MobileTI: A Portable Tele-Immersive System

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This is a collaborative project with University of California, Berkeley, NCSA, and University of California, Davis.
Background: Tele-Immersive Systems

Applications in wheelchair basketball training, medical consultation, military rehabilitation, gaming, etc.
Motivation for MobileTI

• Tele-immersion (TI) is particularly useful for physical activities where full-body motion is intensively involved.

• Most applications demand high portability of the system, so that the users can easily take the equipment and set them up in the areas they deem fit.

Photos courtesy of University of California, Berkeley
Challenges in Existing Design

- Unpredictable *physical environment*, possibly with strong lights, shadows, moving objects in the background
- Bulky *capturing* setup with handmade 3D camera clusters that are hard to move
- Hard wires connecting time *synchronization* trigger server to all 2D cameras on clusters
- Many *networking* elements required to aggregate distributed user data
MobileTI Overview

- **Capturing**: use portable 3D cameras
- **Synchronization**: use wireless triggering
- **Networking**: use virtual machines
Physical Environment

- Positioning of equipment
  - 3D virtual space projected onto a large screen
  - Camera set up next to the screen
  - Camera’s field of view marked on the floor

- Partial control of physical environment
  - Use black curtain used to improve background subtraction to reduce light changes, shadows, and background movement in the open areas
3D Video Acquisition

- Point Grey Bumblebee2 3D camera set up on tripods for capturing
  - Compact size for portability
  - Self-calibrated to avoid re-calibration
  - With ASIC inside that accelerates depth computation
- Mesh-based data [1] representation replaces point clouds
  - Texture-based triangulation reducing amount of data to transfer, thus reducing bandwidth demand

Time Synchronization

- **Wireless triggering** replaces the wired method
  - A server MicaZ mote sending out broadcast packets adaptively (waiting for all cameras to ACK before firing the next signal)
  - A client MicaZ mote connected to each camera (triggering image grabbing upon receiving a packet)
Networking

Virtualization is used to minimize the amount of networking elements.

- traditional setting: one gateway machine in each site
- with virtualization: one gateway control center running N virtualized gateway instances for N sites

- Mesh-based data representation makes wireless data transmission a possibility
- with slight performance degradation

<table>
<thead>
<tr>
<th>Table 1: 3D Video Frame Rate (fps)</th>
<th>Workstation with wired network</th>
<th>Laptop with wireless network</th>
</tr>
</thead>
<tbody>
<tr>
<td>No user</td>
<td>20.2</td>
<td>18.6</td>
</tr>
<tr>
<td>1 user</td>
<td>19.7</td>
<td>17.3</td>
</tr>
<tr>
<td>2 users</td>
<td>18.3</td>
<td>15.3</td>
</tr>
<tr>
<td>More users</td>
<td>16.1</td>
<td>13.8</td>
</tr>
</tbody>
</table>
Experiments

- MobileTI deployed in a public performance center at University of Illinois
- Two sites set up about 100 feet away
- 4 professional dancers and around 60 audiences
- Games engaging audience (“Simon says”, “Twister”)
Lessons Learned for Video Acquisition

- **Lights** on the stage should be avoided as they cause heavy shadows on the background.

- **Background selection** should consider avoidance of external light sources and open areas where people move frequently.

- The background **color** must be distinguishable from the color of clothes and skin of performers.

- The performances are encouraged to wear light color **clothes**.
Acknowledgement

• Contact author: wwu23@illinois.edu

• Project Website:
  • http://cairo.cs.uiuc.edu/projects/teleimmersion/
  • http://cairo.cs.uiuc.edu/projects/Hmedia/

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