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## *activeNotes*: Computer-Assisted Creation of Patient Progress Notes

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# ***activeNotes*: Computer-Assisted Creation of Patient Progress Notes**

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**Abstract**

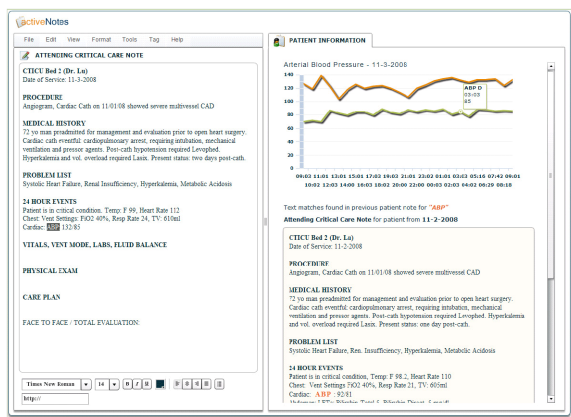
We present *activeNotes*, a prototype application that supports the creation of Critical Care Notes by physicians in a hospital intensive care unit. *activeNotes* integrates automated, context-sensitive patient data retrieval and user control of automated data updates and alerts into the note-creation process. In a user study at New York Presbyterian Hospital, we gathered qualitative feedback on the prototype from 15 physicians. The physicians found *activeNotes* to be valuable and said they would use it to create both formal notes for medical records and informal notes. One surprising finding is that while physicians have rejected template-based clinical documentation systems in the past, they expressed a desire to use *activeNotes* to create personalized, physician-specific note templates to be reused with a given patient, or for a given condition.

**Keywords**

Medical user interfaces, interaction techniques, interactive systems, evaluation

**ACM Classification Keywords**

H5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.



**Figure 1.** A screenshot of our prototype system, which gives an overview of the integrated note editor and patient information view. Figures 2–6 capture enlargements of relevant portions of the screen as a note editing task is performed.

Creating a Critical Care Note requires a physician to gather, review, and comment on previous and current patient data such as lab results, information from medical rounds, and medications, to determine patient health, as well as select relevant information to put into the note. Current Electronic Medical Record (EMR) systems [2, 13, 14] include facilities that can assist note creation; however, the complexity of their user interfaces has been cited as a key barrier to their adoption by physicians [8]. Many EMR systems have multiple patient information windows, as well as deeply structured menus, making the daily creation of patient notes more difficult and time-consuming than it needs to be.

To address the shortcomings of these current systems, we are developing *activeNotes*, a note-creation prototype (Figure 1) that explores enhanced data retrieval and data updates for creating Critical Care Notes. We introduce *activeTags* to support user control of context-sensitive updates to patient information that is inserted into a note from dynamic data sources (e.g., patient database or lab systems). We also explore the specifi-

## Introduction

A *Critical Care Note* is a clinical document, written by a hospital physician, that documents a patient's progress and prognosis. One such note is an *Attending Critical Care Note*, composed daily by an attending physician, for each of the patients under her care. These notes are referred to by other physicians caring for the patient, and are included in the official medical record for legal and billing purposes.

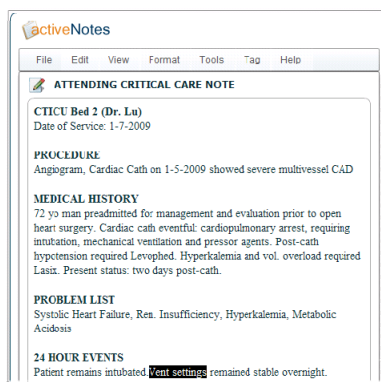
cation of user-customized alerts associated with these updates.

