DESIGNING A PHYSICIAN-FRIENDLY INTERFACE FOR AN ELECTRONIC MEDICAL RECORD SYSTEM

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Abstract: An Electronic Medical Record (EMR) system enables a physician to record patients' health information, request reports from third partly health care providers and retrieve these reports when they are ready. Despite the numerous benefits of EMRs, several factors have inhibited their widespread adoption. An underappreciated but critical factor has been the proliferation of inferior user interfaces which are confusing to navigate and disruptive to a physician's workflow. To be useful, an EMR must allow physicians to record and query information in a natural manner that accommodates the non-linear nature of their workflow. In particular, an interface must permit a physician to record the minutiae of a patient's condition while at the same time preserving the physician's overview of a patient's record so that any aspect of the patient's health can be effortlessly queried and inspected. This paper proposes an interface design that attempts to address several of the usability deficiencies associated with current electronic medical record systems in use today.

1 INTRODUCTION

Electronic Medical Record (EMR) systems (Carter, 2008) are providing an increasingly viable mechanism for physicians to record and retrieve patient related information. The potential benefits of such systems are well documented in the literature: a properly designed EMR can help reduce medical errors, enhance communication between physicians and health care providers and provide a more readily accessible and comprehensive integration of several aspects of a patient's health record (Cimino and Shortliffe, 2006).

Unfortunately, despite the benefits of EMR systems, their rate of adoption has been slow relative to the integration of information technology tools into other occupations (Thompson and Dean, 2009). The challenges encountered when deploying EMRs in medical practices are numerous and varied (Baron et al., 2005). Several reasons have been offered to explain the poor penetration of technology in the health care sector. According to a recent study (Jha et al., 2009), various financial and administrative issues are often cited by hospitals as reasons for the poor adoption of electronic medical record systems.

Surprisingly, this study also showed that physician resistance is stronger in hospitals that have adopted an EMR system than in hospitals without an EMR. This suggests that current EMR technology may be at best inadequate and at worst counter-productive in addressing the needs of physicians. Indeed, technical issues related to the usability of EMRs have been cited as a reason for the low acceptance rates of EMRs in hospitals and clinics (Miller and Sim, 2004). Given this, instead of capital investments in systems which have a high risk of physician resistance and rejection, it may be wiser to investigate alternative interface technologies that are more amenable to physicians' practices and workflows.

The interface design proposed by this paper allows for a natural recording of patient related information while simultaneously permitting seamless request and retrieval of reports from a variety of sources related to a patient's broader electronic health record. This is done without having to navigate a myriad of menu items and to tediously fill numerous data entry fields presented in pop-up modal dialog boxes. By streamlining the interface in this manner, we believe that physicians will become less reticent to adopting EMRs.

This paper is organized as follows: Section 2 gives an overview of the challenges associated with the design of user interfaces for EMR systems and describes

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some of the problems encountered by physicians as they use the systems currently available. Section 3 presents the proposed interface design, which represents the primary contribution of this paper. Section 4 provides a discussion of some of the issues regarding the interface design and presents opportunities for future work. Finally, conclusions are presented in Section 5.

2 EMR USER INTERFACE ISSUES

The user interface of a viable EMR should provide a portal through which all aspects of patients' health record can be seamlessly and accurately recorded and retrieved. Moreover, the EMR interface must permit requisition of orders and the subsequent reception of results from a wide variety of healthcare sources. All this information must then be made easily accessible to the physician and presented in a meaningful way by the EMR.

The literature suggests two aspects that are particularly important with respect to the usefulness of an EMR to physicians: the recording of information into the EMR and the navigation of the interface itself. The goal of this paper is to present an EMR design that makes it easier for the physician to accomplish these tasks. The challenges associated with these issues are discussed in the following subsections.

2.1 Recording Patient Information

Paper records offer physicians enormous flexibility when documenting and annotating patient information (Reuss et al., 2007). Unfortunately, the interface for many electronic health record systems emphasize capturing patient data in a highly structured or restricted coded form. In recent studies, it has been shown that some physicians regularly eschew coded data entry, opting instead to record patient information in free-form text (Zheng et al., 2009). Providing physicians the ability to record free-form text offers them the flexibility to enter information in an order and manner which is most appropriate to their personal workflow and style.

While coded and/or structured data can be useful for clinical decision support and administrative purposes such as report generation, forcing a physician to pigeon-hole clinical observations may result in information critical to patient care being omitted from the patient's health record or recorded in the wrong "box." Information which is outside the domain covered by the restricted coded data of the required by the software may subsequently be forgotten or not communicated to relevant parties.

