**INTRODUCTION:**

Tele-immersion, a new medium for human interaction enabled by digital technologies, approximates the illusion that a user is in the same physical space as other people, even through the other participants might in fact be hundreds or thousands of miles away. It combines the display and interaction techniques of virtual reality with new vision technologies that transcend the traditional limitations of a camera. Rather than merely observing people and their immediate environment from one vantage point, tele- immersion stations convey them as “moving sculptures,” without favoring a single point of view. The result is that all the participants, however distant, can share and explore a life-size space.

Beyond improving on videoconferencing, tele-immersion was conceived as an ideal application for driving network-engineering research, specifically for Internet2, the primary research consortium for advanced network studies in the U.S. If a computer network can support tele-immersion, it can probably support any other application. This is because tele-immersion demands as little delay as possible from flows of information (and as little inconsistency in delay), in addition to the more common demands for very large and reliable flows.

**WHAT IS TELE- IMMERSION?**

Tele-immersion enables users at geographically distributed sites to collaborate in real time in a shared, simulated, hybrid environment as if they were in the same physical room.

It is the ultimate synthesis of media technologies:

* 3D environment scanning.
* Projective and display technologies.
* Tracking technologies.
* Audio technologies.
* Powerful networking.

The considerable requirements for tele-immersion system, such as high bandwidth, low latency and low latency variation make it one of the most challenging net applications. This application is therefore considered to be an ideal driver for the research agendas of the Internet2 community.

Tele-immersion is that sense of shared presence with distant individuals and their environments that feels substantially as if they were in one’s own local space. This kind of tele-immersion differs significantly from conventional video teleconferencing in that the use’s view of the remote environment changes dynamically as he moves his head.

**VIDEOCONFERENCING VS TELE-IMMERSION:**

Human interaction has both verbal and nonverbal elements, and videoconferencing seems precisely configured to confound the nonverbal ones. It is impossible to make eye contact perfectly, for instance, in today’s videoconferencing systems, because the camera and the display screen cannot be in the same spot. This usually leads to a deadened and formal affect in interactions, eye contact being a nearly ubiquitous subconscious method of affirming trust. Furthermore, participants aren’t able to establish a sense of position relative to one another and therefore have no clear way to direct attention, approval or disapproval.

Tele-immersion is an improved version of digital technology. We can make an eye contact, which will give a feeling of trust. This approximates the illusion that a user is in the same physical space as other people, even though they may be far apart. Here rather than merely observing the people and their immediate environment from one vantage point, tele-immersion stations convey them as “moving sculptures”, without favoring a single point of view. They can share a life cycle space. They are able to convey emotions in its right intensity. A three dimensional view of the room is obtained. It can simulate shared models also.

**NEW CONCEPTS AND CHALLENGES**

In a tele-immersive environment computers recognize the presence and movements of individuals and both physical and virtual objects, track those individuals and objects, and project them in realistic, multiple, geographically distributed immersive environments on stereo-immersive surfaces. This requires sampling and resynthesis of the physical environment as well as the users faces and bodies, which is a new challenge that will move the range of emerging technologies, such as scene depth extraction and warp rendering, to the next level.

Tele-immersive environments will therefore facilitate not only interaction between users themselves but also between users and computer-generated models and simulations. This will require expanding the boundaries of computer vision, tracking, display, and rendering technologies. As a result, all of this will enable users to achieve a compelling experience and it will lay the groundwork for a higher degree of their inclusion into the entire system.

In order to fully utilize the tele-immersion, we need to provide interaction that is both as seamless as real world but allows even more effective communication. For example, in the real world someone involved in a meeting might draw a picture on a paper and then show the paper to the other people in the meeting. In tele-immersion spaces people have the opportunity to communicate in fundamentally new ways.

**REQUIREMENTS OF TELE-IMMERSION**

Tele-immersion is the ultimate synthesis of media technologies. It needs the best out of every media technology. The requirements are given below.

**3D environment scanning:**

For a better exploring of the environment a stereoscopic view is required. For this, a mechanism for 3D environment scanning method is to be used. It is by using multiple cameras for producing two separate images for each of eyes. By using polarized glasses we can separate each of the views and get a 3D view.

The key is that in tele-immersion, each participant must have a personal view point of remote scenes-in fact, two of them, because each eye must see from its own perspective to preserve a sense of depth. Furthermore, participants should be free to move about, so each person’s perspective will be in constant motion. Tele-immersion demands that each scene be sensed in a manner that is not biased toward any particular viewpoint (a camera, in contrast, is locked into portraying a scene from its own position). Each place, and the people and things in it, has to be sensed from all directions at once and conveyed as if it were an animated three-dimensional sculpture. Each remote site receives information describing the whole moving sculpture and renders viewpoints as needed locally. The scanning process has to be accomplished fast enough to take place in real time at most within a small fraction of a second.

