

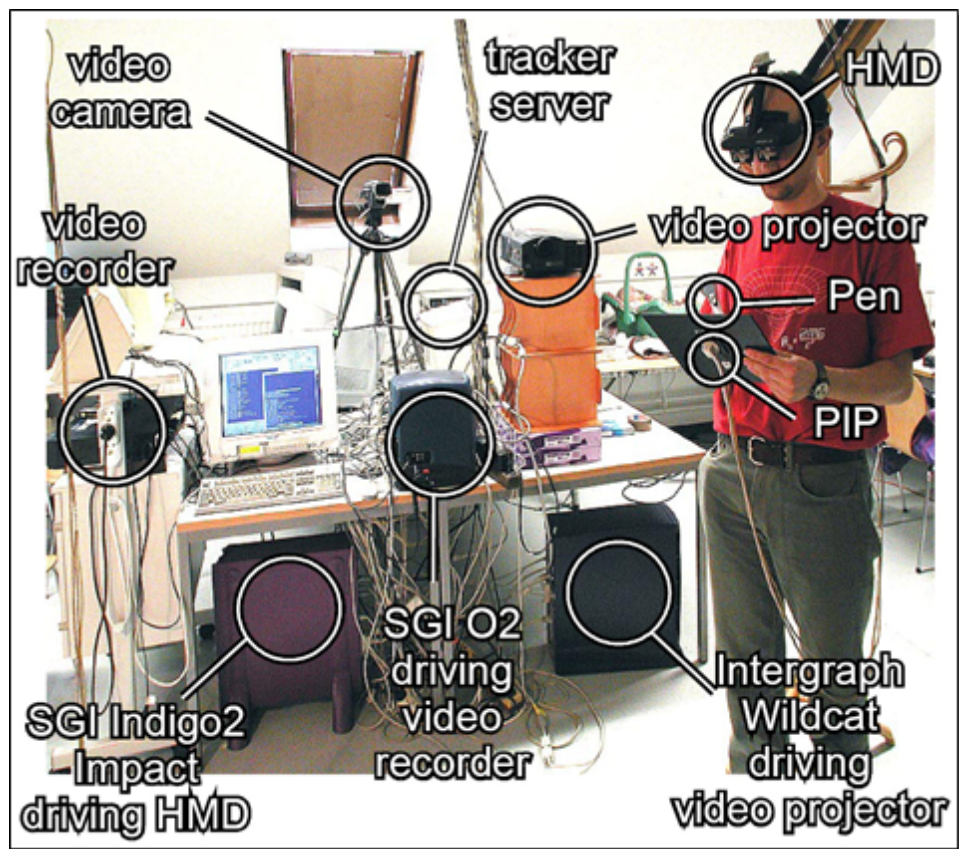


# Enabling Techniques for AR on Mobile Phones

Daniel Wagner  
Principal Engineer, Corporate R&D



# Quick History of Mobile AR



# Quick History of Mobile AR

---



# Quick History of Mobile AR



**Inertial  
sensor**  
**camera**  
**HMD**



**GPS**

**tracked  
touchpad**

**Notebook  
WLAN  
GPRS phone**

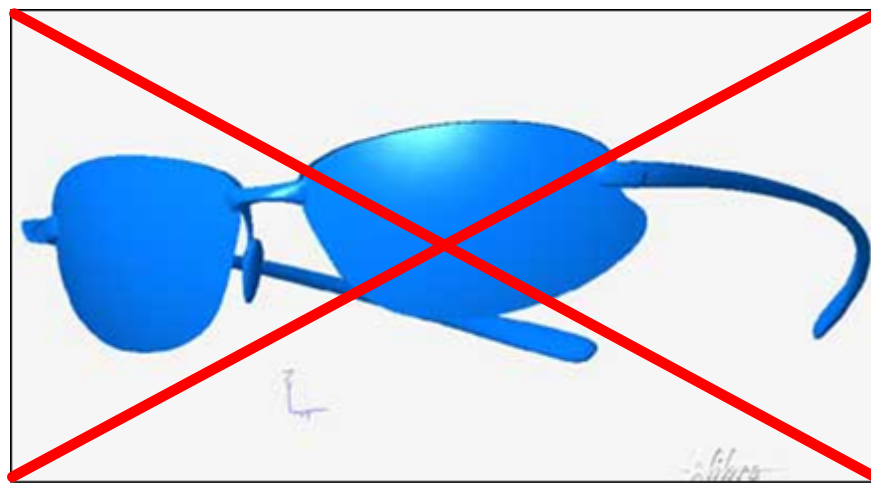
# Quick History of Mobile AR

---



# Quick History of Mobile AR

---



# Most promising AR Device today: The Mobile Phone

---

- Commercial off-the-shelf hardware
  - Low cost
  - Socially accepted
  - Well known
  - Discrete
  - Wide spread
  - Intuitive to use
- All in one solution
  - Display
  - Camera
  - CPU



# The Challenges of AR on Mobile Phones Today

---

- **Detection and Tracking**
  - Aligning virtual content with the real world
  - Accuracy and speed
- **Rendering**
  - Present virtual content at high quality
  - Should look as part of the real world
- **User Interface**
  - AR is a user interface!
  - However, most AR interfaces are bad...

