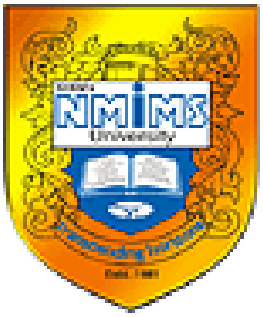
SEMINAR REPORT ON

TELE-IMMERSION



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CERTIFICATE

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INDEX TABLE

List Of Figures

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.

Tele-immersion 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 Internet^, 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.

Tele-immersion can be of immense use in medical industry and it also finds its application in the field of education.

HISTORY

It was in 1965 that, Ivan Sutherland, proposed the concept of the 'Ultimate Display'. It described a graphics display that would allow the user to experience a completely computer-rendered environment.

The term Tele-immersion was first used in October 1996 as the title of a workshop organized by EVL and sponsored by Advanced Network & Services, Inc. to bring together researchers in distributed computing, collaboration, VR, and networking. At this workshop, specific attention was paid to the future needs of applications in the sciences, engineering, and education. In 1998 Abilene, a backbone research project was launched and now serves as the base for Internet-2 research. Tele-immersion is the application that will drive forward the research of Internet-2.

There are several groups working together on National Tele-Immersion Initiative(NTII) to make this wonderful technology available to common man.

WHAT IS TELE-IMMERSION?

Tele-Immersion is a new medium that enables a user to share a virtual space with remote participants. The user is immersed in a 3D world that is transmitted from a remote site. This medium for human interaction, enabled by digital technology, approximates the illusion that a person is in the same physical space as others, even though they may be thousands of miles distant. It combines the display and interaction techniques of virtual reality with new computer-vision technologies. Thus with the aid of this new technology, users at geographically distributed sites can collaborate in real time in a shared, simulated, hybrid environment submerging in one another's presence and feel as if they are sharing the same physical space.

It is the ultimate synthesis of media technologies:

- 3D environment scanning,
- Projective and display technologies,
- Tracking technologies,
- Audio technologies,
- Robotics and haptics,
- Powerful networking.

The considerable requirements for tele-immersion system, make it one of the most challenging net applications.

In a tele-immersive environment computers recognize the presence and movements of individuals and objects, track those individuals and images, and then permit them to be projected 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.

Tele-immersive systems have potential to significantly change educational, scientific and manufacturing paradigms. They will show their full strength in the systems where having 3D reconstructed ‘real’ objects coupled with 3D virtual objects is crucial for the successful fulfillment of the tasks. It may also be the case that some tasks would not be possible to complete without having such combination of sensory information. There are several applications that will profit from tele-immersive systems. Collaborative mechanical CAD applications as well as different medical applications are two that will benefit significantly.

Tele-immersion may sound like conventional video conferencing. But it is much more. Where video conferencing delivers flat images to a screen, tele-immersion recreates an entire remote environment. Although not so, tele-immersion may seem like another kind of virtual reality. Virtual reality allows people to move around in a pre-programmed representation of a 3D environment, whereas tele-immersion is measuring the real world and conveying the results to the sensory system.

FIRST FEEL OF TELE-IMMERSION

A swift investigation revealed that three researchers, led by UNC computer Scientists Henry Fuchs and Greg Welch, in May 2000 opened a pair of portals connecting Chapel Hill with Philadelphia and New York. Through these portals, they could peer into the offices of colleagues hundreds of miles away, in life-sized three dimensions and real time. It was as if they had teleported distant chunks of space into their laboratory. The experiment was the first demonstration of Tele-immersion, which could radically change the way we communicate over long distances. Tele-immersion will allow people in different parts of the world to submerge themselves in one another's presence and feel as if they are sharing the same physical space. It's the real- world answer to the StarTrek Holodeck, the projection chamber on the Starship Enterprise where crew members interact with projected images as if they were real.

May's experiment was the culmination of three years' work by the National Tele-Immersion Initiative (NTII), a project led by virtual pioneer Jaron Lanier. The test linked three of the members of the group:UNC Chapel Hill, the University of Pennsylvania in Philadelphia, non-profit organization called Advanced Network and Services in Armonk, New York, where Lanier is chief scientist.

At Chapel Hill, there were two large screens, hung at right angles above desk, plus projection cameras and head tracking gear. The screens were flat and solid, but once the demo was up and running they looked more like windows. Through the left-hand screen, Welch could see colleagues in Philadelphia as if they were sitting across the desk from him. The right-hand screen did the same for Armonk. When Welch changed point of view, the images shifted in a natural way.

