The Blue-C: Integrating Real Humans into a Networked Immersive Environment

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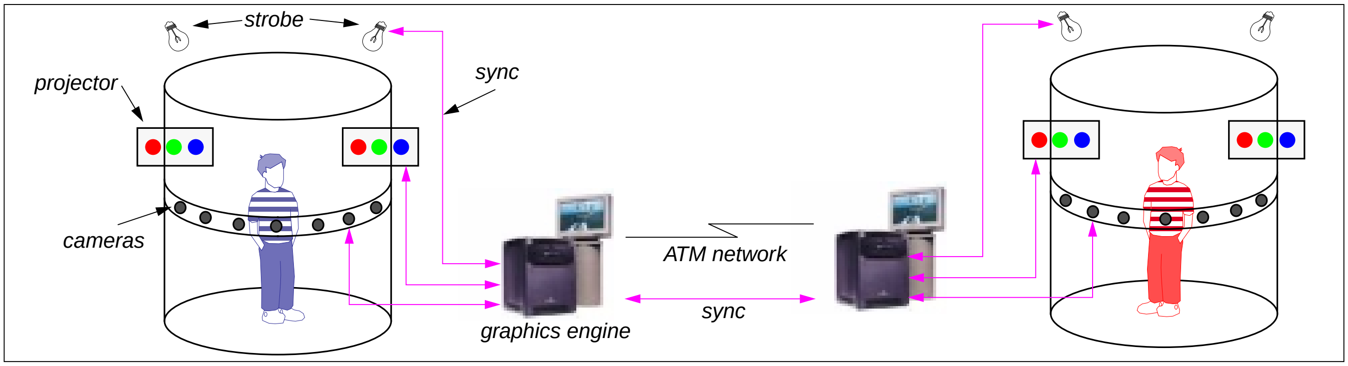

Figure 1: Schematic setup of the Blue-C. environment.

ABSTRACT

In this paper, we report ongoing work in a new project, *The Blue-C*. The goal of this project is to build a collaborative, immersive virtual environment which will eventually integrate real humans, captured by a set of video cameras. Two Blue-C.s will be interconnected via a high-speed network. This will allow for bi-directional collaboration and interaction between two persons sharing virtual spaces.

The video streams are used for both texture and geometry extraction. We will generate a 3-D light field inlay enriched with the reconstructed geometry, which will be integrated into the virtual environment.

The design and construction of the Blue-C. environment, including both hardware and software, is an interdisciplinary effort with participants from the departments of computer science, architecture, product development, and electrical engineering. Parallel to the development of the core system, we are designing new applications in the areas of computer aided architectural design, product reviewing, and medicine, which will highlight the versatility of the Blue-C.

Keywords

virtual reality, immersive environments, collaboration, interaction, telepresence, telecollaboration.

1. INTRODUCTION

The use of *spatially immersed displays* (SID) has become increasingly popular over the past decade. They enable the user to work in virtual spaces while being physically surrounded with a panorama of imagery [3]. Probably the most common SID used today is the CAVE™ or one of its variants [1]. This environment typically comprises a room-sized cubical with up to six back-projection units. Distributed versions of SIDs allow users to interact with remote collaborators in telecollaboration applications. Those systems usually integrate video-based human avatars, possibly enhanced with pre-constructed geometric models, into the virtual environment [4, 2, 5].

A different approach to constructing dedicated SIDs, is to integrate the projection units and the projection surfaces directly into existing office environments. The *office of the future* [7] is a good example.

Full integration of human collaborators into SID environments, as opposed to using video-based avatars, is still an open problem. In the Blue-C. environment, we will extract both textures and geometric information from up to 16 live-video streams. It is especially important to enhance the texture information with accurate geometric data. This information is needed to solve the problem of occlusion, which often arises when placing purely image-based models into synthetic environments.

One of the major challenges is the demand for simultaneous video acquisition and projection. To solve this problem, we introduce a new method which employs modified active stereo shutter glasses.

