Mixed Fantasy

Delivering MR Experiences

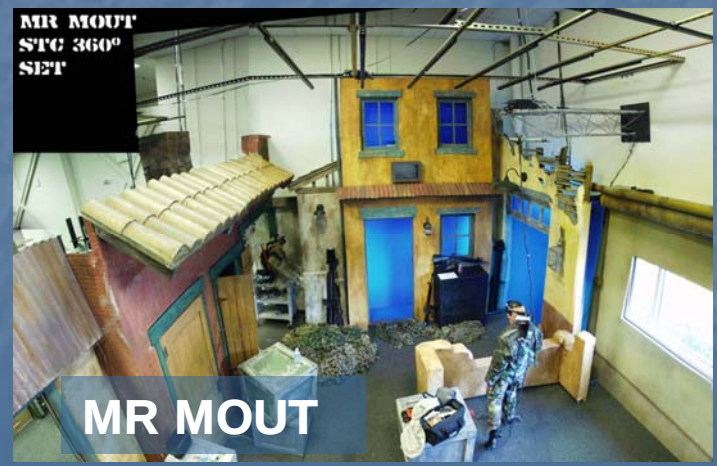
Charles E. Hughes, CS + Film/DM + MCL, Chief Geek
Christopher B. Stapleton, IST MCL + Digital Media,
Chief Freak, creative lead at Islands of Adventure
Paulius Micikevicius, CS, Post Doc, now at Armstrong
Darin E. Hughes, IST MCL, Audio Producer
Scott Malo, IST MCL, Modeler and Content Producer
Matthew O'Connor, IST MCL, Lead Programmer

The Ambiance
Send us your best students, please

- **Institute for Simulation and Training**
  - Visual System Laboratory (Moshell 1990)
  - Media Convergence Laboratory (Stapleton 1999)
- **Computer Science**
  - Graphics and Distributed Processing
- **School of Optics**
  - ODALab (Rolland)
- **Psychology**
  - MITMIT (Peter Hancock)
- **Industrial Engineering**
  - Synergy (Kay Stanney)
- **+ Film & Digital Media, English (Text & Technology)**

