Association for Information Systems
AIS Electronic Library (AISeL)

PACIS 1995 Proceedings

Pacific Asia Conference on Information Systems (PACIS)

December 1995

Building An Intelligent Decision Support System: A Case-Based Approach

Frada Burstein
Monash University

A. Sowunmi
Monash University

H. Smith
Monash University

A. McMillan
Monash University

C. Cole
Monash University

BUILDING AN INTELLIGENT DECISION SUPPORT SYSTEM: A CASE-BASED APPROACH

Burstein, F.V., Sowunmi, A., Smith, H.G., McMillan, A.V., and Cole, C.
Faculty of Computing & Information Technology, Monash University, Melbourne, AUSTRALIA

The quality of a business decision is dependent on the experience of the decision-maker. In the context of computer support for decision-making we have been investigating the ways in which expert knowledge may be collected and provided for decision support. A potentially useful technology is that of case-based reasoning in which knowledge of particular cases/experiences are stored and appropriate cases retrieved to support a specific decision. We are currently developing such an application to perform as an intelligent decision support for the Faculty of Computing & Information Technology in Monash University. This example illustrates the usefulness of this new technology in business decision-making situations. The longer term aim is to provide a collection of cases which will act as a form of organisational memory to enable knowledge to be represented and passed on to later decision-makers.

1 Introduction

The use of computers in business today has extended well beyond rudimentary record keeping. Current computerised systems frequently aim to improve the decision-making of a business as well as to ensure records are maintained effectively. "Classical" decision support techniques such as those employed by operations research and management information systems can provide this support in some structurable and recurring decision situations. However, many decision situations are "poorly structured" because the particular problem has not arisen before and generalisation from previous decision situations is difficult. In these situations the technology to support decision-making should not attempt to replace true decision-making, in other words the technology should assist the decision-maker to explore the current decision situation. Case-Based Reasoning (CBR) is a technique used in artificial intelligence to model aspects of human reasoning and memory (Kolodner 1993). We believe that CBR may be an appropriate approach in poorly structured decision situations. This paper will attempt to show that an "intelligent" computer-aided decision-making system can be built based on the technology of case-based reasoning.

2 Case-Based Reasoning

Case-Based Reasoning is an offshoot of the artificial intelligence research of recent times. It is based on the premise that a new problem may be solved by remembering and possibly adapting similar past episodes, much as humans appear to do. A case-based system stores a representation of a number of past events which may then be retrieved at a later date to help with the solution of a new problem. In order to perform this retrieval, each stored case must be indexed on the features which make that case significant. These features are usually at least one of the following: problem/situation identification, solution and outcome of the case/situation (Kolodner 1993). This relatively new technology has had a number of research applications (Watson and Marir 1994).

Domains where CBR has been applied include reasoning about evidence in medicine (CASEY), mediating in resource disputes (MEDIATOR), recipe planning (CHEF), providing advice in landlord tenant law (PROLEXS) and in family law (IKBALS) (Slade 1991; Zeleznikow and Hunter 1994).

3 An Example Application of CBR

The Faculty of Computing and Information Technology (FCIT) at Monash University processes many applications for credit transfer from students both within and outside Australia. Given recent changes to the Faculty's courses and the range of backgrounds of the applicants, the task of determining credit is a daunting one. At present, the Faculty attempts to determine rules in advance for a wide range of backgrounds. Once these rules have been determined, individual applications can be evaluated if they have characteristics covered by the rules. Where rules do not exist, if an application matches exactly with a previous case (all the features of the case are identical), the previous decision becomes a precedent. However, precedents are limited to identical situations, leaving a large number of applications for which there are neither rules nor precedents and which must then be determined "from scratch". Once a decision has been made for these cases they can be included in the collection of precedents. Currently all applications for credit are documented so that there is a database of cases in existence which includes all decisions made.

FCIT is not alone in attempting to structure this decision-making process. For example, another faculty in Monash makes use of generalisations from past cases in order to generate rules. These rules will then be stored as data in databases. Another university in Australia has coded the rules for credit transfer into an expert system. However, neither of these approaches deal with support for decision-making where no precedent or rule exists. Furthermore, such approaches are slow to respond to changing circumstances as pointed out earlier.

Our system will support the decision-making for those cases where neither rules nor precedents exist and will be more responsive to changes in offerings by both FCIT and by the institutions from which prior knowledge is gained. It will retrieve cases from the case base where the features of the credit application are similar to the current credit application. Where a precedent exists, the match will be exact and the matching decision will be applied. However when there is no precedent the most similar cases will be displayed for the decision-maker to ensure consistency of the outcome.

