Help Decision Support on the Macintosh

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Abstract

The paper describes an implementation of the HELP decision-support system for the Macintosh personal computer. Following a brief background description of HELP as it is implemented on a Mainframe (TANDEM) computer, the principle features of the Macintosh version will be described. These include: the **data-driven** feature (an observation or decision may evoke another hypothesis or frame to be executed), the **nesting** feature by which a knowledge frame calls another frame whose output is needed to complete execution of the first), the **ASK driver** (the method by which the expert can direct the data requests when he creates a frame), the **Query driver** (a method by which the "program" determines the set of data items to be asked), **inheritance of properties** among items in the data hierarchy, and Decision-driven Data Acquisition **(DDA)**[1].

Introduction

The HELP (Health Evaluation through Logical Processing) decision-support system is the expert system portion of a large Hospital Information System in use at several hospitals. It consists of knowledge frames that are disease or decision specific, that are created by experts in various medical specialties, and are evoked automatically when data is stored in a patients record. The current Mainframe version is implemented on a Tandem computer for reasons that are described elsewhere[2]. The reason for implementing the expert system component of HELP on the Macintosh is to make it available as a stand-alone, easily portable system that will allow it to be used in a variety of different settings, for both educational and clinical decision support. Significant enhancements have been made to the Macintosh version, that are not available on the TANDEM, which should increase the range of settings in which HELP can provide decision support.

Functional features

HELP on the Macintosh provides for both forward and backward chaining in its reasoning process (Figure 1). Forward chaining is accomplished thru a system called the data-driver and backward chaining thru a mechanism called nesting by which one decision frame can contain a reference to one or more frames in the knowledge bases.

Data-driver

In the HELP system, the act of storing new information in the patient record may evoke one or more hypotheses for which the new information is relevant. This means that the system maintains a file containing pointers from each item of

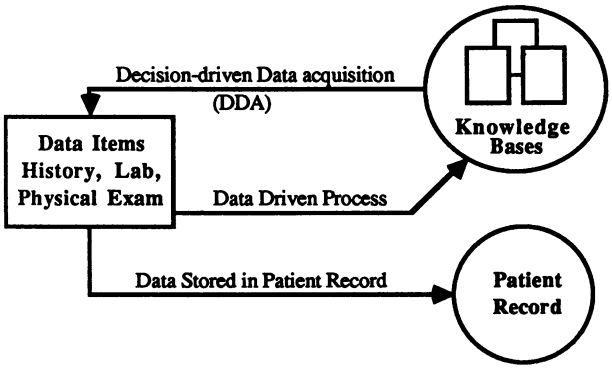

Figure 1: Knowledge Model

information used by any knowledge frame to that frame. Each item also has an associated conditional statement that specifies the circumstances under which that item should evoke the frame. For example, the frames that diagnose Anemia are evoked by a new value for hemoglobin only if that "value is less than 13 gm/100ml". The entries in this data-driver table are made automatically each time a frame is down-loaded. The subject matter expert who builds a frame may designate which items in the frame are to be used as data drivers in evoking the frame (Figure 2 - Item A).

Nesting

If, during the execution of a HELP frame, an item is encountered that calls for the result obtained by processing another frame and that result is not already available in the patient record, execution of the original frame is suspended while the referenced frame is processed. Such a nesting process can be carried to any depth. The data from the nested frame is then used in any calculations or logic of the "calling frame", reducing the dependence of the data items. This is a powerful feature of the Macintosh version. With nesting, it becomes practical to develop frames that act as distinct packets of knowledge and may be referenced in several other frames (Figure 2 - Item A). Such frames serve much the same function as subroutines in a program. Using this scheme, complex decisions can be represented as a set of easy-to-understand and easy-to-manage frames, while showing the structure of the medical knowledge.

ASK item

A frame in the HELP system is an expression of the logic used to make a decision. Each HELP frame must specify the items of information that are to be used in arriving at its decision. A frame may also specify alternate sources of any item of information, if at time of execution of the frame that item is not found in the patient record. This is accomplished by use of an ASK item.

