Augmented Reality and Internet2 for Advanced Collaborative Environments

Felix G. Hamza-Lup, Ph.D

Optical Diagnostics and Applications Laboratory &
Computer Science
University of Central Florida
fhamza@cs.ucf.edu
Outline

• Introduction: I2 and FLR
• The Augmented Reality Paradigm
• Application Domains; Distributed Collaborative Environments
• AR Collaborative Environments @ ODALab
  – VRDA Tool
  – AR Training Tool
  – 3D Video Conferencing
• AR System Components
  – Position Tracking Sensors
  – 3D Visualization Devices
• Consistency in Distributed Environments
• Concluding Remarks
Logical map of Internet2 core topology

We are here
Florida Lambda-Rail (FLR)

- Part of a larger national fiber optic network, the National LambdaRail (NLR)
- Linking research institutions around the country with connectivity to international research networks
- Foundation for the next-generation networks needed to support large-scale research, education outreach, public/private partnerships.
- Participating universities are: FAU, FIT, FIU, FSU, NSU, UCF, UF, UM, and UWF
  - November 2002 – Formed consortium
  - May 2003 – Incorporated as the Florida LambdaRail, LLC (non-profit limited liability corporation)
  - February 2004 - Applied for 501(c)(3) tax-exempt recognition
Florida Lambda-Rail

- Future Services:
  - IP connectivity to NLR
  - IP connectivity to Internet
  - IP connectivity to Internet2
  - Share IP transport between member institutions
  - Dedicated wavelengths between FLR members and other FLR or NLR institutions

- Prospects
  - Collaborative Environments
  - Video teleconferencing
  - Interactive distributed simulations
  - Access to digitized databases
  - Processing and visualization of large data sets
  - Distance Learning

http://www.flrnet.org
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What is Augmented Reality (AR)?

- Augmented Reality (AR) is a growing area in Virtual Environment research.

- AR 3D Environment is a *computer generated (partially), interactive*, three-dimensional environment in which a person is *immersed*.
  - *Computer generated*: who else could do it?
  - *Partially*: only some of the objects in the scene are computer generated.
  - *Interactive*: needs real time computation.
  - *Immersed*: needs a device and proper content to give this impression (ex. Head Mounted Display).

- Augmented Reality Environments generally include:
  - calibration procedure.
  - dynamic superimposition procedure to bring virtual objects *in register* with real objects.
Virtual Environment Taxonomy

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Application Domains

- Training *(Medical, Technical, Military etc)*
- Entertainment
- Engineering Design
- Consumer Design *(Magic Book, M.Billinghurst)*
- Robotics and Tele-robotics
- Manufacturing, Maintenance and Repair
- more to come...
AR Applications in Medicine

- AR Diagnostics/Prognostics
- Medical Procedure Training

AR Medical Training Concept

AR Diagnostics Concept

Courtesy of S. Johnson

Courtesy of A. State
Distributed Collaborative AR Environments

- Distributed Collaborative Environments
  - still in their infancy
  - require interdisciplinary research
Distributed Collaborative AR Environments

- DCE useful for
  - Information/knowledge dissemination
  - Reduced costs, time and risks
  - Increased efficiency through team work

- Examples & Trend
  - Industry
    - Military simulations: (VR) SIMNET, NPSNET, (MR) MOUT …
    - Entertainment: (VR) networked games, (MR) Project (ISMR’99) …
    - Medicine: (AR) training tools (MMVR’03) …
  - Academia: (VR) MASSIVE, DIVE, DEVA, (AR) Studierstube, Coterie…
  - Trend toward Mixed Reality (focus on AR)
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AR Collaborative Environments at Optical Diagnostics & Applications Laboratory

- past, present & future -
One Goal

- Use Internet 2 and available tools for development of distributed AR applications.
Technology

• Head Mounted Projective Displays
HMPD History

• 1996 Fisher, US Patent for monocular projection display
• 1997 Kijima and Ojika, First demonstration of implementation
• 1997 Ferguson, US Patent conceptually generalized to binocular
• 1999 Rolland and al., First ultra compact optics
• Biocca and Rolland, US Patent Filed (pending)
• 2002 Hua and Rolland, US Patent filed (pending)
• 2003 Rolland et al., US Patent filed on fabric free wearable projection display (pending)
Technology

**Optical See-through vs. Video See-through HMDs**
Technology

Optical Diagnostics and Applications Laboratory Internet2 Project

- Video Output to Head Mounted Display
- VRDA Augmented Reality Demonstration
- Optical tracking device
- UCF Internet2 network 132.170.169.x
- UCF Campus Cisco ATM switch 1010
- UCF Internet 2 Router 45MB DS3 to University of Florida Gigapop (Future OC3 from Quest)
- Cred Cisco 5500 switch
- Video streaming dual encoder/decoder system
- Video on demand video server
- Internet2 Backbone to Michigan State University and University of North Carolina at Chapel Hill
- Respective campus switch
- Video streaming dual encoder/decoder system
- Video Output to Head Mounted Display
- NTSC Video
- 100BaseT network
Internet2 Connection for Video Streaming and other modalities (e.g. haptic)
Distributed AR Applications
VRDA TOOL

