Extended Reality in Industry 4.0 (ERI)

Lecture 11: Augmented Reality Tracking Methods

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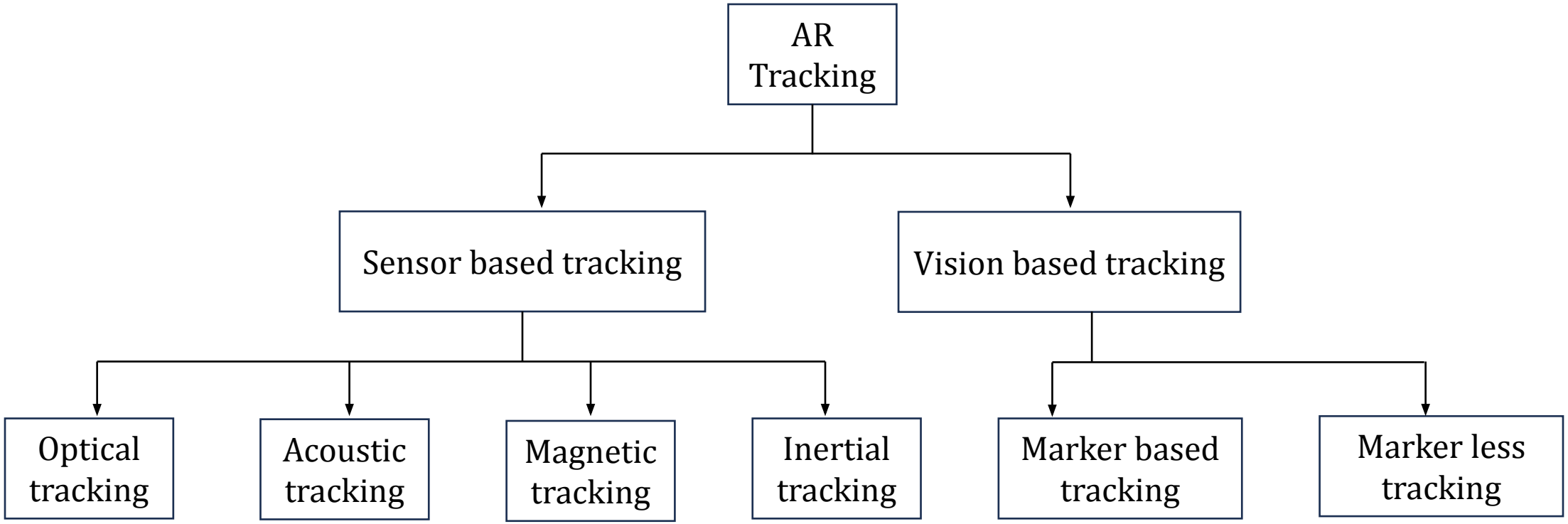
Tracking technologies

- Tracking technology is required to track the position and orientation of the object of interest which could either be a physical object or captured by a camera with reference to the coordinate plane (3D or 2D) of a tracking system.
- Once the points of reference are collected after tracking, then another important factor is to determine at which particular point the virtual objects have to be mixed with the real environment.


AR Tracking
Sensor based tracking
Vision based tracking
Optical tracking
Acoustic tracking
Magnetic tracking
Inertial tracking
Marker based tracking
Marker less tracking

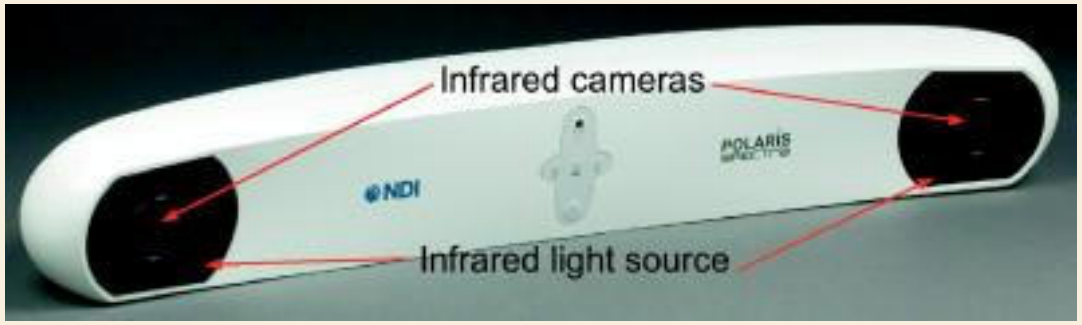
Sensor based tracking – Optical tracking

- Optical tracking is the dominant technology in medical field.
- Optical tracking identifies the pose of a tracked object by measuring light that is either **transmitted** or **reflected** by this object.
- When this light is **transmitted** from the object, typically through LEDs, we refer to this as ***active optical tracking***.

