**RC24705 (W0812-052) December 9, 2008**
**Computer Science**

# IBM Research Report

## Intelligent Data Assistance for Patient Note Creation

**Lauren Wilcox[1,2], Jie Lu[2], Jennifer Lai[2], Steven Feiner[1], Desmond Jordan[3]**

[1]Department of Computer Science
Columbia University
New York, NY 10027

[2]IBM Research Division
Thomas J. Watson Research Center
P.O. Box 704
Yorktown Heights, NY 10598

[3]College of Physicians and Surgeons
Columbia University
New York, NY 10032

**Research Division**
**Almaden - Austin - Beijing - Cambridge - Haifa - India - T. J. Watson - Tokyo - Zurich**

# Intelligent Data Assistance for Patient Note Creation

**Lauren Wilcox[1,2] Jie Lu[2] Jennifer Lai[2] Steven Feiner[1] Desmond Jordan[3]**

[1]Department of Computer Science
Columbia University
New York, NY 10027
{wilcox, feiner}@cs.columbia.edu

[2]IBM Watson Research Center
19 Skyline Drive
Hawthorne, NY 10532
{jielu, jlai}@us.ibm.com

[3]College of Physicians and Surgeons
Columbia University
New York, NY 10032
daj3@columbia.edu

**ABSTRACT**

We present intelligent data assistance for the creation of daily patient progress notes by hospital physicians. We report on the development of prototype note creation software and findings from experimental use of the prototype by physicians in two intensive care units. The physicians were quite positive about the need for, and value of, intelligent data assistance for note creation and provided suggestions for additional features. Analysis of the feedback revealed strong agreement among physicians in their preferences and suggestions, and supported the applicability of intelligent data assistance to medical note creation applications in general. We distill the findings to two categories of intelligent data assistance needed to create usable and useful medical note creation systems: (1) *input assistance* within the clinical document editor and (2) *review assistance* for system-provided patient information. We also discuss the need for lightweight *user customization* of data assistance to motivate future work.

**Author Keywords**

Note creation, automated assistance, tags, clinical notes, clinical documentation, medical user interfaces, information retrieval.

**ACM Classification Keywords**

H5.2 [Information Interfaces]: User Interfaces, Input. I.3.6 [Methodology and techniques]: Interaction Techniques.

## INTRODUCTION

Creating daily patient progress notes is an important task for physicians in a hospital Intensive Care Unit (ICU). These notes serve multiple purposes. First, a note ties together relevant and important patient information that is scattered across different sources (e.g., laboratory reports, examination results, prescription drug orders), creating a comprehensive view of the patient's current status. A physician's assessments and plan for the patient are based on this integrated view of multiple data sources. Second, a patient note serves as the primary source for current patient status when multiple healthcare team members communicate with each other. Finally, a patient note is included in the patient's official medical record for legal and billing purposes.

Despite its importance, current tools and applications available to ICU physicians do not adequately support the creation of patient progress notes. Most Electronic Medical Record (EMR) systems can integrate relevant patient information from multiple data sources, but have form-based or template-based interfaces for entering physician notes. These systems are designed primarily to support billing and legal record-keeping, rather than to support the evaluation and note composition processes of physicians, whose primary mission is patient care, not documentation.

We analyzed the current note creation practices in two ICUs at New York Presbyterian Hospital (NYPH), using observation, semi-structured interviews, and a survey. We found that most physicians used word processing applications such as Notepad or Microsoft Word to support flexible, free-form patient progress note composition, resulting in a time-consuming, frustrating, and error-prone note creation process. Physicians expressed a desire for domain-informed assistance for patient note creation, and concern that predefined forms and templates restricted and impeded the evaluation of patients under their care. Based on our findings, we designed and developed a medical note creation prototype that provides intelligent data assistance with integrated, user-controllable data retrieval, updates, and alerts. We then performed a qualitative study of the prototype with 15 physicians in the ICUs.

In this paper, we build on the previously reported design process and architecture for the prototype, and results from the qualitative study [6]. In contrast to our earlier work, we present here a deeper analysis of the findings, related specifically to intelligent data assistance, and extract two categories of assistance needed to create usable and useful medical note creation systems for physicians. We also propose several guidelines for providing this support in patient note creation applications and present new design choices that follow these guidelines.

