A Social VR Clinic for Knee Arthritis Patients with Haptics

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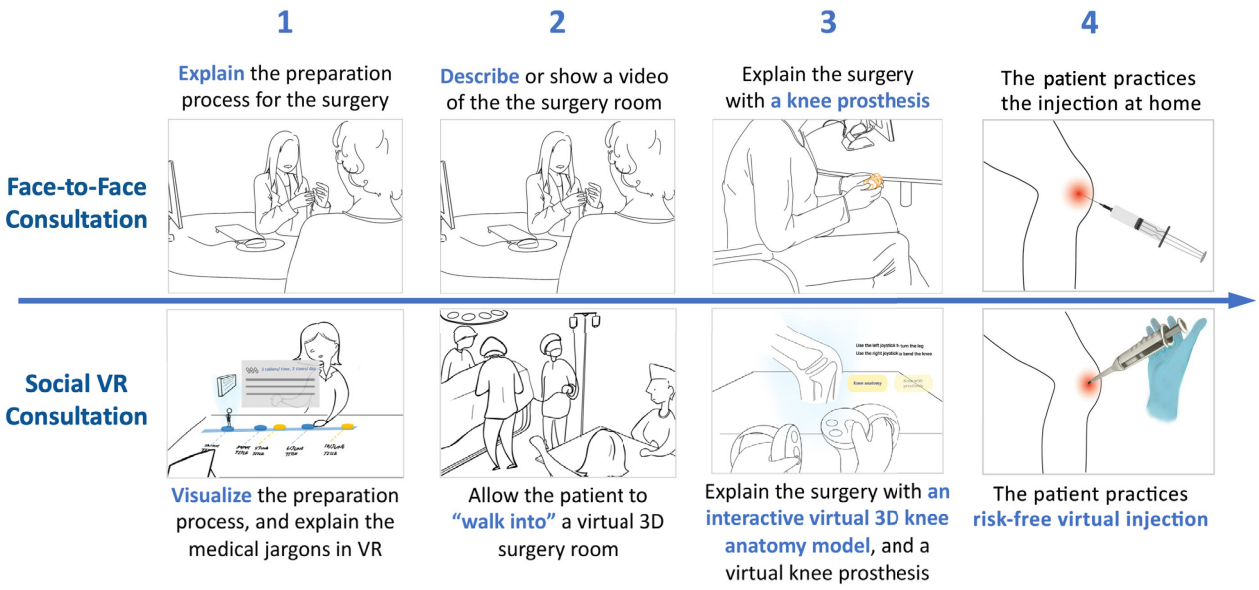

Figure 1: The four main activities related to a medical consultation: comparing the differences in the face-to-face (F2F) consultation with the social VR clinic.

ABSTRACT

Social virtual reality (VR) invites multiple users to interact in a shared immersive environment, which can be potentially useful for remote personalized healthcare. This demo presents a social VR clinic that allows patients to consult a nurse represented as a virtual avatar. It offers a "walk-in" virtual surgery room, enables patients to interact with animated virtual 3D artifacts, and train the patient to use an injection tool wearing a pair of mechanical VR gloves that provide haptic feedback (*SenseGlove*). The demo shows the potential of social VR as a new tool to help patients receive remote personalized medical care.

CCS CONCEPTS

• **Human-centered computing** → **Virtual reality**; *Collaborative interaction*;

KEYWORDS

Social virtual reality, Social VR, VR haptics, Virtual healthcare

ACM Reference Format:
Tong Xue, Jie Li, Guo Chen, and Pablo Cesar. 2020. A Social VR Clinic for Knee Arthritis Patients with Haptics. In *The Adjunct Proceedings of ACM TVX/IMX 2020, Barcelona (Spain), June 2020. Copyright is held by the author/owner(s).* ACM, New York, NY, USA, 4 pages.

1 INTRODUCTION

VR in healthcare has long been envisioned as a promising technology that can potentially approximate the face-to-face communication between patients and medical professionals (e.g., doctors and nurses) [8, 11, 17]. With social VR technologies, multiple users are able to "meet" in a shared, immersive virtual environment and interact with the virtual representations of each other [9]. One of the pioneer VR applications in healthcare was developed in the 1990s, with the main purpose of visualizing complex medical data for

medical professionals to prepare for surgery [23]. So far, many VR healthcare applications have been developed for medical training [20], psychological consultation [21] and remote (psycho)therapy [2].

