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Intelligent Guidance in Adaptive Decision Support Systems

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Introduction & Background

Many semi-structured problems are multi-criteria decision making problems. These problems are not structured enough to use any analytical techniques to find the optimum solution by optimizing the decision criteria. Some time these criteria are subjective criteria and are difficult to quantify as required to get an optimum solution. For example, asset allocation, allocation of investor's assets among different investment instruments (such as stocks, bonds, Tbills, etc.), is a semi-structure problem [Bolster, et al. 1995, Chow 1995]. An investor needs to look at not only return and risk of a portfolio, but also suitability of the portfolio to the unique characteristics (such as occupation, health, risk tolerance, etc.) of the investor. Several optimization models have been proposed for asset allocation, but their use by investors and professional investment advisors is limited [Bellhy 1995, Chow 1995]. There are three major reasons for the limited use. First, most of the models do not consider many unique non-quantifiable characteristics of the investor. Second, some of the variables involved in these models are judgmental, which assumes that the decision maker is knowledgeable enough to provide necessary judgmental inputs. Third, the models reduce the number of decision criteria to a few by combining them in some manner to come up with some unique measure, and then optimize the measure. Such combinations are not always justified for all possible cases.

0: General Architecture of ADSS

Decision support systems (DSS) are appropriate tools for the multiple-criteria semi-structure problems. DSS assist a decision makers in decision processes in semi-structured tasks and support, rather than replace, managerial judgements [Keen&Scott Morton 1978, Sprague 1980]. Solving a semi-structured problem requires user judgmental inputs. A problem solver must have substantial knowledge about the related concepts as well as relations among them in order to be able to generate and evaluate different alternative solutions in terms of their suitability as an appropriate solution.

Adaptive decision support systems (ADSS) can provide the users an adequate decision support in determining appropriate input values for the judgmental inputs [Fazlollahi, et al.]. ADSS are enhanced DSS that support human decision making judgements by adapting support to the high level cognitive needs of the users, task characteristics, and decision context. They provide not only conventional DSS tools, such as "what-if" capability, but also a guidance mechanism that would assure that the user understands the concepts of the problem domain at the needed level. This mechanism enables the system to adapt to the current needs of the user depending on where the user is in the task.

The next section discusses adaptive decision support systems (ADSS). The following two sections describe how the guidance capability is facilitated using Artificial Intelligence techniques.

The Architecture of the System

The Adaptive Decision Support System (ADSS) has four major modules: Data, Model, Adaption and User Interface (Figure 1). Data module stores raw data or facts about the problem, user, concepts and procedures. Model module has models to solve different problems, to deliver instruction or guidance, to diagnose the user to develop user knowledge profile. Adaption module is the intelligent module determines the support needs of the user, task characteristics and decision context. User interface provides communication with the user [Fazlollahi, et al. 1996].

The process that a user goes through while interacting with ADSS starts with assessment of user knowledge and skills in the problem domain. During this knowledge assessment phase the system asks the user questions about concepts involved in the problem as well as relationships among those concepts. The user scores on the concepts represent the user knowledge profile. Depending on user sophistication level, the future guidance will be given at different levels for different categories of users.

The next phase is problem characteristics profile determination. In this phase, the user is asked to submit facts about the problem. The system provides guidance during this phase depending on the contents of a question (task) as well as user's knowledge profile. This guidance, which we call "Guidance #1," assures that the user has sufficient knowledge about related concepts to be able to accurately provide the requested information. The output of this phase is the problem characteristics profile which, in case of asset allocation, gives us information about the user's objectives, expectations, risk tolerance, time horizon, etc.