The sculpture representing a person can then be updated quickly enough to achieve the illusion of continuous motion. This illusion starts to appear at about 12.5 frames per second (fps) but becomes robust at about 25 fps and better still at faster rates.

Measuring the moving three-dimensional contours of the inhabitants of a room and its other contents can be accomplished in a variety of ways. In 1993, Henry Fuchs of the University of North Carolina at Chapel Hill had proposed one method, known as the “sea of cameras” approach, in which the viewpoints of many cameras are compared. In typical scenes in a human environment, there will tend to be visual features, such as a fold in a sweater, that are visible to more than one camera. By comparing the angle at which these features are seen by different cameras, algorithms can piece together a three- dimensional model of the scene.

This technique had been explored in non-real-time configurations, which later culminated in the “ Virtualized Reality “ demonstration at Carnegie Mellon University, reported in 1995. That setup consisted of 51 inward-looking cameras mounted on a geodesic dome. Because it was not a real – time device, it could not be used for tele-immersion.

Ruzena Bajcsy, head of GRASP (General Robotics, Automation, Sensing and Perception ) Laboratory at the University of Pennsylvania, was intrigued by the idea of real-time seas of cameras. Starting in 1994, small scale “puddles” of two or three cameras to gather real-world data for virtual – reality applications was introduced.

But a sea of cameras in itself isn’t complete solution. Suppose a sea of cameras is looking at a clean white wall. Because there are no surface futures, the cameras have no information with which to build a sculptural model. A person can look at a white wall without being confused. Humans don’t worry that a wall might actually be a passage to an infinitely deep white chasm, because we don’t rely on geometric cues alone – we also have a model of a room in our minds that can rein in errant mental interpretations. Unfortunately, to today’s digital cameras, a person’s forehead or T–shirt can present the same challenge as a white wall, and today’s software isn’t smart enough to undo the confusion that results.

Researchers at Chapel Hill came with a novel method that has shown promise for overcoming this obstacle, called “ imperceptible structured light “ or ISL. Conventional light bulbs flicker 50 or 60 times a second, fast enough for the flickering to be generally invisible to the human eye. Similarly, ISL appears to the human eye as a continuous source of white light, like an ordinary light bulb, but in fact it is filled with quickly changing patterns visible only to specialized, carefully synchronized cameras. These patterns fill in voids such as white wall with imposed features that allow a sea of cameras to complete the measurements. If imperceptible structured light is not used, then there may be holes in reconstruction data that result from occlutions, areas that aren’t seen by enough cameras, or areas that don’t provide distinguishing surface features.

To accomplish the simultaneous capture and display an office of the future is envisioned where ceiling lights are controlled cameras and “smart” projectors that are used to capture dynamic image-based models with imperceptible structured light techniques, and to display high-resolution images on designated display surfaces. By doing simultaneously on the designated display surfaces, one can dynamically adjust or auto calibrate for geometric, intensity, and resolution variations resulting from irregular or changing display surfaces, or overlapped projector images.

Now the current approach to dynamic image-based modeling is to use an optimized structured light scheme that can capture per-pixel depth and reflectance at interactive rates. The approach to rendering on the designated (potentially irregular) display surface is to employ a two-pass projective texture scheme to generate images that when projected onto the surfaces appear correct to a moving head-tracked observer.



**Image processing:**

At the transmitting end, the 3d image scanned is generated using two techniques:

* **Shared table approach**

Here, the depth of the 3d image is calculated using 3d wire frames. this technique uses various camera views and complex image analysis algorithms to calculate the depth.

* **Ic3d (incomplete 3d) approach**

In this case, a common texture surface is extracted from the available camera views and the depth information is coded in an associated disparity map. This representation can be encoded into a mpeg-4 video object, which is then transmitted.

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### Fig:1 Left and Right Camera View of Stero Test Sequence

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### Fig:2 Texture and Disparity Maps Extracts from Stero Test Sequence

### Reconstruction in a holographic environment:

The process of reconstruction of image occurs in a holographic environment. The reconstruction process is different for shared table and ic3d approach.

* **Shared Table Approach**

Assuming that the geometrical parameters of the multi-view capture device, the virtual scene and the virtual camera are well fitted to each other, it is ensured that the scene is viewed in the right perspective view, even while changing the viewing position.

* **Ic3d Approach**

The decoded disparities are scaled according to the user’s 3d viewpoint in the virtual scene, and a disparity-controlled projection is carried out. The 3d perspective of the person changes with the movement of the virtual camera

## In both the approaches, at the receiving end the entirely composed 3d scene is rendered onto the 2d display of the terminal by using a virtual camera. the position of the virtual camera coincides with the current position of the conferee's head. for this purpose the head position is permanently registered by a head tracker and the virtual camera is moved with the head.