According to a national survey (2006-2017) in US [19], the time people spent traveling to healthcare services was the longest compared to other professional services like legal services or government activities. The time spent traveling and waiting for healthcare services was over 50% of the time actually spent receiving care. Beside the time cost, traveling for healthcare can be painful for the patients who have disabilities or suffer from chronic disease.

For this demo, we chose the knee osteoarthritis treatment as a use case. The motivation behind this work is to reduce the traveling time and support remote communication between patients and medical professionals. This demo shows a social VR clinic that is built to simulate the real face-to-face (F2F) consultation process and facilities in the hospital, in which patients can interact with the nurses and virtual artifacts. The virtual clinic is implemented with visualized medical information, interactive 3D anatomical models, walk-in consultation and surgery rooms, and most importantly a virtual injection tool with haptic feedback to help train patients to inject medicine to the knee.

2 RELATED WORK

Remote consultation solutions (e.g., VR, video conferencing) cannot completely replace F2F consultations, due to the medical regulations and specific equipment requirements [7]. The social VR clinic in this paper focuses on only one part of the treatment, in which no medical examinations are needed. The goal is to facilitate the real-time remote communication, through structuring and visualizing the information in a 3D virtual clinic. In our social VR clinic, the representations of the patients and doctors are in the form of human-like avatars, with only upper body and hands visible. Research on the influence of user representation realism or the types of user representations are out of the scope of this demo.

VR technologies are considered as an extension to communication technologies such as video conferencing, and are explored as new tools for healthcare, including disseminating health information, providing remote (psycho) therapies [1], and training medical professionals [16]. Medical consultations in VR are distinguished from video consultations by their capacity to portray 3D spatial information [27], to exploit users' natural behaviors, and to immerse users in the virtual world. VR can use avatars to offer appearance, gestures, directional voice, and the ability to interact with the environment and virtual artifacts [10]. Even though video conferencing simulates F2F communication quite authentically [6], the visual view in videos is still fundamentally different from sharing the same physical space. Walia et al. [28] see VR as a supplemental solution to the nursing shortage and to assist patients with disabilities.

VR is gradually changing from an isolated private experience to a social medium [4]. Social VR invites multiple users to meet and interact in the same virtual environment [5, 15]. Recently, commercial VR platforms, such as Sansar, AltspaceVR, and Facebook Horizon all seek to include social VR features in their systems [9, 13, 22, 24, 29], enabling users to interact with one another under the mediation of a virtual body. Apart from commercial social VR solutions, academic research has also investigated social VR technologies and use cases. Orts-Escolano et al. [18] demonstrated a real-time high-quality 3D reconstructions of an entire space, which enables low-latency communication between two or more remote users, almost as if they were co-presented in the same physical space. Cavallo et al. [3] created a collaborative VR/AR space, where remote users are able to interact in a 3D environment and play with virtual artifacts in real time. These social VR systems show the potential to offer immersive experience approximating the real-life one.

3 CONSULTATION EXPERIENCE

The remote consultation experience offered in this demo is based on a patient treatment journey identified in a previous ethnographic study [14]. For patients who need to have the knee replacement surgery, there are typically three consultations.

The first consultation. During the first consultation, the doctor needs to see the patient in person to do the medical examinations, explains the procedure and risks of the surgery, and decides together with the patient about the treatment. Most of the patients start with non-surgical treatments (e.g., medications and injections). Only when the non-surgical treatments do not help, the doctor will suggest the surgery, and schedule two extra consultation appointments.

The second consultation. The second consultation is scheduled with the nurse 6-7 weeks before the surgery. It is a 20-minute Q&A session, where the nurse explains the process for preparing for the surgery, and shows anatomical models of the knee and prosthesis is shown to the patient to help him/her better understand the surgery. Patients are encouraged to ask questions during this consultation. The second consultation involves a lot of conversations and physical interactions.

The third consultation. The third consultation takes about 45 minutes, which is the last consultation happening a few days before the surgery. This consultation is to finally confirm the details of the surgery and to ask the patient to fill in a comprehensive questionnaire about their physical and mental conditions. The third consultation does not involve much verbal or physical interaction.

This demo focuses on the second consultation, where patients do not need medical examinations (e.g., X-ray), and have the most interaction and conversations with the nurse. In addition, this demo also includes a virtual injection training procedure to help patients learn to inject medicines correctly into their knees. Figure 1 shows the four main activities implemented in the social VR clinic. The next section will explain the implementation of the experiences in detail.

