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# REPRESENTING CASES IN A CASE-BASED FMEA SYSTEM

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**Abstract:** *This paper presents the key issues related to case representation in a case-based design FMEA advisory system. There are discussed the main component parts a case consist of and the kind of knowledge they have to encode. Some points on the representational formalism and the usage of machine-usable and human-digestible description forms are presented too.*
***Key words**: case-based reasoning, case representation, FMEA*

## 1. INTRODUCTION

Design Failure Mode and Effect Analysis enables through a team effort - outgoing from past experiences - the evaluation of a new design with a view to preventing previous mistakes occurring again and the prediction of other unforeseen problems (Schubert, 1993). The method covers all new design of components, components used in new situations and modified components. FMEA requires a great deal of effort in time and money. Experts of the analysed domain should be available at all the time and be able to remember similar cases they have experiences with. The process of recognising potential failures is time-consuming, so if a design was analysed once it makes sense to cache the solution in such a way that it can be reused. In this circumstances the effectiveness of the teamwork can be increased considerably through an interactive aiding expert system working with case-based reasoning.

The purpose of the research work done by the author at the College of Mechanical Engineering and Automation, Department of Information Sciences in Kecskemét is to develop a complex software system which integrated with a CAD system and using its constructional designs besides the functional data providing from the designer is able to effectuate a knowledge-based design FMEA (Johanyák, 1997). The system development tool being used is Intellicorp's Kappa PC shell.

In case-based reasoning new problems are approached by remembering old similar ones and moving forward from these. Inferences are made by finding the closest cases in memory, comparing and contrasting with those and asking questions, when additional information is needed.

## 2. BASIC ISSUES

One of the most important issues building a case-based reasoner system is the representation of cases. A case is a contextualized piece of knowledge representing an experience that teaches a lesson to achieving the goals of the reasoner (Kolodner, 1993).

First of all should be defined what a case in FMEA is. In first approach a case would be the complete analysis of a design. The practice is, however, that most of the analysed products are built up from a lot of pieces. In talking to experts about how they use past experiences to recognise potential failure modes and in analysing FMEA protocols it is clear that people access pieces of earlier cases even when a case as a whole seems far from the new case. Thus FMEAs of parts of products should be handled as cases themselves. There are two ways to do this:

- Represent cases monolithically with large cases containing their pieces as parts. This requires a scheme for locating appropriate case pieces within the whole case.
- Represent the pieces of large cases as cases and provide links allowing full cases to be reconstructed.

My system use the second method. The full FMEA is represented by an object that holds global information about the case and a list slot containing the names of objects which are representing the part FMEAs as individual cases. This contain links to the full case.

Using this scheme the memory can notice similarities between part cases and has the potential to create generalisations.

## 3. THE CONTENT OF CASES

The second issue we should focus on is about the content of a case. Bellow the word case will be used in means of the FMEA of a part of a product. In particular there are three pragmatic issues:

- What component parts does a case have?
- What kinds of knowledge does a case need to encode?
- What formalism is appropriate for representing cases?

The kind and deepness of knowledge encoded in a case depends on where the system will be fielded, which product families will be analysed (Borgulya, 1995). There are three major parts to any case which are recorded:

- Situation description: the constructional and functional information about the part, failure modes, effects and causes, control measures and a link to the description of the whole case.
- Solution: all the activities proposed for eliminating the failures.
- Outcome: the resulting state of the situation after all the solution measures were carried out.

Two case libraries have been created for the system. One of them contains cases telling true stories about design failures occurred in industrial praxis. The other one contains FMEA protocols collected and worked up.

The case representation are similar in both. The reasoner begins always its search process for matching cases in the first one.

### 3.1 Situation description

The situation description part of a case encodes the state of the problem as reasoning begins. While designating the descriptive features of a case must be taken into account the fact that the reasoner determines whether an old case is applicable to a new situation by examining the similarities between descriptions of the problem in the old situation and the new one (Knauf, 1993).

The content of the two case libraries is a bit different but by both is common that the problem presentation has three major components:

- Goals to be achieved in solving the problem.

- Constraints on those goals.
- Other features of the problem situation.

By cases collected in the first case library, where the effects and the causes of failures and the failure modes themselves were well known, the goal could be formulated as „recommend action”. The aim of the engineer faced with the problem was to find a way to eliminate the failure.

By cases belonging to the second case library the main goal remains „recommend action”, but three subgoals are recorded. These are „find potential failures”, „find effects of failures” and „find causes of failures”.