Mixed Fantasy

Delivering MR Experiences

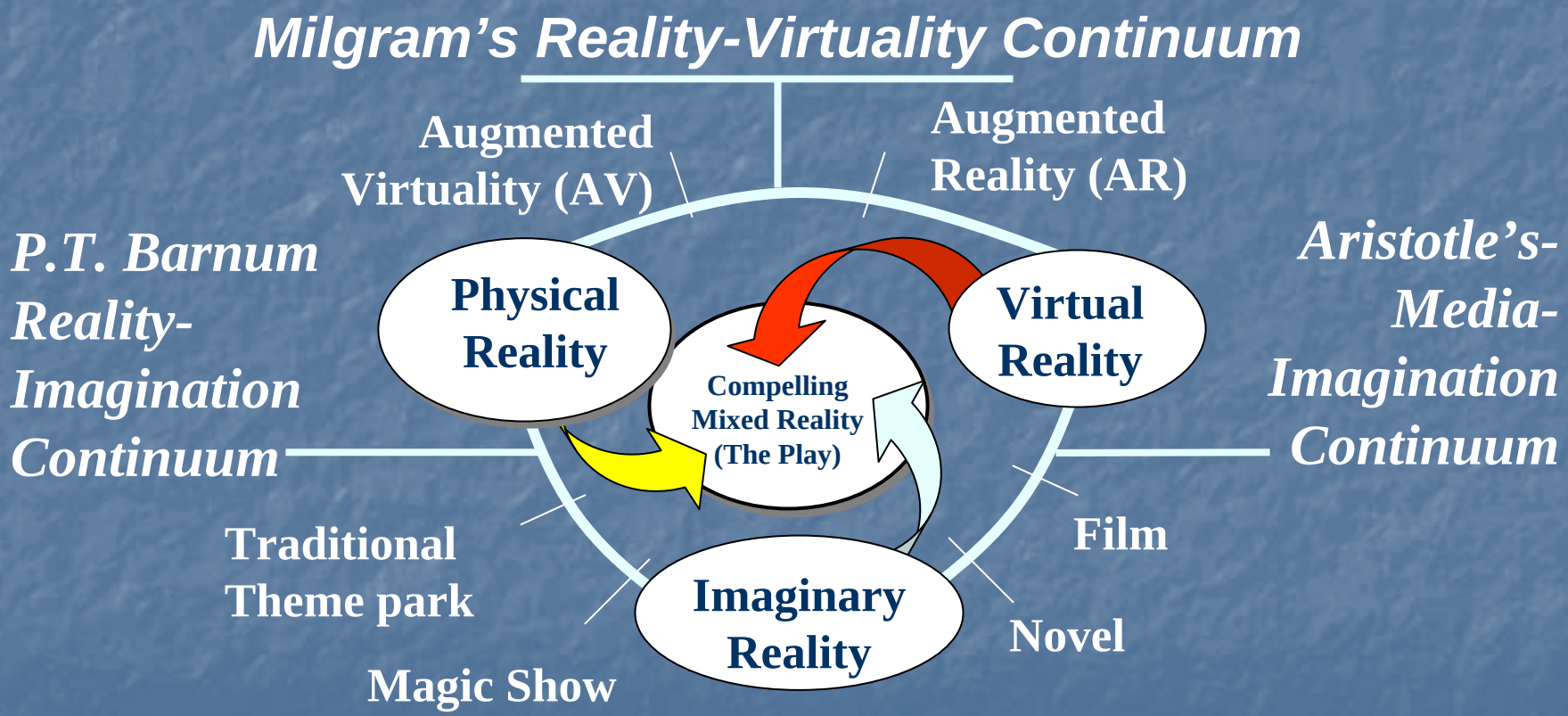


Basic Concepts

Story and multi-modality invite the user's imagination along for the ride

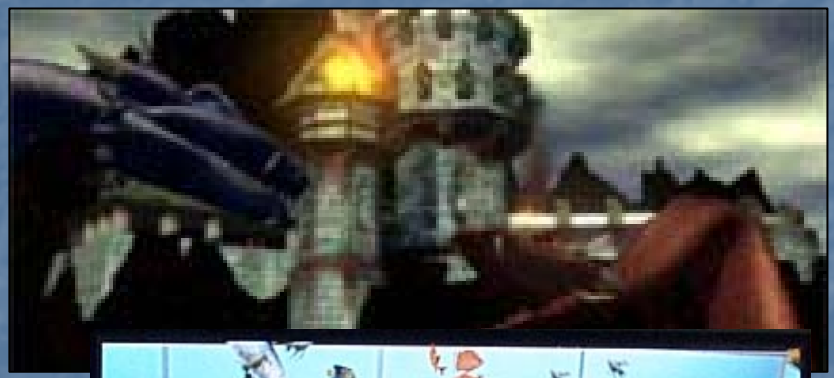
Allow multiple experience levels

Mixed Fantasy Continuum

