A Graphical Display for Electrocardiogram Data in an Integrated Hospital Information System

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Abstract

The U.S. Department of Veterans Affairs (VA) has undertaken a project to integrate diagnostic images into its existing text-based hospital information system. Through this technological innovation high-quality image data from cardiology, pulmonary and gastrointestinal medicine, endoscopy, pathology, radiology, hematology and nuclear medicine can be displayed, conveniently to the physician or clinician. As a part of this endeavor, diagnostic-quality 12-lead electrocardiogram images, including both median and rhythm data, can now be viewed as a part of the patient record at any DHCP (Decentralized Hospital Computer Program) imaging workstation.

Introduction

To support its physicians in providing high-quality health care, the VA is installing and evaluating a distributed imaging system that integrates image management and communications into its existing text-based integrated hospital information system (DHCP).

The initial test site for the DHCP Integrated Imaging System is the Washington (DC) VA Medical Center, a 700-bed facility that provides acute and long-term care for the veterans of the Washington area. Approximately twenty-five imaging workstations are installed and in routine use, providing the ability to capture, display, store, and retrieve clinical images.

With full networked connectivity between multiple image servers, 80386/486-based high-resolution true color image workstations, and the DHCP hospital information system, the system has been handling various medical images such as: cardiology studies, microscopic pathology slides, and endoscopic examinations. The desire to include electrocardiogram (ECG) waveform images in the patient record has led to the development of a graphical-display extension for the DHCP system that renders full diagnostic-quality ECG images.

Implementation

Most vendors are currently providing graphical displays for their standalone ECG systems. Due to screen and memory limitations, however, most of these displays rely heavily on subsampling the data for image display, resulting in a nondiagnostic quality image. Additionally, clinicians wanted to see the image in the same format as they were accustomed to seeing on paper output from the electrocardiogram system.

This new software, like most of the software developed by the VA, is written in MUMPS to work within the framework of the DHCP imaging system. The DHCP imaging workstation is a two-monitor system for both text and graphics display. An analog RGB monitor is used for graphics display and is driven by the Truevision AT-VISTA graphics display adapter. MUMPS Graphics ZCALL functions enable both text and graphics to be drawn on the graphics screen.[1]

Incorporating the ECG images into DHCP required a few changes. At the DHCP imaging workstation, images are typically presented in 8-bit grayscale or 16-bit color, with a displayable resolution of 756 x 468. To reproduce the ECG images in a diagnostic-quality format similar to what clinicians were accustomed to, a 4096 horizontal pixel resolution was required, far exceeding the 4 megabyte memory availability of the AT-VISTA adapter in 16-bit mode. Therefore, an 8-bit color image was used to fully display the ECG data without data loss from subsampling, and in a manner that would not cause confusion to clinicians. Limiting the selection of colors and creating an accompanying palette of these select 8-bit colors reduced memory constraints and freed additional memory to fulfill the 4096 horizontal pixel resolution requirement.

Descriptive text data from the DOS ECG data file (i.e., patient name, id number, date/time of exam, etc.) is read and displayed on the screen. A grid is then calibrated and drawn to the screen's addressable memory of 4096 x 468, using the ZCALL linedrawing function.

Rhythm data from the DOS ECG data file is read into a MUMPS global, and mathematically processed if necessary, depending on the ECG-lead, and then drawn to the screen. Two colors are used to avoid viewer confusion when traces collide. Then median data is read from the same file, again processed if necessary, and drawn to the screen. An overall image, calibrated and identical to diagnostic output that the clinician is accustomed to using, is now available in addressable memory for viewing. A screen-handling function then enables horizontal panning of the image at the viewer's discretion. The viewer can move through all twelve of the ECG leads, displayed at 2.5 second intervals, as well as a full 10 second segment of lead II. Following this, the median data, for all twelve leads, is displayed.

Discussion

Since an electrocardiogram is an important tool in diagnosis, it is imperative that it be accessible at any time. Including the electrocardiogram image in the DHCP patient record will allow clinicians to access this information faster and more efficiently. Uncompressed ECG data files are approximately 45k in size and compressed files can be as small as 4k, requiring little from today's many gigabyte systems.

Currently, methods for more rapid processing of the images are under study. Further work will include integrating electrocardiograms created on other vendor's systems into DHCP and to incorporate, graphically, other diagnostic studies, such as Holter monitoring.

References:

1. Dayhoff, RE and Maloney, DL. Interacting with Images in a Hospital Information System, Proceedings of the 1990 MUMPS User's Group Meeting, Orlando, Fl. June 1990.

2. Rowlandson, I. Marquette Electronics 12 SL ECG Analysis Program - Statement of Validation and Accuracy.