# Augmented and Virtual Reality

*basic concepts*


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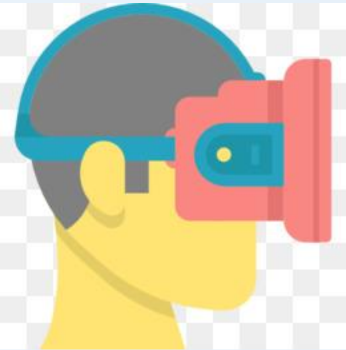
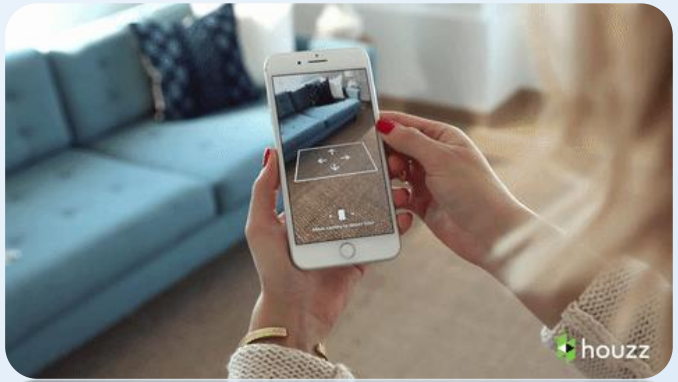


# Agenda




- Technology hype curve
- AVR evolution
- Industry 4.0 push with AR
  - Industrial maintenance, Construction sites, Aviation industry
- Fundamental concepts –
  - Transformation, zooming, panning,
  - clipping, rotation and Rendering

# References


Websites :

- developers.google.com/ar,
- dev.to/arunkumarvallal, mobidev.biz, gerardfriel.com/ar/the-history-of-ar
- Harvard Business Review – “*Managers-Guide-to-AR*”
- “Virtual Reality/Augmented Reality White Paper” CAICT, Huawei Technologies Co.

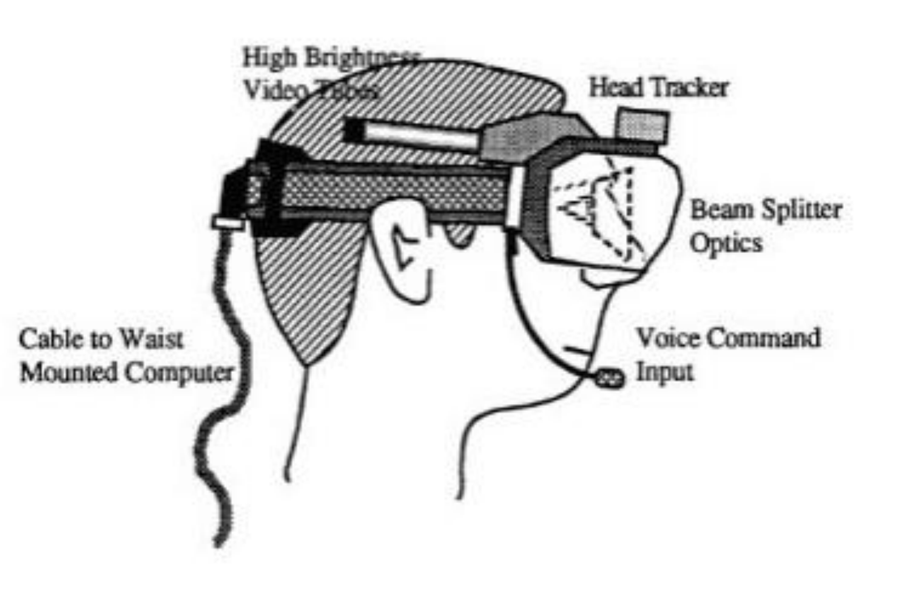
Books

- “Theory and applications of marker-based augmented reality” – Sanni Siltanen
- “Computer graphics”- Hearn and Baker

# The origins

- In 1968, Ivan Sutherland created a working prototype of what is widely considered to be the first VR system and the first AR system.
- Although it used simple wire-frame graphics, the project was the genesis of AR. Sutherland wrote about his work in a Harvard University paper entitled “A Head-Mounted Three-Dimensional Display”
- Sutherland’s system required that the user wear a cumbersome HMD that was so heavy it had to be suspended from the ceiling. Based on this, the device was nicknamed the Sword of Damocles.