# Example: Gaming

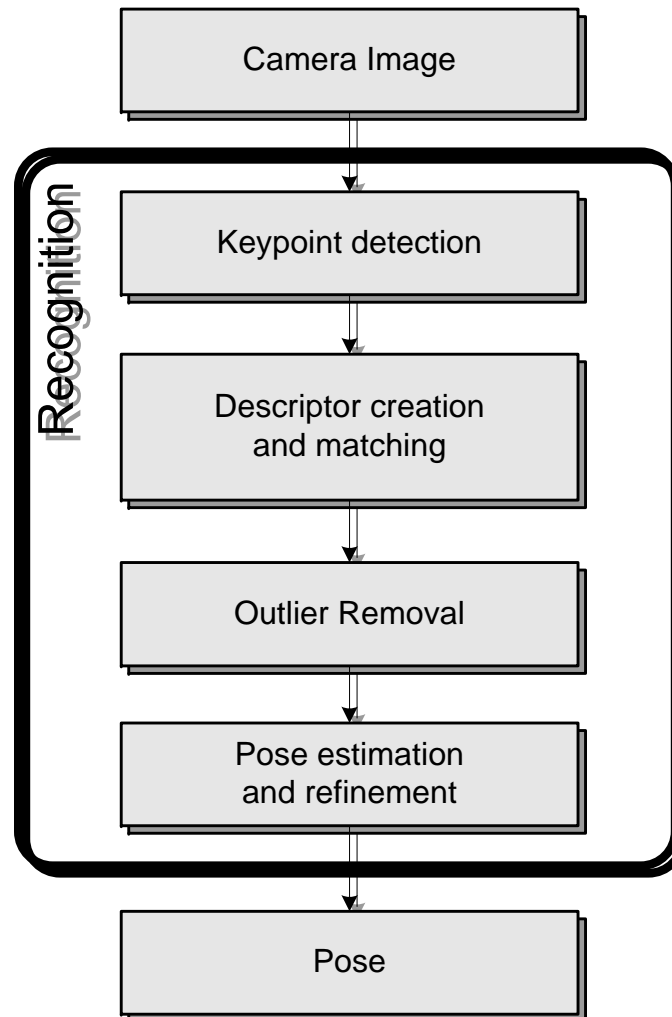
---



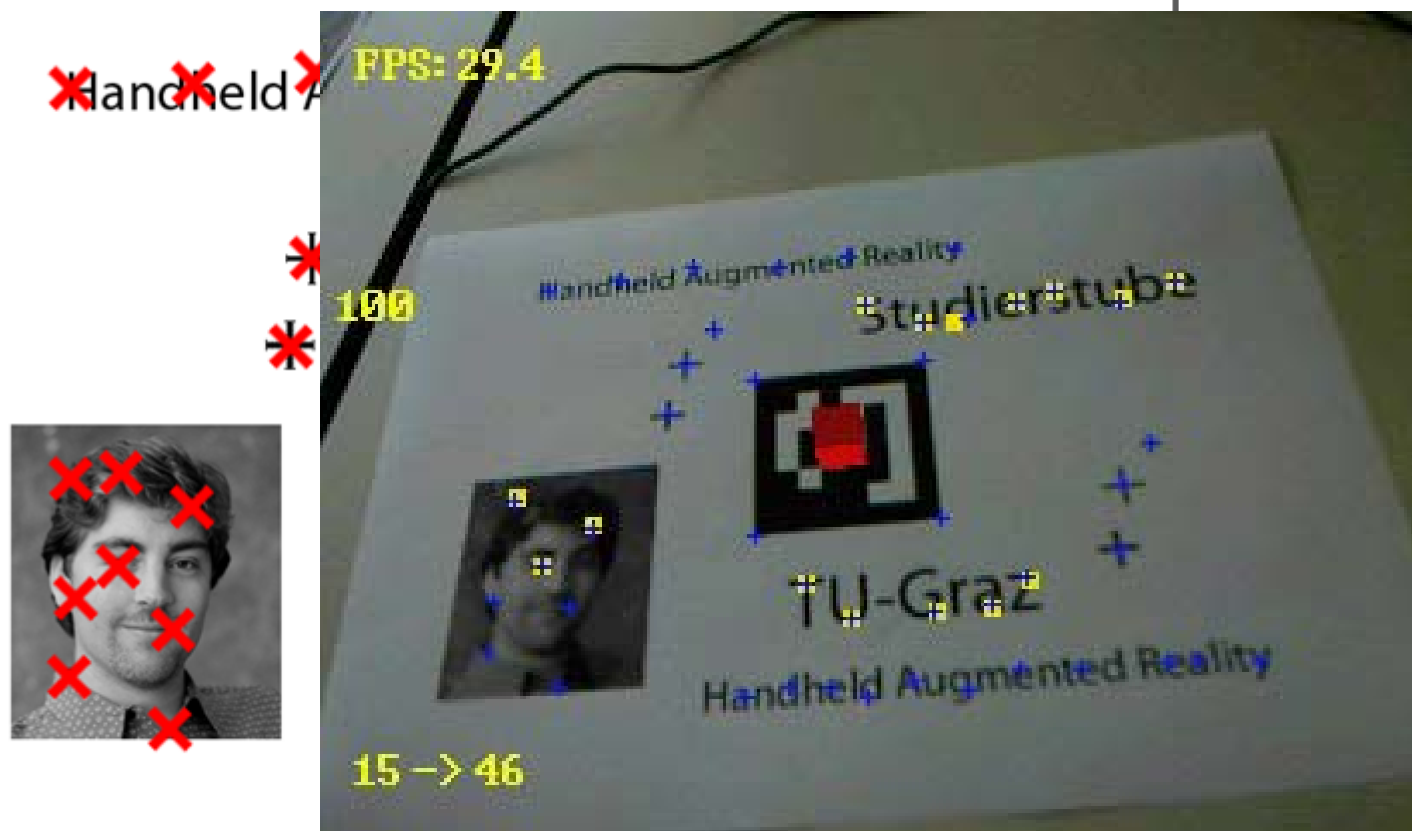


# Detection and Tracking

---



# Detection and Tracking



# Current Detection & Tracking Technologies

---

## ■ Sensors

- Linear accelerometer
- GPS
- Compass
- Gyro
- Usually data easy to access and interpret

## ■ Computer vision

- Use the camera stream to “understand” the real scene
- Requires expert knowledge in computer vision

Ideally we'd combine **all** technologies available!

# Issues with built-in Sensors

---

- Linear accelerometer
  - Ok, but of little use except for simple UI gadgets or when using the compass
- GPS
  - Very inaccurate, expect 30-100 meters of error
  - Update rate: ~1Hz
- Compass
  - Very inaccurate, expect up to 30° of error (especially indoors, near cars, trams, power lines, large metal)
  - Update rate: ~1Hz
- Gyro
  - Probably ok, but mostly useful to stabilize other sensors (e.g. compass, vision)

# The Camera as a Sensor

---

- Cameras
  - High resolution (320x240 – 800x480)
  - High update rates (30Hz)
- Required for see-through effect anyways, so let's use it for more!
- Vision based tracking works in the same domain as rendering, so results should be good (even though they are often quite inaccurate)

# Challenges with Vision-based AR

---

- **Lighting**
  - Mobile phone cameras work poorly under bad lighting
- **Fast camera movement**
  - The faster the camera moves, the harder it is to detect and track objects
- **Real time**
  - Mobile phones are slow!
- **The world is large**
  - We can not detect and track everything

# Issues with AR on Mobile Phones Today

---

Phones are always designed for specific tasks –  
AR is currently not among those tasks...

