Mobile and Ubiquitous Computing
2022/23
MEIC/METI - Alameda & Tagus

Augmented Reality - An Overview

Motivation

- Applications and hardware provide more and more immersive experiences.
- The physical and digital UI is a nuisance on the side.
- Reality is competing for our attention.

What is Augmented Reality?

- Extending visual reality with additional integrated elements.
- Creating a new UX environment without losing the context of reality.
- Integrating the UI in the environment.

History

- **1968:** Ivan Sutherland creates the first augmented reality system: optical see-through display with simple wireframe drawings.
- **1992:** term “augmented reality” coigned.
- **1997**: augmented reality defined: real-virtual mix, real time, 3D.

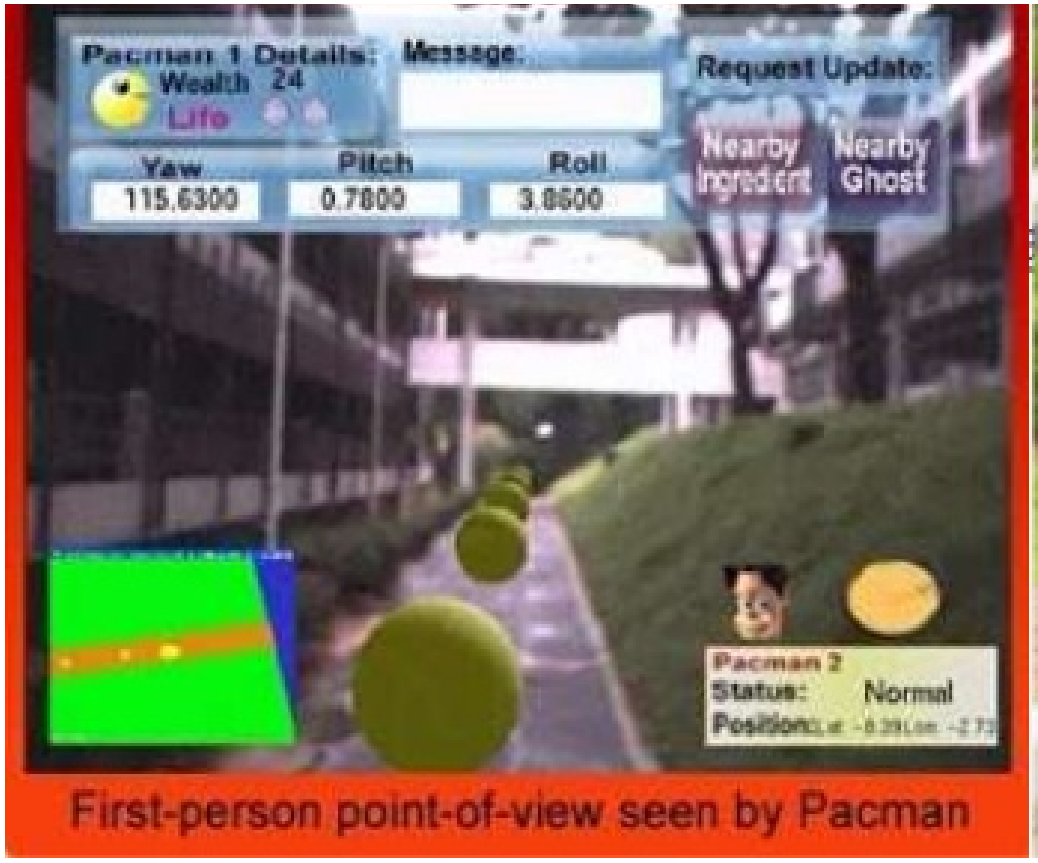
History

- **1997:** Steve Feiner's Touring machine

- **2000:** First commercial phone camera

History

- **2003:** Human Pac-Man



First-person point-of-view seen by Pacman