# Terminology



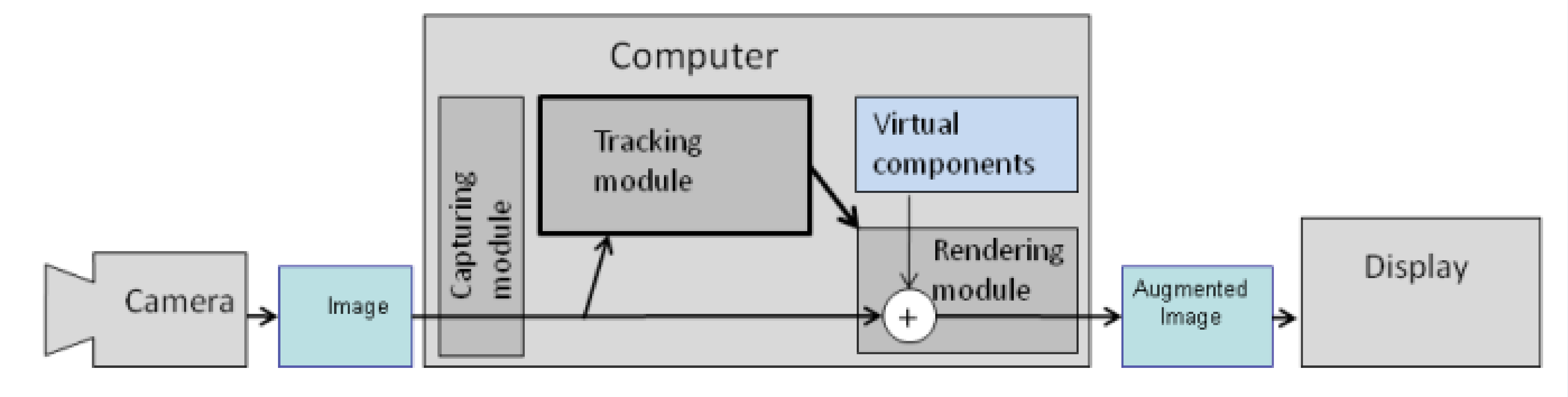

- Tom Caudell, a researcher at aircraft manufacturer Boeing coined the term augmented reality in 1992.
- He applied the term to a head-mounted digital display that guided workers in assembling large bundles of electrical wires for aircrafts .
- This early definition of augmented reality was a system where virtual elements were blended into the real world to enhance the user's perception.

# Simple Augmented Reality

- A simple augmented reality system consists of a camera, a computational unit and a display.
- The camera captures an image, and then the system augments virtual objects on top of the image and displays the result.

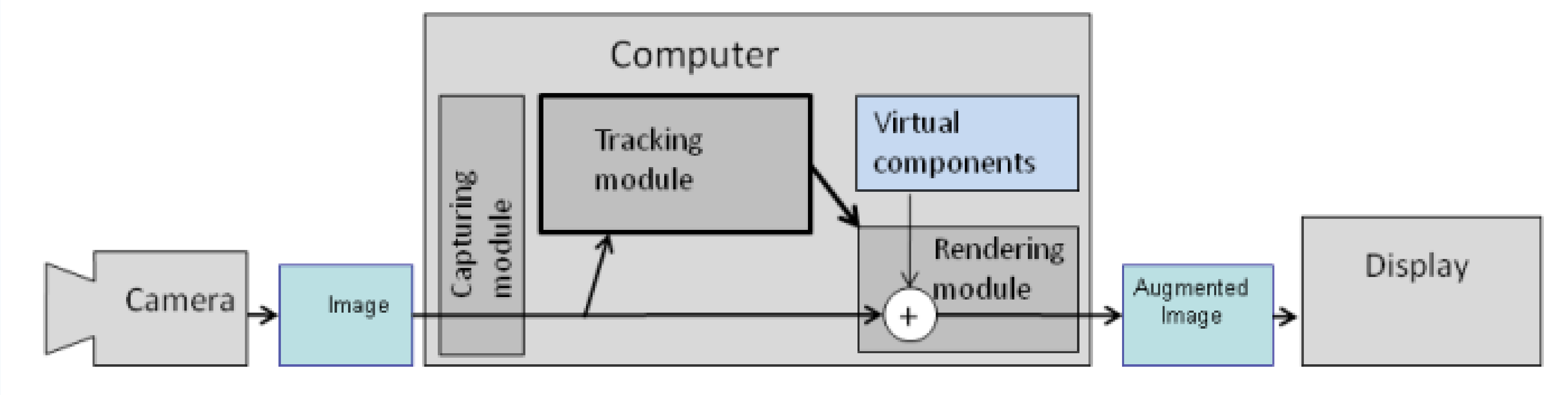
- Simple marker-based augmented reality system. The system captures an image of the environment, detects the marker and deduces the location and orientation of the camera, and then augments a virtual object on top of the image and displays it on the screen.

