Intelligent Systems to Support Human Decision Making

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INTRODUCTION

Rational decision making is an essentially human activity. As analytical techniques, data acquisition, and computer technologies have increased in power and availability, researchers have developed systems to augment and extend human reasoning capabilities. One such class of systems is intelligent decision support systems (IDSS) that are enabled by advances in Artificial Intelligence (AI). New applications of IDSS are emerging to enhance business decision making in such areas as finance, healthcare, marketing, commerce, command and control, and cybersecurity.

The term 'intelligent' within DSS is used to describe systems that mimic human cognitive capabilities in some way (Phillips-Wren, 2012). These systems utilize AI tools for tasks such as acquiring data, reasoning from data, learning patterns, suggesting classifications, remembering past behaviors, and selecting optimal decisions for current and future states. AI tools can be used to extend human capabilities by, for example, surveying and selecting relevant information from extremely large and distributed data sources, applying analytical tools to unstructured data, creating generalized solutions from rule-sets and probabilities, and finding associations in information from multiple sources that may influence a decision. Tools such as Artificial Neural Networks, Fuzzy Logic, Intelligent Agents, Agent Teams, Case-Based Reasoning, Evolutionary Computing, and probabilistic reasoning, when integrated into decision support systems, can help a decision maker to evaluate and select alternatives. Such systems are particularly helpful in complex problems that involve uncertainty, large amounts of data, and are not deterministic.

This chapter views analytical AI techniques as essential aids to improve business decision making with IDSS. The objectives of the chapter are to: (1) review the literature on the human decision making process related to IDSS; (2) demonstrate that IDSS are emerging for real applications; (3) examine the primary AI tools embedded in IDSS today, i.e. Neural Networks, Fuzzy Logic, Evolutionary Computing, and Intelligent Agents; and (4) suggest future research directions in IDSS.

BACKGROUND

A decision is a reasoned choice between alternatives (Simon, 1955), while decision making is the process of choosing between alternatives in order to satisfy a goal or goals (Turban & Aaronson, 1998). Decisions can be characterized as structured, semi-structured or unstructured (Turban & Aaronson, 1998). Structured decision problems are routine and can be solved with a standard model. Unstructured decision problems have no agreed-upon criteria or solution and rely on the preferences of the decision maker. In between these two types of problems, there is a wide range of semi-structured problems that generally have some agreed-upon parameters and yet require human input or preferences for a decision. Semi-structured decision problems are particularly amenable to decision support since they require a combination of user guidance and analytical methods to develop alternatives based on criteria and potential solutions.

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Data can also be considered as structured, semi-structured or unstructured. Structured data are data that can be represented in a format or schema such as a relational database. Numeric data, and textual data that can be converted to numeric form such as dates, have an underlying structure. At the other end of the spectrum are unstructured data with no underlying structure. For example, audio files, video files, and visual images such as photographs are unstructured data. In-between there are semi-structured data in which the underlying structure is contained within the data themselves, a characteristic sometimes called self-describing (Buneman, 1997). For example, disparate databases using different schema may have the need to exchange data. Decision makers may exist in complex environments, with structured, semi-structured or unstructured decisions that require structured, semi-structured or unstructured data.

Researchers suggest that a comprehensive understanding of human decision making is needed for effective use of, and benefit from, artificial intelligence (Pomerol, 1997, 2008) since AI attempts to mimic human intelligence in some way. Indeed, advances in AI have shown significant promise in assisting and improving human decision making, particularly in real-time and complex environments (Phillips-Wren et al., 2009).

SUPPORTING HUMAN DECISION MAKING IN THE AGE OF 'BIG DATA'

Issues, Controversies, Problems

Humans often use sub-optimal strategies to make decisions. They avoid multi-criteria choices with strategies such as rationalization, reasoning by analogy, heuristics, trial and error, local adaptations, avoidance of loss, and control of risk (Pomerol & Adam, 2008). They display cognitive bias with errors in decision making such as anchoring in the past, maintaining the status quo, looking for evidence to confirm their choices, framing a problem to obtain the desired solution, errors in estimating and forecasting, and appealing to sunk cost as a rationale (Hammond et al., 2006). The age of 'big data' has exacerbated these cognitive errors by distancing decision makers from the data they require to make rational decisions.

To assist users to overcome their cognitive limitations, decision support systems (DSS) have been developed (Turban & Aaronson, 1998). However, as problems have become more complex and dynamic, and the amount of relevant data and information has exploded, more sophisticated approaches such as intelligent systems are needed to assist the decision maker.

Solution Methodologies and Recommendations

Intelligent Decision Support Systems (IDSS)

IDSS are based on models of human decision making. The most used and best known behavioral process model of human decision making for management decisions was proposed by Simon (1955, 1997). Simon's theory of Bounded Rationality proposes that decision makers are limited by the information they possess, time to make the decision, and their own cognitive resources. He then developed a behavioral view of decision making as a normative process model consisting of four, phases: (1) Intelligence, (2) Design, (3) Choice, and (4) Implementation (Simon, 1977, 1997).

Computerized systems called Decision Support Systems (DSS) have been developed based on Simon's model. DSS are a broad range of interactive systems that assist decision makers to utilize data, models and knowledge to solve semi-structured, ill-structured, or unstructured problems (Sprague & Watson, 1996). The decision maker may perform actions such as providing values of input variables or criteria for the decision, drill-down for explanations, select analysis methods, and reject alternatives. There are many types of DSS specialized for different types of users and