Representing Medical Decision Making Strategies in a CBR System

Roberto Henrique Heinisch, M.D.
heinisch@hu.ufsc.br
Rosina Weber, M. Sc.
rosina@eps.ufsc.br
Alejandro Martins, Dr.
martins@eps.ufsc.br
Ricardo M. Barcia, Ph.D
rbarcia@eps.ufsc.br
Federal University of Santa Catarina,
Industrial Engineering and Cardiology Service of University Hospital
Florianópolis, SC, Brazil

Abstract. This paper describes and compares the development of two organizational structures to represent medical decision making strategies. We generate the solution to a new problem by applying a previous solution from a medical record in a CBR system that performs decision-making about hypertension drug therapy. The case libraries are structured in accordance with the approaches of flat memory and discrimination network. Cases are originated by a retrospective knowledge acquisition about 47 patients who underwent ambulatory care of a university hospital. The similarity-based retrieval employed in the flat structure resembles what physicians do when handling their routine cases of arterial hypertension. Physicians identify a similar case in memory by recognizing the content embedded in the new situation, like a script. The hypothetico-deductive method for searching the case solution follows a similar strategy to the one represented in the prioritized discrimination network. The inclusion of cases in the case library of the discrimination network required more complex procedures than in the case library of the flat memory. These two decision support systems could contribute significantly to patient care. The system we are researching on has educational purposes as well.

1. Introduction

Case-Based Reasoning is both a paradigm for computer-based problem solvers and a model of human cognition. The problem solver reuses the solution from some past case to solve a current problem. As a model of human cognition, case-based reasoning represents a human cognitive process to solve problems.

There are strong links between Case-Based Reasoning and Medicine. Medical practitioners often reuse past experience to solve medical problems. Also, the enormous volume of information derived from clinical cases represent resources that should be fully exploited, indicating a direct use of CBR. Consequently, case bases can be used as substantial knowledge sources that can strongly enhance medical processes such as diagnosis, treatment, and outcome evaluation, as well as teaching (Macura, 1997).

Shank and Abelson (Shank and Abelson, 1977) proposed that our general knowledge about situations is recorded in scripts. The clinical knowledge of experienced physicians may be characterized as a collection of *illness scripts* (Schmidt, 1990). When the physician recognizes a patient's clinical picture, a script comes to mind. Clearly, physicians make choices of treatment, in a particular set of clinical circumstances, by identifying an analogous situation (Greenber, 1995). There are many situations in which medical practitioners use the case-based reasoning cognitive model to solve problems. For example, several factors are considered in the selection of a drug therapy of systemic arterial hypertension. The choices of therapy, particularly for the first drug, should be made with care. The physician is challenged to find a match between a unique patient and knowledge stored in his mind (Hamm, 1995). The process of clinical reasoning is based on factors such as experience and learning, inductive and deductive reasoning, interpretation of evidence and intuition that is often difficult to define. Trying to improve clinical reasoning, a number of attempts have been made to analyze the factors involved and to define the cognitive approaches that clinicians apply to solve problems. This also included the modeling of computerized decision support systems that are designed to emulate certain features of decision making and the application of decision theory to understand how judgments should be reached. The decision to initiate pharmacologic treatment of arterial hypertension requires consideration of several factors: the degree of blood pressure elevation, the presence of target organ damage, and the presence of clinical cardiovascular disease or other risk factors. The objective of identifying and treating high blood pressure is to reduce the risk of cardiovascular disease and associated morbidity and mortality. Hypertension detection and confirmation begins with proper blood pressure measurements.

A computerized medical decision support system can be defined as a computer system that helps physicians make clinical decisions (Masarie, 1991). Computer systems can provide decision support by enhancing physician access to relevant patient data and clinical knowledge during the decision-making process (Elson, 1995). In this paper, we describe and compare the development of two organizational structures for a case-based system to support medical decision-making. We generate the solution to a new problem by applying a previous solution from a medical record in a CBR system that performs decision-making about hypertension drug therapy. The computer system was developed based on an actual sample of patients who seek for medical care. The patients' records contain the data gathered during the diagnosis process; the analysis and the probes performed, and the suggested therapy.

