Advancing Advanced Visualization in the Clinical Environment

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Background

Traditionally, 3D visualization has been performed along with certain clinical applications such as stent measurement or coronary artery calcium scoring as a post-processing step on highly specialized workstations. Neither physically nor logically integrated into clinical workflow, these workstations are also typically not well suited for routine diagnostic image interpretation. As more imaging modalities produce volumetric data sets, the opportunity arises to divide 3D visualization and analysis into two categories; those tasks performed (perhaps by technologists) as post-processing steps, and 3D navigation and visualization that is part and parcel of the radiologist's interpretation process. PACS workstations used for interpretation have lagged in providing 3D functionality while specialty workstations have lagged in providing clinical workflow and routine image manipulation tools. Even when PACS workstations do provide for 3D functionality, it is typically limited to basic functions. As commercial software, there is a long development and deployment time for requested features.

Advanced 3D visualization and analysis software is available in the research community. Much of this research software is available for free as open source software under a variety of licensing schemes. This software is usually highly innovative and very sophisticated. The downside, if there is one, is that the software is designed by engineers and scientists for engineers and scientists, and so lacks the user interface necessary for routine clinical use and the integration into clinical workflow. This paper describes our efforts to develop a more radiologist friendly interface for one of these research software packages. This visualization component will be integrated into a clinical workstation described elsewhere.

Evaluation

Northwestern Memorial Hospital (NMH) currently operates a large GE Centricity PACS (GE Healthcare, Milwaukee Wisconsin) [1]. Centricity, as typical of other major commercial PACS, provides functionality for worklist driven workflow, hanging protocols, and display and manipulation of 2D images and stacks of 2D images. Volumetric functions such as maximum intensity projections, multi-planar reformatting and surface rendering are not inherently provided by the software. In the Centricity environment, it is possible to load the dataset into GE's visualization workstation software (GE Advantage Windows, GE Healthcare MIlwaukee, WI) but a context switch to the new application is required. Similarly, NMH operates several specialty 3D post-processing workstations that require a physical move to a new workstation and reloading of the dataset before visualization can take place.

Slicer (www.slicer.org) is "freely available, open-source software for visualization, registration, segmentation, and quantification of medical data" that is now a component of the National Alliance of Medical Image Computing (NA-MIC). The software is built upon the open source Visualization Toolkit (VTK) and Insight Toolkit (ITK) libraries. It also offers the ability to add in user defined modules that extend its functionality for specific needs.While providing very advanced visualization functionality, the software lacks integration into clinical workflow and more importantly a graphical user interface that could be navigated by a radiologist in the course of a clinical interpretation session.

We have taken the source code for Slicer 3 and modified it so as to be incorporated into a diagnostic workstation currently under development in our laboratory. The modified Slicer 3 code will provide the advanced visualization and analysis functionality while other components provide for 2D image display and integration into clinical workflow. The workstations at NMH are running the current Windows operating system, and thus the new workstation interface is being developed in the C# programming language with .NET architecture (Microsft Corp., Redmond, WA). To integrate Slicer 3, which is a cross platform application written in the C++ programming language, the main function of the program was wrapped into a managed C++ class and compiled as a dynamically linked library (DLL). Member functions were added to the class to interface between Slicer's unmanaged code and the managed code of the workstation. This reworking of Slicer's code allows the .NET interface to build the Slicer 3 application and access the objects within it. The next step in the integration process was the transfer of Slicer 3's displays (VTK render windows) into the .NET interface. Pointers to window handles were passed through Slicer's GUI objects to the VTK render window via functions added to those libraries. Changing the window handle from its default location in Slicer to a component inside the new .NET interface draws the rendered window region inside of the .NET GUI. Slicer was further modifed to suppress the building and display of its original GUI as it was replaced by the .NET GUI. The end result is a new user interface, built on top of the feature rich and activily developed Slicer software, that is fully customizable for the clinical environment.

With respect to the graphical user interface for 3D visualization, we have made a number of innovations. Slicer provides tools for manipulating a volumetric dataset and visualizing, for example, a cut surface. We have simplified the user interfacer to these controls while simultaneously providing access to the three orthogonal planes of reconstruction that are commonly used by radiologists. This mitigates the need to reconstruct these planes on the acqusition modality. We have removed extraneous and advanced user interface controls thought to be used infrequently by radiologists in the clinical setting. Access to these functions is maintained in a "research mode". The actual control of functionality is abstracted in the Slicer model so that functionality may be assigned to user interface devices at the users' discretion. Specifically, these controls include keyboard shortcuts and uses of 2D input devices to control a 3D space, and present that space to the radiologist in an intuitive fashion.

Discussion

Advanced volumetric visualization is currently provided in the clinical setting in a haphazard and inefficient fashion. Typically, the functions are provided by specialty workstations that do not provide more mundane clinical functionality. At the same time, the general purpose, diagnostic workstations, in general, fail to provide advanced and integrated 3D visualization and analysis. This makes the routine use of advanced functions cumbersome and inefficient in the clinical setting. Commercial systems, in general, suffer from market driven engineering [2] and innovation is typically low and slow.

Research software packages on the other hand provide advanced functionality, many free of cost. The software is, however, typically written by engineers and scientists for engineers and scientists and therefore typically ignores the requirements of the clinical environment. Combined with HIPAA and institutional review board (IRB) regulations for the performance of research, this hampers efforts to facilitate translation between the research and clinical domains.

Conclusion

The Transforming the Radiologic Interpretation Process (TRIP) initiative encompasses far more than visualization of volumetric datasets. None-the-less, advanced visualization functionality must be provided and done so in a fashion that integrates with clinical workflow. At the same time, a software platform for innovation and change is necessary so that other methodologies for TRIP may be evaluated. Research software that provides advanced functions not elsewhere available can be modified to provide some of that functionality. We are taking an advanced research software package and rendering it useful in a clinical setting. Our platform combines the common, expected features of a diagnostic workstation with the advanced functionality and extensibility of Slicer. This platform may lead to accelerated translational imaging informatics.

References

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