8-25-1995

The Generalization of a Decision Simulation

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Abstract

This paper discusses a research project in which an artificial intelligence decision making model in the domain of politics is applied to business decisions in general and an information technology decisions in particular.

We describe the original VOTE program, which simulated Congressional roll call voting. Then we discuss extensions to VOTE motivated by its application to business domains. The primary sample decision problem is the purchase of a personal computer.

The VOTE program is not a prescriptive model of decision making, but rather an attempt to create a realistic simulation of human cognitive behavior.

Introduction

A Boeing 747 is expensive and complex. A pilot must undergo extensive training to learn how to fly a 747. It is not enough to know how to measure wind speed or altitude or fuel consumption. The pilot must understand how to integrate disparate pieces of information, make decisions, and take appropriate actions. A mistake can mean crashing the airplane. Aircraft simulators provide a realistic (and economical) alternative to training pilots with real planes.

Corporate information systems are expensive and complex. Decisions involving information systems may not be as time-critical as those required of a pilot, but poor decisions can be no less costly. A manager, like a pilot, must understand how to integrate disparate pieces of information, make decisions, and take appropriate actions.

An aircraft simulator is a complete package. It attempts to recreate all aspects of the flying experience. There are not simply a few equations used to predict a flight path. Rather, there is a complex, interactive computer program that models the disparate set of factors involved in flying a 747.

We are developing simulators for human decision making. These programs are not mathematical or probabilistic decision models. Using a variety of artificial intelligence techniques, we have built cognitive models that demonstrate a range of decision making behavior.

We do not view these programs as decision support systems. Traditional DSS focuses on selected components of a decision process. Rather, we are trying to capture the entire decision making process. In the aircraft domain, a DSS is akin to a fuel gauge or altimeter. We are trying to simulate the complete package.

We start from the premise that people provide an existence proof for the decision making process. People make decisions. Characteristics of human decision making include the following:

- **Agents have goals**. Goals may be abstract or concrete, qualitative or quantitative.

- **Agents have relationships with other agents**. Agents can adopt additional goals through interpersonal relationships.
- **Agents have limited resources**. Without resource limitations, there would be no need for decisions.
- **Goals vary in importance**. Agents can express preferences based on ordinal goal importance.
- **Decisions require explanations**. The decision itself must be justified.
- **Agents have experience**. Human memory serves as the repository of human experience. Decision making, as a cognitive process, requires both remembering and learning.

These points comprise the design principles for our initial decision simulation, the VOTE program. Our aims are twofold. First, we are interested in the scientific question of understanding human behavior. Our computer simulations provide an explicit model of decision making. Second, we are interested in the technological question of creating a program that can make meaningful decisions.

In the next section, we describe VOTE. The last section discusses our current work extending the VOTE model to business decisions.

The VOTE Model

The VOTE decision making model is based on the explicit representation of goals, choices, relationships, and strategies, and the use of natural language to produce explanations. [Slade 1994]

The decision making model was demonstrated in the VOTE program, which simulated the roll call voting of members of the United States House of Representatives. Given a member of Congress and a specific bill, VOTE would try to determine how that member would vote and then produce a natural language explanation of the resulting decision in English or French.

Below is an example of the VOTE program simulating Congressman Morris Udall voting on a bill banning flag burning.

```
> (vote 'udall 'hr-2978)

* Member: Morris K. Udall
* Bill: Flag Desecration
* Bill banning the desecration of the flag.

--- Intermediate output omitted ---

* English rationale:
```

Morris K. Udall votes against bill HR-2978, the flag desecration bill. After weighing the implications, he believes that provisions of this bill are not constitutional. He completely supports the United States Constitution and the Bill of Rights. Udall readily endorses the right of freedom of speech. Even so, Udall realizes that members of the Democratic party oppose the right of burning the American flag in protest.

```
* French rationale:
```

Morris K. Udall s'oppose au projet de loi HR-2978, la loi de la profanation du drapeau. Après une considération approfondie, il croit que les dispositions de ce projet de loi ne sont pas constitutionelles. Il est un champion de la Constitution américaine et de la déclaration des Droits. Udall désire vivement appuyer le droit de libre expression. Cependant, Udall comprend que les membres du parti Démocratique s'opposent au fait de brûler le drapeau américain lors d'une manifestation.

The natural language explanation above is not canned text, but is generated automatically by VOTE. Similarly, the French text is not a translation of the English text, but is generated from the underlying knowledge representations. Like decision making, natural language generation is a complex cognitive process. VOTE demonstrates the synergies possible when these processes are combined.

Specific aspects of the model include the following.

