Improving Radiology Communications and Patient Trust with Virtual Reality

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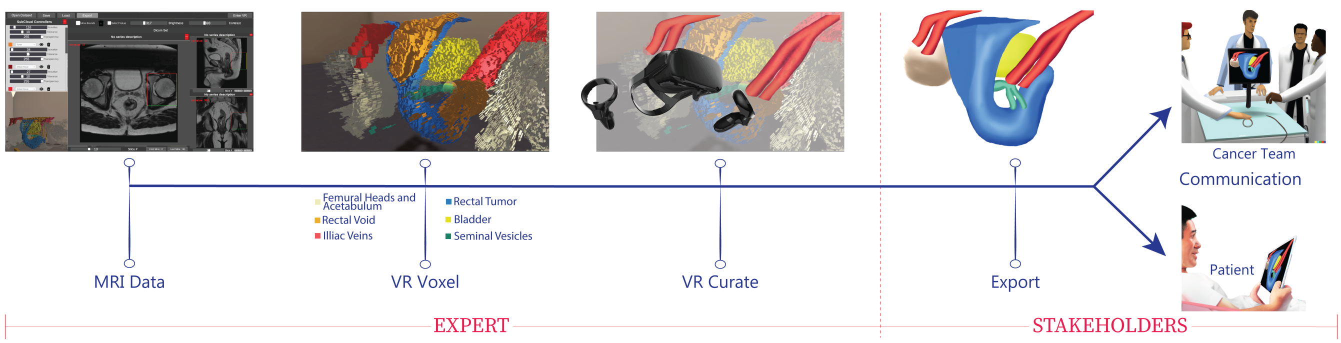

Figure 1: System pipeline components from left to right: (1) typical radiological MRI (2) voxelization of the structures, (3) viewing and curating in VR environment, (4) export of curated results, (5) use and benefit. Reprinted with permission from [2], ©2024 IEEE.

Abstract

Interpreting 3D information based on 2D slices of the data is notoriously difficult. Yet in the medical field makes intervention choices based on radiological scans on a daily basis. Volumetric reconstructions of these data sets, via voxel clouds and surface meshes can reduce the cognitive complexity of this task. However, creating these reconstructions requires extensive software training and time, often on the part of a technician separate from the treatment team. To shorten this process, we present a system designed for radiologists and surgeons on the care team. We integrate tools familiar to these experts and provide a stereoscopic environment for quick spatial comprehension and intuitive data curation. Based on the feedback from oncology collaborators on the system in its current state, it is not only helpful for communicating tumor progression but, additionally shows promise as a teaching tool to assist with building skills for traditional interpretation of radiology images.

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CCS Concepts

• **Human-centered computing** → **Visualization systems and tools**; • **Applied computing** → *Health care information systems.*

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1 Introduction

The staging and treatment of cancer often requires analysis of anatomical spatial relationships inferred from 2D imaging techniques, such as magnetic resonance images (MRI). However, the ability to read MRI comes with a steep learning curve [6]. Even for experts, interpreting this information is a taxing process because it requires the viewer to construct a mental model to form the spatial conclusions from this flattened data. This, in turn, hinders the communication process among the treatment team due to diverging interpretations and misunderstandings that can negatively impact patient outcomes [4]. Reconstructing these images back into 3D models, creating explicit visualization of the anatomy, alleviates the mental and communication strains this diagnostic process incurs.

One long-standing method to create these visuals is direct volume rendering, which creates 3D texture projections from the stack of images, highlighting structures using transfer functions. This works well for rigid structures such as bone and muscle but is ill-suited for softer tissues. Also, due to the nature of 3D texture projection, viewers are unable to investigate internal structures. Alternatively, we can create surface and volume reconstructions using semi-automated segmentation. However, this process involves complex software and a trained technician to correct errors from the model over-processing data noise and sensitivity to perturbations in the pathology [1]. Despite these current options resolving some of the communication challenges, the additional time and training needed to develop the visualizations has impeded widespread adoption.

We present a system that offers physicians the ability to generate their own reconstructions that they trust and enhances existing radiology training paradigms, rather than adding to them.

2 System Design

By eliciting feedback from our medical collaborator, we have performed several cycles of an iterative design loop to address adoption barriers, feature feasibility, and target the areas that are least served by existing solutions. Our design solution can be characterized by two major components: a familiar 2D scan interface using desktop peripherals (the leftmost image in Figure 1) and a VR exploratory environment (shown in the 2nd and 3rd images from the left in Figure 1).

2.1 Familiar Data Selection

The initial phase of identifying and isolating the pertinent structures to be visualized must mimic the ubiquitous style of traditional radiology viewing platforms, as seen in the first image of Figure 1. This is to garner adoption by physicians, who are wary of unfamiliar and intricate interfaces that can slow down patient care. Thus, the isolation of relevant structures also utilizes interactions that are already collected as part of a standard radiology report, i.e., z-bounding slices and boxing regions of interest. As these interactions relying on fine motor movements, this stage of the system uses a desktop workstation.

2.2 Spatial Data Interactions

The system is meant to provide accurate 3D models at an accessible level to medical practitioners; thus, after initial structures have been selected, the system leverages the enhanced spatial reasoning afforded by virtual reality (VR) [5, 7] and transitions to an immersive environment. This supports experienced physicians in distinguishing between poorly captured details and segmentation artifacts to be removed. Additionally, since interacting with 3D data in this way has a lower cognitive load than interacting with it on 2D displays [3], the system serves as a teaching platform for trainees that are new to interpreting radiology images.

3 Expert Feedback

Over the course of designing and developing this system, we have collaborated extensively with our university's teaching hospital staff. A consistent comment from these meetings is the perceived increase in understanding anatomic details simply from seeing and rotating the reconstruction in the VR environment. While the unfamiliar style of the voxelizations can cause initial disorientation, this is frequently replaced by trust when they experience overlaying the MRI slices with the structures. Through demonstrations with the teaching staff, there is strong support for the system's utility as a training tool for MRI scan interpretation. The tangibility and spatial alignment makes it easier to see the spatial structures obscured in the individual images in the stack. When discussing the system in terms of later stages of care, there has been interest in not only using the volumes to verify logistics of procedures, but also to help educate patients on the details of their pathology and better understand the proposed treatment.

4 Conclusion

Developing an understanding of anatomy from stacks of radiology images is a known strenuous skill to develop in the medical field. The creation of 3D reconstructions are an intuitive solution to the communication barriers between radiologist, patient and treatment team. The goal of the system is to enable the explicit 3D reconstruction of patients' MRIs that is trusted by and accessible to members of cancer treatment teams, something existing solutions are still struggling to achieve. The reconstruction can then be used for exploratory analysis, team communications, patient-specific procedure planning, and patient education.

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