Spatial AR

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Spatial AR

- Key movie:
  - Star Trek’s Holodeck
  - Combining holography with magnetic force fields and energy to matter conversions.

- Key book:
  - Spatial Augmented Reality by Oliver Bimber and Ramesh Raskar

- Other Key people:
  - Chris Schmandt
    - MIT Media Lab
  - Xiang Cao
    - Toronto DGP Lab PhD, MSR, Xiaoxiaoniu CEO, UIST/CHI PC
  - Brett R. Jones
    - UIUC 2014 PhD, MSR, Lumenous CEO

Spatial AR (SAR)

- What Kind of AR?
  - Spatially Immersive Display (SID)
  - Projected AR (Projection Mapping)

- What Kind of Space?
  - Outdoor
  - Indoor (Mostly solved)

- What Problem to Solve?
  - Geometry
  - Rendering
  - Tracking
  - Registration

- What For
  - Military, Education
  - Arts, Gaming

Key References in Spatial AR

- Survey or Book

- Key Innovation

- Key Website
  - http://projection-mapping.org

The Ultimate Display 1965

- "The ultimate display would, of course, be a room within which the computer can control the existence of matter. A chair displayed in such a room would be good enough to sit in. Handcuffs displayed in such a room would be confining, and a bullet displayed in such a room would be fatal. With appropriate programming, such a display could literally be the Wonderland into which Alice walked."

  — I. Sutherland, The Ultimate Display.
Spatial Input/Display Correspondence in a Stereoscopic Computer Graphic Work Station (SIGGRAPH 1983)

Magic wand uses a magnet 6 degree-of-freedom digitizer Tablets was placed within the work space for input intensive tasks


Graphical Marionette (SIGGRAPH 1986)

Video


Virtual Environment Display System (I3D 1986)

An excellent piece of early virtual reality research. NASA Telepresence research. Not mentioned in the text, but clearly the authors envisioned two-handed manipulation (along with voice input and 3D localized sound).

A head-mounted, wide-angle, stereoscopic display system controlled by operator position, voice and gesture has been developed for use as a multi-purpose interface environment.


Interactive Simulation in a Multi-Person Virtual World (CHI 1992)

A multi-user Virtual World has been implemented combining a flexible-object simulator with a multisensory user interface, including hand motion and gesture, speech input and output, sound output, and 3-D stereoscopic graphics with head-motion parallax. The implementation is based on a distributed client/server architecture (cloud computing) with a centralized Dialogue Manager. The simulator is inserted into the Virtual World as a server. A discipline for writing interaction dialogues provides a clear conceptual hierarchy and the encapsulation of state. This hierarchy facilitates the creation of alternative interaction scenarios and shared multi-user environments.


Surround-Screen Projection-Based Virtual Reality: The Design and Implementation of the CAVE (SIGGRAPH 1993)

This paper describes the CAVE (CAVE Automatic Virtual Environment) virtual reality/scientific visualization system in detail and demonstrates that projection technology applied to virtual reality goals achieves a system that matches the quality of workstation screens in terms of resolution, color, and flicker-free stereo. In addition, this format helps reduce the effect of common tracking and system latency errors. The off-axis perspective projection techniques we use are shown to be simple and straightforward. Our techniques for doing multi-screen stereo vision are enumerated, and design barriers, past and current, are described. Advantages and disadvantages of the projection paradigm are discussed, with an analysis of the effect of tracking noise and delay on the user. Successive refinement, a necessary tool for scientific visualization, is developed in the virtual reality context. The use of the CAVE as a one-to-many presentation device at SIGGRAPH ’92 and Supercomputing ’92 for computational science data is also mentioned.


Windows on the World 1993

X11 server
Track head/body/hand and selected objects
User “wears” virtual information surround
Windows fixed to display, surround, world
Hypermedia links between physical and virtual objects
Spatially Immersive Displays (SIGGRAPH 1997)
The Future of Virtual Reality: Head Mounted Displays Versus Spatially Immersive Displays


• Psychological factors are an important limitation:
  • even if HMDs are globally ill-adapted for day-to-day work, users will still avoid them due to weight, eye, and neck fatigue prevent use over several hours.
  • user interface designs appear to be a major source of user discomfort.
  • psychological factors are an important limitation: users are reluctant to use such apparatus.
  • HMDs isolate users from one another; collaborative work in the same room is required to create the illusion of spatially immersive environment, and people can bump into one another.

