Manufacturing Feature Library as a Manufacturing Information Management System for Process Planning

[1]Hendry MULJADI, [2]Keiichi KITAJIMA, [1]Hideaki TAKEDA, [2]Koichi ANDO

[1]National Institute of Informatics, [2]Shibaura Institute of Technology
[1]2-1-2, Hitotsubashi, Chiyoda-ku, Tokyo, Japan, [2]3-7-5, Toyosu, Koto-ku, Tokyo, Japan
hendry@nii.ac.jp

Abstract

A manufacturing feature can be defined simply as a geometric shape and its manufacturing information to create the shape. For the generation of process plans in a manufacturing feature-based process planning system, it is necessary to develop a manufacturing feature library that consists of pre-defined manufacturing features and the manufacturing information to create the shape of the features. In other words, manufacturing feature library plays an important role for the extraction of manufacturing features with their proper manufacturing information. However, to manage the manufacturing information flexibly, it is important to build a manufacturing feature library that is easy to manage. In this paper, the implementation of Semantic Wiki for the development of the manufacturing feature library as the manufacturing information management system is proposed.

KEY WORDS : manufacturing feature, manufacturing feature ontology, feature library, process planning, Wiki, Semantic Wiki, RDF

1 Introduction

Process planning plays an important role in the manufacturing cycle as it determines how a product is to be manufactured. It is also important to emphasize that almost any industrial inquiry concerning the manufacturing process such as floor space, due dates, lead time, work in process etc, addresses process planning as a data source (Halevi, 2003). However, manual process planning is time consuming, labor intensive and may involve human errors (Elmaraghy, 1993). In order to solve these problems, Computer Aided Process Planning (CAPP) as a means to support humans effectively to generate process plans has been a research topic for over 35 years (Luttervelt, 2003).

In the context of CAPP system development, feature technology has emerged as the enabling technology to convert CAD product data to manufacturing information (Han & Rosen, 1998). A manufacturing feature can be defined simply as a geometric shape and its manufacturing information to create the shape. Many different approaches have been developed to extract features from the CAD product data (Subrahmanyam, 2002). However, most feature recognition methods only deal with the automatic extraction of geometric shape from the CAD product data.

For the generation of process plans, it is necessary to deal with the extraction of proper manufacturing information to create the shape. For the extraction of manufacturing features and their manufacturing information, it is necessary to develop a manufacturing feature library that consists of pre-defined manufacturing features and the manufacturing information to create the shape of the features (Kanamaru, Ando, Muljadi & Ogawa, 2004). The manufacturing information consists of the required machine and tool data, the estimated cost and time data, etc (Scallan, 2004). However, managing manufacturing information is not an easy task. A manufacturing feature library needs to be easily modified or customized, since manufacturing technology is progressing and facilities available in an industrial plant may not be the same as the other.

In this paper, the implementation of Semantic Wiki for the development of the manufacturing feature library is proposed. The structure of this paper is as follows. Section 2 describes MewKISS, the Semantic Wiki engine used for the manufacturing feature library. Section 3 describes the implementation of MewKISS for the development of the manufacturing feature library. Section 4 states the conclusions drawn from this research.

2 MewKISS

2.1 Extending MediaWiki

MewKISS is an abbreviation for MediaWiki with Simple Semantics. The word "KISS" is written with full capital letters to stress that the proposed Semantic Wiki is developed by following the KISS principle that stresses simplicity. The word "KISS" is originally an abbreviation for "Keep It Simple, Stupid!" or "Keep It Short and Simple".

MediaWiki is the Wiki software used for the development of MewKISS. MediaWiki has the category management function that allows a Wiki page under the namespace ("Category:") to be used as a metadata. Metadata is simply defined here as data about data (Takeda, 2004). This function allows user to create class-sub-class relation and class-instance relation of Wiki pages. However, the metadata cannot be processed nor manipulated easily by computer applications.

Using the existing category management function as a reference, MediaWiki is extended. The extension has enabled MediaWiki to write labeled links. In other words, the extension has enabled MediaWiki to write Resource Description Framework (RDF) statement, which consists of subject-predicate-object triple. RDF is a language to express metadata about information resource on the Web proposed by the WWW Consortium (W3C) (Miller, Swick & Brickley, 2004). RDF has a simple data model that is understandable by human and is easy for computer applications to process and manipulate.

The Wiki syntax to write the RDF triple is [[Term:target_page|property]]. The RDF triple is <source_page><property><target_page>. Each time the Wiki syntax is used, the Wiki engine will store the RDF triple into a table in the Wiki database.

Fig.1 shows the example of the Wiki syntax writing on a Wiki page. The Wiki page on which the syntax is written will become the source page of the RDF triple. Figure 2 illustrates an RDF triple that is stored in the new table of the Wiki database. Figure 3(a), (b), (c) show how the labeled link relations are displayed on the source page, target page and property page respectively. Displaying labeled link relation allows users to navigate the relation between pages easily. And since the original MediaWiki can be used for a collaborative content management, MewKISS can be used as a collaborative and integrated content and metadata management system (Muljadi & Takeda, 2005).

