DESIGN AND IMPLEMENTATION OF ONTOLOGY FOR MANUFACTURING REQUIREMENTS

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ABSTRACT

Product structure provides important information that has become a part of product manufacturing requirements in a real manufacturing field. Compared to reading and interpreting the 2D CAD engineering drawing manually, automated information extraction is the best way to provide product manufacturing requirements where a more precise and accurate extracted information are guaranteed. However, heterogeneity in engineering drawing produced anonymous terms that further become an occurring problem in automation process. Meanwhile, heterogeneity of product in engineering manufacturing causes the product structure data to be represented in different ways which further increases the complexity of product configuration. In order to solve these problems, we proposed a dynamic ontology named the Product Structure Ontology (PSO) whereby the engineering terms can be controlled and standardized, therefore eliminating the heterogeneity in engineering terms. The proposed PSO will also solve the problem of heterogeneity in engineering products through the annotation of the standardized terms with engineering products. We applied our PSO on automotive spring products. In this paper, we introduce a methodology that has been used to develop our PSO comprehensively by providing artifacts such as category, anatomy and scheme. Provided with these artifacts, the proposed PSO can be extended, reused and even duplicated into other products. The overview of the PSO annotation and its evidence are also presented in this paper. We also provide PSO resources including PSO website, browser, database availability and documentation. Lastly, the utilization and evaluation of PSO are presented.

Keywords  
Product Manufacturing Requirements, Product Structure, Ontology, 2D CAD Engineering Drawing.

1. INTRODUCTION

There has been much discussion in recent years about formalizing knowledge using ontology whether for general usage or specific domains. Noy and McGuiness [1] definition affirm that ontology defines a common vocabulary for researcher, who needs to share information in a domain of use. For more appropriate meaning, ontology is a category of things that exist or may exist in some domain. It is an explicit formal specification of the objects, concepts and other entities that are assumed to exist in some area of interest and the relationships that hold among them. In the context of Artificial Intelligence, we can describe ontology by defining a set of representational terms. As there are many concepts in product manufacturing requirements and it remains divergent among company, ontology becomes important to support the sharing and reuse of formally represented knowledge by explicitly stating concept, relations and axioms in this domain.

The best way to provide product manufacturing requirements is by information extraction of the 2D CAD engineering drawing compared to reading and interpreting the drawing manually. The information extraction for example involves table extraction and process identification to capture elements contained within 2D CAD engineering drawing table, geometric objects and its dimension respectively. By doing this, tendency to miss such indications can be avoided, thus information extracted is more precise and accurate. Also, inconsistencies in product manufacturing requirements caused by varying engineer’s experience and knowledge can be avoided. However, the occurring problem from the automation process is the existing of anonymous terms due to heterogeneity in engineering drawing. In this research, we are more focused on engineering terms used in 2D CAD engineering drawing and leaf spring product design in automotive manufacturing industry as our case study.

The rest of this paper is structured as follows: Section 2 describe the motivation of this work. Then, an overview of related work is given in section 3. The PSO Category, PSO Anatomy, PSO database schema, PSO annotation and its evidence will be presented in section 4 as well as the shared PSO resource including PSO website, browser, database availability and documentation. Finally, conclusion is presented in section 5.

2. MOTIVATION

PSO is a part of Manufacturing Requirement Management System (MRMS) project, funded by Zilun Systems Sdn. Bhd. under Malaysian Grant Scheme (vote no. 63681). This project development is about configuration of product, recognizing
manufacturing requirements and scheduling the production job according to production line availability and workstation capability for automotive manufacturing industry. PSO is a set of standard engineering phrases (terms) and a set of annotation between those terms and engineering products. It has been developed in order to answer the need for standardization of heterogeneous terms in engineering domain, and annotation was designed to solve the heterogeneity of product in product configuration. This ontology introduces concept related to product structure and the terms are displayed in the form of tree structure.

