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The role of knowledge engineering in modernisation of new metal processing technologies

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Abstract

The paper deals with various aspects of knowledge engineering in the area of metal processing technologies. The discussion concerns: needs of the knowledge, role of the knowledge engineering, methodologies for the knowledge structuralisation, integration and distribution. The aim of this paper was highlighting the needs and prospects related with informatisation of foundry industry.

Key words: metal processing technologies, information systems, knowledge engineering, knowledge integration

1. Introduction

Rapid progress that has been observed recently in the field of information accessories and programmatic tools creates enormous possibilities for computer-aided control of manufacturing processes. However, full-scale use of these potentials requires, on one hand, considerable financial inputs, while - on the other - solutions that would allow for a specific nature of various production branches and possibilities offered by individual plants and enterprises. A feature quite unique of the metal processing industry is the great diversification of applied technologies, not always modern but requiring the use of different materials and equipment, and - as a consequence - characterised by different requirements imposed on individual operations and different values of the characteristic parameters. The choice of a best modern technology and best technique to prepare the production process is often preceded by laboratory researches and/or simulation experiments.

The above circumstances, additionally enhanced by always more stringent requirements of product quality and reliability (introducing ISO standards, among others), are the very reason why any modernisation of production and the choice of its best profile will rely so much on an easy access to information on new technologies, national and international standards, and data on marketing activities and research works currently done.

2. The tasks and needs of information science as applied to metal processing industry

For both research works and well organised industrial activities an easy access to and an operative use of the available information resources is necessary. At present, however, these resources are usually available in a scattered form only, while databases (if existing at all) are heterogeneous and not always accessible. Under these conditions, building of an information system which

would provide an easy access to the above resources, performing at the same time the function of a knowledge integrating link, is to be considered the condition number one in modernisation of metal manufacturing industry. The system in question can be characterised in short as an easily expandable (modifiable) environment**,** organising cooperation of components implementing relevant information resources. [1]

Effective operation of an information system requires great flexibility combined with adaptability to the dynamically changing needs (services rendered). By application of the methods of artificial intelligence and programming tools of new types, a spontaneous (automatic) adaptation of the system structure and organisation is possible, thus conferring a new quality to the rendered services and improving the versatility of applications.

The most important useful functions of the system include:

- Assistance in selection of information on modern materials and technologies for foundry industry,
- Expert opinions on various technologies of fabrication,
- Expert opinions on diagnosis of defects in metal products,
- Rendering available the programming tools for studies of physical processes related with fabrication of castings,
- Supporting various processes of education and professional upgrading.

The main requirement imposed onto the new system is that, providing a suitable network-tool infrastructure is created, the mechanisms (procedures) operating in this system should be able to connect it to the external sources of knowledge. In terms of the expert work that can be done using thus organised resources of knowledge and information, a situation is created in which the system is strongly supporting the choice and application of a best strategy of selecting the necessary information and - in the case of a diagnostic problem - the choice of a best strategy for the reasoning process during its practical execution.

The system under consideration is assigned for a widely understood technical assistance, aiding the task of designing modern technologies and quality assurance in the manufactured metal products [2,3].

From a description of the requirements and functions it follows that the system has decentralised structure as regards both information resources and potential service users. All these resources are of a variable character but all require access to the network. When a task is assigned, the system prepares a composition of the best resources, aided by a dialogue with the user. Attention deserves here the fact that the great diversity of the utilised sources of information may sometimes be a handicap in their integrated use. Therefore, the individual information resources are at the very beginning subjected to the operation of ordering (standardisation) through formation of knowledge components unified in formal respect.

A useful function of the system is access to the knowledge and information on a relatively vast range of problems. The conditions to which this function is subjected may, at the same time, form design guidelines for the environment:

1. Access to the knowledge is in the form of widely understood expertises from a given thematic range, executed jointly with the user. In this respect the system functionally approaches the expert or decision-aiding systems.
2. Expertise is usually based on several sources of which at least some are accessible in the system. A function primitive in respect of the expertise is the compilation of components suitable and satisfactory to the user.
3. Components - because of a vast nature of the problem-related area in the sense of the subject matter as well as the humans who are creating this area - they represent information resources of variable nature and perhaps differing also slightly in the knowledge base, mainly in the sense of the applied terms and relations that exist between them.
4. Generally, the complexity of an expertise may require previous cooperation with the user in establishing a mode of its execution, that is, the choice of components. From the user's point of view, also the mode in which given component is used may be ambiguous and requiring some adjustments (in this particular case - this will be a mode functionally complex or in terms of knowledge not fully understandable).
5. Apart from some integration obtained at the knowledge-information level, it is also necessary to provide an integration of components at the technology-information level.