## Note Creation in the ICU

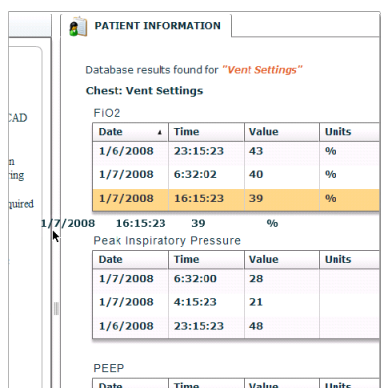
The design of *activeNotes* is motivated by previous literature on Intensive Care Unit (ICU) practice [7], which explores the importance of such notes and the need for computer-assisted support for their creation. Our work is also informed by studies of previously designed Critical Care Note creation prototypes [3, 4, 11, 14, 15] and field work conducted over a six month period in the New York Presbyterian Hospital (NYPH) Cardiothoracic ICU (CTICU). Our fieldwork includes observations, semi-structured interviews, and a survey of eight attending physicians in the CTICU and Surgical ICU (SICU).

We surveyed eight attending physicians (four serving in an ICU less than 3 years, one for 5 years, and three for over 20 years). Their typical day in an ICU lasts 9–12 hours, with 5 (2.5–8) hours on average spent on medical rounds. Each physician writes 10–18 (mean = 16) Attending Critical Care Notes per day. Six create 80–90% of the note during medical rounds. Of these six, five use a laptop to compose patient notes at bedside, and one writes on paper, typing after rounds. The remaining two of the eight create their notes after rounds, also typing, but relying only on memory.

The physicians estimated that as many as eight hours can elapse between the point at which the note is created and the time it is finished and submitted to the patient's official medical record. During this time, physicians continue to monitor patient status and adjust assessments and plans for the patient accordingly. All of the physicians agreed that patient notes should be



**Figure 2.** Our system detects information needs given note context and user input (in this case, Ventilator settings for the past 24 hours). Upon user request, results of automatically formulated queries will be presented in the right-hand pane of activeNotes.



**Figure 3.** The user can click on or drag query results from the right-hand pane to insert them directly into a Critical Care Note.

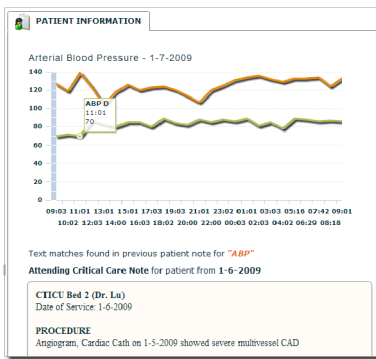
updated to reflect changes, but disagreed on when and how the updates should be performed (immediately when new information is learned, periodically, or once before notes are included in the medical record). Six of the eight physicians said that it is currently either somewhat or very inconvenient to make updates to a Critical Care Note directly. They rely largely on their own memory or jotted reminders to remember the specific items that need to be updated in a note, and such a list varies from patient to patient.

Current EMR systems deployed in the NYPH ICUs [2, 4, 13, 14] use either form- or template-based interfaces for note creation. Physicians must spend time navigating through hierarchical structures to examine data, instead of viewing it in the context of the note they are creating [2, 13]. Form fill-in user interfaces have limited pull-down choice lists for data and annotations, as well as text boxes that physicians must fill in individually [4, 14]. Semi-structured interviews revealed that physicians find the current interfaces to be too restrictive for three main reasons. First, physicians write about half of a patient note using free-text entry (e.g., the patient's past history, assessments, and plans); however, current EMR systems do not allow physicians to adequately enter free text. Second, they force a pre-set order in which to document aspects of a patient's health, making editing and analysis of patient data at different stages of note creation difficult. Third, even in a specialized ICU, it is difficult to capture and express the clinical condition of a patient with any one standard form or template. One physician stated, "I am hostile to rigid templates. They impede my ability to think about the patient." Most physicians continue to use a document editor, since it gives them flexibility to decide what to include in a patient note and where.

## activeNotes with activeTags

The activeNotes prototype offers physicians two side-by-side views: an editable note view and a patient information view in which the system displays results from data queries. As a note is edited, activeNotes dynamically interprets new content created by the physician in the context of the existing note to detect potential information requests. If requested via a hot-key, the system automatically formulates the corresponding queries for retrieving information from multiple data sources. The physician can review and insert the retrieved data in real time (as shown in Figures 2–4) and associate an activeTag with note content that will control subsequent updates to that data (as shown in Figures 5–6).

