

A PRECEDENCE SCHEME FOR SELECTION AND EXPLANATION OF THERAPIES

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ABSTRACT

A general scheme to aid in the selection of therapies is described. A topological sorting procedure within a general production rule representation is introduced. The procedure is used to choose among competing therapies on the basis of precedence rules. This approach has a degree of naturalness that lends itself to automatic explanation of the choices made. A system has been implemented using this approach to develop an expert system for planning therapies for patients diagnosed as having ocular herpes simplex. An abstracted example of the system's output on an actual case is given.*

I INTRODUCTION

Several knowledge-based programs have been written that go beyond diagnosis and proceed to recommend treatments. The MYCIN program [1] used a production rule scheme to arrive at a diagnosis. However, it contained special routines and a separate class of rules for the selection of potential therapies. The lack of a general procedure severely limits attempts at automatic explanation of therapy. The CASNET [2] program linked treatments to the assumed progression of the disease diagnosed. However, a clear explanation of the reasoning behind the choice of therapy was lacking. Early work on the Digitalis Therapy Advisor [3] gave that program some capability for explanation of the chosen therapy. It accomplished this by translating a trace of the code used. More recent work on that subject [4] attempted to provide explanations based on knowledge of a consulting program generated from an automatic programmer. An extensive domain model of facts about the application was required. The capability to achieve good performance in general has not yet been demonstrated by an automatic programming approach.

Most other expert consultation systems attempted to explain their choice of treatment in terms of a trace of the reasoning process tailored to the application. These approaches do not seem to be easily transferable to other domains. This paper describes a procedure that integrates well with a production rule scheme and has been found natural for the selection of treatments and the explanation of that selection.

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II TREATMENT SELECTION

Often a diagnosis will not definitively correspond to a particular treatment. Rather, a set of possible treatments will be indicated. The choice of a treatment may involve information about the disease, the patient, the patient's medical history, and the treatment itself. An approach that we have found to be valuable in selection of a therapy is a topological sorting procedure. The various therapies being considered are sorted according to findings and diagnoses determined for the patient. The therapy of choice is the first therapy in the sorted list.

The following example is taken from the model developed for ocular herpes simplex in collaboration with Dr. Chandler Dawson of the Francis I. Proctor Foundation, University of California at San Francisco. The diagnosis was reached by using a production rule system based on EXPERT [5]. The model indicated that antiviral drugs were indicated for treatment. The antiviral drugs being considered were trifluorothymidine, vidarabine, and idoxuridine. The sort procedure was used to choose the appropriate therapy.

Define $<$ to be the precedence operator ($A < B$ means that A is to be ordered before B). In the example, several criteria were used as sort keys to order the drugs.

no resistance $<$ *resistance*

The above indicates that resistance to a drug makes it less preferable.

no $<$ *mild* $<$ *moderate* $<$ *severe*
allergy $<$ *allergy* $<$ *allergy* $<$ *allergy*

Evidence (or history) of a patient's allergic reaction to a drug makes that drug less preferable.

efficacy(trifluorothymidine) $<$

efficacy(vidarabine) $<$

efficacy(idoxuridine)

Also the efficacy of trifluorothymidine makes it preferable to vidarabine and likewise vidarabine is preferable to idoxuridine. The precedence rules are invoked in an ordered fashion. The drugs are to be ordered by resistance first, then allergy then efficacy. For example, the efficacy of a drug is less important than the allergic reaction in this model.

The sort procedure is integrated into a rule-based system that performs the diagnosis and therapy selection. The example that will be used here was abstracted from an actual case. The system made the following diagnosis.

Diagnosis

The evidence strongly suggests patient severely allergic to trifluorothymidine, lesion resistant to idoxuridine, corneal ulcer, and active infectious herpetic corneal infection.

Since the patient was diagnosed to be severely allergic to vidarabine and resistant to idoxuridine the order of preference of the available drugs can be calculated.

vidarabine < trifluorothymidine < idoxuridine

Before the treatment recommendation can be made, choices must be made concerning such matters as the route of administration, dosage, and length of treatment. Here, other precedence sort rules were used in conjunction with production rules to arrive at the complete treatment recommendation.

Treatment Recommendation

The evidence strongly suggests you should administer vidarabine ointment five times daily. Reexamine in 4 to 5 days.

III EXPLANATION

A major benefit of the sort is the ability to readily explain the reasoning behind a choice of therapy. Here, trifluorothymidine was chosen because the patient was allergic to vidarabine and the disease was resistant to idoxuridine. By associating explanatory strings with each sort key, the following explanation of the choice is automatically output.

Treatment Rationale

Vidarabine was chosen as the most efficacious antiviral with no evidence of allergy or resistance.

In addition, the system is capable of responding to a restricted set of queries by the user in a reasonable fashion.

Why vidarabine?

It is the most efficacious antiviral with no evidence of allergy or resistance.

Why not trifluorothymidine?

Evidence of severe allergy.

Why not idoxuridine?

Vidarabine is the most efficacious antiviral.

Alternative treatment?

The evidence moderately suggests that you should administer trifluorothymidine drops every two hours during the day. Reexamine in 4 to 5 days.

IV ADVANTAGES AND LIMITATIONS

The sort precedence rules can be easily and succinctly described. For the above example, the desired sort is described in the model by 5 short lines. This replaced an equivalent twenty one EXPERT production rules each of which is composed of multiple disjuncts. A binary decision tree to accomplish this same task would consist of several thousand nodes.

The sort procedure requires a few assumptions of the disease model. The ordering of importance of the sort keys must be strict. For instance, in this case resistance is a more important factor than allergy. No interdependencies between or combinations of the keys is considered. For the application chosen in this study, these assumptions have not presented any difficulties. As part of the development of a general system for therapy planning, this approach is being examined for applicability in more complex domains.

V CONCLUDING REMARKS

This paper presents an approach to therapy selection which lends itself to explanation. The precedence scheme can be easily and succinctly represented and provides a qualitative approach to therapy selection that has been found natural for an application to the domain of ocular herpes simplex. The approach has been integrated into a planning system. Although a particular domain has provided impetus for the development of the approach presented, the method is general and is currently being tested in another domain, the treatment of rheumatic diseases.

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