# Flowchart for a simple augmented reality system




- The capturing module captures the image from the camera. The tracking module calculates the correct location and orientation for virtual overlay.
- The rendering module combines the original image and the virtual components using the calculated pose and then renders the augmented image on the display.

# Flowchart for a simple augmented reality system



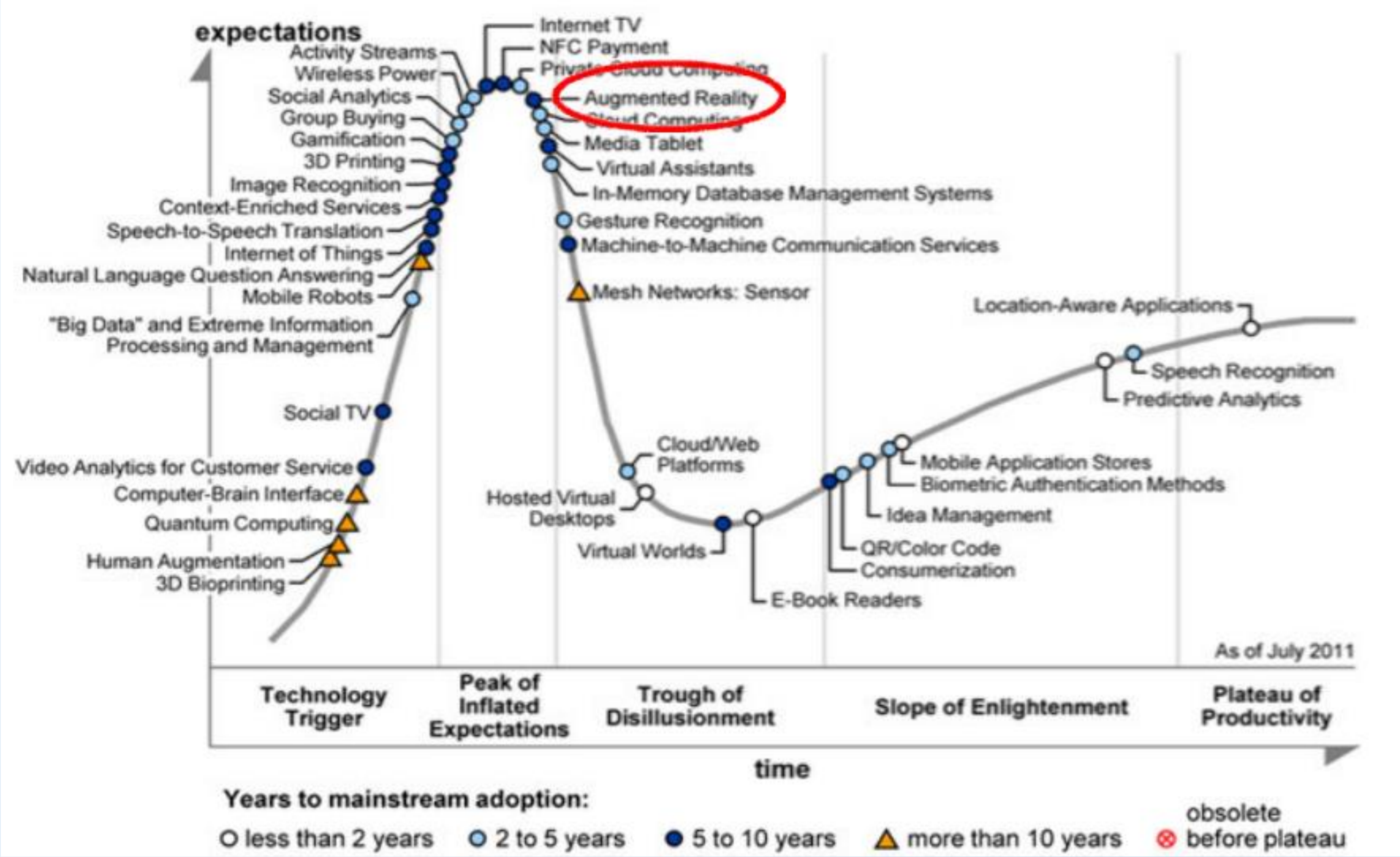

- The tracking module is “the heart” of the augmented reality system; it calculates the relative pose of the camera in real time.
- The term pose means the six degrees of freedom (DOF) position, i.e. the 3D location and 3D orientation of an object.
- The tracking module enables the system to add virtual components as part of the real scene.