4 IMPLEMENTATION

A combination of spoken and visual information is easier for patients to remember than only verbally explained information [12, 25]. Therefore, the social VR clinic maximizes information visualizations by (1) visualizing the preparation timeline and explaining the medical jargon; (2) allowing the patient to "walk into" a 3D virtual surgery room to "meet" the medical staff, and (3) enabling the patient to interact with an animated 3D knee anatomical model and a knee prosthesis to see what the differences are before and after the surgery (Figure 2(a)-(c)). By wearing an HTC Vive Pro

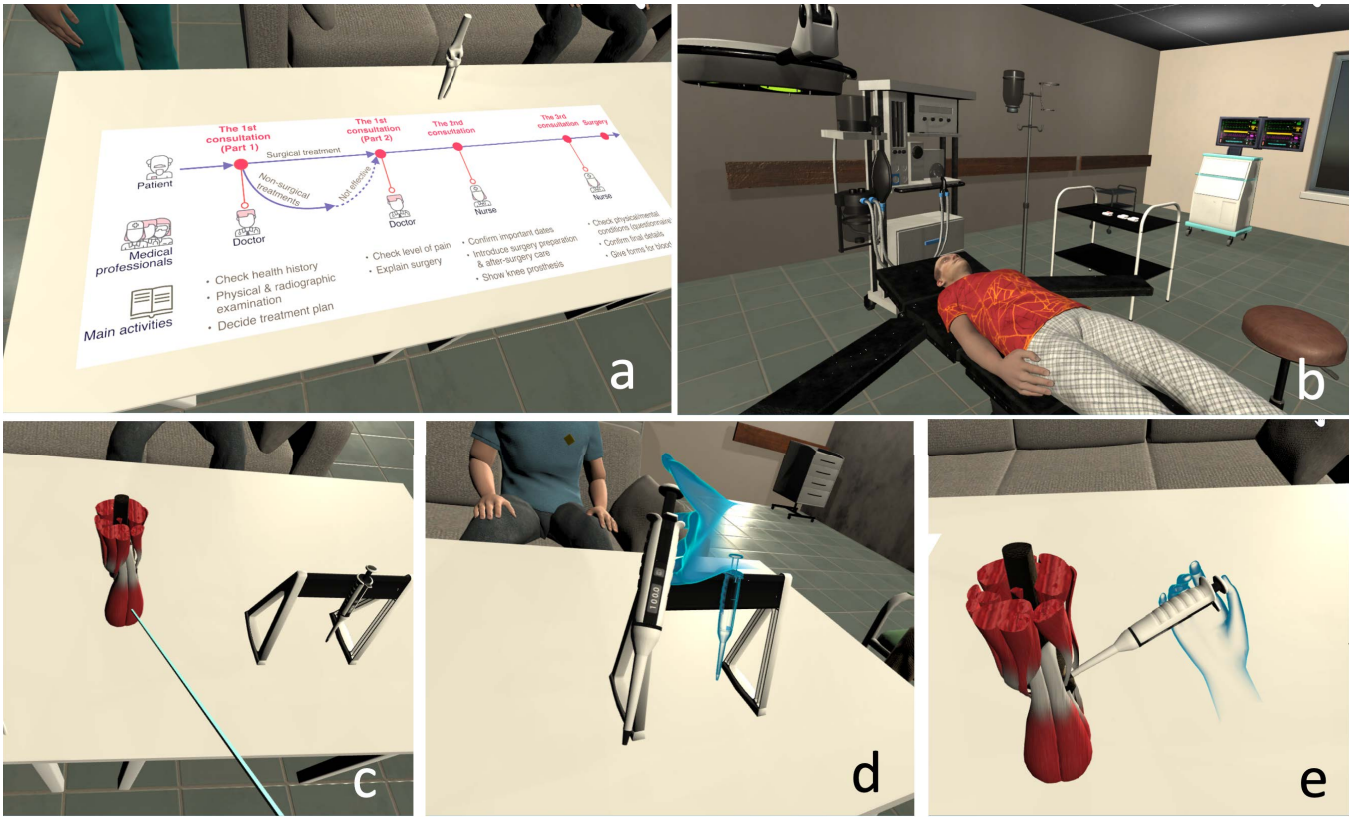

Figure 2: The social VR clinic demo: (a) a visualized surgery preparation timeline; (b) a 3D "walk-in" surgery room; (c) 3D interactive knee anatomical and prosthesis models; (d)&(e) train the patient to use an injection tool with haptic feedback.

