Simulator of Patient Traffic in a Cardiology Department for Testing the Integration of an ECG Management System with an Existing Clinical Database

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Abstract

In the context of HYGEIAnet, the regional health network of Crete, a clinical cardiology database (CARDIS) was installed in several hospitals. To fill the need for a computerized ECG management system, a collaboration was organized between ICS-FORTH and Mortara Instrument, Inc., aimed at integrating the Mortara E-Scribe/NT software with CARDIS.

In order to test the combined system before installation, a computer program was developed to simulate patient traffic in a cardiology department. The program was run for three simulated 'months' and a total of around 2000 ECG recordings were archived for access from CARDIS. During the testing period, a number of software problems were identified and corrected.

The same approach could be used for testing other database components, with a view to precluding the loss of real clinical data as a result of software malfunction.

1. Introduction

In the context of HYGEIAnet, the regional health network of Crete [1], a clinical cardiology database (CARDIS) was installed in several hospitals. CARDIS maintains a comprehensive archive of patient demographic and clinical data, including details of specific cardiological examinations.

In view of the large number of resting ECGs recorded each day in the cardiology departments involved, there was a need for a computerized ECG management system. After an investigation of commercially available systems, a collaboration was organized between ICS-FORTH and Mortara Instrument, Inc., with a view to integrating the Mortara E-Scribe/NT software with CARDIS [2]. The aim was to produce an effective solution with the minimum outlay in terms of time and effort.

In this paper we briefly describe the integration of the ECG management system and CARDIS. However, the main focus will be on the method used to test the combined system before installation, using specially designed software for simulating patient traffic in a cardiology department.

2. Requirements and design

The desired system had a number of specific requirements:

- Automation of bulk and individual exam ordering.
- Avoiding useless data re-entry, mainly on the medical device side.
- Solution of the language problem, i.e. Greek character set not supported by the ECG device.
- Use of existing dedicated tools for exam confirmation and reporting.
- Automated archiving of confirmed examination results.
- Graphical display and printout of ECG recordings from CARDIS.
- Seamless integration of software components.

In order to achieve these aims, close collaboration between the two partners was required. Although some of the above requirements were already built in to the E-Scribe/NT software, others required modifications or additions.

2.1. Automated ordering

Automatic downloading of examination orders to the electrocardiograph is a standard part of the E-Scribe/NT system. However, it was necessary to produce a new software component to allow initiation of the order preparation from the CARDIS side.

2.2. Data entry and the language problem

Entry of patient data on the electrocardiograph itself can be tiresome for the technician, especially when a large number of routine ECGs are to be recorded. This operation can also be a source of errors. For this reason, it was decided that patient demographic and other data would be entered exclusively through CARDIS and would be copied from there to the E-Scribe/NT database for download to the electrocardiograph when necessary. In this way, the E-Scribe/NT database would mirror CARDIS at all times. Another advantage to this approach was that information such as the patient's sex and age, which are used by the electrocardiograph's interpretation program, would be transferred automatically and accurately to the device.

The problem of patient data was exacerbated in our case by the fact that patient names in CARDIS are entered in the Greek alphabet, which is not currently supported by any commercially available standalone electrocardiograph. The solution was to implement a special transliteration algorithm that converts Greek names to the Latin alphabet before download to the ECG device. When the ECG recordings are transferred to the E-Scribe/NT database, the Greek version of the patient's name is reinserted in the record and stored in the archive.

2.3. Graphical display of ECG

It was considered desirable that digitally stored ECGs should be viewable on computers that do not have the E-Scribe/NT software installed, and perhaps even through a Web browser. To achieve this, an existing, multi-manufacturer ECG viewer/printer (Figure 1) was extended to be capable of reading data in the Mortara UniPro format.

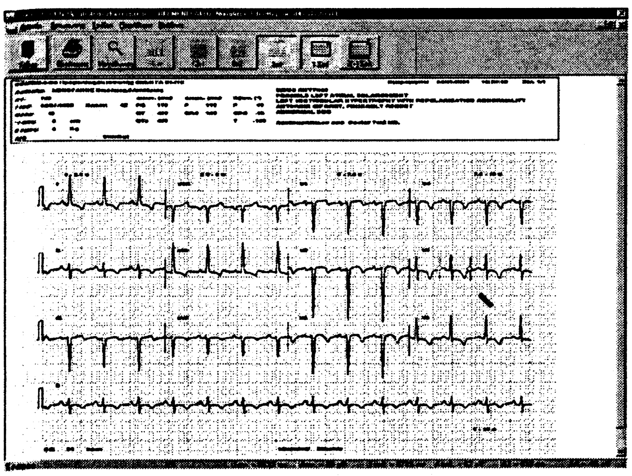

Figure 1. ICS-FORTH UniPro ECG viewer and printer.

2.4. Seamless integration

The aim of the design was that the user should not have to be aware of which functions were carried out by which software, but should be presented with a system that operated as a unit, except that the two components were designed to offer different views of the ECG data: CARDIS, from the point of view of an individual patient's clinical record; E-Scribe/NT for access to the entire ECG archive for statistical or research purposes.

A schematic diagram of the integration of the two component systems, showing the main ECG workflow, is given in Figure 2. Exceptional cases, such as emergency ECGs for patients who have not been entered into the CARDIS database, are handled by special procedures.