The realisation of the above mentioned tasks in the field of foundry industry is done through, operating since several years, INFOCAST system, designed by the Foundry Research Institute in Krakow in cooperation with the Department of Computer Science AGH and the Academic Computer Centre - CYFRONET.[4, 9]

The principles of operation of an INFOCAST system are subjected to constant revising and updating; the fields of knowledge comprised in this system are also being extended and enlarged by the new thematic modules (components). Studies are carried out on possible improvement of system infrastructure, specially through elaboration of tools which enable knowledge integration and upgrading user's interface.

In studies on the structure and development of a given class of information systems, the key role have solutions applicable in the creation of knowledge components and in the development of tools for their integration, adjusted to the user's specific needs. These methodological and tools-oriented solutions applied in the system will be shortly characterised in further part of the paper.

3. Methodology of knowledge creation about product defects

For a rational performance of technological process it is necessary to possess not only the skill of detecting a defect, but also some knowledge of how to determine its type, establish the causes of its occurrence, and finally take measures which will prevent its reccurrence. Thus defined problem requires exploration of different resources to find only this knowledge which will be helpful in solving of a particular problem.

In terms of the knowledge engineering, which is one of the fields of modern information science, knowledge is a formalised notation of causal-resultant relations and of relations that are

present in the data sets and information resources regarding certain problem areas.

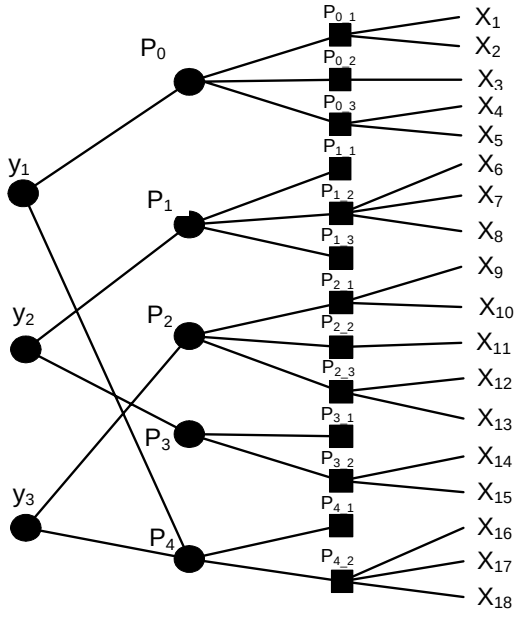

Fig. 1. The structure of relations between defects and process parameters

In this approach, the creation of knowledge consists in acquisition of information and data from the accessible resources, subjecting them next to the successive stages of processing until a formalised form is obtained.
In the proposed methodology, the first stage of creating our knowledge about the defects consists in determination of relationships between the sets:

DEFECTS $\longleftrightarrow$ CAUSES

A development of this relationship means assigning to CAUSES of defects NODES or technological OPERATIONS in which a given CAUSE may appear. Further, to NODES (OPERATIONS) can be ascribed the groups of technological parameters responsible for the occurrence of a cause, and - as a consequence - of defect. An example of thus obtained tree of relations is shown in Fig. 1.
The information structure produced in this way is now a basis for creation of a formalised entry, adequate for the adopted procedures of inference and, as a consequence, for defect diagnosis.

IF (premise) THEN (conclusion)

Taking into account practical conditions of metal processing, specially as regards casting technologies, it has been decided to examine some formalisms, taking into account the fact that knowledge may be incomplete and uncertain.

As a consequence the following formalisms were examined:

- classical logic
- fuzzy logic
- Bayesian networks
- logic of plausible reasoning.

