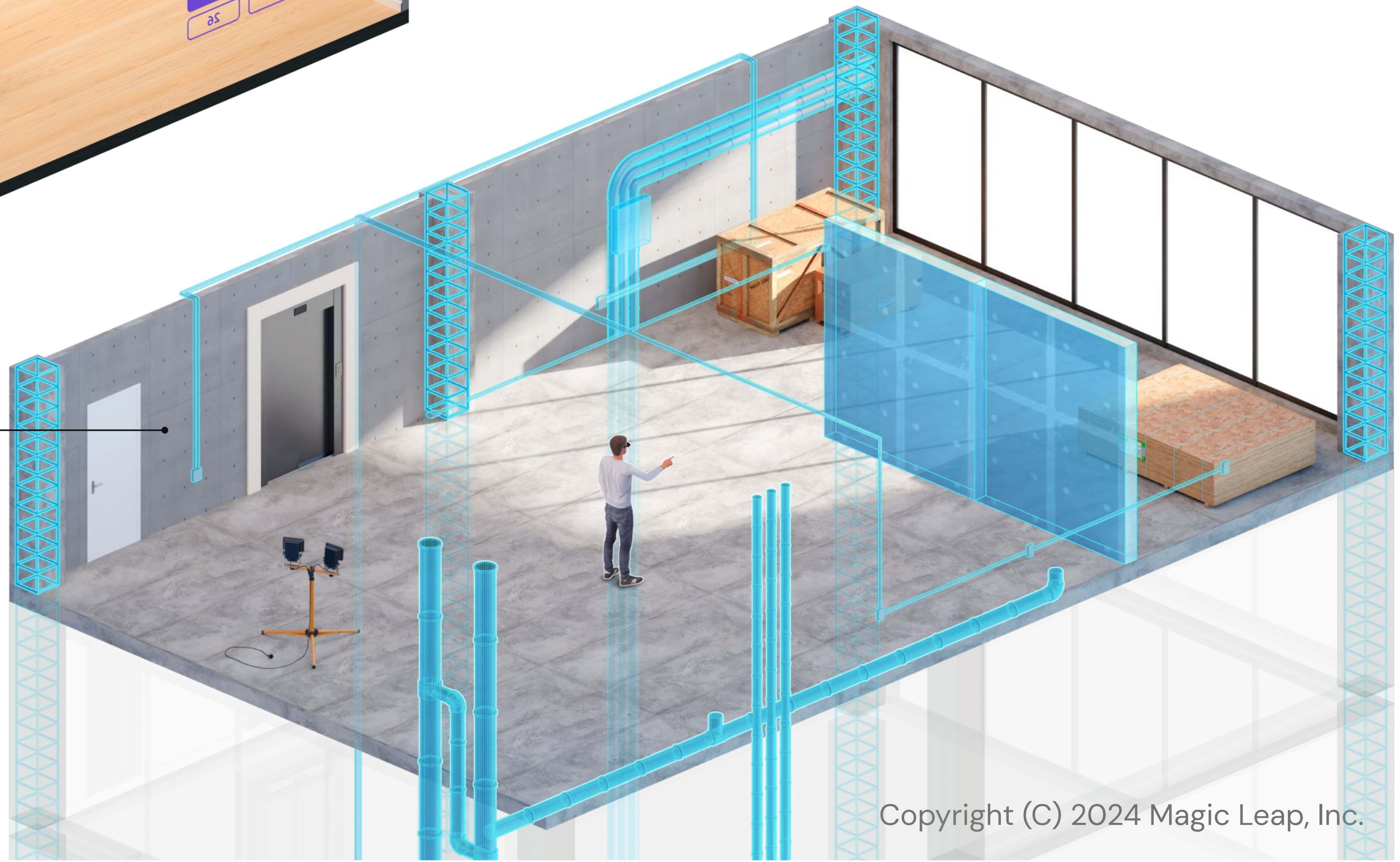
For example, by accessing all camera system data, companies within their field of specialty can implement their own hand-tracking algorithms, allowing them to enable more specialized solutions in their market.

Surgery*



Clinical assessment

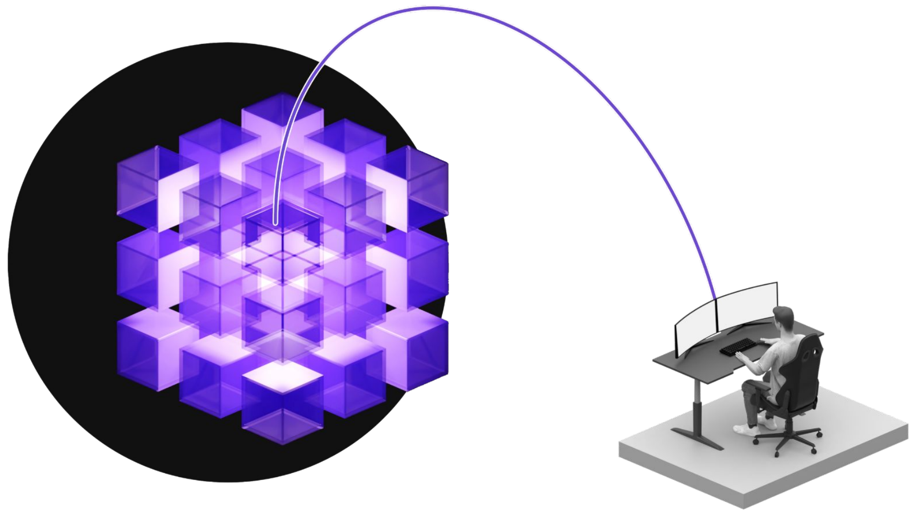




Construction

*Magic Leap 2 MedTech achieved IEC 60601 certification as a UL Recognized Component, intended for integration into systems designed for end use in medical environments. Prior to such end use, further testing and certification may be required.

1.3 Benefits for developers and users

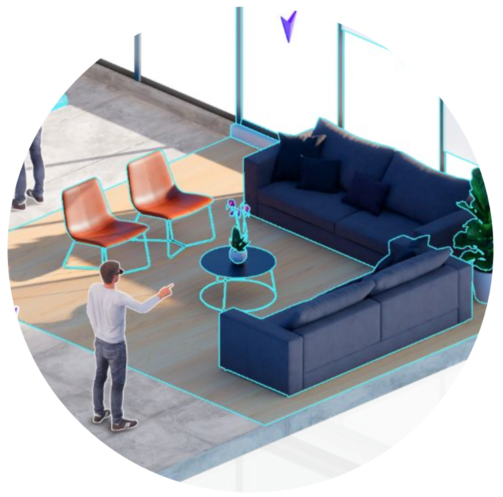


For developers

With greater access to a range of sensor data, developers can build more valuable algorithms and applications.

Developers can configure specific parameters for their applications, giving them more creative freedom to solve problems, and access to data for their varied use cases.

By removing limitations and making Sensor Data Access available, developers will be able to unlock what's possible with AR at a faster pace with more room to bring new high-value solutions to the market.



For end users

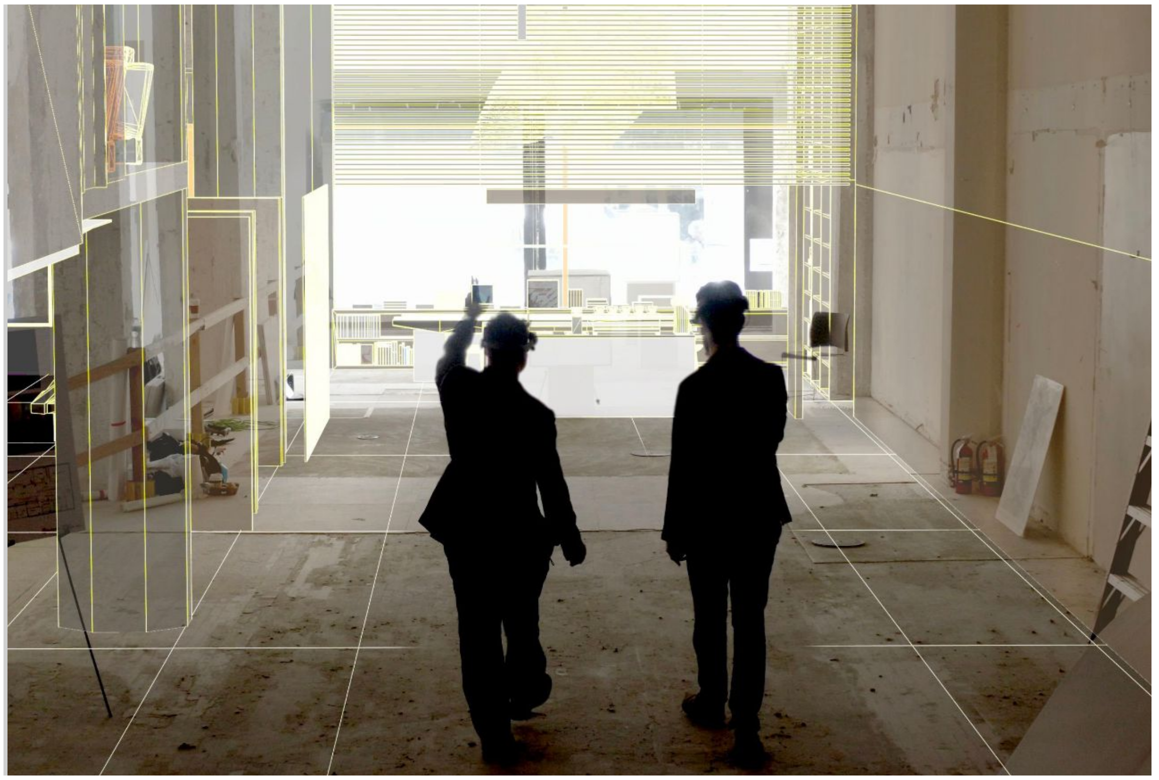
End users can have more advanced and personalized solutions tailored to their needs. They can get more valuable insights based on data analysis, and engage in experiences only made possible with Magic Leap 2.

1.4 Benefits across sectors

MedTech*

Healthcare professionals can leverage Sensor Data Access by tracking patient data for assessments including using eye cameras to follow eye movements and capture eye images.

In an operating room, Sensor Data Access can enable the development of applications that can track a patient's body, surgical instruments, and guide healthcare professionals during surgery.



AEC

Architects, engineers, and construction workers can use sensor data to overlay virtual content on the physical environment, as well as facilitate user localization and site navigation. This allows users to present ideas more efficiently, prevent costly errors, and expedite quality assurance in complex environments.

Warehouse and fulfillment

Warehouse and fulfillment managers deal with complex processes that encompass a variety of moving parts like people, equipment, orders and inventory. Technicians can leverage the RGB, world, and depth cameras to support computer vision algorithms, which automatically scan for, identify, and count objects in the environment. This improves productivity, increases inventory optimization, and reduces errors.

Magic Leap 2 MedTech achieved IEC 60601 certification as a UL Recognized Component, intended for integration into systems designed for end use in medical environments. Prior to such end use, further testing and certification may be required.

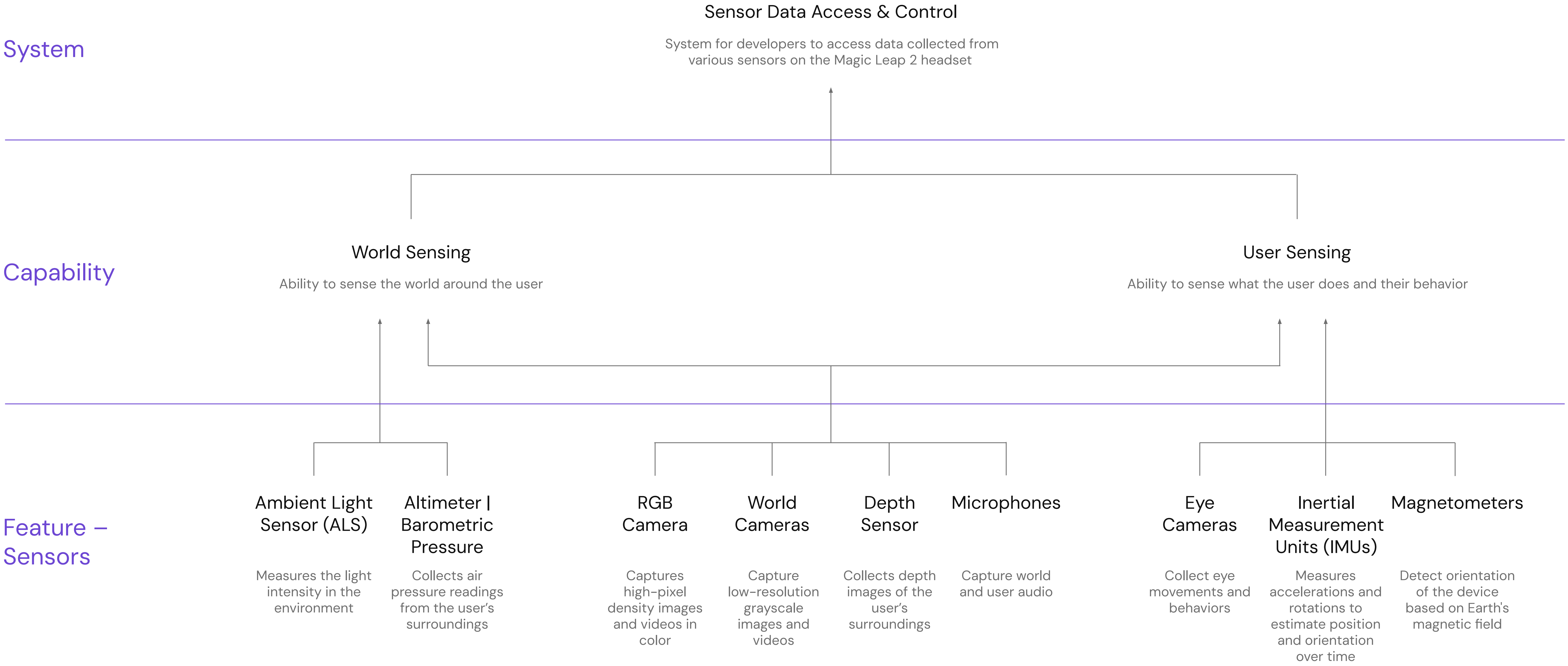
1.5 Privacy

Applications that access certain sensor data must request explicit user acceptance before data is offered through APIs.

Magic Leap 2 was designed to include external and internal-facing privacy status indicators. The external-facing indicator light helps to alert others when sensors are capturing information. The internal-facing privacy indicators provide UI for when an application is using the RGB camera, microphone, or is streaming content to an external source.

Certain device sensors, such as the World Sensing Cameras and Depth Sensors, are required for basic device functionality (e.g., to display augmented reality in your environment) or may be controlled by your managing enterprise (or app provider), and may not present a privacy status indicator when in use.

1.6 Sensor Data Access & Control structure



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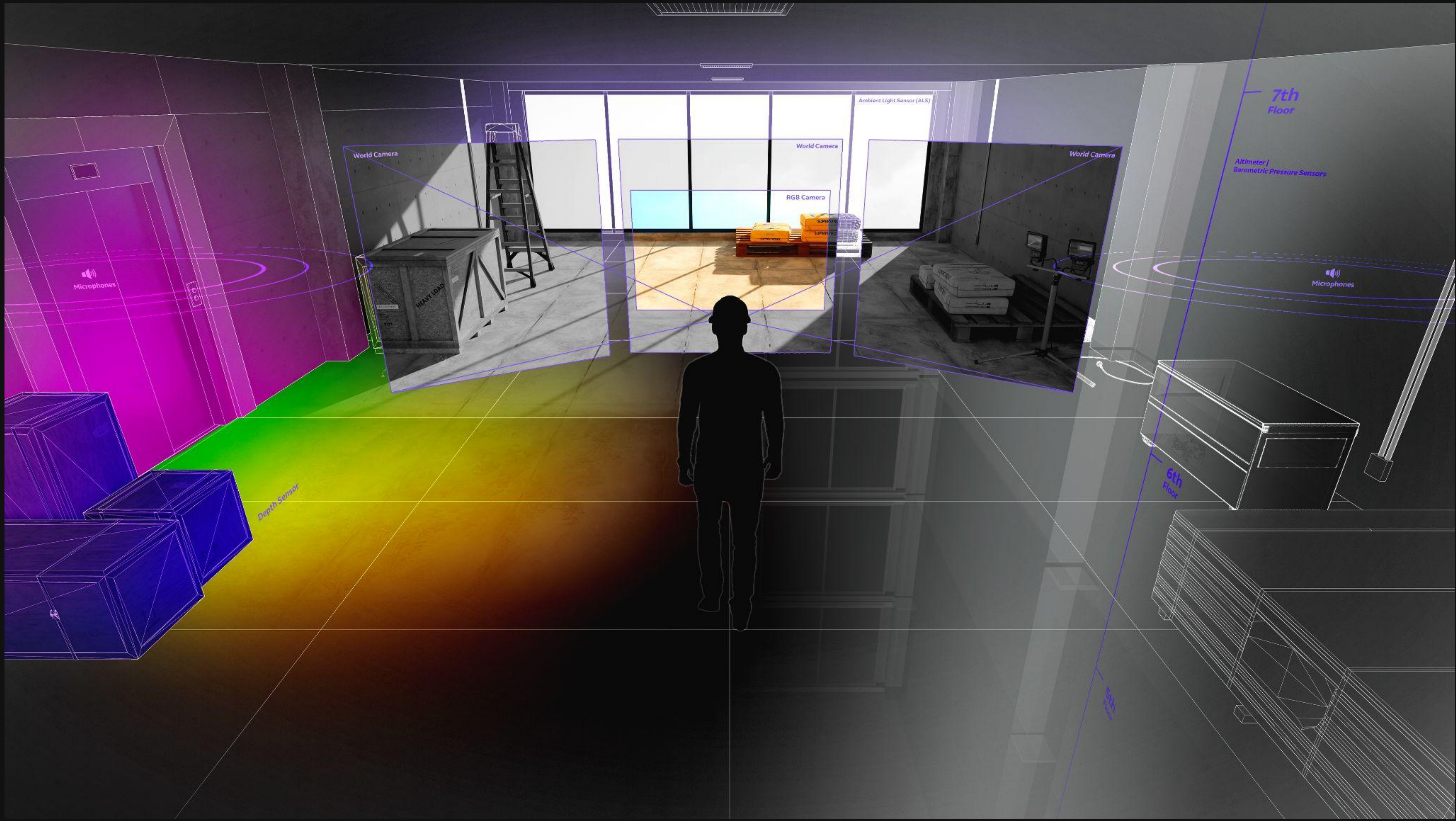
2.1 World Sensing

What is it?

In order for the Magic Leap 2 to gain contextual awareness, it relies on its sensors to track the physical environment the user is in.

World Sensing enables the device to sense what is happening in the world around the user.

It can capture images and videos of the environment, map the depth of physical elements, measure light intensity and air pressure, and capture ambient sounds.

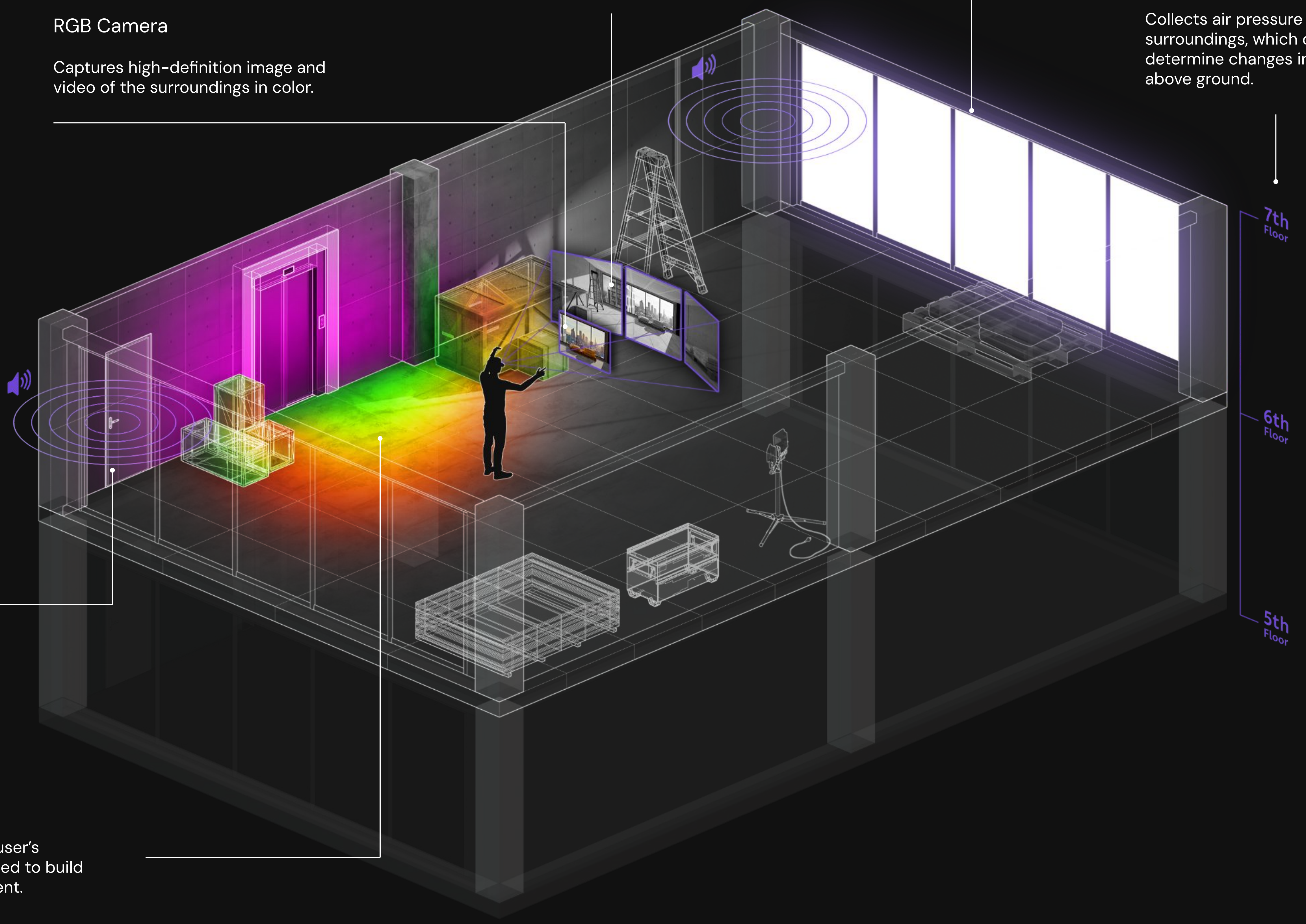


How does it work?