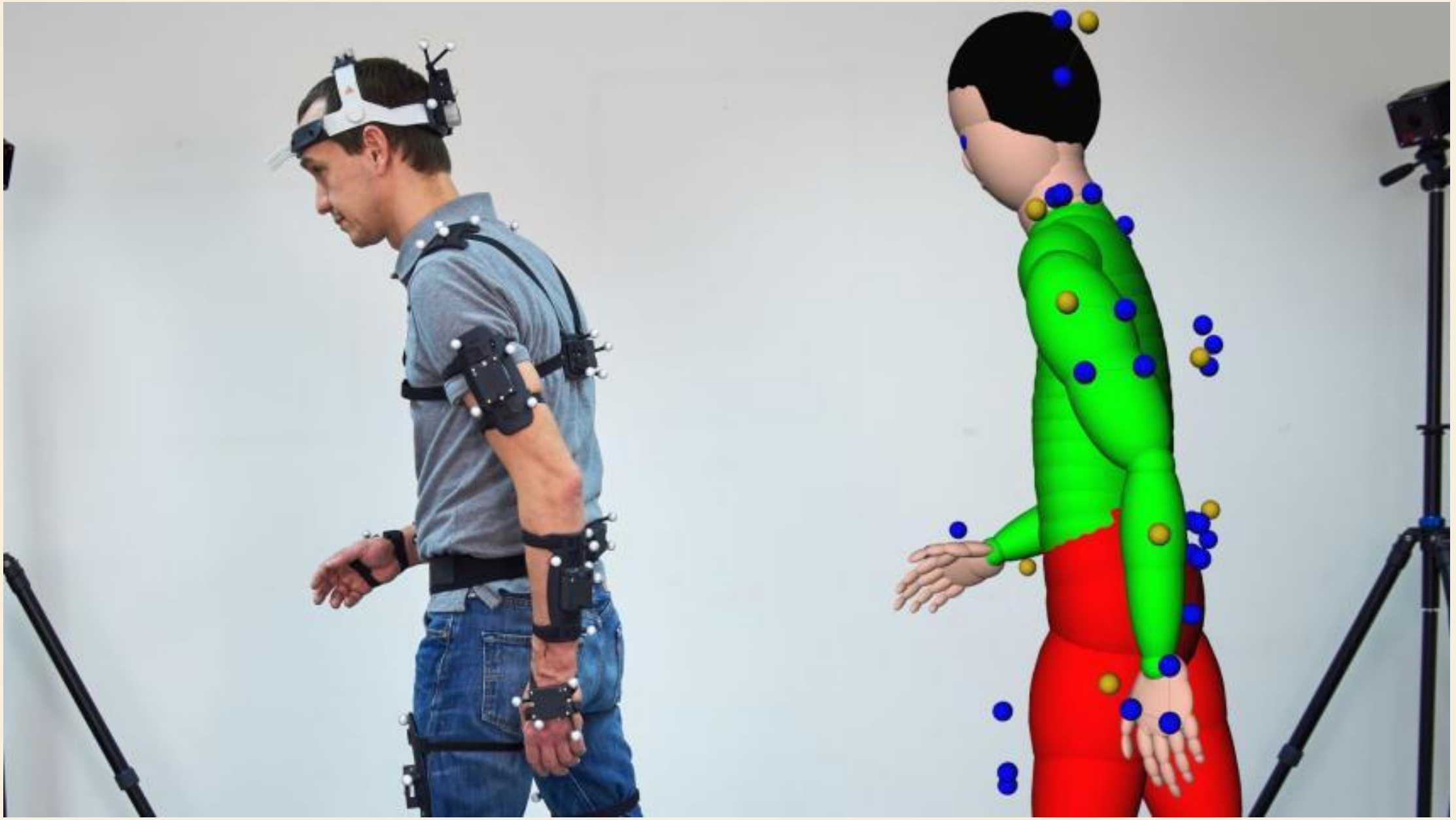
Sensor based tracking – Optical tracking

- In *passive optical tracking* light is **reflected**.
- Since active tracking requires cables running to the LEDs, it is used rarely only in the operating room. Hence, we will focus on passive tracking.
- Passive tracking is achieved through specific markers connected to the objects to be tracked. They are typically spherical and coated with an infrared light retroreflecting material. This light is transmitted from an infrared light source at the optical tracking system, reflected by the markers, and finally measured by two cameras that are positioned at a defined distance from each other.

Sensor based tracking – Optical tracking



Sensor based tracking – Optical tracking



Sensor based tracking – Acoustic tracking

- It is a technique used to determine the location and movement of objects in physical space by measuring sound waves.
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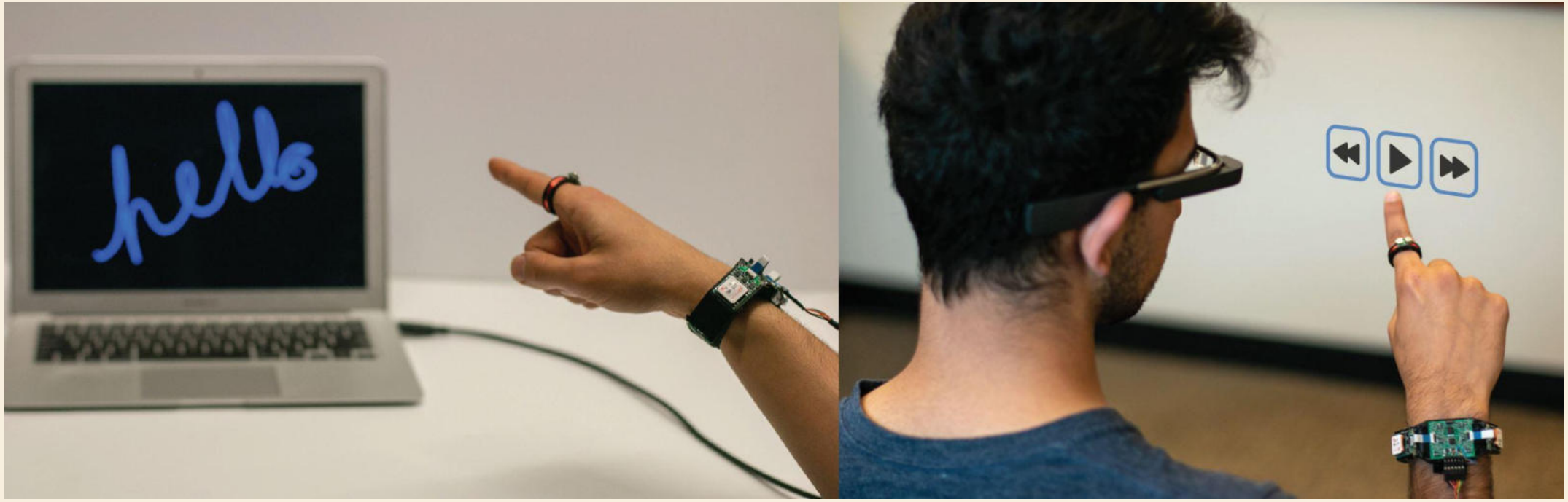
- One standard method of implementing acoustic tracking for AR involves ultrasonic sound waves.