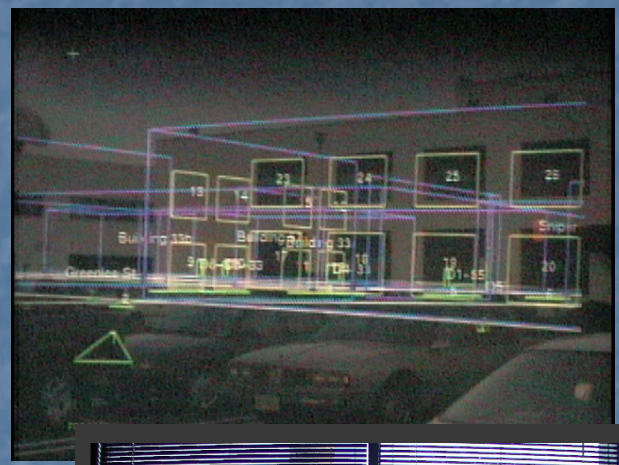


Mixed Reality

VIRTUAL REALITY



AUGMENTED VIRTUALITY



AUGMENTED REALITY

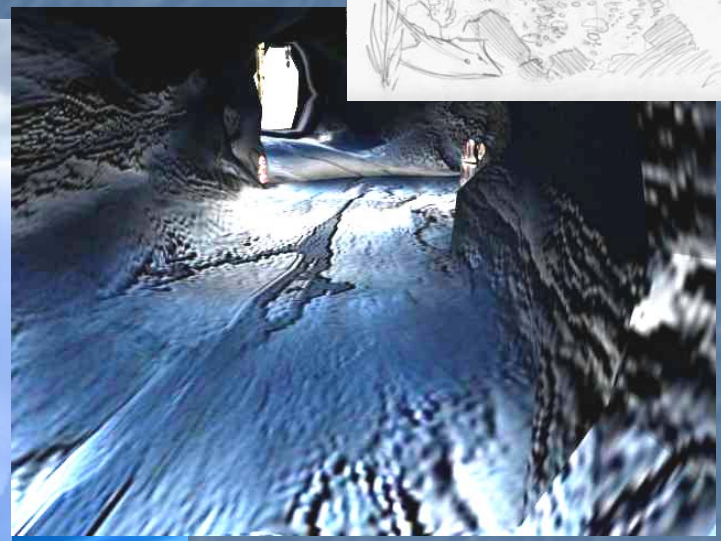
Divers, Swimmers, Waders

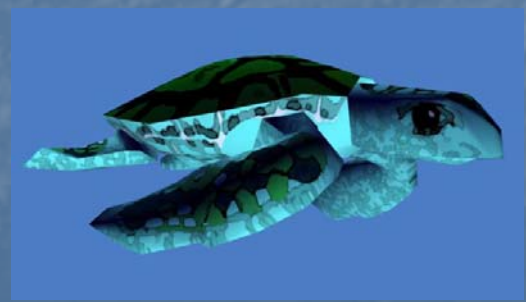
Production

Stories

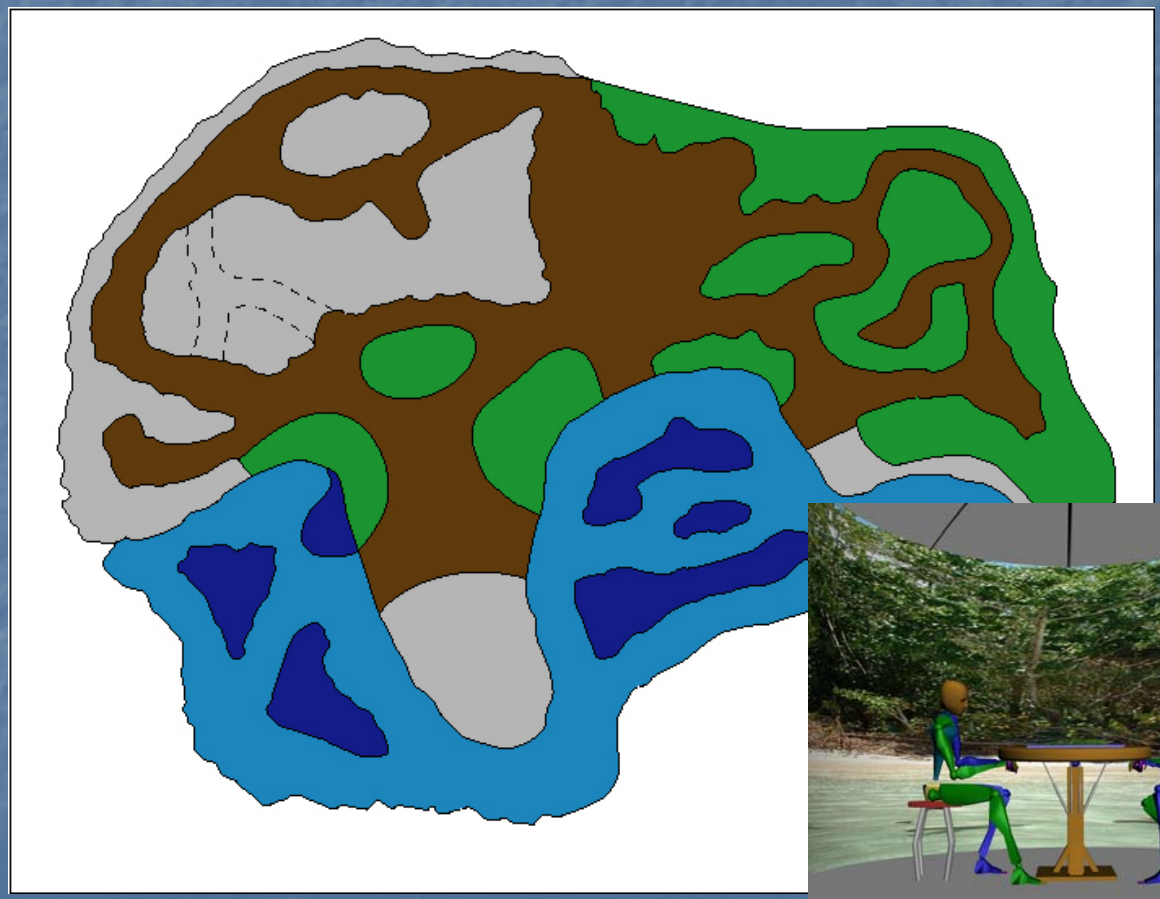
Time Portal

MS Isle

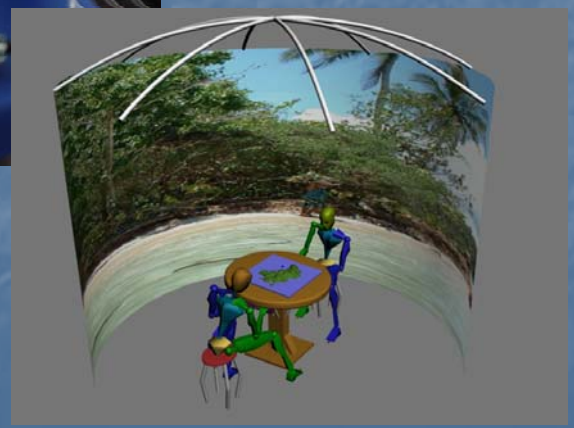




MS Isle Collaboration



Demo Dome Kiosk
Portable & Collaborative



Geeks and Freaks

- Storyboard
- Animatic
- VR experience (linear, non-interactive)
- VR experience (interactive)
- MR experience

