Designing A Social VR Clinic for Medical Consultations

Jie Li
CWI
Science park 123
1098XG Amsterdam, NL
j.li@cwi.nl

Huib de Ridder
TU Delft
Landbergstraat 15
2628 CE Delft, NL
H.deRidder@tudelft.nl

Guo Chen
CWI
Science park 123
1098XG Amsterdam, NL
g.chen1995123@gmail.com

Pablo Cesar
CWI & TU Delft
Science park 123
1098XG Amsterdam, NL
P.S.Cesar@cwi.nl

Abstract

Social Virtual Reality (VR) invites multiple users to "interact" in a shared immersive environment, which creates new opportunities for remote communication, and can potentially be a new tool for remote medical consultations. Using knee osteoarthritis consultation as a use case, this paper presents a social VR clinic that allows patients to consult a nurse represented as a virtual avatar with head, upper body and hands visible. We started with an ethnographic study at a hospital with three medical professionals and observed three patient consultation sessions to map the patient treatment journey (PTJ) and distill design requirements for social VR consultation. Based on the results of the study, we designed and implemented a social VR clinic to meet the identified requirements. Our work expands on the potential of social VR to help reshape patient treatment by reducing the workload of medical staff and the travel time of patients. In the future, we plan to conduct user studies to compare face-to-face (F2F) with social VR consultations.

Author Keywords

Virtual reality; social VR; VR consultation; telehealth; user studies

CCS Concepts

•**Human-centered computing** $\rightarrow$ **User studies; Virtual reality;**
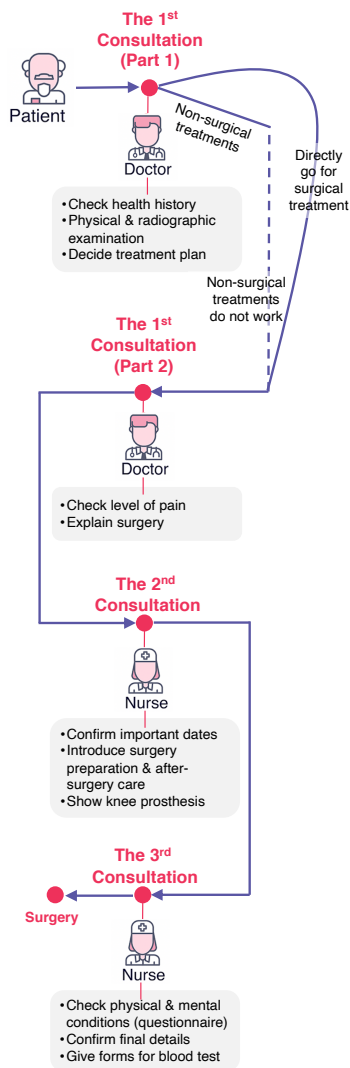
Figure 1: The patient treatment journey for knee osteoarthritis.

Introduction

Virtual Reality (VR) in healthcare has long been envisioned as a promising technology that resembles face-to-face (F2F) communication between patients and medical professionals [11, 15, 23]. With social VR technologies, multiple users can "meet" in a shared, immersive virtual environment and interact with the virtual representations of each other [12]. So far, many VR healthcare applications have been developed for medical training [28], psychological consultation [29] and remote (psycho)therapy [6]. A national survey (2006-2017) in US found that the time people spent traveling to healthcare services was the longest compared to other professional services (e.g., legal/governmental services). The time spent traveling and waiting for healthcare was over 50% of the time actually spent receiving care [26]. Beside the time cost, traveling is painful for the patients who have disabilities or suffer from chronic disease.

Knee osteoarthritis is a condition in which the natural cushioning (i.e., cartilage) between joints wears away and patients suffer from the pain caused by the bones rub against one another [9]. We chose knee osteoarthritis treatments as a use case, aiming at reducing the traveling time of patients and the workload of medical staff. This paper has two contributions: (1) gather requirements for social VR remote consultation; (2) Design and implement a social VR clinic to support remote consultation based on the requirements. We conducted an ethnographic study with medical professionals and patients in a hospital. The results illustrated a detailed patient treatment journey, and showed the heavy workload of medical professionals and their communication problems with patients. We defined four main requirements according to the study results. The implemented social VR clinic addressed the requirements by simulating the real hospital environment, offering a walk-in virtual surgery room and realistic 3D anatomy models to support the remote consultation. Our work demonstrates the potential of social VR as a new remote communication tool.