Sensor based tracking – Acoustic tracking

- Ultrasonic emitters are placed in the physical environment, and the device worn by the user used for AR (such as a smartphone or HoloLens) receives the signals and uses them to determine the emitter's location.
- The system determines the user's location and direction based on how long the sound takes to reach the sensor. The device can then use this information to display virtual objects in the correct position relative to the real world.

Sensor based tracking – Magnetic tracking

- A magnetic tracking system can track head or body pose. A handheld user input device can include a magnetic emitter that generates a magnetic field, and the head-mounted AR device can include a magnetic sensor that senses the magnetic field. Magnetic information from the sensor can be analyzed to determine the location and/or orientation of the sensor and thereby the wearer's pose.



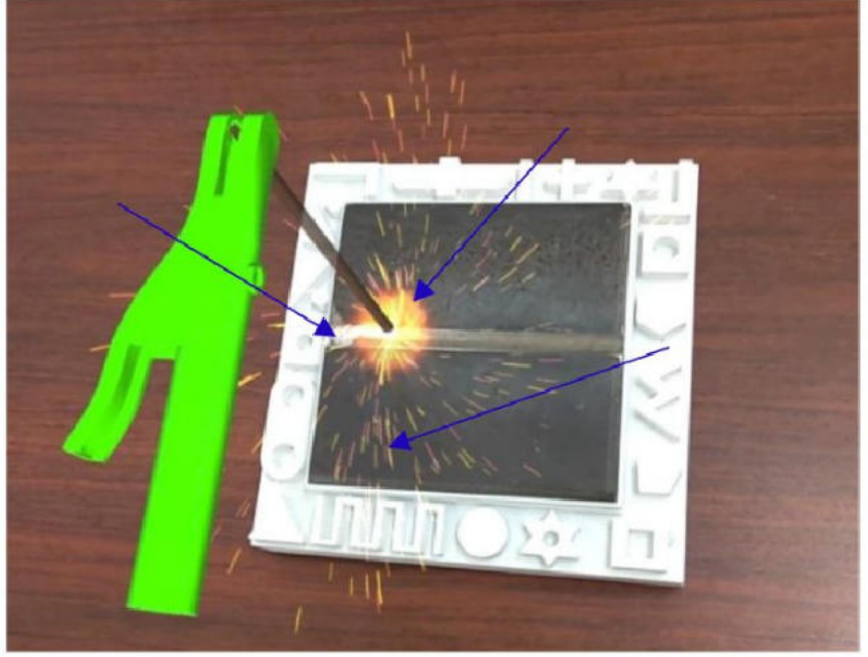
Sensor based tracking – Inertial tracking

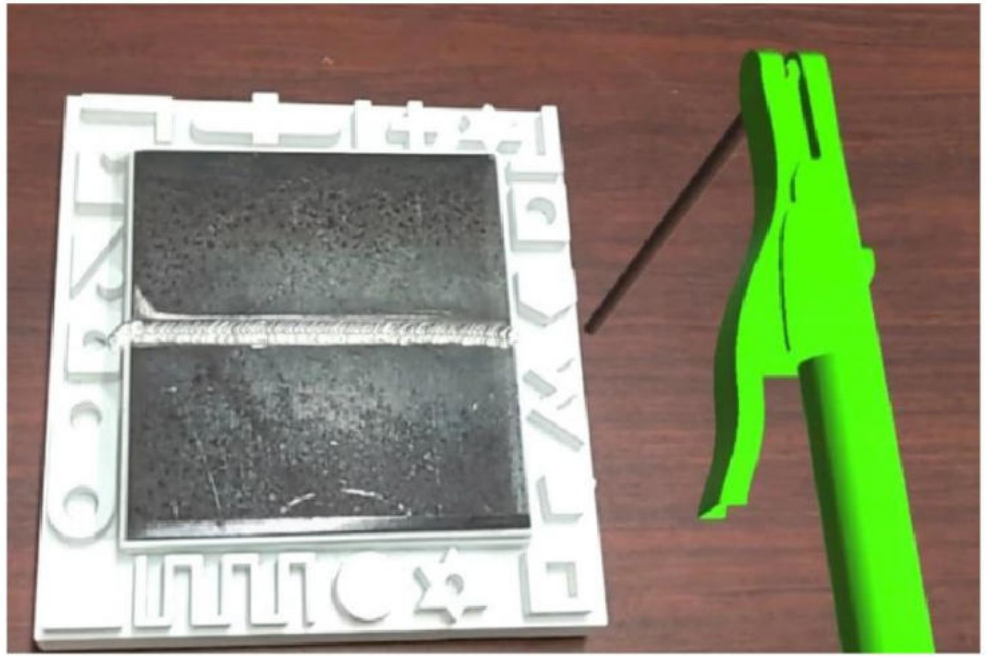
- Inertial tracking refers to tracking an object or device's movement and orientation using sensors that measure changes in velocity, acceleration, and angular velocity.
- This method is commonly used in robotics, virtual reality, and other applications requiring accurate movement tracking in three-dimensional space.
- Inertial tracking systems typically include a combination of accelerometers, gyroscopes, and magnetometers that provide a complete picture of an object's motion and orientation. Example: IMU sensors