If he leaned in, images got larger; if he leaned out they got smaller. He could even turn his neck to look round the people.

To make it work, both target sites were kitted out with arrays of digital cameras to capture images and laser rangefinders to gather positional information. Computers then converted the images into 3D geometrical information and transmitted it to Chapel Hill via Internet2. There, computers reconstructed the images and projectors beamed them onto screens.

The images were split and polarised to create a slightly different image to each eye, much like an old-fashioned 3D movie. Welch wore glasses differently oriented polarising lenses so his left eye saw one image right eye the other, which his brain combined to produce 3D images.

A head-mounted tracker followed Welch's movements and changed the images on the screens accordingly. Like the first transcontinental phone call, the quality was scratchy, also jerky, updating around three times a second rather than 10, the minimum speed needed to capture the full range of facial expressions. It only worked one-way: the people in Armonk and Philadelphia couldn't see Chapel Hill.

All this may sound like conventional videoconferencing. But Tele-immersion is much, much more. Where videoconferencing delivers flat images to a screen, Tele-immersion recreates an entire remote environment.

SYSTEM OVERVIEW AND ALGORITHMS

A tele-immersion telecubicle is designed both to acquire a 3D model of the local user and environment for rendering and interaction at remote sites, and to provide an immersive experience for the local user via head tracking and stereoscopic display projected on large scale view screens. A typical setup can be depicted as follows.

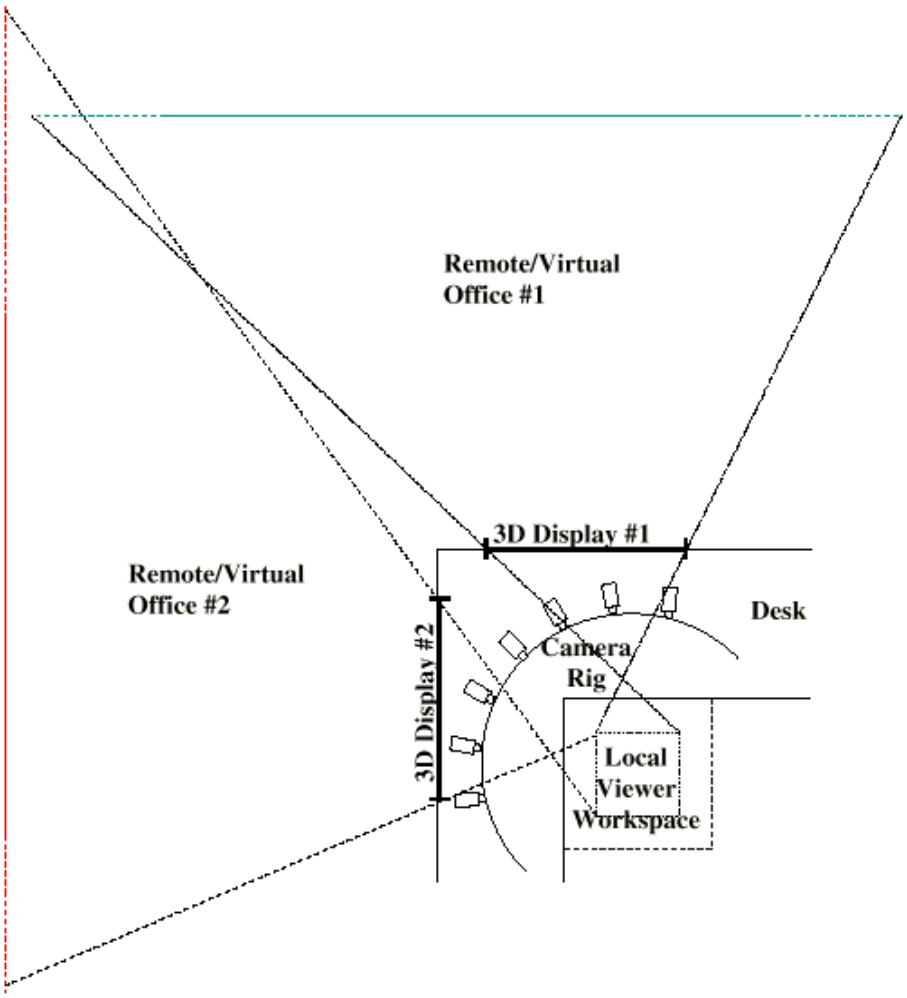

Fig.- System Overview

The user moves freely in a 1m workspace at his desk. Remote users are rendered on 90cm X 120 cm screens by projector pairs. The user wears lightweight polarized glasses and a head-tracker to drive the stereo display function. A cluster

of 7 firewire cameras are arranged on an arc at 15^{o} separation to 'surround' the user and prevent any break presence due to hard edge where the reconstruction stops. These cameras are used to calculate binocular or trinocular stereo depth maps from overlapping pairs or triples. The technical obstacle to the combining of camera views, is that each reconstruction is performed on a separate computer which adds to the overhead of the system.