In the remainder of this paper, we give a brief overview of the different components of the Blue-C.

2. COMPONENTS OF THE BLUE-C.

Figure 1 depicts the setup and conceptual components of the Blue-C. The envisioned approach features the following hardware and software components:

- **Projectors** for real time video image projection
- **Cameras** to acquire raw video image data
- **Stroboscope** to actively illuminate the Blue-C. during acquisition
- **Tracking system** to provide positional information
- **Real-time video processing** to perform compression and geometric reconstruction of 3D information
- **Graphics rendering engine** for real-time 3D rendering
- **Infrared emitter and shutter glasses** for both stereo view generation and black-shuttering during acquisition
- **Blue-C. Communication Layer (BCL)** for controlling and synchronizing all Blue-C. devices and managing network communication
- **Application Building Interface Toolkit (ABIT)** providing a high-level API for the design of sophisticated application scenarios
- **Audio and sound synthesis** for advanced sound transmission and synthesis

The video streams will provide raw data, both for geometric and photometric reconstruction. Real-time subsystems will perform all required computational tasks, such as lightfield approximation, video texture compression, silhouette extraction, geometric modeling and compression. The encoded geometric and photometric information will be transmitted over a high-speed ATM network in real-time, 3-D composed and rendered by the graphics rendering subsystem as a *geometry enriched light field* [6]. Sound and voice will be transmitted and rendered using a conventional multi-channel sound environment.

The color of the Blue-C. projection screens has to be determined thoroughly to balance robustness of silhouette extraction or similar reconstruction methods against color distortions of the video projection. The projectors have to be color-calibrated accordingly.

3. ACTIVE ILLUMINATION

Our basic idea is to illuminate the Blue-C. actively with a stroboscopic light source during video image acquisition. The stroboscope will be synchronized with the cameras, the projectors and with the shutter glasses, which are needed to generate stereoscopic views in conventional SIDs. We have modified the electronics of the glasses which control the shutter, by symmetrically inserting a new black phase at the change from the opaque phase of the left eye to the opaque phase of the right eye. This is accomplished by dilation of the original dark phases for both eyes. Note that by doing this, there is no need to modify the electronics of the projectors or the infrared emitter. Hence, the infrared emitter is used to control the synchronization of all components. Figure 2 depicts the phase sequencing and synchronization of the shutter glasses and the stroboscope.

Video image acquisition will be accomplished during this fully-opaque phase by shooting the strobe flash and recording a single video frame.

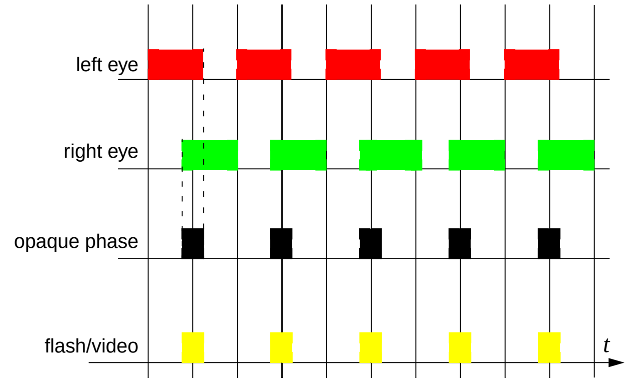

Figure 2: Phase sequencing of the shutter glasses and flash synchronization required to operate the Blue-C.

Currently available CRT projection technology will allow a maximum of 40 Hz per phase. Based on experimental results, we believe that an opaque phase at ~20 Hz will be sufficient to avoid any visual disturbance.

4. CONCLUSIONS AND OUTLOOK

We are still in an early phase of the project which is scheduled for a duration of three years. We are currently in the development of the hardware and software components described above. A small-scale prototype, comprising a stereo display, stroboscopic lighting, and modified shutter glasses, has already been completed. The first full-size prototype is planned for early 2001.

5. ACKNOWLEDGMENTS

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