Detailed studies on application of these formalisms are presented in [4, 5, 6, 7].

4. Ontogrator – system for integration of heterogenous knowledge sources

Ontogrator [8] which is another part of INFOCAST, is a system for integration and organization of access to various information and knowledge stored in independent computerized sources that stay external to it. The sources can be of various structuralization: data in relational data bases, documents, XML files, web pages etc. It is assumed that the sources gathered knowledge of some domain like casting technology or metallurgy. Integration of such sources is realized by defining two kinds of ontologies: "domain otologies" representing concepts of the domain together with dependences between these concepts, and "data source ontologies" describing each data source. Use of the knowledge gathered in the system consists in navigating through notions of the domain ontology and - after identifying the interesting concept – in retrieval of the information about chosen this way topic (coming from different data sources).

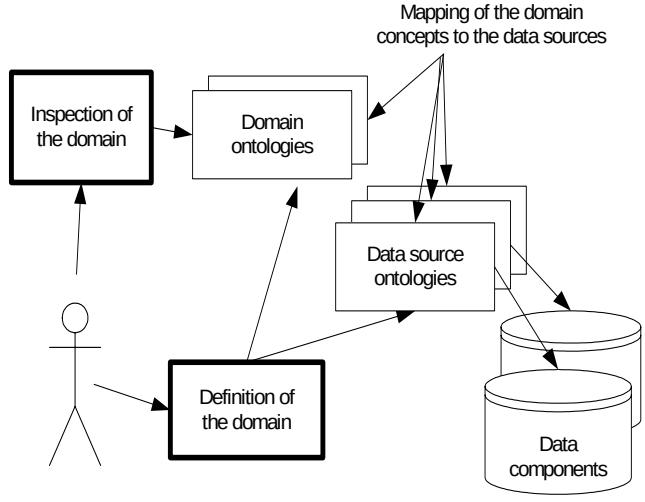

Fig. 2 Ontology driven access to heterogeneous data sources – general concepts

A system of this type can be characterised briefly as an easily extensible (modified) platform that organizes cooperation of components implementing these resources. It is assumed that the components have been built at different moments of time, under different conditions, and using computer technologies (tools) that did not keep exactly the same standards and, in consequence, are hardly integrated. In order to make the cooperation of the components possible as well as to facilitate the use of the system

by users of different profiles, providing possibly full knowledge about the components and system in a symbolic and ready-to-process form is assumed. In this way a formal basis for the architecture becomes the idea of systems with explicit knowledge.[10]
Ontogrator makes available information stored in independent, external computerised sources. In order to allow coordinated presentation of these data and, in particular, to gain a synergy effect that can arise from some differences (with respect to the origin and scope), their sources must be subject to prior integration, supported also by the system. Both the integration process and mechanism necessary to aid the effective queries in the, built this way, conglomerate of data intensively use the, applied to sources, shared interpretation given in the form of an ontology. The integrated sources become components of the discussed information environment that here is dedicated to casting technology but can be prepared also for any other engineering domain.
It should be mentioned that the presented implementation of Ontorator assumes that a component does not need any input data except those necessary to carry out a query and produce information that is directly presented to a user. Such assumption does not exclude "classic" data sources (e.g. data bases), but cooperation (data exchange) among components is not supported. This, somehow simplified, solution is adopted because the majority of candidates for components are legacy systems operating in the above sketched mode. Moreover, integration of those systems seems to be of far more importance than designing of an environment fully flexible and complete.
The idea of ontology driven integration and access to heterogeneous data sources is shown on Fig 2.

5 Final remarks

This study discusses the demand for information resulting from modernisation of foundry industry, implementation of new technologies and raising competitiveness of products in European markets. Against this background, the basic functions of an information system assigned for diagnostic and decision-related tasks were sketched.
In this context, a reference was made to INFOCAST system which, in national scale, is a unique solution dedicated to the needs of foundry industry. As important for a given class of systems were indicated problems regarding the creation and integration of modules in domain knowledge, describing proper solutions used in INFOCAST system.
The aim of this paper was highlighting the needs and prospects related with informatisation of foundry industry; in parallel with a reference to the work undertaken in this scope by Foundry Research Institute in Krakow.

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