Working with new cases the reasoner could find only partial matching old cases. Thus „adapt old solution” should be added to the list of subgoals.

Constraints are those conditions which should be adjusted the solution to. They can be material, financial, dimensional, etc. prescriptions.

Other features of the problem situation are the catchall that holds any other descriptive information about the situation relevant to achieving the situations goal.

By cases from the first case library features of the situation include the constructional and functional description of the part that was faulty, the failure modes, effects of failures, causes of failures and controls that were foreseen at the time the failure occurred.

By cases related to FMEAs carried out one have to deal with fewer features. Here the only descriptors are the constructional and functional features of the part being analysed.

### 3.2 Solution

The solution is the set of concepts or objects that achieve the goals set forth in the situation description, taking into account the specified contextual features (Kolodner, 1993) (Watson, 1997).

The solution to a failure analysis is a list of recommended actions which is the reasoner expecting from to eliminate the potential failures. By cases worked up from FMEA protocols and by new cases the solution ties together several part results. These originate from achieving the aims listed as goals and subgoals. Thus the solution consist of failure modes, effects and causes of failures and recommended actions.

Further developments of the system will be focused on including a new element, which is the expectation about what the outcome will be. This can be a very useful tool for the reasoner during adaptation and critiquing of old cases.

### 3.3 Outcome

The outcome of a case specifies what happened as a result of carrying out the recommended actions. Cases in the first case library does not include outcome because they contain in their solution only that actions which resulted in avoiding of the failure. Thus the outcome is a specific part of cases in the second library. This part of the cases tells whether the goals were achieved or not.

Further development of the system will augment the outcome with information about the degree to which expectations were met or not. This will allow the FMEA team working on a new case to predict whether an old solution should be attempted or not.

## 4. ISSUES OF DESCRIPTION FORMALISM

In the foregoing were presented some considerations on the important parts of cases and the knowledge they have to encode. The last question is „how”.

The system was developed using an object oriented expert system shell. Each case is represented by an object that contain a lot of slots. Their names begin with a „goal_”, „constr_”, „feat_”, „sol_” or „out_” prefix depending on whether the slot is referring to a goal, a constrain, a feature, a part of the solution or an outcome. Designing this part of case representation appeared two opposite demands.

The allowable slot values on the one hand should be symbolic and simple for the computer to reason about them. On the other hand this system is developed to give advice for FMEA team members who are not necessarily computer experts. Thus the system has an user-friend interface and those parts of the case which are not used directly by the reasoner during the retrieval and adaptation of old similar cases are presented in graphical and text form.

The system will be integrated with GSSL’s AFR Husk module that behind the recognition of part features enables the graphical presentation of the 3D CAD model of the analyzed element. This assures a human-comprehensible case description.

## 5. SUMMARY

The representation of cases determines essentially the efficiency of a case-based expert system. The case description consist on three main parts the situation description, the solution and the outcome. Case libraries built during this project include this parts. Designing the representation formalism was taken into account that case descriptions should contain parts with symbolic slot values and parts which facilitate the usage of the system through visual and text notations.

## 6. REFERENCES


Borgulya, I. (1995) *Szakértői rendszerek, technikák és alkalmazások*, ComputerBooks, ISBN 963-618-049-0 Budapest

Knauff, M.; Schlieder, Ch. (1993). Similarity assessment and case representation in case-based design, *Proceedings of EWCBR '93*, Richter, M. M. et al. (Ed.), pp. 37-42, University of Kaiserslautern, November 1993, ECCAI, Kaiserslautern

Kolodner, J. (1993). *Case-based reasoning*, Morgan Kaufmann Publishers, ISBN 1-55860-237-2, San Mateo

Johanyák, Zs. Cs. (1997). A model of a knowledge-based FMEA software system, *Proceedings of 8th DAAAM International Symposium*, Katalinic, B. (Ed.), pp. 147-148 , ISBN 3-901-509-04-6, Dubrovnik, October 1997, DAAAM International , Vienna

Schubert, M. (1993). *FMEA - Fehlermöglichkeits- und Enflußanalyse. Leitfaden*, Deutsche Gesellschaft für Qualität e.V., ISBN 3-410-32841-6, Frankfurt am Main

Watson, I. D. (1997). *Applying Case-Based Reasoning. Techniques for Enterprise Systems*, Morgan Kaufman Publishers, ISBN 1-55860-462-6, New York



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