X-MATE:
Creating an interpretation model
for credit risk assessment

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Abstract

The X-MATE system is a knowledge based system designed to underwrite mortgage applications for a major UK building society. It was designed and implemented by the Knowledge Systems Centre of Hewlett Packard in collaboration with the Artificial Intelligence Applications Institute of the University of Edinburgh. The structure of the system was based on an adaptation of the interpretation model for Assessment tasks, which was drawn from the library of interpretation models associated with the KADS methodology for the development of knowledge based systems.

The paper looks at this interpretation model in detail, with particular attention to the variation from the model provided in the KADS model library. It then compares X-MATE with another KBS which made use of the KADS Assessment model (the FraudWatch system developed for Barclaycard by Touche Ross), and with other KBS which tackle the task of credit risk assessment.

The purpose of this paper is two-fold: firstly, to show how an interpretation model was used in a KBS project which did not adhere to the whole of the KADS methodology; and secondly, to suggest that the variation on the Assessment model which was used by the X-MATE project team is in fact appropriate for a wide variety of tasks involving risk assessment. The latter point is supported by the FraudWatch system, which was based on the same adaptation of the Assessment model as the X-MATE system; it is also supported by the re-use of the same model in a non-financial KBS application. Some advantages of this 'risk assessment' interpretation model are discussed.

1 Introduction

The use of knowledge based systems (KBS) in the financial sector has been growing considerably in the last few years. The number of such systems in use in the UK alone is probably in three figures. Applications have included monitoring compliance with the Financial Services Act, improving customer service in life underwriting, designing programmes for audits, generating personal financial plans, and identifying opportunities for arbitrage in spot markets [9].

One of the most popular applications for knowledge based systems has been that of credit risk assessment, both for loans to individuals and loans to companies. The usefulness of these systems is hard to gauge, partly because many companies (particularly in the UK) are reluctant to admit they even use such systems. However, among those who have revealed their use of KBS are the Midland Bank, whose system appears to have achieved its aim of reducing the paperwork for managers when assessing a loan to a company [1]; Barclays Bank, whose system appraises company strengths and monitors company data [1]; the Swiss Bank Corporation, whose system is intended to speed up the processing of loan applications [7]; Dai-Ichi Kangyo Bank, whose system saves a staff member wading through a 200-page manual [10]; and a number of American companies, including Chase Manhattan [11] and American Express [13].

2 The X-MATE system

The X-MATE (EXpert Mortgage Arrears Threat Advisor) system was developed by Hewlett Packard's Knowledge Systems Centre with assistance from the Artificial Intelligence Applications Institute of the University of Edinburgh, for a large UK building society. Its task was to assess the likelihood of mortgage applicants meeting their loan repayments.

2.1 The problem

The building society's problem was that the percentage of defaulters was too high, and it was difficult to enforce quality control on acceptance of applications because, within certain guidelines, the acceptance or rejection of applications was almost entirely at the discretion of the local branch manager.

2.2 Knowledge acquisition

Knowledge acquisition was carried out (largely by interviews) with experts at the building society's Head Office. These people were staff who had considerable experience of mortgage application assessment; some had particular experience in analysing defaulting cases. A number of different experts were interviewed, as well as one or two potential users of the system, in order to obtain their perspective on the task of assessing a mortgage application. The experts were cooperative, perhaps because they all recognised the existence of a real problem. The experts also agreed with each other in most cases.

2.3 Analysis of the knowledge

Much of the knowledge which was acquired could be represented as heuristic rules. An example of a rule would be:

IF the applicant is about to go self-employed
AND he is expecting a significant increase in salary
THEN there is a high risk (that his salary might fall below expectations)

It became obvious to the development team that the task of deciding whether to accept a mortgage application does not involve classifying applicants into one of a large number of different categories, but rather one of identifying the risks associated with an application, and deciding if the total of all risks is acceptable. To put it a different way, the task is to **assess** the risks associated with a mortgage application. This revelation led to consideration of the *interpretation model* for Assessment suggested by the KADS methodology.

An interpretation model suggests the types of information which are required when performing a task of a particular type, and the inference actions which are required to step from one type of information to another. Interpretation models in KADS are primarily intended to provide a framework for knowledge acquisition. The interpretation model used in the X-MATE system is described in section 4 below.

2.4 Design of the system

Interpretation models are primarily intended to provide a framework for knowledge acquisition in the analysis phase of the KADS methodology. However, the design phase of KADS draws heavily on the results of the analysis phase, and it is not unusual for interpretation models to provide the structure for the design of the KBS. This trend is encouraged by the originators of KADS [3]. This was exactly what happened in the X-MATE project; the interpretation model which was used to guide knowledge acquisition became the basis of the design of the system.

