Involving Patients In Health Care: Explanation In The Clinical Setting

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Abstract

The long-term goal of our research is to improve the overall effectiveness of physicians' time, by improving the information exchange between physicians and chronic-care patients, initially migraine patients. The computer system we are constructing has a partial knowledge base about migraines, common therapies, and common side effects of those therapies. The system consists of two main programs: data collection and explanation. The design of our system is based on empirical data concerning patients' information needs.

I. INTRODUCTION

The long-term goal of our research is to improve the overall effectiveness of physicians' time, and thus improve the quality of health care, by improving the information exchange between physicians and chronic-care patients, initially migraine patients. Patients' attitudes about their ailments and their therapies influence a number of factors related to clinical success [12], [1], [14], [6].

Since doctors' time is already in short supply, there is little time to improve patients' understanding of diagnostic procedures, the mechanism of disease, or the rationale for a particular therapy. Providing patients with written material is one approach, but it has several shortcomings. Most importantly, it is difficult to tailor written materials to the needs of individual patients. Also, patients have no recourse when they don't understand a written text.

An alternative means of facilitating information exchange between patients and physicians in the near future is to use advanced computer technology to explain physicians' instructions to and answer questions by patients after and between office visits. While the doctor-patient relationship cannot be replaced, we believe a computer system can supplement the information provided by physicians. In contrast to many other knowledge-based systems, the design of our system is based on empirical data, in this case from ethnographic studies of explanations actually given in the clinic.

II. BACKGROUND

Doctor-Patient Discourse

Empirical research on medical discourse (e.g., [11], [33], [31], [8], [24] demonstrates that an "information gap" often exists between physicians and patients. First, they do not always communicate in the same language [33], [15]. Second, physicians ask the questions and patients provide the answers [33], [34], [11]. In short, interaction between physicians and patients tends to be structured in such a way that the flow of information from doctor to patient is severely constrained.

Explanation in Medical Informatics

Some medical expert systems contain explanation facilities (e.g., MYCIN [2], NEOMYCIN [4], Digitalis Advisor [29], and XPLAIN [28]). However, the explanations they are able to offer have distinct drawbacks. For example, they have been unable to engage in explanatory dialogue or to modify later explanation on the basis of earlier material presented to the user [19]. Moreover, these systems, like most others in medical informatics, were designed to be used by health care providers.

Migraine

Migraine affects approximately 20% of the population [13]. It is sometimes difficult to diagnose and can be time-consuming and awkward to treat [26]. One reason why treatment of migraine is difficult may be that many primary care practitioners lack the time to ferret out the details of the history that allow proper diagnostic classification. It is often only when the patient fails to respond or becomes an "analgesic abuser" that neurologic referral is made. Another hindrance to the effective treatment of migraine is the fact that about half of the patients do not get sufficient relief from the regimen initially prescribed. Thus patients must be motivated to return for further visits in spite of unsuccessful past therapy.

Ethnographic Research

We believe that in order to design truly useful intelligent assistants, we must first have detailed knowledge of the nature and scope of the information needs actually experienced by clinicians and patients. In order to understand how to respond to these needs most effectively, we also need detailed knowledge about what types of explanation best meet the needs of particular types of patients. Ethnographic observation of communication between physicians and patients is providing this information, supplemented by semi-directed interviewing. (See [9] for more discussion.)

III. SYSTEM DESIGN

The system we have begun to build will:

• Collect information from patients at the time of initial and subsequent visits to the Neurology Clinic.

(Because there is little novelty in this part, we omit discussion of the prototype here.) One purpose of this history-taking component is to gather medical and personal information about the patient so that the explanation component can tailor its explanations to individuals.

- Produce a printed summary of the patients' data before each visit to the physician. (Again, this is not the primary emphasis of the research effort, but is considered necessary. This is not discussed in the present paper either.)
- Instruct patient-users about their individual treatment plans and possible side-effects of drugs to be used in that treatment.
- Produce explanations in everyday language to questions posed by patients in response to questions asked by the system (during data gathering) or to information presented by the system.