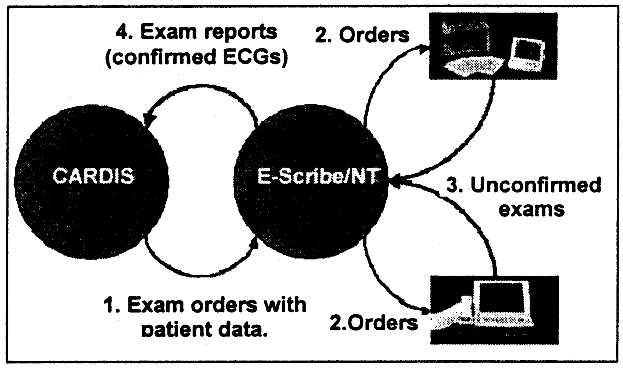

Figure 2. Schematic representation of the integration.

3. Testing

Given that the system described above would be handling a large amount of data that could at times be crucial for diagnosis, it was essential to carry out thorough testing before installation in a real-life clinical setting. To this end, we developed a special computer program to simulate patient traffic in a 40-bed cardiology department.

3.1. Simulator program

The simulator program was written in Perl, using the Win32-GUI module to produce a simple user interface (Figure 3). A CARDIS archive with fictitious data for a pool of around 1,000 patients was created to serve as a sample population.

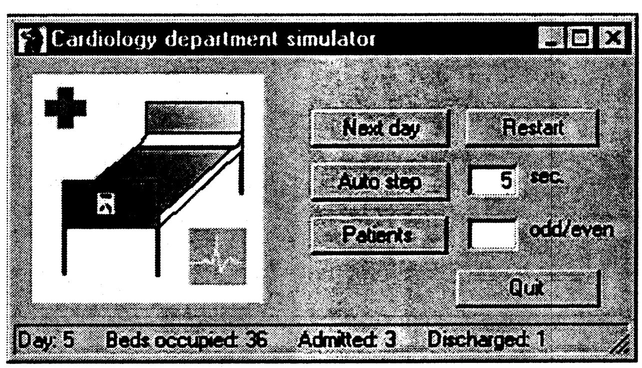

Figure 3. The patient traffic simulator program.

The simulator 'admits' and 'discharges' patients from the clinic on a day-to-day basis. The duration of hospital stay and the time between successive admissions for the same patient are based on real data from 8,000 admissions to a local cardiology clinic over the period 1994 to 2000, using a weighted randomization algorithm (with some fixing for edge effects). Details of patients currently in the clinic on each simulated 'day' are passed to the E-Scribe/NT database and bulk ECG ordering is triggered automatically. The program can be advanced from one day to the next manually, or by using an 'autostep' command with an interval specified by the user. It keeps a log of patient movements throughout each run and will display a roster of patients who are in the clinic on the current 'day'. It is also able to resynchronize the two databases if this should be necessary. The status bar displays the number of patients currently in the clinic and the total admissions and discharges for the day.

3.2. Testing procedure

The simulator software was used to test the E-Scribe/CARDIS interface over a simulated three-month period (Table 1). ECG recording was performed using an ECG simulator device before transmission, confirmation and storage in the E-Scribe/NT database. The digital ECG recordings for each simulated 'day' were then viewed from CARDIS, with reference to the patient roster mentioned above, and checked for consistency of data. During the testing period a total of around 2,000 ECGs were archived and verified for access.

Table 1. Testing procedure. Steps 2-4 would normally be carried out by the nurse or medical technician and step 5 by the cardiologist.

Initialise simulator and synchronize databases
1. Advance simulator to next 'day'
2. Download ECG orders to electrocardiograph
3. Record ECGs using ECG simulator device
4. Upload ECGs to E-Scribe/NT
5. Confirm ECG recordings and store in archive
6. Open patient roster for day
7. Check access to digital ECGs from CARDIS
Repeat steps 1-7

4. Discussion

The value of computer-based simulators in medical training has been well established [3,4]. Software mimicking cardiological problems, most notably the cardiology patient simulator 'Harvey' [4-6], but also simulators of various aspects of cardiac hemodynamics [7-9], has been in use for some time. However, simulations of the administrative processes and workflow in a cardiology department are few and far between [10].

The use of our own patient traffic simulator enabled us to identify a number of problems with various parts of the implemented interface and ECG procedures and to correct them. It thus allowed us to test and debug the system thoroughly before its installation in a real clinical setting.

An added benefit is that the same simulator can be used as a training aid for medical technicians and cardiologists, allowing as much practice as is necessary for them to familiarize themselves with the operation of the hardware and software, without running the risk of corrupting or losing valuable clinical data. The simulator is also useful for demonstrating the entire system in a way that makes it easier to understand the whole workflow procedure. By presenting the operation of the CARDIS/E-Scribe integration step-by-step, with reference to the flow of information, the whole process may be appreciated more clearly. In this way, it has also helped caregivers to indicate areas in which the interface could be improved (e.g. improvements in the ordering mechanism to provide more flexibility, automatic translation of the diagnosis provided by the cardiograph to facilitate the confirmation procedure).

5. Conclusions

Integration of a commercially available ECG management system with an existing clinical information system provides a rapid (about 4 man-months), practical solution that does not require major modifications to either software component.

A simulator program like the one described here is an extremely useful tool for testing the reliability and functionality of such an integrated system that supports healthcare processes. Its main value is in detecting problems before the deployment of the integrated solution in a clinical setting, thus avoiding the possible corruption or loss of genuine clinical data.

Acknowledgements

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