System Architecture and Toolkits for Image-Guided Intervention Systems

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Background and Motivation: Several toolkits exist for visualization and image processing, such as VTK, ITK and 3D Slicer, but there are no widely used open source toolkits for interventional devices such as medical robots and tracking systems, nor are there open architectures for the integration of these subsystems into image-guided intervention systems.

We propose to address this problem by using formal development processes to create software toolkits and an open architecture for image-guided interventions, as shown in Figure 1. We believe that this will increase the pace of development and clinical deployment of new image-guided devices.

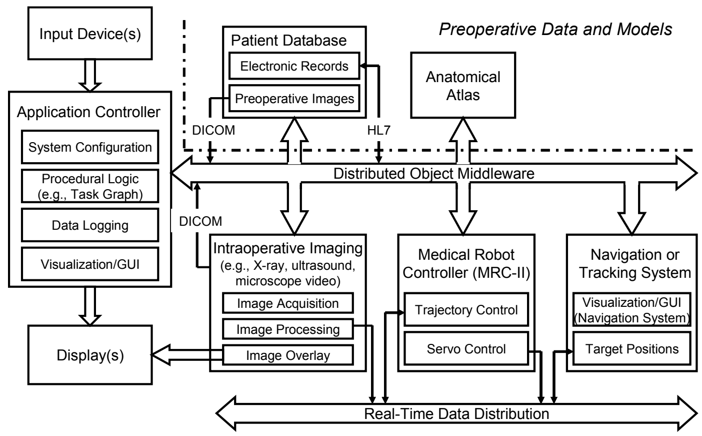

Figure 1: Architecture for Image-Guided Intervention Systems

Methods: Our efforts are focused on:

Visualization and Application Control

This is the core interface responsible for user interactions and the coordination of the various subsystems. It is difficult to create a single toolkit to satisfy all users, so our architecture will support both 3D Slicer and IGSTK.

3D Slicer was originally developed at MIT and is now enhanced and maintained by the SPL at BWH. It is based on VTK, ITK and TCL/TK and provides visualization, registration, segmentation and quantification of medical data (www.slicer.org).

The ISIS Center at Georgetown University is leading an effort to apply a rigorous development process (C-PLAD) to the development of an Image Guided Surgery Toolkit (ISGTK), which is based on VTK, ITK and FLTK (www.igstk.org) [1].

Middleware and Real-Time Networking

Middleware is a vital component of the system architecture because it must provide a transparent interface between the different subsystems. In the past, we experimented with CORBA [2], but are currently evaluating other options. A key issue is the need for real-time data distribution between several subsystems.

Medical Robot Controller

A first generation Medical Robot Controller (MRC) was developed at JHU to support several projects within the CISST ERC. We are currently applying a formal development process to create a new version, MRC-II, as part of the *cisst* software package (www.cisst.org). MRC-II is portable and provides periodic real-time tasks when used with a real time operating system such as RTAI/Linux, but can also be used with traditional operating systems such as Windows and Linux.

Navigation/Tracking Systems

IGSTK includes a uniform interface to different tracking systems. This is similar to the *cisTracker* library developed at JHU for use within the CISST ERC and JHU researchers are advising the IGSTK team. We are also working towards the definition of a generic research interface to commercial navigation systems.

Results and Conclusion: We have several toolkits in varying stages of development. 3D Slicer has been freely available for several years and has a broad user base and many applications, such as an in-MRI robot [4]. IGSTK and MRC-II are in active development. The former has been used for electromagnetic tracking of a surgical needle [1], while the latter has controlled a small snake robot intended for laryngeal surgery [3]. We are striving towards a unified architecture and middleware that would tie these toolkits together. We also believe that standards for interoperability are key research enablers and urge industry and academia to define and adopt them.

References

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