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METHODS AND TECHNIQUES FOR INDUSTRIAL DEVELOPMENT

Editors:

Franc CUS

Valentina GECEVSKA

Fulvia CHIAMPO

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Reviewers:	Prof. Dr. Ivo Pahole, Univ.Dipl.Mech.Eng. Faculty of Mechanical Engineering, University of Maribor Prof. Dr. Mirko Ficko, Univ.Dipl.El.Eng. Faculty of Mechanical Engineering, University of Maribor
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A WORD FROM THE EDITORS

The scientific monograph METHODS AND TECHNIQUES FOR INDUSTRIAL DEVELOPMENT has been prepared during the realization of the project No.517361-TEMPUS-1-2011-1-IT-TEMPUS-JPHES titled: Technical Education on Resources Savings for Industrial Development*,* funded with support from the European Commission in frame of TEMPUS IV Programme.

Tempus Programme (Trans-European Mobility Scheme for University Studies) supports the modernization of higher education and creates an area of cooperation in countries surrounding the EU, countries from the Western Balkan, Eastern Europe and Central Asia, North Africa and the Middle East. Tempus Joint Projects for Higher education and Society, such as TERSID Project, aim increasing cooperation and networks building between higher education in the EU Member States and partner countries applying the principles of the “Bologna Process”, and networks between higher education and society based of the EU experiences.

In the framework of the TERSID Project, there participate six EU universities: Politecnico di Torino in Italy, University of Maribor in Slovenia, Bochum University of Applied Sciences in Germany, Aristotle University of Thessaloniki in Greece, The University "Dunarea de Jos" of Galati in Romania and Transport and Logistics Institute of Riga in Latvia. The Central Asian universities in the framework of the TERSID Project are: Tashkent Turin Polytechnic University in Uzbekistan, Navoi State Mining Institute in Uzbekistan, Tashkent State Technical University in Uzbekistan, Karaganda State Technical University in Kazakhstan and Kazakh National Technical University of Almaty in Kazakhstan. Also, the Project has involved fourteen partners coming from industries, National governments and NGOs.

As a regional Project, TERSID has been carried out in Uzbekistan and Kazakhstan, focused on the renewal of some curricula for the engineering field, to introduce:

- modern methods and techniques for industrial development to be adopted for competitiveness improvement and economics and social growing,
- modern and efficient technologies to be adopted for saving of natural resource as prevention action and for pollutant treatment as reduction action.

This publication offers comprehensive chapter series from scientific researchers conducted by regional authors, authorities in the fields and summarizes the principal scientific contributions. The chapters deal with range topics from optimization techniques in production development, quality in production processes, product and process development, technologies for business development and factors of social and economic development. Edited by three editors with contributions from chapters’ authors, this scientific monograph presents advanced topics for students, educators, and practitioners.

The editors acknowledge with gratitude the European Commission, EACEA Agency who funded TERSID Project under the TEMPUS IV Programme. Finally, the editors would like to thank all chapters’ authors and Project Consortium Partners who devoted their work and expertise with the greatest enthusiasm. We encourage all the colleagues involved in the project to continue this successful cooperation, which is highly valuable for all partners, EU partners and Central Asian partners.

Editors:

Prof. Dr. Franc Cus

Prof. Dr. Valentina Gecevska

Prof. Dr. Fulvia Chiampo

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SEMANTIC INTERPRETATION OF GEOMETRIC AND TECHNOLOGICAL FEATURES

Milan TRIFUNOVIC, Milos STOJKOVIC, Miroslav TRAJANOVIC, Miodrag MANIC

1. INTRODUCTION

In the earliest phase of product and technology development, very important, even strategic, decisions are being made under conditions of considerable uncertainty. In these situations, assessments, and therefore decisions, are based completely on knowledge derived from experience, i.e. semantic analyses of earlier cases (for which there is relevant data).

At the beginning product designer considers all the details from the limited set of input data, in order to recognize elements of current case, which could indicate similarity with some earlier case. Depending on whether, and to what extent, expert succeeded to recognize similarity or dissimilarity, he makes decision to classify current case into a set of similar and mutually indicated cases. In the next step, expert is searching for adequate response (decision) in data space which is limited by the set of similar and mutually indicated cases. The decisions that have been made and experience with application, serve as some kind of model for decisions that should be made in relation to the current case.

Development of PLM and Computer-Aided-X systems is characterized by particular interest for integration of semantic data models into the product models [1,2]. Expectations are that semantic models should provide a high level of abstract formulation of real objects and situations at one side, and be used for computer aided intelligent reasoning on the other side (assessment, decision making, etc.) [3].

Milan TRIFUNOVIC, Faculty of Mechanical Engineering in Nis, University of Nis, Serbia; Milos STOJKOVIC, Faculty of Mechanical Engineering in Nis, University of Nis, Serbia; Mioroslav TRAJANOVIC, Faculty of Mechanical Engineering in Nis, University of Nis, Serbia; Miodrag MANIC, Faculty of Mechanical Engineering in Nis, University of Nis, Serbia

Functional product modeling represents relatively new approach to product modeling (some PLM systems, such as Catia and UGS have modules for functional product modeling for more than 12 years). This approach is characterized by modeling of so-called abstract entities. Abstract entities are used to describe properties of some objects on product model, their functional relationships with other objects, and scenarios of real situations in which given object and product model could be found during it's lifecycle. Functional product modeling is based on UML [4]. However, object-oriented structure of UML's files did not show itself capable of generating response to unpredicted input data packages [5,6].

Current semantic data models, present in the semantic web (Topic Map, RDF/S, DAML-OIL, OWL), are also based on object-oriented data structure. What is specific is that classes and objects are scattered across the web, with precisely defined pointers to web locations (URI) where the class definitions with attributes and constructors are stored. These definitions can be accessed through a web browser. However, like in all other object-oriented data structures, strictly structured knowledge of these models limits them to respond autonomously and meaningfully for the cases of unpredicted input data package [3].

2. ACTIVE SEMANTIC MODEL

ASM is a new semantic model which has been developed in-house. Its primary aim was to capture and interpret semantics of the design features related to manufacturability issues [7]. ASM intends to use an alternative approach to knowledge representation in comparison with the existing semantic models by moving the focus of data structuring from concepts to semantic relations or associations (the term which is used in ASM). This idea of structuring the meaning in associations is chosen to support the thesis stating that the knowledge that people have about things (visual representations, objects, situations, etc.) is contained in associations between concepts that abstractly represent those things [8]. Furthermore, ASM has proved itself as a more flexible and productive in capturing and interpreting semantics of data compared to the existing semantic models [9]. Here, we will explain ASM in brief.

2.1 Structure

The ASM structure consists of:

- *Associations*,
- *Concepts*,
- Concept *bodies*, and
- *Contexts*.

The structure of ASM association is characterized by eleven parameters [9].