During an encounter, patients often communicate their complaints and symptoms to the physician in the form of a story. For many physicians, accurately capturing these stories (also known as patient narratives), is essential to patient care (Walsh, 2004). An EMR designer must appreciate the physician's need to capture all aspects of the patient's narrative during the encounter and allow the physician to construct the narrative in a natural manner. Allowing the physician to enter information using free-text offers more flexibility over more restrictive structured or coded data entry. As a result, the method of data entry becomes more fluid and accommodating for the physician.

Ultimately, an EMR must never force the physician to forget that he or she is recording information from a patient and not just recording information to a database. By making the entry of patient information more natural to the physician, the disruption to communication between the physician and patient is kept at a minimum.

2.2 Workflow and Interface Navigation

The importance of document management and the clerical tasks implicitly performed by physicians must be acknowledged in the design of an EMR interface. In particular, patient information must be immediately accessible and not hidden within a labyrinth of windows or dialog boxes (Rose et al., 2005). For example, navigating between physician orders and their associated results should be seamless and natural.

Physicians often complain about the "loss of overview" as they navigate an EMR interface (Ash et al., 2004). This loss of overview can be caused or exacerbated by the plethora of pop-up windows or dialog boxes that are used by some EMRs to present or request information or to alert physicians about exceptional circumstances such as potentially serious drug-drug interactions (Grossman et al., 2007). Sometimes, these dialog boxes are implemented as "modal windows" which prevent the physician from continuing until the event has been addressed. Such modal dialog boxes are distractive and have been shown to introduce inefficiencies in a physician's workflow (Belden et al., 2009).

The navigation of an EMR interface should be very accommodating to a physician's unique style and needs. Retrieval of relevant information from a variety of sources should be efficient and tasks such as orders and requisitions should be performed with a minimal number of steps. The numerous health events that occur during the care of a patient must be pre-

sented in a way that is contextually meaningful but without overwhelming the physician or cluttering the user interface. Details regarding these events and their interactions with one another must be made readily available by the interface.

Some of the inefficiencies associated with EMR navigation may be attributed to fundamental aspects of the underlying EMR architecture bubbling up to the interface itself. When EMRs allow database abstractions and other low-level implementation details to bleed into the user interface, a physician may become infected by technical considerations that are unrelated to the immediate care of his or her patients. These artifacts can cause a physician to lose overview during the assessment and planning phases of a patient's treatment; patient care may degrade as a result.

By reducing or eliminating conventional user-interface elements such as modal pop-up windows, pull-down menus, buttons, checkboxes, lists, *etc.*, a more streamlined interface that offers free-text entry and easier navigation can be developed. The basic foundation for this interface is proposed in the next section.

3 INTERFACE DESIGN

To address the issues described in the previous section, the proposed interface design presents to physicians a pane-based view of the patient record, as shown in Figure 1. This interface is designed to offer physicians a broad overview of the patient record while allowing them to quickly focus on smaller details as the need arises.

As the physician records and retrieves clinical information to and from the EMR during the patient encounter, the interface does not change considerably from one view to the next. No disruptive or obstructive pop-up windows are ever displayed by the interface. In particular, the physician is not required to navigate an abundance of windows and dialog boxes in order to record or retrieve information to and from the EMR, regardless of whether the information being retrieved is local or remote. In addition to offering a more natural workflow, this interface may help reduce the loss of overview for the physician. The components of the interface are described in further detail in the following subsections.

3.1 Demographics Pane

The Demographics pane at the top of the window simply contains generic information about the patient, such as name, age, date of birth and address. Unlike other panes, the demographic pane cannot be resized or closed — it is always present so that that the physician never loses focus of the patient currently being treated. This helps to maintain overview, as described in the Section 2.2.

The demographics pane can also be used to navigate to other patients. As data is entered in the various fields of this pane, the contents of the Viewer pane below it will contain a list of patients that satisfy the supplied criteria. Patients can then be selected from this list and their associated details will be presented in the Events pane.

