Knowledge-Based Decision Support with Self-Learning Methods

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***Abstract* - Intelligent systems are available and helpful to support the decision process for diagnostics in complex technical processes. Normally, such a decision support system consists of a knowledge-based module, which is responsible for the real assistance power, given by an explanation and the logical reasoning processes. The knowledge acquisition and generation of the complex knowledge correlations are crucial, because there are different correlations between the complex parameters. So, in this approach, (semi)automated self-learning methods are researched and developed for an enhancement of the quality of such a decision support system.**

Keywords – computer-aided assistance; self-learning methods; expert system; decision support; intelligent diagnostics; knowledge base.

I. INTRODUCTION

In the field of diagnostics for complex process behavior, the computer-based assistance is very important and useful. Concerning an enhancement and optimization of the decision making process of the diagnostic experts, there is a need to correlate all information obtained from the available data of the inspected process or system. Ideally, these data sets can be retrieved from the machine facility, the individual components, the functionality and the process parameters. For human beings, it is sometimes impossible to find out hidden knowledge in large data sets. This paper is divided in four sections:

The second section outlines the necessary data and structures as well as technical properties that are important for presented self-learning methods and expert support. The third section describes certain techniques and methods that are used in the approach presented to implement a semi-automated assistance through statistical and self-learning procedures. The last section discusses the results and possible procedures that can significantly support the work of an expert.

II. INFORMATION TECHNOLOGY

In the information technology, knowledge-based methods are predestined to make available both the human expertise and the background deep knowledge to perform the logical reasoning process [1]. So, the need is to find out a suitable structure to store and manage the heterogeneous distributed knowledge and the expertise of the experts. Furthermore, intelligent self-learning mechanisms can help to enhance the power of the knowledge base.

A. Ontology and Dependencies

On the basic layer, a frame-based information system is performed with all features of the different ontologies. The descriptive layer for the interested information categories is a hierarchical class–subclass system with a refinement process and a special specification from class to subclass.

An ontology concept [2] consists of the declarative part of the semantics, the meaning in this knowledge-based approach, the sources (publications, authors and so on) and multimedia representations (pictures, tables, movies) of the machine components, the parameters and the functionalities. On the next layer, the concept of the semantic dependencies is subdivided into weak and strong types of relations. The knowledge domains of the first layer can be correlated by so called weak links, i. e., semantic associations between the different domains. Considering a selected domain, the diagnostic expert is suggested to also regard the semantic neighbored knowledge domain. However, there exist no strong logical dependencies between the two knowledge items. The human expert can be guided from one point of interest to another in an intelligent manner. An additional type of relation is performed by a stronger relation, such as a rule in a rule based approach. If the premises of the first domain are given, then the second knowledge items result as a conclusion from the preconditions [3].

B. Knowledge Representations

The frames represent the static multimedia information (text, pictures, and audio) including the source information (i.e., HTTP-addresses, literature and links).

The context and the correlations between the different frames are represented as associations, sometimes undirected, sometimes logically directed as implications. This software component is responsible for an intelligent, context sensitive navigation through the knowledge base and the ontologies [4].

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The rules represent the complex conditional dependencies by using the known operators NOT, AND and OR, based on predicate calculus. The visualization represents the frames as nodes and the used relations between the nodes as scripted edges. So, the information set can be shown by relations like a workflow in the ontology-based structure.

C. Visualization

Additionally to a wiki-based description of information by knowledge concepts and the relations, a well performed visualization enhances the fast understanding and leads to a better overview of the refinement structure of the semantic network and the relations within the net.