Knowledge Base

A preliminary version of the knowledge base about migraine and drugs has been implemented in Loom, a knowledge representation language [16]. Loom's modeling language is a hybrid consisting of two sublanguages. The *definition language* represents knowledge about the defining characteristics of domain concepts and relations, and uses that knowledge automatically to infer and maintain a complete and accurate taxonomic lattice of logical subsumption relations between concepts and relations. The *assertion language* specifies constraints on concepts and relations and asserts facts about individuals.

The terminological component (referred to as the *t-box)* contains definitions of concepts such as drug, disease, patient, treatment, etc. and definitions of relations such as side-effect, therapeutic-suitability, etc. For example, the definition of the concept Drug-For-Migraine in our t-box is:

```
(defconcept Drug-For-Migraine "migraine drug"
    :is        (:and Drug :primitive
                  (:the drug-use Migraine-P-
                          Therapeutic-Procedure))
    :disjoint-covering ( Ergot-Alkaloid
                          Beta-Adrenergic-Blocker ....))
```

This definition says that the concept Drug-For-Migraine is a Drug. Thus it inherits all of the attributes associated with Drug. Moreover, the filler of the attribute drug-use is further specified to be Migraine-P-Therapeutic-Procedure. The disjoint-covering means that any instance of this concept belongs to only one of the concepts listed in the covering.

The assertional component of the knowledge base (the *a-box)* contains facts about particular drugs, particular diseases, etc. Some of the facts associated with a particular drug (Inderal) in our a-box are:

```
(tellm (:about propranolol Beta-Adrenergic-Blocker
        (trade-name "Inderal")
        (generic-name "Propranolol")
        (side-effect constipation)
        (...additional side effects...)
        (contraindication Chronic-Obstructive-
            Pulmonary-Disease)
        (contraindication congestive-heart-failure)
        (...additional contraindications....)
```

Loom provides tools in an integrated environment for reasoning about its knowledge, and about the structure of its knowledge. In particular, Loom provides augmented production rules, terminological classification, and a full first-order query language that allows the use of meta-predicates (i.e., predicates about the structure of the knowledge).

The Explanation Module

Because expressing an answer or an explanation in natural language is a complicated problem, most computer systems are limited to printing pre-stored text. In contrast, the system we are building generates the text dynamically, in the context of the particular patient's information need. We build on previous experience in designing and implementing a similar facility in another domain [17].

The explanation module constructs answers to patient's questions by accessing knowledge from several knowledge sources: (1) the medical knowledge base described above, (2) a library of explanation operators that encode strategies for answering the range of questions we allow users to ask, (3) the patient model containing knowledge about this patient obtained from the history-taking program and the physician's input, and (4) the dialogue history, which contains a record of previous questions and explanations generated by the system. The explanation module consists of three components: query analyzer, text planner, and text generator.

The query analyzer. In the present project, we are not attempting to provide a general capacity to analyze any question expressed in English. In previous work [21], [22], we have found that graphical interfaces that use the mouse as a pointing device are very easy to use for people who cannot type and who have little knowledge of computers. We are implementing such an interface. The patient can build a question in two different ways. In the first case, the patient selects the question type (e.g., Describe) from a main menu and is guided by the system through dynamically generated menus for the selection of the appropriate arguments (e.g., drug). In the second case, the patient starts from a particular topic (e.g., Inderal) and then selects the desired question type (e.g., Describe). We are able to implement this second case because parts of the text generated by the system are mouse-sensitive. Whenever the patient clicks on a text segment that is mouse-sensitive, the system presents her with a menu that contains only the question types that are applicable to the selected topic. At this point, if the patient selects a question that requires other arguments, the system presents a dynamically generated menu containing the appropriate types of additional arguments. For example, if the patient mouses "Inderal" on the screen, and then selects the question type "Compare", the system puts up a menu of other drugs so the patient can choose a drug with which to compare Inderal. As soon as the patient has constructed a complete question, it is translated into a communicative goal for the text planner to achieve.