The *names* (***cpt***$_i$, ***cpt***$_j$) are two parameters that define the junction points of each association in the semantic network. These two parameters are used to designate two concepts or contexts that are associated by the association. A concept in ASM is defined just with its *name* and is used to designate object, activity, or abstract concept (such as feature, attribute, number, value, emotion, adverb, etc). There can be only one concept with given name, but there can be many associations belonging to different contexts associating it with other concepts.

Besides two different *names*, an association in ASM is defined by additional two sets of parameters:

Topological parameters: *roles* ($\boldsymbol{r_i}$, $\boldsymbol{r_j}$) of concepts (e.g. type, subtype), *type* (***t***) of associating (e.g. classifying), *direction* (***d***) of associating (←, ↔, →) and *character* (***c***) of associating (+, -);

Weight parameters: *accuracy* (***h***) of associating for given context (0; 0.25; 0.5; 0.75; 1) and *significance* (***s***) of associating for given context (0; 0.25; 0.5; 0.75; 1); and affiliation parameters: *context* id to which association belongs, and *user* id to identify who has created the association (Fig. 1).

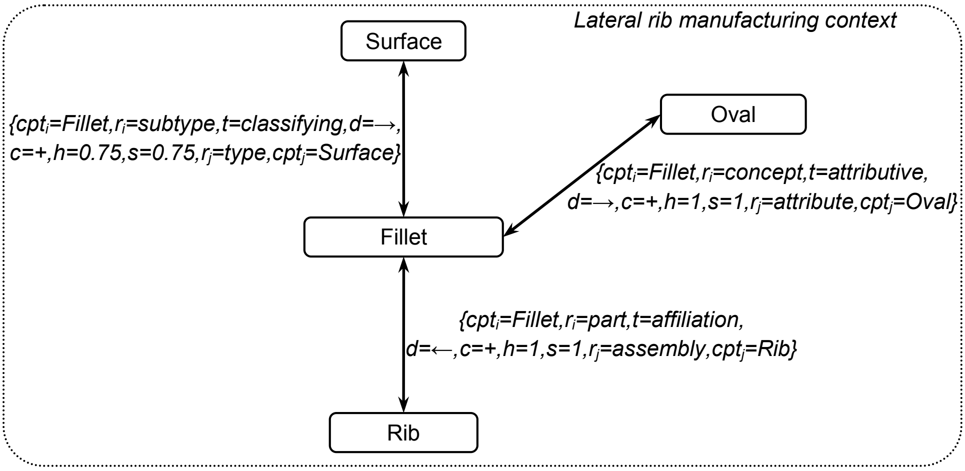

Figure 1. *ASM association structure: Several associations with specified parameters belonging to a context*

Concept body is a specific realization, i.e. instance or occurrence of a concept which is commonly used to encapsulate an instance of formalized knowledge about some concept. For example, concept Blue-Color can be embodied by one or plenty of specific values of color codes and procedure to generate this color on the computer screen in accordance to its code. Thus, one concept can have several concept bodies, i.e. its real represents. The concept and its bodies are connected by specific type of association in which concept plays role of *concept* and body plays the role of a *concept body*. By these associations ASM builds the difference between the concepts and their bodies and connects them at the same time.

A specific type of ASM data structure are *contexts* (*CTX*) which are represented by sets of associations, i.e. segments of the semantic network. Each context serves to describe the semantics of a complex concept, a situation or an event. Each context is defined by its *name* and its creator (*user*). *General context* is defined and built in ASM structure independently of the user, while other *particular contexts* are created by the user. All the associations from particular contexts are assigned to the general one, but usually with different parameters. *Association plexus* (*PLX*) in ASM is, in general, a context subset (mathematical structure) and can be considered without specific abstract meaning. The main reason why association plexus is treated as a separate entity in ASM is because it enables and facilitates identification of similarity or analogy of topology between different segments of the semantic network.

The ASM structure is not domain-specific and can be used for knowledge representation in diverse fields. The knowledge from specific domain should be represented through context(s), while associations as semantic relations between contexts allow knowledge from one context to be applicable to others.

2.2 Interpreting the semantics of data in ASM

Cognitive Data Processing (CDP) algorithms represent a set of data processing procedures with which ASM attempts to perform data semantic interpretation. They enable ASM to acquire new knowledge independently and make meaningful decisions and responses. This group of algorithms consists of:

1. the procedure of determining:
   a. the class of similarity of associations, and,
   b. the degree of semantic similarity of concepts
2. the algorithm for Determining the Similarity of Associations (DSA) (the core of this algorithm is the procedure for Determining the Parameters of Association (DPA))
3. the algorithm for Determining the Similarity of Contexts (DSC)
4. the algorithm or the Procedure of Contexts Upgrading (CUP)
5. the algorithm for the creation of heuristics and knowledge "crystallization".

Two most important procedures – procedure for determining the parameters of association and procedure of contexts upgrading – will be presented here.

2.2.1 Procedure for determining the parameters of association

Determination of semantic similarity of two concepts is usually performed for the concepts which are not directly connected by associations (CPT_X and CPT_N), i.e. in the cases when there exists at least one layer of concepts between CPT_X and CPT_N known to ASM (layer of *connectional* concepts CPT_i (Fig. 2)) through which they are connected. Pairs of associations through which concepts CPT_X and CPT_N are connected to the same connectional concepts CPT_i are called *common* associations (Fig. 2). The process of determining semantic similarity of two concepts results in the creation of association(s) between these two concepts. The parameters (type, direction, character, accuracy, and significance) of this (these) association(s) are determined through the procedure for determining the parameters of association. Concepts CPT_X and CPT_N which are directly connected with one or more associations (Fig. 2) are already semantically categorized. However, determination of semantic similarity for these concepts is possible and needed after every modification of semantic network (after the creation of new associations).

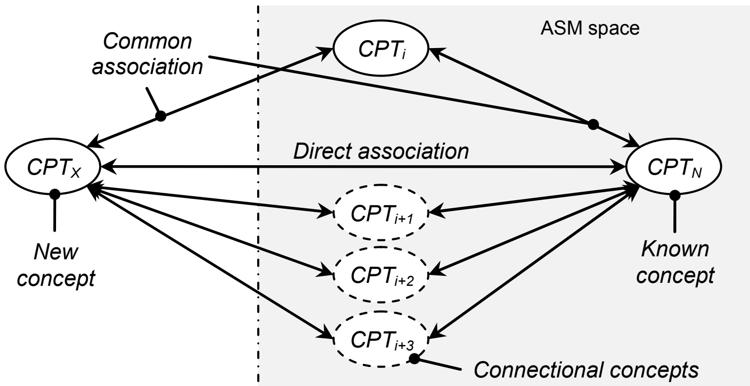

Figure 2. *Schema of semantic relations and concepts with illustration of used terminology*

The association parameters values, and, therefore, the semantic features of a new concept, generally depend on the set of parameter values of all the association pairs. The associations parameters also depend to a large extent on the contexts containing these associations and semantic elements (concepts and contexts) connected by them. In other words, two concepts can be in completely or partially different semantic relations, depending on the context wherein they are observed. The characteristic of each association in terms of its belonging to a certain context implicitly connects that context with members of this association (concepts or contexts that are connected by this association). This implicit connection between association members and context to which this association belongs is determined by the values of association parameters that are appropriate for given context (Fig. 3).