The Magic Leap 2 device can sense and understand the physical world around it through six types of sensors.

The six types of World Sensing sensors include the RGB Camera, World Cameras, Depth Sensor, Microphones, Ambient Light Sensor, and Altimeter/Barometric Pressure Sensors. The first four sensors (RGB Camera, World Cameras, Depth Sensor, and Microphones) can be used for User Sensing as well.

The data collected from these sensors create an output that helps us understand and map the physical environment of the user.



ALS

Measures light intensity in the environment.

World Cameras

Three lower resolution cameras which collect wide view images and video of the surroundings in grayscale.

Altimeter

Collects air pressure readings of the surroundings, which can be used to determine changes in the altitude above ground.

RGB Camera

Captures high-definition image and video of the surroundings in color.

Microphones

Collect acoustic sound from the world around the user.

Depth Sensor

Collects depth images of the user's surroundings, which can be used to build spatial scans of the environment.

Why is it important?

Capturing and understanding the user's physical environment enables developers to build smarter and more effective spatial experiences.

Sensors help the device understand the physical space the user is in and how they are interacting with the world. This enables the device to gain contextual awareness.

Accessing world sensing data is important for developers and businesses to enable them in building algorithms that are better suited to different environments and scenarios. It also provides valuable information about spaces and user behaviors within a physical space.

2.2 User Sensing

What is it?

To enable seamless experiences that feel magical and personalized, we need sensors that can track the user.

User Sensing enables the device to sense what the user does and their behavior.

It can capture the user's eye movements and expressions, voice, position, orientation, motion, direction, and more.

How does it work?

Magic Leap 2 has three types of sensors that are specifically designed for user sensing. This grouping of sensors includes the Eye Cameras, Inertial Measurements Units (IMUs) and Magnetometers.

In addition to those, the RGB Camera, World Cameras, Depth Sensors, and Microphones are also collecting data streams that assist with user sensing overall (in addition to World Sensing).

RGB Camera

Captures high-definition image and video of the user's hands and gestures in color.

World Cameras

Three lower resolution cameras collect wide view images and video of the user's hands and gestures in grayscale.

Microphones

Capture audio of the user’s voice and sound.

Eye Cameras

Collect gaze tracking, eye expressions, eye movements, and other important information about the user’s eyes.

IMUs

Measure the relative position, orientation, and motion of user.

Magnetometers

Detect the orientation of the user based on Earth's magnetic field.

Depth Sensor

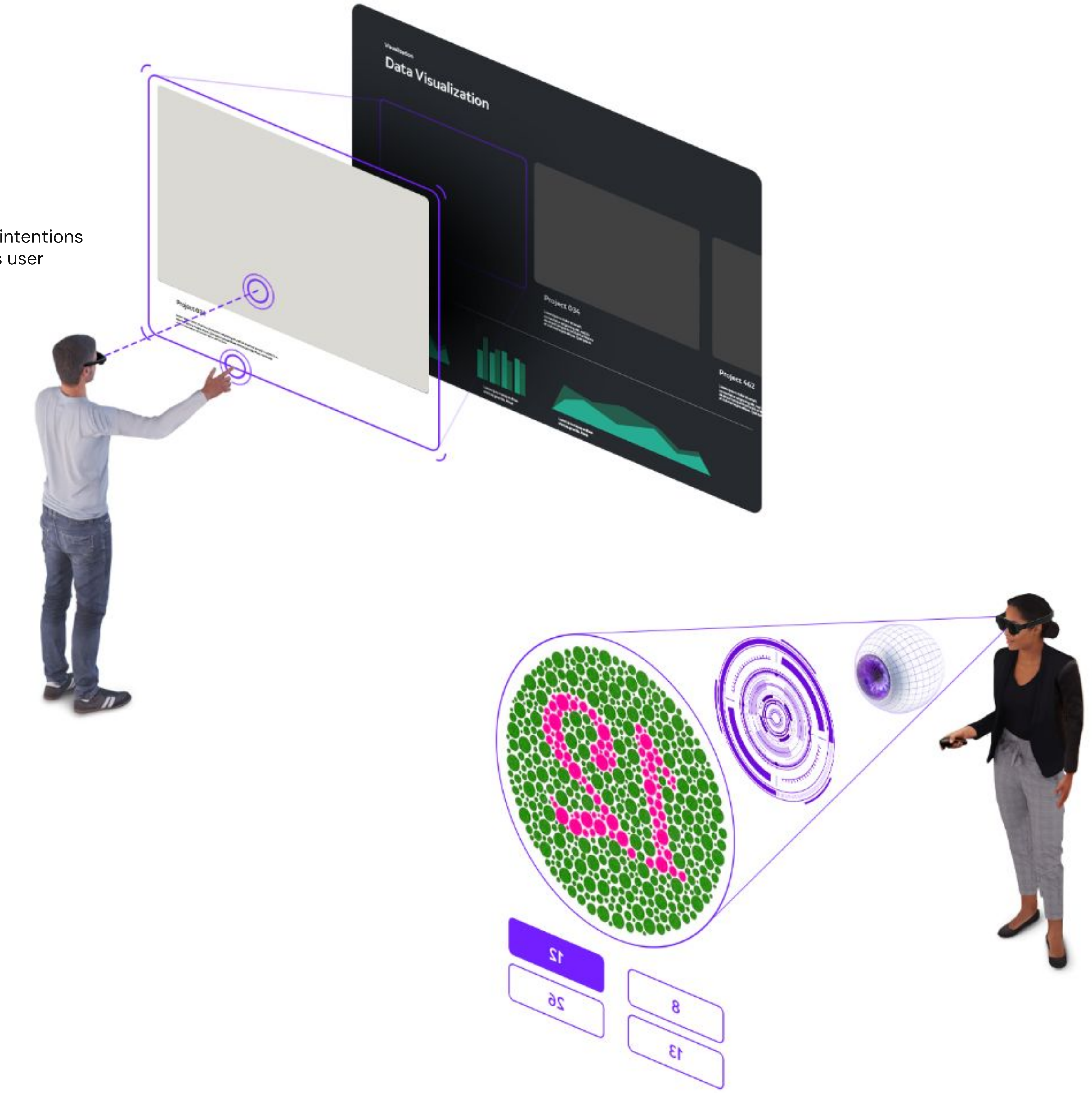
Collects depth images of the user's hands and gestures.

Why is it important?

The data collected from these sensors create an output that helps the Magic Leap 2 device understand the user's movements, behaviors, how they are responding to their environment, and the content they are interacting with.

Accessing this data enables the Magic Leap 2 device to predict the user's intentions to build a seamless user experience, and allows developers and businesses to build more complex and high-value algorithms that leverage user input.

Predicting user's intentions to build seamless user experiences



Leveraging user's data to build valuable algorithms such as clinical assessments

Sensor Data Access & Control Capabilities

Features – Sensors

Combining Sensors

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World + User Sensing

3.1 RGB Camera
3.2 World Cameras
3.3 Depth Sensor
3.4 Microphones

World Sensing

3.5 Ambient Light Sensor (ALS)
3.6 Altimeter | Barometric Pressure Sensors

User Sensing

3.7 Eye Cameras
3.8 Inertial Measurement Units (IMUs)
3.9 Magnetometers

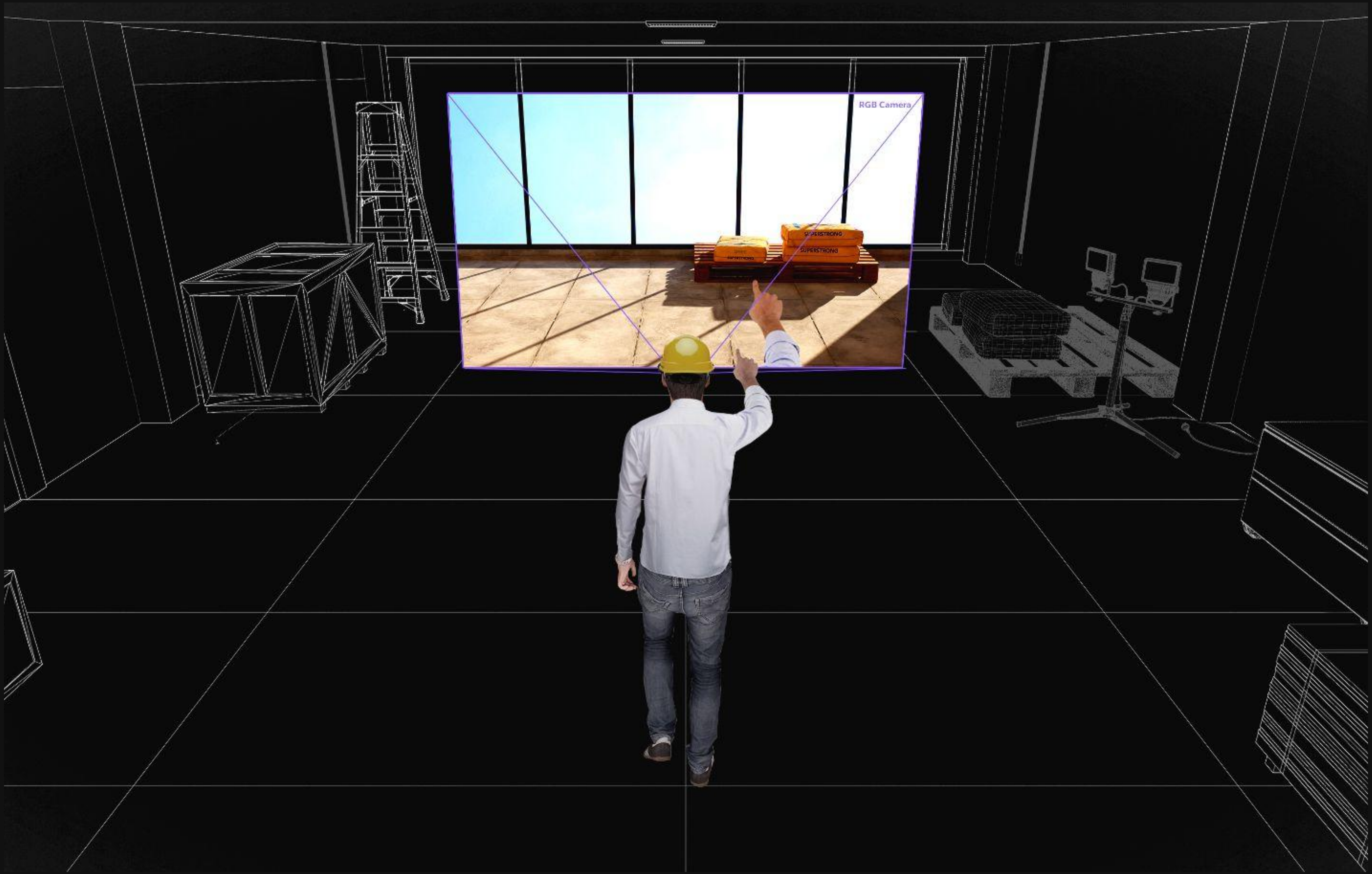
3.1 RGB Camera

What is it?

The RGB Camera is a high-pixel density color camera which attempts to replicate how the human eye views the world.

It is a general purpose 12.6 MP camera that includes an autofocus element. It can be used to take pictures or videos of the world, capturing both the environment and user interactions.

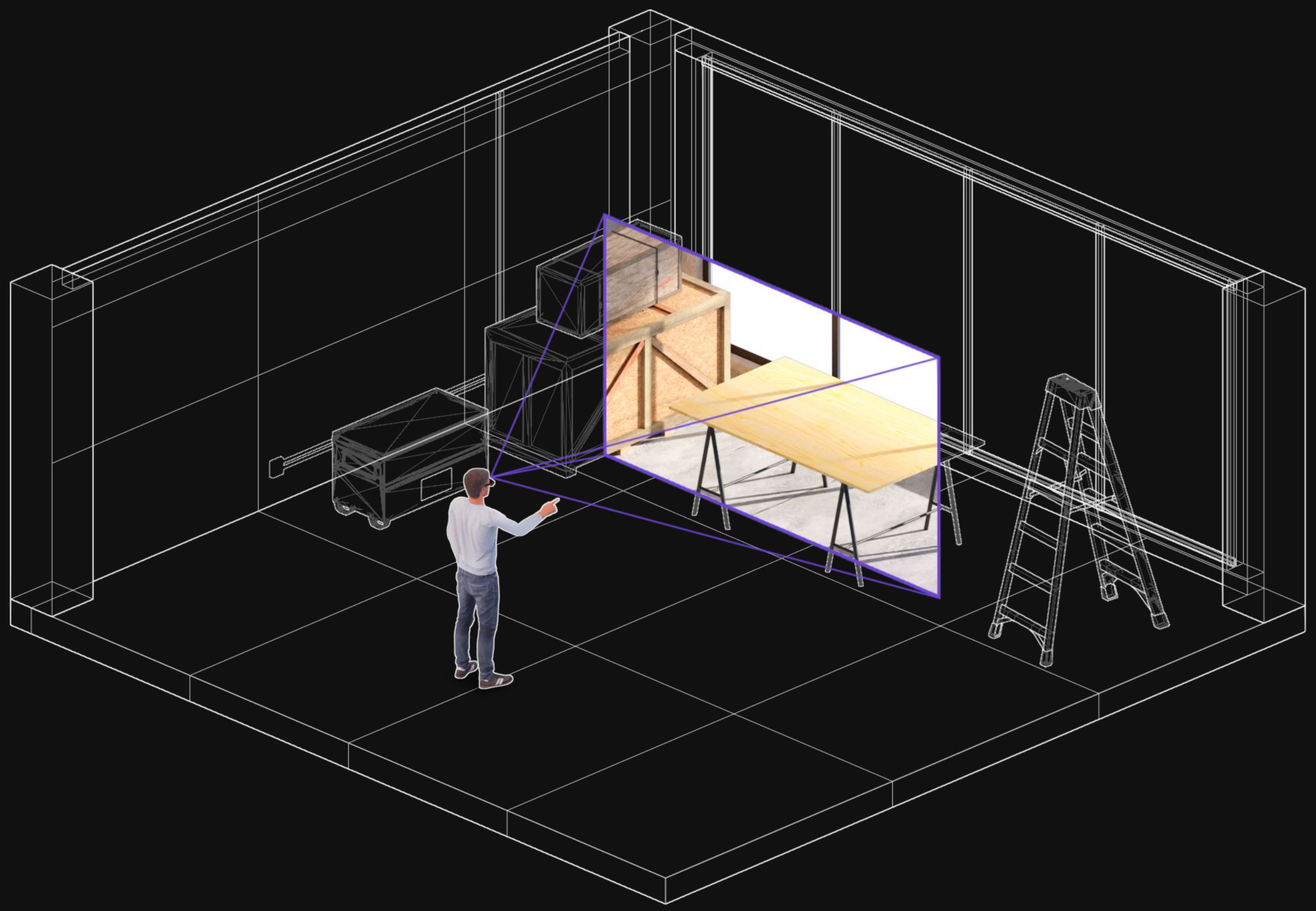
The higher pixel density means this camera captures clear and sharp high-resolution images–but at the same time, it consumes more power and requires more data processing.



How does it work?

The RGB Camera delivers in-color images of people and objects by capturing light in red, green, and blue wavelengths (RGB). It sees the visible wavelength and attempts to replicate how the human eye views the world.

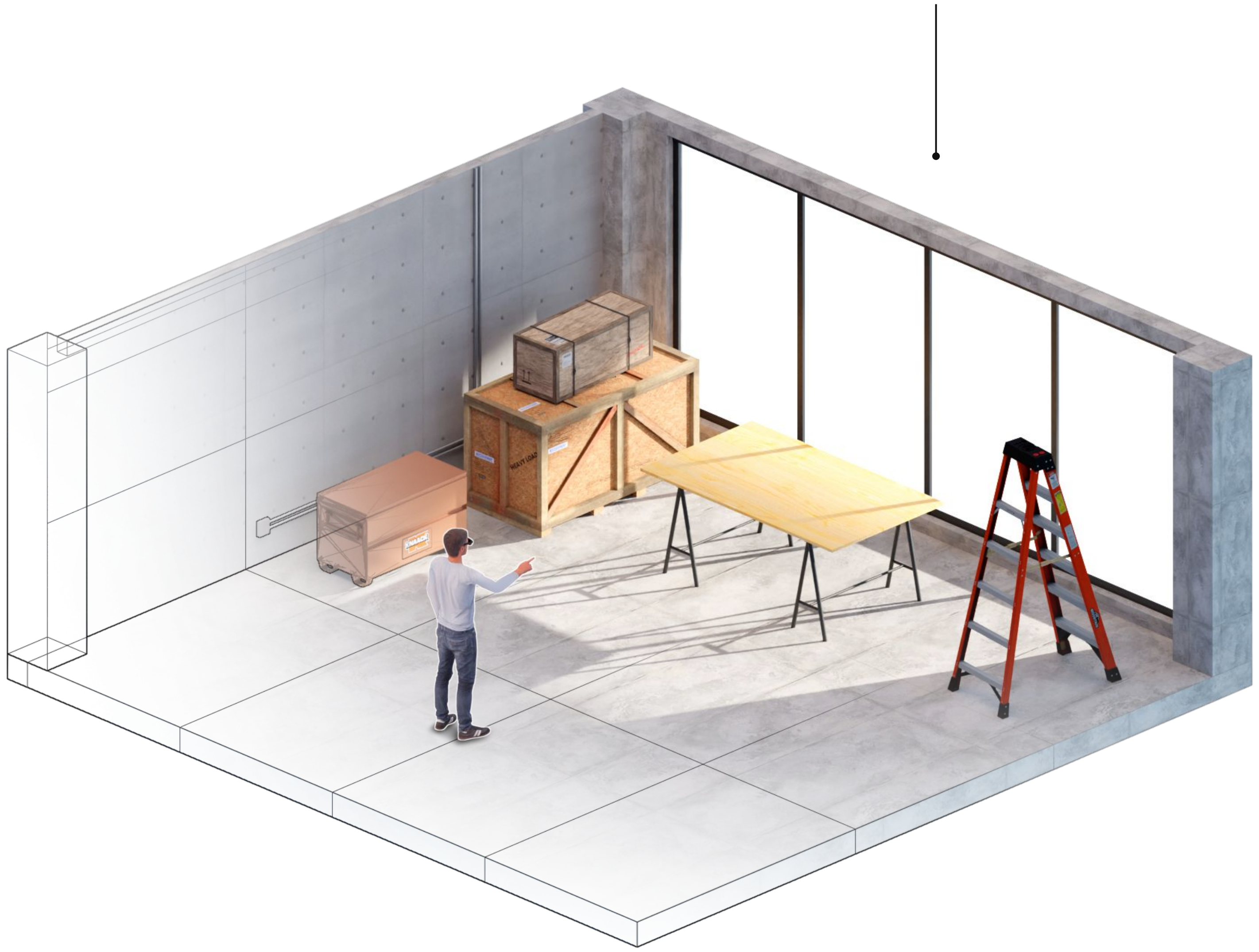
Developers can access raw color pixel data from the RGB camera and have the option to configure media capture type (photo or video), frame rate, resolution, media output format, capture mode (real-world, virtual content), autofocus mode, auto exposure, white balance, and color correction. Camera intrinsics are also available (i.e. focal length, field-of-view, aperture, and more).



Why is it important?