# Flowchart for a simple augmented reality system

- The fundamental difference compared to other image processing tools is that in augmented reality virtual objects are moved and rotated in 3D coordinates instead of 2D image coordinates.
- Camera calibration can be part of the AR system or it can be a separate process
- Third party - Matlab and OpenCV have a calibration toolkit.

# Gartner hype cycle for emerging technologies in 2011

In October 2011, a Google search produced almost 90,000 hits for "augmented reality blog".



# AR evolution

- As a technology, augmented reality is now on the top of the "technology hype curve" .

The last decade has seen tremendous push for AR ecosystem, due to fact that :

- The processing capacity of the computational units has increased tremendously, along with transmission bandwidth and memory capacity and speed.
- This development of technology has enabled the transition of augmented reality onto portable, everyday and cheap off-the-shelf devices such as mobile phones.
- For example, in 2010 Kinder launched chocolate eggs with toys linked to AR content if presented to a webcam.

# AR evolution

- Furthermore, cloud computing and cloud services enable the use of huge databases even on mobile devices.
- This development enables a new type of location-based services exploiting large city models, for example.
- Cameras on smartphones and laptops has made AR more realistic and portable

# Industry 4.0 push with AR

- Augmented reality benefits industrial applications where there is a need to enhance the user’s visual perception.


# Industry 4.0 push with AR

- Augmented 3D information helps workers on assembly lines, or during maintenance work and repair, to carry out required tasks.
- This technology also enables visualization of new building projects on real construction sites, which gives the viewer a better understanding of relations with the existing environment

