Mixed and augmented reality

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Overview

1. What is augmented reality?

2. What techniques exist?
   - Optical see-through HMDs
   - Video based systems
   - Interaction devices

3. What are the applications of augmented reality?
   - Medical application
   - Entertainment

4. What are the main problems?
Definition

Classification

Mixed Reality

Real Environment  Augmented Reality  Augmented Virtuality  Virtual Environment

What does augmented reality do?

Augmented reality (AR)

- combines the real with a virtual world
- is interactive in real time
- is registered in 3D
Motivation

Goal of augmented reality

- enhance the perception of the real world by supplementing information from the virtual world
- can be applied to all senses
What is augmented reality?
What techniques exist?
What are the applications of augmented reality?
What are the main problems?

Distinction

What is AR not?
blends of the real and the virtual worlds in movies (e.g. Jurassic Park)
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Distinction

What is AR not?

- virtual reality systems with no elements of the real world
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Optical see-through HMDs
Video see-through HMDs
Monitor-based AR systems
Projector-based AR systems
Interaction devices

Optical see-through HMDs
What is augmented reality?

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Optical see-through HMDs

Video see-through HMDs

Monitor-based AR systems

Projector-based AR systems

Interaction devices

Properties of optical see-through HMDs

Advantages

- resolution of the real world is not limited
- viewing still possible after power blackout
- no eye offset

Disadvantages

- virtual objects appear semi-transparent
- delays from the scene generator cannot be compensated
- hard to match contrast
Video see-through HMDs

- Scene generator
- Video cameras
- Head Tracker
- Video compositors
- Combined video

Video of real world
Head locations
Graphic images
Real World

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Optical see-through HMDs
Video see-through HMDs
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### Properties of video see-through HMDs

#### Advantages
- easier composition of the real and the virtual world
- real and virtual delays can be matched
- additional registration strategies

#### Disadvantages
- more complex
- limited resolution
- delay in both real and virtual world
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Monitor-based AR systems

Optical see-through HMDs
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Mixed and augmented reality
## Properties of monitor-based AR systems

### Advantages
- good integration in existing environments
- user is not required to wear special gear

### Disadvantages
- not flexible
  - not portable
  - very specialised
- same disadvantages as video see-through approach
Projector-based AR systems
Properties of projector-based AR systems

**Advantages**
- perform well for closed environments
- very exact registration possible

**Disadvantages**
- not portable
- difficult installation and calibration
- very specialised
How do users interact with virtual objects?

Several approaches exist:

- **common virtual environment interfaces**
  - same interface as in virtual environments

- **heterogeneous interfaces**
  - interaction device is part real, part virtual

- **tangible interfaces**
  - use of real objects to interact with the virtual world
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Interaction - Example
Supporting physicians with AR

Figure: 2D ultrasonic scan of a fetus
Supporting physicians with AR
Supporting physicians with AR

Further examples

Use of augmented reality

AR systems can

- provide X-ray vision through ultrasound visioning
- guide the surgeon in minimally invasive operations
- assist physicians in training
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Medical application
Entertainment

AR in entertainment - Sony’s Eye Toy system

Video of real world

Video camera

Playstation
AR in entertainment - Sony's Eye Toy system
What is registration?

registration refers to the accurate alignment of real and virtual objects
What is augmented reality?

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Registration

Static errors

Dynamic errors

Focus problems

Registration

What is registration?

- goal: show virtual objects exactly where they are supposed to be
Registration

Why is accurate registration needed?

Without accurate registration,

- illusion of merging virtual and real world is compromised
- applications needing high accuracy cannot be performed (e.g. surgeries)

How to obtain accurate registration?

- User tracking
- Sensing Environment
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Registration
Static errors
Dynamic errors
Focus problems

Tracking

Goal
Obtain the user’s position and viewing direction as accurate as possible

Methods

- indoor
  - magnetic sensors
  - video sensors
- outdoor
  - GPS
  - gyroscopes

Often hybrid solutions are used to overcome individual weaknesses.
Environment sensing

Goal
Obtain knowledge about positions of all objects of interest with the use of sensors.

What does AR demand of sensors?
- great bandwidth
- high accuracy
- long range
Environment sensing

Goal
Obtain knowledge about positions of all objects of interest with the use of sensors.

Methods used
- fiducial markers
- distinct features of the environment
- computer vision
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Problems in registration

What kind of errors can occur?

- **Static errors**
  - visible even when the user does not move.

- **Dynamic errors**
  - visible when the user or the environment moves.
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Problems in registration

What kind of errors can occur?

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Reducing static errors - calibration

Goal

Reduce registration errors that result from incorrect viewing parameters, such as

- center of projection
- eye offset
- field of view

Methods

- manual calibration
  - directly measure all parameters
- drawback: lots of parameters to measure
Reducing static errors - calibration

Goal

Reduce registration errors that result from incorrect viewing parameters, such as
- center of projection
- eye offset
- field of view

Methods

- semi-automatic calibration
  - user has to perform certain tasks
  - automatic techniques then used to obtain viewing parameters
- drawback: relies on user correctly performing tasks
Reducing static errors - calibration

**Goal**
Reduce registration errors that result from incorrect viewing parameters, such as:
- center of projection
- eye offset
- field of view

**Methods**
- automatic calibration
  - use redundant sensor information to measure parameters
- drawback: needed information not always available
Reducing dynamic errors - delay

What is delay?

Each part of the AR system needs time to perform its task:

- registering the environment
- calculate the virtual objects
- rendering

End-to-end system delay is defined as measurement between:

- registration of user’s position and viewpoint
- displaying the virtual objects
Focus in optical see-through systems

**Problem**

- focus of the human eye accommodates with the real world correctly
- virtual world is seen at a fixed distance with fixed accommodation
  ⇒ depending on distance, one world might appear unsharp
Focus in video see-through systems

Problem

- display shows composition of both worlds
- environment before or behind the object is not in focus
⇒ virtual objects have to be rendered with matching depth-of-field
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Conclusion

Further work

- ease of setup and use
- intuitive interfaces
- enhancing ubiquitous tracking
- advanced rendering
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Thanks for your attention!