Therefore, it can be stated that the association parameters values, and, consequently, the new concept's semantic features in the given context, depend on the set of parameter values of all the association pairs that belong to that context.

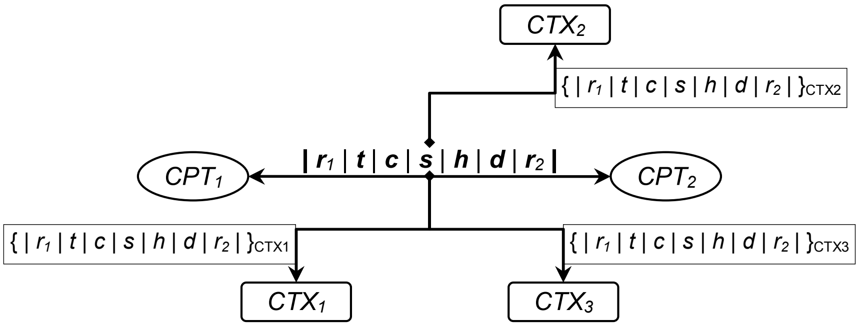

Figure 3. *Connection between semantic relations (associations) and sets of semantically close associations (contexts)*

There are three characteristic cases that determine what ***type*** will be assigned to the association created during the categorization:

1. ASM determines complete match of all parameters of all association pairs. In this case ASM creates an association of *synonymous* type between these two concepts (CPT_X is synonym for CPT_N).
2. ASM determines that new concept CPT_X and known concept CPT_N have associations of at least the same type toward connectional concepts CPT_i. In other words, these associations can be of the same or different character, direction, accuracy and significance. In this case ASM creates association of *similarity* type between these two concepts (CPT_X is similar to CPT_N) (Fig. 4).

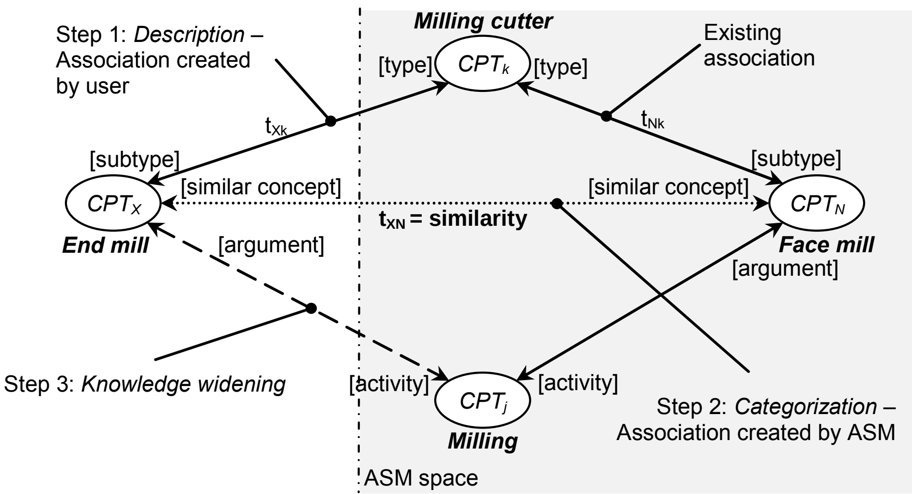

Figure 4. *Determination of the type of association for the case when concepts have associations of at least the same type toward connectional concepts*

3. ASM determines that concepts CPT_X and CPT_N have associations of different types with the same (connectional) concepts CPT_i, i.e. roles of concepts CPT_X and CPT_N in these associations are

different. The type of association that will connect concepts CPT_X and CPT_N will be determined depending on the class of association plexus in which new concept CPT_X is found. For example, an easily recognizable class of association plexus is the one that describes some activity (Fig. 5). In this kind of plexus, besides the concept that represents the activity itself, there exists motive for performing that activity, activity subject or subjects (who is performing the activity), activity object or objects (against which the activity is performed), activity argument (with which the activity is performed), product, and result of activity. Therefore, it is sufficient to introduce part of association plexus to enable ASM to recognize the class of association plexus for the description of activity. In the next step ASM starts directed search procedure over the semantic network in order do determine the rest of the associations from the plexus. This procedure is intended for pre-planned types of plexuses (association plexuses that describe activity, assembly, etc.). This procedure is based on the CASE algorithm which contains explicitly defined causal mechanism (rule) for every pre-planned CASE.

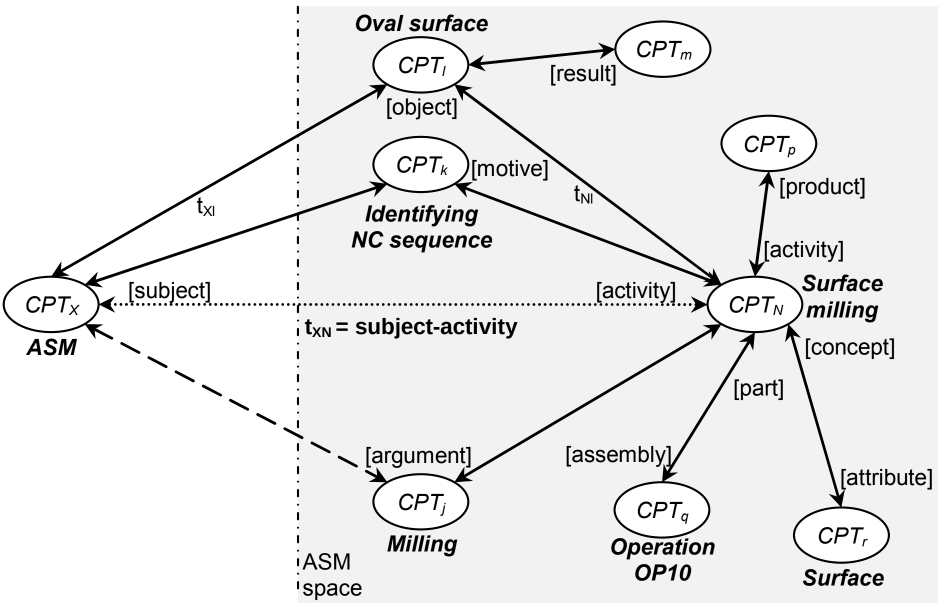

Figure 5. *Association plexus describing the activity Surface milling*

The values for ***accuracy*** and ***significance*** of the association being created between concepts CPT_X and CPT_N are determined according to the following equations:

$$s_{xn} = 1 - \frac{\sum_{i=1}^{k} \left| s_{Xi} - s_{Ni} \right|}{k} \tag{1}$$

$$h_{xn} = 1 - \frac{\sum_{i=1}^{k} \left| h_{Xi} - h_{Ni} \right|}{k} \tag{2}$$

where k is the number of association pairs formed between concepts CPT_X and CPT_N and the same concepts CPT_i from the semantic network.