# Construction Sites

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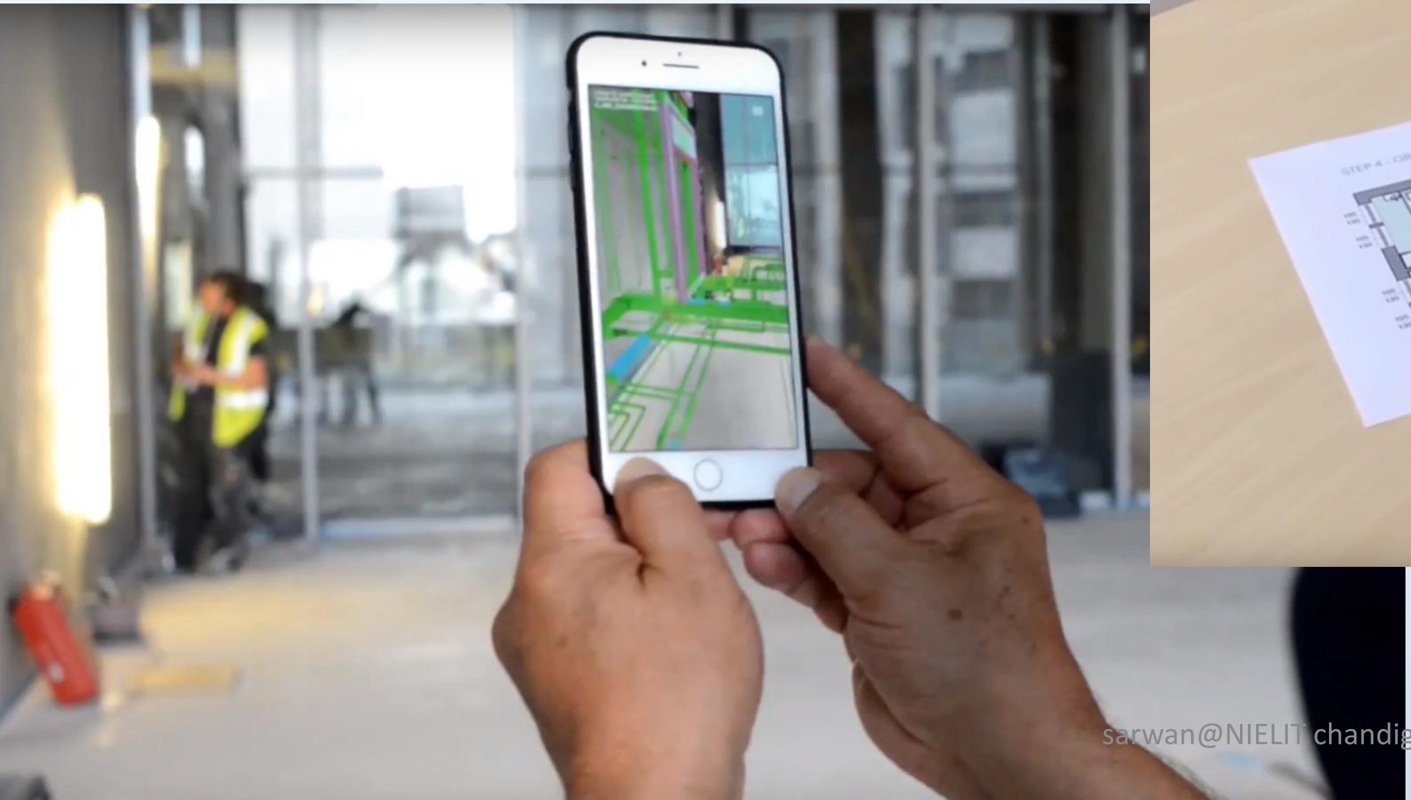
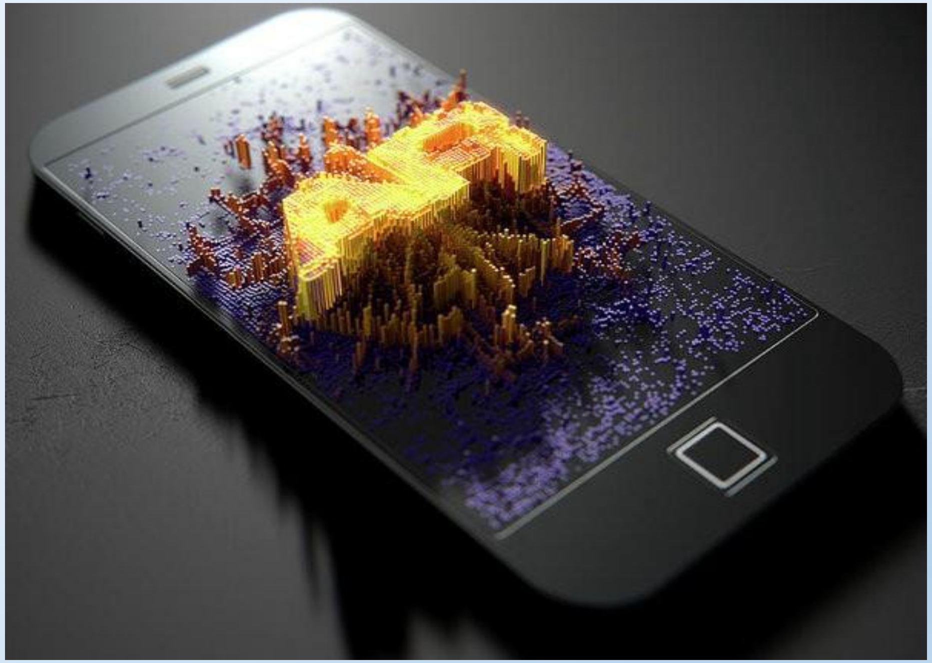


# Construction Sites

# Aviation industry

# Augmented Reality

## How it works

# Augmented reality (AR)

- **Augmented reality (AR)** is an experience where designers enhance parts of users’ physical world with computer-generated input.
- In AR, part of the surrounding environment is actually ‘real’ and just adding layers of virtual objects to the real environment.
- A medium in which digital information is overlaid on the physical world that is in both spatial and temporal registration with the physical world and that is interactive in real-time

# AR Fundamentals Concepts

Three key capabilities to integrate virtual content with the real world as seen through phone's camera:

- **Motion tracking** allows the phone to understand and track its position relative to the world.
- **Environmental understanding** allows the phone to detect the size and location of all type of surfaces: horizontal, vertical and angled surfaces like the ground, a coffee table or walls.
- **Light estimation** allows the phone to estimate the environment's current lighting conditions.

# Other Key Concepts

- Occlusion
- Placing
- Scaling
- Solid Augmented Reality assets

# Tracking

- AR relies on computer vision to see the real world and recognise the objects in it. The process of scanning, recognizing, segmentation and analyzing environmental information is called *tracking*.
- Inside out
- Outside In
- Motion Tracking

# Environment understanding

- The ability to detect and generate a flat surface is known as Plane finding. Information about the physical world around AR devices. A major part in Environmental understanding, how it is detecting the planes or horizontal surfaces in an area.