**Projective & display technologies:**

By using tele-immersion a user must feel that he is immersed in the other person’s world. For this, a projected view of the other user’s world is needed. For producing a projected view, big screen is needed. For better projection, the screen must be curved and special projection cameras are to be used.

**Tracking technologies:**

It is great necessity that each of the objects in the immersive environment be tracked so that we get a real world experience. This is done by tracking the movement of the user and adjusting the camera accordingly.

**Moving Sculptures:**

It combines the display and interaction techniques of virtual reality with new vision technologies that transcend the traditional limitations of a camera. Rather than merely observing people and their immediate environment from one vantage point, tele-immersion stations convey them as “moving sculptures”, without favoring a single point of view. The result is that all the participants, however distant, can share and explore a life size space.

* **Head & Hand tracking –**

The UNC and Utah sites collaborated on several joint design-and-manufacture efforts, including the design and rapid production of a head-tracker component (HiBall) (now used in the experimental UNC wide-area ceiling tracker). Precise, unencumbered tracking of a user’s head and hands over a room sized working area has been an elusive goal in modern technology and the weak link in most virtual reality systems. Currant commercial offerings based on magnetic technologies perform poorly around such ubiquitous, magnetically noisy computer components as CRTs, while optical-based products have a very small working volume and illuminated beacon targets (LEDs). Lack of an effective tracker has crippled a host of augmented reality applications in which the user’s views of the local surroundings are augmented by synthetic data (e.g., location of a tumor in the patient’s breast or the removal path of a part from within a complicated piece of machinery).

**Audio technologies:**

For true immersive effect the audio system has to be extended to another dimension, i.e., a 3D sound capturing and reproduction method has to be used. This is necessary to track each sound source’s relative position.

**Powerful networking:**

If a computer network can support tele-immersion it can probably support any other application. This is because tele-immersion demands as little delay as possible from flows of information (and as little inconsistency in delay), in addition to the more common demands for very large and reliable flows. The considerable requirements for tele-immersion system, such as high bandwidth, low latency and low variation (jitter), make it one of the most challenging net applications.

* **Internet 2® –the driving force behind Tele-immersion**

It is the next generation internet. Tele-immersion was conceived as ideal application for driving network engineering research. Internet2 is a consortium consisting of the US government, industries and around 200 universities and colleges.

It has high bandwidth and speed. It enables revolutionary internet applications.

* **Need for speed:**

If a computer network can support tele-immersion, it can probably support any other application. This is because tele-immersion demands as little delay as possible from flows of information (and as little inconsistency in delay), in addition to the more common demands for very large and reliable flows.

* **Strain to Network:**

In tele-immersion not only participant’s motion but also the entire surface of each participant had to sent. So it strained a network very strongly. Bandwidth is a crucial concern. Our demand for bandwidth varies with the scene and application; a more complex scene requires more bandwidth. Conveying a single person at a desk, without the surrounding room, at a slow frame rate of about two frames per second has proved to require around 20 megabits per second but with up to 8-megabit-per-second peaks.

* **Network backbone:**

A backbone is a network within a network that lets information travel over exceptionally powerful, widely shared connections to go long distances more quickly. Some notable backbones designed to support research were the NSFnet in the late 1980’s and the vBNS in the mid-1990’s. Each of these played a part in inspiring new applications for the Internet, such as the World Wide Web. Another backbone research project, called Abilene, began in 1998, and it was to serve a university consortium called Internet2.Abilene now reaches more than 170 American research universities. If the only goal of Internet2 were to offer a high level of bandwidth (that is, a large number of bits per second), then the mere existence of Abilene and related resources be sufficient. But Internet2 research targeted additional goals, among them the development of new protocols for handling applications that demand very high bandwidth and very low, controlled latencies (delays imposed by processing signals en route).

The “last mile” of network connection that runs into computer science departments currently tends to be an OC3 line, which can carry 155 megabits per second-just about right for sustaining a three-way conversation at a slow frame rate. But an OC3 line has approximately 100 times more capacity than what is usually considered a broadband connection now, and it is correspondingly more expensive.

**Computational Needs**

Beyond the scene-capture system, the principal components of a tele-immersion setup are the computers, the network services, and the display and interaction devices. Each of these components has been advanced in the cause of tele-immersion and must advance further. Tele-immersion is a voracious consumer of computer resources. Literally dozens of such processors are currently needed at each site to keep up with the demands of tele-immersion. Roughly speaking, a cluster of eight two-gigahertz Pentium processors with shared memory should be able to process a trio within a sea of cameras in approximately real time. Such processor clusters should be available in the later year.

