Medical 3D Images in Multimodal Virtual Reality

Alexander Prange
German Research Center for Artificial Intelligence (DFKI)
Saarbrücken, Germany
alexander.prange@dfki.de

Michael Barz
German Research Center for Artificial Intelligence (DFKI)
Saarbrücken, Germany
michael.barz@dfki.de

Daniel Sonntag
German Research Center for Artificial Intelligence (DFKI)
Saarbrücken, Germany
daniel.sonntag@dfki.de

ABSTRACT
We present a multimodal medical 3D image system for radiologists in an virtual reality (VR) environment. Users can walk freely inside the virtual room and interact with the system using speech, going through patient records, and manipulate 3D image data with hand gestures. Medical images are retrieved from the hospital's Picture and Archiving System (PACS) and displayed as 3D objects inside VR. Our system incorporates a dialogue-based decision support system for treatments. A central supervised patient database provides input to our predictive model and allows us, first, to add new examination reports by a pen-based mobile application on-the-fly, and second, to get therapy prediction results in real-time. This demo includes a visualisation of real patient records, 3D DICOM radiology image data, and real-time therapy predictions in VR.

ACM Classification Keywords
I.2.1 J.3

Author Keywords
multimodality; position sensor; hand and pen gestures; speech; 3D images; decision support; virtual reality; radiology;

INTRODUCTION
We present a novel multimodal real-time decision support system for the radiology domain, where radiologists can visualise and interact with patient data in VR by using natural speech and hand gestures. Our multimodal dialogue system is an extension of previous work [3, 5] where we use an Oculus Rift DK2 in a remote collaboration setting. In our new scenario, the radiologist starts with a patient examination form he or she fills in by using a tablet with built-in stylus for notes and drawing. The handwritten multi-stroke sketches are transcribed by using handwriting recognition, then analysed and stored based on common medical ontologies [7]. The doctor then examines the patient records in VR where he or she can interact with the 3D medical images of the patient. Tyler et al. present a scenario where neurology images are displayed in VR [1]; we focus on the multimodal interaction with magnetic resonance imaging (MRI) material. One medical application of our scenario is immersive telemedicine, e.g., virtual tumour board reviews. Our end-to-end system provides a GPU-accelerated machine learning model for automated decision support that computes therapy predictions in real-time, too. This video[1] shows the complete workflow.

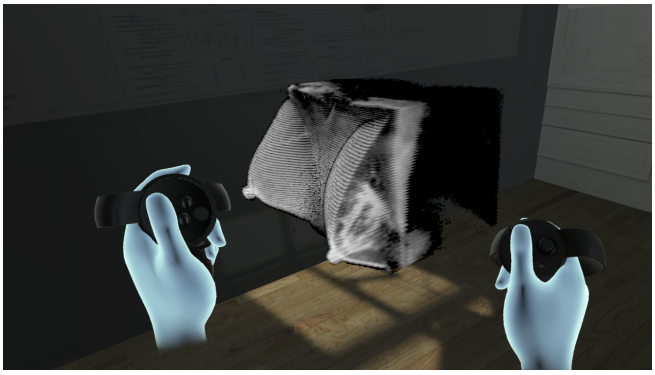

Figure 1. 3D image data manipulation in VR

ARCHITECTURE AND DECISION SUPPORT MODEL
We implemented a *Patient Data Provider* service for connecting to *PACS* (picture archiving and communication system) and *RIS* (radiology information system). The mobile application retrieves patient data and medical images through this interface and sends back completed reports of the radiologist. As depicted in figure 3, all devices and services are connected through a central hub, the *Proxy Server*.

For real-time data acquisition, we use a mobile device with a digital pen [6]. The speech-based dialogue system supports task-based interaction with the patient data shown on the virtual display (e.g., *"Open the patient file for Gerda Meier."*, *"Show the next page."*); question answering functionality about factiod contents of a patient record (e.g., *"When was the last examination?"*); and the RNN-based therapy prediction component (*"Which therapy is recommended?"*). We use SiAM-dp [4] for the speech-based multimodal dialogue and integrated it into the VR application.