## INTELLIGENT DATA ASSISTANCE

### Input Assistance within the Document Editor

We define *input assistance* for medical note creation as the provision of interaction techniques for inserting system-provided content into a patient progress note in response to a user request for patient information during note composition. Based on the analysis of our prior studies at NYPH,

we identify three categories of input assistance most needed for patient progress note creation.

1. *Patient Information Completion*
A survey we conducted of physicians in two ICUs at NYPH revealed that the current note creation practice is time-consuming. To create a patient note, physicians gather factual patient information from multiple sources such as EMR systems and the patient database. Patient information is manually inserted and is susceptible to typographical errors and omissions. As a result, physicians wish to be able to interact with patient information directly within the document editing environment, and flexibly import patient data as well-composed phrases into the medical note.

For example, if a physician types "Vent Settings", she would like the system to understand her input as an information request for the patient's ventilator settings for that day, and present an interactive view of various ventilator settings for the patient. She would also like the ability to select, in the interactive view, information items of interest, such as the ventilator setting of "Respiratory Rate", to be inserted into the note. The insertion should include a header for the information (if not specified in the information request) followed by the corresponding value and units if necessary for billing ("Respiratory Rate 30/min"), forming the phrase "Vent Settings: Respiratory Rate 30/min".

2. *Patient Information Updates*
Throughout a typical day, physicians keep track of patient information, such as lab results, vital signs, and ventilator settings, as these may undergo several changes. Physicians often want these updates reflected in the patient progress note, but they currently have to rely on their memory or written reminders on paper to recall, for each note created during the day, which information items need to be updated with new values. Therefore, in addition to having the ability to insert system-retrieved patient information items into a note, physicians would like the ability to set up automated updates for the system-provided data items that they insert.

For example, if a physician would like to keep a value inserted in the note up-to-date, she would like to do so by binding that value to the query used to obtain the information inserted, and set up the query to be rerun automatically on a schedule that she specifies, either replacing the previous value with the most recent value (keeping a history of all previous values) or storing the updates for later review.

3. *Information Request Completion*
Physicians may specify the patient information items that they need in different ways (e.g., "RR", "Resp Rate", or "Respiratory Rate") and in different places in the note. To be able to use the above two types of input assistance more effectively, physicians desire system support to match user-typed text with system-recognizable information requests. This assistance should make users aware of terms that the system can recognize to generate queries, allow physicians to explore candidate information requests, and offer an alternative to typing the entire word or phrase.

Our note creation prototype currently supports *patient information completion* and *patient information updates*, focusing on automated, user-controllable patient data retrieval, updates, and alerts. When signaled, the system tries to automatically recognize a physician's information requests in the note being edited in the document editor interface, and performs context-sensitive patient data retrieval. Aggregated retrieval results are presented in a single patient information window for easy review and insertion into the note. The system also allows physicians to tag data-related note content for automated updates to the values of the data in the note. Physicians can customize when and how frequently updates are performed and create tailored alerts associated with these updates through the interface provided for the tags. The tag interface allows for a simple, real-time update request to incorporate new data (e.g., a lab result), and the creation of a physician-personalized template for a given patient or medical condition. Participants in our qualitative user study clearly stated that intelligent note-driven data retrieval would allow them to directly incorporate necessary patient data, which would save considerable time spent data gathering. They also confirmed the benefits provided by automated data updates and alerts, and liked the system-supported user controls to initiate and configure them [6].

We anticipated that *information request completion* might be useful, but we intentionally left this out of the prototype to avoid distracting the user with completion suggestions and reduce the complexity of entering note information. However, our qualitative study of the prototype reveals strong agreement among physicians on the need for the system to provide information request completion.

During our study, physicians were sometimes uncertain about the types of information requests that the system could understand and satisfy; they were not sure what input they needed to provide to request the patient data, or what note content they could tag for updates and alerts. For example, we saw instances where the physicians tried different ways of expressing the same information need to find one understood by the system. Physicians were also unclear about whether a request was at the right level of granularity to generate executable data queries for retrieval and updates. For example, they wondered if typing "Vitals" would result in information about vital signs such as blood pressure, heart rate, and temperature.

Many physicians mentioned that they could use the help of a context-sensitive list in the form of a drop-down menu containing system-recognizable information requests related to their current note input. Taking this suggestion into consideration, we are augmenting the system with information request completion assistance to provide dynamic, context-sensitive guidance to aid physicians in expressing their needs for patient data.