- **Qualitative reasoning**. Our decision making model contrasts with traditional decision theory [Luce and Raiffa, 1957], which is based on calculating an expected value from quantitative probabilities and payoffs. In our model, an agent's goals are reasoned about qualitatively. Goals can vary in importance, using ordinal values. In the example above, VOTE reasons that Udall has goals of supporting the Constitution and freedom of speech.
- **Interpersonal relationships**. An agent is not isolated. Agents have relationships with other agents, through which goals are adopted. A decision maker incorporates the goals of others into the choice process. In the example, Udall has a positive relationship with the Democratic party, which has the goal of banning flag burning. This adopted goal creates a conflict.
- **Case-based reasoning**. Agents learn from experience. Past decisions are used to illuminate and mediate current decisions. New decisions become part of the case library to influence future decisions. VOTE uses a member's voting record to infer goals and provide justifications.

- **Decision strategies**. In addition to goals, relationships, and past cases, the model uses explicit strategies in arriving at a decision. These strategies are higher level schemata that provide an organizing rationale for the decision. In the example, Udall's decision strategy is to oppose the bill as being unconstitutional.
- **Natural language generation and explanation**. In realistic decision making situations, it is not enough simply to make the decision. The agent must also provide a justification of the decision, especially in circumstances in which there may be adverse consequences of the decision. VOTE's decision strategies are tied to specific explanations.

The VOTE program relies on a set of interrelated databases, including issues (over 200 currently in the database), constituency groups (150), bills (42), members (67), and decision strategies (16). We note that multiple decision strategies are required since the explanation of the decision depends on the strategy employed. It is not enough to use one simple strategy of summing the weights of the conflicting issues and relationships.

VOTE is fairly large. It comprises over 10,000 lines of code and 9,000 lines of data, which are represented using an object-oriented database.

The purpose of VOTE is not to predict individual voting decisions, but rather to demonstrate the computational feasibility of a particular model of interpersonal relationships and decision making. Having said that, we observe empirically that VOTE's accuracy rate on thousands of predictions exceeds 75%.

Extensions to VOTE

In an effort to extend the VOTE model, we have begun to change domains from politics to business. Decisions in both domains involve an abundance of goals, limited resources, goal adoption through interpersonal relationships, past cases and experience, and the need to explain decisions.

A sample decision problem for the new program would be deciding what PC to purchase, and providing a justification for the choice. Adapting the program to such business problems requires a number of changes. We have identified the following extensions to make VOTE better suited to business decisions.

- **Non-Binary choices**. Decisions can involve fewer or more than two options. The program should permit an arbitrary number of choices. For example, in purchasing a PC, a buyer may consider a dozen or more options. Multi-choice decisions can be reduced to a series of binary choices, but we are implementing more general and cognitively appropriate strategies.

- **No Bills, just Options**. Rather than represent choices as discrete bills, a choice can be any combination of options. There is no bill database, just an option database. In the PC purchase case, each candidate PC is an option in the database.

- **Qualitative Arithmetic**. Business decisions are not purely qualitative. The program must also be able to reason about quantitative factors, such as price. Using artificial intelligence techniques developed for qualitative physics, [de Kleer and Brown 1985] we propose a model of qualitative reasoning about quantitative values. In the PC domain, the program can then reason qualitatively about quantities such as processor speed, memory size, disk space, and battery life. [Slade and Madhavan 1995]

- **Uniform Agent Representation**. In VOTE, there was a distinction between members and groups. Members made decisions and had relationships with groups. However, members did not have relationships with other members, and groups did not make decisions. We eliminate those distinctions and only have agents. Agents make decisions and have relationships with other agents. A CIO deciding on a common PC platform has to consider the goals adopted from the constituencies of management, users and technical personnel.

- **Domain Independent**. We aim to separate the generic decision making and natural language generation knowledge from the domain knowledge. The program will be a decision making "shell." The core of program should be able to reason about buying stocks and bonds as well as buying Pcs.

- **Dynamic preferences**. In making a decision, an agent may lack a priori knowledge of his preferences. The program should be able to infer additional preferences during the decision making process. For example, a novice PC buyer may not appreciate the relative importance of memory size, processor speed, or a CD-ROM. In the course of making the decision, the agent develops preferences by relating these features to meaningful goals.

- **Dynamic options**. In certain decision problems, when faced with a choice between A and B, the correct answer is C. That is, the agent is able to construct new options that are superior to the existing choices. In the PC purchase domain, an agent trying to decide between a Mac or a Windows PC might discover that there is a Mac with a PC card.

- **Decision making cycle**. A roll call vote is a discrete event. However, many business decisions comprise a series of choices, each of which builds on the past decisions and guides the future decisions. In the PC domain, buying a PC may involve other decisions, such as software, networks, training, support, and future upgrades. Making one decision can generate others.

- **Objectives**. The normal VOTE choice is between two alternatives. One formulation of the PC purchase choice would be to evaluate an option against some stated objective. That is, a choice might focus on a single alternative evaluated against some specific satisfaction criteria. Thus, the program needs to be able include an objective, as well as options.

In the talk, we will discuss examples from the current versions of the decision models. The programs, in Common LISP, are available via anonymous ftp from is.stern.nyu.edu in /pub/vote or as the URL file://is.stern.nyu.edu/pub/vote/ using a Web browser.

References

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