Cases are the essential entities in which case-based reasoning works (López & Plaza, 1997), since they are the main expert knowledge source. Thus, when designing a case-based system we must pay special attention to case

representation and its organization. In order to perform the medical decision-making process, we propose two distinctive approaches: a formlike representation in a flat organizational structure and a discrimination network.
One of our goals is to make use of a decision support system that captures medical knowledge tailoring it to educational purposes. Case studies already play a useful role in medical education; besides, we can benefit from storing knowledge from several experts in one system.

2. Organizational Structures and Case Representation

The case libraries are structured following the approaches of flat memory and discrimination network. Cases are originated by a retrospective knowledge acquisition of a sample of about 47 patients of the cardiology ambulatory who underwent ambulatory care of a university hospital to treat systemic arterial hypertension. This source database was especially elaborated and validated with records embodying extensive data what enhanced the information collection.
The cases in the proposed structures represent records of medical experiences. They consist of descriptions of the content and context of the problems and solutions. The problem description of each case includes the characteristics that are taken into account in the decision making process of the patient therapy. The solution description refers to the treatment given to the patient.

2.1. Flat Memory

In the flat memory structure, a formlike representation is used with a set of fields (attributes) and values that discriminate cases (**figure a**). The values for each attribute are collected from the medical records, namely, age, sex gender, previous diagnosis and results of laboratory tests. The solution description is also captured from the medical record and it refers to the name of the pharmacological group that was chosen by the practitioner in the opportunity that the patient began the treatment.
In the flat structure, learning is carried out by the addition of new cases to the case base; this illustrates the advantageous simplicity of such organizational structure, providing easy maintenance.

CASES/ ATTRIBUTES	CASE 1	CASE 2	CASE 3	CASE n
INITIALS	LCS	AM	VMO	…
AGE	75	25	40	…
SEX	male	female	male	…
DIABETES	no	yes	no	…
…	…	…	…	…

Figure A . Formlike memory case representation of systemic arterial hypertension cases in the flat structure.

The similarity-based retrieval employed in the flat structure resembles what physicians do when handling their routine cases of arterial hypertension. Cases are viewed as portraits; they are considered in the totality. Similarity is assessed in each candidate case with respect to the new (target) case. The most representative features - the ones considered by the physician when selecting a treatment - contribute in similarity assessment more than the less relevant ones, what is represented by a decreasing weighing.

