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Integration of Expert Systems Into Decision Support Systems for Decision-Making

Young H. Park*

ABSTRACT

The purposes of this paper are to compare expert systems and decision support systems, and illustrate the possible benefits when expert systems are integrated into the model base of a decision support systems for supporting decision-makers. Integrating expert systems capability into decision support systems may enhance the quality and efficiency of both computerized systems. This integration can improve selection of model, analysis, model management, judgement, and modeling. Thus the results are much more powerful decision support systems than are presently available.

Introduction

In recent years there have been rapid developments in two technologies aimed at improving decision-making: decision support systems (DSS) and expert systems (ES). A DSS is an interactive system that helps decision-makers utilize data and models to solve unstructured or semistructured problems. An ES is a problem-solving computer program that achieves good performance in a specialized problem domain that is considered difficult and requires specialized knowledge and skill. The number of applications of DSS or ES has been increased by the use of personal computers, advances in data base management systems, incorporation of "user-friendly" software interface techniques, etc. Applications of both DSS and ES for decision making in the business arena is expected to increase significantly (6).

One of the most pertinent problems is how to integrate ES into an existing management information system, specifically into a DSS, in order to create more powerful and useful computer-based systems.

*Department of Management, New Mexico State University, Las Cruces, New Mexico 88003

In the following sections, DSS and ES are discussed and compared, followed by a representative examples of integrated systems of DSS and ES. The integration of expert systems into the model base of a decision support system is then presented.

Decision Support Systems

Decision support systems have been applied to many different disciplines, including manufacturing, marketing, human resource management, accounting, and the like. The power of these systems has been demonstrated in the business world, leading many to conclude that DSS is the way of the future. DSS is designed to assist managers in their decision processes and improve the effectiveness of the decisions. The decreasing cost and the increasing sophistication of both hardware and software have made these systems available not only to large organizations but to small businesses as well.

A DSS is composed of four components: data management, model management, dialogue management, and the user, as illustrated in Figure 1. The data management consists of database and database management systems (DBMS). The model management contains modelbase and modelbase management system (MBMS) for analytical purposes. The dialogue management is composed of interface software for user communication with the system. The last component is the end-user whose judgement and cognitive style are vitally important to the success of a DSS.

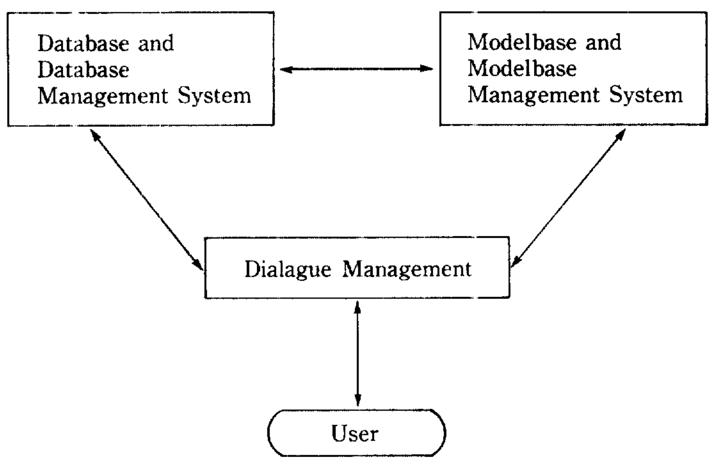

Figure 1. Components of a Desision Support System

1. The data in the DSS database may contain internal transaction data, external sources data, and private data. A DSS may have a separate extracted database for exclusive use. The database is created, accessed, and updated by a DBMS. The DBMS is a series of software programs.
2. The modelbase is computer programs. This may include optimization and nonoptimization models

such as linear programming, portfolio, inventory model, and nonlinear programming. The computer programs in the modelbase are managed by the modelbase management system (MBMS). For example, it is difficult for MBMS to decide "which model should be used for what occasion?" because model selection requires expertise. If it is integrated with ES, the ES can assist the DSS to choose models.

