Modelleren van expertise in expertsystemen

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Summary

Research design
Human experts possess the ability to solve problems without an explicitly formulated algorithm. Expert systems are a way to represent this ability as a model of the expert. To build an expert system one has to solve two consecutive problems:

1. There is a human expert and his knowledge. Is it possible to capture this knowledge? What methods can be used for knowledge acquisition?
2. Experts solve problems. In what way(s) is it possible to build an expert system based on the acquired knowledge?

Whenever one succeeds in modeling the knowledge in an expert system, one has a solution (a heuristic algorithm) for the kind of problems that are solved by the expert. In the information age this kind of systems will be important.

In this thesis I give solutions to both questions. I give these solutions embedded in existing theories, methods and techniques. This is done in three stages. At first it is necessary to redefine and/or to extend a number of theoretical concepts and theories in order to be of more use. After having extended the theory I extend the system development method ISAC to use it for the development of expert systems. As a kind of proof of the pudding I describe in the third stage the development of an expert system that makes decisions in the field of the insurance of the transport of certain goods.

Theory
In economics and management science there is a long tradition of modeling the (economic) behaviour of human beings. Research in this field has focused on the analysis of data generated by human decision making. That implies that most of the analysis concerns the consequences of decision making and not the decision making process itself. In the information era the decision making process is becoming more and more important. Which data are used by a decision maker, what kind information does he need, how does he reach a conclusion, which rules is he obeying to? Those are the questions that need to be answered if one wants to model the decision making proces.

The existing concepts and theories do not suffice. E.g. decision theory is mainly concerned with well-structured problems while human experts are concerned with ill-structured problems. In a rather extensive chapter 2 I deal with the theoretical shortcomings. I propose new definitions for data, information and knowledge and I introduce the notion of experience as a useful intermediate concept between information, the decision making process and knowledge. These notions are then related to the standard classification of information systems: transaction processing systems, management information systems, decision support systems and expert systems. By relating these two it is easy to illustrate clearly the special place of expert systems among other systems.

Besides I distinguish between three kinds of knowledge: factual knowledge, reasoning knowledge and background knowledge. This distinction turns out to be relevant when structuring the knowledge of an expert for an expert system. Finally I

explore the concept of rationality, especially the concept of bounded rationality, show that it has evolved from an axiom via a classification notion to a notion that can be used as a judgment. This interpretation is the basis for the test of expert systems in the chapters to come.

Models
Modeling has a long history in science. An expert system is a model of a human expert. Still it is hard to explain why expert systems are a special kind of models within the existing classifications of models. Therefore I propose a new classification of models. Instead of the ad-hoc classifications found in literature (e.g. prescriptive or descriptive, mathematical or verbal), I base my classification on the principle that models are a means of communication. Hence I introduce the term "model language" and apply the common notions of vocabulary, syntax, semantics and pragmatics to models. This forms a sound basis for a decent distinction between a multitude of models. Although it can not (yet) be proved that this classification method is the best there is, I demonstrate that it is better than what has been done before.

Method
After having explained the basics of expert systems and expert system shells, I explore existing methods for the development of expert systems and find two omissions. The methods for the development of information systems lack a decent treatment of the special problems caused by the use of expert knowledge in the solution of ill-structured problems. The methods that emerged from the AI-laboratories on the other hand lack a relation to the development of information systems. So I propose an extension of the well-known development method ISAC: next to Activity-diagrams and Information-diagrams I propose the use of Knowledge-diagrams to analyse the use of knowledge in the decision making process. On top of that I fill the gap between the structure of the knowledge domain and the logical design of the expert system by specifying a number of rules that, if followed, will lead to a neat logical design that results quickly in a technical design.

System
One of the more difficult problems in the world of insurances is the insurance of transportation. A lot of influences determine the risk and an eventual loss. It is impossible to use only the law of large numbers as in life insurances, as not only each transport is different, but the risk of the same transport may vary heavily over time. In short, it takes a human expert to decide on the premium and the conditions.

Centraal Beheer, a Dutch insurance company, gave the opportunity to start a project to answer the question whether or not it is possible to support the decision making process with an expert system. In fact two questions were raised:
1. Is it possible to represent the expert knowledge in some kind of expert system?
2. If so, what should the system look like?

These questions were answered in three stages, resulting in three systems. The first system was to test the procedural structure of the decision process. The second system was based on the first, but a statistical model was added. This system was used as a simple mechanism to generate a premium to be paid for the insurance of a certain

transport, that could be commented on by the expert. The expert's comments were used to build the third system. It is a knowledge based system in which the theoretical notions that I developed are implemented each in their own subsystem. There is a database subsystem for registration of factual knowledge, a log subsystem for the registration of experiences, an expert subsystem containing reasoning knowledge and a hypertext subsystem containing background knowledge. The user is free to choose between the systems. Updating is performed by the human expert and is based on the registrated experience, factual knowledge and human interpretation.

Conclusions

In this thesis I show that it is possible to model the knowledge of a human expert. The system is, considering the simple structure, rather successful. When it is tested by experts, it gives results that are correct in more than 95 percent of the cases.

To develop an expert system like this one, one needs to have a method. In this thesis I extend an existing method so it can be used to structure the knowledge domain and besides I give the necessary rules that result in a neat logical design.

These results are embedded in existing concepts and theories. To achieve this I have extended existing theories, sometimes redefined existing notions so they became usable and sometimes added new notions to fill conceptual gaps.