3.2 Events Pane

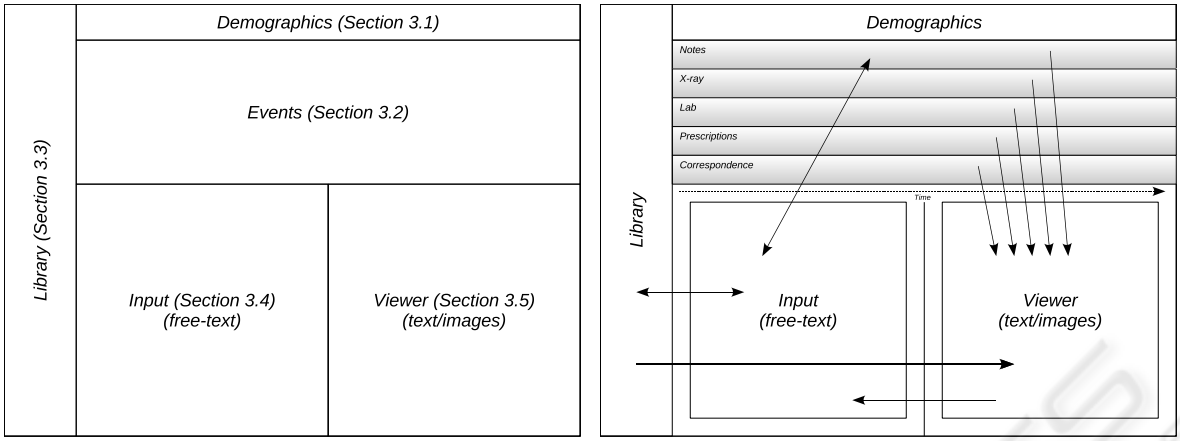
The Events pane provides a segregated, time-ordered view of a single patient's health events (Bui et al., 2007). This puts the entire patient's history in temporal context and offers the physician a "big picture" view of the patient's general history. This user interface element is the primary vehicle used for navigating the patient chart and for maintaining a physician's overview of the patient record. As shown in Figure 1(b), this pane is divided into subpanes, each of which correspond to various domains of health information. There are five broad domains containing the *Notes* recorded by the physician, *Lab reports*, *X-ray reports*, *Prescriptions* and *Correspondences* related to the patient. Each of these subpanes can be expanded, collapsed, zoomed and scrolled to reveal more or less information as required by the physician.

Events are represented by small squares (colloquially referred to as *rhondots*) within the subpane. The horizontal position of each event represents the date the event took place, whereas the vertical placement indicates the time of day the event occurred.

Events that are related to one another can be connected by arrows, thereby making it clear which events were triggered by an initiating event. This would enable a threaded event viewer across several provider domains, making it relatively easy to find the originating order for a given lab result, for example. Such a feature would rely upon the underlying communication infrastructure using consistence reference identifiers to relate the events together.

Colours and other visual attributes can be used to indicate the urgency of the events. For example, green could be used to represent normal events, while blue and red could be used to represent abnormal and critical/important events, respectively. Unread events can be represented by a square; events that have been viewed by the physician can be changed to circles.

More details on each event can be viewed by dragging its square to the Viewer pane. An event can be



(a) Main Layout (b) Events Subpanes and Workflow

Figure 1: Interface Design Layout. The topmost pane shown in 1(a) contains patient demographics. The pane immediately below contains a graphical representation of all the patient's health events. To the left is a pane containing a generic library of resource materials that can be queried by the physicians during input. Finally, the two panes at the bottom are used to record and display detailed patient information. Figure 1(b) shows the collection of subpanes within the Events pane that contains clinical data from a variety of sources. This pane of panes provides the physician with a broad, time-ordered overview of all the patient's information currently available to the physician from a variety of sources. Each event would be represented by squares or dots (not shown). The arrows represent the general workflow that occurs between the panes.

annotated by dragging it to the Input pane, adding the annotation, and dragging it back to the event pane; a new note linked with the original event will then be created in the *Notes* subpane. Context menus (activated by right clicking the mouse in the subpane) can be used to select and plot various quantifiable data items extracted from the events contained in that subpane. An Events subpane can be expanded, if necessary, to make the plots easier to read.

3.3 Library Pane

The Library pane is a vertical container along the left hand side of the display which acts as a repository for a generic collection of clinical practice guidelines, templates, formularies, patient educational pamphlets, diagnostic checklists, requisitions, *etc.* Each element in the library has a title and a body of associated text. The titles are arranged in alphabetical order in the pane. To prevent titles from overlapping, only frequently referenced titles are initially displayed and accessible inside the pane. Dragging these to the Input or Viewer panes will cause the title's corresponding body of text to be placed in the appropriate pane. As with the subpanes in the Events pane, the library pane can be zoomed and scrolled as needed.

In addition to dragging information out of the Library pane, the contents of this pane can be queried directly as information is entered in the Input pane.