3.1 Choice of a Software Platform

We are currently using the CBR tool ESTEEM™ as a development platform for this project. Our rationale for selecting this software is two-fold. First, ESTEEM™ provides flexibility in manipulating similarity measures between cases. Second, the software can accommodate cases stored in a variety of formats, e.g., dBASE™, Lotus 1-2-3™ and Microsoft Access™. This is a significant advantage because FCIT proposes to adopt Access™ as the database application for recording credit transfer cases.

While the database would contain every application for credit transfer, our case base would retain only a representative subset. Once a case has been stored as a precedent, subsequent cases which do not provide additional information relevant to the decision situation will be stored in the database but not in the case base. This improves the efficiency of the case base by reducing the storage space required for data and indexes, and by reducing the time required for indexing and searching. Note that within the context of credit transfer a single precedent is just as effective in decision-making as a collection of precedents. Statistical information about the existence of several precedents related to the same kind of decision situation can be extracted from the database and provided to the decision-maker to strengthen the case. This information is also useful to maintain consistent decision-making.

3.2 Case Representation

Within our project we have represented cases using identified features and their corresponding values (see Fig.1). The figure 1 shows a total of 11 features of cases from a credit transfer project. Each feature is shown with its corresponding value type which may be text, numeric or "one of a list" where the decision-maker selects from a list of alternatives.

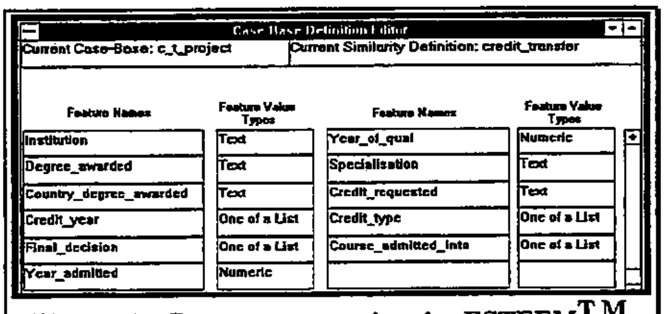

Figure 1. Case representation in ESTEEM™

The process of determining the features and structure of a case requires the active cooperation of the decision-maker. The analysis of the present FCIT database has resulted in notable re-structuring. For instance, the database represents the *'credit_requested'* feature as a single text field so that a case where *'credit_requested'* is recorded as *'advanced standing into 2nd year'* will not be recognised as similar to a case where it has been stored as *'advanced standing into second year'*. In our case representation we have split this feature into two by adding an optional feature, *'credit_year'*, see Fig.1. This feature *(credit_year)* is now represented as a selection from a list of numeric values while the original feature *'credit _requested'* remains a text field. A further revision could be to represent *'credit _requested'* as a list of options, but this currently seems clumsy given the size of the potential list. This redesign of the case structure has improved the ability to retrieve similar cases.

3.3 Learning from New Cases

When there are no cases already existing in memory which are sufficiently similar to the current situation, the system is in a position to "learn". This may be desirable either because the new case contains significantly different values for existing features or because the new case contains one or more features which are not present in the case base.

To illustrate the first kind (a new case with significantly different values for existing features) the vast majority of applicants for credit transfer from outside Australia have previously studied within the Asian continent. Therefore a new case involving an applicant who studied in America can provide an opportunity for learning and should be recognised as such. We are building rules within ESTEEM™ which will determine the continent where an applicant studied from the value of the *'country_degree_awarded'* feature. Effectively, the system will be able to identify a new application from a previously unrecorded continent. Since the system can distinguish between these "typical" and "non-typical" cases the decision-maker does not have to dwell elaborately on "typical" cases.

A more significant opportunity to capture new knowledge occurs when a new case contains features which are not present in the current case base. Our proposed technique for handling this situation requires the decision-maker to identify the most similar existing feature. If one exists then the new case may be stored using this existing feature, or at least its degree of importance. However, if the decision-maker is unable to identify an existing feature then a new one will have to be created.

In both of these situations the decision-maker has the option of incorporating the new case into the case base. This ability to recognise and add new situations to the case base implies that memory may be both selective and dynamic.

4 CBR as a Basis for Intelligent Systems

The ability of case-based systems to learn is significant since it allows a system to provide support to the decision-maker in situations not previously encountered and to keep this experience for the future. Learning is one of the characteristics of humans that is considered to make us intelligent; others include the ability to reason and solve problems, the use of natural languages and the development of expertise so that intelligent systems improve their performance as they learn.

CBR claims intelligence compared with most software systems because such systems can:

(a) learn by adapting known cases to new situations and storing these new cases,

(b) reason using rules embedded in the case base,

(c) appear to use natural language by using symbolic representations rather than purely numeric representations,

(d) improve their performance (expertise) through abstractions induced from the collection of past cases (experience).