History

- **2008**: First museum AR guide

History

- **2013**: Google launches Google Glass

Characteristics of Mobile AR Apps

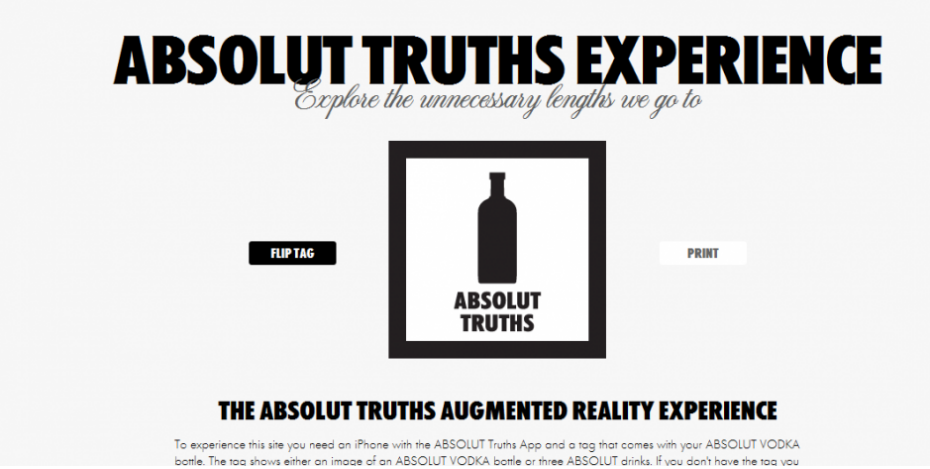
- **Input**: Uses various device and companion device sensors, e.g. camera, gyroscope, microphone, GPS.
- **Processing**: Determines information that is going to render in the screen of the mobile device.
- **Output**: Projects its output to the screen of the mobile device together with the current view of the user (i.e. augments the user's reality).

Application Domains

- Tourism & Navigation: historical and practical information about new locations.
- Training & Education: complement reality with instructions, tips, collaboration hints. (see https://www.youtube.com/watch?v=-DYqlaMWTVg)
- Assembly & Maintenance: give hints on how to assemble a machine or what to observe, verify in maintenance procedures. (see https://www.youtube.com/watch?v=Y5ywMb6SeGc)

