
Medical Intelligence Informatics

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Abstract

In this paper we discuss research efforts to apply technology designed for military intelligence operations to medical and health informatics applications.

Keywords

healthcare information, electronic health records, spoken language understanding, associate technology, user-centered design

ACM Classification Keywords

H.1.2 User/Machine Systems: Human information processing; H.5.2 User Interfaces: Natural language; H.3.3 Information Search and Retrieval: Query formulation; J.3 LIFE AND MEDICAL SCIENCES: Medical information systems.

General Terms

Human Factors, Design

Introduction

This paper addresses shortfalls in how healthcare information is collected, stored, distributed, and analyzed that thwart basic understanding about patient conditions, as well as efforts to understand patterns of health incidents in individuals and groups. The state of affairs for medical "intelligence" is similar to that of military intelligence. At the small unit level out on patrol, details are not often reported in a way that can

be shared or analyzed across geography and time (different medical information systems and procedures), reported data is described differently by different people (different terminology and record fields), data is not easy to share among units (offices, hospitals, states), and the people who actually need information may not know what to ask for or how to create a valid query for it (patients and families rooting for information in medical records). The patient is often the only central repository for his own and his family's health history and the doctor or a distributed set of doctors is often the only window into the actual medical records that are behind that health history.

We discuss several user-centered technology efforts that have been designed to assist in the collection, analysis, and usage of military intelligence that needs to be collected on-the-fly, as it happens, and without interrupting the flow of normal events. We believe these efforts have the potential to be applied to the collection and usage of medical data to address similar constraints. Doctors, patients, and other medical professionals must be able to collect and store information more easily, ask the right questions to ensure comprehensiveness of data, and maintain context and history as events unfold in a way that captures both what happened and why it happened.

Collecting Health Information

The first step is improving mechanisms for basic reporting of information in formats that can be stored, shared, understood by multiple audiences, and ideally digitized in formats that can be analyzed by multiple systems for modeling and prediction. One way to improve the ease of reporting as well as the standardization of reporting formats is through the use

of a spoken language understanding system that takes in audio data from a speaker, extracts critical information, and provides a consistent representation of the resulting data.

We have worked on Spoken Language Interaction for Computer Environments (SLICE) for multiple military contexts and are extending the domain to allow medical information to be reported in domain-appropriate language, parsed into machine readable formats, organized in more standardized ontologies without completely restricting individual preferences in reporting style, and requested as needed. SLICE goes beyond speech recognition by understanding the context in which utterances are spoken and determining the intent, and then communicating with both the user and networked information resources to compute user-centered solutions. To date, those solutions have included filling out reports, sending requests, database access, issuing alerts/notifications, and performing a variety of system commands. When there is insufficient information for the task at hand, the system prompts the user for that information.

We are working to improve the flexibility of describing medical situations using SLICE. With end-users, in this case medical experts, we define a vocabulary list and utterance grammar that is modeled on a standard medical ontology but remains flexible to allow for user preferences. The transcribed text is reduced to a subset of critical information. The grammar provides a set of rules and definitions that can efficiently categorize treatments, symptoms, and mechanisms of injuries into standardized report formats, consistently representing the data while providing the caregiver with flexibility to describe situations in a natural and appropriate style.

Doctors would use such a system in place of or as an enhancement to spoken dictation, thereby creating more usable data. The interactive and minimally intrusive nature of the technology could assist other medical personnel who are less used to relying on dictation (e.g., nurses, medical technicians, or first responders) in creating and updating medical information while on rounds or in transit. And ideally, patients themselves could learn to use such a system to continually monitor and document their changing conditions, symptoms, or applications of treatments such as medication or daily tests.

Asking the Right Questions

The second step for improved data and history collection is the ability to ask the right questions based on history and current status. Tactical Access to Complex Technology through Interactive Communication (TACTIC) technology is designed improve query construction to provide a bridge from human to information in any situation for which a) there is a complex information environment in which information requests are typically composed and executed by an expert (someone extremely familiar with the data sources, required values, parameters, and expected results that relate to an information query) and b) there is a need to enable relative novices to be able to use this complex information environment to acquire operationally relevant information in near real-time with minimal assistance.

