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 h8ve 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 tne 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 trifluorthymidine vidarabine and idoxuridine The sort procedure was used to choose the appropriate therapy

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

$$no\ resistance \prec resistance$$

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

$$no\ allergy \prec mild\ allergy \prec moderate\ allergy \prec severe\ allergy$$

Evidence (or history) of a patients allergic reaction to a drug makes that drug less preferable

$$efficacy(trifluorthymidine) \prec efficacy(vidarabine) \prec efficacy(idoxuridine)$$

Also the efficacy of trifluorthymidine 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 tnfluorthymidine lesion resistant to idoxundme corneal ulcer, and active infectious herpetic corneal infection

Since the patient was diagnosed to be severely allergic to vidarabme and resistant to idoxundme the order of preference of the available drugs can be calculated

vidarabme < *tr if luorthymidi ne* < *idoxundme*

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 vidarabme 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* tnfluorthymidine was chosen because the patient was allergic to vidarabme and the disease was resistant to idoxundme 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 trifluorthymidine?

Evidence of severe allergy

Why not idoxuridine?

Vidarabine is the most efficacious antiviral

Alternative treatment?

The evidence moderately suggests that you should administer tnfluorthymidine 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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