Since association accuracy and significance take values from a finite set of standard values (0; 0,25; 0,5; 0,75; 1) for the sake of simplicity, it is necessary (though not required) to adopt values for these parameters that will be different from the calculated values. These values are adopted as follows:

Table 1. *Adopting the values for accuracy and significance of association*

Conditional part	Result
$s_{xn} \geq 0.5$	s_{xn} = first bigger standard value
$s_{xn} < 0.5$	s_{xn} = first smaller standard value
$h_{xn} \geq 0.5$	h_{xn} = first bigger standard value
$s_{xn} < 0.5$	h_{xn} = first smaller standard value
$s_{xn} = 0$ or $h_{xn} = 0$	Remove $A_{cptx \leftrightarrow cptn}$

Determination of the association ***character***, in the case when there is only one association pair between concepts CPT_X and CPT_N, is carried out using the following matrix (which is illustrated in Fig. 6):

Table 2. *Matrix for determining the character of association (only one association pair)*

c_{Xk}	c_{Nk}	c_{XN}
+	+	+
+	-	-
-	-	+
-	+	-

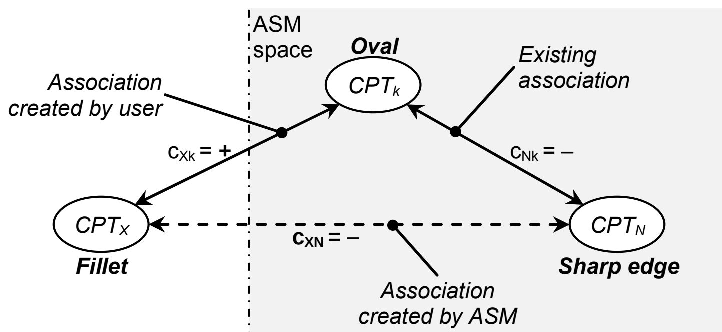

Figure 6. *Typical schema of associations during the determination of association character (only one association pair)*

In the case when there are multiple association pairs (and, consequently, more connectional concepts) between concepts CPT_X and CPT_N, the function for determination of the character of association which should be created between concepts CPT_X and CPT_N varies depending on the case:

1. When there are multiple association pairs between concepts CPT_X and CPT_N which have the same characters. In this case ASM creates association of positive character between concepts CPT_X and CPT_N. Concepts CPT_X and CPT_N associate the same connectional concepts CPT_i in the same way – affirmative or nonaffirmative.
2. When there are multiple association pairs between concepts CPT_X and CPT_N which have different characters. In this case ASM creates association of negative character between concepts CPT_X and CPT_N. If all association pairs have the same types, then ASM creates the association of negative character and *antonymous* type.

Determination of the association ***direction*** in the case when there is only one association pair between concepts CPT_X and CPT_N is carried out using the following matrix (which is illustrated in Fig. 7):

Table 3. *Matrix for determining the direction of association (only one association pair)*

d_{Xk}	d_{Nk}	d_{XN}
→	→	→
→	←	↔
→	↔	→
←	→	↔
←	←	←
←	↔	←
↔	→	→
↔	←	←
↔	↔	↔

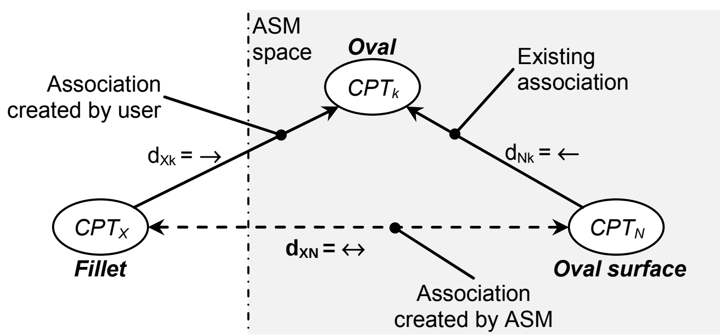

Figure 7. *Typical schema of associations during the determination of association direction (only one association pair)*

In the case when there are multiple association pairs (and, consequently, more connectional concepts) between concepts CPT_X and CPT_N the function for determination of the direction of association which should be created between concepts CPT_X and CPT_N is also defined according to the matrix:

Table 4. *Matrix for determining the direction of association (multiple association pairs)*

d_{X1}	d_{1N}	d_{X2}	d_{2N}	d_{X3}	d_{3N}	d_{XN}
→	→	←	→	→	←	→
→	←	←	→	→	←	↔
→	↔	...	...	...	...	...
←	→	...	...	...	...	...

Procedure for determining the parameters of association is presented in detail in [10].

2.2.2 Procedure of contexts upgrading

The most common and probably most significant case of semantic content similarity between different association plexuses or contexts is called *topological analogy* (similarity) (Fig. 8). Topologically analogous association plexuses or contexts have the same type of topology (combination of appropriate values of topological parameters of associations) and the same structure. Associations belonging to two different association plexuses or contexts, which have similar values of weight parameters and the same values of topological parameters are called *topologically correspondent associations* (TCA) (associations represented by the same type of line in Fig. 8). Concepts belonging to TCA-s of two different association plexuses or contexts, which have the same role in these TCA-s are called *topologically correspondent concepts* (TCC) (concepts represented by the same background pattern in Fig. 8). Two types of topologically analogous association plexuses or contexts are distinguished: *semantically distant* (association plexuses or contexts do not share concepts, nor are their concepts similar, synonyms or connected over series of up to four associations) and *semantically close* (association plexuses or contexts share one or more concepts, or have concepts which are similar, synonyms or connected over series of up to four associations).