The physician can add new resources to the library simply by writing text in the Input pane and then dragging it to the Library pane. The first line of the text can be used as the title. A body of medically related information can be programmatically imported into the library, if necessary, as part of the installation procedure of the EMR in the physician's office. The Library pane may also contains documentation related to the usage of the EMR itself, which can be requested by making queries in the Input pane (see below).

3.4 Input Pane

All information that the physician wishes to record in the EMR is done via the Input pane. All progress and SOAP notes as well as requisitions, prescriptions and correspondences are created here in a relatively free-text manner. Once the note is finished, it is dragged to the Events pane where it will automatically be stored in the *Notes* subpane. Generic information not particular to any patient can also be created here and dragged to the Library, as described above.

The objective of the Input pane is to provide the physician more flexibility when recording patient information than is offered by traditional EMRs that may require a large amount of structured or coded data entry. This pane is intended to serve the same purpose as the blank piece of paper in a traditional chart — the physician has the ability to record unstructured text to capture the patient narrative in a way most natural to his or her style.

As the physician types the note, dynamic analysis of the text and data extraction takes place. This means that as characters are typed, words and phrases can automatically change colour to inform the physician that something of interest has been understood by the EMR. This provides the physician with instant feedback that the EMR has successfully extracted information from the note. For example, quantitative data such as heart rate and blood pressure could be identified, provided a consistent syntax is used.

Notes are traditionally subdivided into coarse sections. For example a SOAP note has subjective, objective, assessment and plan sections. As various subsection heading text is entered by the physician, the editor would enter different contextual modes of operation which would affect the dynamic analysis of the following text.

Ideally, all prescriptions and requisitions for lab work or diagnostic could be made inside the Input pane. This makes prescriptions and requisitions possible without having to navigate through numerous pop-up screens and meticulously enter coded data along the way (possibly losing patient overview in the process). Any incomplete or erroneous requisitions and dangerous prescription interactions could be detected dynamically and reported in an unobtrusive manner to the physician by turning the background colour of the text red with an annotation indicating the problem, for example.

The success of this Input pane interface depends, in large part, on how well the dynamic text processing algorithm can glean the intentions of the physician as they construct their patient notes and requisitions (Jagannathan et al., 2009). By having physicians adopt modest syntactic conventions as part of their note taking, we believe that it will be possible to construct a text processor that will be able to provide the physician with useful real-time feedback during the note taking process.

3.5 Viewer Pane

The Viewer pane is used to display a wide variety of data related to the patient chart. Events from the Events pane can be dragged and dropped onto this pane and the pane will render the contents of the event in a human readable format. The contents could be either text, images or a combination of both. Annotations of the event can be made by dragging the event to the Input pane, making the annotation, then dragging it back to the Events pane.

4 DISCUSSION AND FUTURE WORK

A prototype of this EMR is under development. The current plan is to develop a web-based application so as to ensure easy deployment across a wide variety of computing platforms. The Bespin project from Mozilla labs (`https://bespin.mozilla.com/`) implements an editor component that may be useful for entering medical notes in the context of the Input pane described in Section 3.4.

The true measure of viability of the EMR interface design described by this paper can only be made once the construction of a working prototype that implements the design is complete. Initially, it is expected that preliminary implementations of the EMR will be used by medical school students in their first or second year as an elementary training tool. Various surveys and evaluations will be conducted on both the students and their instructors for the purposes of gathering feedback regarding the usefulness of the application and to obtain suggestions for potential improvements. The remainder of this section describes some of the problems that are anticipated and provides some possible mitigations.

Due to the free-text nature of the input, much work remains in defining all the necessary syntactic clues that would be used in the Input pane to allow the physician to intuitively record and query patient information. For example, the exact details of the query syntax and the format of the CPOE and prescription sections of a note need to be addressed. When designing the grammatical and syntactic format for these elements, care must be taken to make the input as natural as possible so as not to make the EMR frustrating or cumbersome to use by the physician.

The user interface should allow the partitioning of events that are displayed in the Events pane according to a patient's specific problem. For example, it should be possible to isolate those medical events pertaining to a patient's cancer treatment, while ignoring events related to her broken hip. This would reduce the amount information presented to the physician and allow him or her to focus on a specific condition. A syntactically consistent textual tagging mechanism used within the free-text note may be helpful in this regard.