[1] http://medicalcps.dfki.de/www/wp-content/uploads/KDI_V2_Pro_v04_2.mp4

IUI'18 Companion March 7–11, 2018, Tokyo, Japan

ACM ISBN 978-1-4503-5571-1/18/03.
DOI: https://doi.org/10.1145/3180308.3180327

Figure 2. Multimodal system in virtual reality

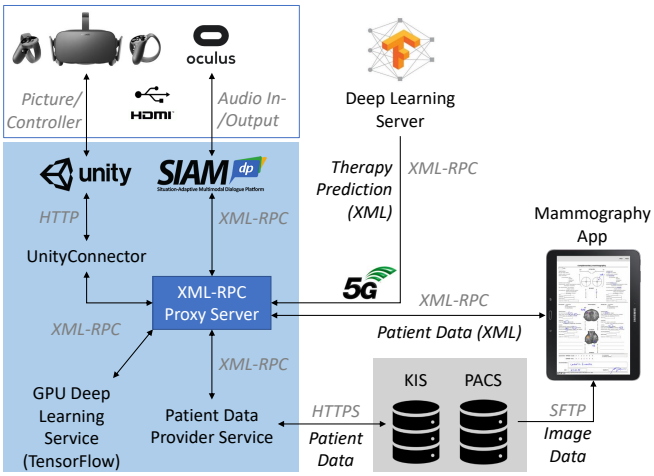

Figure 3. Architecture

The image viewer retrieves medical images in the DICOM format directly from the hospital's PACS, converts them into a suitable format and renders them inside VR as 3D objects. By using natural speech and hand gestures the user can scroll through the layers of the image stack and rotate them. Together with the possibility to walk around in the VR room, this allows for an immersive visualisation of medical images as tangible objects, allowing doctors to get a 3D perception of the data (see figure 1). Our medical dialogue system facilitates the doctor's interaction with a decision support module about which therapy is most suitable for a given patient. We integrated a prediction model for clinical decision support based on deep learning [2] as a backend service, running on a deep learning server.

CONCLUSIONS AND FUTURE WORK

A multimodal dialogue system in combination with 3D image visualisation and manipulation in VR provides an immersive user experience. Currently, we are investigating how the VR application, together with dialogue-based therapy prediction based on machine learning, impacts the medical findings process in daily hospital routine. Future work includes additional input modalities such as eye-tracking to improve the interaction in VR.

ACKNOWLEDGEMENTS

This research is part of the project "clinical data intelligence" (KDI) which is funded by BMWi and "Interakt" funded by BMBF.

REFERENCES

1. Tyler Ard, David M. Krum, Thai Phan, Dominique Duncan, Ryan Essex, Mark Bolas, and Arthur Toga. 2017. NIVR: Neuro Imaging in Virtual Reality. In *Proceedings of Virtual Reality (VR), 2017 IEEE*. IEEE, Los Angeles, CA, 465–466.
2. C. Esteban, O. Staeck, S. Baier, Y. Yang, and V. Tresp. 2016. Predicting Clinical Events by Combining Static and Dynamic Information Using Recurrent Neural Networks. In *2016 IEEE International Conference on Healthcare Informatics (ICHI)*. 93–101.
3. Andreas Luxenburger, Alexander Prange, Mohammad Mehdi Moniri, and Daniel Sonntag. 2016. MedicaLVR: Towards Medical Remote Collaboration Using Virtual Reality. In *Proceedings of the 2016 ACM UbiComp: Adjunct (UbiComp '16)*. ACM, New York, NY, USA, 321–324.
4. Robert Nesselrath. 2015. *SiAM-dp : An open development platform for massively multimodal dialogue systems in cyber-physical environments*. Ph.D. Dissertation. Universität des Saarlandes, Postfach 151141, 66041 Saarbrücken.
5. Daniel Sonntag, Volker Tresp, Sonja Zillner, Alexander Cavallaro, Matthias Hammon, André Reis, Peter A. Fasching, Martin Sedlmayr, Thomas Ganslandt, Hans-Ulrich Prokosch, Klemens Budde, Danilo Schmidt, Carl Hinrichs, Thomas Wittenberg, Philipp Daumke, and Patricia G. Oppelt. 2016. The Clinical Data Intelligence Project. *Informatik-Spektrum* 39, 4 (2016), 290–300.
6. Daniel Sonntag, Markus Weber, Alexander Cavallaro, and Matthias Hammon. 2014. Integrating Digital Pens in Breast Imaging for Instant Knowledge Acquisition. *AI Magazine* 35, 1 (2014), 26–37.
7. Daniel Sonntag, Pinar Wennerberg, Paul Buitelaar, and Sonja Zillner. 2009. Pillars of Ontology Treatment in the Medical Domain. *J. Cases on Inf. Techn.* 11, 4 (2009), 47–73.