3. The user interface of a DSS is the software and hardware for facilitating user communication with the system. The dialogue process may consist of three parts: the action language for user communication and data input, the display or presentation language for what the user sees or hears, and the knowledge base for the information the user must know.
4. The users themselves are an important component of a DSS because different users have different needs according to their organizational level, functional area, educational background, and analytical support requirements.

Expert Systems

One of the most promising applications of artificial intelligence (AI) - and one of the areas where AI research has become most usable by industry, is the development of ES. Expert systems - also known as knowledge-based systems, expert advisors, and intelligent computer consultants - are computer programs that are able to equal the performance of human experts on specialized, professional tasks. An ES works, almost as a human consultant might, in response to a user query. It asks the user for new information, relates pieces of information to lines of reasoning and general rules, decides what additional questions need to be asked, arrives at conclusions, and makes recommendations.

An expert systems is composed of a number of components that work together to produce the desired results (12). The components, depicted in Figure 2, include: the knowledge base, the inference engine, the explanation subsystem, the knowledge acquisition subsystem, and the human interface.

1. The power of an ES comes from its knowledge base. A knowledge base is very similar to the database of a DSS. However, a knowledge base not only stores facts and figures, it also keeps track of a series of rules and explanations associated with the facts.
2. The second major component of an expert system is the inference engine. The brain of the ES is the inference engine. It is similar to the modelbase of a DSS. The inference engine is a computer program that provides a methodology for reasoning about information in the knowledge base and for formulating conclusions.
3. The fundamental goal of an explanation subsystem is to explain its line of reasoning to the user if and when the user requests the information. The system can explain to user such as how a certain conclusion was reached, and/or how a certain alternative was rejected.
4. A knowledge acquisition subsystem is needed to assure the growth of a system. Just like a human expert, this system is able to acquire new rules and facts and delete or modify existing ones.
5. Human interface is very similar to dialogue management of a DSS. This interface must translate input from the user and must make the system's output understandable to the user. this communication is best carried out in a natural language, and in some cases it is supplemented by graphics.

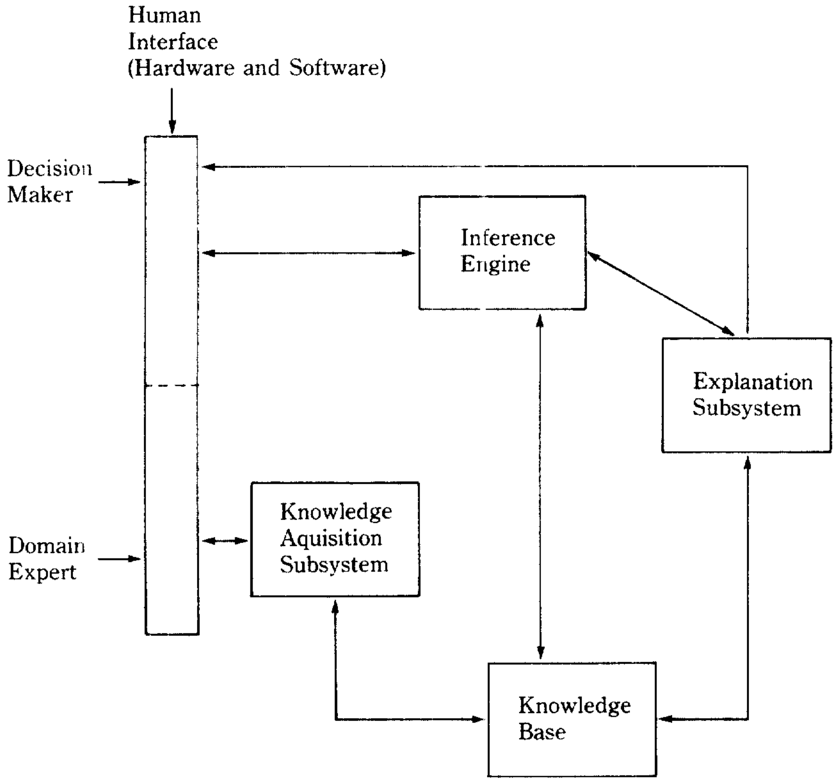

Figure 2. Components of an Expert System

Comparison of DSS and ES

The fundamental goal of DSS and ES is basically the same; they seek to improve the quality of the decision. However, their underlying philosophies, objectives, and explanation capability are quite different. A comparison of DSS and ES helps in integrating the two types of systems.