Related Work

To properly manage health, it is essential that patients know about their health. However, communication between medical staff and patients is often ineffectual, thereby limiting the patients' knowledge of their health and treatment options [34]. Ventres et al. [36] introduced "shared presence", describing "doctors and patients entering into a deep sense of trust and respect" that facilitates the treatment, and supports effective consultations. Aelbrecht et al. [2] pointed out that patients' needs may differ: some emphasised the emotional support, while others found problem-focused discussions important. Riedl and Schüßler [27] stressed that participatory decision making led to improved doctor-patient relationship and interpersonal exchange [3]. Kelly et al. [17] found that a warm and empathic treatment atmosphere is important. These factors need to be well considered when developing technologies to support medical consultations.

Remote medical consultation is cost-effective, providing similar quality as F2F consultation, and erases geographic distance [8]. VR technologies are considered as an extension to existing communication tools (e.g., video conferencing), and are explored as new applications for healthcare, including disseminating health information, providing remote (psycho) therapies [1], and training medical professionals [22]. Medical consultations in VR are distinguished from video consultations by their capacity to portray 3D spatial information [35], to exploit users' natural behaviors, and to immerse users in the virtual world. VR can use avatars to offer appearance, gestures, directional voice, and ability to interact with the environment and virtual artifacts [13]. Walia et al. [37] see VR as a supplemental solution to the nursing shortage and to assist patients with disabilities.

Methods: An Ethnographic Study

We selected knee osteoarthritis treatment as a use case to design the social VR clinic. To get an overview of the treatment process and the content communicated, an ethnographic study [4, 38] was conducted in the Reinier de Graaf hospital located in Delft, The Netherlands. The study has two parts: (1) one-to-one semi-structured interviews [20] with three medical professionals, and (2) observational studies at three nurse-patient consultations [16, 5].

Medical Professionals

Three medical professionals participated in the semi-structured interviews, including two surgeons (the doctors) and one consultant (the nurse). Both doctors have over ten years of experience in the treatment of knee osteoarthritis. They perform surgery, discuss with patients about treatment plans, and examine their recovery progress. The nurse works closely with the two doctors, and prepares patients for the surgery. The nurse that participated in the observational studies is the same person as in the interviews.

Figure 2: The categorization of the open coded transcripts

Procedure

The interviews were conducted at the office of medical professionals. Each interview lasted one hour with prepared interview questions illustrated in a booklet. The professionals were asked to explain their answers while filling in the booklet. In this way, we expected to guide them to tell concrete stories rather than provide abstract answers to the questions, helping obtain latent information behind the conversations [30]. Besides the interviews, observational studies were conducted by two researchers during three patient-nurse consultations. The interviews and observations were both audio recorded and later on transcribed.

Data Collection and Analysis

Three types of data were collected in the studies: (1) transcribed audio recordings; (2) the filled booklets by the med-

ical professionals and the notes taken during the observations; and (3) the printed materials from the hospital (e.g., a patient manual about the surgery.)

The transcripts and notes were independently coded by two researchers, following an inductive open coding approach [32]. The overlapping codes from the two researchers were kept for later categorization. Keeping or discarding the non-overlapping codes were decided by the two researchers. Afterwards, the selected codes were sorted into two main categories: (1) patient treatment journey, and (2) problems and opportunities for medical consultation.

Results

This section presents the results of the ethnographic study. The three medical professionals are labelled as M1-M3.

Patient Treatment Journey

For patients who need knee replacement surgery, there are three consultations (Figure 1). All patients start with the first consultation with the doctor, for examination and making decisions about the treatment. When the patient needs to have the surgery, a second and third consultations will be scheduled with the nurse.

The first consultation. The doctor meets the patient in person to do the medical examinations in this consultation. M2 described the main tasks involved, *"I do three things: asking the history, doing a physical examination and having the patient examined by the X-ray."* The doctor explains the procedure and risks of the surgery, and shares the decision about the treatment with the patient. *"I tell them [the patients] about the process, complications and risks of the surgery. We made decisions together (M1)."*

The second consultation. Most patients start the treatment with non-surgical treatments (e.g., medications and injec-
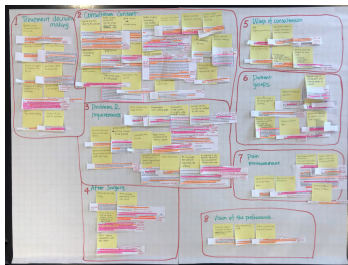
tions). As mentioned by M2, *"Here in the hospital, we only operate 15-20% of the patients. For the other 80-85%, we treat them through injections, physiotherapy and medications."* When the patient needs surgery, then we schedule the second consultation with the nurse 6-7 weeks in advance. The second consultation is a 20-minute Q&A session with the nurse, where the preparation of the surgery is explained in details. Patients are encouraged to ask questions during this consultation *"I show them [the patients] the knee prosthesis model, and talk about the surgery. I always make sure the patients feel the weight of the prosthesis. If they do not have many questions, I will point out a few important things for them to remember (M3)."* The second consultation involves a lot of conversations and physical interactions.