The RGB camera enables solutions that require a detailed understanding of the user's surroundings and interactions. For example, it can be used for the object recognizer & scene understanding modules, for virtual 3D overlay, for marker tracking, or for capturing and recording the user's interactions with the physical and digital worlds.

High-resolution world understanding in color

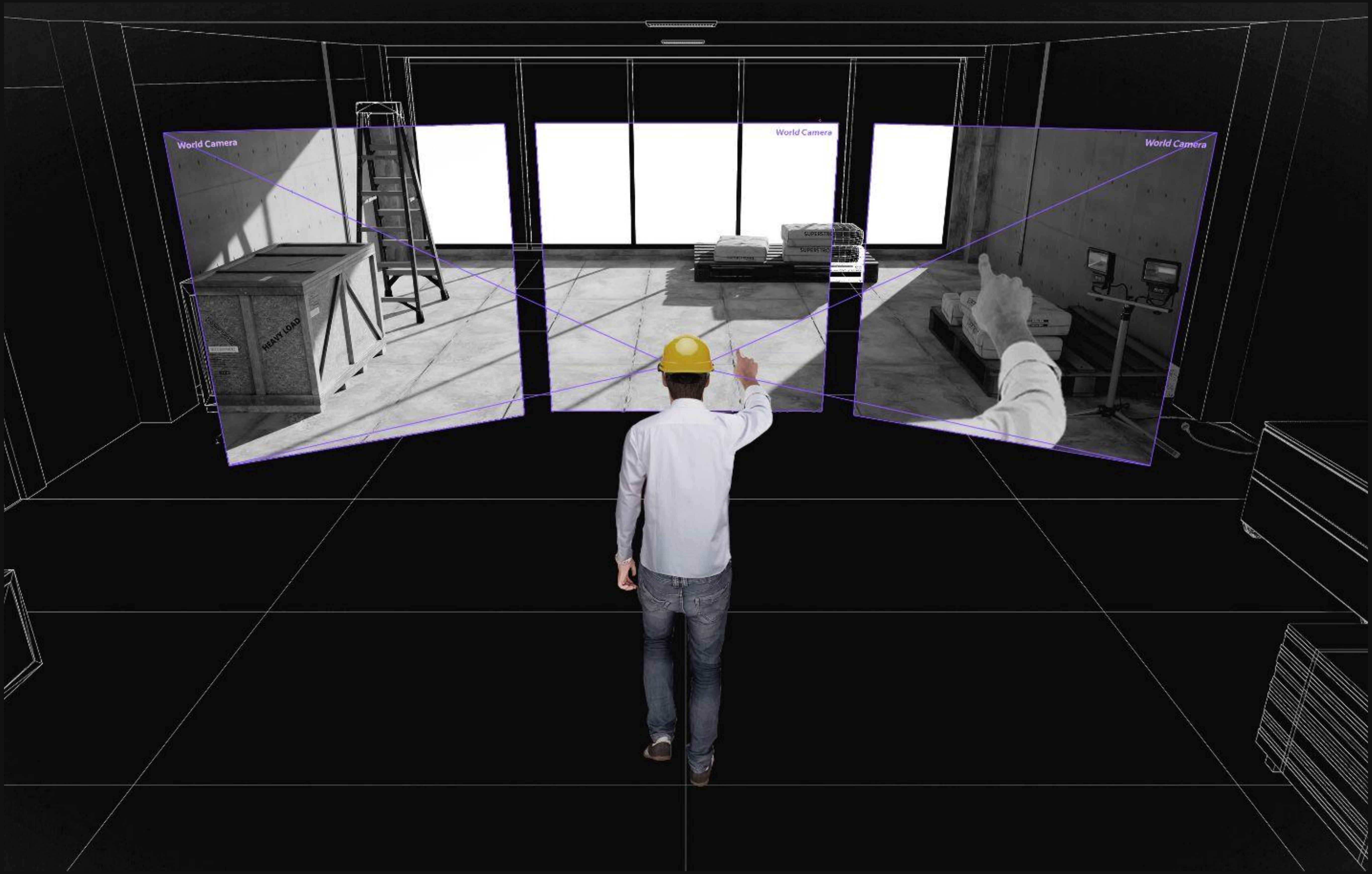


3.2 World Cameras

What is it?

On the Magic Leap 2 device, there are three outward-facing 1.0 MP cameras which collect wide-view images and video in grayscale of the user's surroundings and interactions.

These cameras are low-resolution cameras compared to the images and video captured on the RGB camera, however this means they consume less power and are more efficient for data-processing.

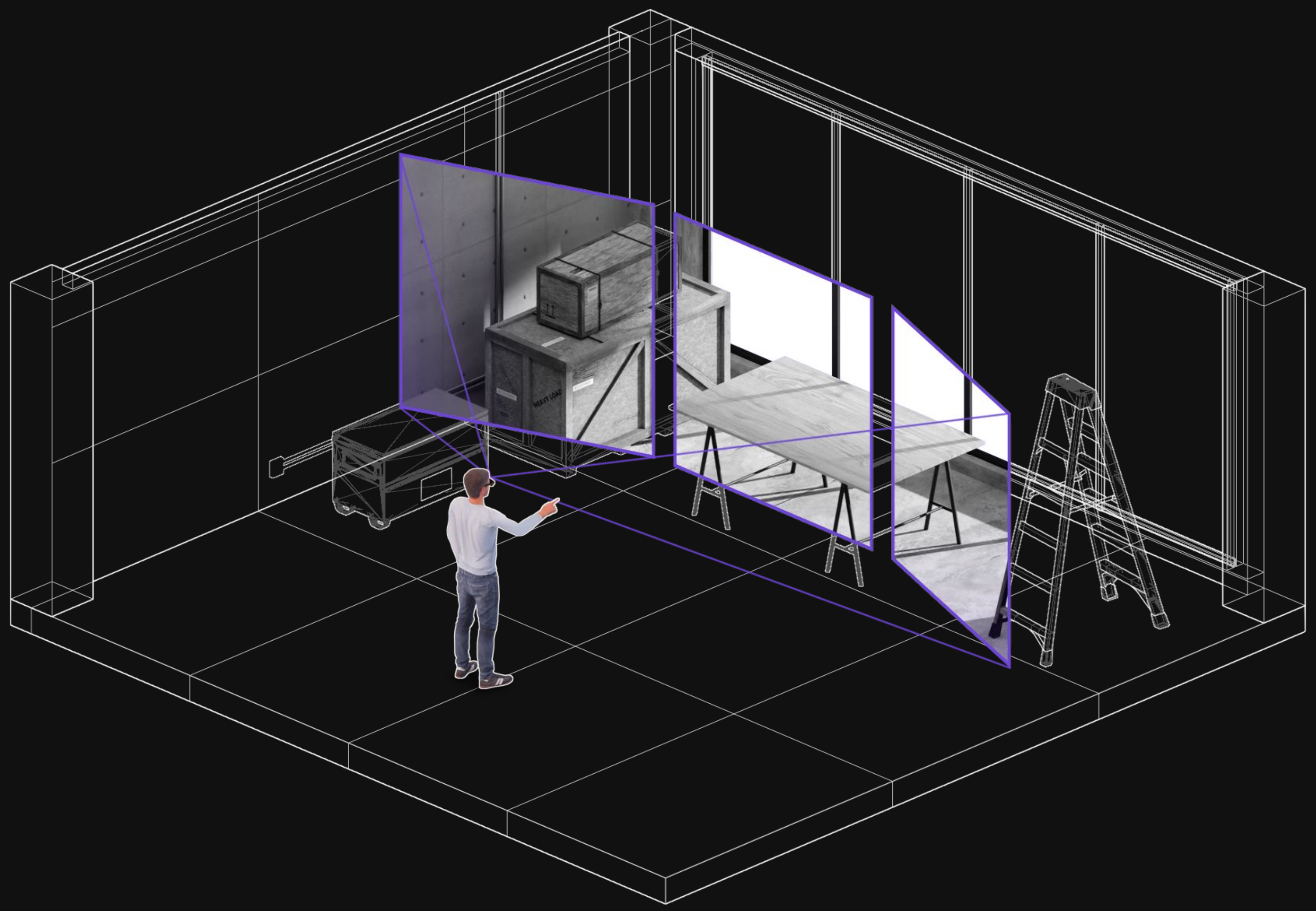


How does it work?

Each World Camera has 2 modes: Normal Exposure (NE) mode and Low Exposure (LE) mode.

Developers have the ability to configure the media capture type (image or video), frame rate, gain, and exposure of these cameras. The camera intrinsics are also available (i.e. focal length, field-of-view, aperture, and more).

They can access raw grayscale pixel data from the left world camera, right world camera, and center world camera.

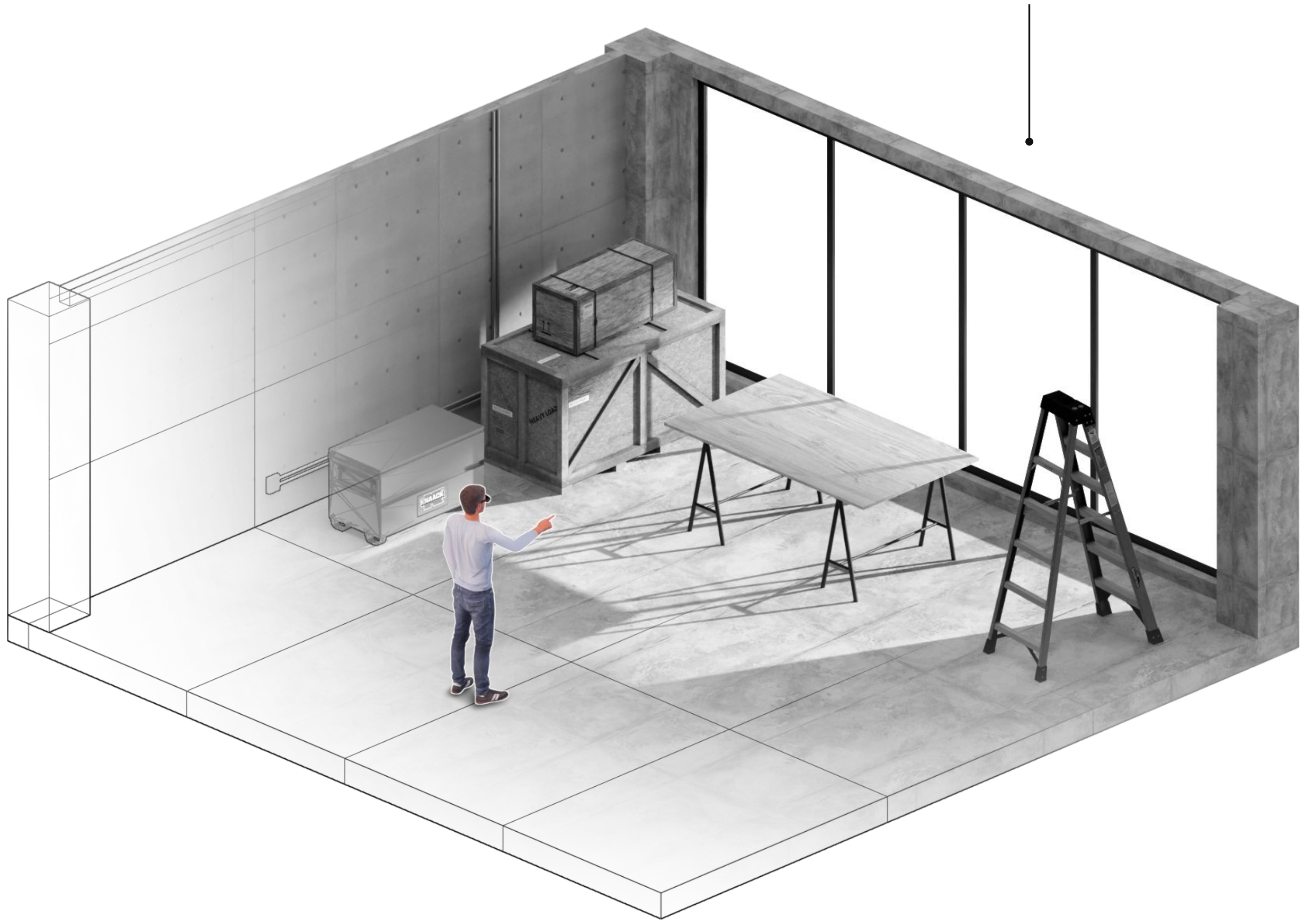


Why is it important?

The world cameras enable solutions that require an understanding of the user's surroundings and interactions, but don't require the detail of a high-pixel density camera. They have a wider field-of-view (meaning they can capture more of a scene at once) and they use less power, making them more efficient for data processing.

World cameras can determine user-related data, like the position of the user's head, and they can identify hand gestures to be used for input and content manipulation. They are also used for refining spatial scans of the environment, for virtual 3D overlay, marker tracking, and object tracking.

Grayscale, lower-resolution world understanding



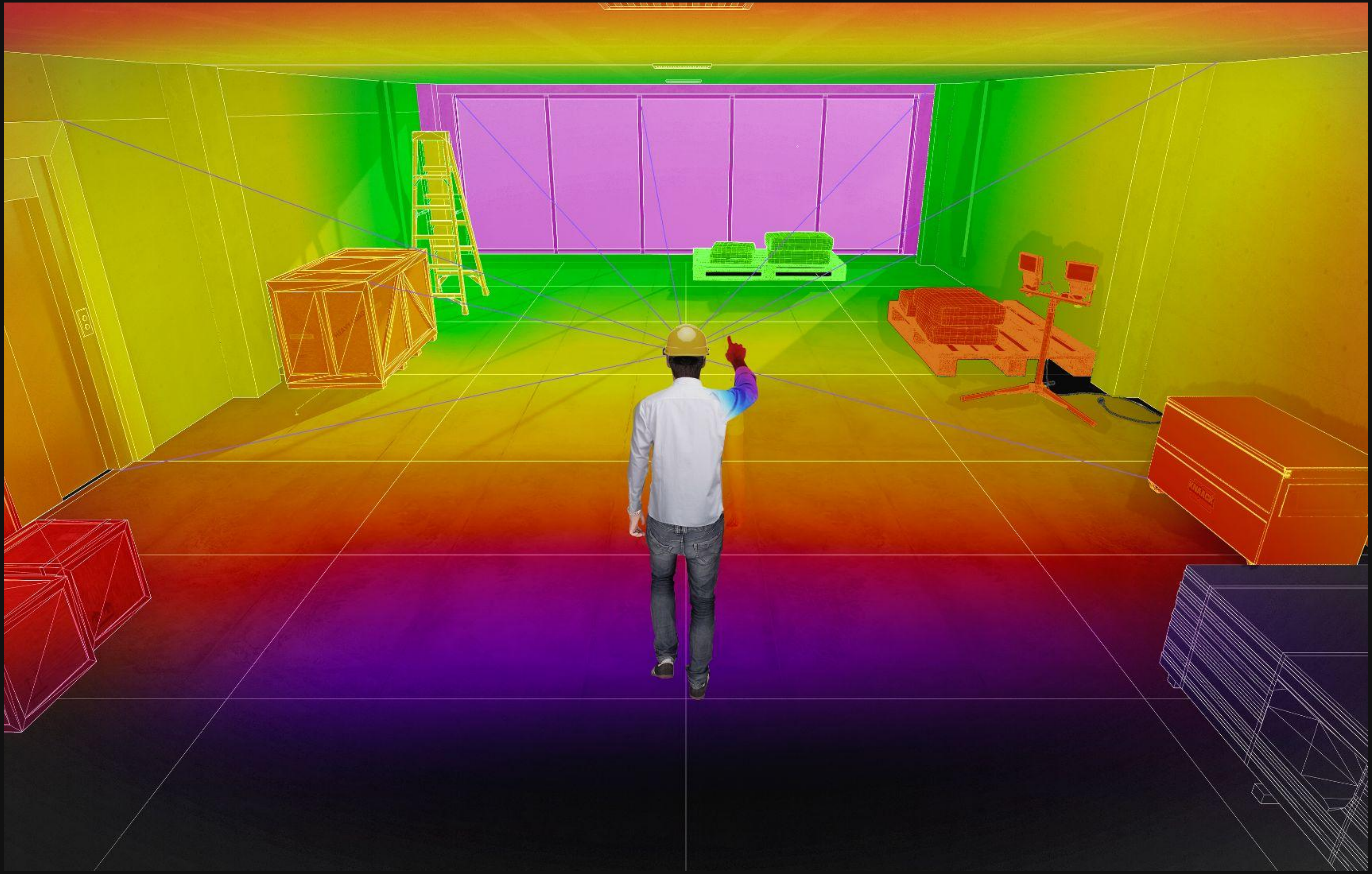
3.3 Depth Sensor

What is it?

Magic Leap 2 has a time-of-flight depth sensor that consists of an image sensor and illuminator.

Depth sensors collect depth images of the user's surroundings, which can be used to build spatial scans of the environment. They measure the distance between the device and objects, as well as the distance between objects.

Depending on the wavelength selected, it can also detect heat.

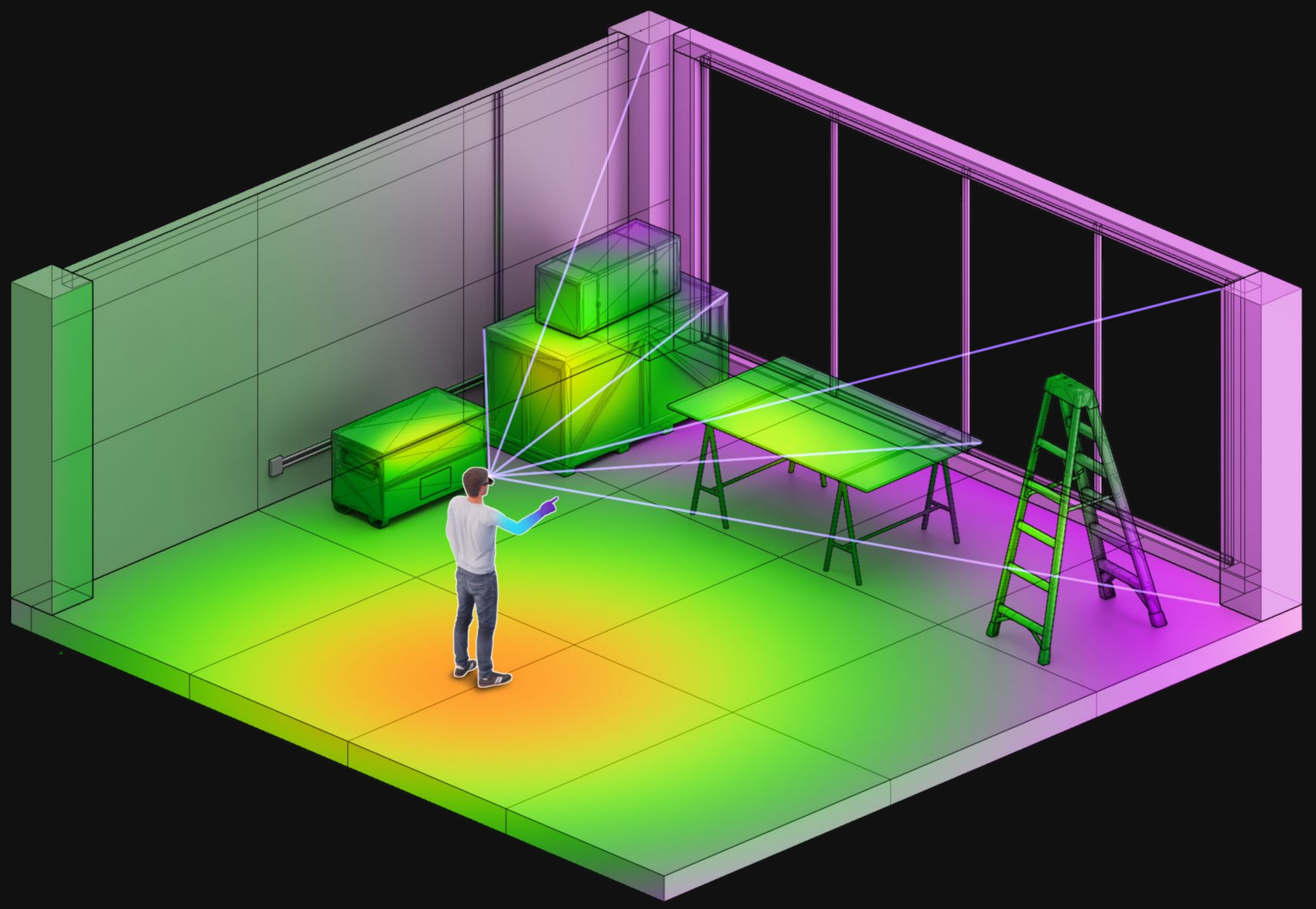


How does it work?

Time-of-flight distance sensors use the time that it takes for photons to travel between two points to calculate the distance between those points. Based on the time-of-flight, we can derive the depth of user's surroundings.