In manufacturing requirements field, heterogeneous of engineering phrases (terms) are used in 2D CAD engineering drawing. The usage of terms may be different between companies. It is dependent to the drawer of 2D CAD engineering drawing and company standard. For example, some company may use ‘shaping’ but some company may use ‘forming’ to refer to the same manufacturing process which is to change the shape or physical appearance of a material or part in creation of a product. Besides that, heterogeneous of product in engineering manufacturing might cause product structure data to be represented in different ways and make product configuration even more complex. In this study, we focus on three types of automotive leaf spring: multi-leaf spring, parabolic spring and air link spring. Although there are only three types of automotive leaf spring, but it has a varying product design and structure. Product design determines and specifies the parts of a product and their interrelationship [2], while product structure provides a hierarchical classification of the items which form a product. With the product structure, the understanding of the components which compose a product as well as their attributes can be represented. The product structure shows the material, component, parts, subassemblies and other items in a hierarchical structure that represents the grouping of items on an assembly drawing or the grouping of items that come together at stage in the manufacturing process.

3. LITERATURE REVIEW

Product Ontology (PRONTO) by Vegetti et al. [3] defines concept, relation among them and axioms to be applied in the complex product modeling domain. It is primarily related with complex product structure which involves an association of hybrid structures (combining composition and decomposition types of operation) to end product like in some food (milk and meat) and petrochemical industries. Another work which engages ontology in order to represent product was discussed by Lee et al. [4]. The study reports the effort to build an operational product ontology system for government procurement services which is designed to serve as a product ontology knowledge base. Thevenot et al. [5] presents their approach to retrieve and reuse relevant information when redesigning product. They used heuristics and shared ontological component information and proposed a framework to capture, store, retrieve, reuse and represent information for product family redesign using ontology, graph query, formal concept analysis, commonality assessment and genetic algorithm-based optimizer. As a reference to utilize ontology in manufacturing field, Manufacturing’s Semantic Ontology (MASON) proposed by Lemaignan et al. [6] aimed to draft a common semantic net in this domain. Their paper discussed a usefulness of ontology for data formalization and sharing, and shows the sufficiency of Web Ontology Language (OWL) for ontologies especially in manufacturing environment. Meanwhile, Lepratti [7] proposed an innovative ontology-based approach called Ontological Filtering System (OFS) to formalize natural language contents in a systematic way. They present a concept for improving the human-machine interaction by means of an innovative procedure for the processing of natural language instruction. Although ontology are now in widespread use, but the nature and the use of ontologies are unfamiliar. Therefore, Darlington and Culley [8] takes a practical approach through the use of example to clarify what ontology is and how it might be useful in an important and representative phase of the engineering design process. They discussed the use of ontology and explored a methodology for developing ontology. They also described the application of these ontologies for supporting the capture of the engineering design requirements.

From the literature review we gained insight of ontology concept and its use. These authors however, did not release their ontology design and consequently the developed ontology cannot be reused or duplicated to other products. To solve the problem of heterogeneity of terms and products, we come out with a dynamic ontology called Product Structure Ontology (PSO) in which the vocabulary can be controlled and standardized, making it suitable to be applied to all automotive spring products. Our methodology for developing the PSO is based on Noy and McGuinness methodology which has been modified based on its suitability. We also come out with two PSO artifacts called PSO Category and PSO Anatomy. Whereby, with these artifacts, the PSO can be extended and reused, duplicated into other product as well as its annotation being made in comprehensive and complete manners.

4. DISCUSSION

4.1 Methodology of Product Structure Ontology

The methodology to develop PSO consist 8 steps as shown in Figure 1. The first step is to determine ontology and scope. We accomplish this step by determining the domain of interest covered by PSO, establishing the ontology used and providing guidance as to the structure and content of the ontology. From this step, we can determine that the purpose of the PSO is to provide a knowledge context, which can assist in raising and answering the questions appropriate to completing the design requirement relating to the manufactured product. The second step is to enumerate important terms and this step is the starting-point for building this PSO. It consists of two tasks, which is identification of the key concept and relationships in the domain of interest, and production of unambiguous text definitions for such concept and relationships. The approach adopted for enumerating the terms for the PSO is conceptual mapping. Conceptual mapping refers to an informal process of brainstorming and discussion with domain experts to identify important concepts in manufacturing requirements of interest. The third step is to define PSO class and class hierarchies. This step consists of placing the selected concepts into some sort of hierarchical organization. We used a top-down approach to the development of the PSO class hierarchy. A top-down approach is essentially breaking down the category of knowledge to gain insight into its compositional sub-category. In a top-down approach, an overview of the knowledge is first formulated, specifying but not detailing any first-level category. Each sub-category is then refined in yet greater detail,
sometimes in many additional sub-category levels, until the entire specification is reduced to base elements. In PSO development, we firstly define the first-level category of knowledge namely “product-specific knowledge”, “industrial-specific knowledge” and “generic-term”, next we detailed out the knowledge with their sub-category and define their child. The fourth step is creating class instances. Creating an individual instance of a class means specifying the actual value of a specific instance of the class. This step is executed to make sure the knowledge about the real world can be captured. These four steps consist of designing PSO in Protégé-owl editor [9] as shown in Figure 2 before the PSO in MySQL format is created. The following steps involves design of PSO database schema, create an evidence code, create an annotation and finally, developing a browser of PSO. The details of these steps are given in the next section.