The third consultation. The third consultation takes about 45 minutes, happening a few days before the surgery, to confirm the the surgery details, and to ask the patient to fill in a comprehensive questionnaire about their physical and mental conditions. As M3 told us, *"We need to make sure when the patient comes to the surgery, everything is recorded. The surgeon and the ward are prepared. We ask everything in the questionnaire: their physical, mental conditions, whether they have people to take care of them, their home environment..."* The third consultation does not involve much verbal or physical interaction.

Problems & Opportunities for Medical Consultation
Communication difficulties. The three medical professionals pointed out that communicating with the elderly is difficult. *"I think the biggest problem we are facing now is the communication with the elderly. Most of the patients are above 80 and some of them have dementia (M3)."* The medical professionals also have limited time to repeat the explanations, but they try to explain things in an under-

standable manner, avoiding using medical jargons. M3 told us, *"We tell them about the surgery in an easy way. If we need to use medical terms, we explain them well to make sure they understand them. We show them the prosthesis and tell them how the surgeon is going to operate on their knee."*

Heavy workload. The medical professionals complained about their heavy workload. Due to the privacy protection, the consultation is a one-to-one session with every patient. M3 told us, *"It takes a lot of time, and is boring for me to repeat the same story six times a day. We had the consultation in groups before, but we found patients reluctant to talk about their problems or ask questions in front of others. So, we changed it to private sessions."* Another aspect of the workload is that the medical professionals must be "*approachable by the patients all the time* (M3)".

Social VR: new opportunity. The medical professionals occasionally use video conferencing to answer minor questions from patients, but they found it difficult to explain and visualize things there. *"We tried to do it remotely, but it turned out to be unpractical, because we had difficulties to show visuals and documents (M3)."* The medical professionals all agreed that social VR can provide distinguished advantages compared to video consultations, such as displaying 3D animated information, and allowing users to use gestures, hear directional voice, and interact with the virtual objects. *"I can see this [social VR clinic] is plausible in many ways, like visualizing the medical knowledge and having people meet in the same [virtual] space (M2)."* The medical professionals also see social VR as a supplemental solution to the nursing shortage and to assist patients with disabilities, as M3 said, *"If we can record the explanations and visualizations in social VR, and let the VR nurse to repeat the it. This can save me and the patient a lot of time."*
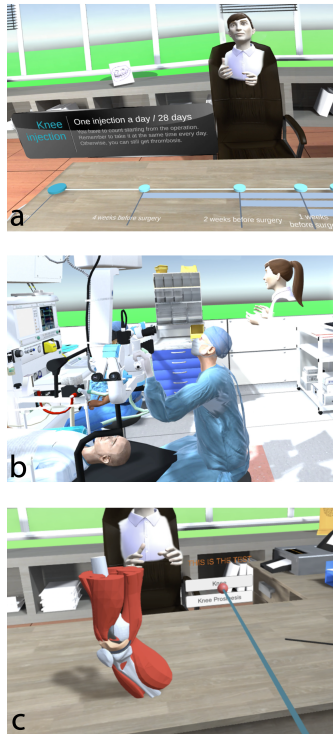
Figure 3: The social VR clinic: (a) visualized surgery preparation timeline; (b) 3D "walk-in" surgery room; (c) 3D interactive knee anatomy and prosthesis models

Design & Implementation of a Social VR Clinic

We decided to focus on the second consultation of the PTJ to design the social VR clinic. This consultation has three main activities (Figure 4): (1) explain how patients should prepare for the surgery and stress the important information (e.g., dates, medications); (2) show a video about the surgery room; (3) explain the surgery process using the knee prosthesis and ask patients to feel its weight.

Design Requirements

Based on the ethnographic study, and the related work, we defined the requirements for a social VR clinic (RQMT 1-RQMT 4):

RQMT 1: Replicate the three main activities of a F2F medical consultation;
RQMT 2: Enable verbal and non-verbal (e.g., spoken, visual, gestural) communications;
RQMT 3: Provide visualizations and animations of the medical knowledge to assist the communication;
RQMT 4: Enable record and replay of the consultation to reduce the repetition and workload.