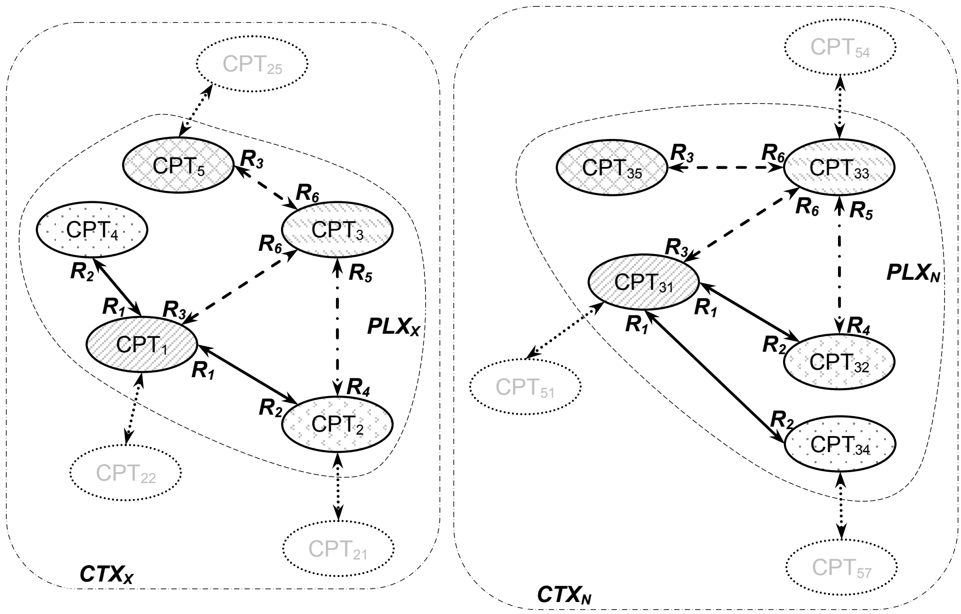

Figure 8. *Association plexuses PLX_X and PLX_N are topologically analogous*

ASM responds to input by recognizing topological analogy between new and known association plexuses (from the narrowed semantic network space) and upgrading the new association plexus modeled on remainder of the context (whose subset is recognized as topologically analogous association plexus). The response is being formulated through creating new associations between concepts from new association plexus and known concepts in the network.

Association plexus upgrading procedure is based on similarity between new and known association plexuses. New association plexus concepts will be connected modeled on their TCC-s in similar association plexuses.

In the case when new association plexus PLX_X is topologically analogous to certain known association plexus PLX_N (the more TCA-s they have, the better), regardless of whether they are semantically close or semantically distant, ASM will use the logic of topologically analogous association plexus upgrading (element © denotes topological correspondence (for associations and concepts) or topological analogy (for contexts and association plexuses); element $\leftrightarrow$ denotes association between concepts):

If

$$\left\{A_{i,j}^{PLX_X}\right\} © \left\{A_{k,l}^{PLX_N}\right\} \wedge \left\{CPT_i^{PLX_X}\right\} © \left\{CPT_k^{PLX_N}\right\}$$
$$\left(\Rightarrow PLX_X © PLX_N\right) \tag{3}$$

where

$$A_{i,j}^{PLX_X} = A_{CPT_i \leftrightarrow CPT_j}^{PLX_X}, A_{k,l}^{PLX_N} = A_{CPT_k \leftrightarrow CPT_l}^{PLX_N}, PLX_N \subseteq CTX_N$$

then it is possible that there exists context CTX_X, whose subset is new association plexus PLX_X, which is topologically analogous to known context CTX_N:

$$\exists CTX_X \mid CTX_X \supseteq PLX_X \wedge CTX_X \copyright CTX_N \tag{4}$$

Therefore, new association plexus PLX_X should be upgraded to context CTX_X, modeled on the remainder of the known context CTX_N (Fig. 9).

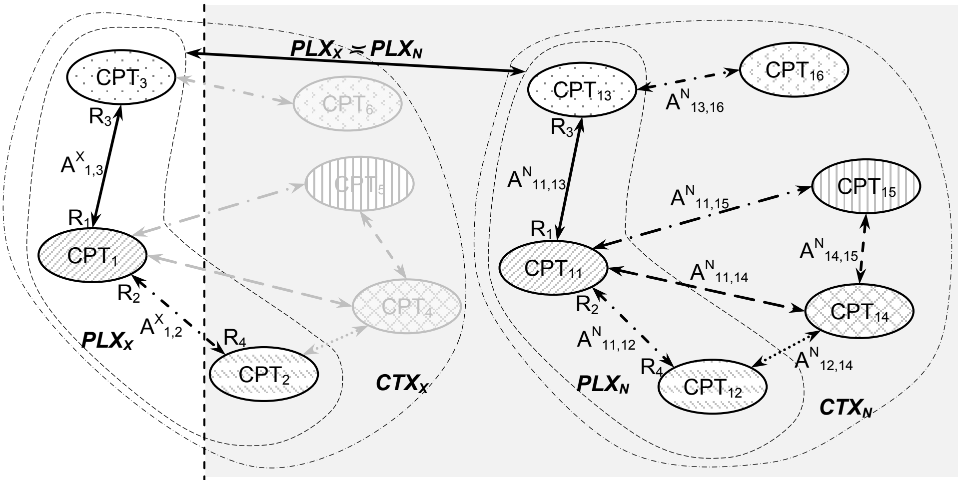

Figure 9. *Logic of topologically analogous association plexus upgrading. TCA-s of topologically analogous association plexuses PLX_X and PLX_N are: $A^X_{1,2}$ and $A^N_{11,12}$; $A^X_{1,3}$ and $A^N_{11,13}$. TCC-s of topologically analogous association plexuses PLX_X and PLX_N are: CPT_1 and CPT_{11}; CPT_2 and CPT_{12}; CPT_3 and CPT_{13}.*

Logic of topologically analogous association plexus upgrading is carried out in three attempts (sub-procedures). First and second attempt are carried out in several iterations.

Each iteration for every attempt is followed by the iteration of the previously presented process of determining semantic similarity of concepts, which also can result in the creation of association(s) between concepts.

In first attempt ASM searches for all associations in the semantic network involving concepts from new association plexus, which are topologically correspondent to associations from known association plexus involving their TCC-s, and adds these associations if TCC-s have the same roles in them. In second attempt ASM searches for concepts in the semantic network which are similar to concepts from new association plexus in specific context, and are involved in associations which are topologically correspondent to associations from known association plexus. ASM adds associations involving them, which are topologically correspondent to associations from known association plexus, except that the found concept will be replaced by its similar concept in new association plexus. The goal of the third attempt is to find *candidate* concepts in the semantic network which should be connected with the remaining concepts from new association plexus. Candidate concepts and their corresponding concepts from known association plexus are usually semantically distant. Focus of the third attempt is the similarity between associations involving candidate concepts and associations involving their corresponding concepts from known association plexus.

Procedure of contexts upgrading is presented in detail in [11] as our approach in realization of analogy-based reasoning in semantic network.

Experimental evaluation of the presented procedures was done for the following cases: product quality assessment in the early stages of product design [12]; automation of choosing and composing manufacturing process for free-form design parts [13]; exception detection in business process management systems [14]. Procedure of contexts upgrading is also being evaluated in the areas of digital reconstruction of free-form objects and Raven's Progressive Matrices tests.