Upon creation of an activeTag, our system interprets the content with which it is associated in the *context* of other text in the document in order to formulate queries on source content. For example, if the query needs identifying patient data for the query, it will obtain it automatically from other sections of the Critical Care Note. activeTags allows users to tag terms or phrases anywhere in the document and offers control of update and alert mechanisms for managing the tagged content. The physician can configure the actions of an activeTag, using a right-click-enabled, context-sensitive menu to obtain the updated values at specified times, and have these updates automatically reflected in the note, as well as evaluated against user-specified alert mechanisms. Rather than linking to a specific single source, activeTags are associated with one or more queries, such that the content linked to by an activeTag is not a document, single entry in a database, or action, but a set of queries that may be used to retrieve results according to user-specified, data-aware, rules.



**Figure 4.** If several data points for the patient are returned in the query results, an interactive chart is presented. Future work will explore a variety of interactive visualizations of patient information.

## Related Work

Entity Workspace [1] explores the effectiveness of an integrated environment for searching, reading, and creating notes with the goal of sensemaking in the medical domain, but thus far addresses high-level information discovery from structured information (e.g., question answering). In contrast, we focus on supporting specific queries to retrieve relevant information from data sources, as well as previous patient notes, for the patient for whom a note is being created.

Prior work on note creation includes eNote [3], which uses a rigid template, emphasizes auto population of patient history from previous sources, and does not retrieve lab values and vitals. In contrast, activeNotes uses flexible templates with user-defined tags, and user-guided selection of note content from retrieval results that include both the previous note and lab values/vitals. Other work focused on specific aspects of patient progress note input includes that by Rosenbloom et al. [11] and Weir et al. [15]. All of this work motivates the need for computer-assisted support for patient information retrieval and the note input and updating techniques that we explore in activeNotes.

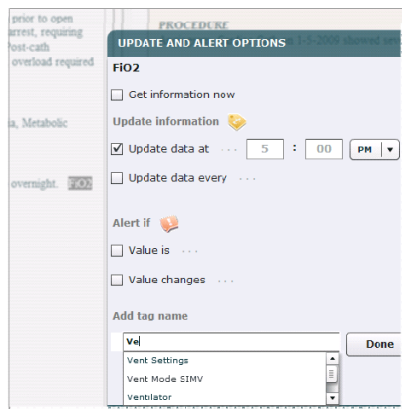
activeNotes supports activeTags for updating data and alerts. The term “tag” is often applied to a text string used to group or describe items [9]. While we are inspired by these types of static tags, we extend the idea to dynamic data entries. activeTags for these entries serve as identifiers of the data and as placeholders [10, 6] that reflect the ultimate values of the data, and are associated with a set of rules to control how the data entries are reflected in a document [4]. Extending a number of ideas explored in the hypertext literature, we provide users with mechanisms to manage how dy-

namic source content is reflected in the new document. However, activeTags go several steps further: they contain source content that is determined by interpreting a user’s information request automatically, based on an analysis of note content, as well as queries for searching for patient data from multiple sources, also determined automatically.

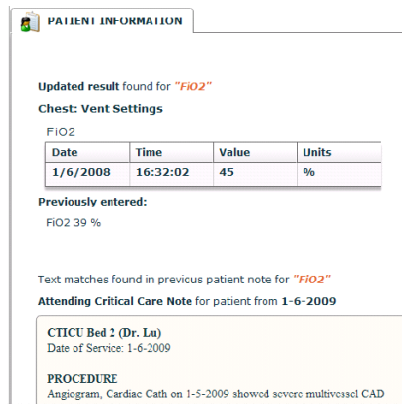
## Qualitative Study

To begin to evaluate our design of activeNotes, we conducted a qualitative review session with 15 (11 male, 4 female) physicians (11 attending physicians, 4 residents) in NYPH ICUs, all between 29–55 years old. We provided a ten-minute training session and asked the physicians to perform a composition task. Both the training and study task were conducted using a laptop computer with a mouse. The task involved first reading a scenario describing background information on a fictional patient and the previous Attending Critical Care Note for the patient. The scenario and note were based on a randomly selected, anonymized patient profile from historical data. The note was provided in two printed versions for training purposes: one resembled a standard note printed for the patient’s medical record, with no additional annotations; the other was annotated to include underlined and bold faced terms. The annotated terms indicated words that activeNotes could recognize and use to retrieve patient data.