**Anchors**

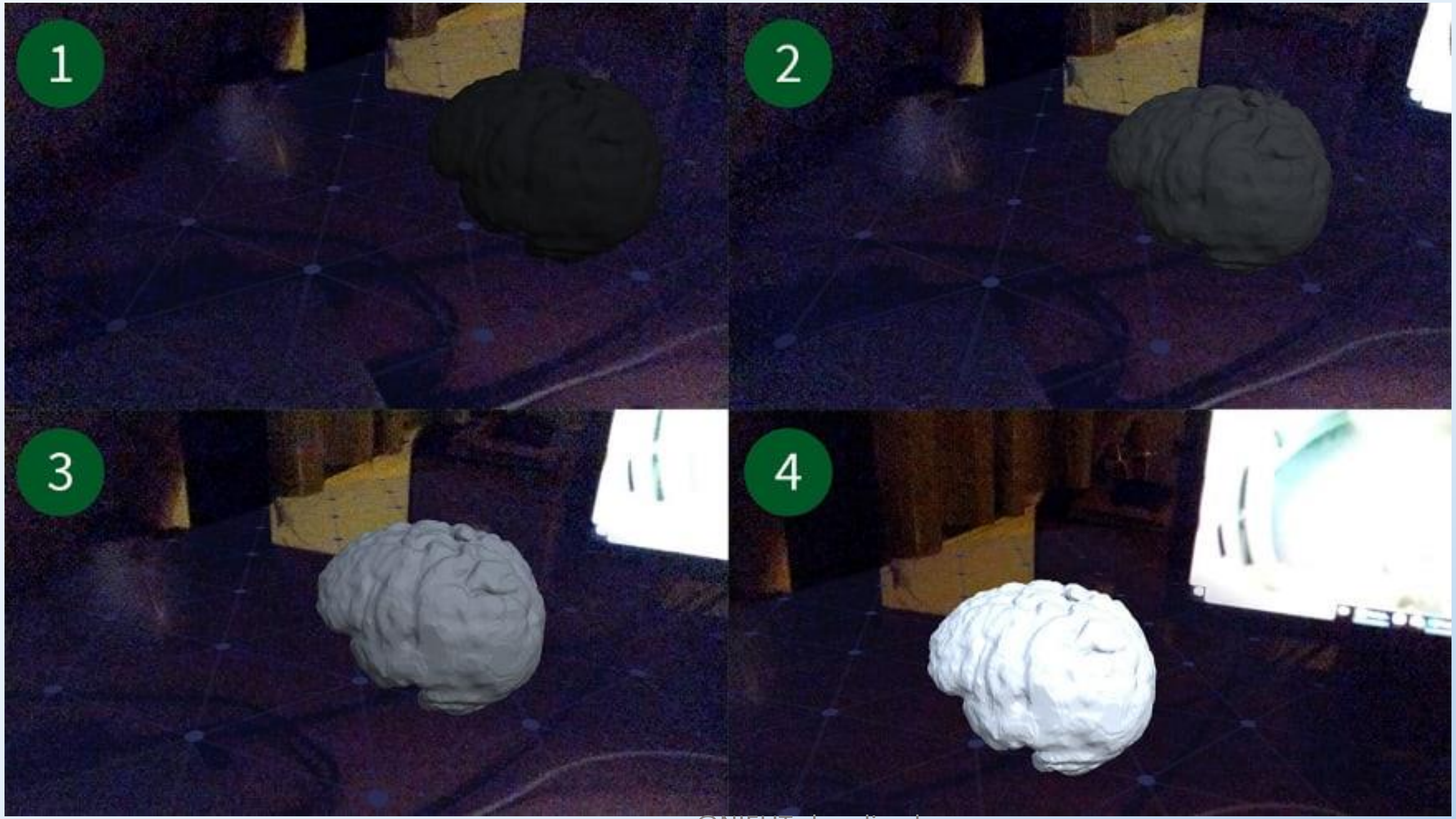
- User-defined points in which AR objects are placed. A virtual object attached to a featured point, which is identified and tracked by Simultaneous localization and mapping (SLAM).

**Type of Anchors**

- Plane Anchors
- Image Anchors
- Face Anchors
- 3-D Anchors

# Light Estimation

- Detecting the lighting automatically of the place around, which forms a better appearance of virtual visuals for the users.



