Enhancing Medical Communication Training Using Motion Capture, Perspective Taking and Virtual Reality

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Abstract. The aim of this work is to increase the effectiveness of real world medical training simulations by helping trainees gain a better understanding of the importance of communication and teamwork. Therefore we develop an online application which can be used together with real world simulations to improve training. To produce the online application we reconstructed two real world scenarios (one with students and one with practitioners) in an immersive virtual environment. Our application enables the trainees to view the scenario from different perspectives or to freely explore the environment. We aim to integrate it into the medical student curriculum at the University of Tübingen.

Keywords. Medical education, simulation, virtual humans, virtual world, perspective-taking.

Introduction

Medical simulation centers are constantly trying to improve the effectiveness of their training [1]. Therefore they use a variety of approaches involving patient simulator systems, pre-recorded videos and interactive media applications. Some medical simulations even use Virtual Environments (VEs) to achieve better training effectiveness ([2], [3], [4], [5], [6], [7]). In order to have more realistic visualization of the patient some scientists ([4], [8]) use both patient simulator systems for gaining haptic feedback and VE for providing more realistic visual feedback of the patient. Indeed VEs have already been shown to be beneficial and are used to increase the effectiveness of many features of the real world simulations.

To help trainees learn how to examine patients and how to make them feel comfortable, Raij et al. used immersive virtual social perspective-taking [5]. Using a VE they put trainees into the patient's shoes. They found that perspective-taking was a useful ap-

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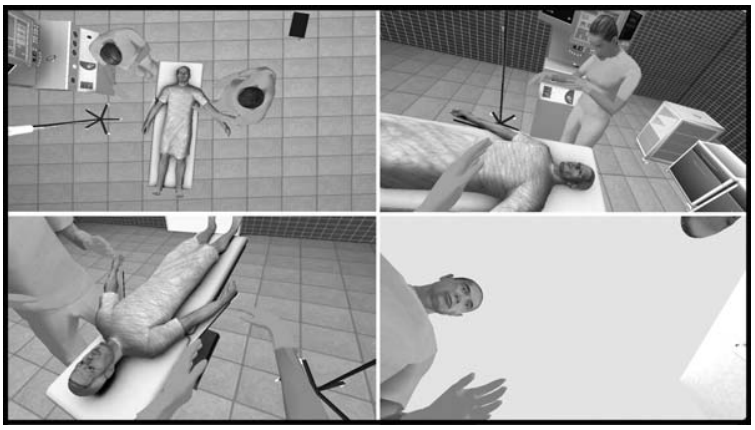

Figure 1. Perspective-taking practitioners' scenario (from top left to bottom right): overview, trainee 1, trainee 2, patient.

proach for helping trainees improve their behavior in similar social interactions. Furthermore, the work of Cowan et al. suggest that perspective-taking in VE, could be very useful for practitioners to appreciate the contribution and the expertise of their teammates [3]. Thus teammates can build team relationships that are beneficial for optimal health care delivery. Cowan et al. suggest that serious games could be used as a platform for such applications to give the possibility to many people to train in the same scenario simultaneously [3]. Already several applications, such as the "Pulse!!" [9] and the knee replacement surgery of Sabri et al. [6], are using this approach.

The recent research in this field and a local medical training facility inspired us to develop an online application which can be used together with real world simulations to give trainees a better understanding of the importance of interpersonal communication and teamwork in delivering safe patient care. Our goal is to reconstruct real world scenarios in an interactive application which gives the trainees the opportunity to observe and analyze their own performance by viewing the scenario from the perspective of their teammates or the patient (see Figure 1). To achieve our final goal we created a pipeline to rapidly and realistically generate medical scenarios. Using the pipeline we captured a routine medical training scenario with trainees (medical students). For improving the pipeline and getting better understanding of the training procedure we captured a scenario with practitioners which had didactical purpose.

1. Motivation

The training center, TuPASS [10] located in Tübingen Germany, emphasizes on the importance of communication and teamwork by recording each real-world training scenario with a set of video cameras and discussing the scenario right after each training session. The trainer uses these recordings to show the trainees that crucial factors for patient safety are not only in-depth medical knowledge and mastering medical skills but also good communication and teamwork.

Although these recordings are very useful, the perspective of the scenario is restricted to the fixed location of the video cameras. The trainee can be provided with

greater viewing-control over the scenario by using realistic medical scenarios generated in VE with motion capture and 3D visualization techniques. Allowing perspective-taking or even navigating through the VE, the trainee can observe each detail to gain a better understanding of the actions in the scenario.

Having in mind that many training centers, such as TuPASS, have a diversity of equipment and patient simulators, but they can only have a restricted number of trainees, an online application could be of great benefit for them. The training center can use the online application as an additional tool to the real world training sessions and make the application easily available for more trainees to improve their skills at home. Additionally, the trainees and the trainer can analyze and discuss the VE medical scenarios together by visualizing them in an immersive display, such as head-mounted display (HMD) or large screen display.