In this research area, we consider the patient and his or her medical history to be the complex information source and the individuals rooting through medical records to be the information seekers. The TACTIC interface assists users in formulating requests for

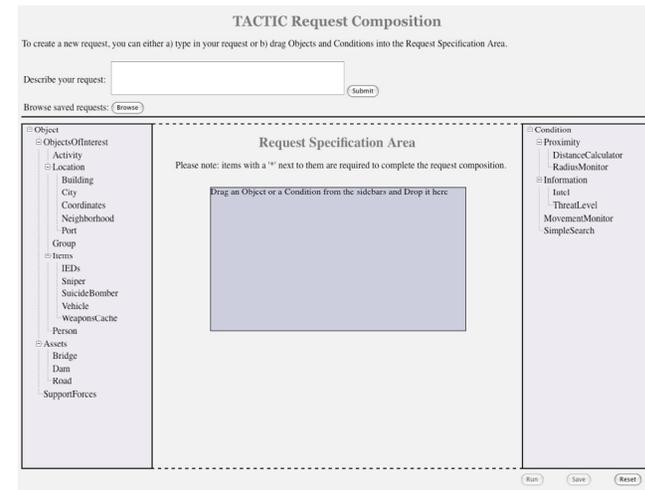


figure 1: Example TACTIC interface.

information by producing a set of templates that can easily be configured based on current information needs. As the queries are constructed, known information is used to help the user understand what other questions should be asked, what parameters should or can be specified, and what types of relationships between information can be explored. The system uses the rich store of data, such as patient and healthcare information that has been built up in electronic health records (EHRs), to ensure thorough interrogation of current information.

In one prototype of this technology (figure 1), the working area of the screen comprises three panes that contain the Objects and Conditions as well as the Request Specification Area (RSA), which is the primary workspace of the user. The user drags objects and conditions into the RSA which then uses an accordion-style interface element to expose required and optional

characteristics to create a valid query. Object choices refine the list of possible conditions and vice versa.

Data in the underlying information source could be also used to suggest or prompt for questions to be asked. For example, a system for a first responder system like an EMT would be able to wirelessly access the data on an individual's EHR and suggest questions to ask based on chronic conditions or current medications of the injured person.

Maintaining Rationale over Time

Finally, there is the challenge of tracking linked data, or more simply, the progression of events over time. Technology developed to support operators in maintaining situation awareness across disruptive events (e.g. shift changes) illustrates techniques for lightweight capture of ongoing dynamic event data. The Situational Awareness Continuity Across Disruptive Events (SACADE) disruption assistant (figure 2) was designed to help people bridge gaps in situational awareness and prepare briefings to communicate information about event progress and dynamic situations to others. In the healthcare information collection domain, it could be an ongoing tool that individuals use to help log events and enter explanatory information about those events. It could also be used in hospitals to get information about patient status off the "whiteboard" and into a format that can be stored and used as part of a dynamically updated EHR.

The SACADE data model represents key activities, events, and decisions that occur during shift. It serves as the foundation for pre-positioning critical information required for a shift change briefing and is generic and extensible across multiple domains. Future research

plans include integration with plan monitoring software so that the system could prompt users to add annotations when unexpected events happen. This would be particularly useful in a home healthcare monitoring application which would enable an individual

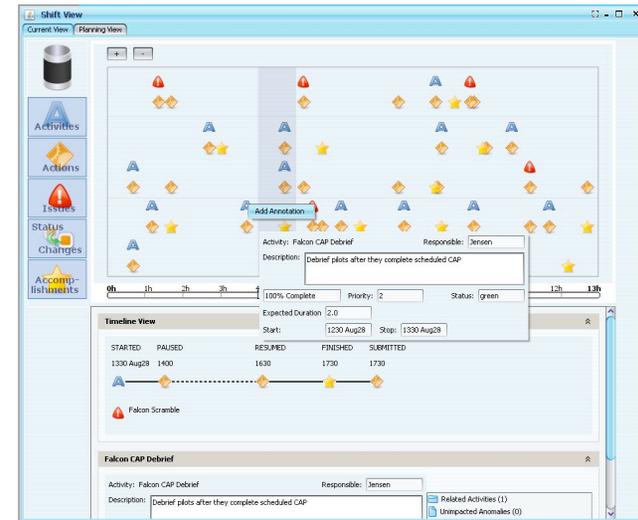


figure 2. SACADE interface with annotation capability.

to track progress of symptoms, vital signs, or medication administration and prompt for annotation when unexpected events (missed medication, anomalous levels, troubling trends over time) occur.

Summary

The technology assistance described in this paper combines to create a suite of information management assistance in the healthcare domain to support the dynamic maintenance of EHRs containing accurate, complete, and rich data about the health of individuals.