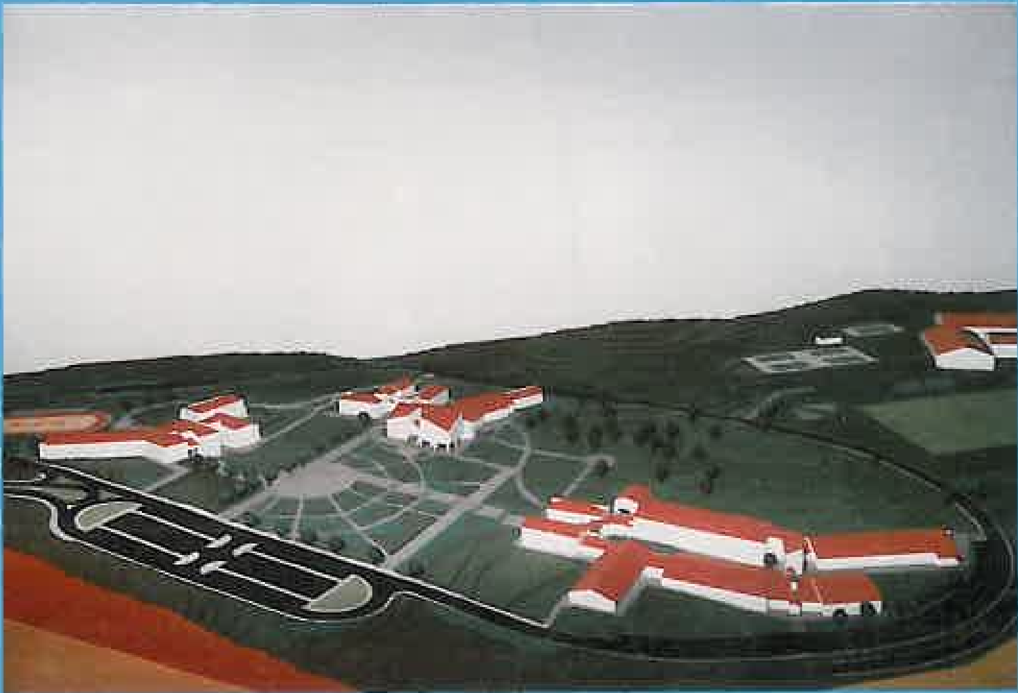
EDUCAÇÃO e TECNOLOGIA



Revista do Instituto Politécnico da Guarda

"EDUCAÇÃO E TECNOLOGIA"
Revista do Instituto Politecnico da Guarda

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PROPRIEDADE: Instituto Politécnico da Guarda

EXECUÇÃO GRÁFICA: Secção de Reprografia do IPG

Depósito Legal N.º 17.891/87

Nº 5 / Setembro / 89

ABERTURA PARA O MUNDO ...

"Português que viva apenas para Portugal, como acho queria o Velho do Restelo, não tem significado algum nem vale a pena existir no mundo; temos de viver para o universo, ou seremos inúteis".

Agostinho da Silva

Sempre defendemos a formação integral do indivíduo. Tal significa, para nós, em termos globais, o crescimento perante conhecimentos gerais e específicos; o acordar das potencialidades de cada um; a afirmação do indivíduo perante ele próprio, em primeiro lugar, perante os outros e o mundo, depois; o, já tantas vezes referido, saber, saber fazer, saber ser; enfim, um caminhar efectivo para a realização e para a felicidade.

O presente número, o quinto, de "Educação e Tecnologia", enquanto "um espaço aberto", objectivo — génese da sua existência e da sua afirmação — na linha do que atrás referimos, inclui já a participação de professores de Instituições ligadas ao Instituto Politécnico da Guarda pelo Programa Erasmus. Isto constitui um sinal evidente da cooperação que, a vários níveis, há alguns meses atrás, foi acordada em protocolos com Bayonne, Brighton, Coventry, Créteil, Pau e Salamanca.

Este aprofundamento de relações entre instituições europeias de ensino superior veio favorecer a vivência do espírito comunitário e imprimir nos alunos a consciencialização do conceito da nova Europa da cultura e dos cidadãos.

Defendemos e prosseguimos um caminho de abertura para o mundo das coisas, das pessoas e do saber, numa perspectiva integradora em que a verdadeira dimensão do humano se procure, se veja e se consubstancie na efectiva comunhão do universal.