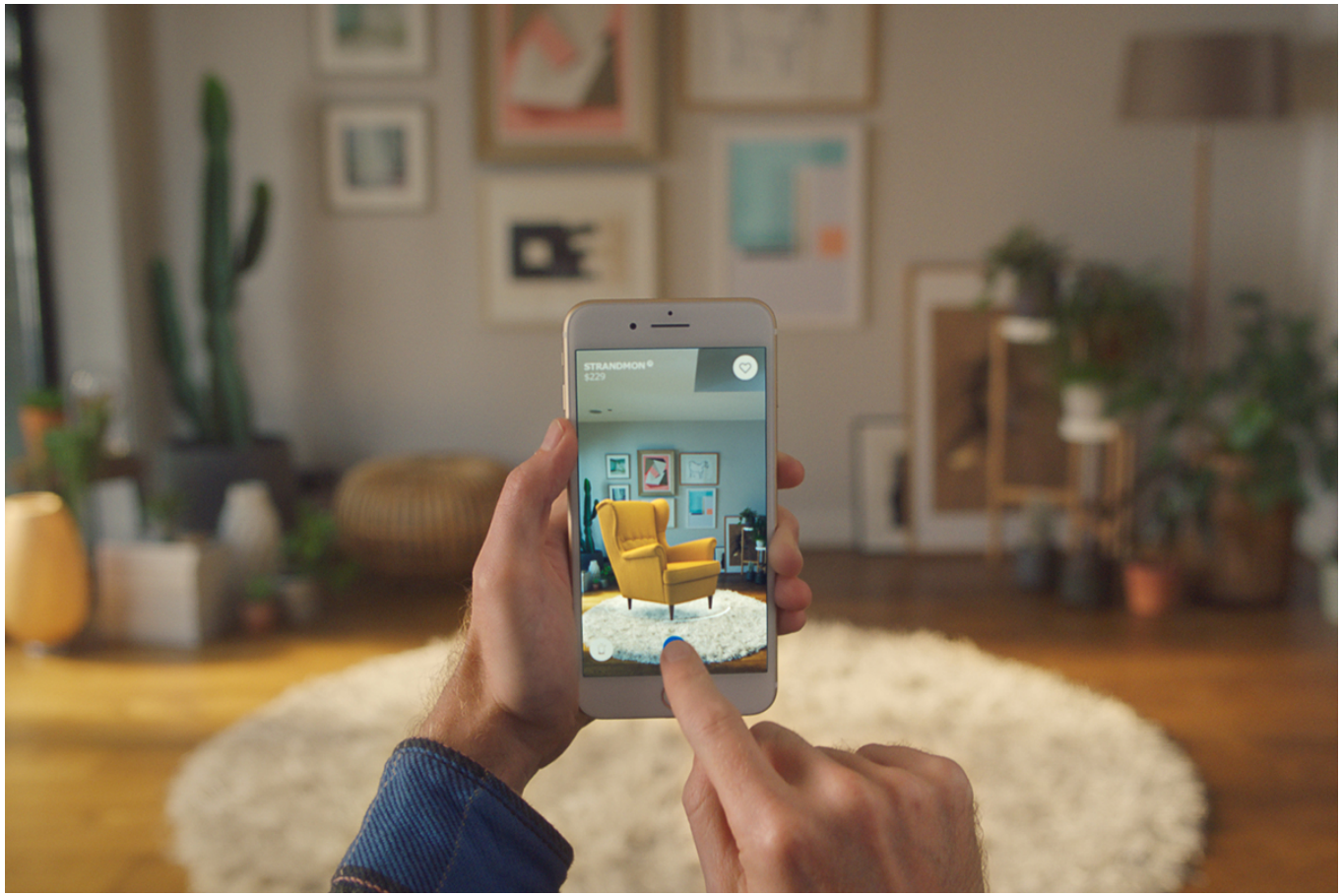
Application Domains

- Entertainment & Advertisement: in games extend the setting, the scenario or user costumes. Add ads to the environment or to a game.



Application Domains

- Scene Construction: for example, add items to an environment, e.g. furniture.



Application Domains

- Information Assistants: show related information to the observed environment, e.g. related species near plants, x-rays over the patient, building overlays.

Components: Display

- Visual see-through:
  - Blocks light
  - Contrast is difficult to tune.
- Video see-through
- Projected

Tracking and Registration

- Tracking and registration: identifying the location and position of the device to decide what to display.
- Can be Sensor-based or Vision-based.
- Sensor based tracking was covered in the “Location” section of the course.

Vision-based Tracking

- Vision-based tracking can be marker-based or feature-based.
- Markers are precise but impractical outdoors. Markers can be pre-input images, colored stickers or QR-codes.
- Feature tracking attempt to match DB real-world images to the camera image and then track them. It’s generic but error-prone and compute (and energy) intensive.

Tracking: Sensor-Vision Hybrids

- Hybrid solutions explore the best of sensors and vision.
- Accelerometers deal well with brief sudden movements but drift in the long term.
- GPS are coarse but good for initial positioning.
- Image tracking is expensive and fragile (lighting, camera occlusion) but detailed.

How to match images to locations?

- Data acquisition: difficult to automate the conversion of acquired data to location databases. Can be manual, using topographical tools or the aid of existing DBs.
- One approach, SLAM:
  - Simultaneous Location and Mapping
  - Navigate an unknown space
  - Create a model
  - Place the device in it
  - The more previous knowledge (e.g. street view) the easier it becomes.
  - Area of extensive current research

