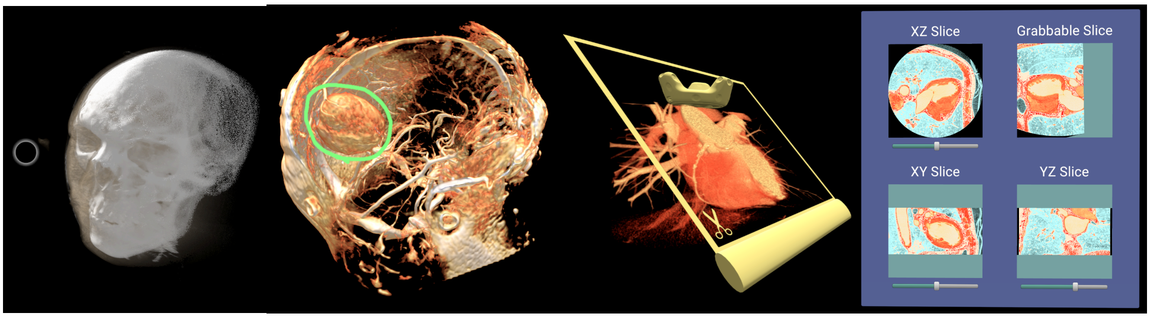
Augmented Reality Medical Volumetric Data

Project Management and Software Development
for Medical Applications



Please send the completed proposal to tianyu.song@tum.de, shervin.dehghani@tum.de and felix.tristram@tum.de. Please note that this proposal will be evaluated by the BMC coordinators and will be assigned to a student only in case of acceptance.

General Info

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Project Abstract

Many devices for medical imaging, such as CT scanners, produce volumetric data. It is of interest to display this inherently three-dimensional data with capable devices, like virtual reality (VR) or augmented reality (AR) devices. We want to investigate and implement ways to compute and render such data on a server, and then stream it to an AR device. The display and interaction modalities of the device should be considered.

Background and Motivation

Medical volumetric data, like CT or MRT scanners produce, are commonly viewed in 2D slices on screens. However, it is possible to display this volumetric data in 3D via direct volume rendering [1]. This improves users ability to understand the data in 3d context, aids in understanding depth and explorability, and allows less experienced users to better understand the displayed data. The coloring and display of these volumes can be precisely controlled via transfer functions [3], which map a given density at a point to a color. Existing approaches mostly focus on either displaying these 3D visualizations in 2D on computer monitors [2], or in 3D on VR devices, tethered to a powerful machine. This is because the rendering of volumetric data takes considerable GPU resources, even on modern hardware. We are interested in showing this data on AR devices, to explore the opportunity to display medical data in-situ, together with different haptic input modalities [5], or collaboratively with patients, without taking them out of the room like with VR glasses.

Student's Tasks Description

The project aims to extend an existing Unity engine framework for loading and displaying medical volumetric data to support AR visualization. This includes multiple smaller tasks: Investigating and implementing a way to stream the rendered data to the headset. Improve existing rendering shaders for better optics, speed, and compatibility with the hardware. Investigate, possibly with users, ways to adjust the colors and visualization to work with the additive displays of AR headsets (no shadows or black color) [4]. The student will gain insight into medical data visualizations and modern hardware, as well as improve their programming skills, especially in 3D environments (C# and shaders).

Technical Prerequisites

Students should have experience and be excited to develop and work with 3D applications and AR hardware in the Unity 3D engine. Basic knowledge and interest to learn more about shader implementation is recommended. Students should be motivated to strive for good usability and user experience and be interested in working with novices or experts to improve and test the system.

References

[1] K. Engel, M. Hadwiger, J. M. Kniss, and C. Rezk-Salama, "Real-Time Volume Graphics," 2006, Accessed: Dec. 30, 2021. [Online]. Available: https://diglib.eg.org:443/xmlui/handle/10.2312/egt.20061064.0595-0748

[2] V. Kraft, F. Link, A. Schenk, and C. Schumann, "Adaptive Illumination Sampling for Direct Volume Rendering," in Advances in Computer Graphics, N. Magnenat-Thalmann, C. Stephanidis, E. Wu, D. Thalmann, B. Sheng, J. Kim, G. Papagiannakis, and M. Gavrilova, Eds., in Lecture Notes in Computer Science. Cham: Springer International Publishing, 2020, pp. 107–118. doi: 10.1007/978-3-030-61864-3_10.

[3] P. Ljung, J. Krüger, E. Groller, M. Hadwiger, C. D. Hansen, and A. Ynnerman, "State of the Art in Transfer Functions for Direct Volume Rendering," Computer Graphics Forum, vol. 35, no. 3, pp. 669–691, 2016, doi: 10.1111/cgf.12934.

[4] A. Martin-Gomez, J. Weiss, A. Keller, U. Eck, D. Roth, and N. Navab, "The Impact of Focus and Context Visualization Techniques on Depth Perception in Optical See-Through Head-Mounted Displays," IEEE Transactions on Visualization and Computer Graphics, vol. 28, no. 12, pp. 4156–4171, Dec. 2022, doi: 10.1109/TVCG.2021.3079849.

[5] T. Lück et al., "Exploring realistic haptics for 3D-printed organ phantoms in surgery training in VR and AR," Transactions on Additive Manufacturing Meets Medicine, vol. 2, no. 1, Art. no. 1, Sep. 2020, doi: 10.18416/AMMM.2020.2009026.