In the following phase, the user uses DSS to perform "what-if" analysis on different alternatives. Here, we first provide the approximately reasonable solution to the problem that an expert would propose to the user considering the problem characteristics. This provides a starting point for the user in the decision making process. "What-if" analysis on different alternatives then allows the user to examine possible outcomes of the alternatives in terms of several criteria. In the case of asset allocation, the system allows the user to examine different portfolios in terms of risk and return, make necessary comparisons with the allocation proposed by the system. At each iteration of "what-if" the system gives the user a guidance, which we call "Guidance #2." This guidance comments on the current selection of alternatives and explains its appropriateness. At this point the user may ask for more explanation and review the related concepts for the problem at hand. This process is believed to converge to a reasonable user-defined solution, while increasing user knowledge about the problem domain and confidence in the decision making process and the outcome. In the case of asset allocation, this guidance comments on the allocation schema that the user currently has chosen in terms of how appropriate the solution is for the user. User can ask the system for an explanation of why a selected allocation may be inappropriate.

The following sections discuss the "Guidance #1" and "Guidance #2." For ease of explanation, we have integrated the problem of asset allocation.

Guidance #1

The domain knowledge is represented in a form of semantic network, where the nodes are associated with the relevant concepts, and arcs represent relationships between the concepts. We assume that the knowledge contained in the semantic network is sufficient for being able to understand and solve the problem. An example of a node, in asset allocation, would be the concept of Portfolio, which is connected to the node "Investment Objectives" by the "has" type of link, thus representing that portfolio serves to fit the investment objectives. At the same time, a portfolio is made up of different securities, such as stocks, bonds, T-bills, and derivatives, which is indicated by corresponding arcs.

The method of overlaying the representation of the user knowledge on the domain expert knowledge [Ng 1995] gives the system information about potential gaps and weaknesses in user knowledge. Then, during Guidance #1 the system identifies what concepts need to be explained to the user on each question about user's financial conditions and objectives. This is done by examining the concepts involved in the question and gaps in user knowledge. If a gap is considerably large, the guidance is given. Each concept may be presented in forms of definition, description, or example.

When a concept is presented, the user is also allowed to follow links to other associated concepts. These links are determined by the semantic network. This process allows system to assure that user understands what information is requested from him or her, thus increasing the reliability of extracted user's characteristics.

Guidance #2

"What-if" is a powerful tool in providing decision support. The system provides such a tool to the user, allowing him to estimate different allocation schemes. The measured outcomes here include the estimated values for risk and return of portfolio. These are defined through the historical risk and return for individual securities. On each iteration, after user makes up potential allocation scheme, the system compares it to the proposed guidelines and interferes if the deviation is significant.

The interference is guided by fuzzy rules which determine what message to send to the user. The conditional (antecedent) parts of rules consider the risk and return values for the user-defined portfolio, as well as deviation of that portfolio from the one proposed by the system. The consequent parts of rules include short evaluation of the portfolio, as well as recommendation on the possible ways of improving the allocation.

Fuzzy terms, such as 'large', 'small' and others are used in the rules to reduce the number of rules required. An example of a rule is :

"IF risk of user portfolio is larger than that of the benchmark AND return of user portfolio is higher than that of the benchmark AND user puts too much money in risky securities, THEN Message = "This portfolio is too risky for you. Try to invest more in Bonds and T-Bills".

The capability to explain why the portfolio is not suitable enough is also provided. The explanation is based upon the Analytical Hierarchy Process model [Bolster, et al. 1995], which describes the suitability of particular portfolio to particular characteristics of the user. The characteristic(s) on which the portfolio is not suitable enough are presented to the user as the reason(s) for system's feedback. For example, for the above situation, the system may give the reason "The risk you are taking is not appropriate for your age". This process is believed to converge to a user-defined reasonable solution.

Conclusion

We described an approach to provide a user with appropriate guidance in solving portfolio allocation problem. The primary purpose of the ADSS is not tutoring the user, but, rather identifying what a person needs to know to approach the problem, and to communicate the knowledge at the right time and in appropriate form. The guidance is also provided as means of supporting the process of decision making, in the case of asset allocation, it is investor's search for appropriate allocation. Although we have discussed asset allocation problem in this paper, the same principles implemented with the use of AI tools can be applied to support users in solving wide range of other semi-structured problems.

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