Capture and Display for Live Immersive 3D Entertainment

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THE TAKE AWAY FROM THIS PRESENTATION

We create compelling cost effective immersive 3D experiences through scalable *camera* and *projector systems*:

- **Life-sized**
- **Ultra high resolution as needed for immersive viewing**
- **Capture and display aspect ratio as appropriate for the panoramic experience**
- **Multiview for 3D *capture* and *display***

See our work at:

http://hpl.hp.com/research/pluribus

http://www8.hp.com/us/en/ad/photonengine/form.html?jumpid=ex_r11260_go_3dinnovations

http://www.hpl.hp.com/personal/Harlyn_Baker/

ABSTRACT

- We describe methods, accomplishments, and direction in a lab-corporate collaborative project over the past year and a half.
- With the goal of taking new immersive technologies to a growing customer base through in-situ demonstrations and experiments, we are combining novel capture and display capabilities in delivering life-sized immersive 3D entertainment experiences.
- We describe scaleable adaptations and innovations needed in delivering immersive life sized 3D to large audiences.

INTRODUCTION

3D is in demand:

- Delivery of live local and off-site presentation of entertainment events such as sports, concerts, and limited-run productions is accelerating:
  i.e., NBA playoffs, World Cup finals, NASCAR races, music concerts, Masters Golf tournament, …

Considering the high end fan base, premium viewing experiences extend the product reach with unique and memorable experiences. *Give everyone the best seat in the house.*

Transmitting live 3D sporting events, e.g., overseas: eliminates high overhead (travel etc.) and multiplies the audience. The opportunities are huge.

BUT, capturing and delivering a compelling 3D experience for live events remains difficult and costly

Cameras:

CG permits retakes, live events don't. Acceptable capture can be challenging.

- Limited fields of view; rapid viewpoint, pan, zoom, and vergence adjustments
- An active camera can cause nausea and fatigue in 3D viewers
- Alternative of a multiple camera solution brings extreme cost (equipment and operators)

Display:

Reality is ultra-HD and panoramic. Simple HD doesn't do it for life-size life-like display.

HP Labs:

Provide complete FOV: entire basketball court; full concert stage, panoramic of special events

- Closer to the *in-arena* experience
- A rich, reduced-cost *like-being-there* 3D experience

The fan watches the action move across the screen rather than having the screen follow the action, with the eyes free to explore (i.e., scoreboard, players, cheer-leaders, other attendees, etc.) all at high resolution.

Mosaicking (22 images → 1)

BabyCam: 30 imagers, same calibration process

Triple-wide 5-view multi-imager camera

Modular multicamera

Extended baseline MultiCam

NBA Cam
(triple-wide binocular stereo)

EWF Concert Cam

RunwayCam
Multi-view multi-baseline
plus 3D portrait at end

Runway Shots (~constant pixels per inch)

Triple-wide HD 3D camera system at the NBA Summer League designed to capture the full court (5760x1080 images, left-right pair)

CAPTURING ULTRAWIDE MULTIVIEW

GOAL:

To provide an immersive 3D view of an event – greater than a single gaze can encompass

REQUIRES:

- Non-standard format imaging: *mosaic to desired shape*
- Rectification of multi cameras for Epipolar alignment
- High video rates to display and simultaneous archival
- Calibration of mosaicking and Epipolar rectification

PROBLEMS:

- Huge data bandwidth
- Synchronization
- Positioning site unlikely to be ideal *(i.e., far from the desired for viewer)*
- Have viewers behave as though present (eyes see 50°field of view, so turn head to take in all) = *presence*
- No "Director" — viewers select content individually from available full scene
- Reduce cost to enable deployment *(minimal crew and gear complexity)*
- Visual distortions based on distance and baseline (*roundness* and *perspective*)

SOLUTION:

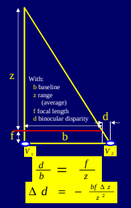
- HP/ISD Herodion HD multi-imager camera array on PCIe bus (Altasens 3372E3-4T)
- Gang imagers as desired *(for mosaic, multi-view, portrait, landscape, etc.)*
- Configure for total imaging effect
- Calibration and over-provisioning enable mechanics-free run-time adjustments
- Camera configurations designed considering *roundness* and *perspective* effects
- LSI 9260-16i RAID array controllers on PCIe bus
- Seagate 1TB SFF SAS disks (12)
- Automated calibration (after Li-Baker 3DPVT 2010, and Kurillo UCB)
- GPU resampling, coloring, and rendering
- Fiber optic links to display