Fig.1 Wiki syntax to write the labeled link: [[Term:target_page|property]]

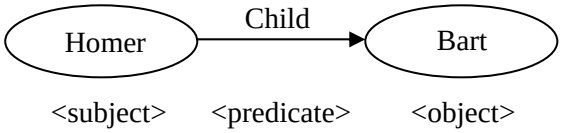


Fig.2 RDF Triple

(a) Display of the source page ->property page->target page

(b) Display of the target page <-property page<-source page

(c) Display of the property page source page->target page

Fig.3 Display on the Wiki pages

2.2 Mapping to other Semantic Web Applications

Enabling MediaWiki to write labeled links with simple syntax allows users to create and manage relations between Wiki pages easily and flexibly. The writing of labeled links allows users to write and edit RDF triples even though users have no knowledge about it.

Fig.4 shows the overall structure of MewKISS. By converting the RDF triples stored in the MewKISS database into XML-encoded RDF data format, the RDF triples can be exported to RDF database such as Sesame. Using Sesame, users can explore the exported RDF triples (see Fig.5), make queries etc (Broekstra & Kampman, 2004). Sesame can also bridge MewKISS to other Semantic Web applications. In other words, metadata created in MewKISS environment can be mapped to other Semantic Web applications.

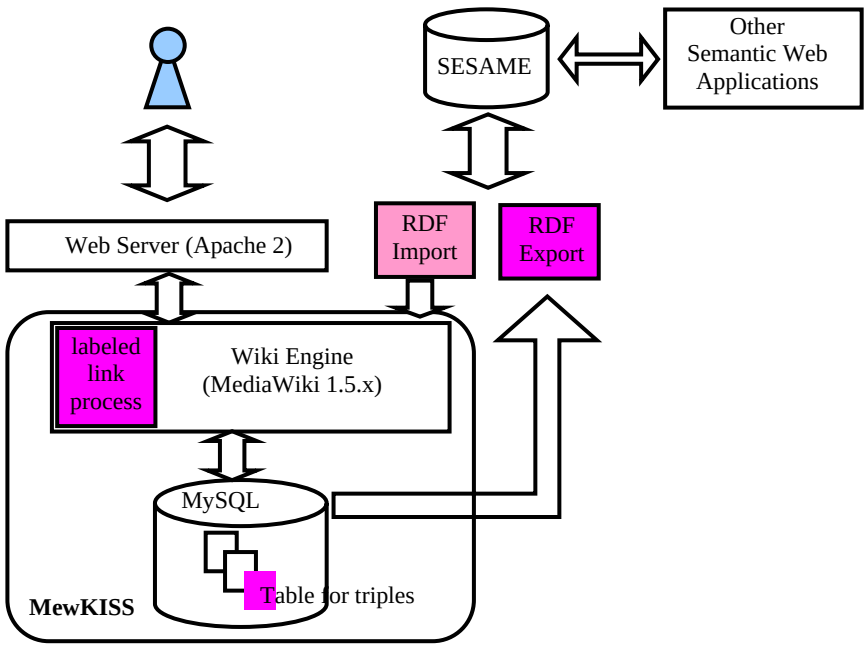
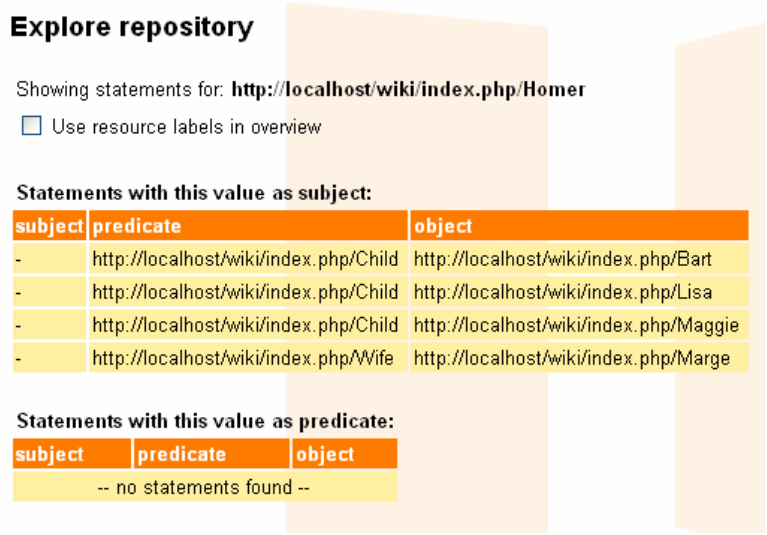


Fig.4 The overall structure of MewKISS

(a)



(b)

Fig.5 Exploring the RDF repository

3 Manufacturing Feature Library

3.1 The Structure of the Manufacturing Feature Library

For the development of the manufacturing feature library, manufacturing feature ontology is created as the structure of the library (see Fig.6). This lightweight ontology is created as follows.