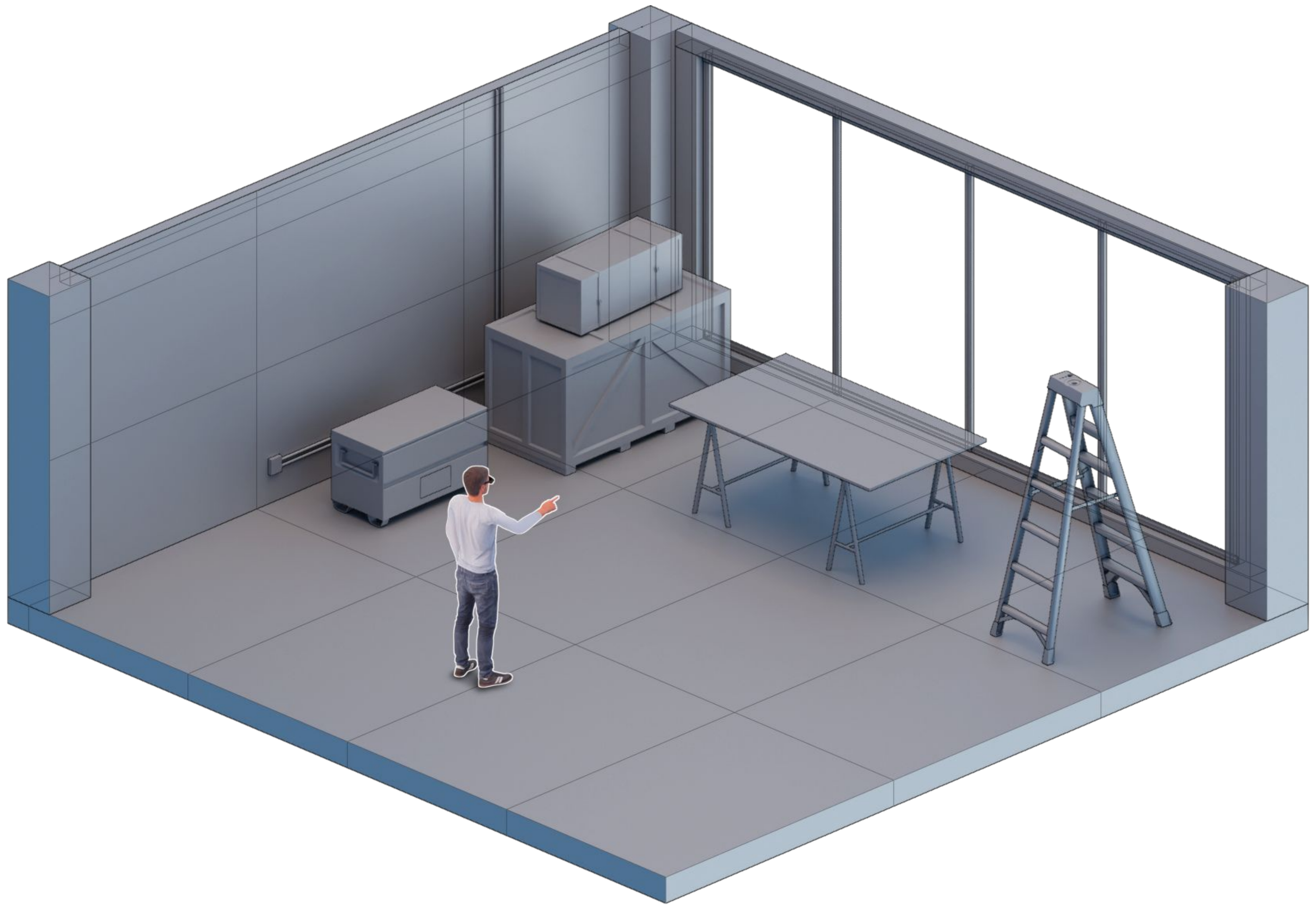
Developers can access processed depth data, confidence data, and raw environment data with and without the illuminator activated.

Developers are able to configure the depth mode (short or long), frame rate, and exposure. The camera intrinsics are available (i.e. focal length, field-of-view, aperture, and more).



Why is it important?

Depth sensors are relevant any time spatial awareness is important for a user. They assist in building spatial scans of the user's environment (by identifying the relative distance of nearby objects) and can be used to detect objects, count people, and aid in the navigation of a space.



3.4 Microphones

What is it?

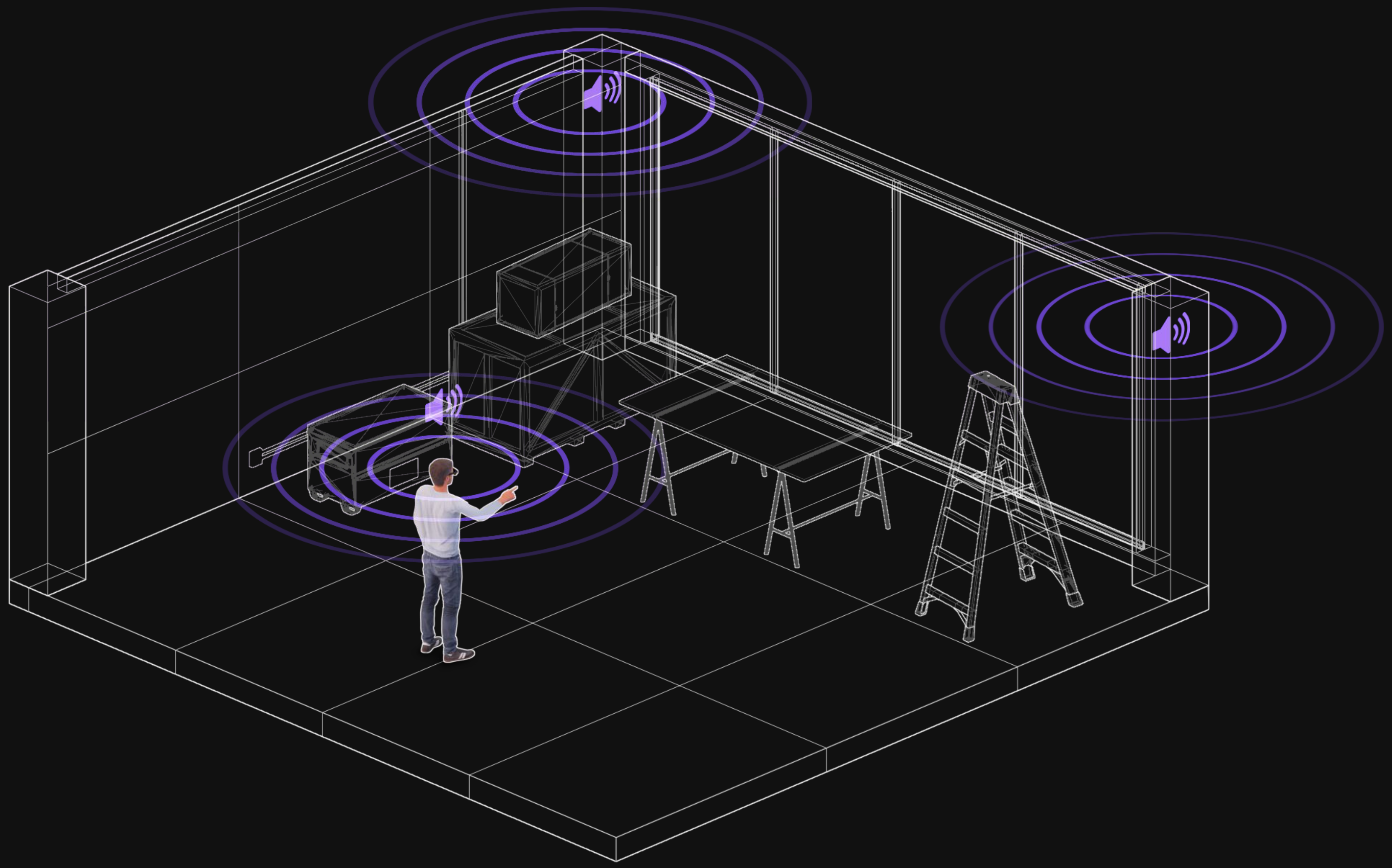
Microphones on Magic Leap 2 devices capture user generated sounds such as voice during video recordings, calls, meetings, and when using voice commands.

They also collect acoustic sound from the world around the user.

How does it work?

The Magic Leap 2 Headset includes 4 microphones. Processed microphone streams with acoustic echo cancellation and a stereo pair are currently available.

Developers are also able to access raw microphone streams.

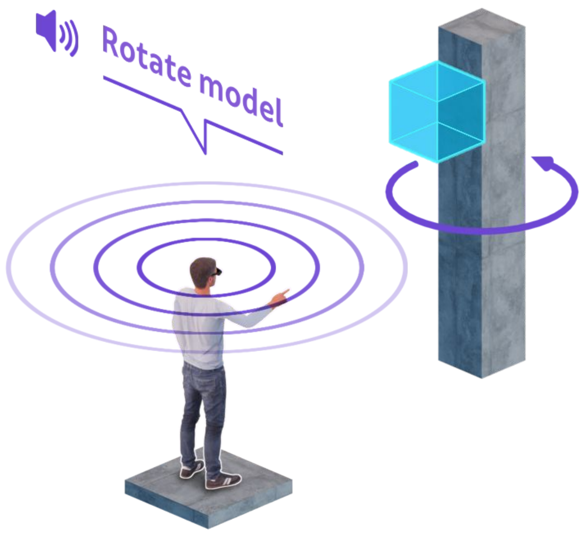


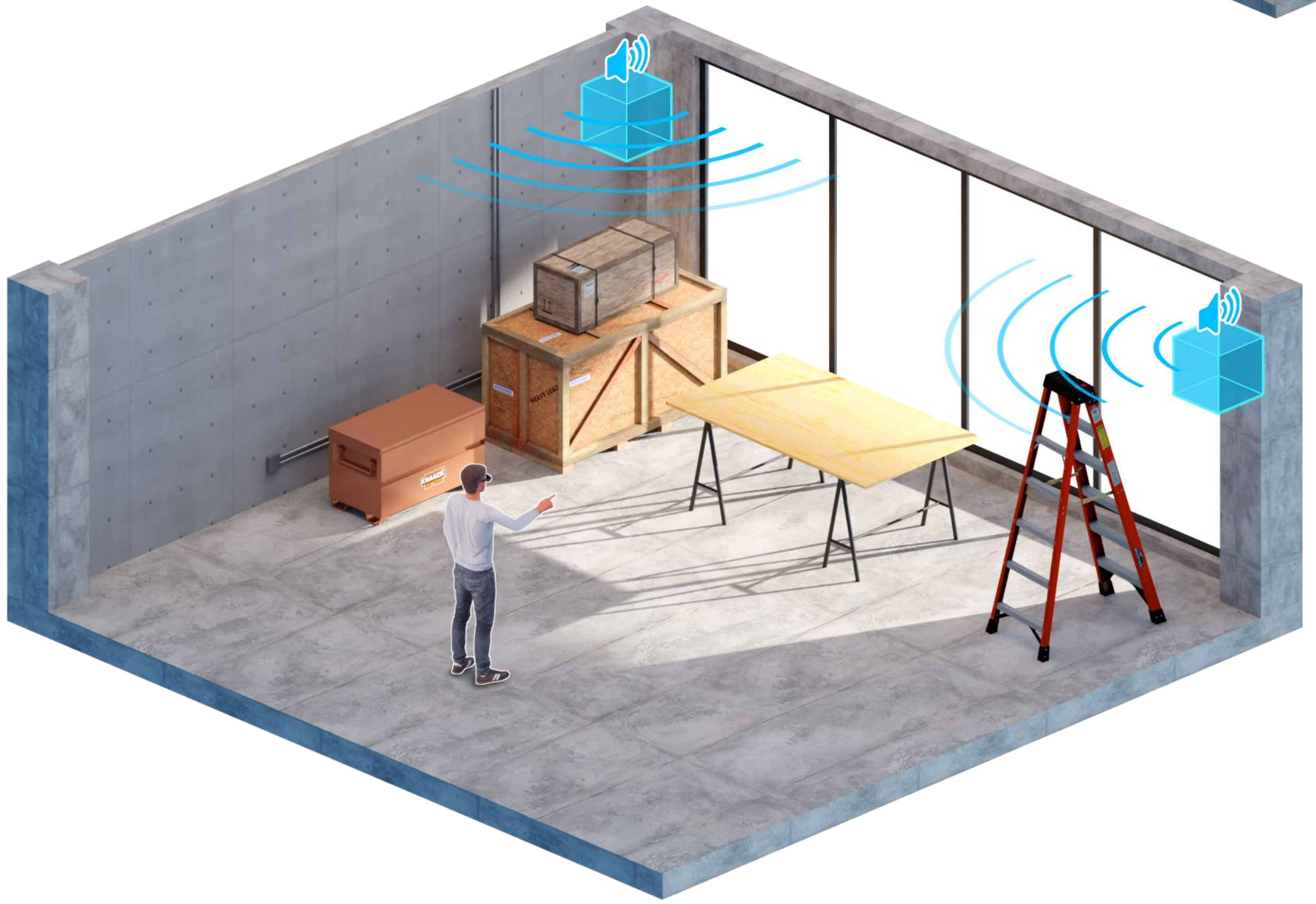
Why is it important?

Microphones serve to collect sounds from the user and the environment, as well as create realistic digital sound effects.

When used in combination with other sensors, microphones can help developers understand audio activity happening with the user and within specific environments.

Voice commands





Realistic digital sound effects

3.5 Ambient Light Sensor (ALS)

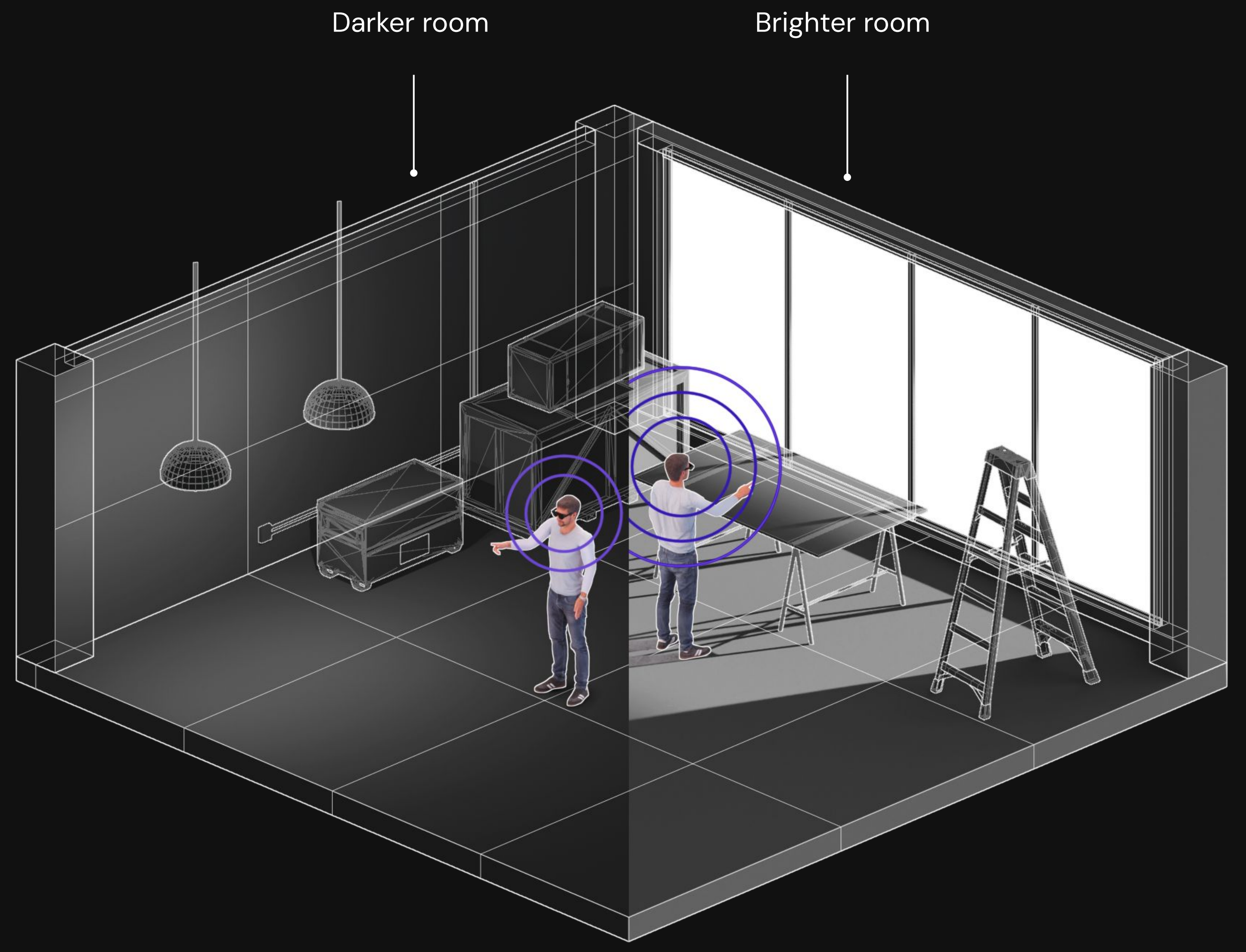
What is it?

Ambient light sensors measure the light intensity in the environment around the user. This can be used to appropriately auto-adjust display brightness and dimming depending on the lighting in the user's location.

How does it work?

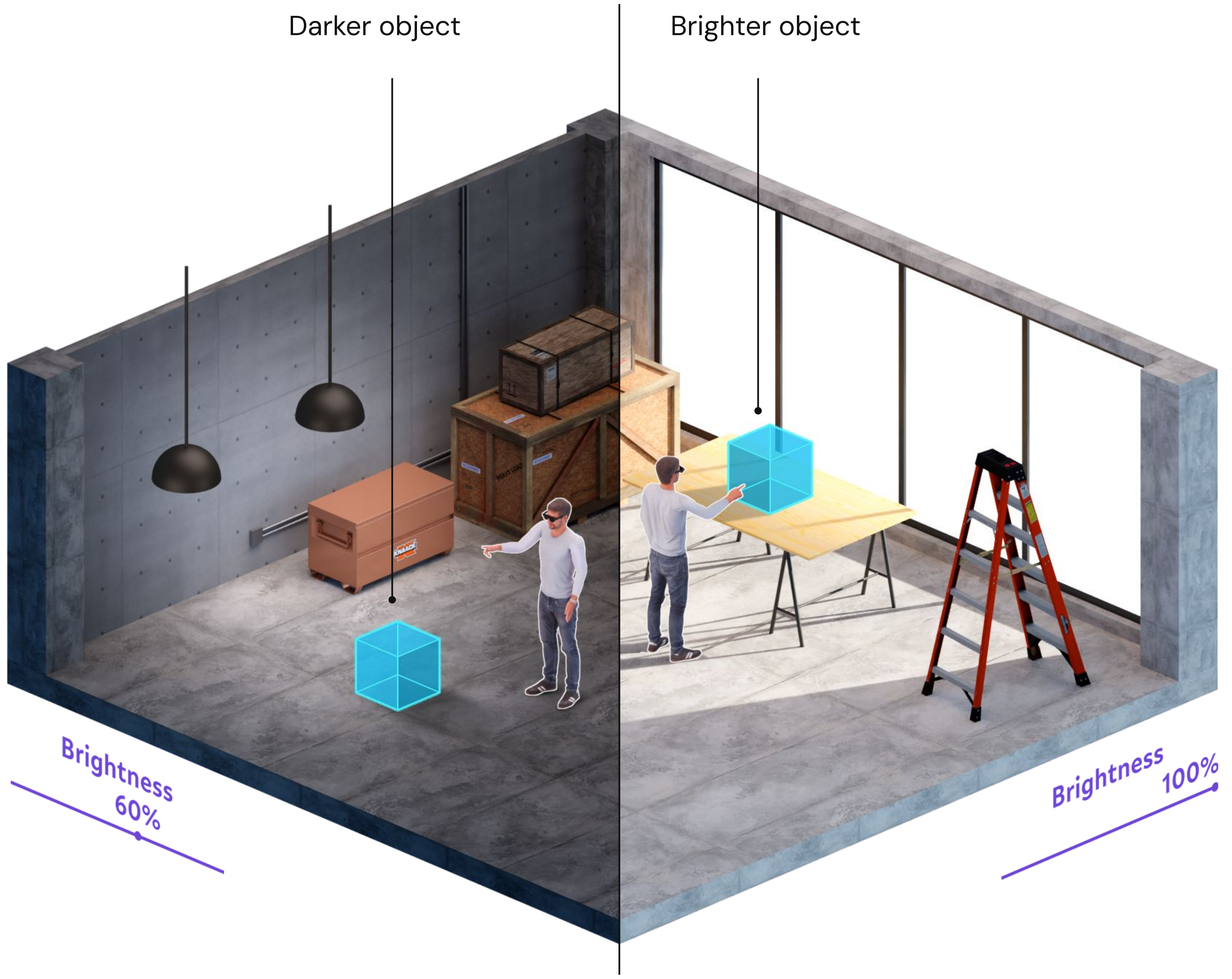
The ambient light sensor works by capturing the light level in the environment using photodetectors.