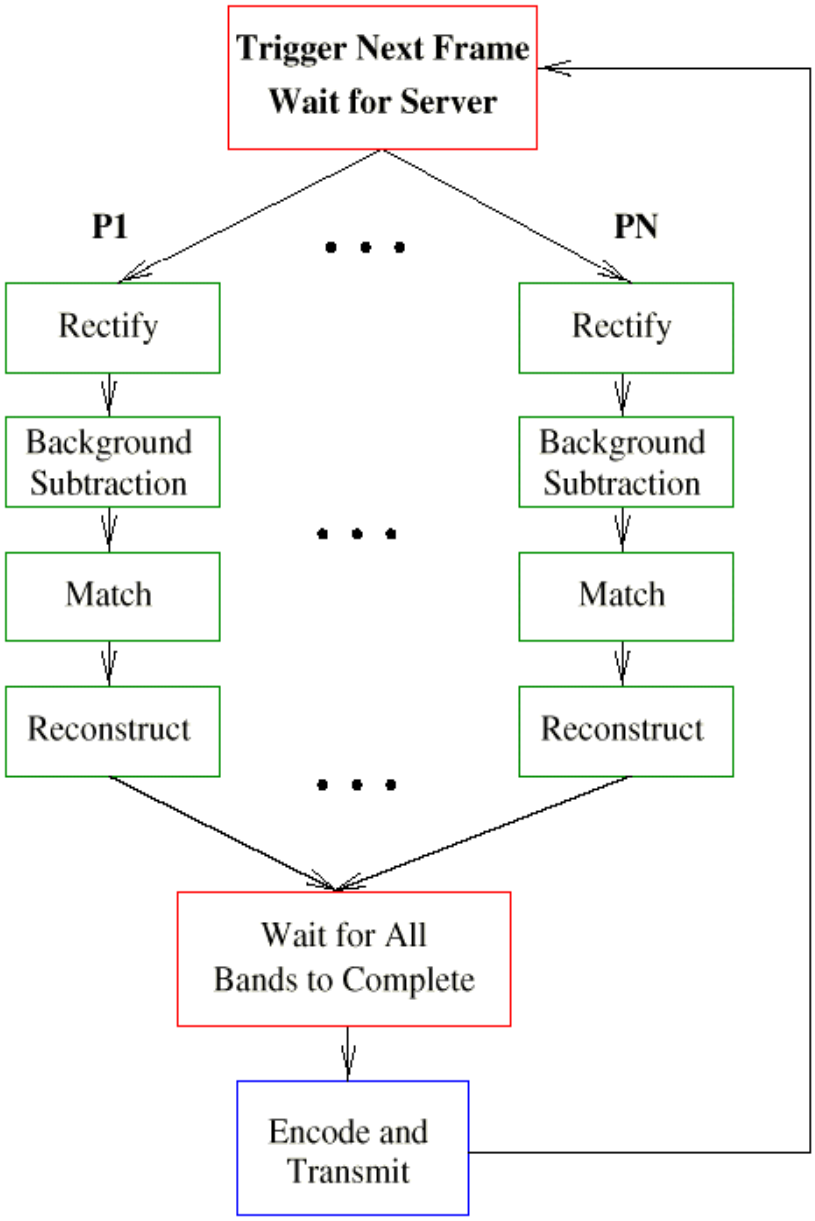

Fig.- Algorithm For Tele-Immersion

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.

- *RECONSTRUCTION IN A HOLOGRAPHIC ENVIRONMENT* –

  The process of reconstruction of image occurs in a holographic environment. At the transmitting end. the 3d image scanned is generated using two techniques. The reconstruction process is different for shared table and ic3d *I* approach.

- *PROJECTIVE AND 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 SCLUPTURES* –

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.

❖ *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* –

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.

❖ *COMPUTATIONAL NEEDS* -

Beyond the scene-capture system, the principal components of a tele-immersion setup are the computers, the network services, the display and interaction devices. Literally dozens of 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.

HOW TELE-IMMERSION WORKS?