Vision based tracking

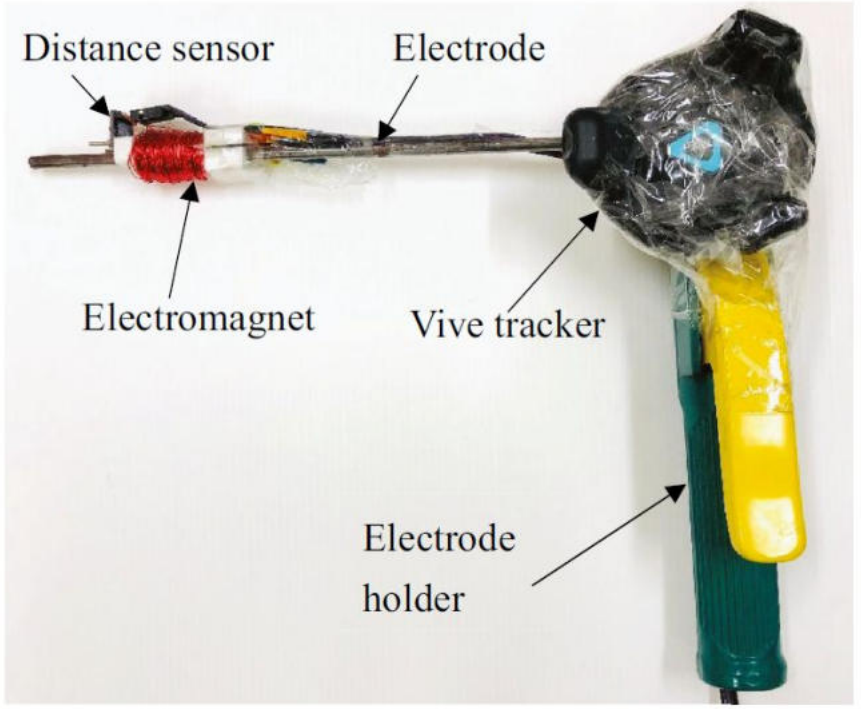
- Marker-based tracking
- Markerless tracking

Model Target

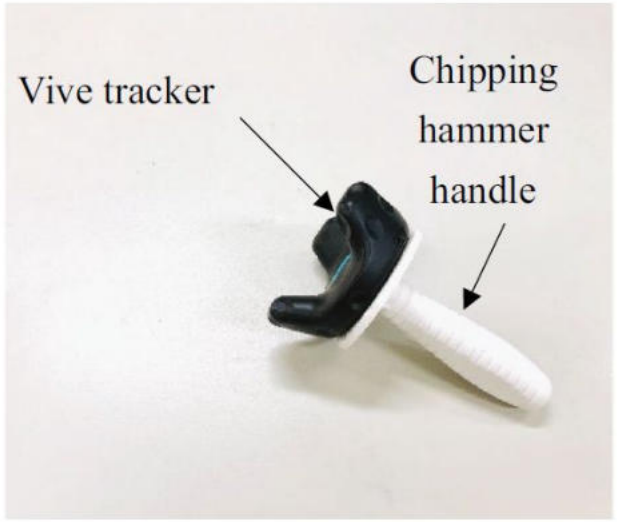




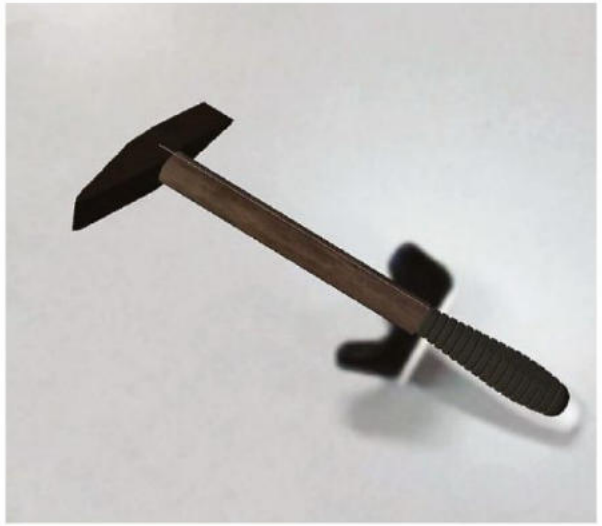
Vive tracker (SRWorks SDK)



(a) A Vive tracker mounted on the electrode holder.