When a user moves around (for example, from a bright room to a dark room) the display on the Magic Leap 2 headset can adjust accordingly, so that the user continues to see content with clarity.

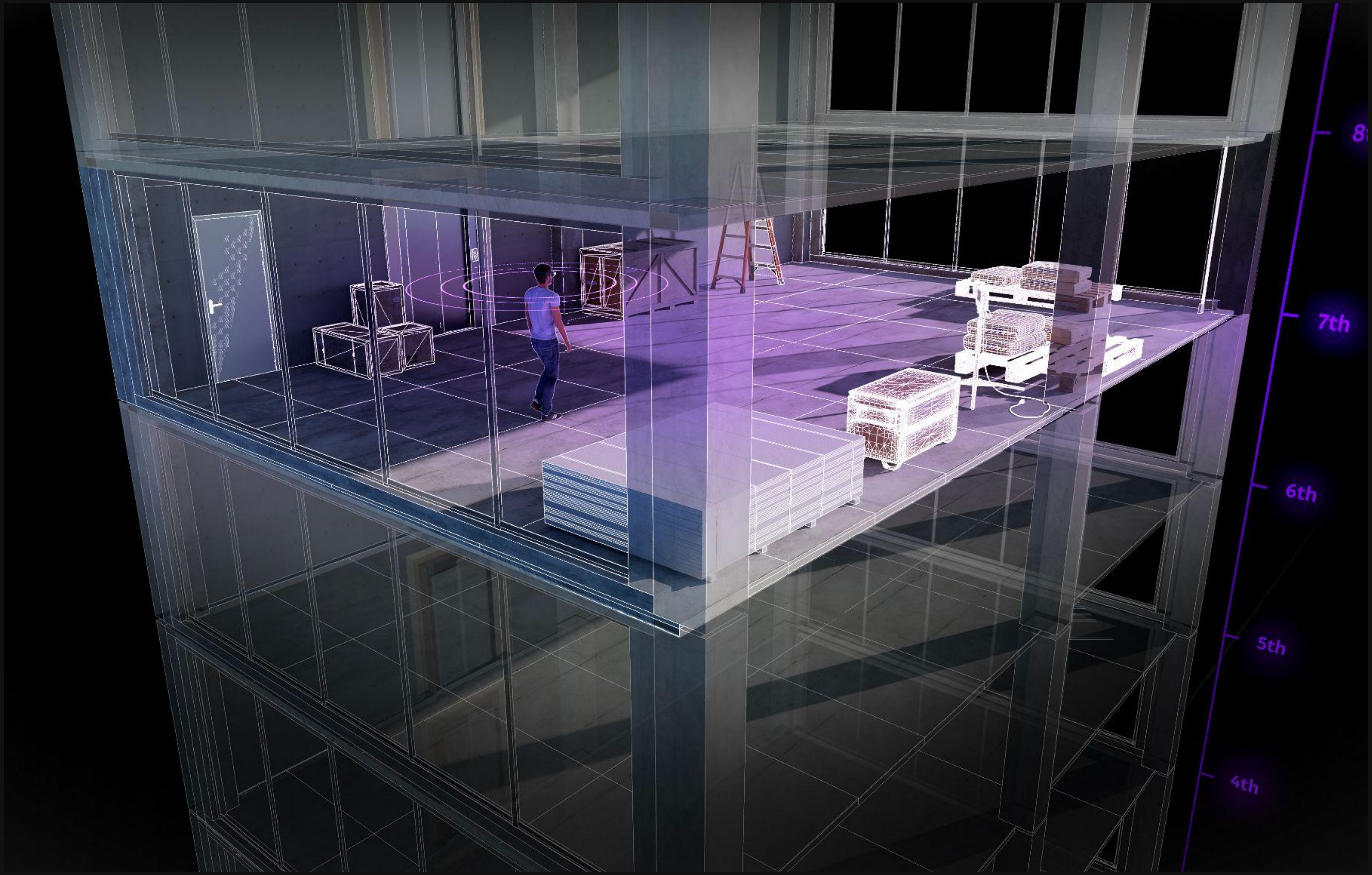


Why is it important?

The ambient light sensor enables our Dynamic Dimming™ technology, which creates the seamless integration of virtual content and elements with the real world. It enables a realistic user experience that is adaptive to the spaces and the environments users move through.



3.6 Altimeter | Barometric Pressure Sensors



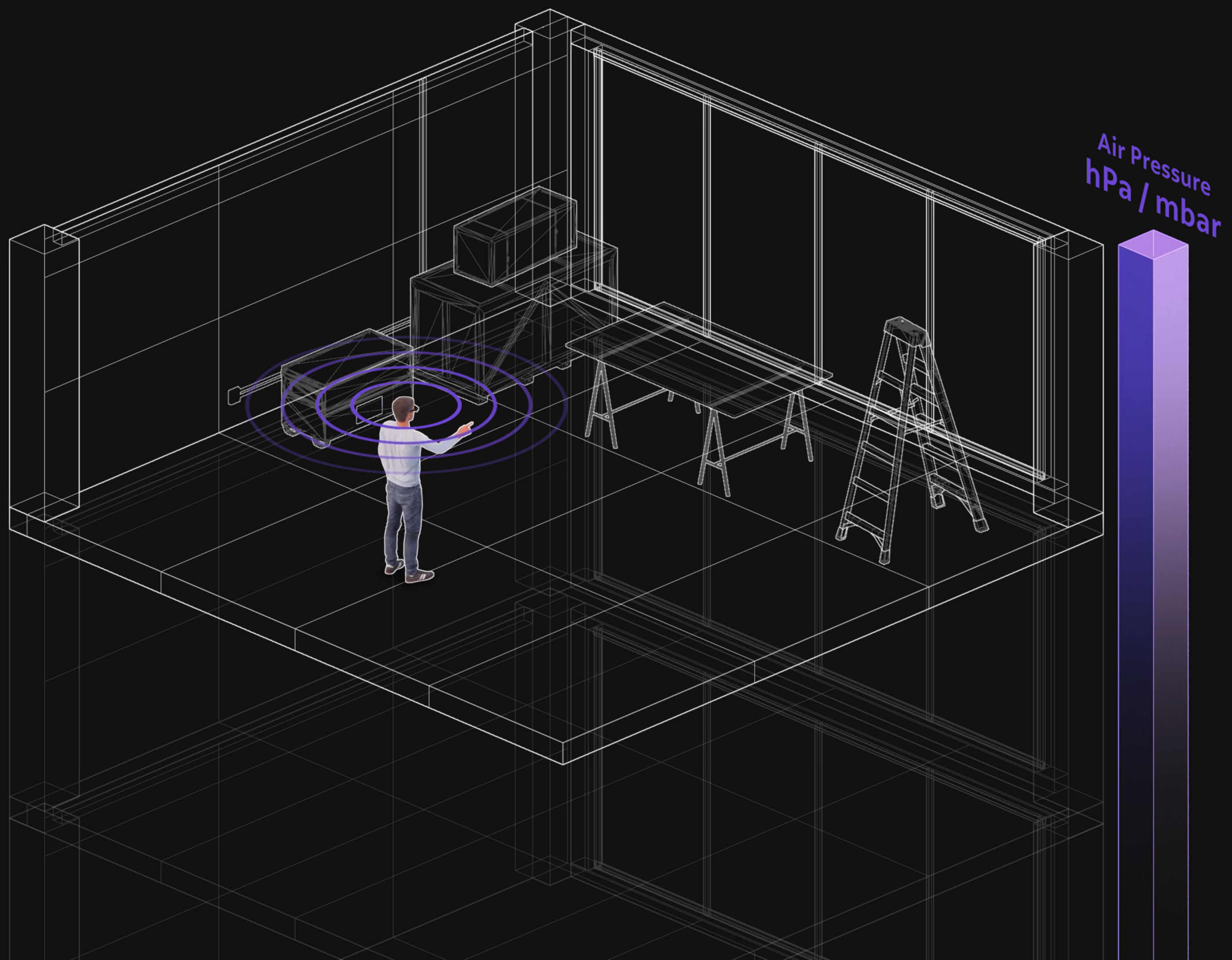
What is it?

Barometric Pressure Sensors–usually referred to as Altimeters–collect air pressure readings of the user's surroundings, which can be used to determine changes in altitude above ground.

How does it work?

Altimeters are included in the Headset and Compute Pack. Ambient air pressure can be measured in units of hPa or mbar, and these measurements can be converted to altitude.

Barometric pressure changes dramatically from environment to environment, so over short periods of time, relative pressure changes can be used to accurately estimate changes in altitude. Users can take a reference of barometric pressure at a starting location, and measure changes in pressure as they move through a space.

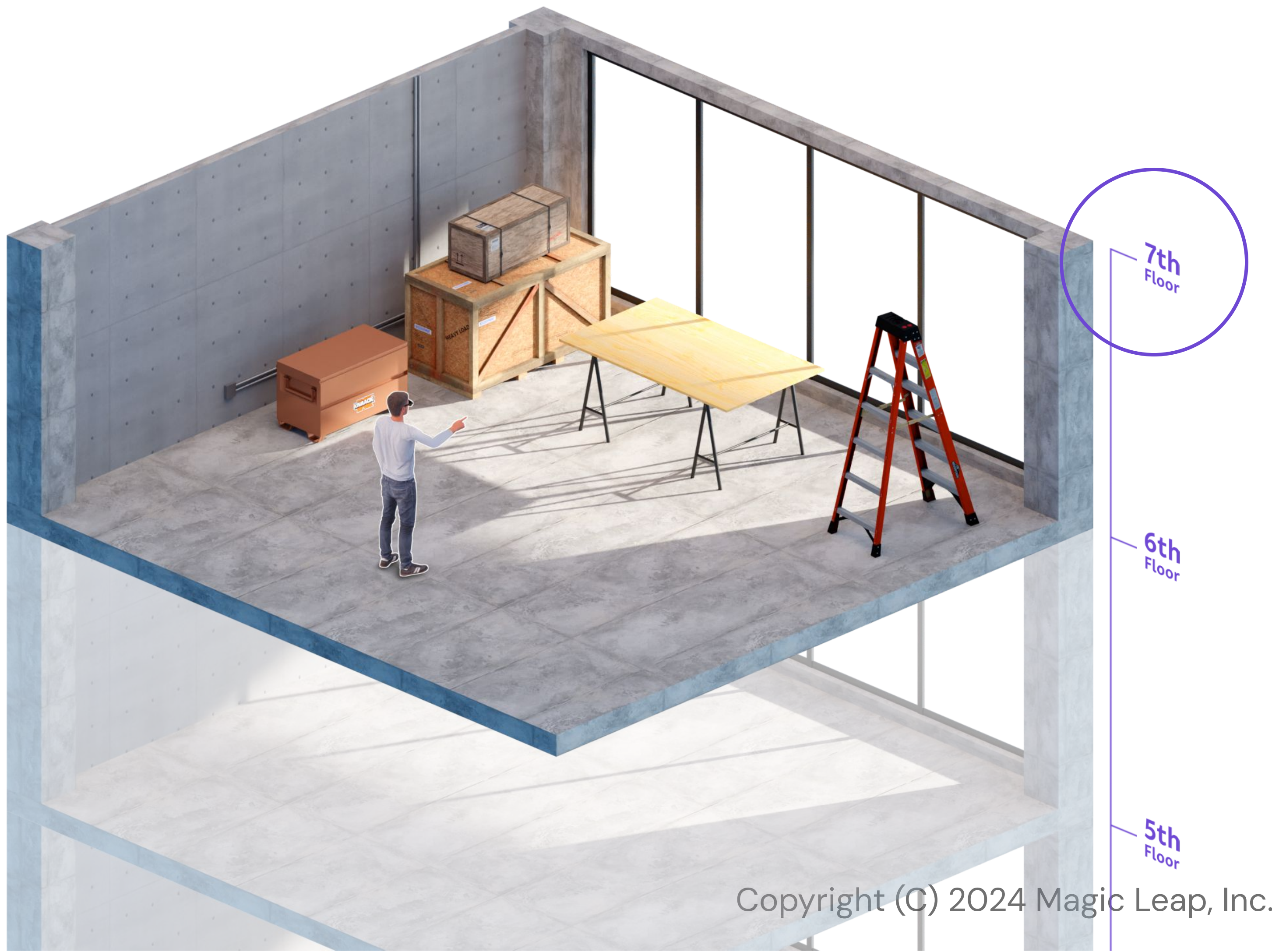


Why is it important?

Altimeters serve as navigational aids, localization aids, and assist in monitoring environments. For example, in a new construction environment, altimeters can determine what floor the user is on in an unmarked building. In existing buildings, altimeters can assist with determining which room the user is actually located in (especially when there are many same-room layouts in one building, like a hotel).

For navigational purposes, altimeters assist with guiding a user from point A to point B when there is a change in altitude (i.e. going to different floors in a building).

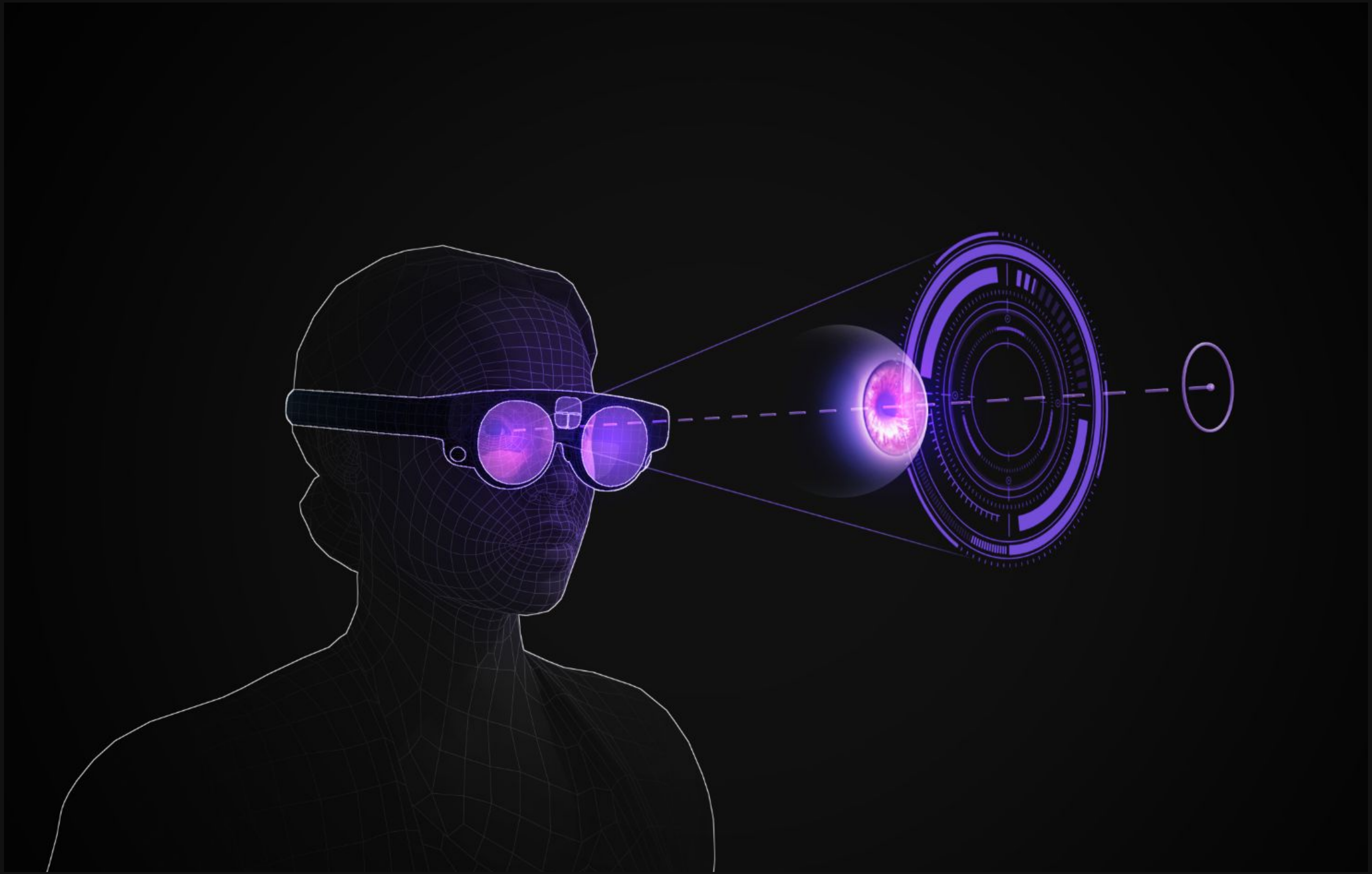
With environmental monitoring, altimeters can be used to measure changes in pressure. For enterprise field workers in condition-dependent workflows, the altimeters can provide information that assists with providing the best service or understanding of maintenance concerns. For example, measurement of room air pressure when configuring an HVAC system.



3.7 Eye Cameras

What is it?

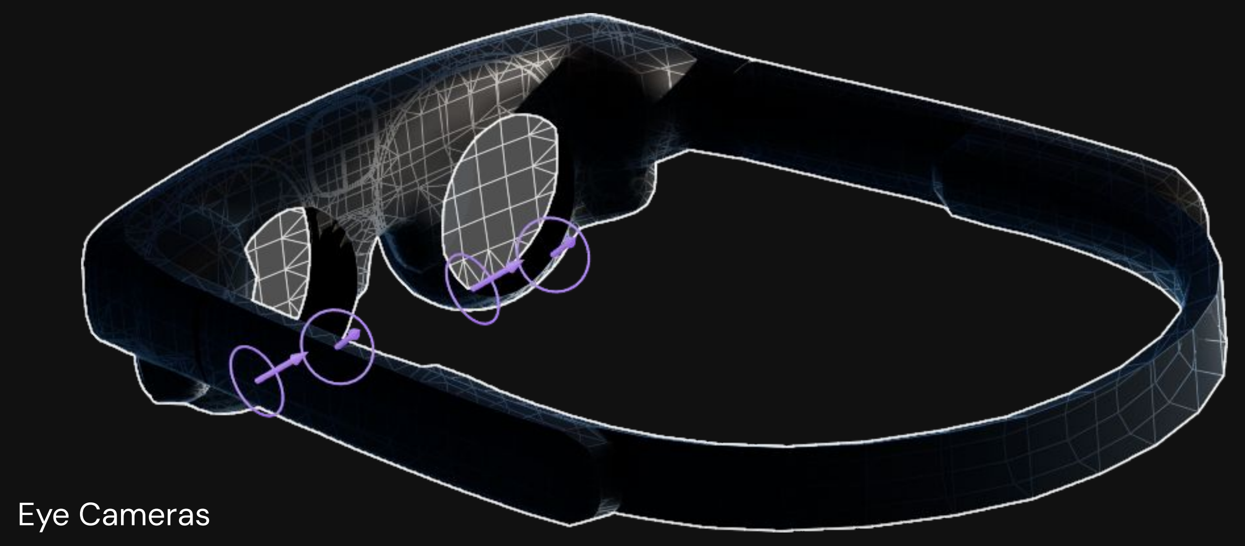
Eye cameras are inward-facing cameras on the Magic Leap 2 device, and can be used to determine where the user is looking, and other important information about user behaviors/conditions in relationship to their eye movements or expressions.



How does it work?

The Magic Leap 2 device leverages two cameras and six LEDs per eye. They are located on the inside of the device to view the users eye movement.

Developers can access data from gaze tracking, gaze behavior classification, eyeball center, eye expressions, pupil location, pupil diameter, and raw eye images.