- Working prototypes at each stage
- Feedback at each stage

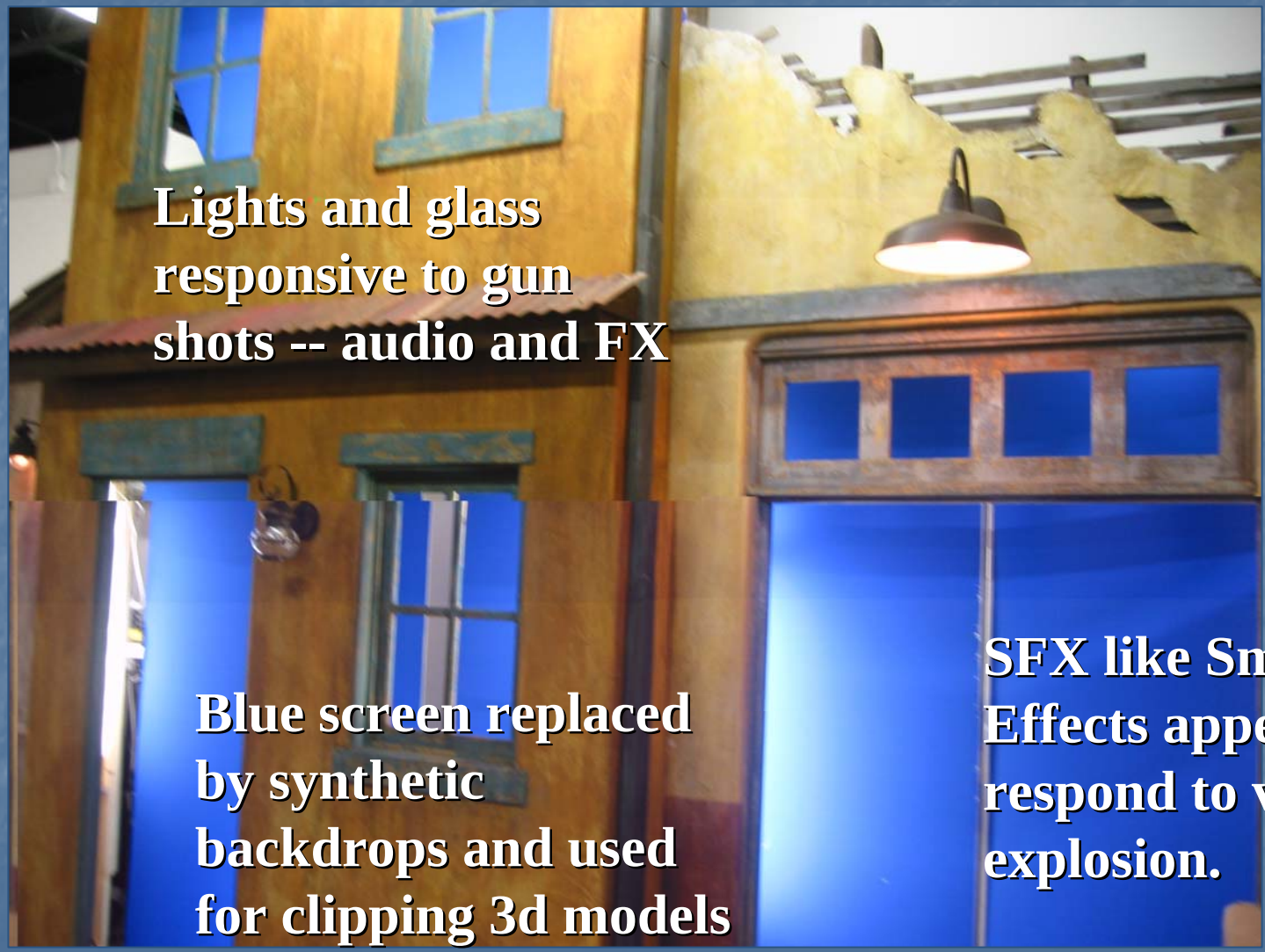
Human Factors Studies

Soon, really

It’s in the mail

MR MOUT

Physical Sets and Activation



Planned HF Testing

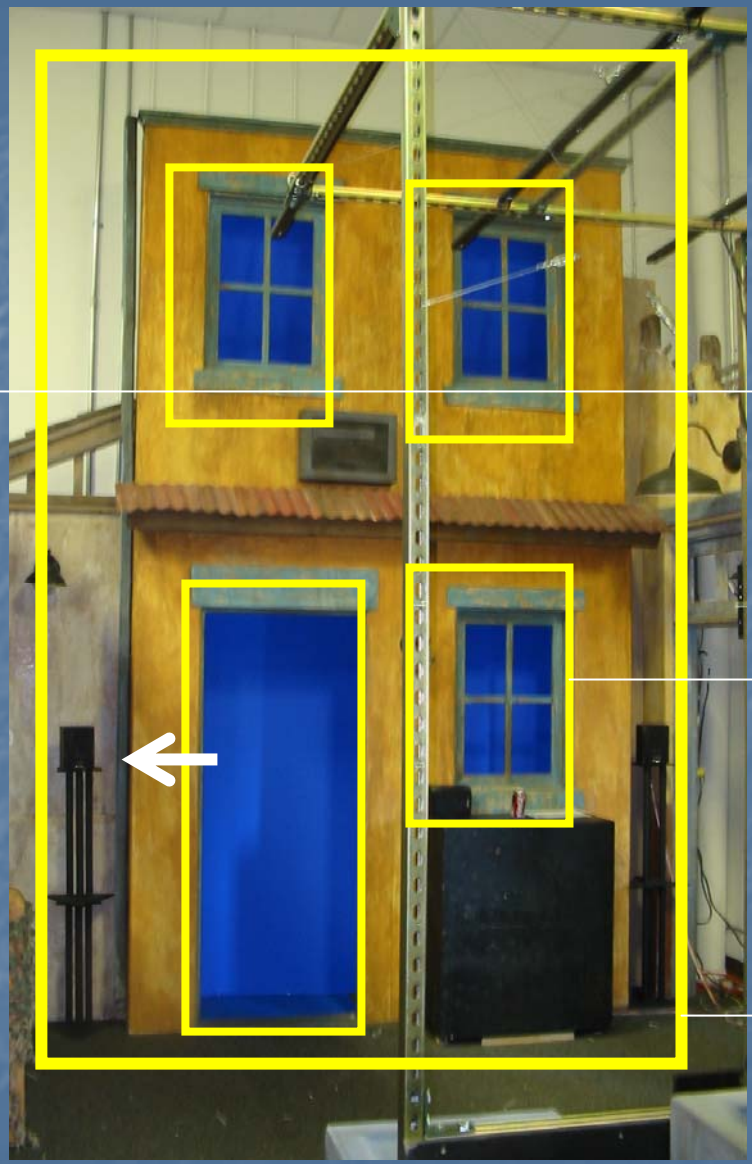
- ARI: Multi-modal cues
  Evaluate effectiveness of Multi-modal (Audio, Visual, A/V, Haptic) Cues Spatially, Directionally, Non-Spatial and non-directional.