Much of the expert knowledge is encoded in the form of rules. Many of these rules use information obtained from the mortgage application form, but some require further information. The X-MATE system was designed so that rules which require extra information are only activated if the application is judged as high risk by application-form based rules. This is an efficiency measure, to ensure that the average time that the system takes to process an application is kept short. In order to reduce the average time per case further, the rules which require extra information are divided according to the source of the information they require: rules which require the results of an automated credit search are looked at first, and if the total risk does not reach a second threshold, the system goes no further. If the second threshold is reached, the system invokes rules which require the user to check certain documentation which the applicant should have provided. There are other rules, requiring questions to be asked of the applicant, but these are not currently implemented in the system.

2.5 Performance of the system

The system was implemented using KAPPA-PC version 1.1 from IntelliCorp Inc. In tests on applications from the previous few years, X-MATE was able to identify 50% of all the applications which were granted, but which have since gone to repossession, without advising rejection of any applications which were granted, and are still meeting their mortgage payments. These tests used only a subset of X-MATE's rules (those which only look at information on the mortgage application form). The thresholds of risk at which applications are referred or rejected can be altered easily, giving the building society the ability to adapt the system to changing internal guidelines.

The system is completed but is not yet in use, due to internal restructuring by the building society.

2.6 How X-MATE differs from KADS-based KBS

The X-MATE project had two key features that differentiate it from other KADS-based KBS projects. Firstly, the project was not based on the KADS methodology throughout; the developers simply found that a KADS interpretation model formed a good basis for guiding knowledge acquisition for the system, and for structuring the system. Secondly, the project did not use the Assessment interpretation model as KADS defines it; the model was adapted to fit the task of mortgage application assessment. The second point, which was crucial to the success of X-MATE, is expanded in sections 3 and 4 of this paper.

3 The KADS methodology

As stated above, the X-MATE system made use of an adaptation of an interpretation model taken from the library of interpretation models associated with the

KADS methodology. A short description of the KADS methodology, and of interpretation models in particular, is therefore appropriate. For more details, see [5].

The KADS methodology separates KBS development into three phases: analysis, design and implementation. The analysis phase supports the acquisition and analysis of the required knowledge. There are a number of techniques available for knowledge acquisition [2] [12]; KADS provides explicit support for analysis of knowledge acquired from the familiar technique of interviewing experts in the chosen field.

The analysis phase uses the acquired knowledge to select a model from a library of *interpretation models*, based on the task type. These models are intended to guide further knowledge acquisition. An example is given in Figure 1:

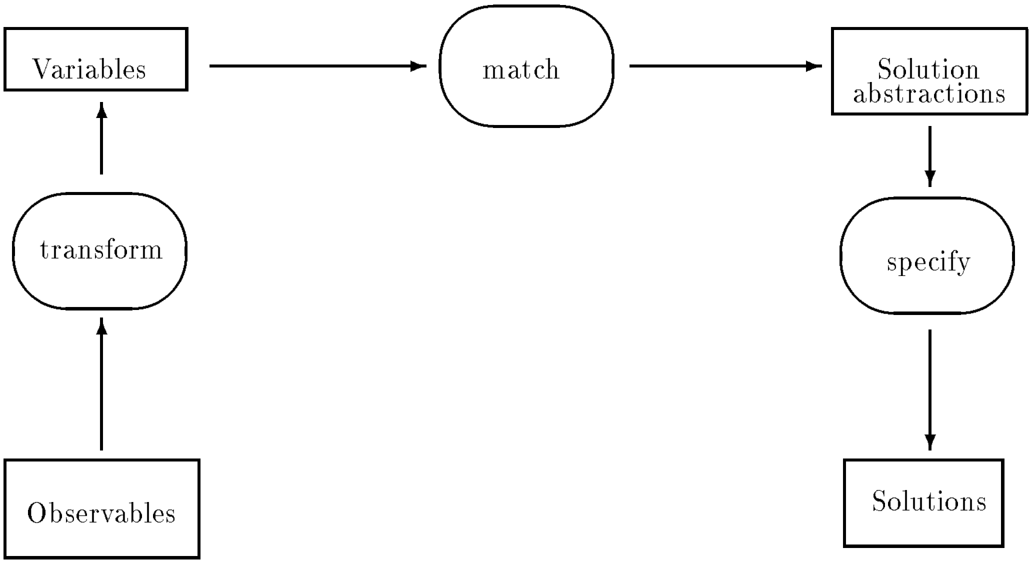

Figure 1: Interpretation model for Diagnosis by Heuristic Classification (from [5])

This diagram represents the interpretation model for diagnosis by heuristic classification. It suggests that this form of diagnosis is performed by transforming observable symptoms into variables, which are then matched against solution abstractions, which are used to specify solutions.

