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DIAGNOSING BUILDING DEFECTS USING CASE-BASED REASONING

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ABSTRACT

This paper will describe a case-study in the use of case-based reasoning for the diagnosis of building defects. Traditional expert systems attempt to model human problem-solving expertise as a purely deductive process. They develop a unique solution to each problem. However, there is evidence that human experts do not always work this way. Instead they remember previous successful solutions (cases) and adapt them. The system developed at the University of Salford has several advantages over conventional rule-based or other model-based expert systems. First, the diagnostic knowledge is represented in English, not in program code. This lets the domain experts validate the knowledge directly and it speeds up development. Second, the system can accept natural language descriptions of the defect (these do not even have to be spelled correctly). Third, the system can handle situations which are similar but not identical to previous cases by doing partial matches. Fourth, unlike most model-based systems it can easily acquire new cases (i.e., learn how to diagnose new defects) by adapting existing cases and by acquiring new cases. This last feature is of particular importance since it means that new knowledge is not lost but can be retained within an organisation.

INTRODUCTION

The University of Salford has been developing expert systems for the construction industry for nearly a decade and was the first in the world to develop a commercially available expert system in this sector [1]. Fault diagnosis is a classic ES domain and thus the diagnosis of building defects would seem an ideal domain for an ES. However, the diagnosis of building defects is complicated by the following factors:

- numerous materials are used in numerous combinations within a building,
- similar symptoms can be caused by different problems,
- there is limited causal information for why materials fail, and
- the cause of a defect may not be discovered until destructive tests are performed.

All of these factors suggest that implementing a diagnostic ES for this domain would be non-trivial. This short paper will present a possible method of overcoming these problems by using case-based reasoning (CBR). This paper contrasts the CBR paradigm with that of model-based reasoning (MBR), it describe characteristics that make a problem domain suitable for CBR, and describe (briefly) the implementation of a CBR system highlighting the good and bad features of the software tool used.

THE CASE FOR CASE-BASED REASONING

During the last thirty years ES have been developed that have an explicit model of the problem domain in which they operate. In many systems the model is implemented by rules, and more recently by objects. In some second generation systems [2] a "*deep*" underlying causal model exists that enables the system to reason from first principles in its application domain. There is little doubt that such MBR systems (whether they be deep or shallow) can be very successful. However, there are two major problems with this approach:

1. such systems are very complex and can take many man years to develop, and
2. once developed they are difficult to maintain.

The first problem was recognised as soon as ES were built and was often attributed to the *knowledge elicitation bottleneck*. However, for many years practitioners believed that ES were easy to maintain. Unfortunately, the experience of R1 and others [3 & 4] has shown that maintaining MBR systems is not as simple as adding or subtracted rules. It is a complex debugging task.

Moreover, there is another problem - ES practitioners did not consider how to build an ES when there is no model available. Overlooking this problem reflects the heritage of ES in academic research laboratories. The early ES (e.g., DENDRAL, MYCIN, PROSPECTOR) all operated in domains where there were good underlying models - scientists are comfortable with working from first-principles, they build models for a living. Unfortunately, in a commercial environment and outside of the Universities many people make decisions without reference to first principles and underlying causal models.

How do such people solve problems - they use there experience. It is no surprise that *expert* and *experience* derive from the same root. The ES community was seduced by rules and neglected the truism that an expert solves problems by applying their experience, novices attempts to solve problems by applying rules. the application of experience to problem solving is the hallmark of CBR. CBR enables solutions to problems to be obtained through the retrieval of relevant experience (case histories) from previous similar situations. It offers a paradigm that is close to the way people solve problems and one that overcomes the brittleness of MBR systems [5 & 6] since new cases can be easily acquired [4].

Thus, there is a strong case for CBR since it has several potential advantages over MBR:

- systems can be built without passing through the knowledge elicitation bottleneck,
- systems can be built where a model does not exist, and
- systems can learn by acquiring new cases

WHEN TO USE CBR

CBR, as discussed above can be used when it is difficult to elicit a domain model or when a well understood model may not exist. But, to implement a successful CBR system you will require either:

- a library of previous problems with their solutions (*episodic* cases), or
- a group of people who can design *prototypical* cases based on their experience.

In many circumstances you can satisfy both of these conditions. As was mentioned above maintaining CBR systems is easier than MBR systems since adding new knowledge can be as simple as adding a new case. This ability to acquire new knowledge easily means that it is perfectly feasible to release a CBR system before it can handle the majority of anticipated problems - CBR systems can "*learn on the job*". Thus, CBR should be considered as a reasoning paradigm where a model may be difficult or impossible to elicit, where episodic cases exist, or prototypical case can be created, where a system needs to be implemented rapidly and where the ability to acquire new knowledge would be advantageous or essential. The diagnosis of building defects seemed to fit these characteristics