- Features not meant to run in parallel
  - Video from camera + video from file
  - Multiple cameras simultaneously
- Features not meant to be accessible for applications
  - DSP processing
  - Low level camera access
- Data paths not optimized
  - Mixing 2D (video) and 3D (rendering)
- Standards are missing
  - For AR in general, but more adverse effect on mobile phones

# What to expect from Future Mobile Phones

---

- More CPU power
  - Higher clock rates (>1 GHz)
  - Multiple cores
- More memory
  - 512+ MB
  - More memory per application
- Better cameras
  - 640x480 at 30Hz (and higher)
  - Stereo cameras
  - Support for using multiple cameras simultaneously
- More and higher quality sensors
  - GPS, compass, linear accelerometer, gyro, proximity, light, pressure...

# How AR needs to improve on Mobile Phones

---

- **Freely available AR libraries**
  - Makes it easier to develop AR applications
  - Brings in new talent (graphics, HCI)
- **Standards**
  - Faster development of new techniques
  - Helps driving development of more AR-suitable mobile phones
  - Dedicated hardware support for AR
- **More flexible and robust tracking techniques**
  - Suitable to untrained and unsupervised users in unknown environments
  - Going large scale (detect and track everything)



## Thank You

Thanks go to my former group at Christian Doppler Lab at Graz University of Technology for the video material and pictures:

[http://studierstube.org/handheld\\_ar](http://studierstube.org/handheld_ar)

Thanks also go to Ron Azuma for giving this talk when I couldn't attend the meeting myself.

# Bonus Material

---

# Natural Feature Tracking

---



# Natural Feature Tracking

---



# 3D Object Tracking

---



# Tracking in the Dark...

---

