KNOWLEDGE REPRESENTATION FOR THE NURSING DIAGNOSIS BY MEANS OF AN EXPERT SYSTEM.

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ABSTRACT

In this article an Expert system for the diagnosis of the problem of health of the fatigue of the role of the caretaker is set out. In order to build the knowledge base of this Expert system it has been necessary to design a Model of the problem, once this Model is defined the knowledge base is composed by a set of rules constructed in logic. The motor of inference of our Expert system uses Gröbner Basis and Normal Forms to obtain the diagnosis from the information contained in the knowledge base. Also it has been implemented an interface to make easy the access to the System to any type of user.

KEYWORDS

Expert system, nursing, CoCoA, Gröbner Basis, fatigue of the caretaker.

1. INTRODUCTION

In this paper, an Expert system for the diagnosis of the fatigue in the performance of the role of the caretaker for any type of user is set out. The System can be used in consultation since it shows quickly the diagnosis and in addition, it offers explanations of the obtained results, being very helpful to the professional.

The implemented Expert system is formed by three basic components:

- A knowledge base that contains the information of the health problem.
- An inference motor which firstly verifies the consistency of the knowledge base and later it obtains automatically the consequences from the information which is in the knowledge base.
- An access and interaction interface for people who consult the system.

This is a Rule-based expert system built in propositional logic, from now on it will be denoted as RBES. This means that the knowledge base is formed by propositional logic formulas like $\Phi \to \Psi$, where Φ are a conjunction and/or disjunction of literals[1] and Ψ is a literal one.

The developed inference motor processes the information in logic formulas as it follows: first, the logic formula are translated to polynomials, and later, Gröbner Basis and Normal Forms are applied to these polynomials, using the language of Computational Algebra language CoCoA[2] (Computations in Commutative Algebra), to verify the consistency of the knowledge base and to obtain consequences (the diagnosis).

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1 They are propositional variables which that can be preceded by the symbol $\neg$ (negation)

2 It is a system to calculate in Commutative Algebra.

The interface is implemented with Java programming language and it has been built so that any person who do not know subjects like Computational Algebra, Logic, Computer science, etc. can use it easily, selecting some items to obtain a final diagnosis with no need of understanding the logical and algebraic processes in which is based the RBES.

In the following sections it is explained how it has been constructed each one of these components.

2. KNOWLEDGE BASE FOR THE FATIGUE IN THE PERFORMANCE OF THE ROLE OF THE CARETAKER.

The proposed knowledge base is based on a knowledge Model and it has been built taking care of D. Orem's discipline model and also taking care of the bibliography, it was defined and described two "general classes": the class Nucleus of Initial Analysis and the class Diagnosis. These classes include the following "particular classes" which are in the problem diagnosis: Determining Factors and Risk Factors of the class Nucleus of Initial Analysis; Etiologic Factors and Signs and Symptoms of the class Diagnosis.

The following step allowed the definition of "subclasses": Kind of the dependent care, relation caretaker with his/her environment, relation caretaker with cared person, caretaker's feelings, expressions of the caretaker's relation with his/her environment, expressions of the caretaker's relation with the care person.

The RBES system is based on the Model and it gives answer to 5 different diagnoses within the same problem, these diagnoses are the following:

- The System will analyze the patient's Vulnerability from the Determining Factors.
- The System will analyze the Risk from the Risk Factors.
- The System will analyze the patient's Predisposition from the intensity of the Vulnerability along with the Risk Factors.
- The System will analyze the patient's Potentiality from the intensity of the Predisposition and the Etiologic Factors. In this case there is a sub clinical phase, taking preventive measures in case a patient presents medium or high intensities.
- The System will analyze the Severity of the problem, whenever Signs and/or Symptoms present, along with the Potentiality. In this case it is spoken of a real problem or clinical phase.

2.1 Determining Factors.

The Determining Factors are those which affect to the person, the caretaker, independently if the problem is present or isn't. They are his/her essential characteristics. With the defined rules with these factors the person's Vulnerability to suffer the problem is obtained. It has been assigned to each Determining Factor a propositional variable $x[i]$ ($i = 1,...,4$), preceded or not by the symbol "$\neg$". The Determining Factors are gathered with the conjunction "and" ($\wedge$).

It is assigned an "Intensity" (denoted by "c") to each conjunction of the Determining Factors. The higher the intensity is the higher the influence in the intensities of the Risk Factors and therefore in the final diagnosis. It has been assigned to the different intensities degrees the literal $c[i]$ with $i = 0,...,3$.

The following table summarizes the allocation of the propositional variables to the Determining Factors as well as to the Intensities.

