Modeling effects of latency on 3D Telepresence users

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While 3D Tele-immersion techniques develop rapidly, the effects of transmission quality on its users remain unexplored. Since the transmission quality such as latency, frame rate, resolution and cost are trade-off nowadays, we argue that it is important to study the user experience in 3D Tele-immersion systems.

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# INTRODUCTION

注：一下还不是introduction，只是我自己做的一些笔记。

看起来，3D Tele-immersion相比于其它更简单的技术而言，其优势并不是我们想象中那么理所当然，也许需要在introduction中讨论一下。

我似乎忽略了FOV等因素。这些因素不属于transmission quality trade-off，但是对人的认知是重要的。

Previous work的调查发现，有41%的视频会议有三个或以上的locations。

我们在技术上的特点：1、我们尝试对齐并merge两个场景中相同的物体，以提供shared objects in the virtual scene；2、我们提供一个可操作的交互过程，来裁剪无用的背景。3、具体实现上的小贡献：尝试了几款商用硬件特别是深度摄像头，发现RealSense最优，使用了最新的显卡，公布了经过深度优化的代码。

# related work

Related work的思路暂定如下：（1）首先介绍基于Reconstruction的3DTI技术（Tele-immersion）有哪些，突出其好处，表明基于Reconstruction的3DTI将会成为下一代的远程通信技术；（2）在之前的工作中，存在对基于robotic或者presed-3D远程呈现的研究，也有对Tele-immersion中一些小问题进行的小型user study，但对Tele-immersion中最基本的问题，如延迟对用户的影响，还不存在；（3）为了开展这份工作，我们参考了Telephone和Video conference中的测量方法，这里总结一下其中的measurement方法。

在Related work的写作过程中，第一部分将参考[Holoportation]，第二部分待定，第三部分将参考[General Recommendation on the transmission quality for an entire international telephone connection]。

## 3DTI technique

In early works, researchers use an array of cameras to construct the virtual scene from physical world.

[Virtual space teleconferencing using a sea of cameras]

[Virtualized reality: Constructing virtual worlds from real scenes]

Then, researchers start to improve the capturing of 3D model in real time.

[3D Tele-Collaboration Over Internet2. 2002] researchers assembled the best of available hardware and software technologies to present a 3D tele-immersion with point cloud.

[Immersive 3D Environment] presented an immersive telepresence system for remote collaboration and training of physical activities.

[Multicamera Real-Time 3D Modeling for Telepresence and remote collaboration. 2010] This system allows to retrieve in real-time a 3D mesh of the observed scene.

[Real-Time Volumetric 3D capture. 2012] described a 3D acquisition system, which is the most similar to our system.

[Real World Video Avatar] transmit and present the figure of a person at a remote location in real time.

Recently, state-of-the art techniques achieve higher rendering quality.

[Fusion4D] contributed a pipeline for live high-quality reconstructions in real-time.

[Encumbrance-Free Telepresence System] presented a 3D telepresence system which is affordable and reproducible, offering the opportunity to deliver it beyond the researcher’s lab.

[Holoportation] for the first time presents an end-to-end system for augmented and virtual reality telepresence. This paper contributes as describing the tele-immersion pipeline in full.

[KinectFusion. 2011] present a system for real-time mapping of arbitrary indoor scenes, using only a moving low-cost depth camera.

[A Volumetric Method for Building Complex] This paper describes the kernel algorithm for creating the 3D model from range image.

[Marching Cubes] is a high resolution 3D surface construction algorithm based on TSDF Volume.

## User study in 3D Telepresence

There are basically three types of techniques in 3D telepresence: Pseudo-3D, Robotic, Reconstruction. The impacts on users were well study in both robotic and embodiment, while the users’ feeling in 3d reconstruction based telepresence remained underexplored.

### Pseduo-3D

[ImmerseBoard]

[Towards Next Generation 3D Teleconferencing Systems]

[Evaluation of Factors Affecting Distance Perception] identify the most important factors that influence decision making and accuracy of distance perception with an immersive large screen display. The paper presents guidelines for setting up this kind of system.

### Robotic

[The Future of Robotic Telepresence]

[Racetime: Telepresence Racing Game with]

[Movement Matters]

[My Student is a Robot]

[Robotic Telepresence at Scale]

[To Beam or Not to Beam]

[JackIn Head] JackIn Head allows remote user to see what the “Body user” can see. “Body user” wears an omnidirectional camera to transmit video to remote user. This paper contributes as an image stabilization technique and a study to this system.

[Augmented reality-aided telepresence system for robot] investigates the use of an immersive telepresence system for industrial robotics. Experiment shows the practicability and effectiveness.

[ChameleonMask: Embodied Physical and Social] uses a real human as a surrogate for the remote user.

[Can you see me now?] study the effects of FOV on users with robotic telepresence systems.

[Bodies in Motion] Mobility significantly increased the user’s feelings of presence but decrease task performance.

[Communication Behavior in Embodied Virtual Reality] Maybe it is not robotic, but embodiment.

### Reconstruction

[TELEPORT] the early immersive telepresence system.

[blue-c] is an early telepresence system.

[MirageTable] provides a one-to-one 3D telepresence experience by using Kinect and projector. Specially this system allows freehand physical interaction with virtual world.

[Immersive Group-to-Group Telepresence] This work built the first telepresence system which provides a shared space in immersive virtual reality environment. This paper and [Adapting standard video codecs for depth streaming] mention that they do not focus on the compression and transmission bandwidth.

[Room2Room] MSR proposed Room2Room system, which allows room to room naked eye 3d telepresence system with only a Kinect and a projector. They did a study and shows that it is significantly better in completion time and presence compared to Skype.

## Measurement of latency in Telecommunication

### Telephone

[General Recommendation on the transmission quality for an entire international telephone connection] For telecommunications, a latency which is longer than 400ms is unacceptable. Currently, 150ms is used as a rule of thumb, a value drawn by telecommunication research. The most applications would be acceptable within 150ms. For more immersive telecommunications such as 3D conferencing, a latency of 100ms would be better.

[The E-model] This model can help ensure that users will be satisfied with end-to-end transmission performance, avoiding over-engineering of networks. It is a tool for assessing the combines effects of variations in several transmission parameters the affect the conversational quality. The output is a scalar rating of transmission quality.

[Objective and Subjective assessment of telecommunication quality] In the annex of this paper it describes a user study to evaluate subjective feedback of telephone call in details.

### Video Conference

In 2D telepresence, huge amount of works related to users’ feeling has been done.

[Are We in sync?] In synchronization of watching video, 500ms is acceptable with video chat, and 2s is for text chat.

[Beyond Talking Heads] This paper in CSCW 2016 conducted a survey with members of distributed teams to investigate how they host distributed meetings. Nowadays most distributed meetings are hosted with video-based conference. The results suggest that tools and approaches are inadequate for meeting scenarios that require participants to not only converse but also to share different types of multimedia content. Note: 41% video-conference involve 3+ locations.

[Taking Notes or Playing Games?] presents a detailed examination of factors that affect perceptions of multitasking in video conferencing. It proposes a conceptual model for the design of video communication tools.

[Accuracy of Deictic Gestures to Support Telepresence] presents a controlled study to assess the accuracy when user showing a shored object on a wall-sized display. Eye gaze is more important than hand gesture.

[Remote handshaking] touch enhances video-mediated telepresence which partner’s action needs to occur but should be invisible in the video.

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