Once an interpretation model has been chosen, the next stage is to instantiate the interpretation model, producing a *conceptual model*. As an example, if the task is medical diagnosis, the symptoms might be high blood pressure and high temperature [observables], which would be transformed (using medical knowledge) into medical conditions such as hypertension and high fever [variables]. Based on these medical conditions, the doctor diagnoses bacterial infection and kidney problems [solution abstractions], which are then used to diagnose the illness: pneumonia caused by glomerulonephritis [solution].

Once the conceptual model is completed, the analysis phase is over, and the design phase begins. The KADS approach to design involves breaking down the conceptual model into functional blocks, and then selecting software techniques, such as rules, methods, algorithms, or databases, to implement each functional block. The implementation phase involves using these techniques to create a working system.

4 Using an interpretation model in X-MATE

Figure 2 shows the interpretation model for Assessment, as specified in the KADS library of models. The Assessment model is intended for tasks in which specified aspects of a particular case are compared against the same aspects of a model of one or more idealised cases. An example of a typical assessment task would be the selection of a new employee from a number of candidates.

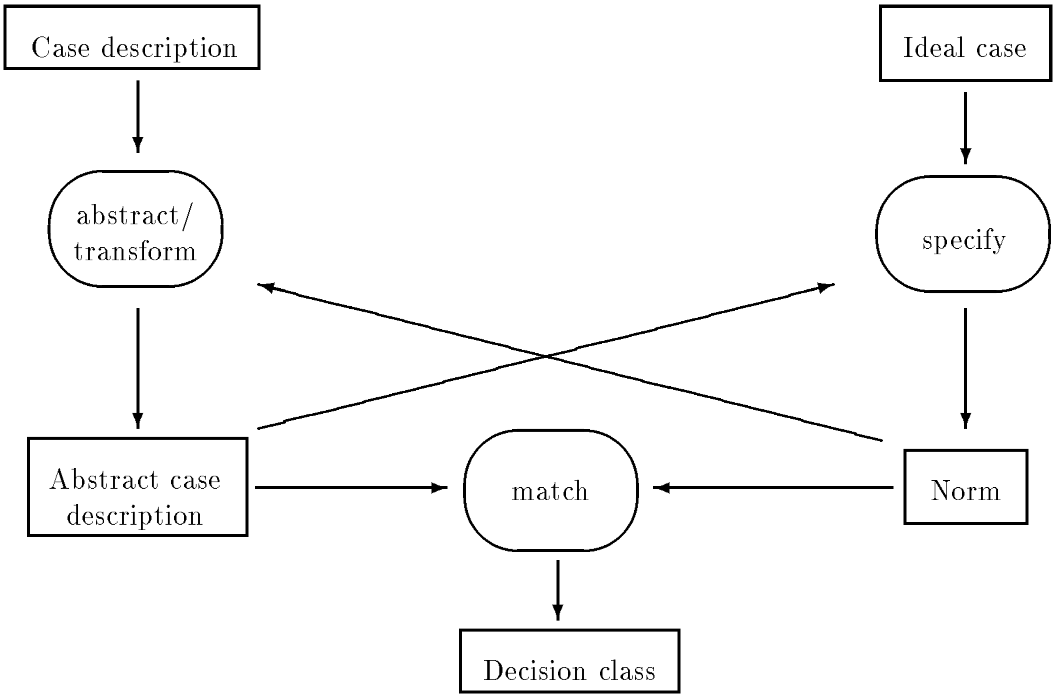

Figure 2: The KADS interpretation model for Assessment (from [8])

First of all, the aspects to be compared must be chosen, and must be extracted from both the current case and from the idealised case. These two sets of aspects are then compared, and rated for their degree of match. In the example given above, a candidate's *curriculum vitae* [abstract case description] would be matched against the qualifications and abilities of an ideal candidate [norm]. The higher the degree of match, the more favourably the candidate would be considered.

In the X-MATE system, the developers realised that an important change had to be made to the model. The task of mortgage application assessment requires the assessor to look for reasons **not** to grant the application; and so the acquired knowledge did not try to compare a new mortgage application against an ideal mortgage applicant, but against a 'typical' applicant **who would be rejected**.