# Motion Tracking

- As your phone moves through the world, ARCore uses a process called simultaneous localization and mapping, or SLAM, to understand where the phone is relative to the world around it. ARCore detects visually distinct features in the captured camera image called **feature points** and uses these points to compute its change in location. The visual information is combined with inertial measurements from the device's IMU to estimate the **pose** (position and orientation) of the camera relative to the world over time.
- By aligning the pose of the virtual camera that renders your 3D content with the pose of the device's camera provided by ARCore, developers are able to render virtual content from the correct perspective. The rendered virtual image can be overlaid on top of the image obtained from the device's camera, making it appear as if the virtual content is part of the real world.

# Environmental understanding

- ARCore is constantly improving its understanding of the real world environment by detecting feature points and planes.
- ARCore looks for clusters of feature points that appear to lie on common horizontal or vertical surfaces, like tables or walls, and makes these surfaces available to your app as geometric **planes**. ARCore can also determine the boundary of each geometric plane and make that information available to your app. You can use this information to place virtual objects resting on flat surfaces.
- Because ARCore uses feature points to detect planes, flat surfaces without texture, such as a white wall, may not be detected properly.
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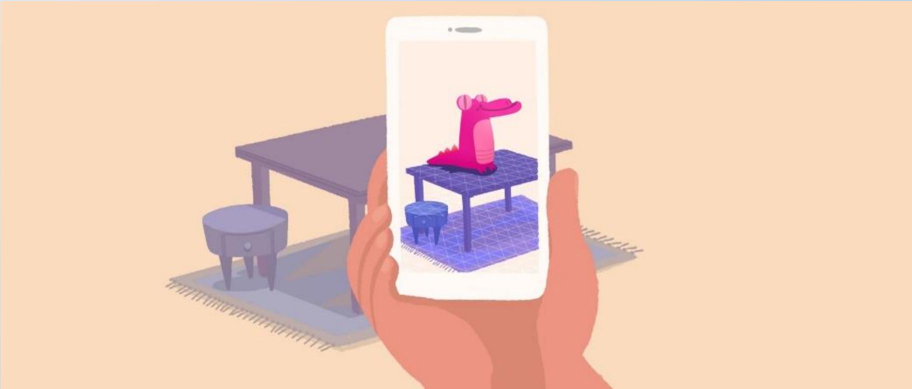
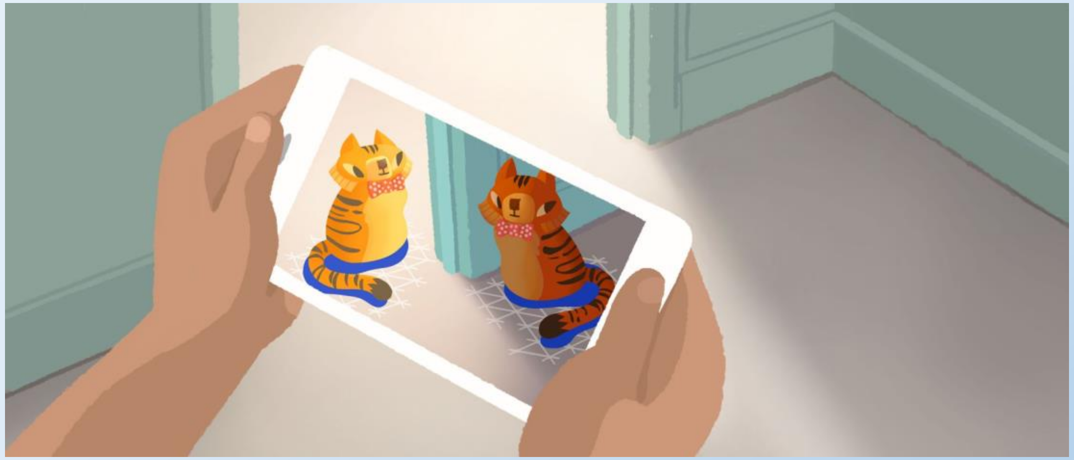