Virtual Reality Dynamic Anatomy
- Dynamic 3D models superimposition
- High frequency dynamic 6DOF tracking

VRDA IMAGING PROCESS

Desktop
Laptop

Deployable Tracking System

2000
2004
2004
Distributed VRDA
Real-time Remote Demonstration from ODALab, Orlando to Networld Interop, in Atlanta Fall 2000 using Internet2

AR Endotracheal Intubations
Medical Training Tool

AR Local Medical Training

Teleportal Visualization designed for Telemedicine

3D Video Conferencing

Stereoscopic Rendered Images and Video Streaming with Real-Time compression methods using Internet2 network infrastructure
A 6 ft- 3D human skeleton appears to float inside a retro-reflective cylindrical display

Identical Networked Rooms link
Physical Local Collaborators and Remote Virtual Collaborators

Local Site

Remote Site

User

Virtual collaborator

3M Fabric surrounds user like a shower curtain and covers floor

Tracking System

Telecommunication Network Link
Extensions to other Distributed AR applications
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AR Components - Sensors

- 6DOF sensors (tracking sensors)
  - Give the position and orientation of the real objects in the environment.
  - Types:
    - mechanical, magnetic, optical, acoustic, inertial
    - hybrid - combinations
AR Components – Sensors
- an example – optical tracking sensors -

• Polaris™ Tracking System: used to determine the position and orientation of the user’s head, HPS and Intubation Tube.

• Probe = rigid configuration of IREDs

• IRED probes:
  – HMD probe - tracks the HMD position
  – HPS probe - gives the manequin’s chin position
  – Digitizing probe - gives the 3D position of the probe tip
3D Visualization System

Head Mounted Projective Displays in the A.R.C. (Artificial Reality Center)


Other 3D Visualization Systems (e.g. CAVE™)
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Distributed AR

Data to be distributed:

- 3D Virtual Components of the scene
- Position and orientation of the real components (e.g. head position) for registration of Virtual components at specific locations (collect and distribute data from real-time sensors) - 6 DOF tracking devices.
- Audio, haptic information (for multimodal distributed AR)
- Video Streams
Consistency in Distributed AR

- Inconsistency Factors -

• Network infrastructure latency
  – Propagation, transmission, buffering delays etc.
  – Influenced by: bandwidth, error rate, congestion.

• System (Node) latency
  – Processing, rendering, buffering delays etc.
  – Influenced by: system complexity
Consistency in Distributed AR
- Maintenance Techniques -

- Humans, perceptual abilities =>
  - tradeoff between *ideal* and *perceived consistency*

- Shared State Consistency Maintenance in VE
  - centralized information repositories (pull/push architectures)
  - dead-reckoning algorithms (convergence & prediction)
  - frequent state regeneration (blind broadcasts, applications that do not require strong consistency)

- Resource management for scalability in VE
  - Communication protocol optimization (e.g. compression/aggregation)
  - Visibility of data (e.g. Area Of Interest)
  - Human perceptual limitations (e.g. LOD, Temporal Contour)
  - System Architecture (e.g. centralized vs. distributed)
Consistency in Distributed AR
- Adaptive Synchronization Algorithm -

- Delay & Delay Variation compensation in distributed AR.

- Each node:
  - runs a set of threads, rendering, interaction, monitoring…
  - has access to a local library of 3D models
  - interaction data is exchanged through messages

- Participants
  - “active” - nodes produce/broadcast/consume interaction data
  - “passive” - nodes consume interaction data, compute delay

- Each node independently adjusts its local scene based on
  - Communication delay
  - Participant’s actions attributes (e.g. velocity)
Consistency in Distributed AR
- Adaptive Synchronization Algorithm -

Multicast Action Attributes

Check Delay
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Concluding Remarks

• We need applications to make best use of the increasing available bandwidth.

• Augmented Reality has a large set of application domains that wait to be discovered.

• Ease distributed application deployment over different administrative domains.
  – Transparent QoS management
Internet2 ODALab Team

Contacts:

• Jannick Rolland, PhD
  Director of the ODA Lab
  rolland@odalab.ucf.edu

• Felix G. Hamza-Lup, PhD
  Associate Director Distributed Systems and Computer Graphics
  fhamza@odalab.ucf.edu

http://odalab.ucf.edu
Collaborators

Frank Biocca, PhD
M.I.N.D. Lab Director, Michigan State University

Ricardo Martins, Vaselin Shaulov
Adastra Labs LLC.
References