João Bento Raimundo

Presidente da C. I. do
Instituto Politécnico da Guarda

CONTRIBUTION OF HYBRID AND HIERARCHICAL REPRESENTATION OF KNOWLEDGE TO THE EXPLANATION OF REASONING

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ABSTRACT

This paper deals with a methodology for explaining the reasoning (includind the classical trace) of expert systems based on a hybrid (production rules and frames) and hierarchical representation of the knowledge to the better structured so that a more precise explanation can be obtained due to entity production rules and frames.

KEYWORDS

Expert systems, explanation, trace, production rules, frames, inference engine.

1. INTRODUCTION

Expert systems should be able to provide, and to justify their reasoning.

The explanation modules of most expert systems based on production rules merely give the trace, in the list of rules that have been used during the reasoning process.

This type of system's explanation rests upon the list of rules arising in the resolution of the problem, using the logical deduction of the experts system.

This approach has certain tailings:

- There is only one form of knowledge representation.

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Production rules only represent knowledge that allows the making of inferences no account of the field of knowledge , while each field needs specific adaptations (ASS 86).

- The presentation of an explanation in the form of a succession of rules is not sufficiently concise.
- In the results produced, the information, necessary to determine the origin of an action is mixed with small points that hide what is essential.

In order to make up for some these tailings, we recommend a method of explanation in an expert system based on a hybrid representation of knowledge (HOC 86a) using two complementary forms of representation: production rules and frames derived from the notion of the frame defined by MINSKY (MIN 75).

The general architecture of this expert system is the following:

a) a knowledge base of the field of application made up of:
   - productions rules divided by the expert into groups.
   - meta-rules which are knowledge of the rules and the groups of rules.

b) a multi-criteria inference engine made up of:
   - an inference mechanism.
   - a knowledge of the control strategy described by frames.

c) a facts base.

2. THE REPRESENTATION OF KNOWLEDGE

The kinds of knowledge are dealt with:

a) Static knowledge, corresponding to the aims of the field and the current situation described by the user. This includes:
   - simple facts corresponding to independent aims.
   - structured facts described by frames.

b) Dynamic knowledge, which allows:
   - the definition of relations between the aims of the static knowledge .
   - reasoning upon itself (on the level of meta-knowledge).

   This meta-knowledge is made us of:
   - production rules operating, on the static knowledge and/or the rules themselves (meta-rules).
   - frames describing the control structure.

The use of this hybrid representation has required the development of a software to representation and manipulation of "frames (HOC 87) allowing the use of the notion of hierarchy and inheritance.

2.1. Production rules

The production rules that express the knowledge of the field are expressed in the usual form:

IF < conditions > THEN < actions >

An exemple of rule:

If position leaf = base of stem
and appearence leaf = hairy
and arrangement leaf = bow
and shape leaf = elliptical
Then name family leaf = primulacee

Each entity (leat, stem, environment, flower ...) used in a rule has a frame associed with it.

2.2. Frames (HOC 87)

A frame is a data structure that describes a prototypical situation by the use of a group of characteristics. It is an effective and certain method of forgeting nothing when a concept is dealt with.

A frame is defined by a name and a list of attributes; each attribute is described by a list of predefined facets and the values that are associated with it.

The general form of a frame is the following:

```
(name-frame)
(attribute 1 (facet 1 value 1 ... valuen)
             (facet 2 value 1 ... valuen)
             (facet n value 1 ... valuen)
(attibute 1  (facet 1 value 1 ... valuen)
             (facet 2 value 1 ... valuen)
             (facet n value 1 ... valuen)
```

The software tool developed for representing and manipulating this knowledge with the help of frame has several predefined facets (the identifiers of these facets always begin with the character $).

The attributes are chosen by the user. It is to be noted that there are some predefined attributes that have a link is-a (est-un) which allows an example to inherit frames directly that are hierarchically superior to it.

The totality of these facets define the semantic of the representation. They make it possible to completely define an attribute by its type ($un, $listede), the associated value ($valeur) or by default ($defaut) the restrictions ($domaine, $intervalle), the means of obtaining a value ($si-besoin), the unit or mesure ($unite), the detailled description ($description), a rational explanation ($explication) and so on.

The basic types that are predefined are text (texte), real (réel), integer (entier), boolean (booleen) and symbol (symbole).