- M&S: Mixed Reality Training Effectiveness
  Compare effectiveness of MR spectrum of training (Live, Desktop, VR, MR) with target acquisition under stress.

- MCL: MR Audio Perception
  Audio semantics, Perception of 3D audio display in Y-Axis, Audio/Visual deception in 3D audio display

- MIT$^{2:}$ Leader Decision Making
  Preliminary (MRM 2.5): Time Pressured Decision-making with 3D Spatially registered Visual Cues (vs text-based)
  Secondary (MRM 3.0): Unit Leader Decision Making in MOUT training.

ARI Tests
West Visual Cues



Non Directional, Non Spatial Cue

Fine Detail Spatial Cue

Directional Cue

Rough Detail Spatial cue

Science & Technology

Integrating components

Achieving interactive frame rates

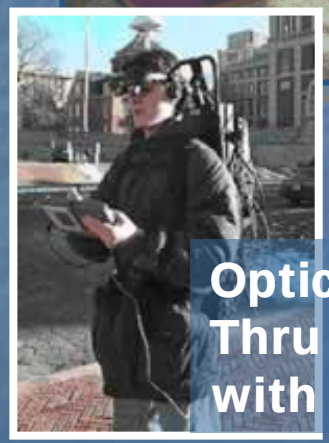
Tools of the Trade

Virtual Assets

Video See-Thru Display with Tracker

Desktop and

Embedded Projection Display



Optical See-Thru Display with GPS

The Pieces

- Graphics engine
  - The workhorse must display and analyze
- Audio engines
  - 3d engine and/or Multiple stereo engines
- Special effects (DMX controlled actuators)
- Sensor servers (trackers, light, sound, ...)
- Story engine (SE)
  - The only one who understands semantics

Delivery System

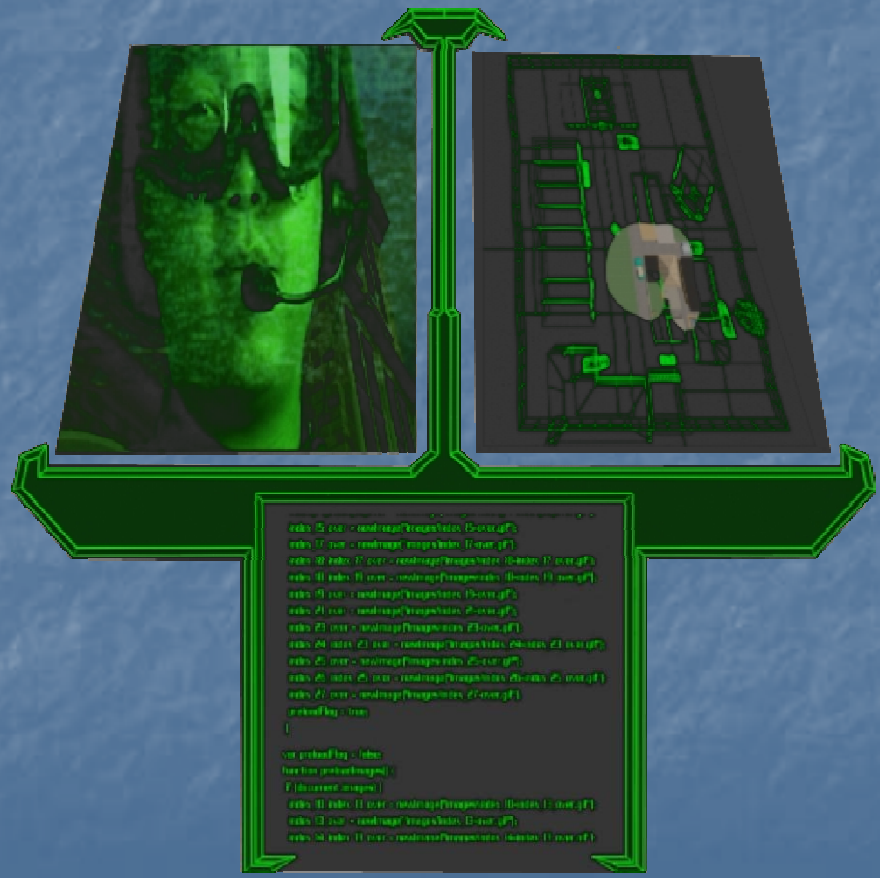
Bringing it Together

Graphics Engine

- Capture real; augment with virtual
  - Blend animations; manage path movement; ...
- Analyze scene and relation to interactions
- Communicate with SE
  - Simple protocol

```
SHARK_PATH MAKE PATH PATH1
SHARK_PATH LOOP
SHARK MAKE MODEL JAWS
SHARK ASSOCIATE SHARK_PATH
SHARK SHOW
SHARK LOOP SWIM 200
USER ASSOCIATE SHARK
USER MOVETO 0 0 –1000 3000
```