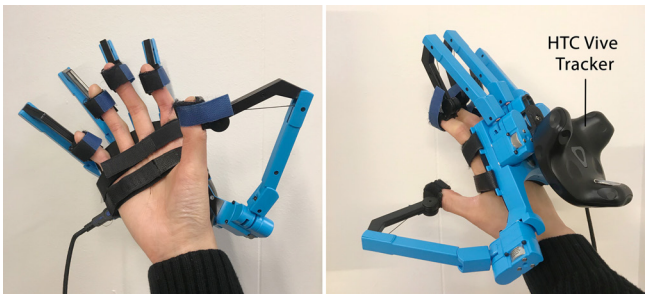

Figure 3: Use SenseGlove with HTV Vive tracker to position the hands in VR spaces. SenseGlove can track the fingers, hand and wrist of user's hand gestures, and provides force feedback on fingers.

Eye Head-Mouted Display (HMD)[1], the patient can interact with the virtual nurse, teleport within the virtual rooms and operate the virtual artifacts. The nurse is represented by an avatar, which mirrors the real-time head, hands, mouth and body movements of the nurse. The recorded social VR consultation can be replayed and shared to the patient.

In addition, the patient is equipped with a mechanical VR gloves (SenseGlove[2]). SenseGlove can position hands in VR using the HTC Vive tracker[3], and can accurately track the fingers, hand and wrist of the patient's hand gestures, and provide force feedback on fingers. So, the patient can have the sensation of grasping objects (figure 3). With SenseGlove, the patient can grab, hold and press a virtual injection tool and practice injection with realistic haptic feedback such as feeling the resistance when pressing the plunger of the virtual injection tool (figure 2(d) & (e)).

The prototype is implemented in Unity[4] (version 2018.4.1f1). The HTC Vive and the tracker are supported by SteamVR Plugin, and the SenseGlove is integrated to unity by the free SenseGlove SDK[5]. The demo project runs on a 2.20 GHz Intel i7 Alienware laptop with an Nvidia RTX 2070 graphics card. Both the HTC VIVE and Sense Glove are wired and connected to the laptop.

The knee and the prosthesis model implementations were adapted based on professionally 3D scanned medical models from *Thingiverse*[6]. We added the material layer and motion to the models in Unity and incorporated them into the prototype. The surgery room

[1]https://www.vive.com/eu/product/vive-pro-eye/

[2]https://www.senseglove.com, retrieved on March 31, 2020
[3]https://www.vive.com/ca/vive-tracker/, retrieved on March 31, 2020
[4]https://unity.com/
[5]https://github.com/Adjuvo/SenseGlove-Unity
[6]https://www.thingiverse.com/thing:340254, retrieved on Aug. 26, 2019

is based on an Asset from the Unity Store[7], including a set of realistic medical devices, furniture objects and animations.

5 DISCUSSION & CONCLUSION

As an extension to technology-mediated communication technologies such as 2D video conferencing, social VR provides many benefits. First, social VR immerses the users in the same virtual world, providing more realistic experience [26]. Second, social VR uses virtual representations to offer embodiment experiences to users, and abilities to interact with the virtual environment and 3D virtual artifacts [10]. Third, social VR brings social connectedness to the experience, allowing people to have a sense of co-presence, and to see and feel from other person's perspective.

In this demo, we present a social VR clinic for patients to remotely consult medical professionals. The goal is to support patients to travel fewer times to the hospital but still communicate well with doctors and nurses, and receive sufficient healthcare. The social VR clinic was implemented to simulate a real consultation office, a walk-in surgery room, 3D anatomical models and facilities in the hospital. More importantly, it offers a virtual injection tool to train patients to inject medicines with haptic feedback. The demo expands on the potential of social VR to help reshape remote medical consultations. Future work will continuously explore use cases for social VR, and investigate more haptic experiences, such as feeling or perceiving the weight of virtual objects.

ACKNOWLEDGMENTS

This work is funded by the European Commission H2020 program, under the grant agreement 762111, *VRTogether*, http://vrtogether.eu/. We also would like to thank *SenseGlove* for their help in the implementation.

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