The text planner. The task of the text planner is to decide what to say to the patient when given a communicative goal. Examples of communicative goals are to inform the patient about the side-effects of a drug and to describe prophylactic treatment to the patient. The text planner decides how to construct answers to users' questions in a natural and informative manner, taking into account what the system knows about the particular patient and the previous dialogue with that patient.

As the term "text planner" indicates, this component is a planning system and is built along the lines of other artificial intelligence planning systems. Posing a goal leads to the retrieval of knowledge units (facts, operators) which are useful in attaining that goal; the attempt to apply those knowledge units may result in the posing of further goals, etc. The output of the text planner is a sequence of formulas (a text plan) that corresponds to the sequence of ideas that should be communicated to the patient. The text planner builds on previous work by [18], [20], and has been modified to access Loom knowledge structures and produce input specifications appropriate for the FUF English sentence generator [7].

The text generator. The task of the text generator is to translate the sequence of formulas (the text plan) generated by the text planner into the English sentences which the system will print on the screen for the patient to read. A general solution to this problem has been implemented in the FUF natural language generation system [7].

Additional Sources of Information

In addition to the knowledge bases mentioned above, the explanation module needs to have access to a description of the patient and to a record of the dialogue with that patient.

Patient model. Information about the patient is gathered by the history and summary system mentioned above. The patient's answers are organized in a format that is readable by the explanation module, and includes information about symptoms, past treatments, relevant habits (e.g., a strenuous exercise program), other medical treatments, and so on. As the text planner shapes the message to the patient, it chooses among alternative ways of answering the patient's question based on knowledge in this information store. For example, explanations of drug side effects might be affected by information about a particular patient's history of allergies.

Dialogue history. In order to produce a natural dialogue, the system must take previous interactions into account in a number of ways. For example, a system that keeps repeating the same message over and over again is likely to irritate the user. Similarly, a patient who is constantly asking for more information should be provided by the text planner with fuller messages than a user who never does so.

Prototype and Examples

The prototype consists of a knowledge base of 400 medical concepts, a text planner that is capable of selecting and ordering the content to be included in explanations, and a sentence generator. Knowledge about medical concepts includes information about the types of migraine treatment and a variety of drugs that can be used for each type of treatment. Knowledge about effectiveness, contraindications and side-effects is associated with each drug.

The prototype system can respond to the following <u>types</u> of user queries, and we are currently enlarging this set:

Describe migraine-pharmacological-treatment
Describe <particular-drug>
Describe <disease>
Describe <side-effect> of <drug>
Compare <drug1> and <drug2>
Compare <treatment1> and <treatment2>

The following are examples of explanations produced by the prototype system in response to the queries shown. We include these examples to illustrate some of the knowledge that has been represented and the complexity of the texts that can be generated, not yet to produce explanations for patients. Note that these texts are synthesized directly from the knowledge base using a text planner that has knowledge about how to satisfy explanatory goals and about how to construct a coherent text. A major feature of this work is that these texts are not canned or generated by filling in simple templates although this may not be evident from examples given out of context. Once we have more information from the field study that is currently underway, we will replace these explanation strategies with strategies capable of producing texts tailored to the concerns of individual patients.

Examples:

<u>1. Describe migraine pharmacological treatments.</u>

"There are three types of migraine pharmacological treatment. First, there is migraine prophylactic treatment. Migraine prophylactic treatment is used to prevent migraine. Migraine prophylactic treatment is suitable for frequent or severe headaches. Migraine prophylactic treatment requires you to take a drug daily. Amitriptyline (Endep, Elavil), Nimodipine (Nimotop) and Propranolol (Inderal) are examples of drugs for migraine prophylactic treatment.

"Second, there is migraine analgesic treatment. Migraine analgesic treatment requires you to take a drug when headaches occur. Migraine analgesic treatment is suitable for infrequent or mild headaches. Migraine analgesic treatment is used to relieve pain. Fiorinal (Fiorinal), Ibuprofen (Rufen, Nuprin, Motrin, Advil) and Naproxen (Naprosyn) are examples of drugs for migraine analgesic treatment.