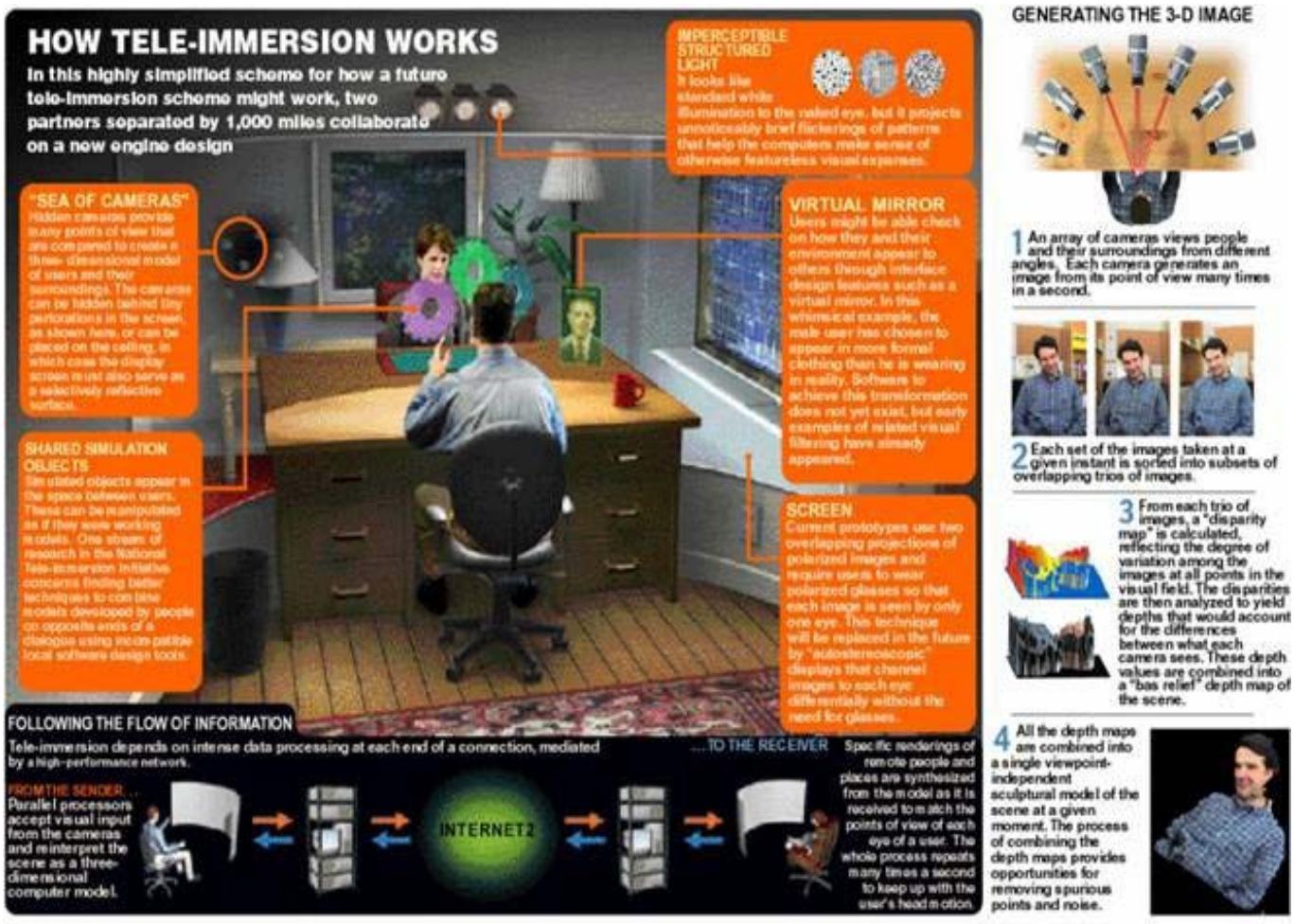

Fig. – Tele-Immersion Implementation

Above figure is a nice description of the Tele-Immersion implementation. Two partners separated by 1000 miles collaborate with each other. There is a sea of cameras which provide view of users and their surroundings.

Mounted Virtual Mirrors provide each user a view how his surrounding seems to other. At each instant camera generated an image which is sorted into subsets of overlapping trio.

The depth map generated from each trio then combined into a single view point at a given moment.

SCIENCE OF TELE-IMMERSION

Tele-Immersion has an environment called TIDE. TIDE stands for Tele-Immersive Data exploration Environment. The goal of TIDE is to employ Tele-Immersion techniques to create a persistent environment in which collaborators around the world can engage in long-term exploration and analysis of massive scientific data-sets. When participants are tele-immersed, they are able to see and interact with each other and objects in a shared virtual environment. The environment will persist even when all the participants have left it. The environment may autonomously control supercomputing computations, query databases and gather the results for visualization when the participants return. Participants may even leave messages for their colleagues who can then replay them as a full audio, video and gestural stream.