To make this assistance possible, we are designing an intelligent auto-completion menu that dynamically displays can-

didate information requests that complete the current note input (Figure 1). In the example in Figure 1, the system has provided a context-sensitive menu of system-suggested completions in response to the user typing "Re". We are also providing options that allow a user to request automatically initiated completion assistance during typing, or to explicitly request completion assistance with a hot key such as "Alt".

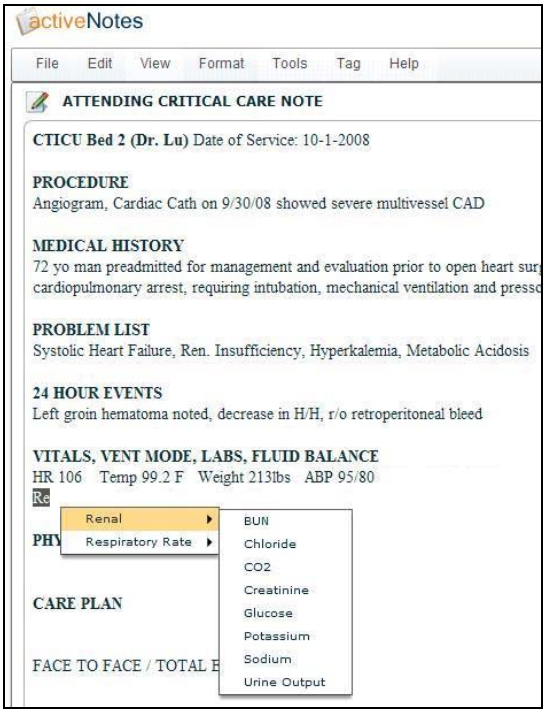


**Figure 1. Our design of a multi-level menu of completion suggestions for an information request beginning with "Re".**

Our information request completion assistance differs from the traditional auto-completion support provided for form input [2, 3] in two key respects. First, the candidate information requests and their ranks are determined based on the context of the request within the note, instead of simple prefix matching. Specifically, we are developing an algorithm to rank and select the candidate information requests by calculating the likelihood of each candidate's relevance in the current note context. This algorithm gives a higher rank to information requests that are most relevant to the current note section and have not yet been specified in that section. In Figure 1, the information requests are populated and ranked based on contextual features of the note including the section heading "VITALS, VENT MODE, LABS, FLUID BALANCE".

The algorithm further incorporates context-dependent user tailoring into the ranking by boosting the rank of prior menu choices learned from user interaction history with the auto-completion menu, such as previous use of a completion in the same section, within the same note, and across notes. For example, in Figure 1, using boosting, "Respiratory Rate" could be ranked above "Renal" if the user had inserted this term before "Renal" more often in previous notes (noting the issues involved in designing adaptive menus [1]).

The second aspect of completion assistance that differs from traditional auto-completion is the structure of the completion menu. Our completion assistance menu is hierarchical, containing candidate information requests instead of a flat list, to enable users to expand a high-level item to reach lower-level child menu items. For example, the high-level information request, "Renal", maps to a set of finer grained information requests. Physicians can either choose the higher level term as the completion, or select one of the finer grained items.

### Review Assistance for Patient Information

Patient information review is a progressive process in which data exploration, note input, and note editing occur iteratively as a note is composed. Physicians review the gathered data to obtain knowledge about patient status, analyze trends in measurements, detect abnormalities, and evaluate patient progress. However, currently physicians have to manually coordinate multiple patient information windows to relate different data items and draw inferences.

To assist physicians in reviewing patient data, our prototype system provides a single window to present tables and charts created in real time by aggregating numeric patient data showing 24-hour trends. It also displays yesterday's patient note with highlighted content that matches current note input.

The physicians participating in our study appreciated the ability to view patient data within a 24-hour window and have easy reference to the prior progress note. However, the physicians' feedback uncovered additional user needs for review assistance. Almost all participants said that they would want to see more automated statistics and summaries about the gathered patient data, including the minimum and maximum values within the past 24 hours, as well as original baseline values for the patient. They would also like to review related data items together.

To satisfy these needs, we are extending the functionality of our review assistance to calculate statistics, generate summaries of the retrieved patient information, and provide coordinated views of multiple related patient information items.

Figure 2 shows three separately designed charts chosen for presentation by our system. Here, the results of the patient information requests span different time periods; however, they could be combined and normalized to use the same axis [4]. Basic statistics are calculated and shown to summarize the data. Highlighted bars are also used to help indicate the same point in time on each chart. Both summary results and points within the charts can be inserted into the patient progress note.

