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Solving of diagnostic issues with mathematical modeling approach. (Case study: Inference engine architecture in the neurological diseases diagnosing expert system)

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Abstract. The paper is a feasibility study on the usable mathematical formulas for design of inference engine of expert systems. First of all diagnosing topic has been investigated as the main issue. In the following medical diagnosis as the instance of diagnostic issues has been researched. Then problem-solving algorithms are expressed in three levels of abstraction to solve the diagnosis issue. In the next step some of the mathematical formulas that supposedly can be used, but in fact cannot be used also marked. Bayesian formula for calculate of occurrence probability of a hypothesis (assumption) has been surveyed. As well as utilization of this formula for calculating the probability of disease is proved with justifiable reasons.

Key words. Diagnosis issue, inference engine, mathematical modeling, Bayesian method.

1. Introduction

Nowadays expert systems are a part of artificial intelligence so that they are very useful and efficient. Expert systems rely on proficiency of specialists and accuracy of computer, improve the quality of decisions. On the other hand diagnosis-based issues are used in the design of inference engine of expert systems. Initially it is necessary to explain briefly about the diagnosis issue as main issue to the design of inference engine [1–3].

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1.1. Analyzing the diagnosis issue in diagnostic expert systems

Ultimate goal of each diagnostic issue is satisfaction from the obtained results. Therefore, the experts use the goal oriented methods for correcting diagnosis (Goals driven methods) [4]. Also inference engines are structured controllers that using the rules for obtain the results. These controllers are known as the decision-making engines. Their main role is use and process of exist information in the knowledge bases and solve the certain issue [1]. Generally the functions of inference engine in each cycle are selection, comparison and elimination of the controversial cases stages. It is necessary to mention that three source of knowledge are used at the each stage: working memory, situation memory and knowledge base [2].

Diagnostic expert systems used in the finding defects and diagnosis that are not found or are hardly to be found by humans. For example, find the cause of incompatibility in the systems and equipments or the diagnosis of disease type of the patient from the observed symptoms. One of the most important diagnostic applications is the medical field thus variety of medical diagnosis expert systems have been developed and there are many problems in this path that must be solved. This is where the in-depth analysis of diagnosis issue becomes to the imperative problem. Therefore you must have a comprehensive understanding of the medical diagnosis issue. In most cases, those who are recognized experts in our diagnostic expert system using of goals driven techniques. Because the end result of this effort is the patient satisfaction from diagnose insufficiencies, here goal-oriented method can be a good approach to solve the problem. In the medical examination that performed by medicines the diagnostic processes is being carried out in the following sequence:

Symptoms and characteristics of the disease are set; All diseases are taken into account in accordance with observed signs in the patient; Calculate the probability of each candidate diseases; Choose a disease that is more likely to occur than others; Fill out the questionnaire related to the disease, at the same time supplementary examinations, checks and medical tests are offered; If the disease does not appear to carefully selected, probability of the next candidate diseases are tested; If other signs are observed in patients or the results of analyzes represents a another kind of disease, diagnosis algorithm are repeated on the another candidate diseases; I the disease is diagnosed, prescribe appropriate drugs to treat it.

However, regardless of whether the algorithm, there is an uncontested issue that medical diagnostics is medical art of doctor. Other factors, including the rapid development of medical science, uncertainty of medical knowledge and etc. complicates the issue.

Diagnosis process is a shortcoming of an analytic knowledge that reveals the evidence in the various classes [5]. Thus, looks the evidences (the symptoms and indicators of the disease) in the disease classes [3]. Solving the diagnosis issue has the three successive step: in the first step established the algorithm at top and bottom level of abstract for this issue, in the second step created the structure of this algorithm, in the latest step created the controller instructions or in other words write the semi code of this issue [6].

1.2. Mathematical modeling in diagnosis issue

The ultimate goal of each diagnostic issue is satisfaction from the obtained results. Therefore, the experts use the goal oriented methods for correcting diagnosis (Goals driven methods) [4]. Two mathematical rules are used in diagnosis issue. First rule was expressed as:

$$(A \equiv \text{TRUE}) \wedge (A \to P) \Rightarrow \forall a \in A(P \equiv \text{TRUE})\,. \tag{1}$$

If A is true, and P is outcome of A, and a is sample of A, then P must be true [3]. The second mathematical principle that is used in diagnostic issues is like this: B is the outcome of A, if B contradictory is false and a is sample of A then A is false:

$$(A \to B) \wedge \neg B \Rightarrow \forall a \in A(\neg A)\,. \tag{2}$$

These rules are used in the logic of inference engine. But there are some of the rules in the inference engine that are in conflict with mathematical rules. For example, there is a rule that applied in expert systems but is not valid as mathematical principle. This is called deny rule [6]:

$$(A \to B) \wedge \neg A \Rightarrow \forall b \in B, B = (\neg B)\,. \tag{3}$$

The rule can be used in expert systems but is not valid as mathematical principle. Because for example to the medical diagnosis, we do not cancel the surgery for a patient so that the patient does not need any surgery, perhaps the problem of return to conscious can cancel the surgery.

Secondary mathematical law that is valid in the world of mathematics is called nominally principle, but it cannot be used to inference engine of expert systems:

$$\forall x \in (B \subseteq A) : F(x) \to G(x); \forall x \in A : F(x) \to G(x)\,. \tag{4}$$

Due to the mathematical principle, if for all members of A majority, $F(x) \to G(x)$ is valid and B is a subset of A, so $F(x) \to G(x)$ is valid for all members of B. This mathematical principle does not meet the diagnosis expert systems, because for current situation of A majority, $F(x) \to G(x)$ is valid but in the same situation for all members of B majority, $F(x) \to G(x)$ is not valid.

Uncertainty nature of diagnosis issues leads us to one of the probability principles. Since the data of diagnosis systems are uncertain accordingly the uncertainty analysis is necessary [5]. For implementation of uncertainly, the Bayesian inference probabilistic method can be suitable. Bayesian method reflects the uncertainty in a range of assumptions and presumptions. Thus selected problem in the expert systems are placed in the hypothesis. Occurrence probability of the hypothesis can be found. Bayesian method determines the value of initial occurrence probability of hypothesis [3]. Of course, this evaluation is not final result, it just updated in the subsequent steps. Value of the specified assumptions is obtained via following

formulae:

$$P(Di|E) = [p(E|Di) * p(Di)]/p(E) = \frac{[p(E|Di) * p(Di)]}{[\sum_{j=1}^{n} p(E|Dj) * p(Dj)]}\,. \tag{5}$$

Here, Di denotes the ith problem, E is the symptom and sign of problem, $p(E)$ stands for the initial occurrence (probability of the problem), $P(Di|E)$ means that the symptom E is valid and Di is the ith problem, $p(E|Di$ means that problem Di is valid at occurrence probability of symptom E and n is the number of problem (hypothesis).

2. Conclusion

Often, creating and testing strategies are used in the inference engine of diagnostic expert systems. The process of diagnosis is the lack of the knowledge that reveals the evidence to the different classes. Diagnosis Looks to the classes of the domain for evidence, signs and indicators. For solving diagnostic issue, Bayesian formula is useful for all diagnostic expert systems. The advantages of this model include: Through the Bayesian method, creating of causal map is possible, and using this causality map with Bayesian calculation leads us to trustworthy calculation.

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