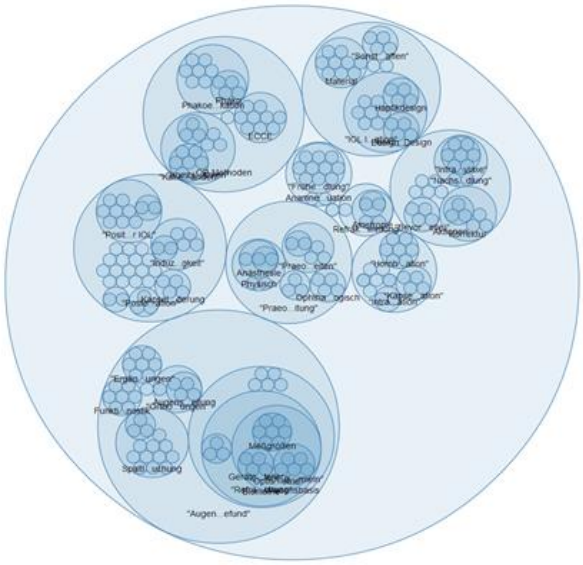

Figure 1. Circle Pack Visualization of Structured Classes

The Circle Pack visualization [5] provides a useful alternative by representing hierarchical relations through containment. It is very convenient to see, in which classes (concepts) other classes are embedded. With a convenient zoom process, one bubble can be refined in its own substructure. So, it is possible to see an overview of the overall structure and the position of a certain information concept. Concepts are displayed as circles (Figure 1). Child-concepts are located inside their circles.

III. SELF-LEARNING ASSISTANCE

Often, hidden knowledge is given by a lot of structured data like machine parameters. For humans, it is not possible to extract this knowledge. Self-learning methods are one method to extract and find out the hidden knowledge from the structured data set by using statistical methods. In the field of knowledge discovery, advanced methods and applications could be performed to produce machine and process correlations. So, new knowledge was generated by finding causal relations between the machine components, the process parameters and function parameters by a dependency ranking process. After transformation in association rules, logical based representations were available for the diagnostic experts to evaluate the new knowledge. This evaluation process is done by a human expert.

A. Learning Methods

With ontology based technologies, the diagnostic expert knowledge, including the background deep knowledge and the reasoning process, is modeled and represented. To do this, a special wiki-system is developed to represent this information in a declarative manner to the human experts. Additional semantic information is used for modeling the concepts and relations between them. This guarantees a comfortable navigation through the knowledge items. Data mining methods, especially subgroup analysis methods, are developed, extended and used to analyze and find out the correlations and conditional dependencies between the structured machine data. After finding causal dependencies, a ranking must be performed for the generation of rule-based representations. For this, the machine data are transformed into a computer understandable format. The imported data are used as input for algorithms of conditioned probability methods to calculate the parameter distributions concerning a special given goal parameter. This procedure is responsible for the rule generation.

B. Results of Self-Learning

The computer-based information and decision support system for human experts guarantees a high quality diagnostic decision of the human experts, as it enables them to navigate through the concepts and the relations in a semantic network, supported by a logical reasoning process. The entire knowledge base is subdivided into different domains, such as “machine parameters” and “process parameters”. It enhances the functionality of a classical information system and it is useful for understanding complex machine facilities by the explanation of the reasoning process. With knowledge discovery methods like subgroup analysis (i.e., data mining software VIKAMINE [6]), significant correlations can be found concerning one target parameter. After the generation of association rules, the human experts can evaluate or revise the knowledge gained from the machine learning process. So, the self-learning process extends the knowledge base and is available as information system for further processing.

IV. CONCLUSION

The aim and the advantage of such a (semi)automatic self-learning information system for diagnostics is the extension of the classical knowledge base by finding new parameter correlations. The discovered knowledge is transformed into association rules and can be used as a rule-based knowledge representation in the information system. Even more than one goal parameter of interest can be considered by the semi-automated learning process. With ranking procedures, the strongest premises and also conjunctive associated conditions can be found regarding the parameter of interest. This procedure detects the structure for new dependencies. So, the knowledge hidden in structured

tables or lists can be extracted as rule-based representation. This is a real assistance power of the knowledge based decision for the diagnostics in complex technical processes.

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