Compared to humans CBR systems are very poor at all these activities and it can be argued that this is not intelligence at all. However, in the field of artificial intelligence such performance is considered to be adequate to claim limited intelligence. Some of the authors have previously argued that knowledge-based systems is a more descriptive term for such software (Burstein, Smith, Arnott and O'Donnell 1993).

5 Potential Benefits and Limitations of CBR for Decision Support

The major benefit of employing CBR technology for decision support is that it augments human memory. As we have illustrated with our project, the decision support system is capable of making similarity judgments between cases. Therefore a decision-maker is not obliged to retain a mental record of all past decisions. This is particularly beneficial to FCIT when a less experienced person may be required to make some of the decisions regarding future processing of credit applications. Secondly the technique fosters consistency in decision-making by ensuring that all relevant past cases have been considered.

The most obvious limitation of CBR is that only existing, stored cases are used. A CBR system does not recognise concepts beyond its stored cases. This can be contrasted with classical rule-based systems where generalised knowledge from the problem domain is used. However, from our perspective, CBR for decision support relies on feedback from the real-world via the decision-maker. As a result we anticipate such feedback will assist in fine-tuning the system's organisation and operation resulting in improved performance over time. In storing cases, it is imperative that the case representation contains the decision made and possibly an evaluation of the outcome and/or effectiveness of the decision. This information links the decision with the context in which it was made and provides a decision-maker with feedback.

Storage of cases in computers requires considerable memory space. Most CBR systems to date have dealt with very small case bases. The issue of storage capacity is a concern to us since the completed system is anticipated to contain between 80 and 100 cases.

Another limitation of CBR is that the description of cases includes only those features which have been identified as significant for those cases. Kolodner (1993) justifies this by noting that other heuristic methods share this limitation and by nature may not provide optimal solutions. In this context, a decision support system cannot produce an optimal solution. The credit transfer project is attempting to use CBR to encourage the decision-maker to adapt a retrieved case in order to reach a new decision. Therefore the issue of an optimal solution is not significant since the focus is on recalling past similar cases which the human decision-maker may be unaware of or cannot recall.

6 Conclusion

Case-based reasoning is still a new technology, having only recently been applied to commercial problems. The application of CBR to intelligent decision support systems is even more recent. However, existing CBR applications and our credit transfer project illustrate its potential usefulness in business decision-making situations. CBR offers another technique with which to model human thinking, possibly more successfully than in the past, since the human ability to recall situations when a similar case is encountered is fundamental to much human decision-making. On the other hand, memory of past similar situations is easy to lose, either through oversight of the human involved or through change in staffing.

We have attempted to show that CBR is a technology which can support decision-makers in poorly structured decision situations. Aspects of poorly structured decisions which identify suitable applications for CBR are:

- there is no easily discernible underlying structure to the decisions ;
- a collection of past cases exists or can be built up;
- decisions are based on precedent or prior experience and the decision-maker requires access to this;
- the case descriptions include a record of the decision made - without this it would be impossible to support a decision.

CBR is less effective than a rule-based system when the rules have already been determined, ie., the decision is reasonably well structured. CBR is more demanding of space and more time-consuming than a normal database and should only be used where there are similar cases that cannot be retrieved directly as in a database. CBR does however offer an approach to poorly structured decision-making situations, particularly where adaptability of response is important. This ability of the system to adapt is the key to the term "intelligent" decision support. CBR is not suited to systems where the decision-maker wants a ready answer, rather it is appropriate as an aid to remembering and a prompt to explore similarities between situations.

In summary, the current project to explore the use of CBR as an intelligent decision aid illustrates the application of another useful technology emerging from artificial intelligence research. As with all such technologies, extravagant claims may be made. Our proposal is that CBR should be viewed simply as another technology to be applied when appropriate; the major advantage being that CBR can assist in poorly structured problem domains and domains where a degree of adaptability is necessary.

References

Burstein, F., Smith, H., Arnott, D. and O'Donnell, P. A.. "On the Nature of Intelligent Decision Support Systems," Australian and New Zealand Conference on Intelligent Information Systems, 1993: IEEE.

Kolodner, J. *Case-Based Reasoning*, Morgan Kaufmann, California, 1993.

Slade, S. "Case-Based Reasoning: A Research Paradigm," *AI Magazine* (12:1), 1991.

Watson, I. and Marir, F. "Case-Based Reasoning," *The Knowledge Engineering Review* (9:4), 1994.

Zeleznikow, J. and Hunter, D. "Building Intelligent Legal Information Systems: Knowledge Representation and Reasoning in Law," *Kluwer Law and Taxation Publishers, Computer Law Series* (v13), 1994.