Training included using three sample terms for which the system formulated queries and provided results. Results were presented in the right-hand panel of activeNotes, with highlighted occurrences of the keyword in the previous note, and other data query results. Thus, the participants could use the information request utility to navigate the previous note, as well as



**Figure 5.** A context-sensitive menu enables *activeTags* for user-specified updates to patient information and specification of alerts.



**Figure 6.** Updated results are shown with a history of previously-entered text. The Critical Care Note is updated according to physician preferences.

view results from the patient database. We first demonstrated the types of information requests the system could support (e.g., a specific item like “FIO2” and a request at a higher level, such as “Vent Settings”). We then showed participants how to insert data by clicking on the retrieved results. Finally, we demonstrated how to tag note content, set automatic updates, and create personalized data alerts.

Participants then performed information requests for an item for the patient’s current note, and upon success, they continued to complete that section, without intervention, using a “think out loud” protocol. After each participant completed a section, we asked them a series of qualitative questions to structure their feedback, such as “What is the greatest benefit of the system?” and “What is a major drawback of the system?”

## Feedback

The physicians were uniformly positive in their desire to use activeNotes to compose patient progress notes. Several volunteered that it was an improvement over the current method for retrieving and noting patient information. Sample comments include: “This is head and shoulders above what we’re using now.”, and “This is a heck of a lot better than anything else I’ve used.”

Half of the participants explicitly mentioned the ability to tag items for updating and/or alerting as the key feature that they would keep. Opinions varied as to whether updates or alerts were the more important form of tagging. In all, using tags to set up updates, alerts, or both was considered important by 13 out of the 15 participants.

Physicians felt the ease with which they could include up-to-date information would result in higher quality notes: “What I like about this is that every note that is composed is ‘fresh.’ I can bring in today’s information easily without having to retype so many things, so I don’t worry about copying something and not updating it, but I can also write comments and put things exactly where I want them in the note.”

Major drawbacks mentioned included a concern that it might take a while to learn what keywords the system could recognize. While we had prepared a vocabulary based on the data available to us, we found that physicians sometimes used the hot-key after terms that made sense, but for which we did not have an entry in our dictionary. Participants were unclear about how to determine whether a term that they used in a note would be understood by our system.

## Discussion

One surprising finding was the physicians’ inclination to try to use our system to create templates. We had avoided a template-based GUI, noting that physicians rejected prior template-based note-creation systems. When introduced to the automated data retrieval capability and activeTags, however, half of the attending physicians we studied expressed a desire to use our system to create their own note templates.

These physicians mentioned that they would like to create sample notes for specific problems with information requests as “placeholders.” They suggested that they could apply the sample notes to patients based on problems the patients were experiencing, and then visit each information request, setting up updates to reuse the note the next day with the most up-to-date values

already inserted. One commented, "My notes are in my own format, so I can easily recognize them. I want to create that format myself. I want to be able to decide when I put in values that I think are important, not be told what to put in and in what order." This finding points out a promising direction for future work.

Feedback received thus far indicates that the activeNotes user interface is an improvement on current applications for creating Critical Care Notes. Integrating updates and alerts into an environment for note creation and patient data retrieval was also mentioned as a helpful addition. Longer study is needed to compare responses across physicians in other ICU environments and address different usage scenarios, system requirements, and deployment architecture. We are now focusing on adding integrated system support for connecting with and retrieving from multiple systems and data sources used in the CTICU. We are also designing a comparative study that addresses quantitative human factors, and evaluation of note quality by both attending physicians and billing professionals.

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