The X-MATE developers therefore used a variation on the Assessment model, in which aspects of a particular application are compared against 'high risk' applications (HRAs). Three different HRAs were used in X-MATE, because it became clear from the knowledge acquired that there were three major categories of applicants who failed to meet their mortgage repayments: those who were too indisciplined with their finances, those likely to suffer a reduction in income, and those with no intention of paying. It is a resemblance (rather than discrepancy) between the application and any of the HRAs that indicates a risk.

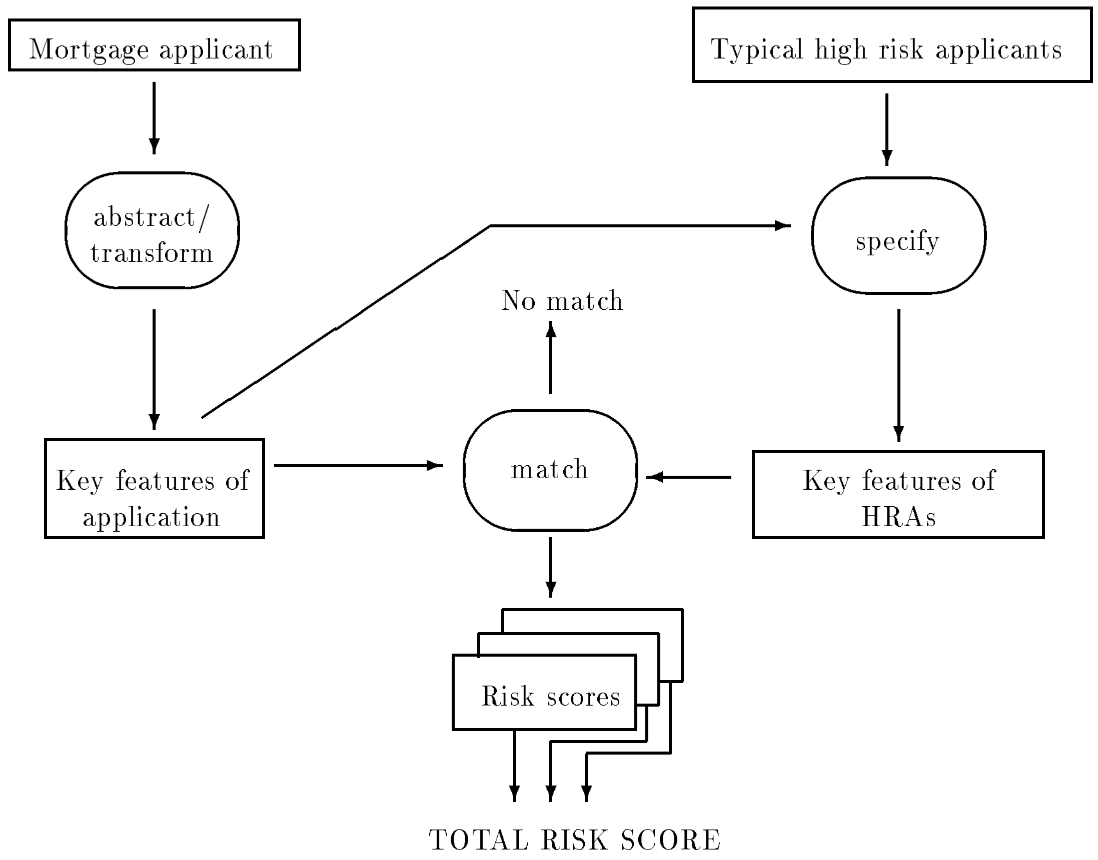

Figure 3: The interpretation model used by the X-MATE system

The three knowledge-based processes in the model are *abstract/transform*, *specify* and *match.*

- Abstraction: In the task of assessing mortgage applications, a large part of the process of abstracting case details is done by presenting the applicant with an application form and asking him to fill it in.

- Specifying: Specifying the key features of HRAs was done during the development of the KBS. Many of the key features relate to information which is presented on the mortgage application form. The knowledge about key features of HRAs is coded implicitly in the conditions of the rules, and in the degree of risk which is attached to certain circumstances of the applicant. These rules are subdivided according to which HRA they are representative of.

- Matching: Matching is a task performed by the system, primarily using heuristic rules. The knowledge which is applied in the matching process is what combinations of features indicate a risk, and how strong a risk is indicated in each case. If a risk is indicated, a risk score is awarded to the application, and is added to any risk score already present. When matching against the key features of all the HRAs has finished, the total risk score for the application is calculated.