All users are separated by hundreds of miles but appear collocated able to see each other as either a video image or as a simplified virtual representation (commonly known as an avatar). Each avatar has arms and hands so that they may convey natural gesture such as pointing at areas of interest in the visualization. Digital audio is streamed between the sites to allow them to speak to each other.

TIDE will engage users in CAVEs, ImmersaDesks and desktop workstations around the world connected by the Science and Technology Transit Access Point (STARTAP) - a system of high speed national and international networks. TIDE has three main parts:

- *TELE-IMMERSION SERVER (TIS)*
- *TELE-IMMERSION CLIENT (TIC)*
- *REMOTE DATA AND COMPUTATIONAL SERVICES*

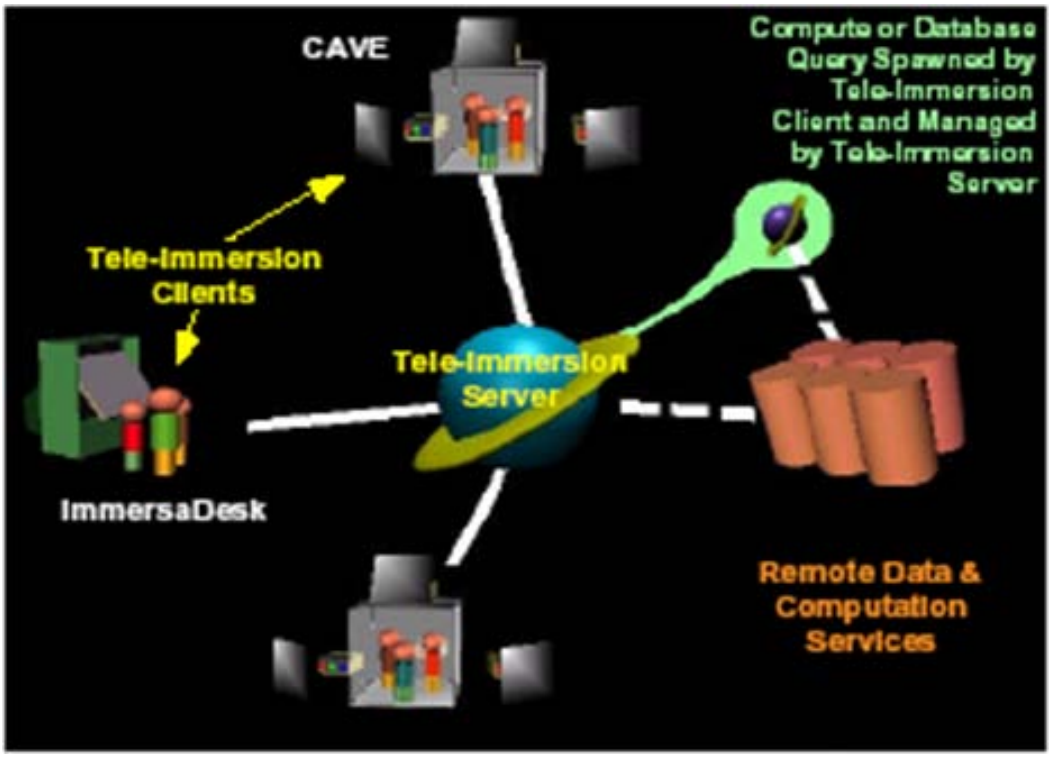

Fig. – Tele-Immersion Data Exploration Environment

- *TELE-IMMERSION SERVER:*

The Tele-Immersion Server's primary responsibility is to create a persistent entry point for the TICs. That is, when a client is connected to the TIS, a user can work synchronously or asynchronously with other users. The environment will persist even when all participants have left it. The server also maintains the consistent state that is shared across all participating TICs. Finally the TIS stores the data subsets that are extracted from the external data sources. The data subsets may consist of raw and derived data sets, three dimensional models or images.

- *TELE-IMMERSION CLIENT:*

The Tele-Immersion Client (TIC) consists of the VR display device (either CAVE, ImmersaDesk, etc) and the software tools necessary to allow

"human-in-the loop computational steering, retrieval, visualization, and annotation of the data. The TIC also provides the basic capabilities for streaming audio and video, and for rendering avatars to allow participants to communicate effectively with one another while they are immersed in the environment. These capabilities come as part of EVL's Tele-Immersion software framework called CAVERNsoft.