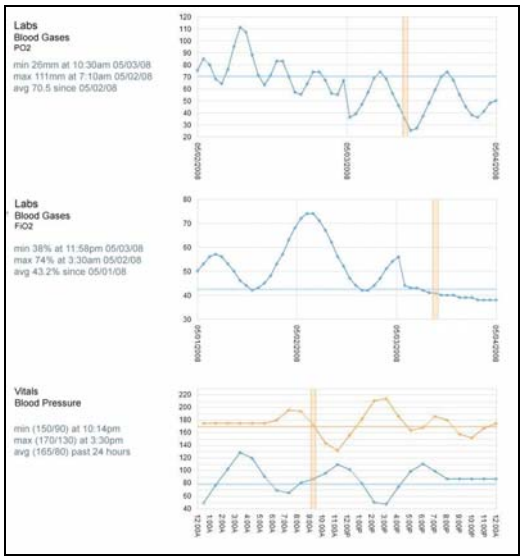


**Figure 2. Our design of graphical charts presented in response to information requests about two different lab tests and patient blood pressure.**

To dynamically determine the best way to summarize and present results of information requests, we are adapting an optimization-based algorithm to determine the optimal visualization of the retrieved data [5]. The algorithm dynamically calculates the values of a set of parameters for visualizing the retrieved data by balancing various criteria of user preferences (if specified), data properties (e.g., quantity, existence of outliers), and search context. Our adaptation extends the original algorithm to accommodate the unique characteristics of patient data and physician information needs in an ICU. For example, time is the most common dimension along which physicians want patient data to be displayed, and physicians often review several related data items together to make inferences or discover relationships. The algorithm utilizes this information to decide how to visualize the retrieved data and which data items to visualize together.

## CONCLUSIONS AND FUTURE WORK

We presented approaches for providing intelligent data assistance to physicians creating patient notes. The types of assistance we described are functionally sophisticated, and will need to be extensively tested. One important finding of our study is agreement among physicians on the need for ways to customize data assistance. There are three essential kinds of customization we plan to address in future work:

1. *Customization of Completion Menus*

In addition to automatic ranking and grouping of information requests, we plan to include support for customization options to allow physicians to customize the information requests displayed in the menu. For example, we will give physicians choices for ranking menu items in alphabetical order or intelligently ranked order based on note context and user interactivity history.

2. *Customization of Data Presentation*

During our study, the physicians indicated different preferences for the presentation of the retrieved patient data. Some physicians prefer text summaries, while other physicians would like to view data plots in graphical charts for easy detection of trends and abnormalities. The physicians also desired the ability to configure how the gathered patient data are plotted in order to customize views. For example, one physician commented: "*It'd be nice to be able to configure how trends are shown upfront, and be able to design graphs from the things you request, for example, White Blood Cell count against platelet count, or temperature changes against BP* [blood pressure]*—to basically customize the trends.*" Our future work will address new interactive controls that allow users to optionally customize data presentation.

3. *Customization of Data Updates*

Our prototype provides intelligent assistance for data updates, allowing users to attach action-binding tags to note content that requires updates. Physicians responded positively to the tags, but wanted more customization options for labeling and parameterizing tagged items. For example, one physician expressed the need for a priority parameter in the tagging interface, so that tagged items could be exported to one view of all items tagged in the note, ranked according to the priority specified. In our future work, we will incorporate physicians' suggestions into our system to support the desired customization options.

## REFERENCES

1. Findlater, L., McGrenere, J. A comparison of static, adaptive, and adaptable menus. *Proc. CHI* 2004. 89-96.

2. Garay-Vitoria, N., Abascal, J. Text prediction systems: A survey. *Univ Access in the Information Society* 4(3). Springer-Verlag 2006, 188–203.

3. Google Suggest. http://labs.google.com/suggestfaq.html

4. Mackinlay, J. Automating the design of graphical presentations of relational information. *ACM Trans. Graph.* 5, 2 Apr. 1986, 110-141.

5. Wen, Z., Zhou, M.X. An optimization-based approach to dynamic data transformation for smart visualization. *Proc. IUI* 2008, 70–79.

6. Wilcox, L., Lu, J., Lai, J., Feiner, S., Jordan, D. activeNotes: Computer-assisted creation of patient progress notes in a hospital environment. *IBM Research Report*, 2008 (*Submitted for publication*).