3. CASE STUDIES

A simplified example of the mold manufacturing workflow will be used for demonstration of the procedure for determining the association parameters. Instead of usual mold air outlet canals, tool constructor has planned conformal air outlet canals. Mold air outlet canals are usually straight, with circular cross section, and are manufactured by drilling (deep drilling). Conformal air outlet canals follow spatial curve (trajectory), and usually have circular cross section. By following the form of lateral ribs, conformal air outlet canals can approach certain parts of the mold and provide more complete air outlet. Because of their shape, conformal air outlet canals, can not be manufactured by drilling (regular technological procedure). Thus, an exception related to the mold geometry causes disturbance of manufacturing process workflow, preventing the regular technological process. Scenario that shows the ASM application in this situation is the following:

ASM semantic network already contains semantic description of the following concepts: straight line, curve, circular cross section, drilling, etc. Some concepts are part of the "mold" context, while others belong to the general context. During the introduction of the concept "Spatial curve" DPA algorithms will (by using the CASE algorithm presented in Fig. 10) connect concepts "Spatial curve" and "Straight line" with the "subtype-type" association, whose character will be harmonized with the character of the association between concepts "Curve" and "Straight line" (negative character). This means that these two concepts are associated nonaffirmative, i.e. one excludes the other. The next association pair that will be processed by DPA algorithms is "Spatial curve"↔"Straight line"↔"Axis". This pair will induce ASM to conclude that "Spatial curve" and "Axis" are similar, but again with negative character. In the last iteration of reasoning ASM will connect concept "Spatial curve" with concept "Drilling", modeled on the association between concepts "Axis" and "Drilling", with the association of negative character (Fig. 11).

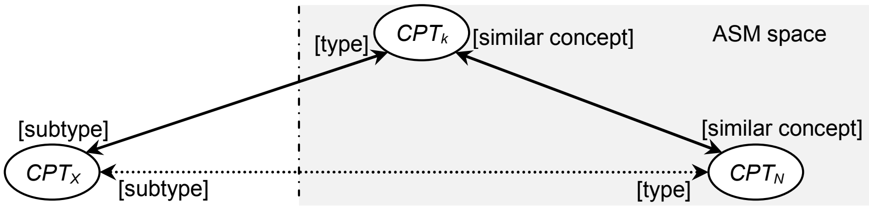

Figure 10. *The schema of decision making for the case with one "similarity" type association*

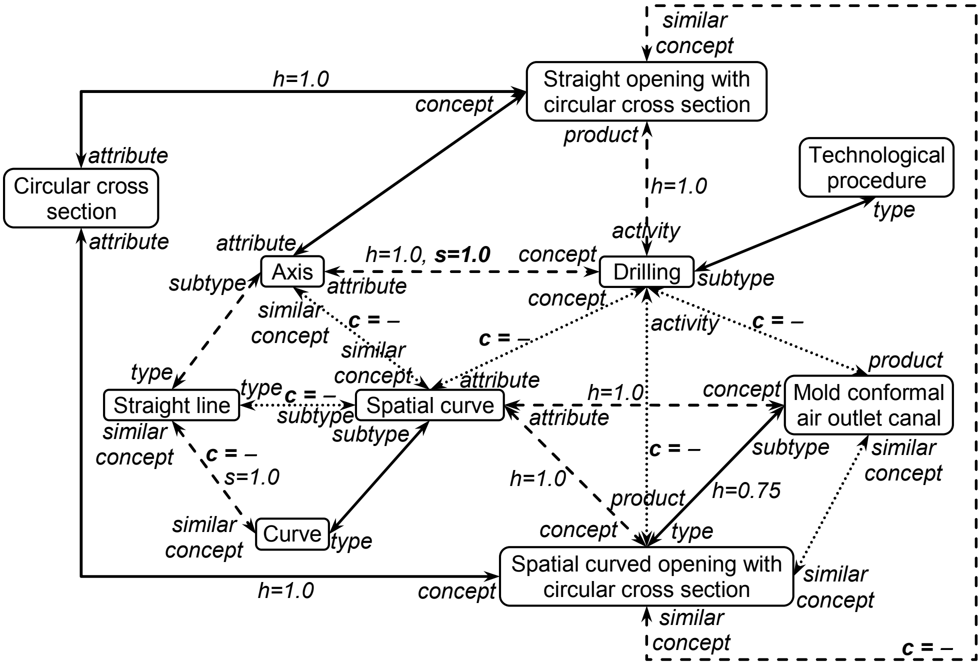

Figure 11. *Part of the ASM semantic network representing geometric and technological features of the mold air outlet canal. Associations represented with "square dot" line type are added based on the analysis of associations represented with "dash" line type.*

In the following reasoning iterations, negative character of the association between concepts "Spatial curved opening with circular cross section" and "Straight opening with circular cross section" will be reflected, in a similar way, on semantic relation between concepts "Spatial curved opening with circular cross section" and "Drilling". Finally, negative character of the association between concepts "Spatial curved opening with circular cross section" and "Drilling" will be reflected on semantic relation between concepts "Mold conformal air outlet canal" and "Drilling" (Fig. 11). The conclusion is that mold conformal air outlet canal can not be manufactured by drilling.

Mold conformal air outlet canals are present in tire tread mold (Fig. 12). Same canals are also present in the injection mold, but are here semantically described by concept "Mold conformal cooling canal". Association pair "Mold conformal air outlet canal”↔”Spatial curved opening with circular cross section”↔”Mold conformal cooling canal” will induce ASM to conclude that “Mold conformal air outlet canal” and ”Mold conformal cooling canal” are similar. Since mold conformal cooling canal can be manufactured by DMLS (Direct Metal Laser Sintering) (positive character), ASM will connect concepts “Mold conformal air outlet canal” and “DMLS” with the “product-activity” association of positive character, thus solving the caused by the disturbance of manufacturing process workflow.

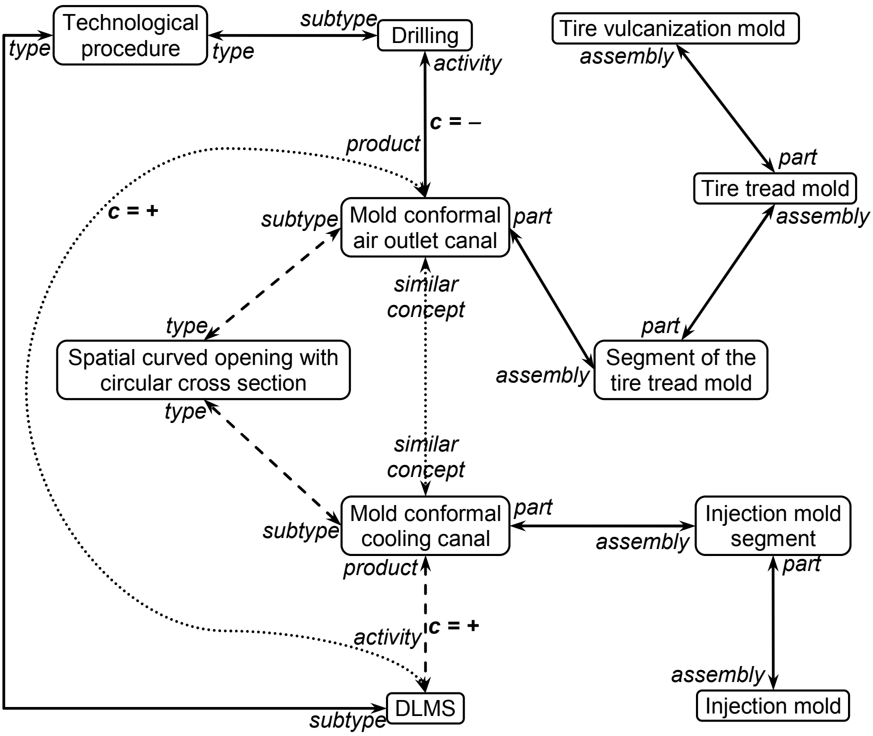

Figure 12. *ASM suggests technological procedure for “Mold conformal air outlet canal”*

Second case study demonstrates ASM ability to conduct semantic interpretation of geometric and technological features of *new*, i.e. *unknown* part, during the design process. In the first phase, after completing geometric modeling of the part using CAD package, user semantically describes part geometry by means of ASM semantic structures. In the second phase semantic description of *new* part geometry will serve as the input data package for cognitive processing which should result in semantic categorization of geometric and technological features of *new* and *unforeseen* part with regard to geometric and technological features of *known* parts, previously described and incorporated in ASM semantic network. In the last phase ASM cognitive data processing algorithms should demonstrate the ability to recognize applicable and relevant responses according, such as selection of adequate manufacturing (CAM) feature.