Field Service 1996
Crossbox telecom junction panel connects clients to main switch
3D graphics identify groups of connection posts
2D windows describe connection status
2D windows can be pulled in/out to avoid clutter
Augmented view: Selected group connected to note

Assist worker in assembling spaceframe building
Goal
- Right piece
- Right place
- Right sequence

The Future of Virtual Reality: Head Mounted Displays Versus Spatially Immersive Displays
HMDs are globally ill-adapted for day-to-day professional applications. A key founding component of the VR concept, HMDs have become less user-friendly, less expensive and thus increased performance. But:
- even if high resolutions and wide field of view required for professional applications; ordinary appear, performance ratio may be driven by reality. Therefore, price will increase faster than performance improves.
- weight, eye, and neck fatigue prevent use over several hours; this is not likely to change even with newly improved performance.
- psychological factors are an important limitation: engineers and decision-makers are very reluctant to use such apparatus.
- HMDs isolate users from one another; collaborative work in the same area is required to create the illusion of spatial immersive environment, and people can bump into one another.

Tools (3D widgets) and a 3D interface.
User examines architectural structures and tools.
2D windows can be pulled in/out to avoid clutter.

The Office of the Future: A Unified Approach to Image Based Modeling and Spatially Immersive Displays
While we are making progress toward our vision for the office of the future, we do not yet have a complete working system. While there are the definitions floating around, the reality is that the ideas described in the paper are not yet fully implemented or standardized. But:
- they provide a better sense of presence through a very large field of view (up to 180° for the ARC Dome and a high-resolution (2000 x 2000) at eye level).
- they allow users to work through reduced fatigue, including isnostroscopy.
- they allow the presence of multiple users in the same environment, who can communicate naturally together.
- large models can be displayed (prints, plane segments, plane sections) as a single interface that is used around with HMD.
- they are very well adapted for applications in which the user interacts strongly with the environment through Virtual Tools (3D-widgets) and a 3D interface.

Touring Machine 1996–
UI: Overlaid Labels UI: Overlaid Labels
Touring Machine: Columbia Campus

The Office of the Future: A Unified Approach to Image Based Modeling and Spatially Immersive Displays
http://www.virtual-reality.com

- David Bennett has 18 years of experience in the visual effects, performance capture, 3d gaming and virtual reality industries.
- http://www.mimicproductions.com

Information Filtering Information Filtering 2000

- Unfiltered: All objects shown
- Filtered: Only objects relevant to route-finding task are shown

UI Component Design

Shader Lamps: Animating Real Objects with Image-Based Illumination (EUROGRAPHICS 2001)

- USC
- Shader Lamps first developed the idea of augmenting the colors of physical objects with video projection, appropriating everyday physical objects as displays

The Everywhere Displays Projector: A device to create ubiquitous graphical interfaces (Ubicomp 2001)

- IBM
- "The Everywhere Displays Projector" allows users to create graphical interfaces on almost any surface
A Self-Correcting Projector (CVPR 2001)


iLamps: Geometrically Aware and Self-Configuring Projectors (SIGGRAPH 2003)

- Pioneer work on handheld projector
- The prototype of Augmentarium
- The focus of this paper is geometry. Successive sections address issues about the geometry of display surfaces, 3D motion of a hand-held projector, and geometry of a projector cluster.
  - Specifically
    - Shape-adaptive display
    - Object-adaptive display
    - Planar display using a cluster of projectors
    - Curved display using a cluster of projectors

Interaction Using a Handheld Projector (IEEE CGA)

- Pioneer work on handheld projector
- It avoids a context switch between the physical object and screen.
- It avoids resolution problems if a complex scene is being rendered on a small screen.
- Temporary, opportunistic placement of the projector lets the user operate around the workspace without holding a handheld device but still have the augmentation available.
- When required, projection is the most natural approach for shared multi-person viewing of the augmentation.