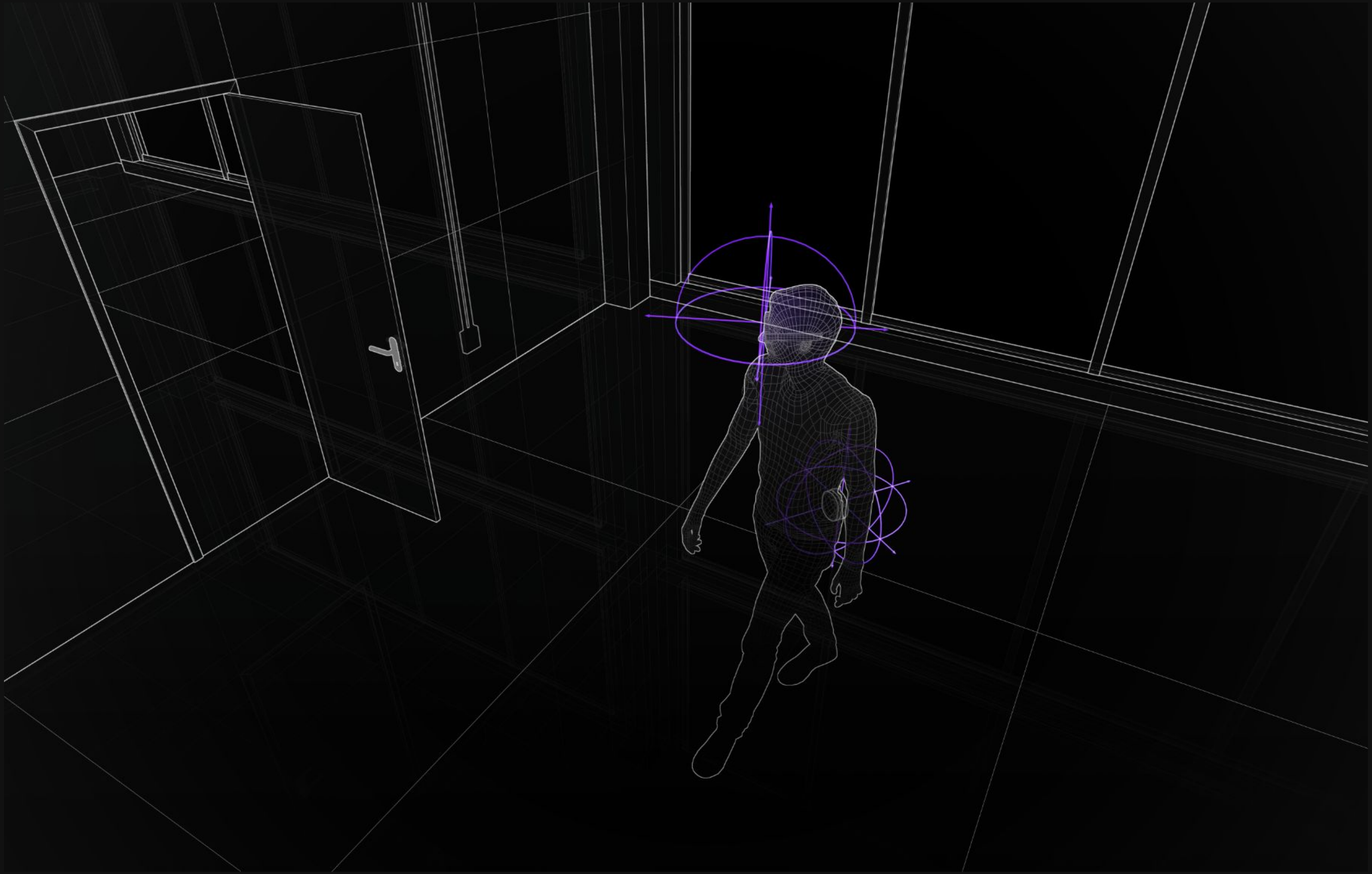


Why is it important?

Eye tracking cameras show and assist the device in understanding where the user is placing their visual attention, can show indications of cognitive process, and be used for clinical assessments.

They can also be leveraged by enterprises to better understand a user’s experience from the inside out, and aid with training scenarios that require analysis of gaze behavior and response.

3.8 Inertial Measurement Units (IMUs)



What is it?

Inertial Measurement Units (IMUs) are sensors that measure the relative position, orientation, and motion of the Magic Leap 2 device.

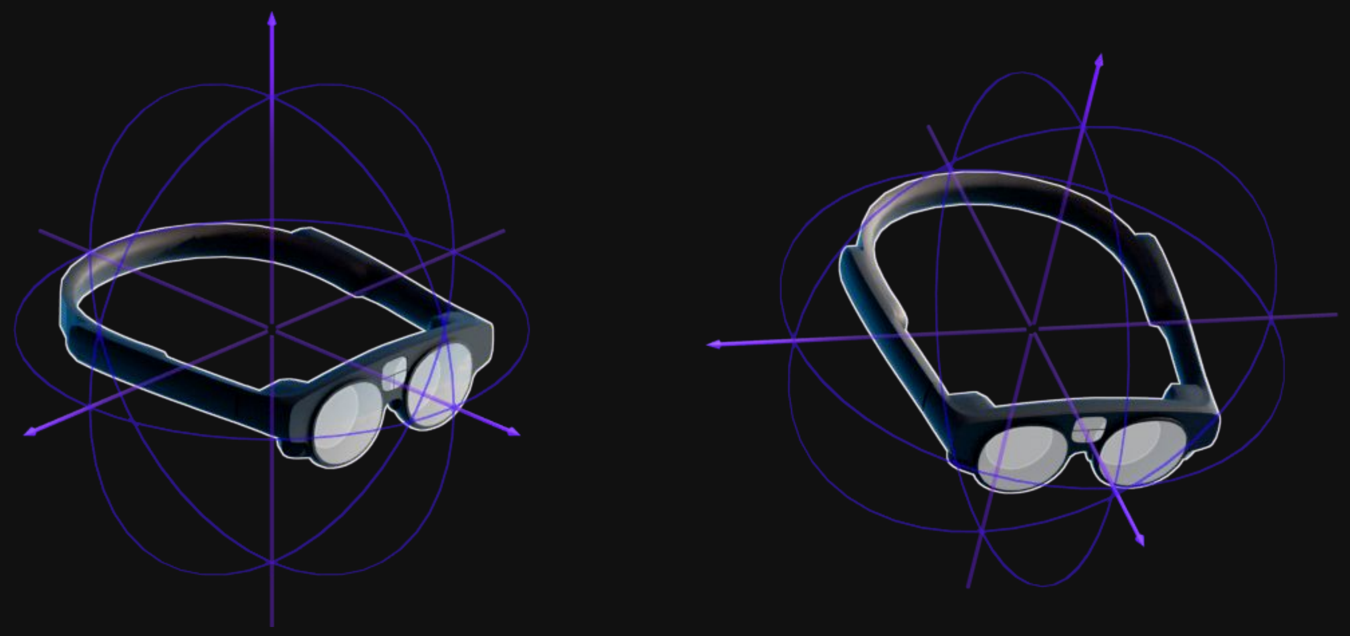
There are two of these sensors in the Headset and one in the Compute Pack.

How does it work?

IMUs are motion tracking devices that measure accelerations and rotations to estimate position and orientation over time.

The accelerometer serves as a linear motion sensor on the XYZ axes. The gyroscope captures rotations around the XYZ axes. An IMU is made up of both so that the state of the device can be managed in 3-dimensions.

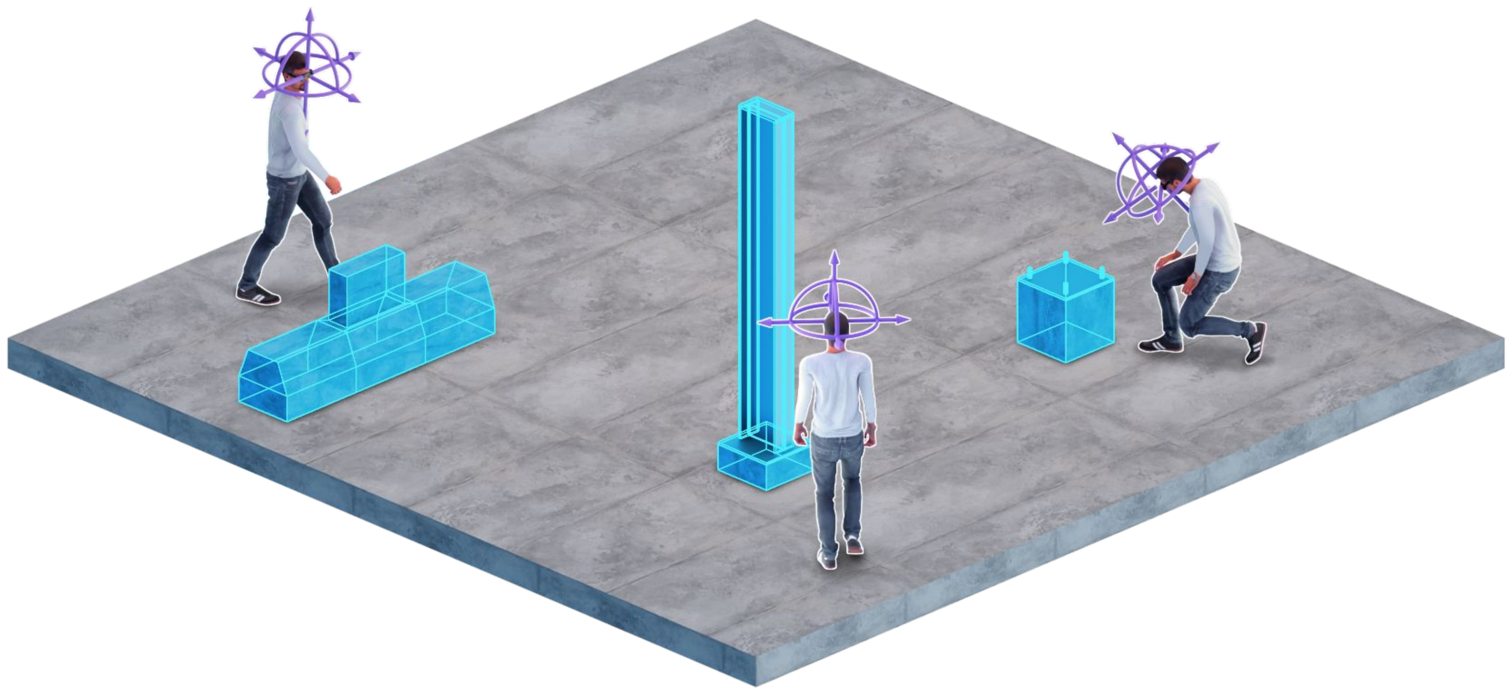
IMU data is available at rates up to 1,000 Hz.



Why is it important?

When used in combination with World Cameras, IMUs make it possible to align digital content accurately in relation to the three-dimensional positioning of the headset. This is important for creating successful SLAM algorithms.

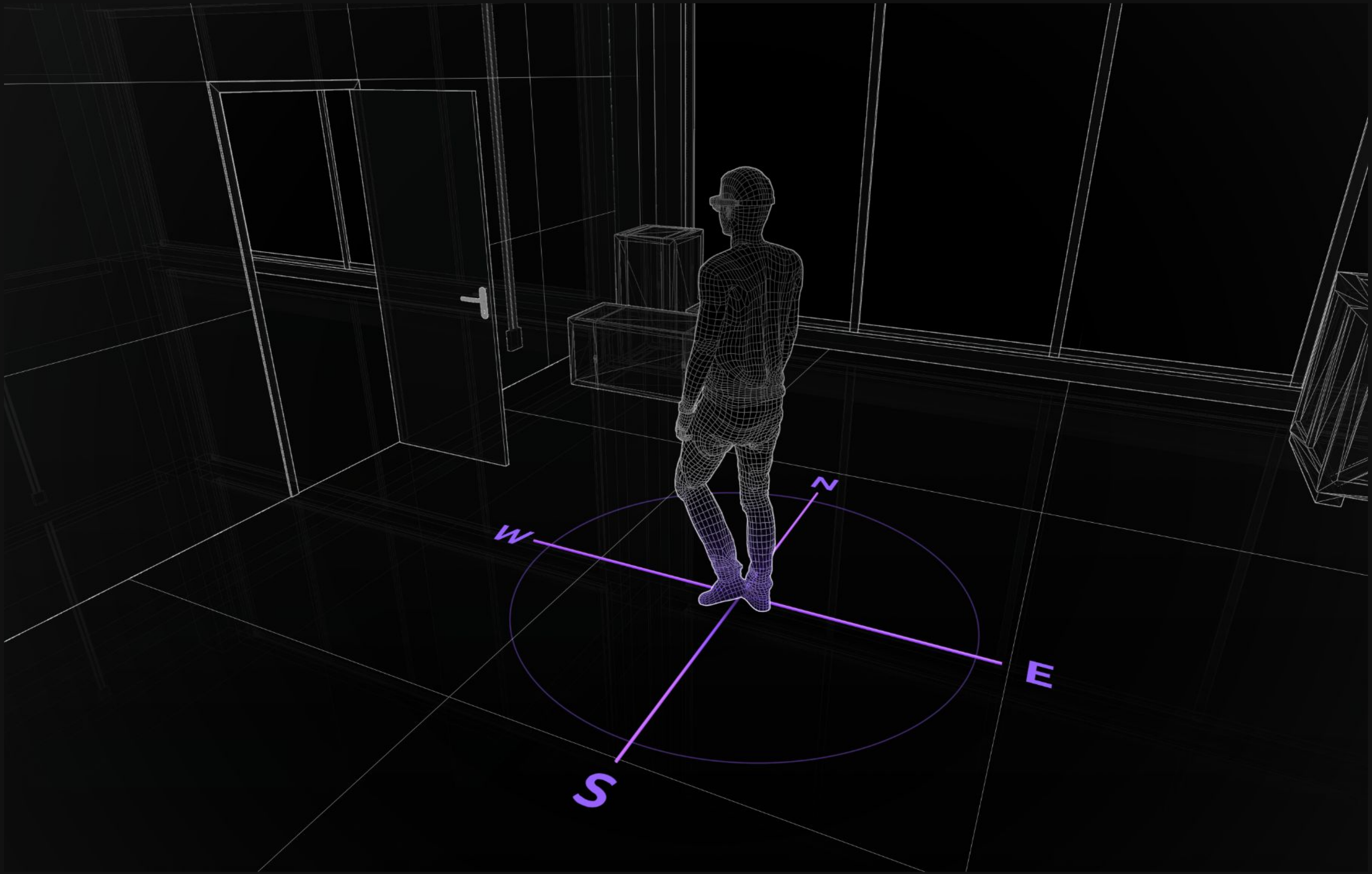
IMUs are also used for tracking the movements and motions of users, such as muscular tremors when used for diagnostic aid. IMUs also provide bio-behavioral data, like tracking ambulatory movements such as walking and gait.



3.9 Magnetometers

What is it?

Magnetometers are magnetic sensors that can detect orientation of the device based on Earth’s magnetic field.



How does it work?

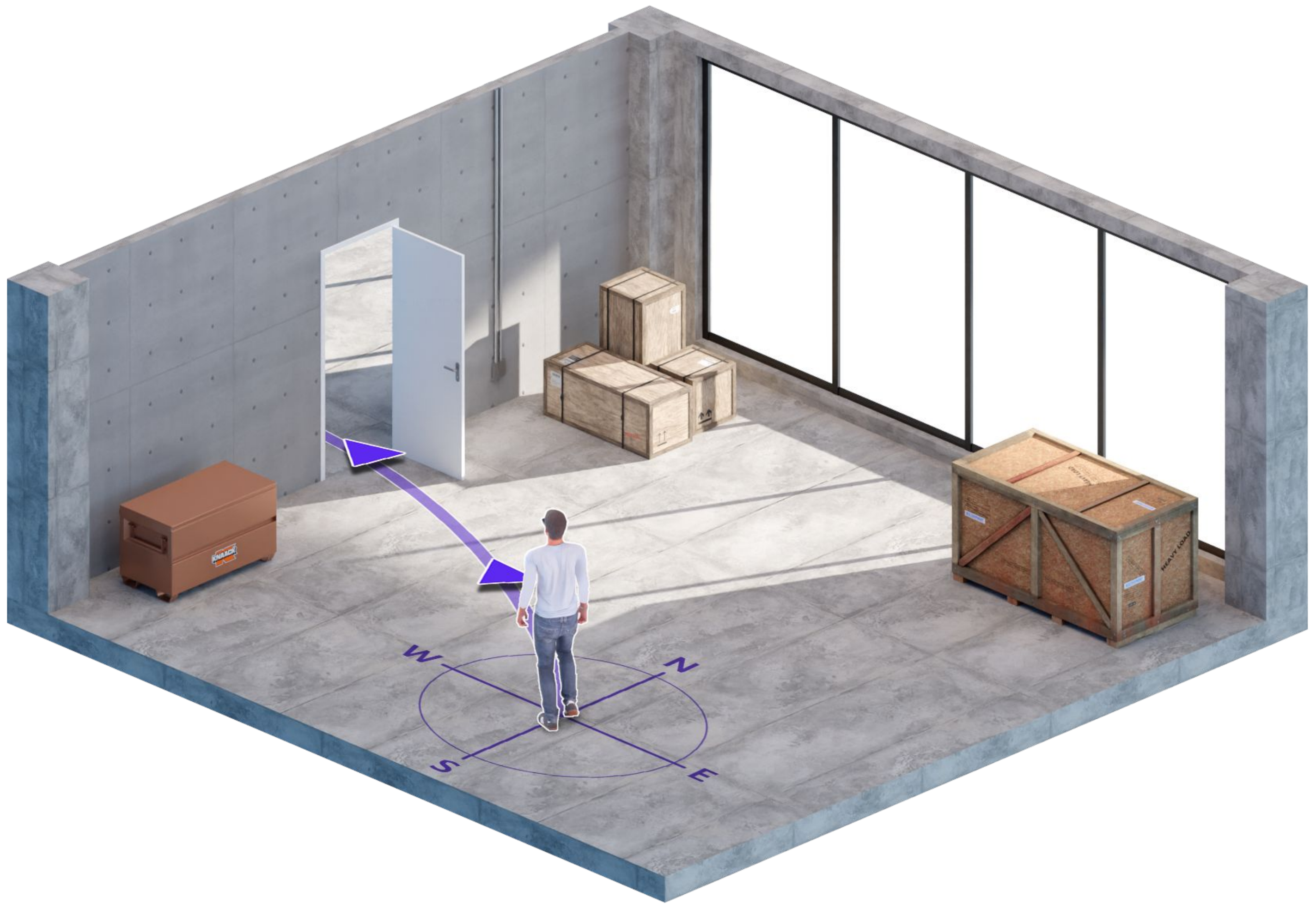
When combined with a gravity vector which points towards the center of the Earth, the magnetometers enable determination of the user's orientation with respect to cardinal directions (north, south, east, and west).

Two magnetometers are present in the Headset. Developers have the ability to sample both magnetometers at rates up to 100 Hz. End user calibration of the magnetometer supports e-compass and pedestrian navigation use cases.

Why is it important?

Magic Leap 2 does not have GPS, so magnetometers aid in orienting the user in both mapped and unmapped spaces.

Apps can provide directional guidance to the user regardless of a space's mapped status. For example, an app can use the magnetometer data to direct the user to exit from the north side of a building. Magnetometers are also used to help improve motion vector determination.



Sensor Data Access & Control
Capabilities
Features – Sensors
Combining Sensors

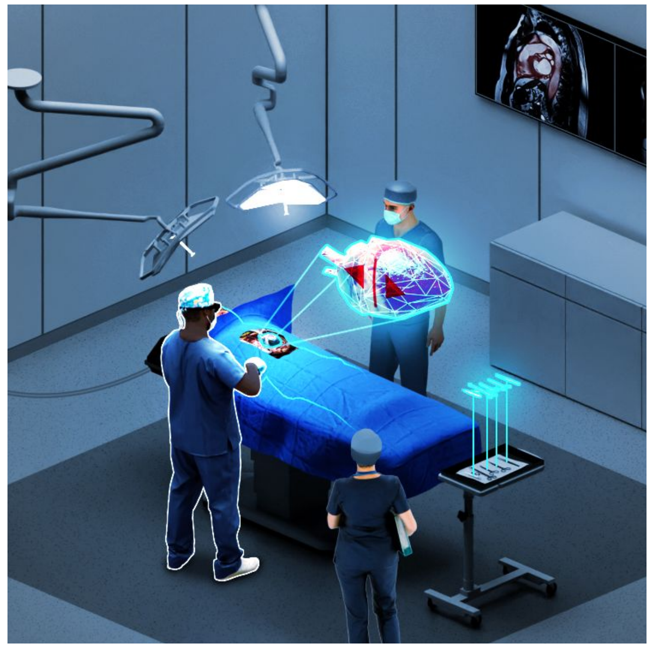
4

Sectors and scenarios

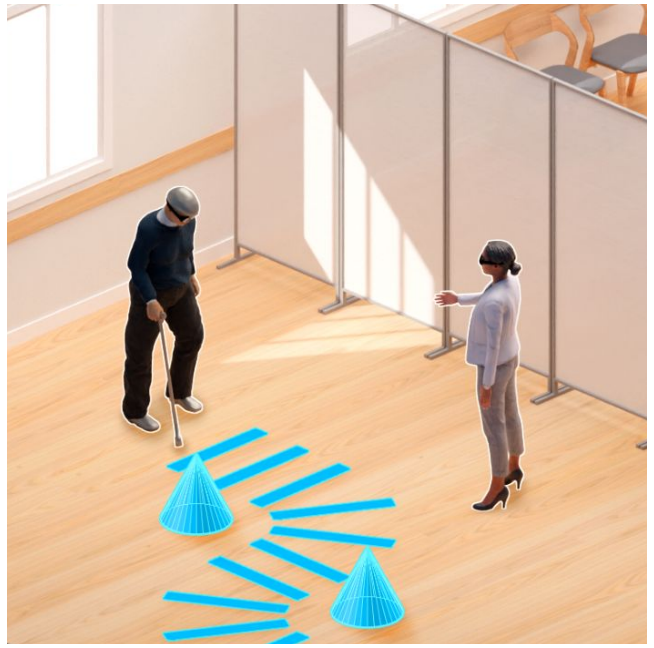
In order to exemplify the value of combining data from different sensors–to build valuable algorithms and applications–we are showcasing scenario examples of solutions that developers can potentially build through Sensor Data Access.

