Unambiguous Goal Seeking Through Mathematical Modeling

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INTRODUCTION

All decision-making support systems (DMSS) provide both input and output feedback for the user. This feedback helps the user find a problem solution and captures any created knowledge for future reference. Goal seeking is an important form of DMSS feedback that guides the user toward the problem solution. Often in the decision support literature there is a concentration on providing forward-oriented decision assistance. From this perspective, the decision problem is viewed from the problem forward, towards a solution and advice is given with that orientation. In the literature, this is most often seen in "what-if" analysis.

Goal seeking takes an inverted view where a preferred or optimal solution is known and the advice provided identifies values for the decision problem variables so that the optimal or preferred solution is obtained. Goal seeking approaches can be useful not only in identifying a solution, but also examining and explaining the relationships between decision variables. Unlike what-if analysis, which is forward oriented, goal seeking starts with a preferred outcome and decision makers do not have to manipulate decision variables in a recursive manner to examine different decision scenarios.

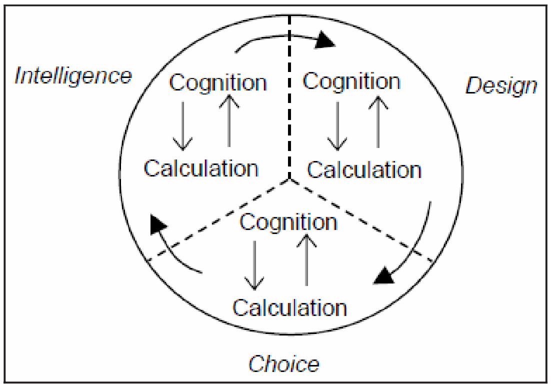
Frequently described as a system of equations, solvable models, on which what-if analysis and goal seeking operate, describe known outcomes and show the transformation steps that turn inputs into outputs. Particularly with solvable models, decision makers are able to measure how accurately a model depicts a system and evaluate the results of changes to decision variables. However, conditional ambiguity can limit or constrain the effectiveness of solvable models. In practical implementations, solvable models are developed and generally programmed in a high-level language; operationalized using conditional If…Then statements. In these cases, goal seeking can lead to conditionally ambiguous advice.

By incorporating a mathematical approach to the implementation of these models, it is possible to create unambiguous goal-seeking. This requires the conversion of If…Then conditionals to mathematical formulations. This conversion leads to a series of simultaneous equations that can be solved, yielding explicit decision variables values that generate a desired decision target. This article discusses how to achieve unambiguous goal seeking through the use of mathematical modeling. The following sections provide a background on decision support systems and the use of goal seeking, followed by the presentation of a case that demonstrates how the ambiguity in goal seeking can be resolved with mathematical modeling. This chapter is concluded with a discussion on the implications of this methodology for decision support.

BACKGROUND

The process of decision making is a complex and well-researched topic. This topic has been researched from the perspectives of psychology, statistics, and management as well as information science. For more than 30 years, researchers and information systems specialists have built and studied a wide variety of systems for supporting and informing decision-makers that they have called decision support systems or management decision systems (Scott-Morton, 1971). In the past few years, some additional terms such as business intelligence, data mining, online analytical processing, groupware, knowledgeware, and knowledge management have been used for systems that are intended to inform and support decision makers (Power, 2001).

Figure 1. Decision phase model, adapted from (Simon, 1960)



The development and implementation of decision making support systems requires knowledge about and understanding of managerial decision making; associated levels of reasoning and problem solving; and the roles managers play in organizations (Kersten, Mikolajuk, & Yeh, 1999). Support for decision making requires prior knowledge and understanding of the problems, processes, and activities leading to a decision. These tasks can be achieved by studying the reasoning activities involved in a choice process and remembering that they engage human faculties acting within clearly distinguishable phases (Mintzberg, Raisingham, & Theoret, 1976; Simon, 1960), as shown in Figure 1.

In many applications, the decision variables and uncontrollable inputs have a highly interdependent influence on the problem or opportunity objective (Kennedy, 1998). Without a valid decision model, the decision maker may not properly isolate the dependent and independent effects of the variables and inputs (Woodward, 1995). Analysis of the problem should link a decision opportunity to the ability to realize objectives (Heylighen, 1992). This analysis involves the recognition of the type of problem, the definition and interplay of its components, and relationship between the components and earlier experience. Thus, decision making articulated at the cognitive level includes connecting objectives' achievement with problem recognition and definition, and with the situational constraints within which a decision has to be made (Kersten et al., 1999).

A model of the decision problem provides a cognitive aid and analytic framework for experimenting with decision variables, constraints, parameters, and outcomes. Model driven decision support approaches require the decision maker to reduce and structure the problem variables as well as its related data in a manner that can enable the application of an appropriate model. There are several benefits of using models to support decision making. These benefits include low cost, time compression, and an ability to represent very complex systems and processes. As such, there are three types of model abstraction: iconic or a physical replica, analog or symbolic representation, and mathematical or models that use mathematic representations. Of the three, mathematical models are most commonly used in DMSS applications and frequently used for accounting models, representational models, optimization models, and suggestion models.

The composition of mathematical models consists of four steps: (1) identify variables, (2) establish equations describing relationships between and among the variables, (3) simplification of the equations and model through assumptions, and (4) balancing model simplification with its accurate representation of reality. Subsequently, mathematical models can be used to perform quantitative analysis aiding decision making. The availability of mathematical models can allow what-if analyses and goal seeking in decision making support systems (Geoffrion, 1989).

What-if analysis uses a model, typically a mathematical model, to explore problems through the

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