New Software Toolkits for Comprehensive Visualization and Analysis of Three-Dimensional Multimodal Biomedical Images

Dennis P. Hanson, Richard A. Robb, Shmuel Aharon, Kurt E. Augustine, Bruce M. Cameron, Jon J. Camp, Ron A. Karwoski, Alan G. Larson, Mahlon C. Stacy, and Ellis L. Workman

THE SYNERGISTIC integration of comprehensive and generic tools in software systems for advanced visualization, processing, and quantitative analysis of biomedical images has allowed surgeons, physicians, and basic scientists to explore large multidimensional biomedical image volumes efficiently and productively. The "toolbox" approach to biomedical imaging software integration provides an effective mechanism for addressing a multiplicity of applications. Yet, most "toolbox" software systems in biomedical imaging focus at a specific level of integration, that is, at the end-user application or the level of a software developer.

New software toolkits for the detailed investigation and evaluation of three-dimensional biomedical images at several levels of interaction have been developed on standard workstation systems. Each toolkit builds upon the previous one, facilitating use of the software by developers at the lowest level to end-users at the highest level. These software toolkits include the AVW library; AVW/Tcl-Tk toolkit with Tcl/Tk extensions to AVW; AVW/Procs procedure classes for common imaging processes; and Analyze_{AVW}, an implementation of the ANALYZE software system based upon the preceding toolkits.

DEMONSTRATION—BIOMEDICAL IMAGING SOFTWARE TOOLKITS

Figure 1 depicts the integration of these new software toolkits in a paradigm that permits multiple levels of interaction, allowing both developers and end users access to a vast array of biomedical imaging tools for visualization and analysis.

AVW is a comprehensive set of imaging functions packaged into a C-callable library that provides developers with advanced image processing and display algorithms and techniques to facilitate easy integration into specific applications. Each

library function has a well-defined calling sequence utilizing standardized AVW parameters and data structures.

AVW/Tcl-Tk consists of Tcl extensions for all AVW functions and data structures and various Tk extensions for interface components that can be used to build higher-level applications. This facilitates direct use of AVW components in the powerful Tcl/Tk paradigm, permitting easy integration into higher-level applications and programmer extensibility via the Tcl language. This further provides a command-level interface to all of the functions in AVW.

AVW/Procs integrates components of AVW and AVW/Tcl-Tk into common imaging procedures, including processes for visualization, segmentation, registration, and measurement. For example, a procedure for morphologic-based segmentation of anatomic structures is built from basic functions in AVW and can be easily integrated into higher-level applications.

Analyze_{AVW} is an advanced, synergistic implementation of the functionality of previous ANALYZE software systems built upon the new AVW, AVW/Tcl-Tk, and AVW/Procs toolkits. The software system is constructed to allow multiple biomedical volume images to be simultaneously accessed by multiple processes, as demonstrated in Figure 2.

All components of these software toolkits will be demonstrated with various multimodal biomedical image data sets from several different medical applications.

From Biomedical Imaging Resource, Mayo Foundation, Rochester, MN.

Address reprint requests to Dennis P. Hanson, Biomedical Imaging Resource, Mayo Foundation, 200 1st Street, SW, Rochester, MN 55905.

*Copyright © 1997 by W.B. Saunders Company
0897-1889/97/1003-1077\$3.00/0*

Program Level (Applications)	Analyze _{AVW} Visualization and Analysis Program										Other (User-Built) Application Programs															
Integrated Process Level (Procedures)	AVW/Procs Procedure Classes: Visualization, Transformation, Segmentation, Classification, Registration/Fusion, Measurement																									
Applications Programming Level (API's)	AVW/Tcl-Tk Tcl/Tk Developers Toolkit						AVW Library																			
Library Level (Tools)	Tk		Tk Interface Extensions		Tcl		Other Tcl Extensions		AVW Extensions for Tcl		Image I/O	Resource	Transform	Process	Segment	Analysis	Visualize	Model	Other Imaging Tools							
	AVW_wish Interpreter				AVW_tclsh																					
	Windows NT		Xlib		Direct Command Interface																					
			Xserver																							
System Level	Display Hardware/Software						Compute Hardware/Software & Peripherals																			

Fig 1. AVW-based software toolkits: AVW library (lower right), AVW/Tcl-Tk (lower left), AVW/Procs (middle), and Analyze/AVW (top).

Fig 2. Screen capture depicting simultaneous multiple volume image data access by multiple processes in Analyze_{AVW}.