Implementation: Addressing the Requirements

A combination of spoken and visual information is easier for patients to remember than only verbally explained information [18, 33]. Therefore, the designed social VR clinic maximizes information visualizations (RQMT 3). The social VR clinic (1) visualizes the preparation timeline and explains the medical jargon; (2) allows the patient to "walk into" a 3D virtual surgery room to "meet" the medical staff, and (3) enables the patient to interact with an animated 3D knee anatomy model and a knee prosthesis to see what the differences are before and after the surgery. The three activities (Figure 3) are well replicated in social VR clinic (RQMT 1). The nurse is represented by an avatar, which captures the real-time head, hands, mouth and body move-
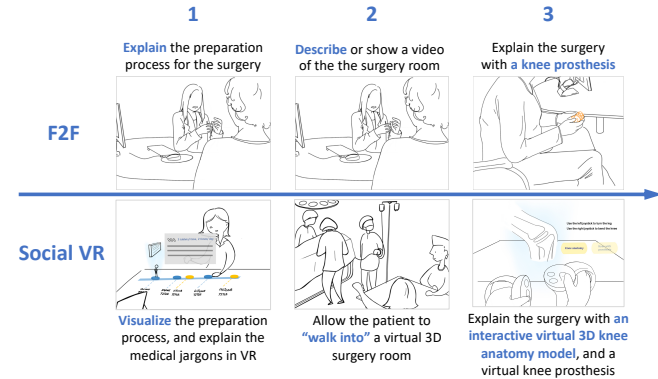

Figure 4: Comparing the three main activities of the second consultation in F2F and social VR conditions

ments (RQMT 2). The recorded social VR consultation can be replayed and shared to the patient (RQMT 4).

The prototype is implemented in Unity[1]. Oculus Integration for Unity is also applied[2], which has pre-built functions, such as interfaces for controlling VR cameras. The knee and the prosthesis model implementations were adapted based on professionally 3D scanned medical models from *Thingiverse*[3]. We added the material layer and motion to the models in Unity and incorporated them into the prototype. The surgery room is based on an Asset from the Unity Store[4], including a set of realistic medical devices, furniture objects and animations.

[1] https://unity.com, retrieved on Aug. 26, 2019
[2] https://developer.oculus.com/downloads/package/unity-integration/, retrieved on Aug. 26, 2019
[3] https://www.thingiverse.com/thing:340254, retrieved on Aug. 26, 2019
[4] https://assetstore.unity.com/packages/3d/props/interior/operating-room-18295, retrieved on Aug. 26, 2019

Discussion

Limitations & Benefits of Social VR

The implemented social VR clinic was based on the 2nd consultation, since it involves the most verbal communication, and does not require medical examination (e.g., draw blood). The current social VR clinic is only for patients who have been previously examined by medical professionals in F2F settings. Some researchers expressed their concerns that remote consultations may be clinically risky, and bring significant technical, logistical and regulatory challenges (e.g., [10]). Therefore, we do not recommend using social VR as the primary means of contact between medical staff and patients, but as an extension and augmentation for remote communication. As an augmentation, social VR provides many benefits. First, it immerses the users in the same virtual world, providing realistic and co-presence experience [19]. Second, it uses virtual representations to offer embodiment experiences to users, and abilities to interact with the virtual environment and artifacts [13]. Third, it enables the sense of social connectedness [19] and allows people to see and feel from other person's perspective [31].

Virtual Representations & Privacy

We implemented a simple non-realistic avatar to represent the users, with only head, upper body and hands visible. This avatar can assist the spoken and gestural communication, but may fail to emotionally engage the users. The medical professionals raised their concerns on the type of virtual representations used in social VR: To use the realistic ones to help them better diagnose or to use the non-realistic ones to protect the privacy of patients? Some research proposed real-time photo-realistic human representations in VR (e.g., [25]), or worked on HMD removal (e.g., [39]), trying to make the user face visible to enhance the presence and immersion. However, the trade-off between the realism of the user representations and the privacy protection should be considered in future work.

Multisensory Experiences in VR

Multisensory experiences can enhance users' presence and immersion, and enable them to have better task performances in a virtual environment [14, 24]. In our study, the medical professionals stressed the necessity of multisensory feedback in VR. For instance, to help patients build a proper expectation of the surgery, they must feel the weight of the prosthesis that is going to be implanted in their knees. However, the weight simulation is not implemented in our prototype. Many studies have investigated the haptics and weight simulations in VR (e.g., [7, 21]). In future work, we are interested in exploring haptic experiences in VR, especially investigating how to accurately simulate the weight of a virtual object.

Conclusion

In this early work, we designed and implemented a social VR clinic for patients to remotely consult medical professionals. The goal is to enable patients to travel fewer times but still receive good quality consultations. The implemented social VR clinic simulates a consultation office, a surgery room, and 3D anatomy models. Our work expands on the potential of social VR to help reshape remote medical consultations. In the future, we plan to conduct user studies, to compare social VR consultation with the F2F one. We will also continuously explore use cases for social VR (e.g., engaging patients with dementia), improve the user representations and investigate haptic experiences, such as feeling or perceiving the weight of virtual objects.

Acknowledgement

http://vrtogether.eu/

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