**Figure 1. The methodology adopted to develop the PSO.**

**Figure 2. PSO design in Protégé-owl editor.**

PSO are structured as a hierarchical directed acyclic graph (DAG). DAGs can be considered to be a generalization of trees in which certain sub-trees can be shared by different parts of the tree. It means that terms can have more than one parent and zero, one or more children. As illustrated in Figure 3, ‘P90731’ (PSO:050432) is a spacer and it can be a part-of two spring product, ‘14-280’ (PSO:010276) and ‘14-126’ (PSO:010275). In the meantime, components can have more than one children like ‘centre-nut’ (PSO:050260) and “spacer” (PSO:050268). Meanwhile, two different products, ‘UH7128L10C’ (PSO:010277) and ‘14-280’ (PSO:010276) share the same engineering process term ‘shearing’ (PSO:030062). The figure also shows how the three types of automotive leaf spring with their diversity of product structure are represented in PSO.

**Figure 3. The PSO in DAG representation.**

### 4.2 The Proposed PSO

Knowledge in product structure ontology is represented by terms in manufacturing engineering. These engineering terms are usually related to the concept of engineering material, manufacturing process, component, machine, tool and die, and product attributes or product characteristics. It also relates to the concept, which is known as a unit of measures. We design knowledge categories for these concepts so it can be kept in a form that is more systematic and easy to be achieved, as well as forming a standard for these engineering terms. The three main categories of knowledge in PSO are: “product-specific knowledge”, “industry-specific knowledge” and “generic-term”.

The product-specific knowledge relates to the item produced in the factory. According to the concept of product structure, terms in this category are used to provide overview of the product and it
is typical information to higher level assembly in a Bill-ofMaterials (BOM). The product-specific knowledge contains standard and general information about the product like ‘part name’ (PSO:010001), ‘part no’ (PSO:010002), ‘drawing number’ (PSO:010003), ‘product type’ (PSO:010004), ‘model’ (PSO:010006), ‘mass’ (PSO:010007), ‘drawn’ (PSO:010008) and ‘unit’ (PSO:010011). Figure 4 illustrates the product-specific knowledge.

Industry-specific knowledge relates to process and all products within the same industry. The industry-specific knowledge contains a concept of engineering material, manufacturing process, component, machine, tool and die. These concepts are required to meet a demand of manufacturing requirements in the production plan activities. For example ‘metals’ (PSO:020012), ‘steels’ (PSO:020022), ‘aluminium’ (PSO:020026) ‘oxy cutting’ (PSO:030091), ‘center hole punching’ (PSO:030092), ‘diamond cut’ (PSO:030096), ‘rivets’ (PSO:050267), ‘spacer’ (PSO:050268) and ‘silencer’ (PSO:050269) are terms in this category of knowledge. Figure 5 illustrates the industry-specific knowledge.

Generic-term relates to general design knowledge. General design knowledge contains a general concept like unit of measures (UoM) and product attributes or characteristics. The UoM are used as a metric system to represent the measure of dimension, length and weight of products. Terms in product characteristic usually are used to identify the features of the product. For example terms under UoM are ‘meter’ (PSO:080281), ‘kilogram’ (PSO:080278) and ‘radius’ (PSO:080280). On the other hand, terms under product characteristics are ‘length’ (PSO:070189), ‘width’ (PSO:070224), ‘thick’ (PSO:070223) and ‘height’ (PSO:070225). Figure 6 illustrates the generic-term.