Immersive *Panoramic* Image Capture

- Synchronized camera array of HD 1080p60 imagers from a single workstation
- Novel configurations (portrait, landscape, variable baselines)
- Seamless mosaicking (imagers close to each other to minimize artifacts
  -- we place one over the other)

Immersive *3D Multiview* Image Capture

- Two–eye (or more) capture for 3D:
  - Implies a *viewing distance* and *baseline*
  - Unlikely to be located where one wants
- Problem 1: ***Roundness***. Change in disparity with change in depth: isotropic?
- Problem 2: ***Gigantism*** and ***Miniaturization***. Reprojected perspective
- **Key Capture Technical Contributions:**
  - Automated simultaneous calibration for panoramic mosaicking and Epipolar alignment (plus color)
  - 6-stream 1080P60 acquisition with full bandwidth store to disk (~1Gbps per stream)
  - Sharpening and denoising GPU pipeline
  - Automated and interactive tools for ganged focus and exposure, etc., sensor register settings



Roundness Constraint

DISPLAYING ULTRAWIDE STEREO

GOAL:

To enable life-size immersive 3D stereoscopic experiences

REQUIRES:

- Large and complex surfaces
- High resolution and brightness
- Synchronization across displays and workstations
- Calibration across displays and workstations

PROBLEM:

These are hard to scale to the sizes we want

SOLUTION:

Flexible configurations of 3D multi-projector systems

- Consumer-grade 1080P-WUXGA resolution projectors, tiled and superimposed seamlessly
- Camera-based automated calibration delivers real-time synchronized 60Hz tiled rendering using GPUs
- Polarization means continuous images (brighter and no flicker)
- Software solution frees us from fixed resolutions and aspect ratios, removing alignment problems
- Sufficiently bright under room lighting to support comfortable simultaneous social interaction
- **Key Display Technical Contributions:**
  - Improved calibration algorithms for larger sized displays
  - Synchronized live 4x1080p60 video ingestion
  - Improved ambient-rejecting rear projection screens
  - Scalable platform to support synchronized rendering across multiple workstations

Projector configurations for multi-HD 3D display.

20'x11' stereo display of Stevie Wonder and EWF at CES 2011:
presenting an immersive 3D experience through life-sized scale and resolution

Earth Wind & Fire at CES, Double-wide 19 imagers with 3 focal lengths (for zoom coverage)

VALIDATION

Design and deployment of multi-imager camera systems and multi-projector display systems to meet demand:

- Camera systems:
  - Triple-wide binocular camera (~ 5760x1080x2) and double-wide triple-view (3840x1080x3) for near-range viewing of full-court basketball
  - 12-imager varied-resolution system for fashion runway viewing *(3 landscapes plus stop-and-turn)*
  - 19-imager system for varied-resolution concert capture
  - Adjustable configurations:
    - Ultra-wide angle 5mm near range 65mm baseline (@15')
    - 12mm triple- view double-wide 130mm baseline (@50')
    - Telephoto 25mm 3vDW 200mm baseline (@100')

  All adapted for *roundness* and *perspective* balance
- Display systems:
  - Double-wide HD 22'x6' 3D 8 WUXGA projectors, supporting up to 4x1080P60 synchronized video via 3G HD-SDI over fiber
  - Double-wide HD 36'x11' 3D 24-projectors
  - Numerous smaller formats in portrait mode for fashion and celebrity-wall stereo display

Demonstrating capture and display technology at numerous venues over the past year

- 11'x6' 3D rear-projection HD wall at Sundance Film Festival and a corporate executive briefing conference; similar at High-end fashion in Beijing, High-end designer in Italy and Switzerland, Marchesa fashion in NYC plus at Fashion Week 2011.
- Herodion capture to disk (30' setback) with live consumer stereo video to double-wide display at NBA Summer League; similar at Fashion Week 2010 (50' setback) and CES (150' setback)
- Simultaneous Herodion and 36' double-wide display at Lab Warehouse site (20', 50', 100' captures)

Curved tiled+superpositioned wall, 8' high

Prototype 22'x6' double-wide HD (3840x1080 @ 60 fps) 3D display using eight tiled+superimposed projectors.

36'x11' stereo 3D screen

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