Delegated Rendering
Show, Occlude, Hide, HUD
Associate also is relevant



Challenge: Real-Time Mixing of Real / Virtual

- Placement of the virtual objects in the real scene
  - Tracking / Registration
  - Occlusion
- Blending the virtual objects into the real scene
  - Rendering
  - Lighting (even virtual lights on real objects)
  - Shadows (all combinations of real and virtual)
- User interaction with the objects
  - Selecting real/virtual objects
  - Real done with impostors

Placement of Virtual Objects

- Occlusion of virtual by real and vice versa

- Approaches
  - Markers (size estimates depth)
  - Chroma-keying
  - Occlusion models
  - Computing depth by stereo vision for selected objects in scene

Chroma-Keying

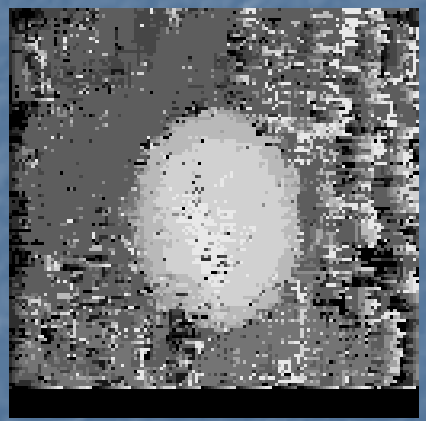
- Allows only two “layers”
  - behind/in front
- Appropriate for portals
  - (doors, windows, etc.)
- Standard in film/TV studios
- Lighting is difficult to control in MR settings

Unidirectional Retro-Reflective Curtain and Personal Lighting

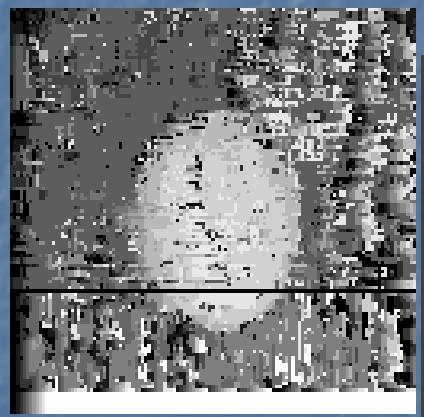
Depth from Stereo

left

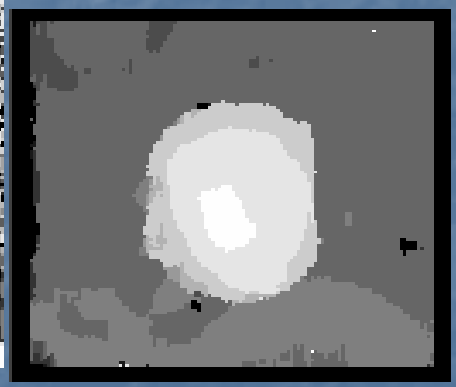
right



CPU: 10.9 ms
GPU: 1.49 ms



CPU + GPU: 1.3 ms



CPU: 113.6 ms

GPU-Based Algorithms

- Recently: 32-bit IEEE-standard floating point
- Performance trends (John Poulton)
  - CPU: 1.7X in a year (14 months to double)
  - GPU: 2.4X in a year (10 months to double)
  - Likely to remain true in the next few years
- Parallelism
  - 8 pipelines
  - Each pipeline operates on 4-vectors
- Advanced functionality
  - Single cycle:
    - Sin and cos
    - Linear interpolation
    - Euclidean distance

Blending the Real and the Virtual

- Using color-transfer to simulate lighting
- Lighting the virtual objects
  - Compute lights from the real scene
    - Dynamic lighting subverts pre-computation
  - Shading algorithms
    - Quality vs. speed
- Shadows
  - Cast by virtual objects
  - Cast by real objects