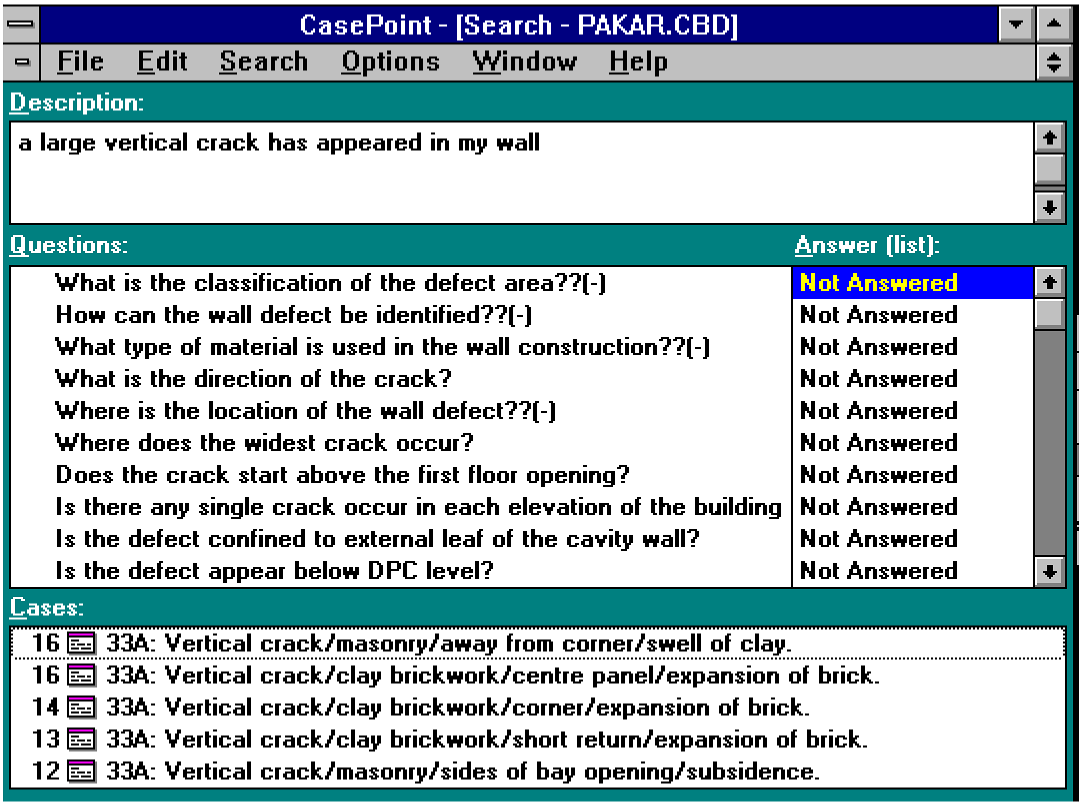
PAKAR: BUILDING DEFECTS EXPERT

PAKAR (Malay for expert) was implemented using Inference's CBR-Express with CasePoint as a delivery medium. PAKAR was developed to investigate several points:

1. that CBR was applicable to problems within the construction industry,
2. that CBR systems could be quickly developed by people who were not programmers,
3. that explanations could be provided by a CBR system to support conclusions, and
4. to assess the suitability of Inference's CBR software.

The intended users of the system might be students or officers in a housing association or local authority. A screen from PAKAR indicating the initial problem description, and questions that PAKAR can ask to focus more closely upon a matching case is shown below. Inference's CBR products use nearest neighbour matching of cases.

When, a defect had been successfully diagnosed further information can be obtained using CasePoint's "*Browse*" option. This allows other MS Windows applications to be executed. In PAKAR we used MS Write to convey additional diagnostic information along with AutoCAD drawings where relevant. PAKAR covers cracking of a building's superstructure, problems caused by damp, problems with windows, roof-lights, and roofs.



CONCLUSIONS

The PAKAR project was successful in demonstrating that:

1. CBR could be used effectively in this domain;
2. a person who was not a computer programmer could successfully develop a CBR system, however it must be said that this was not completely painless;
3. CBR system can explain results by linking additional information to a case - explanation is often cited as an advantage of MBR systems and a limitation of CBR,
4. Inference's software was suitable for the task.

The last finding requires a little more explanation. CBR-Express was found to be very easy to use, and CasePoint an effective and extremely fast delivery system. CBR-Express' ability to handle textual input was found to be the strength of the product, whilst conversely its handling of numerical data is a weakness. The only major limitation encountered was the way that questions are weighted. Questions are used to focus in on a particular case within a set of matching cases. Each question can be set a weight. Many cases can share a question in common, but unfortunately it is not possible for the same question to carry different weight in different cases. Inference have stated that an early version of CBR-Express allowed a question to carry different weights in different cases but that this made the matching process very slow so it was abandoned.

In conclusion, it was possible to develop a diagnostic system without eliciting an explicit causal model. This significantly reduced the development time. Moreover, since CBR systems can easily acquire new knowledge in the form of cases maintaining them becomes easier. This will go some way to ease the problems researchers have identified with model-based ES maintenance [7].

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