Finally, the current web-based design of the interface is somewhat unconventional in that it does not present the physician with a traditional pull-down menu system common in other traditional computer applications. Furthermore, requiring all data be entered as free-text may impose a burden on physicians who are accustomed to having their notes tran-

scribed by someone else. However, many students currently entering medical school are already familiar with many web-based applications and have superior keyboarding skills, making this less of an issue.

5 CONCLUSIONS

This paper proposes an interface design for an electronic medical record system that attempts to rectify many of the problems encountered by physicians using existing EMRs to enter and query patient data. The interface provides a more natural and less restrictive method of data entry by allowing the physician to enter free-form text that undergoes dynamic extraction of quantifiable data and orders. Furthermore, by making the navigation of various components of the patient more efficient, we believe that the design offers a fluid interface which is amenable to a physician's workflow. As such, the work represented here is still in progress — during the upcoming implementation and survey phases of this research, shortcomings in this design will be uncovered and addressed, along the lines as described in Section 4.

While this interface will require training in order to use effectively, we believe that it can help increase the productivity of a physician once this learning curve has been conquered. While this particular interface may not be suitable for all physicians, we believe that the design presents a novel means of interacting with a patient chart that may appeal to physicians who have rejected such systems in the past, thereby helping to increase EMR adoption.

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REFERENCES

Ash, J. S., Berg, M., and Coiera, E. (2004). Some Unintended Consequences of Information Technology in Health Care: The Nature of Patient Care Information System-related Errors. *Journal of the American Medical Informatics Association*, 11(2):104–112.

Baron, R. J., Fabens, E. L., Schiffman, M., and Wolf, E. (2005). Electronic health records: Just around the corner? Or over the cliff? *Annals of Internal Medicine*, 143(3):222–226.

Belden, J. L., Grayson, R., and Barnes, J. (2009). Defining and testing EMR usability: Principles and proposed methods of EMR usability evaluation and rating. HIMSS EHR Usability Task Force.

Bui, A., Aberle, D., and Kangarloo, H. (2007). Timeline: Visualizing integrated patient records. *IEEE Transactions on Information Technology in Biomedicine*, 11(4):462–473.

Carter, J. H., editor (2008). *Electronic Health Records*, second edition. American College of Physicians, Philadelphia, PA, USA.

Cimino, J. J. and Shortliffe, E. H., editors (2006). *Biomedical Informatics: Computer Applications in Health Care and Biomedicine*, third edition, chapter 2, pages 46–79. Springer-Verlag New York, Inc., Secaucus, NJ, USA.

Grossman, J. M., Gerland, A., Reed, M. C., and Fahlman, C. (2007). Physicians' experiences using commercial e-prescribing systems. *Health Affairs*, 26(3):w393–404.

Jagannathan, V., Mullett, C. J., Arbogast, J. G., Halbritter, K. A., Yellapragada, D., Regulapati, S., and Bandaru, P. (2009). Assessment of commercial NLP engines for medication information extraction from dictated clinical notes. *International Journal of Medical Informatics*, 78(4):284–291.

Jha, A. K., DesRoches, C. M., Campbell, E. G., Donelan, K., Rao, S. R., Ferris, T. G., Shields, A., Rosenbaum, S., and Blumenthal, D. (2009). Use of electronic health records in U.S. hospitals. *New England Journal of Medicine*, 360(16):1628–1638.

Miller, R. H. and Sim, I. (2004). Physicians' use of electronic medical records: Barriers and solutions. *Health Affairs*, 23(2):116–126.

Reuss, E., Naef, R., Keller, R., and Norrie, M. C. (2007). Physicians' and nurses' documenting practices and implications for electronic patient record design. In Holzinger, A., editor, *HCI and Usability for Medicine and Health Care*, volume 4799 of *Lecture Notes in Computer Science*, pages 113–118. Springer-Verlag New York, Inc.

Rose, A. F., Schnipper, J. L., Park, E. R., Poon, E. G., Li, Q., and Middleton, B. (2005). Using qualitative studies to improve the usability of an EMR. *Journal of Biomedical Informatics*, 38(1):51–60.

Thompson, S. M. and Dean, M. D. (2009). Advancing information technology in health care. *Communications of the ACM*, 52(6):118–121.

Walsh, S. H. (2004). The clinician's perspective on electronic health records and how they can affect patient care. *British Medical Journal*, 328(7449):1184–1187.

Zheng, K., Padman, R., Johnson, M. P., and Diamond, H. S. (2009). An interface-driven analysis of user interactions with an electronic health records system. *Journal of the American Medical Informatics Association*, 16(2):228–237.