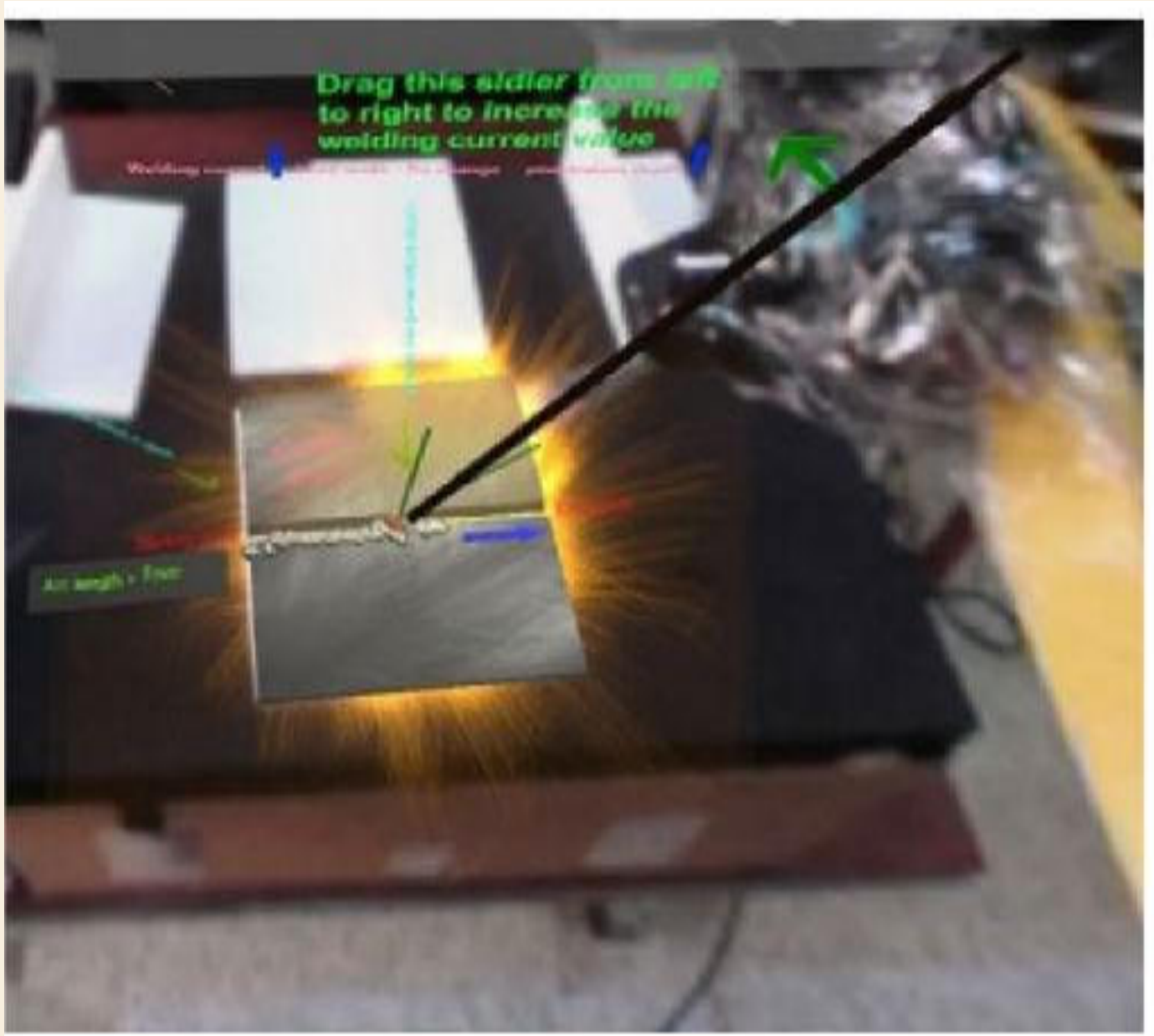


(b) A Vive tracker mounted on the chipping hammer handle.