These scenarios are inspired by real applications. We expanded the experiences to showcase that, by combining data from multiple sensors, possibilities are expansive for creating high-value software algorithms, features, capabilities, and services across sectors.

MedTech



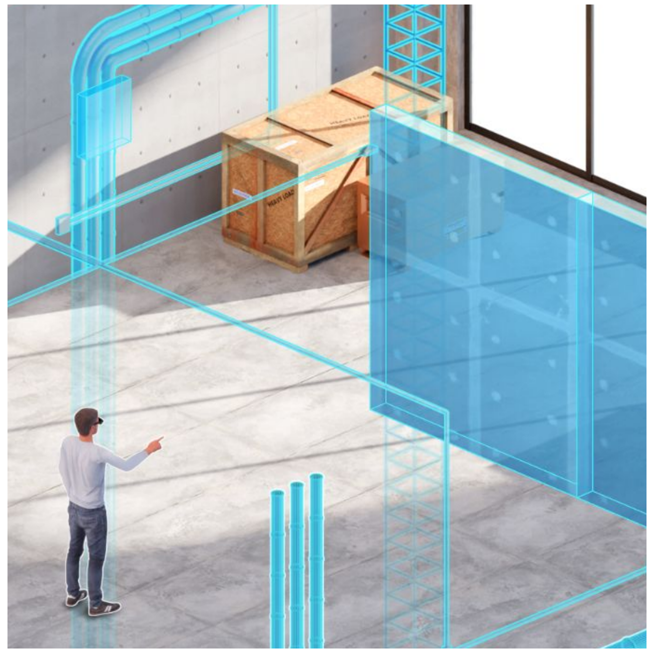
AR-assisted surgery*



Assessments

AEC

On-site visualization



BIM overlay into construction

Public sector

First-responder training

*Magic Leap 2 MedTech achieved IEC 60601 certification as a UL Recognized Component, intended for integration into systems designed for end use in medical environments. Prior to such end use, further testing and certification may be required.

Sector: MedTech

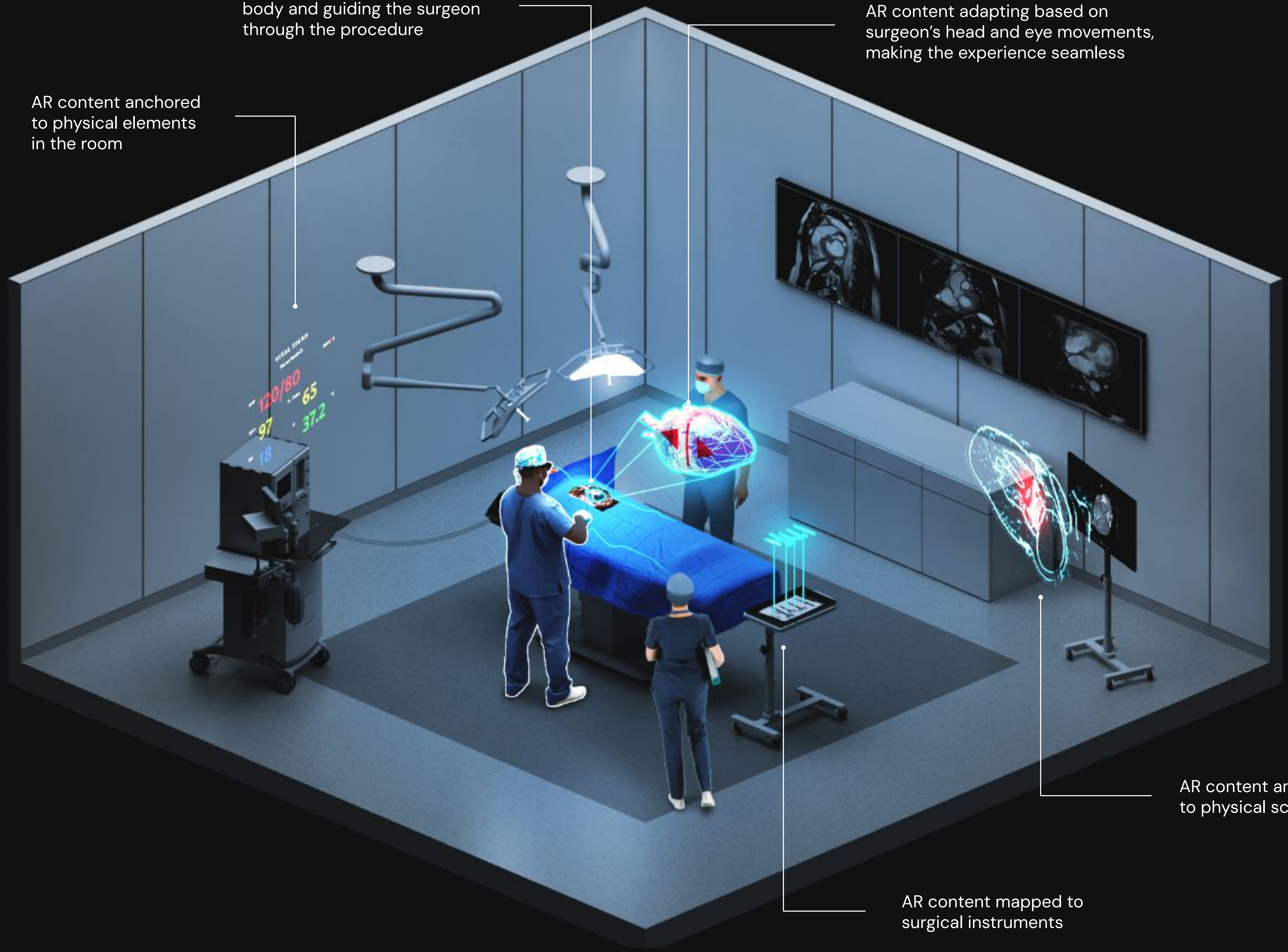
Scenario: AR-assisted surgery*

Experience

By accessing data from the RGB camera, depth sensor, and world cameras, developers can enable experiences that allow surgeons to precisely track a patient's body, surgical instruments, and other physical elements used in live robot-assisted surgery. In the operating room, digital content can be overlaid onto the patient's body, allowing the surgeon to view anatomical details clearly and see content placed precisely in real time.

Magic Leap 2 can also track the physical environment and provide physicians with a 3-dimensional way of interacting with complex information, replace 2D screens in operating rooms, and enhance the physician's ability to collaborate in real time.

By giving access to IMUs and eye cameras, developers can create user experiences that are seamless for the surgeon during the procedure. By sensing the surgeon's head and eye movements, the interface can adapt to best accommodate the information based on their position.



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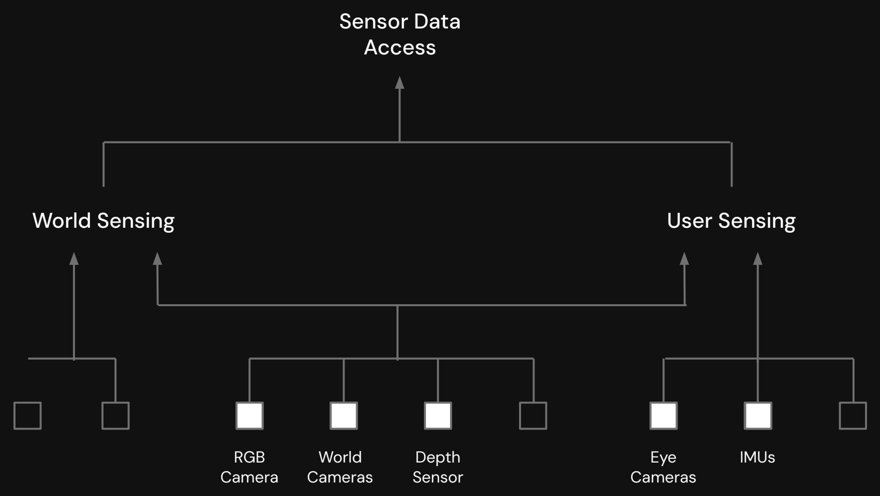
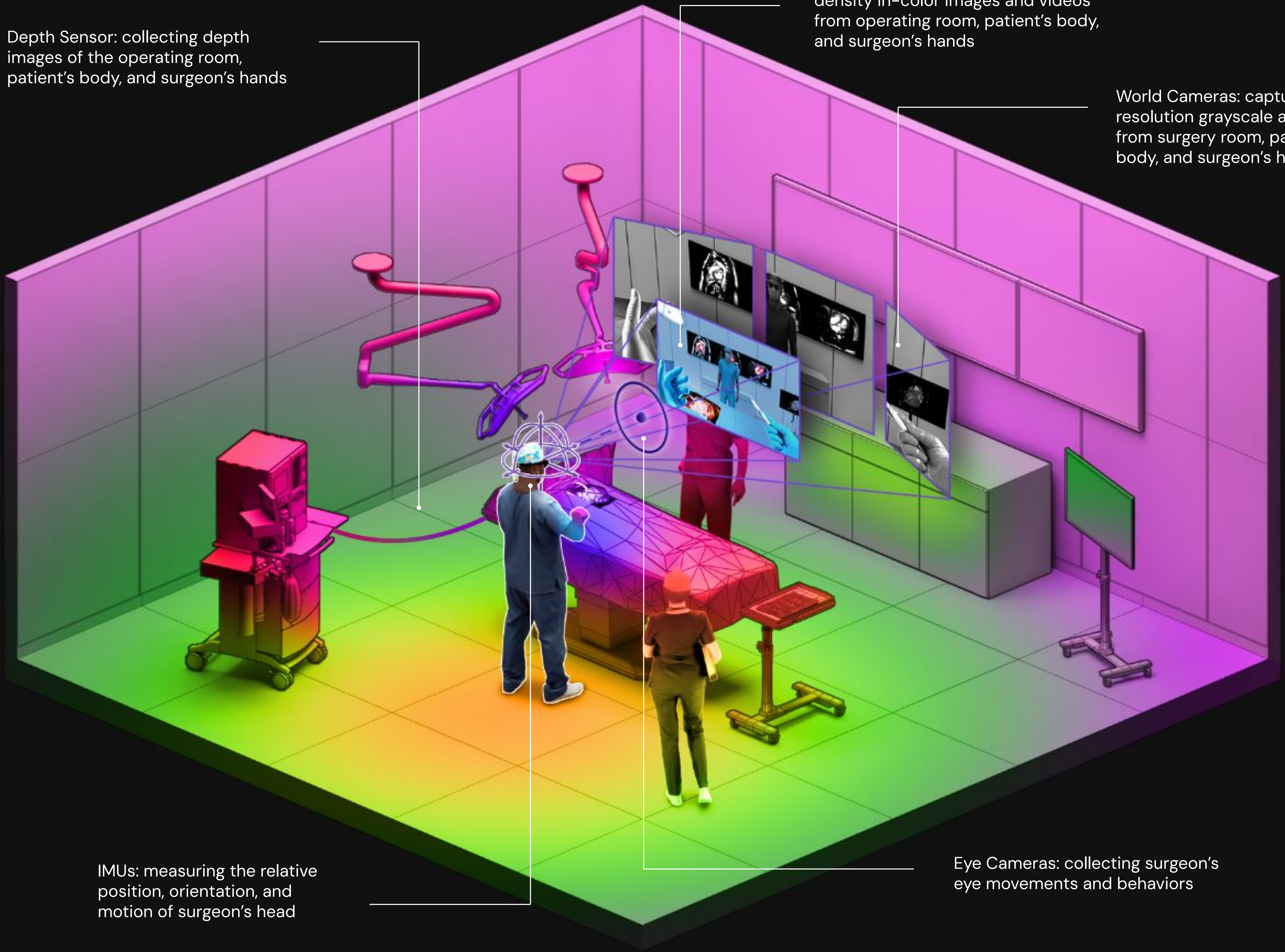
Sector: MedTech

Scenario: AR-assisted surgery*

Possible combination of sensor data





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Sector: Digital Therapeutics

Scenario: Clinical Assessments

Experience

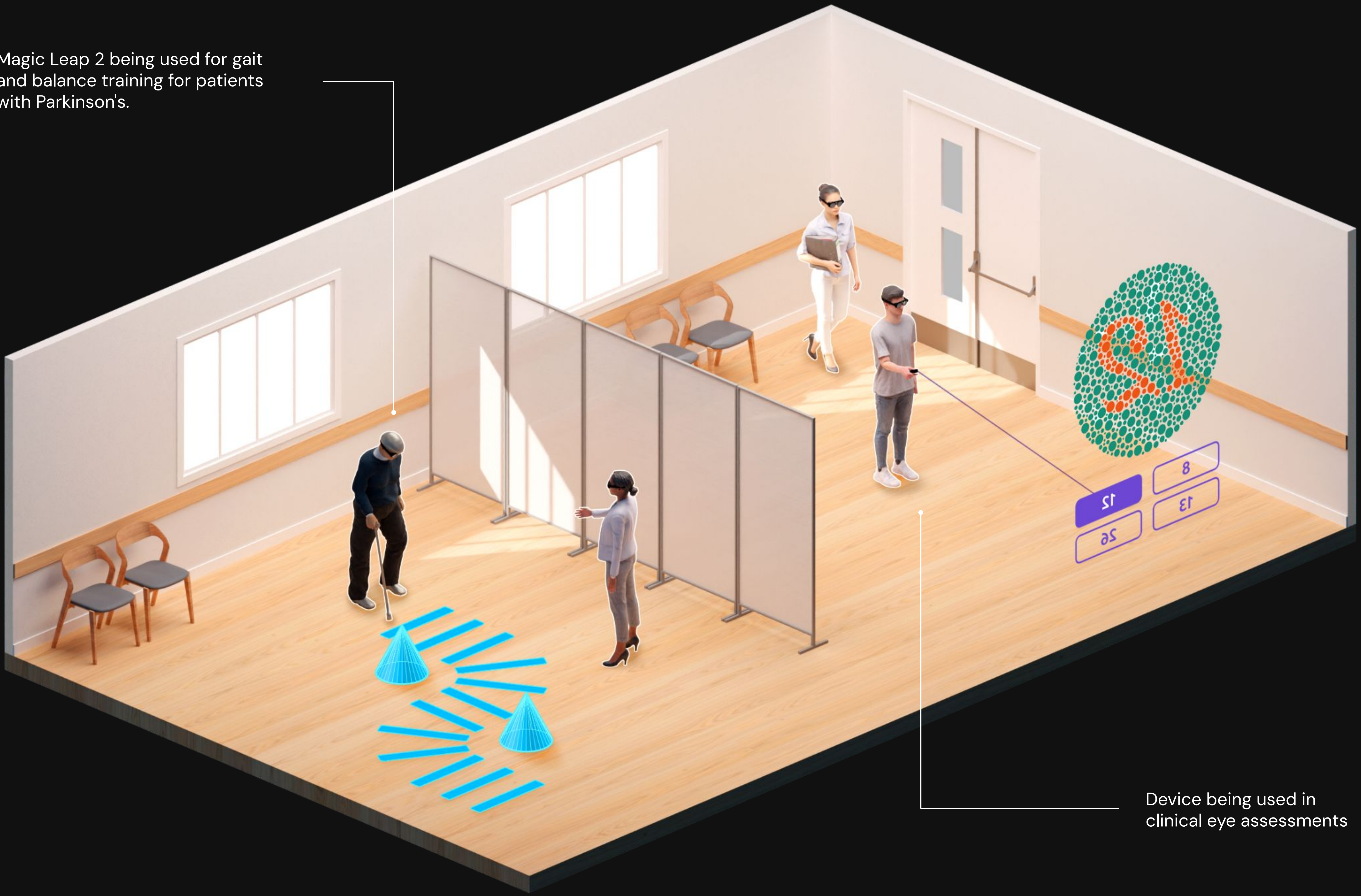
When being used for clinical assessments, developers can use Magic Leap 2 sensors to yield results that are beneficial in both daily operations and life changing for patients in need of creative solutions for complex diagnoses.

By accessing eye camera data, medical professionals are able to conduct tests and assess patients for concussions.

And, by accessing IMU data, developers can create solutions that track the movements of patients overcoming mobility challenges, such as patients with Parkinson’s disease.

"Healthcare professionals may use Magic Leap 2 as a cost-efficient portable alternative to some of the clinical equipments which are the current standard of care for movement tracking

Magic Leap 2 being used for gait and balance training for patients with Parkinson's.

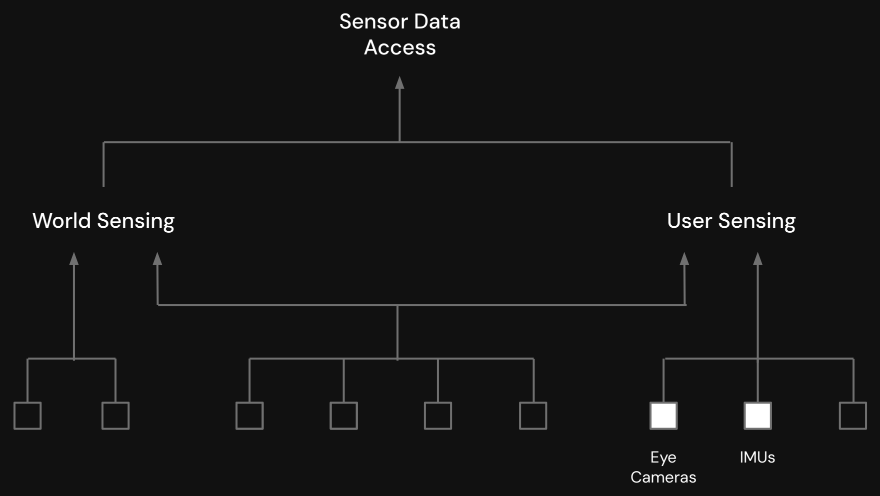


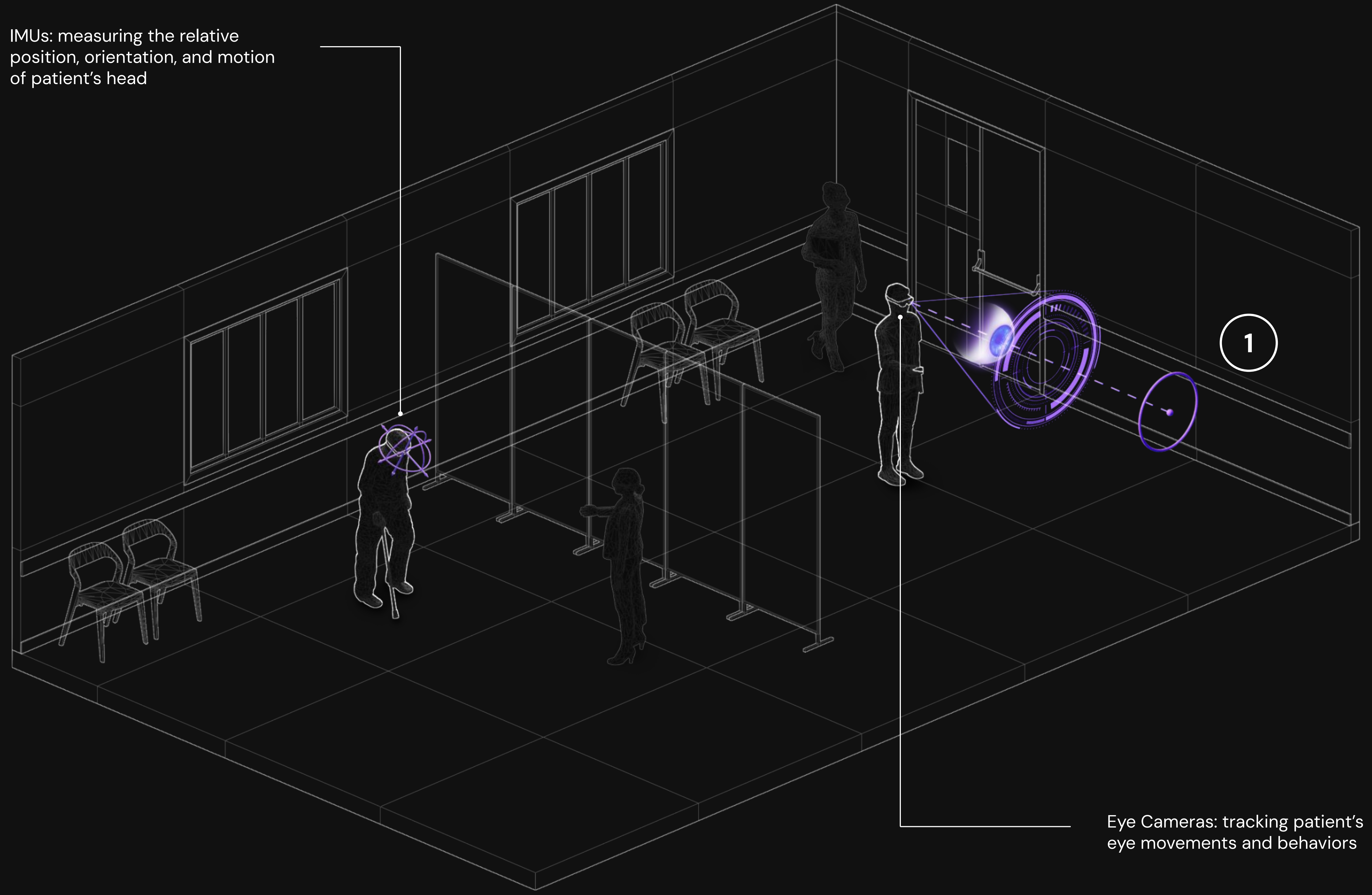
Device being used in clinical eye assessments

Sector: Digital Therapeutics

Scenario: Clinical Assessments

Possible combination of sensor data





Sector: AEC

Scenario: On-site visualization

Experience

Architecture, engineering, and construction of buildings and cities require various stakeholders to successfully communicate concepts, designs, and executions. Traditional tools such as drawings and 2D renderings are limited to the screen they are being shown on.