Some examples of entity frames:

The family frame:

```
(frame-family
        (fam-name          ($un texte))
        (stem              ($un frame-stem))
        (flower            ($un frame-flower))
        (leat              ($un frame-leat))
        (environment       ($un frame-environment))
    )
```

An instance of this frame:

```
(primulacee
        (est-un            ($valeur frame-family))
        (fam-name          ($valeur primulacee))
        (stem              ($valeur stem-pr))
        (flower            ($valeur flower-pr))
        (leat              ($un leat-pri))
        (environment       ($valeur environment-pri))
    )
```

stem-pr, flower-pr, leat-pr and environment-pr are particular cases of the frames frame-stem, frame-flower, frame-leat and frame-environement.

The frame frame-stem:

```
(frame-stem
   (form ($un texte)
        ($domaine "round" "square" "triangular" " rectangle")
        ($defaut "round")
        ($description "from of the stem")
   (appearence ($un text)
        ($domaine "rarely hairy" "hairy" "woody" "herbaceous")
        ($description "consistency of the stem")
        ($explication "can only round, square triangular or
                       rectangle")
   (colour     ($un frame-colour-stem)
   (habit      ($un texte)
               ($domaine "erect" "creeping" "climbing")
        )
```

The frame frame-colour

```
(frame-colour-stem)
   (colour ($valeur green)
        ($description "the colour of the stem")
        ($explication "can only be one colour")
        )
```

An instance of the frame frame-stem:

```
(stem-primulacee
     (est-un       ($valeur frame-stem)
     (form         ($valeur round")
```

```
(appearance ($valeur herbaceous)
(colour     ($valeur colour-2)
(habit      ($valeur erect))
)
```

An instance of the frame frameoclour-stem:

```
(colour-2
  (colour ($valeur green))
)
```

The use of the two following facets is particulary to be noted:

- $description
- $explication

The examples used to illustrate our approach are taken from an application on the flora at the Pyrenees currently being developed. The objective of this application is to be able to identity a plant. The process of identification is based upon the recognition of characteristics owned by each family.

The description of different features is done by visual observation, by touch and finnaly by odour at the level of the species.

A second phase will consist of the determination of the genus and the species of each plant.

2.2. The facets: $description and $explication

- The facete: $description

This allows us to provide the exact title of the attribute. The user might not know the significance of terms used by the system beforehand; the meaning of the term is thus shown at the time of the explanation.

Example:

plant type=primulacée

will be translated into:

The family of this plant is of the primulacée type.

Thanks to this facet is not need to write a sentence generator, but merely to access the frame of the entity and reproduce the value associated to the $description facet.

- The facet $explication

This facet is activated when the user asks for an explanation of the type *why*. It allows, first of all, the rational explanation of the expert to be provided.

To improve the explanation, it is necessary to know the origin (or the source) of the values assigned to the attributes. Let us demonstrate this necessity through the below example.

Consider the following frame:

```
(person
  (name          ($un texte))
```

```
        (adress          ($un texte))
        (no-days-work    ($un entier))
                         ($defaut 5)
                         ($description "Number of working
                                        days per week")))
        (no-hours-work)  ($description "Number of working
                                        hours per week"))
                         ($si-besoin-demander
                            (print "give the number of hours of
                            work")
                            (spu.. - v   frame - no - hours - work
                            (read)))
                         ($si-besoin-calculer
                            (sput-v  sch  no - hours - work(no -
                            -days-wok 8)))
                         ($defaut 16))
        )
```

Consider the following instance of the frame person:

```
    (person1
        (name            ($valeur "henry IV"))
        (adress          ($valeur "rue serviez PAU"))
        (no-days-work    ($valeur 2))
        (no-hours-work   ($valeur 16))
        )
```

In this instance, the value (16) associed with the attribute No-hours-work is brought about by the facet $valeur but absolutely nothing can be said concerning the origin of this value, ie:

- was is calculed?
- was it read (ie asked for)?
- was it obtained by default?

The result of any fact can only be explained if the way in which it was obtained is known.

One of the extensions of this system in relation to others of which FRL (ROB 77) is one, is to cover up this failing. Indeed, at the level of implementation, the facette that produced the value of each attribute of a frame is shown; this is particulary realized in the explanation phase.

3. THE EXPLANATION MODULES

3.1. Presentation and working

The aim of this approach is to provide the user with a clear explanation that interprets the behaviour of the expert system when it makes its deductions.

The idea consists, in a first step, of explaining the reasoning from the starting point of the rules, then of making this explanation module records the each facts deduction during reasoning in order to be able to reproduce the tree diagram of the deduction at the end (this is the usual trace).

Simultaneously, it organises the facts base, putting together all the facts concerning the same entities (plant, flower, type, ...) (KAS 86)

A first form of explanation is thus provided, starting from the diagram deduction tree and the contents of the facts base.