5 Comparison with other work

This section will draw comparisons between X-MATE and two categories of KBS: KBS which have been developed using the KADS interpretation model for assessment, and KBS which tackle the task of credit risk assessment.

5.1 Other KADS-based projects

It is not easy to draw comparisons between the X-MATE project and other KADS-based KBS, because the KADS methodology is a relatively recent arrival on the scene, and consequently there are few published descriptions of KBS projects which have used KADS. However, one system which has been developed using the Assessment interpretation model is the FraudWatch system, developed by Touche Ross, Barclaycard and Barclays End-user Computing. The purpose of this system was to identify fraudulent use of Barclaycards from the pattern of account transactions [8].

5.1.1 The FraudWatch system

The FraudWatch system was built using the KADS methodology throughout. The knowledge for the system was acquired from a small group of people who had sufficient depth of expertise in credit card behaviour. It was initially believed that the appropriate interpretation model would be the Heuristic Classification model, but it subsequently became apparent that the Assessment model was more appropriate.

Having decided on the Assessment interpretation model, the FraudWatch developers adapted the model **in an almost identical fashion** to the X-MATE developers. The pattern of transactions on a particular account (which can be considered to be an abstract description of the user of the card) is compared against three patterns of transactions associated with three "typical fraudulent" accounts: one applies to new accounts, one to cash frauds, and one to run-of-the-mill transactions. The result of the comparisons is that the account accumulates a "risk score". For efficiency reasons, accounts which are considered to be of low risk are weeded out before being compared against the "typical fraudulent" accounts; this is done using a shallow hierarchy of rules, each of which relates to one of the "typical fraudulent" accounts.

5.2 Other KBS for credit risk assessment

A survey of KBS which have been constructed for the task of credit risk assessment reveals several different methods of constructing and designing such systems. The two most popular methods have been to examine different sub-areas of an application in turn (e.g. the system described in [6], which examines economic data, payment behaviour and collateral when deciding whether to grant a personal loan), and using rules induced from historical data with little attention to system structuring (although the system described in [4] used rule induction to classify applicants for a particular loan into a large number of different sub-populations, each with associated risk scores).

It seems that all KBS for deciding whether to grant credit **to individuals** use very similar knowledge, but organised in a different fashion. Deciding whether to grant credit to a company is based on the same principles as assessment of the creditworthiness of an individual, but it is significantly more complicated because the evaluation of the true financial health of the company is an expert task in itself.

6 An interpretation model for risk assessment

Both X-MATE and FraudWatch used the same adaptation of the Assessment interpretation model, despite the fact that they were tackling different (but related) tasks – assessing the creditworthiness of a mortgage applicant, and assessing the likelihood of a particular pattern of transactions representing fraudulent use of a card. It is suggested, therefore, that the adapted model used by these systems is applicable to a wide range of tasks involving assessment of risks, and can therefore be considered to be an interpretation model for risk assessment. This hypothesis is supported by the fact that the model has proved to be applicable in a non-financial domain: Touche Ross, having used the model for the FraudWatch system, used it again when constructing a system which aims to identify fraudulent or illegal applications for shares in electricity privatisation share issues. This system has been used successfully.

The risk assessment model appears to have a number of advantages over other methods of organising a knowledge base. The primary advantage is in maintenance: a knowledge base architecture which performs matching against profiles of high risk categories should be maintainable by altering or adding profiles of these categories, without needing to affect other high risk categories, or to alter the inferencing process. Another advantage is in knowledge acquisition: experts are able to relate to the concept of a high risk category. It is important that the right number of categories is used: if there are only one or two categories, it is hardly worth subdividing the knowledge base, but if there are many categories, the advantages for knowledge acquisition may be lost. Experience with the X-MATE project suggests that the ideal number of categories is between 3 and 5. A third potential advantage is in providing deep-level explanations for training purposes.

7 Conclusion

This paper has outlined the development of the X-MATE system, and its use of an adapted version of a KADS interpretation model as a key component of the system development process. It has shown that the KADS library of interpretation models can be of use to a KBS project which is not explicitly following the whole of the KADS methodology. It has also described the interpretation model used by X-MATE in some detail, noted that the same model was used by another system whose task was fraud risk assessment, and suggested that this interpretation model might be seen as an model for many tasks involving risk assessment. It is suggested that this model is a good way of constructing KBS for risk assessment, because of

- the anticipated ease of knowledge base maintenance
- the benefit which an interpretation model supplies for knowledge acquisition
- the possibilities for providing better explanations

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