By accessing data collected from the world cameras, RGB camera, and depth sensor, developers can create applications that map and place designs, models, and plans accurately on-site. It can also enable the creation of the site's digital twin, where information can persist through time and be updated in real time.

Accessing data from the ALS (ambient light sensor) allows the content to be rendered realistically in the environment, and by leveraging data collected from magnetometers, applications can accurately guide users through the space.

Map and place designs, models, and plans realistically and accurately on-site

Sector: AEC

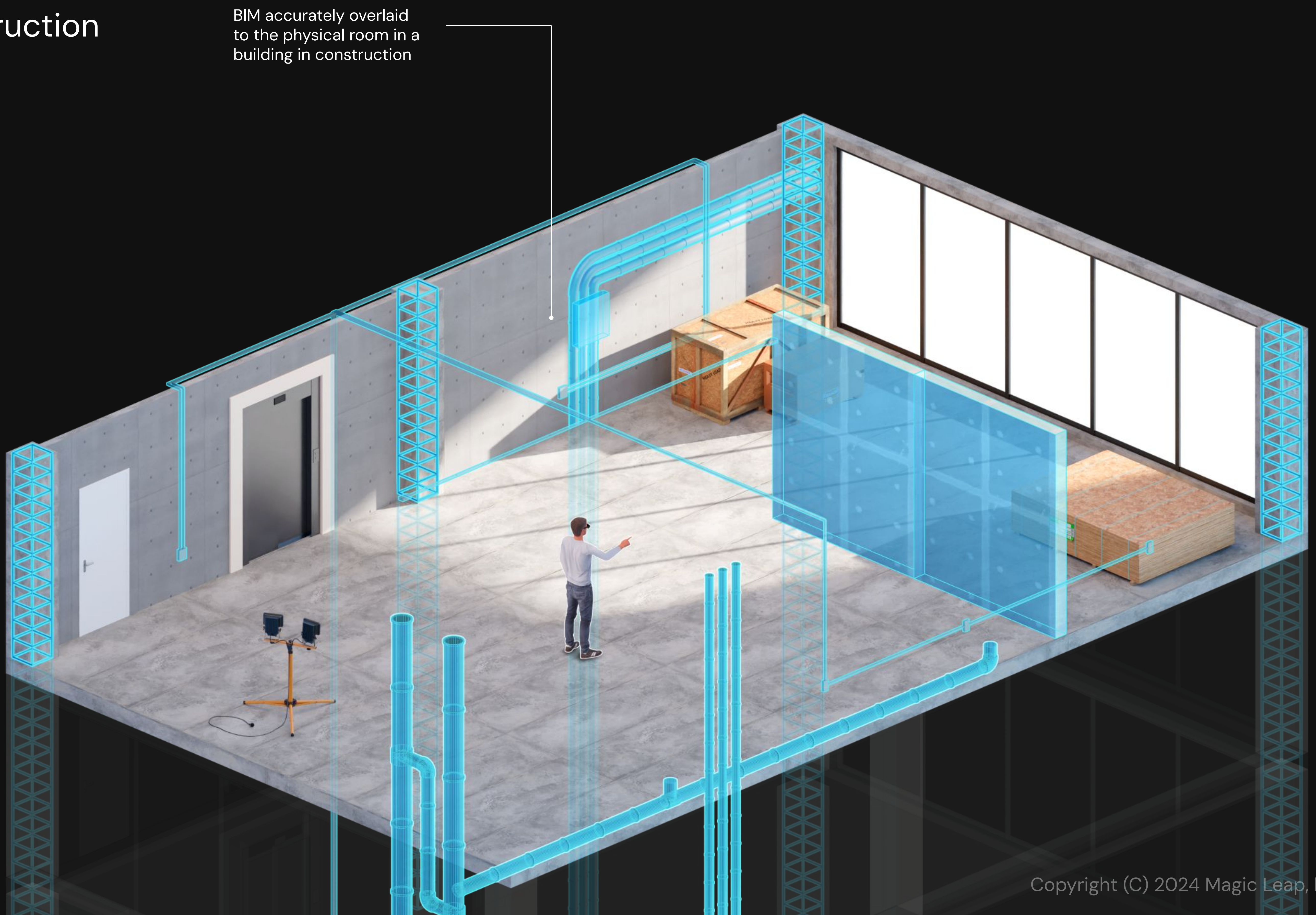
Scenario: BIM overlay into construction

Experience

Building Information Modeling (BIM) currently relies on many streams of data to be accumulated and presented in the form of analog drawings. By using Magic Leap 2, users can consolidate these data streams and display information directly and accurately into the real world, reducing errors and making the process more efficient.

By using data from the RGB camera, world cameras, and depth sensor, the device can overlay 3D content accurately to the walls and floor, showing the structural elements of the building.

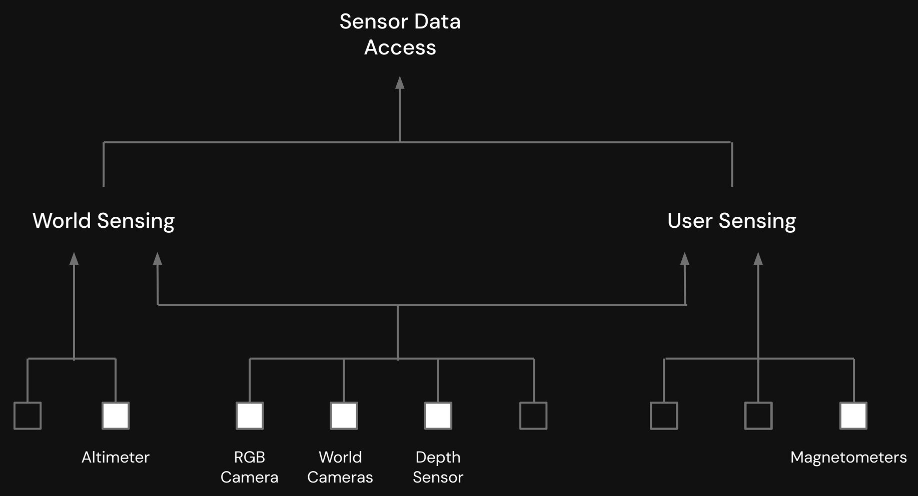
Accessing data from altimeters allows the device to know on which floor the user is located, so it can place the correct content, and leveraging data collected from magnetometers allows the device to accurately guide the user through the space.

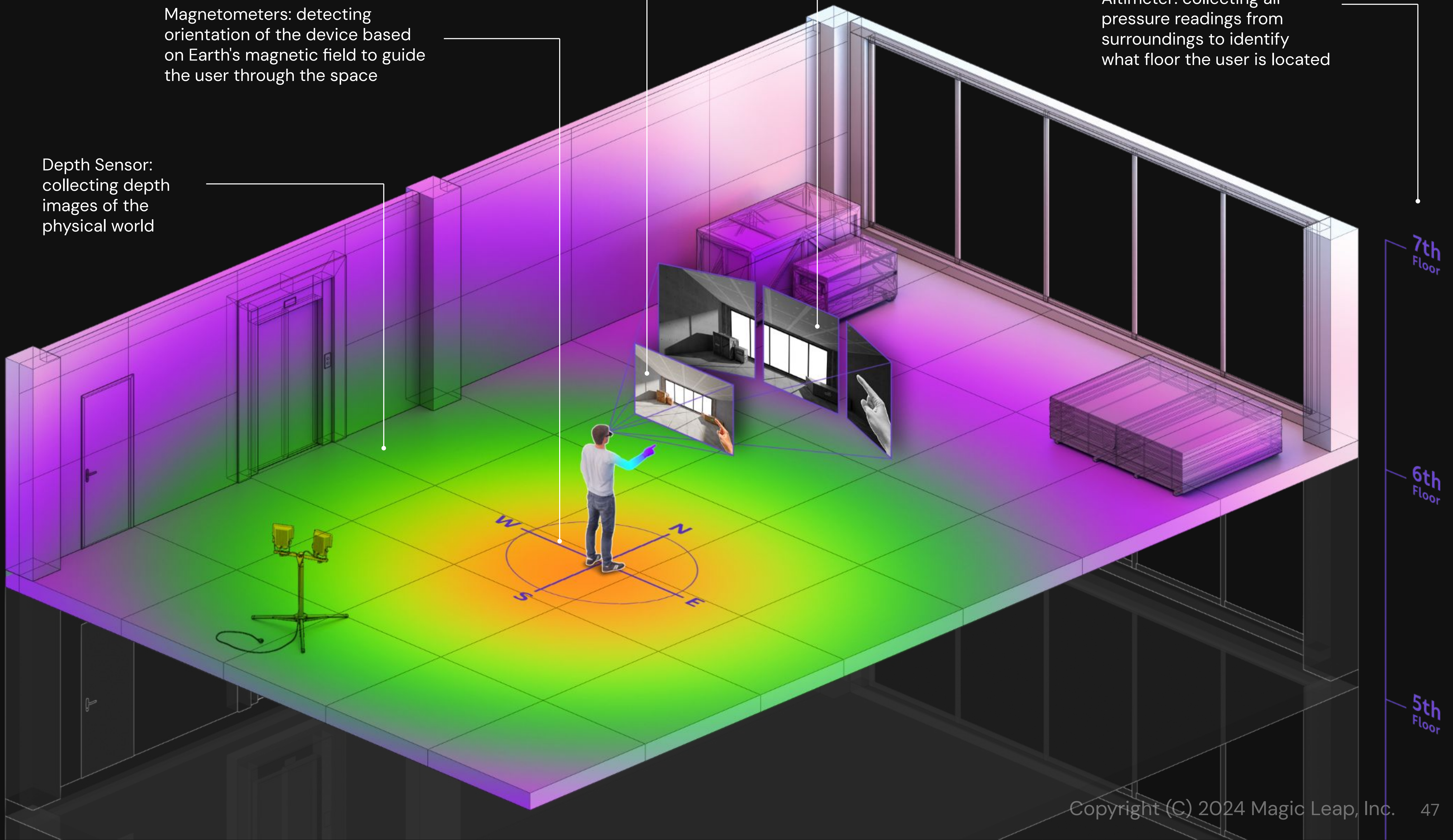


Sector: AEC

Scenario: BIM overlay into construction

Possible combination of sensor data





Sector: Public sector

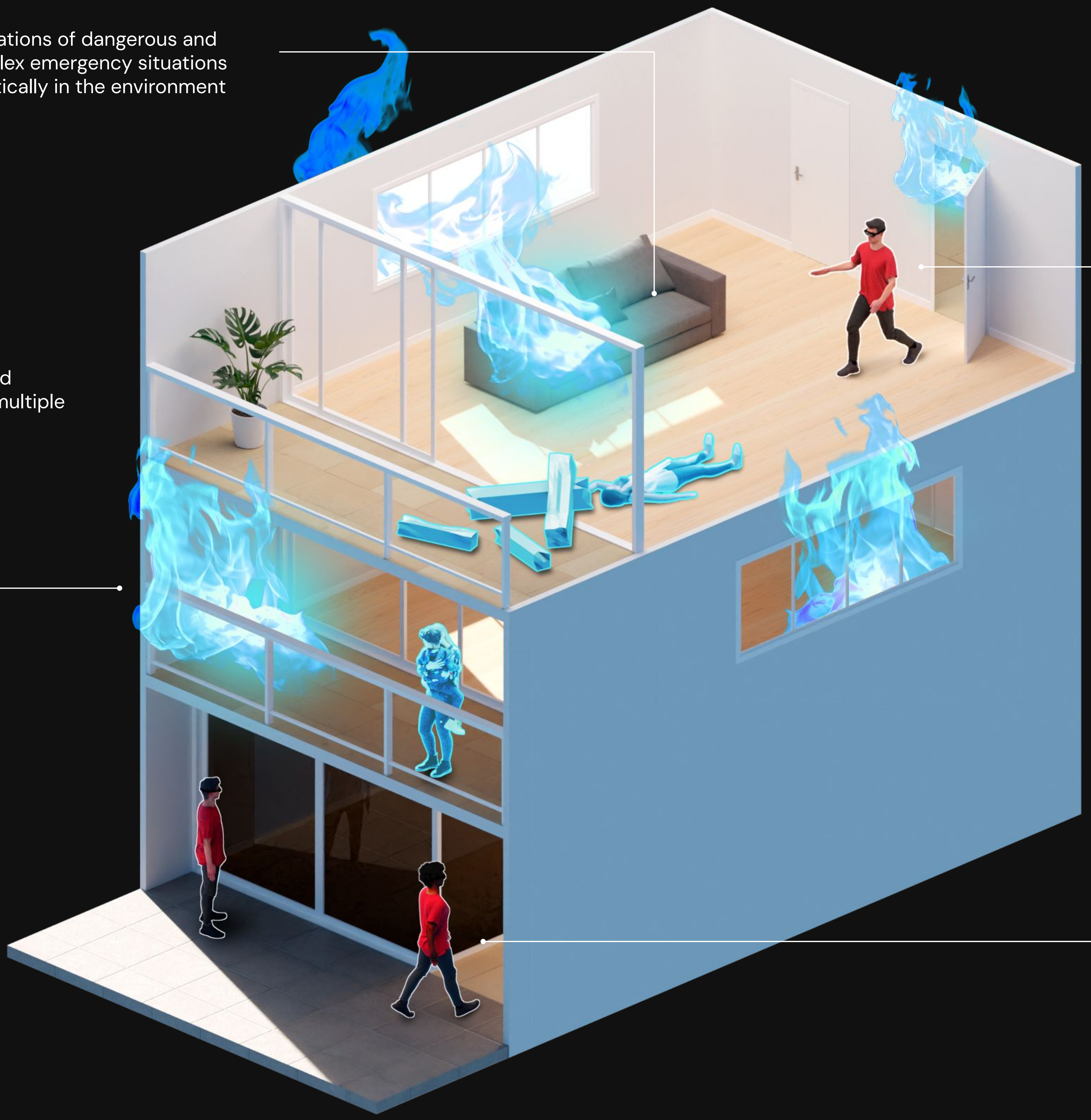
Scenario: First-responders training

Experience

When creating training scenarios for first responders in the public sector, often times these training simulations are costly, complicated, and somewhat unrealistic. Developers can leverage sensor data access in Magic Leap 2 to develop customized training experiences that are realistic and efficient for users and organizations, while preparing first responders for the dangers they might face in high-stakes scenarios.

By accessing data from the RGB camera, world cameras, and depth sensor, developers can map the environment and place content accurately in space, making the simulations connected to the physical environment and therefore more real. Data captured from these cameras and also eye cameras can be used for assessment and performance improvements.

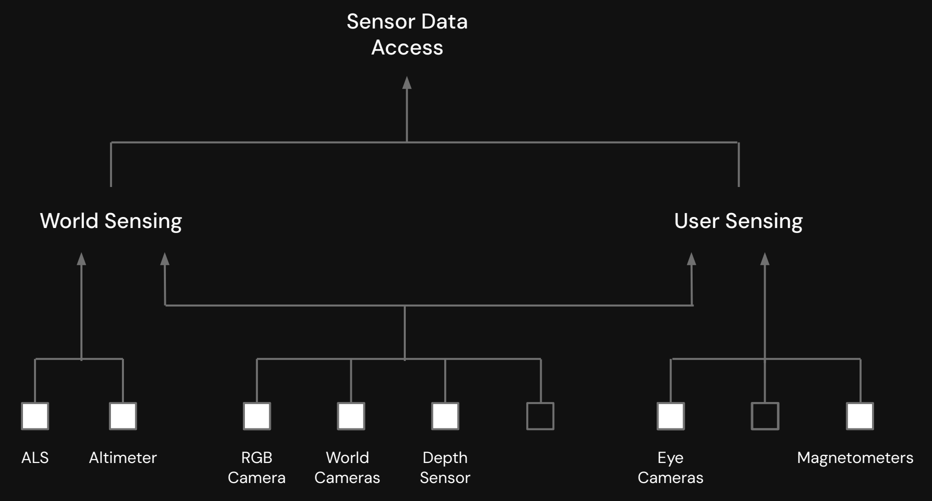
Ambient light sensors (ALS) can be used to simulate environments with changing conditions to create realistic training scenarios and train first responders with high-level realism. And magnetometers can be leveraged to inform the device of its location, and guide the user through a training scenario.

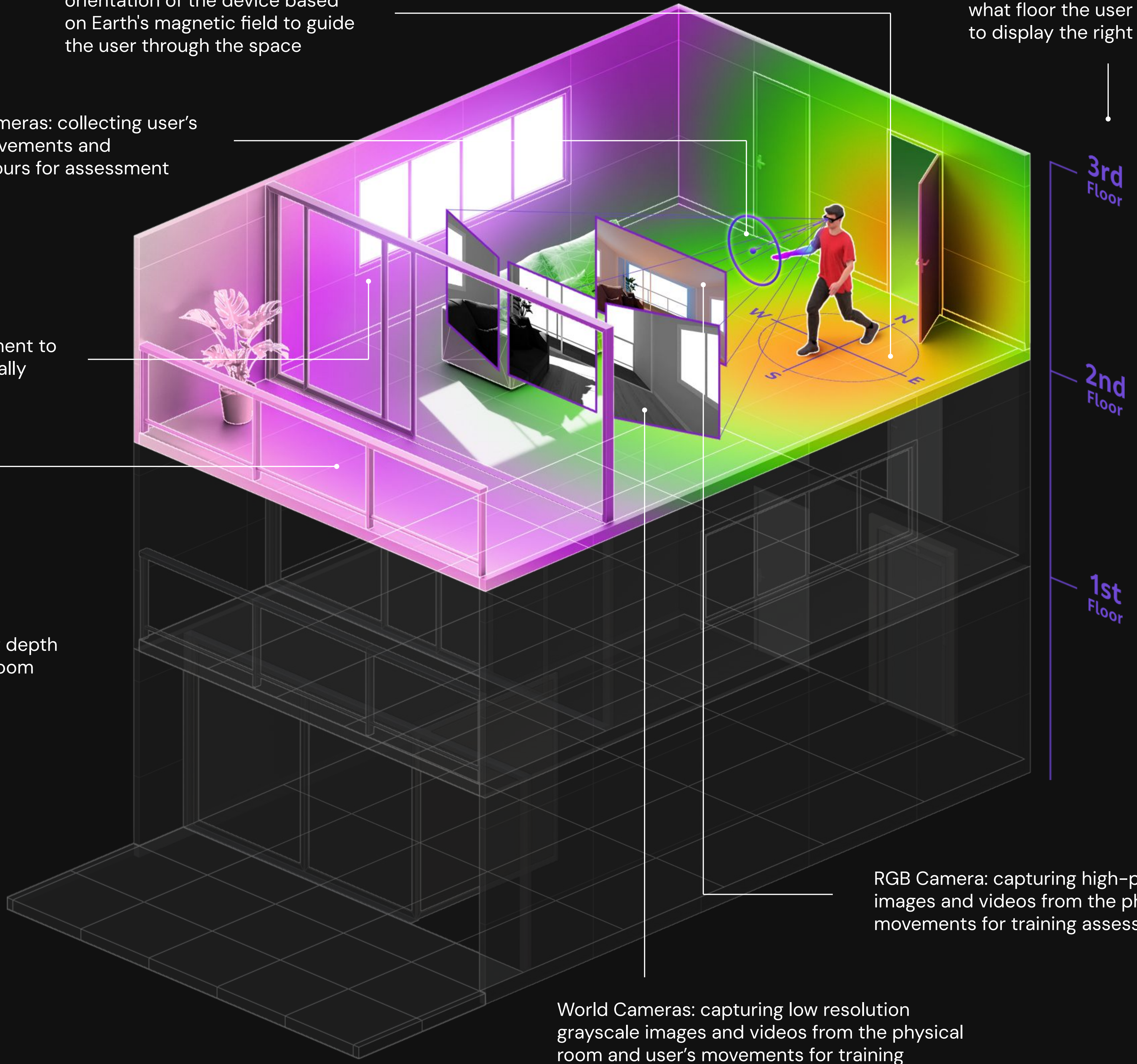


Sector: Public sector

Scenario: First-responders training

Possible combination of sensor data





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