- *REMOTE DATA & COMPUTATION SERVICES:*

Remote Data and Computation Services refer to external databases and/or simulations/compute-intensive tasks running on supercomputers or compute clusters that may be called upon to participate in a TIDE work session.

PERFORMANCE AND RESULTS

For tele-immersion the quality and density of depth points are most important. Although computation times are greater, the high quality of trinocular depth maps makes them a desirable alternative to faster but noisier SAD images. Figures below illustrate a trinocular triple and the resulting rendered depth maps for binocular MNCC (right pair) and trinocular MNCC respectively.

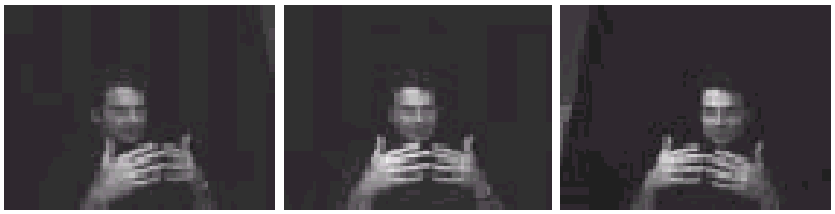

Fig. - Trinocular MNCC

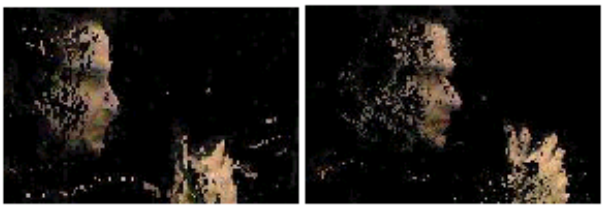

Fig. - Binocular MNCC

The improvement in depth map from use of the trinocular constraint is evident in the reduction of noise speckle and refinement in detail.

An added challenge with the seven camera cluster is the combination of multiple reconstructions into a single rendered view. Figure below shows a full set of camera views for a single frame in the current telecubicle camera cluster. From

this image set, 5 reconstructed views are calculated for overlapping triples. The second figure below shows a profile rotation of the total set of 164000 depth points calculated using trinocular MNCC for the frame in the first figure.

Fig. – Seven Camera Views

Fig. - Five trinocular reconstructions combined and rendered, rotated view

APPLICATIONS OF TELE-IMMERSION

- *Collaborative Engineering Works* -

Teams of engineers might collaborate at great distances on computerized designs for new machines that can be tinkered with as through 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.

- *Video Conferencing* -

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.

- *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 witch 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.

- *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.

- *Entertainment* -

Tele-immersive holographic environments have a number of applications. Imagine a video game free of joysticks, in which you become a participant in the game, fighting monsters or scoring touchdowns.

- *Live Chat* -

Instead of traveling hundreds of miles to visit your relatives during the holidays, you can simply call them up and join them in a shared holographic room.

- *Medicine* -

Tele immersion can be of immense use to the field of medicine. The way medicine is taught and practiced has always been very hands-on. It is impossible to treat a patient over the phone or give instructions for a tumour to be removed without physically being there. With the help of tele-immersion, 3D surgical learning for virtual operations is now in place and, in the future, the hope is to be able to carry out real surgery on real patients. A geographically distanced surgeon could be tele-immersed into an operation theatre to perform an operation. This could potentially be lifesaving if the patient is in need of special care (either a

technique or a piece of equipment), which is not available at that particular location. Tele-immersion 'will give surgeonsthe ability to superimpose anatomic images right on their patients while they are being operated on'.

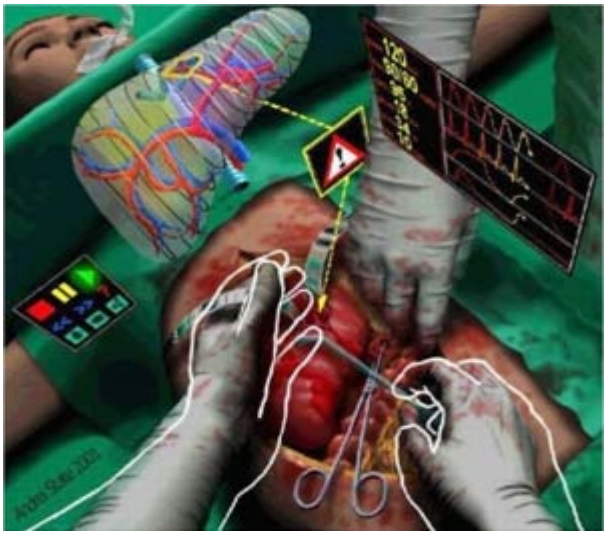

Fig. – Medical Use

- *Uses In Education* -

In education, tele-immersion can be used to bring together students at remote sites in a single environment. Relationships among educational institutions could improve tremendously in the future with the use of tele-immersion. Already, the academic world is sharing information on research and development to better the end results. With tele-immersion in schools, students could have access to data or control a telescope from a remote location.