Rendering and Illumination (real-time using GPU)

42 fps on Radeon 9800

Scene with 80,000 Triangles

Shadows with Virtual Light

with shadow

without shadow

Capturing Real Light

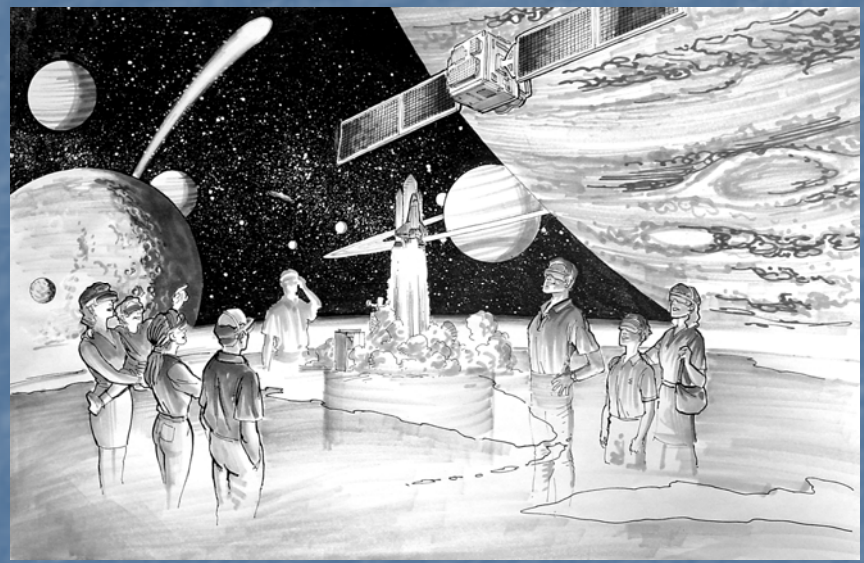
Lady Bug Acquires Dynamic Lighting

Audio Engine(s)

- Communicate with SE using multicast
  - Run forever, once started
- Provide audioscape
  - Synthetic audio: Ambient sounds, SFX, voice commands
  - Event-triggered point source audio
  - 3D Audio directional sound
  - Surround sound

Challenges of Audio for Interactive Environments

- Must provide a means of merging both real and virtual sound sources
- Must be able to place audio in a truly 3D space
- Must have both pinpoint accuracy as well as diffused ambiance
- Must provide accurate acoustical simulation

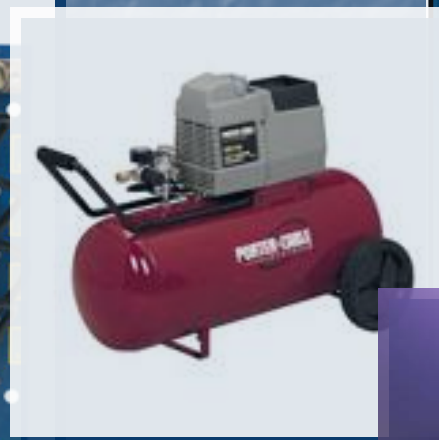


DMX Engine(s)

- Communicate with SE using multicast UDP
  - Can enter early or late
  - Run forever, once started
- Talk to devices using DMX protocol
- Provide show effects
  - Lights
  - Smoke
  - Moving objects (can that gets “hit”)
  - Even falling walls (Styrofoam)

Special Effects

- Colorkinetics SmartJack3 (USB to DMX)
- Colorkinetics JuiceBox2 / iColor MR Lights
- Gilderfluke MP3-50/40
- 4 Channel Dimmer Packs
- Pneumatic / Smoke System
- Sound Transducers (”Bass Shakers”)



Story Engine

- Maintains “ground truth”
- Delegates behavior to various models
  - **Finite state**
  - **Steering**
  - **Anthropomorphic (ant, wolf, …)**
  - **Constraint-based**
  - **Rule-based**
  - **Physics-based**
- Supports after-action review

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Computer Science

Charles E Hughes -- ceh@cs.ucf.edu

Paulius Micikevicius -- paulius@drake.armstrong.edu

Institute for Simulation&Training

Christopher B. Stapleton, + Digital Media -- chris@mcl.ucf.edu

Darin E. Hughes -- darin@mcl.ucf.edu

Scott Malo -- scott@mcl.ucf.edu

Matthew O'Connor -- matt@mcl.ucf.edu