4.3 PSO Anatomy and Schema
PSO is not only just a flat list of engineering terms, as there are set of terms which are related within a hierarchy. Some terms, especially lower-level, are detailed terms and specific to a certain group of knowledge. Terms are linked by three relationships, subsumption “is-a”, meronymy “part-of” and association relationship. The is-a relationship is a simple sub-class relationship, where A is-a B means that A is a subclass of B. For example ‘extruding’ (PSO:030055) is-a ‘process’ (PSO:030000) in product manufacturing and ‘process’ is-a industry-specific terms. The part-of relationship refers to when a child is a component of the parents. For example ‘P20012’ (PSO:050420) is part-of ‘14-280’ (PSO:010276). To make the most precise definitions, new terms should be placed as children of the parent that is closest in meaning to the term. Logically, everything that exists is a sub-type of something else. The association relationship has a purpose to logically relate one concept to another concept. Examples are is-machinable-by-process (between a material and process), enable-realisation-of (between a machine and process), has-characteristics (between process and characteristics) and has-capability (between machine and process).

PSO terms have attributes like unique term ID, term name, definition, synonyms and category of knowledge. To make the most complete definitions, terms should have these entire attributes. For example, a term name ‘casting’ will have PSO:03053 as term ID. Its definition would be “Casting can be described when a molten metal is poured into a mold. The mold is a cast of the desired shape. Once the molten material has cooled, it will have produced the desired form”. Meanwhile, ‘Molding’ would be the synonym and industry-specific would be the category of knowledge. Figure 7 illustrates the overview of PSO anatomy while Table 1 list attributes of PSO terms as well as its example.

PSO in the form of PSO terms and data annotation are stored in a relational database for a more robust representation and query capabilities [10]. Seven tables are involved, namely onto_term, onto_evidence, onto_category, onto_parents, onto_annotation, onto_synonym and onto_product. The terms constituting the nodes in an ontology graph represent the kinds of entities that exist within the domain of this ontology. These terms are stored in the central tables, onto_term. Note that, the relations are also stored in the same table. Table named onto_evidence is used to store the evidence and their code while categories of knowledge are stored in onto_category. Table onto_parents are used to store the classification of terms and annotations are kept in onto_annotation table. The relationships of the synonym of the
terms are stored in onto_term_synonym. It can be noted here that PSO synonym may be broader or narrower than the term string: (i) it may be a related phrase; (ii) it may be alternative wording, spelling or use a different system of nomenclature; or (iii) it may be a true synonym. Table named onto_product is used to store the engineering product. The database structure scheme is illustrated in Figure 8.

4.4 PSO Annotation

Annotation is the process of assigning PSO terms to engineering products. It annotates the PSO terms from onto_term and engineering product from onto_product and then stored them into onto_annotation. The purpose of PSO annotation is to view the relationship between PSO terms and manufacturing product and to analyze the usage of shared terms between products. For example, the usage of term ‘bending’ (PSO:030060) identified in several product 48110-3V700, 48110-3V780 and 48150-2130A through annotation. For now, PSO only allow annotation work to be done in manual method. The annotation data in the PSO database can be added to make PSO more comprehensive and complete. The annotation works in PSO according to two general principles: (i) annotations should be attributed to a source; and (ii) each annotation should indicate the evidence on which it is based.

As an example, consider a component from “industry-specific” terms, ‘centre bolt’ (PSO:050259) was annotated to engineering product 1-51130-023-Z, 2912QAM-010A, 48110-3V700 . This shows that these engineering product shares one type of component, the ‘centre bolt’ (PSO:050259). Another example, a process ‘shearing’ (PSO:030062) also shared by different products 48210-3V610 , 48210-3V620 and others. It helps in recognizing components in products and which process involved in delivering the product. This annotation helps solve the problems of heterogeneity of product by relating these products through terms sharing.

4.5 PSO Evidence

A PSO annotation consists of a PSO term associated with a specific reference that describes the work or analysis upon which the association between a specific PSO term and engineering product is based. Each annotation must include an evidence code to indicate how the annotation to a particular term is supported. However, evidence codes are not statements of the quality of the annotation. Within each evidence code classification, some methods produce annotations of higher confidence or greater specificity than other methods, in addition the way in which a technique has been applied or interpreted in a paper will also affect the quality of the resulting annotation. Thus, evidence codes cannot be used as a measure of the quality of the annotation. Listed below are the evidence codes along with its type:

- ITD Inferred from Technical Documentation.
- TAS Traceable Author Statement.
- NAS Non-traceable Author Statement.
- IDE Inferred by Domain Expert Statement.
- ND No Engineering Data Available.