3.2. The types of questions that could be asked

We are interested in two types of question:

- How was a fact deduced?
- Why did a predicate applied to a certain entity take a certain value?

Examples:

- How was fam-name plant = primulacee deduced?
- Why does size plant = 20?

To reply to a question of the type how, we must explain the behaviour of the system. In fact, we make use the tree diagram of deduction and the contents of the facts base by giving the rules that have led to the deduction of a fact; this is not sufficient to justify reasoning. It is at this level that we use the tree diagram of frames.

The facts base is sturctured in such a way as to allow the grouping, during reasoning, of all the facts relating to an entity.

In the following example, "leat" is the entity concerned in the reasoning:

If position leat = base-of-stem
and appearance leat = hairy
and arrangement leat - bow
and shap leat = elliptical
Then family name of leat = primulacee

Following the triggering of this rule, we find the following group of facts concerning the entity leat in the facts base:

position leat = base-of-stem
appearance leat = hairy
arrangement leat = bow
shape leat = elliptical
family-name leat = primulacee

This structuring allows all that has been deduced about a given to be found easily when an explanation has been generated in order to reply to a question of the type HOW.

3.3 The generation of explanations from rules and frames

The representation of Knowledege used allows us two levels of explanation (how and why):

- The first is based on the use of the tree diagram of deduction and on the way in which the values are obtained in order to divide the tree of deduction into groups, each one corresponding to a part of the reasoning and to an entity.

- The second allows the making of an explanation from the entity frames through the facets $description and $explication. The path of the tree of deduction is not fixed in advance; it depends entirely on the user's answeres.

Example:

The reply to the question

HOW DID YOU DEDUCE fam-name plant= primulacee?

The system prints:

WE HAVE COME TO THIS CONCLUSION BY?

fam-name stem = primulacee
fam-name flower = primulacee
fam-name leat = primulacee
size plant = 20
appearance plant = herbaceous

All this information is taken from the group of rules concerning the entity plant, containing in this case just one rule:

R5

If fam-name stem = primulacee
and fam-name flower = primulacee
and fam-name leat = primulacee
and size plant = 20
and appearance plant = herbaceous
Then fam-name plant = primulacee

If the user does not understand the meaning of the terms used by the system, a clearer explanation is provided by the facets $description and $explication.

Thus we would have:

WE HAVE COME TO THIS CONCLUSION BY:

- the family of the **stem** of the plant is primulacee
- the family of the **leat** of the plant is primulacee
- the family of the **flower** of the plant is primulacee
- the size of yhe **plant** is equal to 20 cm
- the appearance of the **plant** is hairy

In this explanation, the presence of two types of information should be noted:

- a first type concerning the stem, the leat and the flower
- a second type concerning the plant (size, environement, odour)

Let us suppose for instance that user is not convinced that: the stem of the plant the primulacee family.

Since (fam-name type = pr) is a fact can be deduced, a first explanation will be given by the rules. We therefore once again make of the tree diagram an d more exactly of the group of rules concerning "stem" to produce a new explanation.

In the renverse case, where the question concerns "plant" for example:

WHY size plant = 20?

The explanation given by the rules is no longer sufficient and we thus use the knowledge structured through entity frames.

We not that the path through the tree diagram of deduction or the frame tree diagram is not fixed in advance; it will depend entirely on the answer of the user.

To reply to the question:

WHY size plant = 20?

the entity frame plant allows the production, by means of its facet $explication, of:

"Primulacee plants are very small"

If this explanation is convencing, we step the explanation process; otherwise, we show the range of value taken by size, followed by the unit

(frame-name plant = pr) <---- (size plant = 20 <---- frame size)

Example of a message:

size ≤20cm and size ≥10cm

The range values and the unit of measure are taken from the frame plant.

There are several situations where the expression of an explanation by means of synthesis is not enough (the case of an arithmetic expression). We have thus provided for the printing of the formula of calculation that was used in our module (see the facet $si-besoin-calculer) and we define all the variables used in a formula by giving the value taken by each one.

In this application for flora, another method of explanation is being considered: the use of graphs. A possible explanation would be to draw a picture of the flower showing its form, colour and appearance.

4. CONCLUSION

This approach of explanation by use of production rules and frames structured hierarchically, has allowed us to obtain a much more satisfactory explanation and justification than with the usual trace.

In the application for the determination of flora we started by simply dealing with families; the determination of the type and species will complete this system and may well tring up other problems.

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