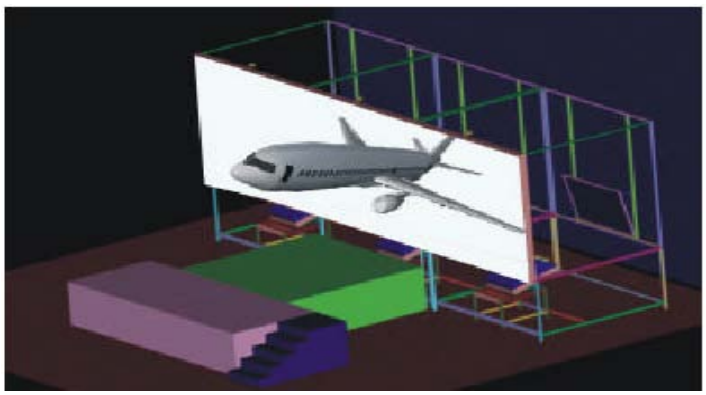

Fig. – Educational Use

- *Future Office* -

In years to come, instead of asking for a colleague on the phone you will find it easier to instruct your computer to find him or her. Once you do that, you'll probably see a flicker on one of your office walls and find that your colleague, who's present in another city, is sitting right across you as if he or she is right there. The person at the other end will experience the same immersive connection. With tele-immersion bringing two or more distant people together in a single, simulated office setting, business travel will become quite redundant.

Fig. – Office Use

- *Other Applications* -

Building inspectors could tour structures without leaving their desks. Automobile designers from different continents could meet to develop the next generation of vehicles. In the entertainment industry, ballroom dancers could train together from separate physical spaces. Instead of commuting to work for a board meeting, businesspersons could attend it by projecting themselves into the conference room. The list of applications is large and varied, and one thing is crystal clear this technology will significantly affect the educational, scientific and medical sectors.

CHALLENGES OF TELE-IMMERSION

Tele-immersion has emerged as a high-end driver for die Quality of Service (QoS), bandwidth, and reservation efforts envisioned by the "NGI and lnternet2 leadership.

From a networking perspective, tele-immersion is a very challenging technology for several reasons.

- The networks must be in place and tuned to support high-bandwidth applications.
- Low latency, needed for 2-way collaboration, is hard to specify and guarantee given current middleware.
- The speed of light in fiber itself is a limiting factor over transcontinental and transoceanic distances.
- Multicast, unicast, reliable and unreliable data transmissions (called "flows") need to be provided for and managed by the networks and the operating systems of supercomputer-class workstations.
- Real-time considerations for video and audio reconstruction ("streaming") are critical to achieving the feel of telepresence, whether synchronous or recorded and played back
- The computers, too, are bandwidth limited with regard to handling very large data for collaboration
- Simulation and data mining are open-ended in computational and bandwidth needs—there will never be quite enough computing and bits/second to fully analyze, and simulate reality for scientific purposes.

In Layman's language the realization of tele-immersion is impossible today due to the following reasons,

1. The non-availability of high speed networks.
2. The non-availability of supercomputers.
3. Large network bandwidth requirement reasons.

THE FUTURE

Researchers aim to make tele-immersion more natural, by jettisoning the headgear and glasses altogether. It is expected that a person should be able to experience tele-immersion by just entering a tele-cubicle. One possibility is to use a screen that transmits different information to each eye, using swiveling pixels that track either left or right eye. Another idea is to turn the entire tele-immerion room onto a screen. Walls, tables, curtains, even floors could be coated with special light sensitive material. Camera would photograph the surfaces, computers would calculate their shapes in 3D, and projectors would shine pre-warped images, making it seem as if they filled the room.