The objective of a DSS is to support the user in making a decision by providing quick and easy access to data and models relevant and applicable to that decision. the objective of an ES, on the other hand, is to provide to the user with a conclusion or decision that is correct all the time. DSS allows the user to confront a problem in a flexible, personal way by providing the ability to manipulate the data and models in a variety of ways while progressing through the decision making process. The user chooses relevant models and directs their use to analyze the problem and the user makes their own conclusion. The user of an ES, however, is directed by the system. Another distinct difference is the type of programming language used to construct the systems. For DSS, the core languages used are higher level languages, such as FORTRAN, COBOL, or BASIC. The nature of the models used in DSS, typically mathematical algorithms, accounts for this approach. ES, on the other hand, is typically constructed using LISP, PROLOG and other languages that are more effective in representing and processing the symbolic type of information needed for expert system development and application. The query directions are basically the same in both DSS and ES. In the DSS, however, the user asks the machine a number of questions. In the ES the machine asks the user a number of questions. The problem area attached by DSS is a broad range of managerial problems, while ES is restricted to much more structured and well-defined problems (21). A DSS works primarily with quantitative data, while an ES works with rules, symbols, and qualitative data. DSS is suitable for dealing with ad hoc decisions, while ES is more suitable for routine and repetitive decisions. DSS usually does not include either reasoning or explanation capability. In other words, the user cannot ask why or how a particular solution was reached. The majority of ES possess some reasoning and explanation capability, which means the system will tell the user why it made a particular recommendation or how particular advice was generated (3). Table 1 summarizes the key characteristics of a DSS compared with an ES.

Table 1. DSS and ES Comparison

Key Feature	DSS	ES
Objectives	To support a decision-maker	To replace a decision-maker
Decision	By human	By system
Major component	Data base Model base Dialogue User	Knowledge base Inference engine User interface Explanation system Knowledge aquisitions.
Programming Language	High-level language (FORTRAN, COBOL)	LISP, PROLOG, and so on
Query direction	User queries the machine	Machine queries the user
Problem addressed	Broad	Specific (narrow domain)
Problem precedence	No precedence	Precedence
Mode of Operations	Quantitative data, ad hoc decisions	Symbols, rules, qualitative data, and routine and repetative decisions
Reasoning capability	None	Yes, limited
Explanation capability	Limited	Yes

Integration Systems of DSS and ES

Most existing DSS and ES are not integrated. DSS operates as support device to decision makers while ES operates as an independent expert consultation system. However, this situation is beginning to change. Integration has already been started in a number of directions. A review of the literature shows promising sings for further integration between DSS and ES technologies.

In certain problem domains both DSS and ES may have distinct advantages that, when combined, can yield synergetic results. The combined results of the DSS and ES could be reconciled and evaluated, with the likelihood that the joint effort would produce better results than either approach independently. Representative examples of DSS/ES integrated systems are presented below

* GURU (24). The system includes spreadsheet, graphics, communication, natural language interface, data base, and word processing programs. This package can be used for development of numerous DSS/ES systems.
* Logistics Management System by IBM (3). The system combines ES, simulation, traditional DSS and computer-based information systems.
* DSS/Decision Simulation by IBM. The system combines traditional DSS, Statistics, operations research, database management, query languages, and AI.
* BUMP (8). This system integrates statistical models with ES capabilities, tells the user which model to use, and provides a user-friendly interface

Benefits of ES Integration into DSS Component

ES can be integrated into the three major components of a DSS: the data base, the model base, and the interface. Proposed here is ES integration into the model base of the DSS. There are several contributions of ES into the DSS. These benefits of the integration are discussed in the followings. The proposed integration is illustrated in Figure 3.