2. Pipeline for Generating Medical Scenario in VE

To minimize the mismatch between the user's real world expectations and the VEs [4], we generate realistic Virtual Humans (VHs) with realistic motions, ability to express emotions, and synchronized body and facial animations. Thus we developed a pipeline which combines body animations extracted from full body motion capture data and blendshape-based facial animations using predefined meshes of facial expressions.

To capture the medical scenarios the TuPASS training center provided us with their medical facilities, equipment and a patient simulator (SimMan 3G). Thus we used their set of video cameras and microphones to record the scenarios. Additionally, we captured the motions of the trainees using two Xsens MVN inertial motion capture systems, which uses full body motion capture suits for tracking the body motions. The motion capture data was first post-processed in the Xsens MVN software and then in Autodesk 3ds Max 2010. This was required because the tracking of the absolute position of the Xsens MVN suits is not accurate over time, especially when there is magnetic interference. Thus for synchronizing and adjusting the absolute position and orientation of the motions we used the video recordings. Once the data was post-processed it was used for the body animations of the VHs (modified characters from Rocketbox Studios GmbH: Complete Characters Library).

We used Poser 8.0 to generate face meshes for the different facial expressions of the VHs [7]. These predefined meshes were used for the blendshape-based facial animations of the VHs. Although the patient was a patient simulator, controlled by the trainer, we animated the face of the VH representing the patient as well. Thus the three VHs in the medical scenario were given realistic facial expressions, blinking and gaze behavior. We used Adobe Soundbooth CS4 to extract the voices of the trainees and the patient [7]. Using the pitch of the audio recordings we generated the lip motions of each VH.

We modeled a 3D hospital-like room in Autodesk 3ds Max 2010. For each scenario we chose 3D models of medical equipment from Evermotion 2009, which resembled the equipment in the TuPASS center. Using Dassault Systémes 3DVIA Virtools 5.0 (Virtools), we followed the procedure described in [7] to set up the scene and the cameras positioned at the eye-height of the VHs. In our application, the user can experience the scenario from 6 different perspectives or choose to freely navigate through the scene. Additionally, to show that the VE scenarios generated with our pipeline can be also used

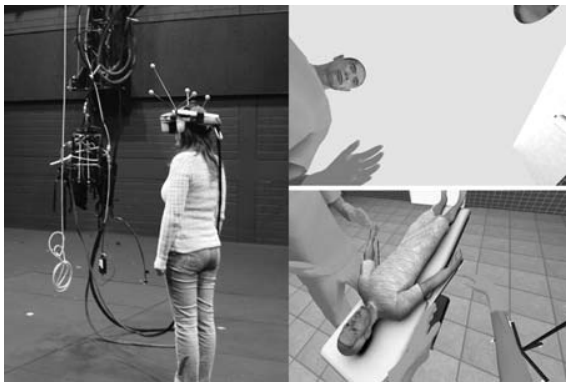

Figure 2. Left: Trainee observing VE scenario in HMD VE. Right top: The trainee views the scenario from the patient's perspective. Right bottom: The trainee views the scenario from her own perspective.

Figure 3. Interactions in the students' scenario.

in an immersive display setup, such as HMD, we setup the scenario in stereo using the nVisorSX60 HMD (see Figure 2).

3. Medical Training Scenario with Students

As our first attempt towards developing an online application for medicals simulations, we captured a routine medical scenario with two student-trainees. It was a scenario in which two doctors performed routine examination of a patient (see Figure 3). It was used to estimate the time frame for generating such VE scenario. Thus we could establish a way to integrate the VE scenarios into the learning curriculum of the students. This would be very useful for capturing real world training scenarios with the students and then later providing them the VE scenarios with their own motions for analysis and discussion. Additionally, we needed to realistically visualize the scenarios in order for the students to gain as much information as possible.

To generate the VE scenario using our pipeline took us about 4 weeks. The most time consuming part was the synchronization and adjustments of the animations. For subsequent animations we estimated 2 weeks post-processing would be necessary. The reason for this is that we already have the VE and VHs setup for the scenarios, we have to only post-process and adjust the new animations.