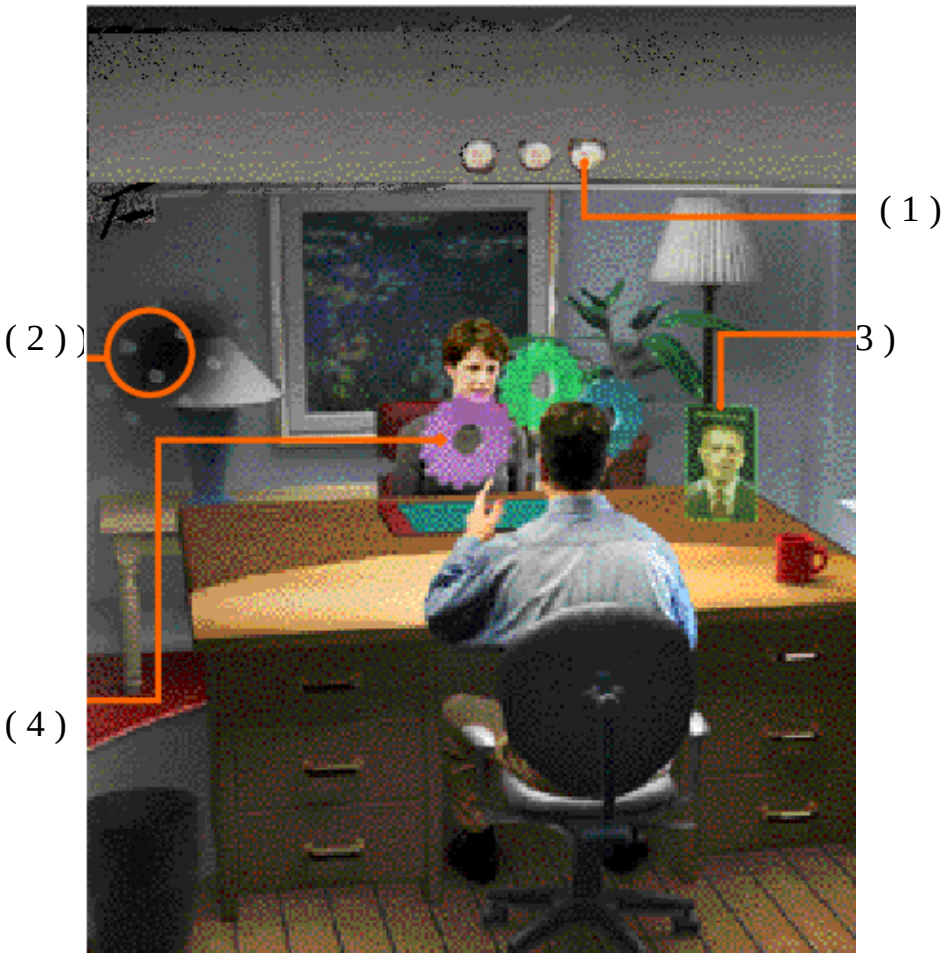

Fig. – The Future

(1) Imperceptible structured light. (2) Sea of cameras.

(3) Virtual mirror. (4) Shared simulation objects.

The above picture shows a tele-cubicle from the future. The virtual objects can be pointed at by using virtual laser pointers. Gone will be the days of the seven prominent cameras facing the user. Instead, cameras will be placed somewhere in the tele-cubicle where it is less prominent. It is expected that there will be a sea of around 50 to 60 cameras in a tele-cubicle to provide a perfect tele-immersive experience.

Imperceptible Structured Lights are going to be a standard part of tomorrow's tele-cubicle. These help in resolving surface ambiguities due to which the computer finds it difficult to recognize what a surface or object is. The virtual mirror enables a user to see how he himself is being viewed by other participants. All users in a particular session can manipulate the shared simulation objects.

In future, it will be possible to manipulate virtual objects. The first prototype of Virtual Reality Mail System has already been developed. In VR-mail, users make a recording by speaking and gesturing. The audio and gestures are captured and saved in a format that allows a synchronized playback at a later time. This recording can then be sent to another user in the Virtual Environment (VE). When the recipient of the message enters the VE, he or she will find a VR-mail message waiting for him or her. The recipient may then play back the message. As in a traditional e-mail system, the recipient is then able to respond to the original sender of the VR-mail. In future, this idea can be extended to Tele-Immersion as well.

CONCLUSION

Tele-immersion techniques can be viewed as the building blocks of the office of tomorrow, where several users from across the country will be able to collaborate as if they're all in the same room. Scaling up, transmissions could incorporate larger scenes, like news conferences, ballet performances, or sports events. With mobile rather than stationary camera arrays, viewers could establish tele-presence in remote or hazardous situations.

Fig. – Tele-Immersion Implementation

Far from just a validating application for the next-generation Internet, tele-immersion is expected to fundamentally change how we view real and virtual worlds.

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

Tele-Immersion is a technology that is certainly going to bring a new revolution in the world and let us all hope that this technology reaches the world in its full flow as quickly as possible.

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