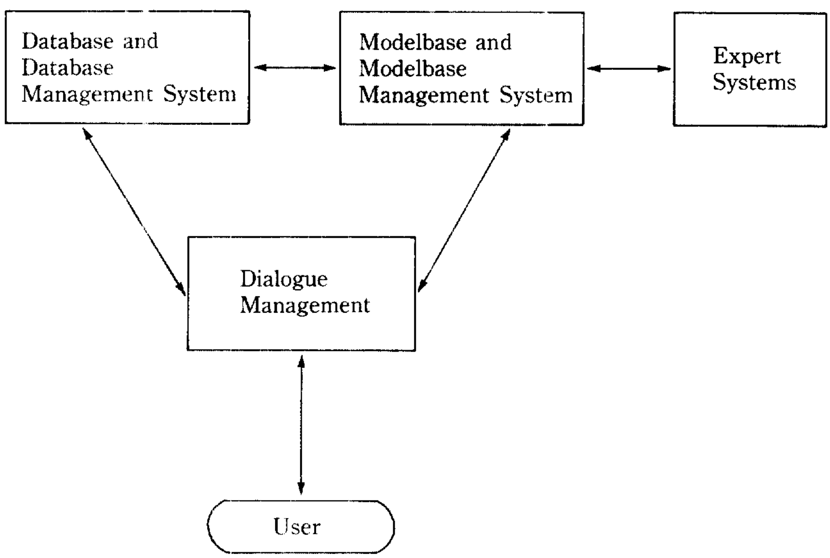

Figure 3. Integrated Structure of DSS/ES

In many cases the results of a computerized quantitative analysis provided by a DSS are forwarded to an individual or a group of experts for the purpose of evaluation. For example, a problem under investigation may be categorized as an optimization problem, but may have several types of applicable optimization methods. Which model should be selected? This can be a complex task, and not many DSS users have adequate training in this area. The first ES contribution in the model base component of a DSS is the identification of the nature and selection of an appropriate model of the problem currently being considered. In which case the ES will function exactly like an expert. Therefore, it would make sense to direct the output of a DSS into an ES which would perform the same function as an expert whenever it is cheaper and/or faster to do so (especially if the quality of the expert is also superior).

The second ES contribution to the model base is the improvement of analysis. After communicating with ES for selecting an appropriate model to use in a decision area, the user may want to analyse the solution and draw a conclusion. However, the information and environmental factors may be continuously changing. Only experts are aware of all the assumptions and problems underlying these models, not the user. Through different techniques, an inference engine can manipulate sensitivity analysis of models and choose the best alternative or make suggestions regarding each alternative.

The third area in which ES can improve the model base of a DSS is to add heuristics to the existing capability of the model base. A DSS operates based on specific algorithms in which a good enough solution is reached and then the process stops. By adding heuristics to model base, not well-defined problem may be handled. By integrating with ES, a DSS can also handle some degree of "fuzziness" in a problem. Thus the user of a DSS can use a more realistic view of a real-life situation.

ES also can provide judgemental elements (4). For example, a forecasting decomposition time-series model requires several judgemental decisions. Such decisions are made only after the data are collected and analyzed.

Finally, ES can be used as a tool to help the user in modeling; for example, in constructing simulation models, in conducting a statistical analysis (8), or by conducting a complex PERT/CPM analysis.

Conclusions

The integration of ES into DSS components is an irrevocable path for developing an integrated system for decision support. Strenuous efforts have been made by various researchers and practitioners in constructing such a system. The purpose of this paper is to illustate the possible benefits when ES is integrated into the model base of a DSS for supporting decision-makers. ES can make DSS a more active and valuable partner in the decision making process. Thus, the integrated systems will be able to answer the question "If-then and why" instead of "what-if". The combined results of the DSS and ES could produce better results than either approach independently.

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