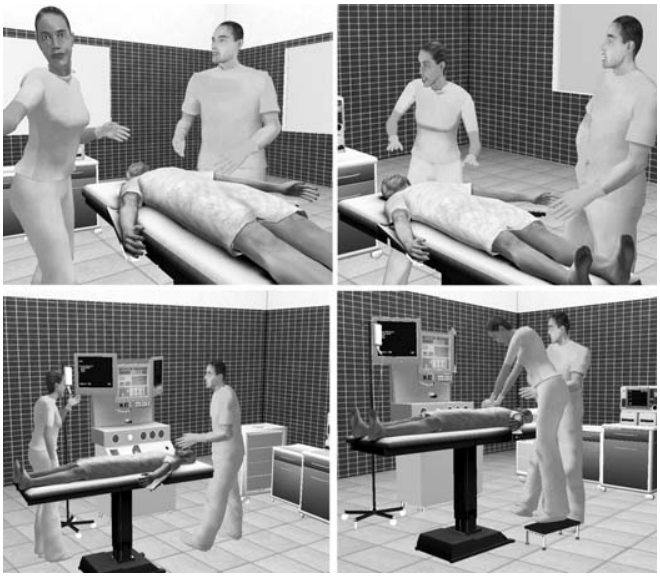

Figure 4. Practitioners' scenario (from top left to bottom right): friendly, arguing, stressed out, cooperating again.

4. Medical Training Scenario with Professionals

For the second part of our work we captured a training scenario with practitioners (see Figure 4). It was used not only to improve our pipeline but also to gain a better understanding of the training procedure. We generated a more complex scenario, which had also didactical purpose. Therefore in the beginning of the scenario the practitioners were asked to show the viewer that they enjoy working together. Towards the middle of the scenario they had a misunderstanding which was planned in the scenario. This misunderstanding caused the patient to become unconscious. At this moment instead of taking care of the patient, the medical professionals began arguing. Then the patient got worse. They had to put their personal problems behind and start cooperating again. By generating this scenario we aimed at extending the purpose of our application and use the VE scenario also as a prerecorded training scenario, which could be shown to students before their practical sessions.

5. Application as an online tool

After capturing and animating the two medical training scenarios we implemented them into an online application [11] (see Figure 5). For generating the application and designing its interface we used Virtools. We integrated buttons which enable the user to change the perspectives of the cameras: left overview, right overview, overview, patient, trainee 1 and trainee 2. Also we allowed the user to freely explore the VE. Furthermore, we have integrated the video of the real world scenario and a video containing the motion capture data. Thus the user can watch them together with the animations or hide them by clicking a button. If desired the user can mute the sound.

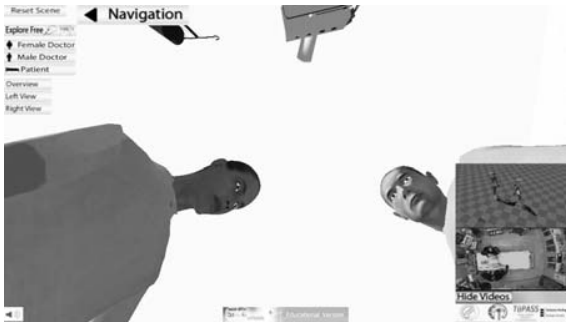

Figure 5. The online application of the students' scenario. A sliding menu with the navigation allowing perspective-taking is located in the up left corner. In the down right corner one can watch the videos.

6. Discussion and Future Work

Using our pipeline we showed that we can generate VE medical scenarios which we can successfully integrate in an online as well as in an immersive HMD application. Thus in our future work we can explore which of these two applications is more useful for the trainees at the TuPASS center. Using our application the trainees will have the possibility to take the perspective of their teammates or the patient. The perspective-taking might give them a better understanding of why they had problems in communication or within the team. Perspective-taking could be a way to improve effectiveness of training, by purposefully pointing trainees' attention to specific features. Since medical simulation centers, such as TuPASS, often teach groups of students during the entire semester, we plan to use our pipeline to capture and animate several scenarios of each group of students over the entire semester. Thus at the end of the semester we could show each group the sequence of VE scenarios. This way they will have the opportunity to observe and discuss their performance over time. Using these VE scenarios the trainer can demonstrate that skills such as communication and teamwork are also very important when trying to provide safe patient care.

Additionally, using perspective-taking for VE scenarios, such as the one generated with didactical purpose, may help for the trainees to immerse in the scenario and gain insights of each specific situation. However, during the post-processing of the second scenario we found out that for our future work we should extend our pipeline to also animate the objects with which the trainees interact. This way we will make the VE scenarios much more believable and hopefully immersive. Additionally, we intend to gather feedback from medical professionals and students for the usability of the interface of the application.

7. Conclusions

This work presented the first steps towards developing an online application [11], which can be used as an additional tool to real world simulations to improve training effectiveness. Our application shows the trainees the importance of communication and teamwork and allows for perspective-taking in different medical training scenarios. Using motion capture, video and audio data we realistically reconstructed two medical scenarios in VE

and implemented them in an online and an immersive HMD application. Since generating each scenario takes about 2 to 4 weeks it is possible to integrate our application into the students' learning curriculum.

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