Unknown geometry is represented by user defined geometric feature: lateral rib on the tread ring of tire vulcanization mold (Fig. 13).

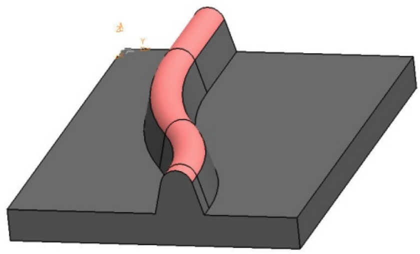

Figure 13. *Lateral rib – geometry whose semantic features does not exist in ASM semantic network*

Known geometry is represented by standard geometric feature – linear protrusion of the parquet rail cross section (Fig. 14).

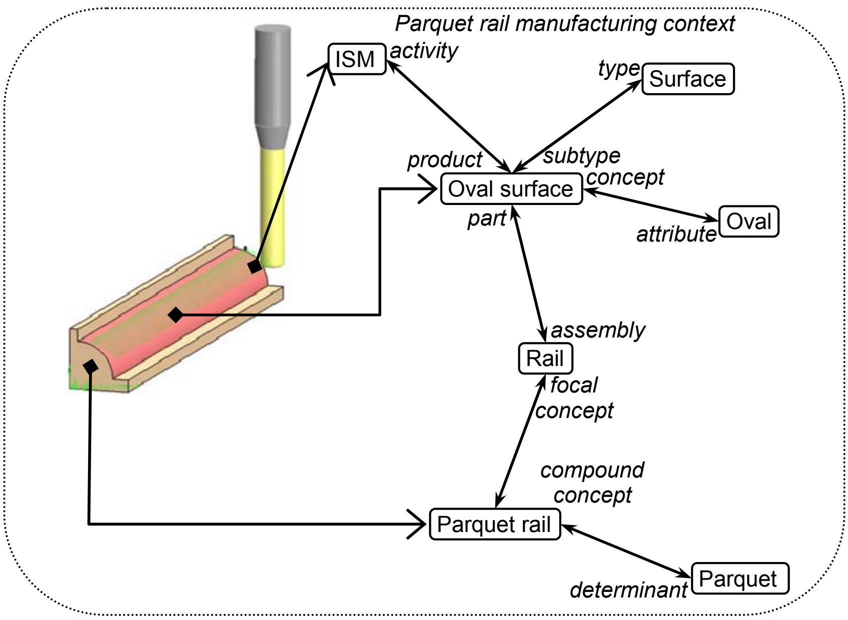

Figure 14. *Parquet rail – geometry whose semantic features exist in ASM semantic network*

The first step of semantic interpretation is introducing the input situation to ASM. In this step, the user creates initial set of associations between the concepts that represent semantic features of geometric elements of lateral rib CAD model and concepts that exist in ASM semantic network (Fig. 15).

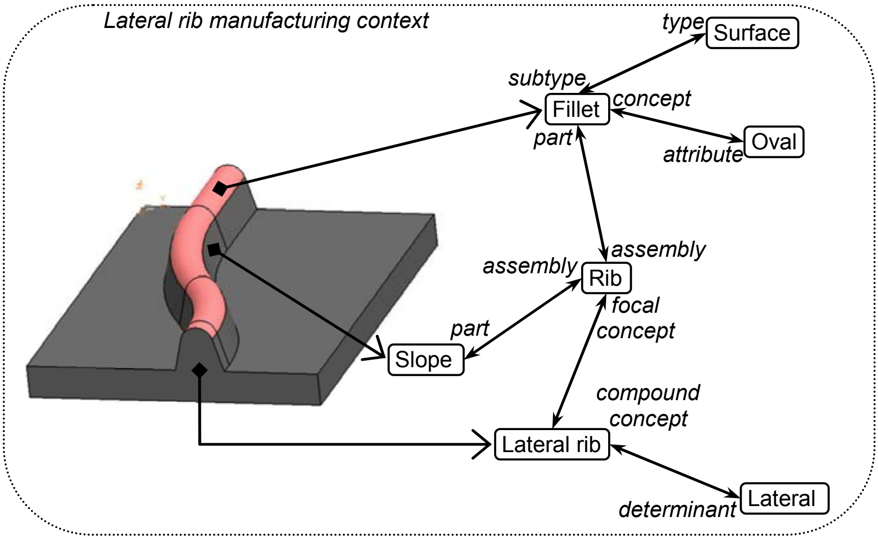

Figure 15. *Introducing unknown geometric element to ASM by creating associations*

Association plexuses representing knowledge about "Lateral rib" 3D model and "Parquet rail" 3D model are topologically analogous and semantically close (Fig. 16). TCA-s of these two association plexuses are represented by the same type of line, while TCC-s are represented by the same background pattern.