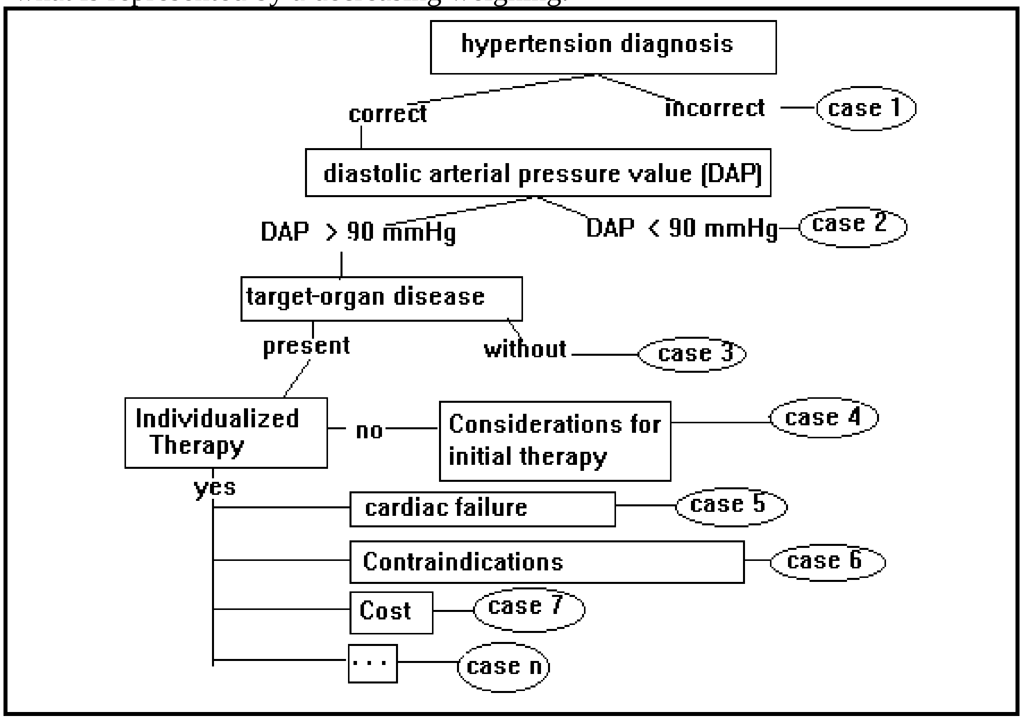

Figure B A prioritized discrimination network case representation for medical decision making of the systemic arterial hypertension therapy.

2.2. Discrimination Network

Another possibility of knowledge representation in this context is a discrimination network. The cases are represented throughout the network and discriminated at its ends. The representation procedure starts from a prioritized list of features built by the medical expert, where each feature is a question. The first question, "Do you agree with the diagnosis?" is in the top node of the net since in the domain of hypertension therapy the first step is to verify whether the hypertension actually occurs. Branches are built for all values of each feature defined in the cases (Figure 2). Each answer is used to ascribe a value. From every node stems two branches for alternative answers to the questions (yes or no). The nodes are added according to the questions associated to the prioritized list of features; whereas the two alternative answers partition the set of values stored underneath it.

Questions are ordered decreasingly by their importance. Compared to the case library of the flat memory, the inclusion of cases in the case library of the discrimination network requires more complex procedures.

3. Concluding Remarks

In the Cardiology Ambulatory of the University Hospital from where the data was taken, the treatment of hypertension is the leading indication for visits to physicians and for the use of legal drugs. Choosing a therapy, particularly for the first drug, is an extremely important task. The first drug chosen may be taken up to 40 or 50 years. Several factors must be considered in the selection of drugs. Therefore, a decision support system can significantly contribute to patient care.

The system we are researching has also educational purposes. Medical students using such a system can benefit from evaluating and revising their solutions.

We have briefly described two distinct attempts to represent medical decision making expertise to support the knowledge representation structure choice in a decision support system.When practitioners recognize patterns as scripts in deciding the treatment of the patient, the analogous strategy is held by the similarity-based retrieval represented in the flat memory structure. The hypothetico-deductive method for searching the case solution follows a similar strategy than the one represented in the prioritized discrimination network.

Another important issue is the support provided by a decision support system when a physician needs a clue on a given patient situation. A case-based system using the flat structure can present a collection of similar cases from its memory, suggesting hypotheses to the physician to start from. Hence, the system designed with he discrimination network can be used by the physician to search and validate such hypothesis, even adding new nodes or questions to it. Concerning the learning new cases, the discrimination network requires more complex procedures than the flat case memory.

Two important criteria should guide case organization: the functionality and ease of acquisition of the represented information (Kambhampati, 1989). The functionality requirement reduces knowledge engineering efforts by ensuring that the representation includes only information that is utilized during some intended use of a case. The ease of acquisition requirement ensures that the case representation does not contain information that would be very difficult to acquire realistically. In this paper, we have addressed these issues of organizing cases. Building a flat case base reduces knowledge engineering requirements. On the other hand, implementing a prioritized discrimination network requires an expert in the building process.

Although both approaches offers advantages, maintenance requirements force us to choose only one organizational structure. Further studies are being held in order to define the final system project design.

4. References

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