"Finally, there is migraine abortive treatment. Migraine abortive treatment is used to abort migraine. Migraine abortive treatment requires you to take a drug at the immediate onset of headaches. Migraine abortive treatment is suitable for infrequent or mild headaches. Cafergot (Cafergot), Dihydroergotamine mesylate (DHE-45) and Ergotamine tartrate (Ergostat, Ergomar, Medihaler Ergotamine) are examples of drugs for migraine abortive treatment."

2. Compare propranolol and ergotamine tartrate.

"Propranolol (Inderal) and Ergotamine tartrate (Ergostat, Ergomar, Medihaler Ergotamine) are migraine drugs. Propranolol (Inderal) is a beta-adrenergic blocker while Ergotamine tartrate (Ergostat, Ergomar, Medihaler Ergotamine) is an ergot alkaloid. Propranolol is used to prevent migraine whereas Ergotamine tartrate is used to abort migraine. Propranolol is effective in 65% of the cases while Ergotamine tartrate is effective in 60% of the cases. Cardiac dysrhythmia, insulin-requiring diabetes mellitus, congestive heart failure, chronic obstructive pulmonary disease and asthma are contraindications for Propranolol whereas pregnancy, malnutrition, peptic ulcer, angina pectoris, ischemic heart disease and peripheral vascular disorder are contraindications for Ergotamine tartrate. Propranolol's possible side effects are depression, low heart-rate, tiredness, hypotension, dizziness and mental dulling while Ergotamine tartrate's possible side effects are vaso-constriction, numbness, diarrhea, stomach ache, nausea and vomiting."

In real human-human advisory dialogues, answers are sensitive to the preceding discourse. After gathering samples of doctor-patient dialogues, we observed some interesting phenomena in human explanation behavior, including the use of "backward references", use of analogies between the currently described concept and a previously defined concept, and the influence of discourse focus on the contents of the given answer. We are currently extending the existing system, so that it can produce context-sensitive answers to take account of backward references, analogies and discourse focus. See [3] for details.

IV. CONCLUSION

From the literature and our own observations we believe that better informed patients will be able to take better care of themselves, and that physicians and nurses do not always have time to frame explanations and instructions (or to repeat answers) in ways that best address patients' concerns. The explanation system we are building is intended to supplement the time that physicians and nurses spend explaining material to patients with chronic disorders. Our work attempts to use state-of-the art artificial intelligence and explanation-generation concepts to go beyond printing pre-stored text or filling in blanks in pre-stored text schemas. Although those methods are currently being used and are probably useful, we believe that an interactive system that can re-explain material in different ways to the same or different patients will have more utility in the long run.

This work builds on ethnographic data collected from observing doctor-patient interactions. The questions that patients are observed to ask are not limited to, and often do not include, those we initially assumed they would ask. Similarly, the kinds of explanations we assumed physicians should give are not always the ones that successfully address patients' concerns. The prototype system we are constructing now provides some textbook information to patients about drugs commonly prescribed for migraine. We are in the process of extending this system to re-explain in the context of missed communication between patient and system. We also plan to take account of less formal, more patient-specific information such as how side effects of a drug may interfere with a patient's life style. We are unable to guarantee that patients will want to interact with a computer system, but past experience with history-taking programs (e.g., [27]) suggests that if we can make a program attractive and easy enough for patients to use, they will use it. We are uncertain, too, about the information our history-taking program will need to gather from patients in order to tailor the presentation of information to the individuals. It remains to be seen whether menu selection of topics and questions within topics will suffice for patient input of their concerns. However, our initial design assumes so in order to avoid the large programming effort of building an open-ended query understanding system.

The ability to tailor the presentation of information to an individual patient's concerns is one of the primary strengths of this approach. Also, a computer program can remind patients of their physicians' instructions and can re-explain what they have been told in the office without requiring additional investment of physicians' time. We are not attempting to change the behavior of health-care providers, nor do we require them to interact directly with computers. Instead, we have shifted our focus to providing information to other parties in the health care process, namely the patients.

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