Interaction Using a Handheld Projector (IEEE CGA)

- Our work has explored a variety of techniques and widgets for interacting with large scale displays using a buttonless passive wand tracked in 3D.
- While our tracking implementation could be improved, it was more than sufficient to explore a wide range of alternatives. Our own experience with using the system, and observations during our informal user study, indicate that the gestures and postures of wand based interaction is easily understood and used.
- As our interaction with computers increasingly moves away from the standard desktop to other forms, including large displays, it is critical that we continue to explore alternative input and interaction modalities that are well suited to the new media. The work presented here is one step in this exploration. Reference

VisionWand: Interaction Techniques for Large Displays Using a Passive Wand Tracked in 3D (UIST 03 Best Paper + SIGGRAPH 03)

- Video
- Our work has explored a variety of techniques and widgets for interacting with large scale displays using a buttonless passive wand tracked in 3D.
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Interacting with Dynamically Defined Information Spaces using a Handheld Projector and a Pen (UIST ’06)

- Video
- Building on these unique affordances of handheld projectors, we explore techniques for dynamically defining and interacting with multiple information spaces embedded in the physical environment using a handheld projector.
- To enrich the interaction possibilities and leverage human ability to perform bimanual tasks, a passive pen is also used to support interactions and local interactions.
- We then explore several usage scenarios supported by the system.

Build Your World and Play in It: Interacting with Surface Particles on Complex Objects (ISMAR 2010)

- Video
- This work has explored a variety of techniques and widgets for interacting with large scale displays using a buttonless passive wand tracked in 3D.
- Our work has explored a variety of techniques and widgets for interacting with large scale displays using a buttonless passive wand tracked in 3D.
HoloDesk: Direct 3D Interactions with a Situated See-Through Display (CHI ‘12)

- https://www.youtube.com/watch?v=JHL5tJ9ja_w

Scanning and Tracking Dynamic Objects with Commodity Depth Cameras (ISMAR ‘13)

IllumiRoom: Projects Images Beyond Your TV for an Immersive Gaming Experience (CHI ‘13)

- Video Trailer
- CHI Best Paper Award, Best Video Award
- Implementation and Invention of multi-camera, multi-camera system to enable generation of peripheral projected illusions
- Implementation of 11 illusions that demonstrate the importance and potential of peripheral projected illusions
- Analysis of the design space of peripheral projected illusions
- Feedback from 10 casual gamers and 15 expert game designers over two separate evaluations showing the most promising dimensions of the design space

RoomAlive: Magical Experiences Enabled by Scalable, Adaptive Projector Camera Units (UIST ‘14)

- Video
- RoomAlive: Magic experiences enabled by scalable, adaptive projector-camera units.
- The video captures and analyzes a unified 3D model of the appearance and geometry of the room.
- DirectX planar surface for AR
- distributed framework to track body movement
- touch detection using optical flow
- pointing using an infrared gun

Dyadic Projected Spatial Augmented Reality (UIST ‘14)

- Video
- A room-scale SAR system supporting dyadic interactions, including a number of early demonstrations.
- A study which tests users’ ability to correctly perceive the distance and size of 2D virtual objects rendered in projected SAR.
- A study which tests users’ ability to determine which of several objects is indicated by the other user’s pointing gesture.

Commercial Projection Mapping (Spatial AR)

Video
Conductive Ink + Projection Mapping = Magic Storytelling

https://vimeo.com/121878247

Pushing the boundaries of storytelling within a space, making it fun and engaging, putting ideas before hardware. A total of 48 interactions and over 100 unique animations make up the broad spectrum of content on the stand, from simple sound toys to more complex exchanges that layer projection mapping and movement around a physical space.

THAT WAS PROJECTION MAPPING on JENNIFER LOPEZ's DRESS!

https://www.youtube.com/watch?v=N0v6ITyTWv4

Racing Extinction and #ProjectingChange

https://vimeo.com/121647251

Lumipen 2: Robust Tracking for Dynamic Projection Mapping (Ishikawa Watanabe Laboratory 2015)

My fun works in SAR on

- 3DVAR (2012): From 3D Reconstruction to Virtual and Augmented Reality
- Enchanting Ema (2014): A Magical Interpretation of Ancient Japanese Beliefs

The END