Mobile Emergency Triage Support System

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Abstract

We are designing and developing a mobile clinical decision support system, known as MET (Mobile Emergency Triage), for supporting emergency triage of different types of acute pain presentations. MET needs to interact with an existing hospital information system, run on handheld computing devices and be suitable for operation in weak connectivity conditions (with unstable connections between mobile clients and a server). The MET system captures necessary hospital data, allows for patients' data entry and provides triage support. By operating on handheld computers, it fits to the regular clinical workflow without introducing any hindrances and disruptions. It supports triage anytime and anywhere, directly at the point of care, and can be used as an electronic patient chart that facilitates structured data collection.

General Design

The MET system (http://www.mobiledss.uottawa.ca) is a mobile clinical decision support system supporting Emergency Department (ED) triage of various types of acute pain presentations. Clinical knowledge is explicitly presented in the form of decision rules that are inferred from past clinical experience, and the system works as a "helper" (or debiaser (Silverman 1992)). It helps to avoid biases and mistakes during patient triage by presenting possible management outcomes together with the strength of the recommendation, reflecting the uncertainty inherent in clinical reasoning. The system has a modular and open architecture with separate clinical modules associated with various acute pain problems, so it can be easily extended to handle new presentations. MET offers triage support anytime and anywhere, irrespective of the stage in the process of patient management. Moreover, it is integrated with the electronic patients' record system (EPRS) to extract data collected during registration and to allow clinicians to transfer results of the ED examination to the EPRS after triaging a patient.

Mobile Component Design

Weak connectivity (i.e., unstable connection between client and server) calls for the extended client-server architecture (Jing, Helal, & Elmagarmid 1999), where a client takes over some functions of a server when a connection is not available. The computer architecture of the MET system is presented in Figure 1.

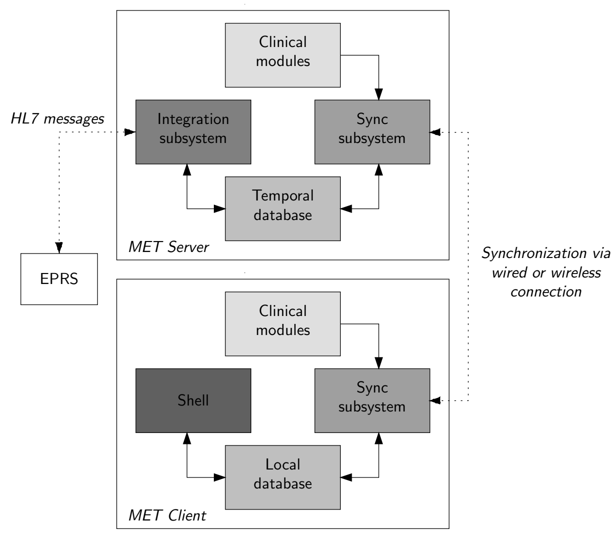

Figure 1: General architecture of the MET system

The MET server integrates via the integration subsystem with the EPRS. It also communicates with clients using the sync subsystem to exchange patients' data and to send necessary clinical modules associated with specific presentations (i.e., the modules are stored on the server and executed on the client side). Clinicians use the MET client to collect clinical data, to support triage decisions, to synchronize data with the server and to retrieve required clinical modules.

We assume that the client must be able to support triage without the need to contact the server. Therefore, this necessitates storing the triage support component and a local patient database.

Unlike with classical knowledge-based systems, where data entered by the experts and case data supplied by the users are stored in the same knowledge base, the MET system maintains the case data in a separate database to simplify management of the clinical modules and facilitate data synchronization with the server.

The MET server communicates with the EPRS using HL7 (Health Level 7) protocol (Quinn 1999). HL7 is the standard of exchanging information between medical applications. It specifies the format and content of exchanged data, however, it defines neither how messages are passed between applications nor how applications store and process these messages. This flexibility allows one to experiment with various network protocols (e.g., TCP/IP or FTP) and to integrate diverse systems without extensive modifications.

By integrating with the EPRS, the MET system saves clinicians from repeating the mundane task of entering demographic data and presenting complaint that are normally collected and entered into the EPRS during registration. Moreover, by sending back values collected during the examination in the ED, the MET system can be also considered as an electronic extension of a patient's chart, allowing for structured and convenient data collection and storage in an electronic format. As reported in the literature, this feature alone leads to improved management (Guerlain *et al.* 2001; Glass *et al.* 2002). Further, because of the design solutions discussed above, the MET system can be introduced into virtually every ED without any updates to the existing network (i.e., a wireless network is not required).

Knowledge Discovery

A retrospective chart review was done, using the records of 606 patients with abdominal pain, seen during the 1997–2002 period in the ED of the Children's Hospital of Eastern Ontario (Ottawa, Ontario). The ED chart of each patient was reviewed with special reference to 12 clinical symptoms, signs, and tests (attributes) and the discharge diagnosis. Reliance on the discharge diagnosis guarantees that the actual clinical outcomes, not the decisions made by the ED staff, are used for developing and evaluating the decision model for early triage.

It is usual that data collected as part of a retrospective chart review contains a significant number of missing values. The analysis of those clinical symptoms and signs that have missing values is very important. Clearly, they should not be discarded (a common approach in other studies was to remove from further analysis the attributes with a number of missing values above a certain threshold), as their importance depends on the context in which they are evaluated.

In this study, the data set created from the patients' charts was studied for regularities using knowledge discovery method based on the original idea of rough sets (Pawlak 1991). This method, described in (Slowinski, Greco, & Matarazzo 2004) is well suited to deal with partially missing and inconsistent data. It permits to assess the relevance of each attribute by means of the Shapley value (Shapley 1953). The method, implemented in ROSE system (Predki & Wilk 1999), was used to analyze medical data set for the regularities. At this point ED physicians were consulted and asked to validate the obtained results.

The information about the relevance of each attributes as indicated by respective Shapley value was considered in the process of generating decision rules. In order to check if all clinical attributes should be used to create robust rules, we iteratively tested subsets of attributes distinguished according to Shapley values, starting with top ones and ending with all twelve. The rules were tested retrospectively on how well they could classify a patient presenting with an abdominal pain complaint. The classification accuracy was estimated through the validation tests. Robustness of obtained rules confirmed our earlier findings (Michalowski *et al.* 2001) and allowed us to use them to develop a decision model for the MET system.

The MET system described here was prospectively evaluated during 6 months long clinical trial in the ED of the Children's Hospital of Eastern Ontario.

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