ITD evidence code refers to annotations made from reviewed papers, documentation or report paper of the engineering manufacturing company. The name of company issuing the documentation must be attached. TAS refers to annotations on the basis of a statement made by the author(s) in the reference cited which has the author(s)’s name mentioned while NAS is used if the author(s)’s name is/are not mentioned. The IDE evidence code is to be used for cases where an annotation was created based on domain expert statement and ND evidence code was created for
annotation that does not fit into any of the available classifications.

For example, annotation of PSO term, ‘centre bolt’ (PSO:050259) with engineering product 1-51130-023-Z is supported by evidence code ITD. This PSO term and engineering product association is based on reference “APM: Manufacturing Standard Quality Control”.

4.6 The Shared PSO Resource

4.6.1 The PSO Website

The PSO website available at http://productstructureontology.uuuq.com/index.html provides information about PSO, downloadable versions of the ontology and PSO annotation. The PSO vocabulary exists in MySQL that provides the data for the ontology browsers. The main interface of PSO website is illustrated in Figure 9. The PSO website can be used by the community to access the PSO vocabularies and PSO annotation dataset (http://productstructureontology.uuuq.com/download.html). We believed that a shared development of this PSO will contribute to the centralization of manufacturing requirements information. Since PSO is new, PSO welcomes input from users in order to enrich knowledge in this domain. The detailed information on how to contribute to PSO data and PSO data annotation is available at http://productstructureontology.uuuq.com/about.html.

4.6.2 The PSO Browsers

The PSO browsers are now available at http://productstructureontology.uuuq.com/browser.html for the PSO vocabularies. The Java-based PSO browser provides interface to the ontology that allows user to use PSO tree to query the database. The PSO uses frames to display results, the first frame display PSO tree which displays the relationship of the terms results to all of its parent and child term. The second frame is created to display full information (including the definition, any synonym and PSO category) for a single term that the user has selected and yet another frame to display PSO annotation. The main interface of PSO browser is illustrated in Figure 10.

4.6.3 The PSO Database

The PSO and the PSO annotations have been loaded into relational database. Implemented in MySQL for a more robust representation and query capabilities, PSO data consist of terms and their information, synonym, product and annotation. The size of PSO data (as November 2008) is shown in Table 2. The scheme of PSO database is available at http://productstructureontology.uuuq.com/scheme.html.

4.6.4 The PSO Documentation

General information to guide users is available at http://productstructureontology.uuuq.com/doc.html. Guidelines for ontology category, ontology annotation and evidence code to support annotations and database guide is also available from this page.

5. THE UTILIZATION OF PSO

The existence of synonymous terms in 2D CAD engineering drawing has been a challenge in information retrieval. For example, the terms ‘mass’ and ‘weight’ has a totally different keyword but it was refer to the same meaning. The conventional approach based on keyword matching is not capable to solve the problem. Therefore, a semantic similarity searching is needed. The semantic similarity searching use the PSO as knowledge based. Currently, there are three approaches involving semantic similarity searching, which can be categorized as information content approach [11-12], distance approach [13-15] and the combination of these approach namely hybrid approach [16-17]. In information retrieval, semantic similarity searching has ability to improve the recall and precision where it’s not only just return the information which have the same keyword but also return other concepts which have semantic relation with the query. For example, the semantic similarity searching capable to compute the relationship between manufacturing process “Diamond Cut” and machine “Shie Yih Press (F28)” even the terms are not exactly match or approximately match in terms of their keyword.

5.1.1 Information Content Approach

Information content approach is a node based approach to determine the conceptual similarity between PSO terms. The similarity between two concepts is defined based on to which they share information in common according to the subsumption “is-a”, meronymy “part-of” and association relationships. The similarity value is defined as an information content value of the
specific super-ordinate class which considering the hierarchical concept space. The information content approach was introduced by [12] and has been experimentally proven that it is significantly better than distance approach. The value of the information content (IC) of PSO terms can be quantified by using the formula as follows:

$$IC(c) = \log^{-1} P(c)$$ (1)

where $P(c)$ is the probability of a PSO term occur in the PSO relationships. IC is negative logarithm of the PSO term’s probability. The probability $P(c)$ using taxonomy concept where the probability of root for the node is 1 and if $c_1$ is-a $c_2$, then $p(c_1) \leq p(c_2)$. This approach is not only consider the “is-a” relationships likes many distance approach (Jiang and Conrath, 1997; Lee et al., 1993; Rada et al., 1989) but it is also use all the three types of relationships: “is-a”, “part-of” and association relationships. The PSO term’s probability can be computed using maximum likelihood estimation (MLE):

$$P(C) = \frac{freq(c)}{N}$$ (2)

where $freq(c)$ is the number of times that PSO term $c$ and all its descendants occur in the ontology while $N$ is the total number of occurrences in the PSO relationships.