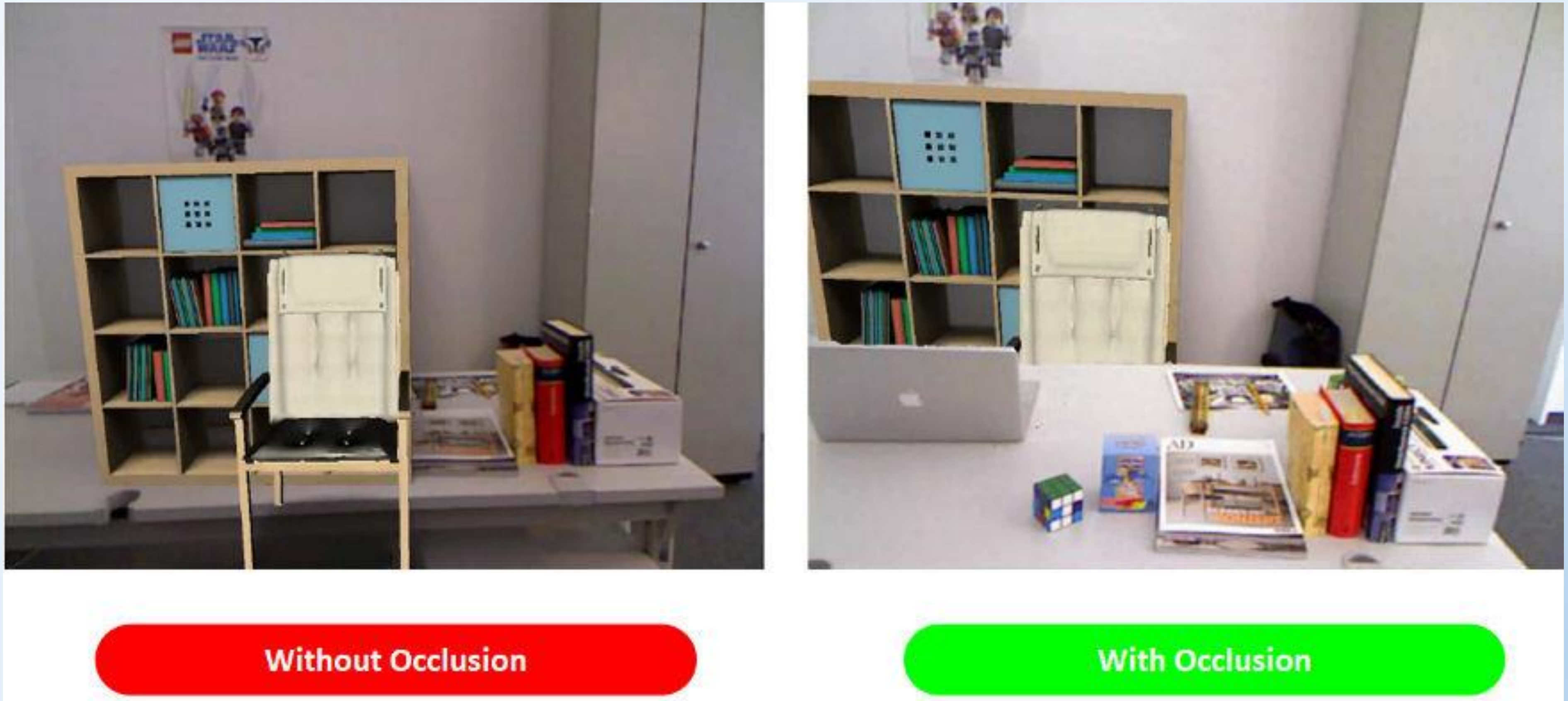
# Light Estimation

- ARCore can detect information about the lighting of its environment and provide you with the average intensity and color correction of a given camera image. This information lets you light your virtual objects under the same conditions as the environment around them, increasing the sense of realism.



# Occlusion

- When one 3D object blocks another 3D object from view is known as Occlusion.



# ARKit and ARCore

ARKit and ARCore are responsible for making markerless AR available on hundreds of millions of smartphones and tablets. Here's an overview of the top SDKs:

- **Apple's ARKit:** Unveiled in 2017, the ARKit SDK brought core AR functionality (for example, plane tracking and anchoring) to the iOS operating system. Millions of people had an AR-capable device in their pocket overnight. The key features of ARKit are space recognition using SLAM, object detection, light estimation, and continuing the AR experience through several sessions. The SDK is free for developers to use.

# Google ARCore

- **Google's ARCore:** In early 2018, Google came out with the free and open-source ARCore, essentially replicating the functionality of Apple's ARKit. Key features include motion tracking, environmental understanding, light estimation, user interaction, oriented points, anchors and trackables, augmented images, and sharing. While ARKit and ARCore started life with feature parity, Google's ARCore has suffered from the device fragmentation that hampers the Android platform. ARCore is on par with ARKit in terms of features, stability, and quality of the 3D images. They both offer development plugins for compatibility with Unity for Android and iOS and Unreal Engine 3D creation tool.
- ARCore is Google's platform for building augmented reality experiences. Using different APIs, ARCore enables your phone to sense its environment, understand the world and interact with information. Some of the APIs are available across Android and iOS to enable shared AR experiences.