Collaborative VideoWalls

Laboratory for Computer Science Research

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Vision: incorporating interactive video

Metropolis (1927)  Bell Labs, 1964 World's Fair

Total Recall (1990)
2015: Vision Realized

Skype

Facetime
But current tech is still limited

How to enable natural group interactivity at a distance?

Workgroup (<10)  Seminar (~25)

Banquet (~150)  Lecture (>300)
Existing models are limited approximations

Limited spatial perspectives (e.g., 3 cameras)
Manual control of perspective
Small viewing areas
Approach and Principles

Goal: Enable group interactivity with existing models
- Core value of the educational processes

Principles:
- Emulate spatial experience with technology
- Users should not change – tech should accommodate
- Approximate spatial paradigms when necessary

Approach:
- Video: Array of cameras and monitors to emulate visual experience
- Audio: Array of microphones and speakers to emulate audio sensation
Videowalls: Enabling Natural Human Interaction
Outline

Introduction
Opportunity
Building video walls
Experiences and use cases
Future work and conclusions
Enabling Trend: Transistors per Chip

CPU Transistor Counts 1971-2008 & Moore’s Law

- 8080
- 286
- Pentium
- 10 core Xeon

Curve shows ‘Moore’s Law’: transistor count doubling every two years.
Enabling Trend: Camera Pixels/$
Enabling Trend: Display Pixels/$

32inch LCD prices

Year

$
Enabling Technology: Systems on a Chip

BCM2835 SoC: Full Linux OS
- Networking
- Security
- Monitoring/reporting

512 MB DRAM
Hardware Video Stream
Encode/Decoders
Graphics/Rendering
Camera Encoders
HDMI output
Stereo audio out
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Building a Wall: Architectural Approach

Use a collection of screens, cameras and microphones

- Similar to RAID storage, striped networks

Compressed Internet streams of video and audio are the unit of abstraction

Software combines streams into a single logical device
Building a Wall: Display Architecture

Tiled set of screens instead of 1 large screen:
- Increased resolution maintaining commodity pricing (pixels/$)
- Flexibility in sizing using different screen sizes and number of screens

Challenge:
- Introduces seam artifacts (bezels … more later)
Building a Wall: Camera Architecture

Tiled set of adjustable cameras
- Increased resolution with commodity pricing (pixels/$)
- Allows multiple viewpoints for realistic perspectives
- Camera adjustment enables many room layouts.

Challenges:
- Holes in view
- Overlaps in view
- Sweet spot is 5'-15' away
Videowall Architecture

Cameras' Field of View

Displays

Speaker

Triple Microphone

H.264 streams

Celt audio stream
Logical Object Discretization for Tiled Displays
Additional Technical Challenges

Network Bandwidth
- H.264 hardware encoders @ 1080p → 3.4 Mbps/stream
- Sensitive to loss → Use TCP

Latency for Interactivity
- Challenge: keep one-way latency < ½ second for all streams
- H.264 encoder
  - Frame rate
  - Buffer sizes
- Audio processing
  - What layer to put echo cancellation?
  - Reduced a lot of processing to improve latency.
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Using Videowalls as Wormholes for workgroups and seminars
Experiences with a Chinese lecture

Small: 4 and 3, students, 1 instructor
- use of white board OK
- Group results worked well
Experiences with Colloquia

Added a camera focused on the speaker's slides

Display on a local projector

Can view the active participants
Existing Deployments

Aidekman Seminar Room
Newark

Dana Library Newark

Psychology Room 101
Piscataway

Language Laboratory
New Brunswick
Short term next steps

2 language classes between New Brunswick and Newark
  - Portuguese for Business
  - Brazilian Literature
  - Instructors in Newark, students in Newark and New Brunswick

Plan to connect Hickman Hall on Douglass campus to Marymount Manhattan College
  - Enable Masters in Political Science with Concentration in United Nations and Global Policy Studies
  - Instructors and students in Manhattan and New Brunswick
Future work: Tiled classroom
Future architecture for remote users

Use middleware services. Adds latency.

- Single incoming and outgoing stream from Media Router per display.
- Incoming rotation and scaling performed.

- Single incoming and outgoing stream from Media Router per display.
- Incoming streams from all sources split and redistributed.
- Streams combined constructed
- Multiple outgoing scaling/quality performed.
Open Questions

Video encoding
  - Perform basic video operations while maintaining computational efficiency in real time?
    • E.g., Crop, scale, overlay, merge

Audio:
  - Real time surround sound?

Usage: include remote users with small screens?
  - Connectivity with other clients (e.g. Skype)
  - How to present videowall at small scales?

Working with seams
  - Seamless displays are not necessary if logically discretized. APIs to support?

Does network quality reach continental and international scales?
Conclusions

Videowalls enable natural group interaction
  – Goes beyond Skype, Facetime, Hangout, Cisco C90

Titled displays and distributed processing/network architecture

Using embedded SoCs key to reducing cost, power, and heat

More software development and experimentation are needed to enable remote users, better audio (e.g. music lesson), and multi-way walls.
More information

http://videowall.rutgers.edu
Backup slides