SLAM

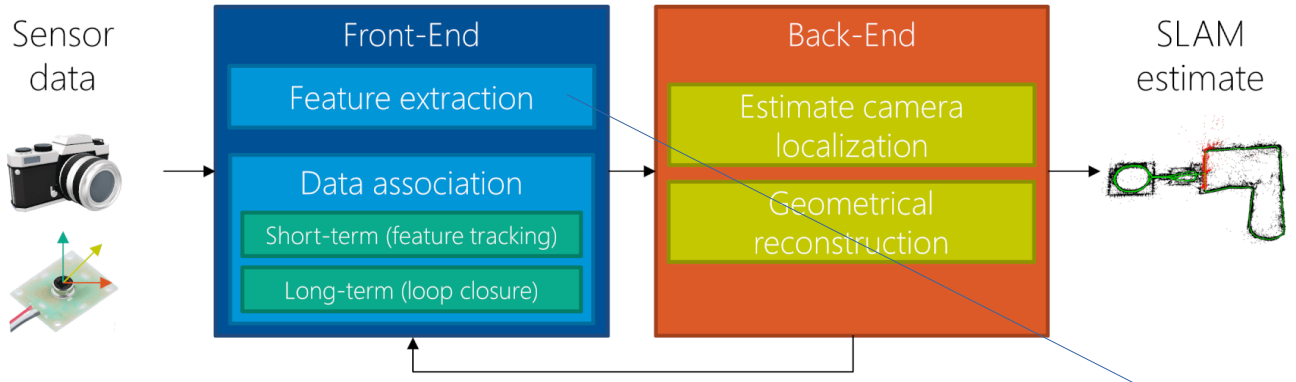
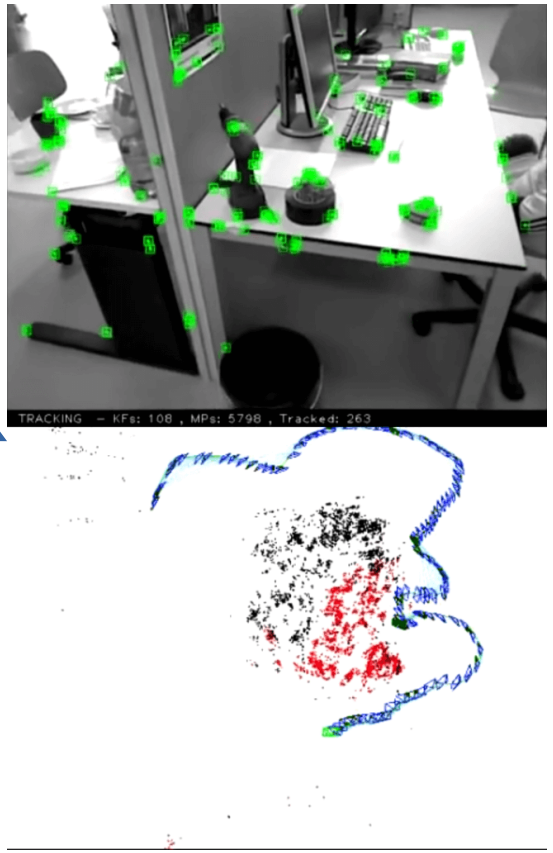


Diagram based on: Cadena, Cesar, et al. "Past, present, and future of simultaneous localization and mapping: Toward the robust-perception age." *IEEE Transactions on Robotics* 32.6 (2016): 1309-1332.
SLAM estimate: R. Mur-Artal, J. M. M. Montiel and J. D. Tardós, "ORB-SLAM: A Versatile and Accurate Monocular SLAM System," in *IEEE Transactions on Robotics*, vol. 31, no. 5, pp. 1147-1163, Oct. 2015.
3D Model of motion sensor by gerduleb: https://www.remix3d.com/details/G009SVNP5RSM
3D Model of camera by Microsoft: https://www.remix3d.com/details/G009SXQ93TH9



Components: SDK

- Most established, mostly providing tracking and SLAM:
  - Wikitude
  - Vuforia
  - Apple ARKit
  - Android AR Core

Challenges for AR

- “Dangerous” mix of power drains: GPS + camera + intensive CPU/GPU use (scene recognition, object orientation and placement).
- Energy poor devices are the most interesting for AR.
- Great candidate for computational offloading. However, video stream processing is bandwidth intensive and may require preprocessing to reduce the stream’s bandwidth.
- Privacy issues of constant video acquisition.

References

- **Mobile augmented reality survey: From where we are to where we go**. Chatzopoulos, Dimitris and Bermejo, Carlos and Huang, Zhanpeng and Hui, Pan. IEEE Access, v. 5, pp. 6917-6950. 2017

- The history of mobile augmented reality. C Arth, R Grasset, L Gruber, T Langlotz. arxiv.org. 2015. https://arxiv.org/pdf/1505.01319