$$freq(c) = \sum_{n \in term(c)} count(n)$$ (3)

where $term(c)$ is the set of PSO terms subsumed by the PSO term $c$. Using the information content (IC) of PSO terms, the similarity between two PSO terms can be determine as:

$$sim(c_1, c_2) = \max_{c \in Sup(c_1,c_2)} [IC(c)]$$ (4)

where $Sup (c_1,c_2)$ is a super class that subsume both PSO terms $C_1$ and $C_2$. The similarity value for those terms is IC value for that super class.

5.1.2 Semantic Similarity Searching

An overview of the semantic ontology-based searching algorithm is shown in Fig. 11. This algorithm takes a PSO term, PSO synonym and a set of engineering terms produce by Engineering Drawing Extraction (EDEx) as an input. It returns a set of PSO terms with assigned semantic similarity score that have higher semantic similarity score. This algorithm starting by calculate the frequency, probability and Information Content of PSO terms in order to make calculation of the semantic similarity score can be done in a faster and easier manner. The frequency, probability and information content of the PSO terms are constant as long as the content of PSO terms, their taxonomy and relationship is not change.

6. PERFORMANCE MEASUREMENT

The performance of PSO-EDEx is measured by the accuracy of the result presented in terms of recall and precision. Recall is the fraction of the PSO terms that are relevant to the query engineering terms that are successfully retrieved. It is a measure of completeness and defined as the number of relevant PSO terms retrieved by a search divided by the total number of existing relevant PSO terms (which should have been retrieved). This means that recall is the probability that a (randomly selected) relevant PSO term is retrieved in a search. A perfect Recall score of 1.0 means that all relevant PSO terms was retrieved by the
search. It is trivial to achieve recall of 100% by returning all PSO terms in response to any query. Therefore, recall alone is not enough but one needs to measure the number of non-relevant PSO terms also, for example by computing the precision. Below are the simple and widely used evaluation measures for recall:

\[
\text{Recall} = \frac{|\text{relevant PSO terms} \cap \text{PSO terms retrieved}|}{|\text{PSO term retrieved}|}
\]

(3.1)

Precision is the probability that a (randomly selected) retrieved PSO term is relevant. It is defined as the number of relevant PSO terms retrieved by a search divided by the total number of PSO terms retrieved by that search and can be seen as a measure of exactness or fidelity. A perfect precision score of 1.0 means that every result retrieved by a search was relevant.

\[
\text{Precision} = \frac{|\text{relevant PSO terms} \cap \text{PSO terms retrieved}|}{|\text{relevant PSO terms}|}
\]

(3.2)

7. CONCLUSION

Ontology plays a central role in formalizing manufacturing requirements knowledge. Our current development efforts focus on the PSO and PSO annotation presenting concepts involved in the manufacturing requirements domain that are primarily related with the product structure. This paper consists of a brief overview about PSO such as its domain, the development methodology and its evidence. Furthermore, the shared PSO resource including PSO website, browser, database availability and documentation is its evidence. Then, PSO anatomy give overview about the relationship between terms, terms attributes and PSO database schema is also presented. It is followed by description about PSO annotation and its evidence. Furthermore, the shared PSO resource including PSO website, browser, database availability and documentation is given. The utilizing and performance measurement of the proposed method are also presented.

We expected the vocabulary development to be ongoing as we create a resource that can accommodate changes in our understanding of manufacturing requirements. For future work, we wish to focus on PSO application in order to identify the anonymous term produced by 2D CAD engineering drawing extractor. This identification process is important to determine their position in product structure. For the extended PSO, additional enhancement includes the ability to support various types of product and effort on the creation of a PSO annotation tools to automate the annotation work.

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9. REFERENCES