TITLE **Acute hemorrhagic gastritis (stress erosion)**
FRAME #7.143.18
TYPE probability
APRIORI (PREVALENCE IN HOSPITAL) = #7.143.104
Risk factors for hemorrhagic gastritis

FINDINGS	sensitivity	specificity
A #7.143.113 **Upper gi bleeding**	.9	.04
B nausea or epigastric pain/discomfort	.3	.2
C upper endoscopy: stress erosions/ hemorrhagic gastritis	.8	.02

Figure 2: Probabilistic Frame

TITLE **Upper gi bleeding**
FRAME #7.143.113
TYPE interpretation
EVOKED BY A, E

FINDINGS
A hematemesis
B coffee ground emesis
C bloody gastric lavage
D tarry stools
E hemoccult positive stools
F upper endoscopy: clot or fresh blood

REQUIREMENTS FOR YES
A OR (B AND E) OR C OR (B AND D) OR F

MINIMUM FOR NO
ALL EXIST

Figure 3: Interpretive Cluster

The ASK driver has several useful features. It allows a specific question or data item to be directed to the most appropriate parties. For example, if an item in a frame is part of a patient history, a request for that item can be directed toward the patient. The ASK driver can infer the value of an item without asking a question if the patient's file contains a value for its parent item in the dictionary. If a patient's record contains a 'no' answer to the parent item "cough", the system infers a 'no' answer to the descendent item "cough with purulent sputum" needed to process a frame for diagnosing Bronchiectasis. In addition, the system will ask the 'parent' question before the 'child' even though the 'child' is the item specified in the frame logic. This intelligence is inherent in the hierarchical structure of the HELP dictionary.

QUERY driver

The Query driver is a procedure that maintains a dynamic file of requests for data made by the ASK driver, orders these items using a weighted value (accumulated probability), and then presents the requests for data in the desired format to be answered by the specified individual. As the questions are answered, the data is stored in the patient's file. This in turn causes a flag to be set that "triggers" other frames to be run using the data-driven component of the system. Frames that have had items answered are also added to the list. Another algorithm then processes the frames and accepts new items from the ASK items in the frames to start the sequence all over again. It is a cyclic process that determines the most pertinent data needs and then generates requests for the results to be entered.

The QUERY driver uses a weighting scheme to select the order in which data items in its list are to be requested. This scheme is based on the probability of the frames that asked for each item. If more that one frame asks for a given item, the probabilities for those frames are summed to arrive at the weight. The weights for the questions on the query stack are then used as a basis for arranging the items in descending order. The five top items are displayed as requests for information. By this process the data items most pertinent at any one time based on the differential diagnosis will be requested thru the Query driver. This mode of the system is called Decision-driven Data Acquisition (DDA).

Relation to HELP on the TANDEM

Although the creation of a knowledge frame for the HELP system can be accomplished with any word processor, the translation of that document into a form (pseudo-code) ready for interpretation either on the TANDEM or the Macintosh is currently performed on the TANDEM. One of the most important features of the HELP system is the ability of the decision support component to access information in a centralized patient data file which accepts data coming from many sources. A link to the TANDEM provides this data for the Macintosh, whereby the needed knowledge frames are downloaded as a batch operation and stored locally on hard disc for the Macintosh. These files are brought down in an ASCII form and then changed to the format required by the Macintosh. The knowledge frame download includes a subset of the data dictionary defined by the terminology required for each of the HELP frames used by the Macintosh in a given setting. These frames in the form of pseudo-code can be processed by the Macintosh interpreter at run time.

Applications of the Decision Support System

The Macintosh version is installed on the internal medicine wards of three University affiliated hospitals for use by third year medical students in a teaching setting. It will be used by a student to work-up a patient with a history and physical exam based on a cognitive model of diagnostic reasoning. The student will enter data from his/her patient and be shown the differential diagnosis that is generated by the system to compare against his/her own. The student will be prompted for information to draw further diagnostic inferences via the QUERY driver. To initiate the process, the user must initially answer some general questions originating from a system review frame to get the DDA process started. When the sum of the probabilities of the remaining frames with data items in the query file falls below a given threshold, no more questions will be asked. The differential diagnosis is stored in the patient record with the calculated probabilities for each frame that was evaluated. These diagnoses can be presented by the Macintosh as a ranked list with the manifestations that support each diagnostic suggestion.

It will also be used to provide medical decision support in outpatient settings that are remote from a centralized medical information system. We have developed a set of knowledge frames which model the decisions an obstetrician may be called on to make as he monitors a woman for complications during her pregnancy. In cooperation with several other primary care physicians we are building an expert system to handle other problems encountered in this setting. Both of these systems will be brought up on the Macintosh. The programs are written in C, and we anticipate that modifying the code to run (without the special Macintosh features) on other microprocessors will not be a major task.

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