One promising avenue of exploration in the next few years will be routing tele-immersion processing through remote supercomputer centers in real time to gain access to superior computing power. In this case, a supercomputer will have to be fast enough to compensate for the extra delay caused by the travel time to and from its location.

Bandwidth is a crucial concern. Our demand for bandwidth varies with the scene and application; a more complex scene requires more bandwidth. We can assume that much of the scene, particularly the background walls and such, is unchanging and does not need to be resent with each frame.

Conveying a single person at a desk, without the surrounding room, at a slow frame rate of about two frames per second has proved to require around 20 megabits per second but with up to 80-megabit-per-second peaks. With time, however, that number will fall as better compression techniques become established. Each site must receive the streams from all the others, so in a three-way conversation the bandwidth requirement must be multiplied accordingly. The “last mile” of network connection that runs into computer science departments currently tends to be an OC3 line, which can carry 155 megabits per second-just about right for sustaining a three-way conversation at a slow frame rate. But on OC3 line is approximately 100 times more capacious than what is usually considered a broadband connection now, and it is correspondingly more expensive.

**Tele Cubicle**

The tele-cubicle represents the next generation immersive interface. It can also be seen as a subset of all possible immersive interfaces. An office appears as one quadrant in a larger shared virtual office space. The canvases onto which the imagery can be displayed are a stero-immersive desk surface as well as at least two stereo. Such a system represents the unification of Virtual Reality and videoconferencing, and it provides an opportunity for the full integration of VR into the workflow. Physical and virtual environments appear united for both input and display. This combination, we believe, offers a new paradigm for human communications and collaboration.

**RESULTS OF THE DEMO ON OCTOBER 2000:**

In the demo in October 2000, most of the confetti was gone and the overall quality and speed of the system had increased, but the most important improvement came from researchers at Brown University. Demonstration of unified system with 3D real time acquisition data (“real” data), 3D synthetic objects (“virtual” data) and user interactions with 3D objects using virtual laser pointer.

The participants in the session are not only able to see each other in 3D but they were able to engage in collaborative work, here a simple example of interior office design. The remote site in the demo was Advanced Network & Services, Armonk, Ny, and local site where images were taken was at the University of North Carolina at Chapell Hill, NC. The data were sent over Internet2 links (Abilene-backbone) at the rate of 15-20 Mb/sec (no compression applied), 3D real time acquisition data combined with static 3D background and synthetic 3D graphics objects. For the interactive part we used magnetic tracker to mimic virtual laser pointer, as well as a mouse.

All synthetic objects were either downloaded or created on the fly. Both users could move objects around the scene and collaborate in design process In between the two people are virtual objects (the furniture models). These are objects that don’t come from either physical place. They can be created and manipulated on the fly-there’s a deep architecture behind them (which was written at Brown University).



Fig 3 Three way video conferencing using Tele Immersion

**APPLICATIONS**

1. **Collaborative Engineering Works**

Teams of engineers might collaborate at great distances on computerized designs for new machines that can be tinkered with as though they were real models on a shared workbench. Archaeologists from around the world might experience being present during a crucial dig. Rarefied experts in building inspection or engine repair might be able to visit locations without losing time to air travel.

1. **Video Conferencing**

In fact, tele-immersion might come to be seen as real competition for air travel-unlike videoconferencing. Although few would claim that tele-immersion will be absolutely as good as “being there” in the near term, it might be good enough for business meetings, professional consultations, training sessions, trade show exhibits and the like. Business travel might be replaced to a significant degree by tele-immersion in 10 years. This is not only because tele-immersion will become better and cheaper but because air travel will face limits to growth because of safety, land use and environmental concerns.

1. **Immersive Electronic Book:**

Applications of tele-immersion will include immersive electronic books that in effect blend a “time machine” with 3D hypermedia, to add an additional important dimension, that of being able to record experiences in which a viewer, immersed in the 3D reconstruction, can literally walk through the scene or move backward and forward in time. While there are many potential application areas for such novel technologies (e.g., design and virtual prototyping, maintenance and repair, paleontological and archaeological reconstruction), the focus here will be on a socially important and technologically challenging driving application, teaching surgical management of difficult, potentially lethal, injuries.

1. **Collaborative mechanical CAD:**

A group of designers will be able to collaborate from remote sites in an interactive design process. They will be able to manipulate a virtual model starting from the conceptual design, review and discuss the design at each stage, perform desired evaluation and simulation, and even finish off the cycle with the production of the concrete part on the milling machines.

**CONCLUSION**

Tele immersion is a dynamic concept, which will transform the way humans, interact with each other and the world in general.

Tele immersion takes video conferencing to the next higher level. It helps insimulation of office environment so it can reduce business travel.

Tele immersion is expected to be very expensive to compete with other communication technologies when implemented.

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