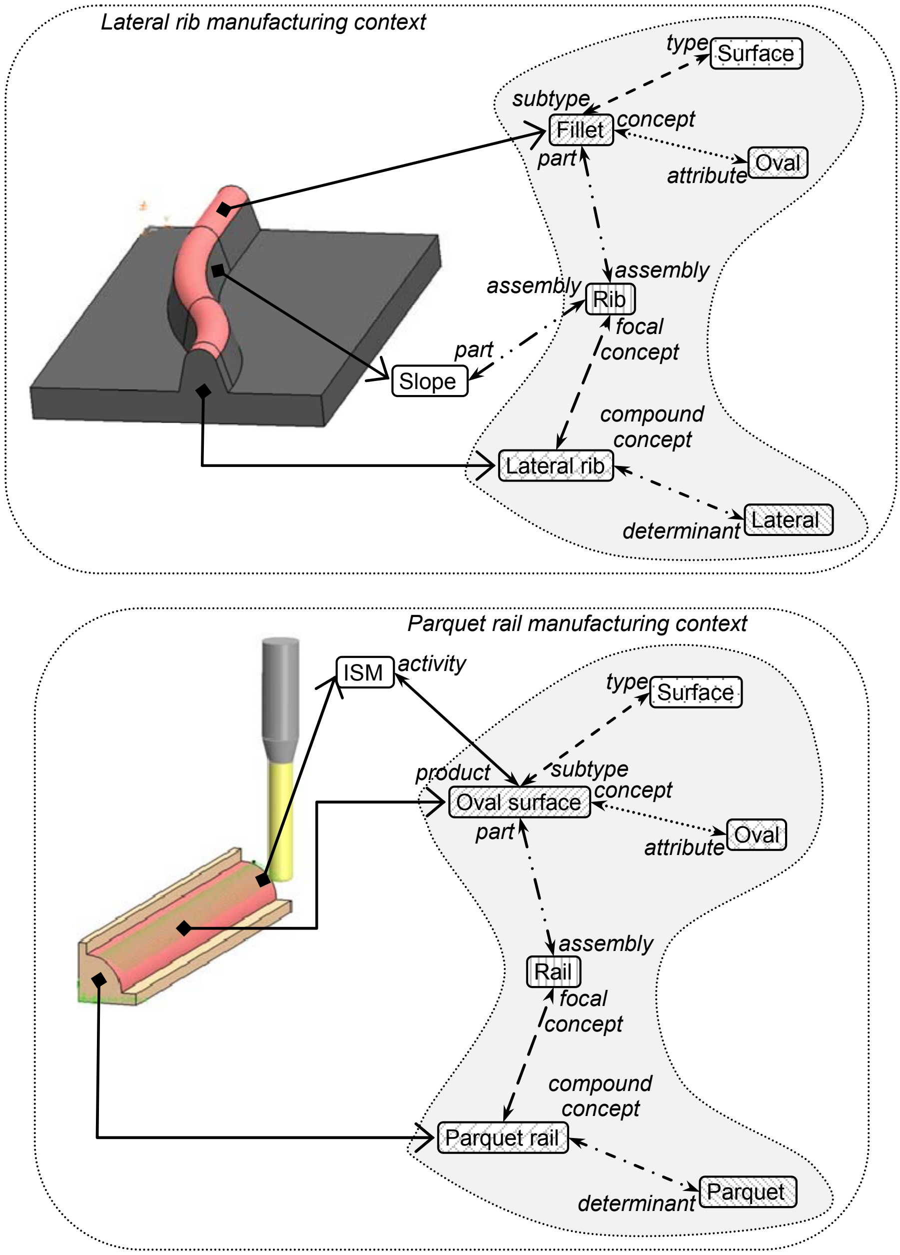

Figure 16. *Recognized topologically analogous and semantically close association plexuses - Subsets of "Lateral rib manufacturing" and "Parquet rail manufacturing" contexts. TCA are represented by the same type of line, while TCC are represented by the same background pattern.*

ASM tries to upgrade new association plexus modeled on the remainder of the "Parquet rail manufacturing" context. Concepts "Fillet" and "Oval surface" are topologically correspondent. Analysis of their *common* association pairs in

General context (Fig. 17 up) shows that they have associations of at least the same type toward *connectional* concepts ("Surface" and "Oval"). This will induce ASM to conclude that "Fillet" and "Oval surface" are similar (Fig. 17 up). ASM searches for concepts in the semantic network which are similar to concept "Fillet" from new association plexus, and are involved in associations which are topologically correspondent to associations from known association plexus. Since concepts "Fillet" and "Oval surface" are similar, ASM adds "product-activity" association between concepts "Fillet" and "ISM" (Isoparametric Surface Milling - ISM) (Fig. 17 down) as applicable and relevant response to input situation.

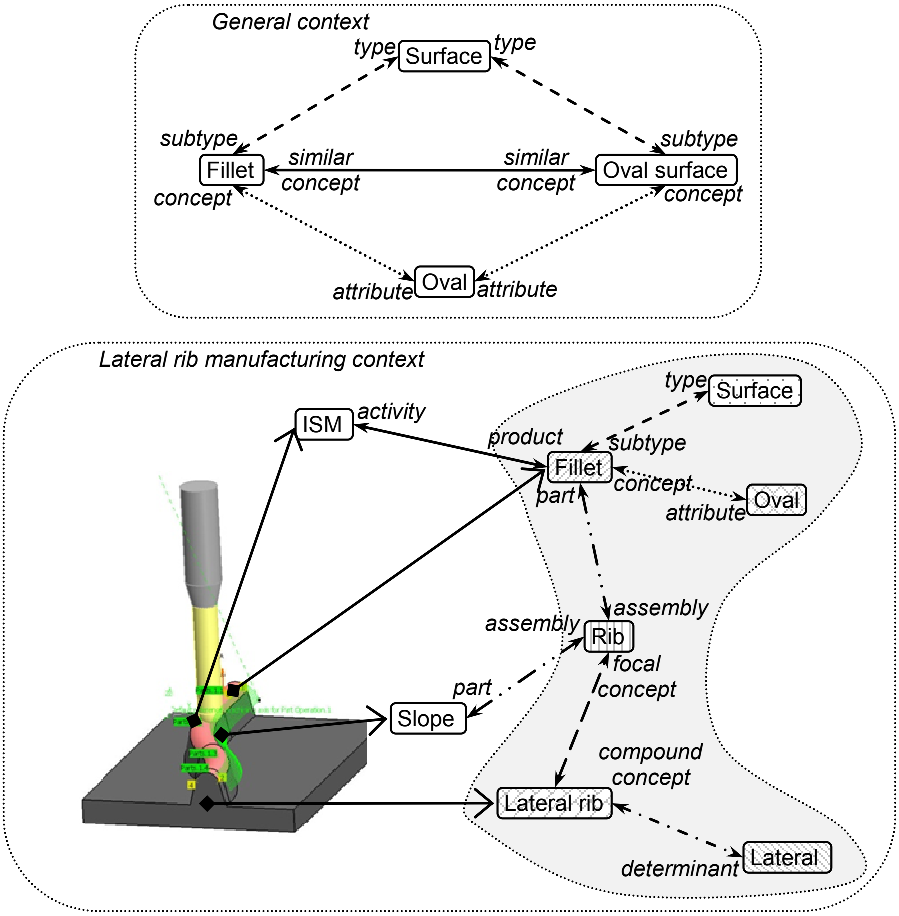

Figure 17. *ASM suggests manufacturing (CAM) feature for "Fillet"*

4. CONCLUSION

Active Semantic Model (and accompanying cognitive data processing procedures) have succeeded in carrying out the first three steps of semantic interpretation of product model data autonomously:

1. *Introduction* – initial associating of a new data set with the data that exist in the ASM semantic network,
2. *Recognition* – determining of similarity of associations between new and the known elements of the ASM's semantic network, and recognizing topologically analogous association plexuses,
3. *Categorization* – generating associations between new and known elements of the ASM's semantic network.

Developed functionalities of ASM create the possibility for the autonomous generation of relatively precise and useful assessments and predictions in situations with unpredicted input data package or input data package defined with insufficient precision.

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