Determining Factor:
x[1]: Age, older than 70 years.
x[2]: Limitation.
x[3]: Responsability
x[4]: Instruction level
x[5]: Job

Intensidades:
c[0]: Null.
c[1]: Low.
c[2]: Médium.
c[3]: High.

Next it is show a table that relates the different determining factors:

Table 1. Determining Factors

¬x[1]				
TC11	x[4]∧x[5]	¬x[4]∧x[5]	x[4]∧¬x[5]	¬x[4]∧¬x[5]
x[2]∧x[3]	3	3	3	2
x[2]∧¬x[3]	2	2	2	1
¬x[2]∧x[3]	2	1	1	1
¬x[2]∧¬x[3]	1	1	0	0

The conjunction $x[4] \wedge x[5]$ is translated as "neither read nor write and works out of the house". The conjunction $x[2] \wedge x[3]$ is read "the patient presents some limitation and does not consider people's care her/his responsibility". The table displays 16 possible conjunctions and in addition in all these combinations it appears a common factor $\neg x[1]$, it is read as "not $x[1]$", it is to say "person is not older than 70 years".

A possible logical formula would be (¬x[1]∧x[2]∧¬x[3]∧¬x[4]∧x[5] → c[2]) that means: "If the patient is smaller than 70 years and presents some limitation and considers that a duty the care of the dependent person and can read and write and works out then the vulnerability of the person is medium"

The implemented System with CoCoA requires that logical formulas are written in Prefixed Form. For example, the Prefixed Form of the formula before describes is the following one, where "IMP" means "implies or then": IMP(Y(Y(Y(Y(NEG(x[1]),x[2]),NEG(x[3])),NEG(x[4])),x[5]),c[2])

This procedure has been followed with the rest of the factors and symptoms, obtaining in this way all the rules of the Expert system.

3. INFERENCE MOTOR

In this section the mathematical basic concepts on which the inference motor is based are summarized.

3.1 Mathematical and logical basic concepts.

A logical formula A_0 is a consequence of the formulas $A_1,...,A_n$, that represent the rules and facts that compose the knowledge base of the RBES, if $A_1,...,A_n$ are true it is deduced that A_0 is also true, in addition it must be verified that A_0 cannot contain propositional variables that do not appear in $A_1,...,A_n$.

In bivaluated logic, with which the System works, it is said that a proposal is true or truth if it has value 1 (in bivaluated logic there are two values: 1 means "truth" and 0 means "false").

A very important step in the mathematical theory which is used in the construction of the RBES is the fact that instead of working directly with logical formulas, rules and facts a transformation of all the rules is made in polynomials; for this reason the system will work with polynomials and so it changes the kind of operation from bivaluated logic to operate with algebra.

The process to translate the logical formulas to polynomials is a complex and tired process. The final result of the process is the following one:

$$\begin{aligned} &\neg x_1 \mapsto 1 + x_1 \\ &x_1 \vee x_2 \mapsto x_1 x_2 + x_1 + x_2 \\ &x_1 \wedge x_2 \mapsto x_1 x_2 \\ &x_1 \to x_2 \mapsto x_1 x_2 + x_1 + 1 \end{aligned}$$

3.2 Main Mathematical Result.

A logical formula A_0 is a consequence of the formulas $A_1,...,A_n$ that represent the rules and facts of a RBES, if and only if the polynomial translation of the negation of A_0 belongs to the ideal generated by the polynomial translation of the negations of $A_1,...,A_n$, along with the polynomials $x_1^2 - x_1,...,x_n^2 - x_n$.

It will be denoted $NEG(A_0) \in J + I$, where J is the generated ideal by the polynomial translations of $\neg A_1,...,\neg A_n$ and I is the ideal generated by $x_1^2 - x_1,...,x_n^2 - x_n$.

3.3 Study of the Consistency.

A Rule Based Expert System is non-consistent if a contradiction is consequence of the information which is contained in the RBES.

It is possible to demonstrate that the inconsistency is expressed with the algebraic fact that element 1 of the polynomials ring belongs to the generated ideal by the polynomials that translate the rules and facts negation of the RBES then in this case the ideal is the whole ring. If the ideal is the ring, the theorem would imply that all the formulas are consequence of the RBES, and the contradictions would also be consequence of the RBES. Therefore, the SEBR is non-consistent if $1 \in J + I$.

4. IMPLEMENTATION OF THE EXPERT SYSTEM

With the use of "NF" (Normal Form) commando of the algebraic tool CoCoA it is possible to verify if a polynomial belongs to an ideal and with the "ReducedGBasis" commando (It reduces Gröbner Basis which is a special set of generators of the ideal) it is possible to prove if element (1) belongs to an ideal. Thanks to the access interface the system is more intuitive and pleasant, making transparent the mathematical operations.