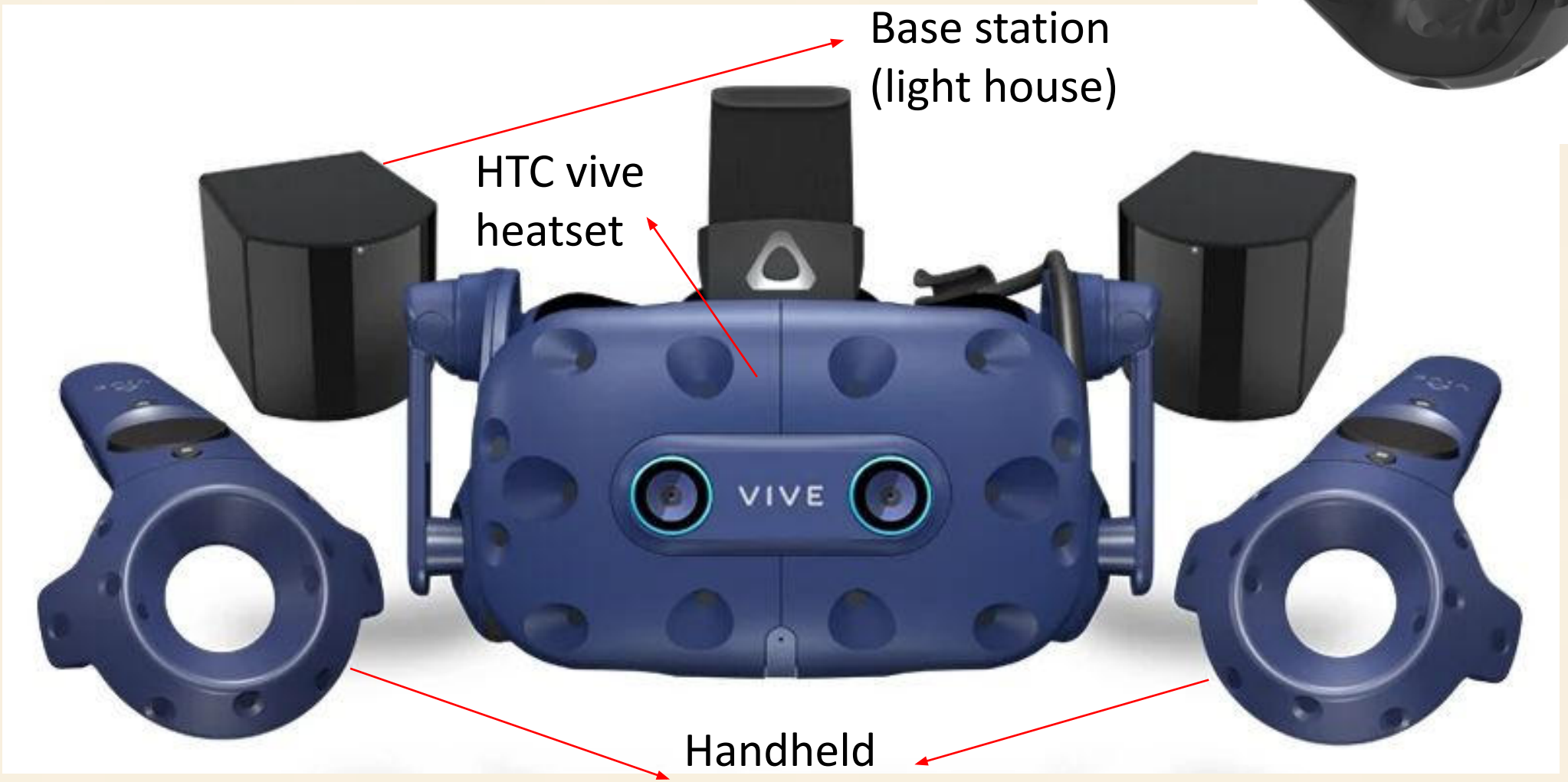


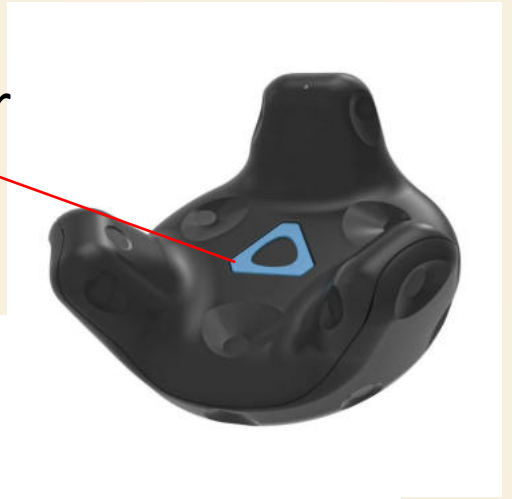
(c) Virtual chipping hammer.