The implementation process consists on the steps:

- Translation of the rules and facts to polynomials.
- The value of Gröbner Basis of the ideal generated by those polynomials is obtained by the CoCoA tool. If the result is (1) then the RBES is non-consistent, if it is different of (1) then it is consistent.
- To translate a question A in a logical formula and to write the Normal Form of the polynomial that corresponds to the negation of this formula module $I + J$, that is to say $NF(NEG(A), MEMORY.I + J)$, to verify if this question is a consequence of the SEBR. If the result is 0, the answer is positive; and if the result is different of 0, then there is not logical consequence.

4.1 CoCoA Implementation.

The CoCoA tool requires that the logical formulas are written in Prefixed Form. The negation, disjunction, conjunction and implication commandos are denoted through the $\neg, \vee, \wedge, \rightarrow$ respectively symbols. The polynomial translation of the bivaluated logical formulas is made with the following instructions:

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NEG(M)   := NF(1+M, MEMORY.I);
O(M,N)   := NF(M+N+M*N, MEMORY.I);
Y(M,N)   := NF(M*N, MEMORY.I);
IMP(M,N) := NF(1+M+M*N, MEMORY.I);
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Once all the potential rules as well as facts are introduced, it is necessary to verify the consistency. The RBES is consistent if each union of the rules set with a consistent set of facts does not lead to inconsistency.

5. INTERFACE

It has been implemented a user interface with the aid of the Java programming language. The RBES executes CoCoA, but the user does not need to have logic and algebra knowledge to obtain a final diagnosis. The user only has to answer each one of the forms that the interface displays. There are five screens which appeared to the user and each one of them will inform of the corresponding diagnosis.

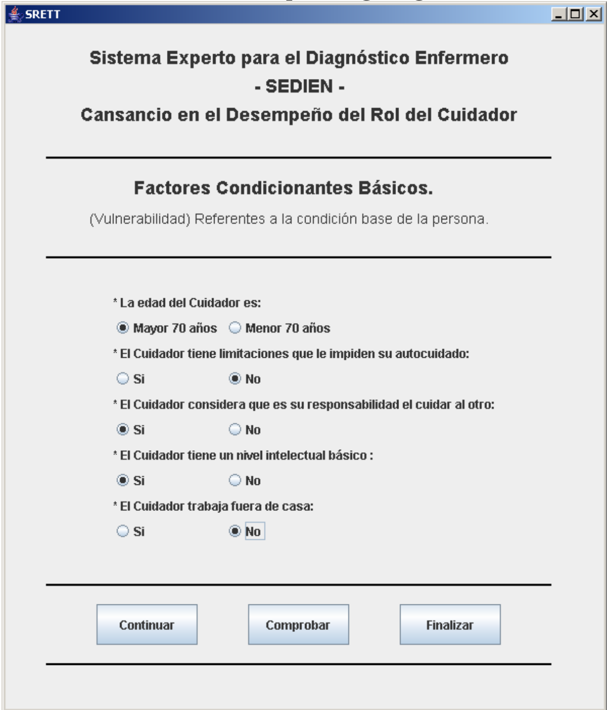

Fig. 1. RBES Screen data entrance.

The user only has to answer each one of the forms that the interface displays. There are five screens which appeared to the user and each one of them will inform of the corresponding diagnosis: vulnerability, risk, predisposition, potentiality and severity.

6. CONCLUSIONS

A Rule-based expert system of aid to the diagnosis of the fatigue of the role of the caretaker has appeared; in addition the knowledge of this diagnosis has been represented through the definition of a diagnosis Model that can allow, like novelty, the extrapolation to any other diagnostic label, as well as to other knowledge areas.

REFERENCES

CoCoA, 2004 http://cocoa.dima.unige.it

Orem D.E., 1993. *Modelo de Orem: conceptos de enfermería en la práctica*. Masson Salvat Enfermería.

L. Jiménez, J.M et al., 2005. *Ontology of the "fatigue in the performance of the caretaker roll": a necessary step in the construction of a diagnosis expert system*. IADIS Virtual Multi Conference on Computer Science and Information Systems (MCCSIS 2005).

T. Becker y V. Weispfenning, 1993. Gröbner bases. *A computational approach to commutative algebra.* Springer-Verlag.

J. Giarratano y G. Riley, 2001. *Sistemas expertos. Principios y programación.* Internacional Thomson Editores, México.