AR tracking using Vive tracker

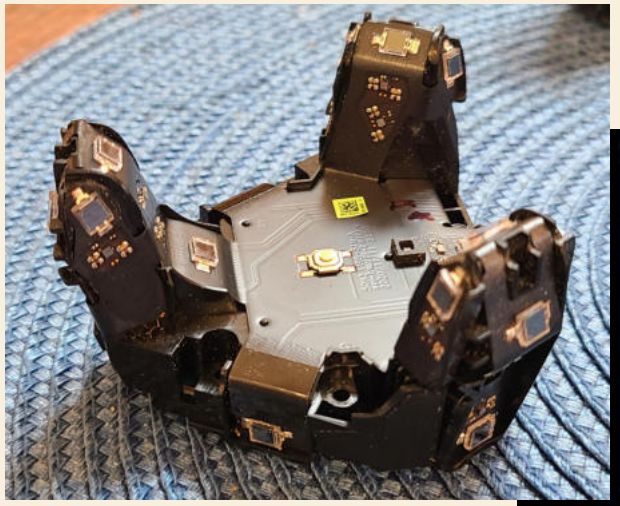


HTC Vive Pro

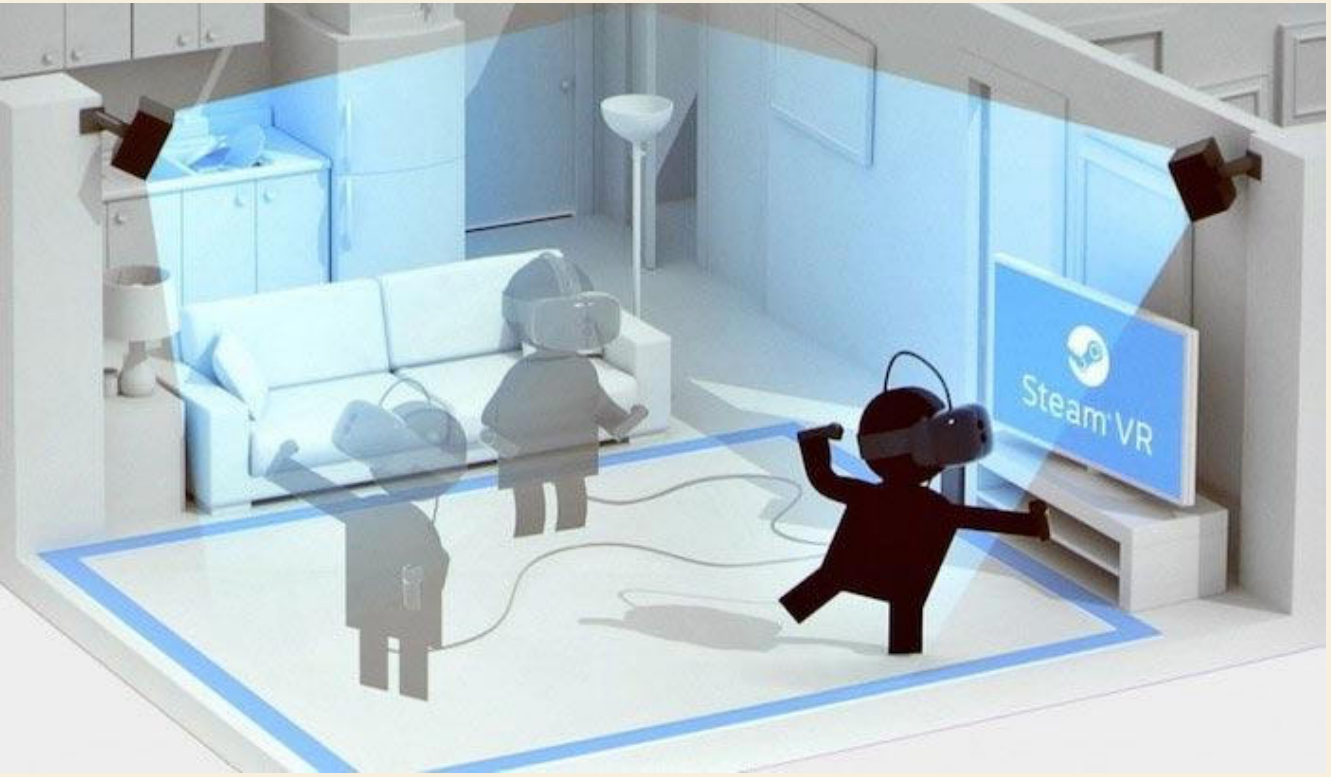

Base station
(light house)
HTC vive
heatset
VIVE
Handheld
controllers

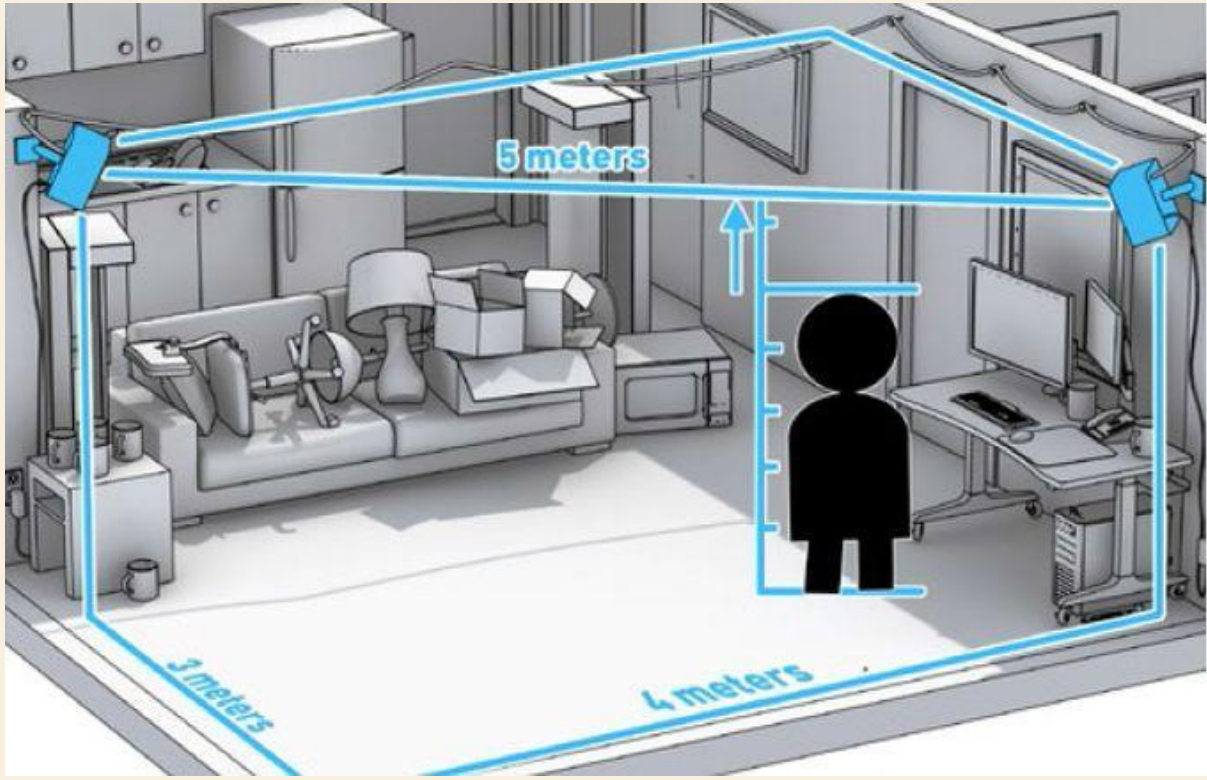

Vive tracker

Disassembly of HTC Vive Pro



HTC Vive Pro play area



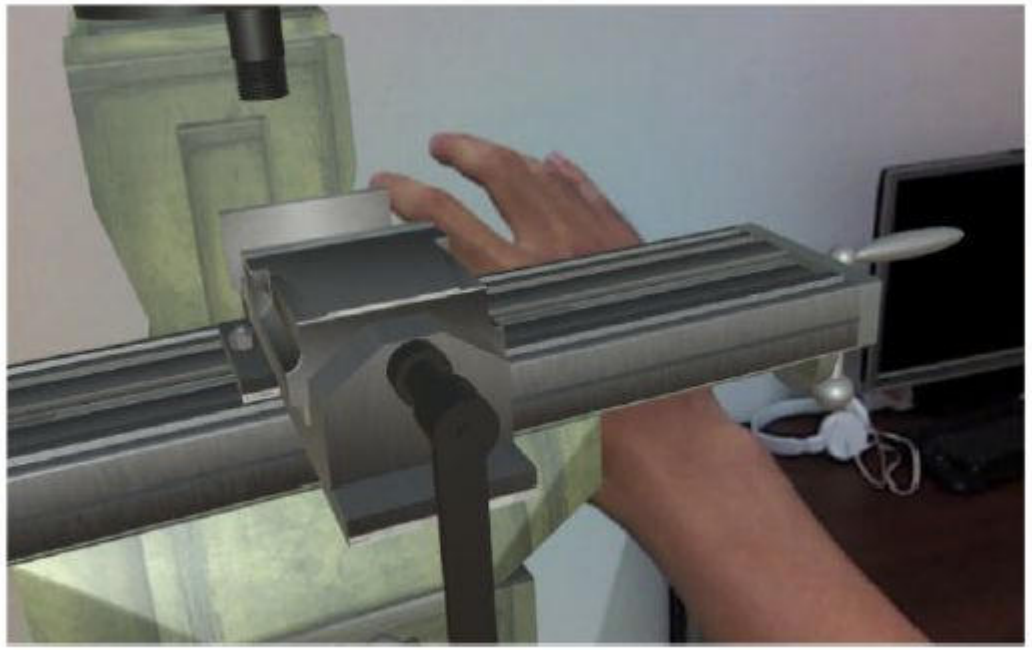


Minimum play area = 2 × 1.5 m
Maximum play area = 7 × 7 m

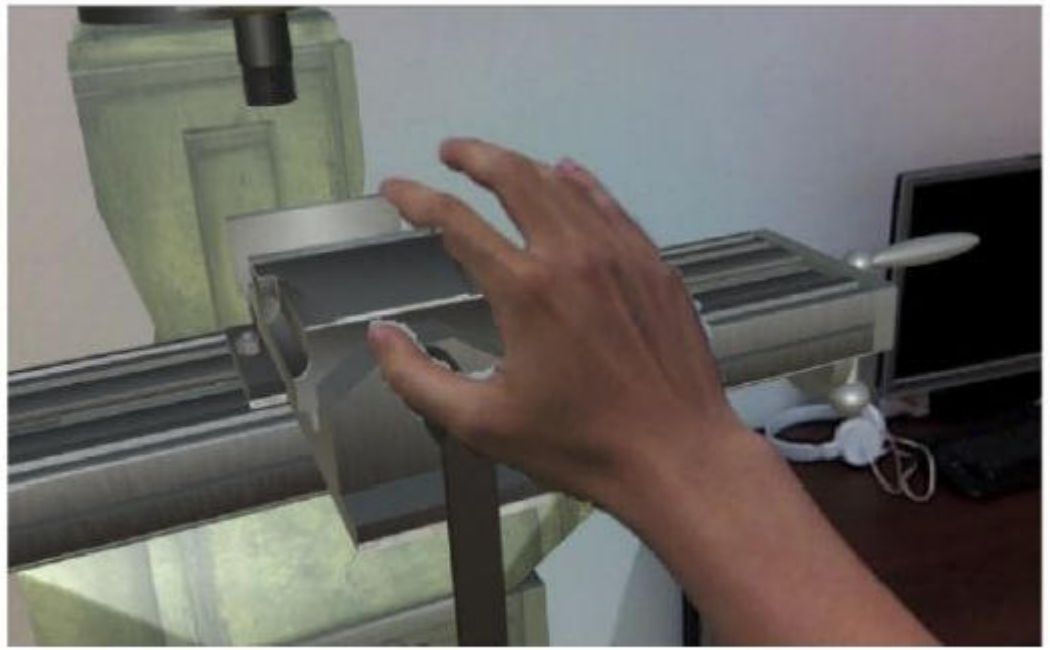
Challenges in AR tracking

Occlusion

- Occlusion is a significant issue that determines the **degree of presence** and the **realism** of an AR environment.
- Without occlusion handling, virtual objects are always rendered on the top layer of the color image captured by an RGB color camera.
- Therefore, it is difficult for users to correctly identify the relative positions of the virtual objects



(a) Without occlusion handling



(b) With occlusion handling

Accuracy


User should wear the welding helmet using left hand to protect the eyes from harmful UV rays.

Latency

- Latency is the delay between the user's action and the response of the AR application
- End-to-end latency should not exceed 20ms for the wearer to have a comfortable experience