(1) Level 0: Ontology name
(2) Level 1: Manufacturing features such as step, slot etc are listed up. The manufacturing features used in this research are based on the library proposed by CAM-I (Butterfield, Green, Scott & Stoker, 1988).
(3) Level 2: Sub-classes of the manufacturing features classes in level 1 are created by describing the manufacturing methods to create the shape of the parent classes.
(4) Level 3: Sub-classes of the classes in level 2 are created by describing the tool types required for the manufacturing method. Some feature classes in level 2 may have no sub-class.

(5) Instances of the lowest classes are created. Each instance contains specific manufacturing information, such as machine type, tool type, machining speed.

Since manufacturing technology is progressing and facilities available in an industrial plant may differ to other plant, the classes of the manufacturing feature ontology may need to be changed or updated. In other words, an easy-to-modify environment is necessary to develop and manage the manufacturing feature library.

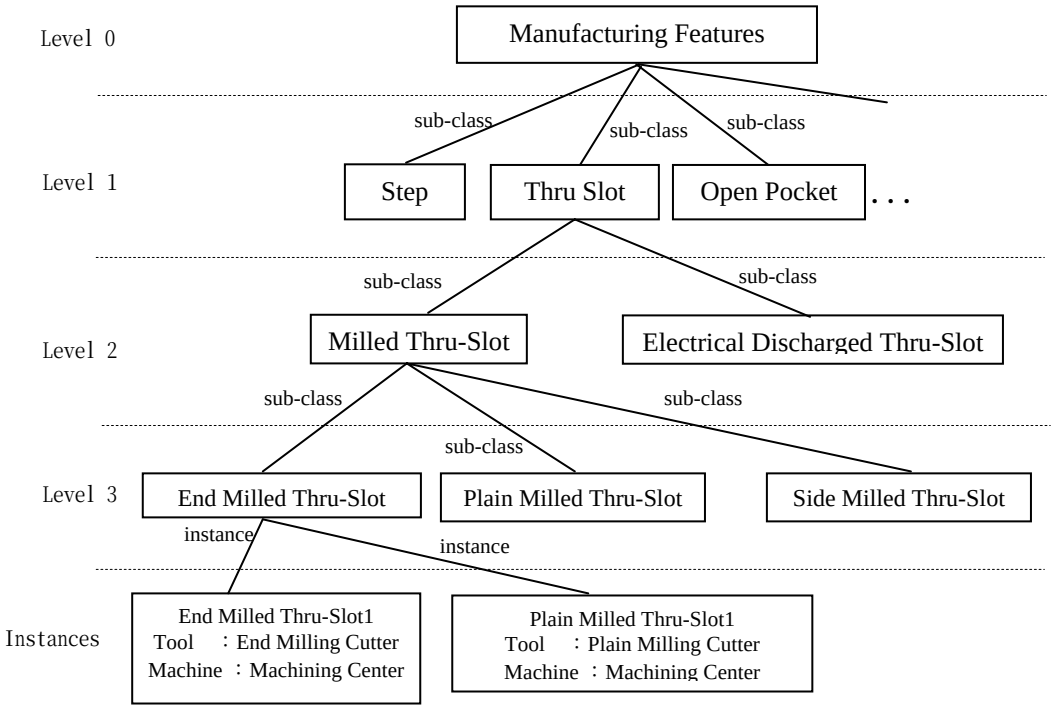


Fig. 6 Manufacturing feature ontology

3.2 Implementation of MewKISS

For the development of the manufacturing feature library, further extension of MewKISS is done. Fig.7 shows the illustration of the manufacturing feature library. A new namespace (“MF:”) is created to deal with the manufacturing feature classes. A new table is also created in the MewKISS database to deal with the new namespace. Each instances of the lowest class of the manufacturing feature is handled as a page without namespace in the Wiki environment. The manufacturing information is also handled as a Wiki page without namespace.

The Wiki syntax [[MF:feature_subclass|subclass]] is used to create class-sub-class relations of the manufacturing feature ontology (see Fig.8). When the Wiki syntax is written on the parent class page, MewKISS will display the labeled link relations as follows.
(1) On the parent class page: -> subclass -> feature_subclass.
(2) On the feature_subclass page: <- subclass <- parent class.
(3) On the subclass page: parent class -> feature_subclass. “MF:subclass” page can be used to check all the class-sub-class relations existing in the manufacturing feature library (see Fig.9).

For the class-instance relation of the manufacturing feature ontology, Wiki syntax [[Term:instance_page|instance]] is used (see Fig.10). When the Wiki syntax is written on the manufacturing_feature_class page, the Wiki engine will display the labeled link relation as follows.
1) On the manufacturing_feature_class page: -> instance -> instance_page
2) On the instance page: <- instance <- manufacturing_ feature_class
3) On the “instance” page: manufacturing_feature_class -> instance_page

On the instance page, relation with manufacturing information can be written using the Wiki syntax [[Term:manufacturing_information|property]] (see Fig.11). Metadata of the manufacturing information can also be created easily using the similar Wiki syntax.

Thus, using the modified MewKISS, users can manage the relation between manufacturing features and manufacturing information, as well as the metadata of the manufacturing information easily.

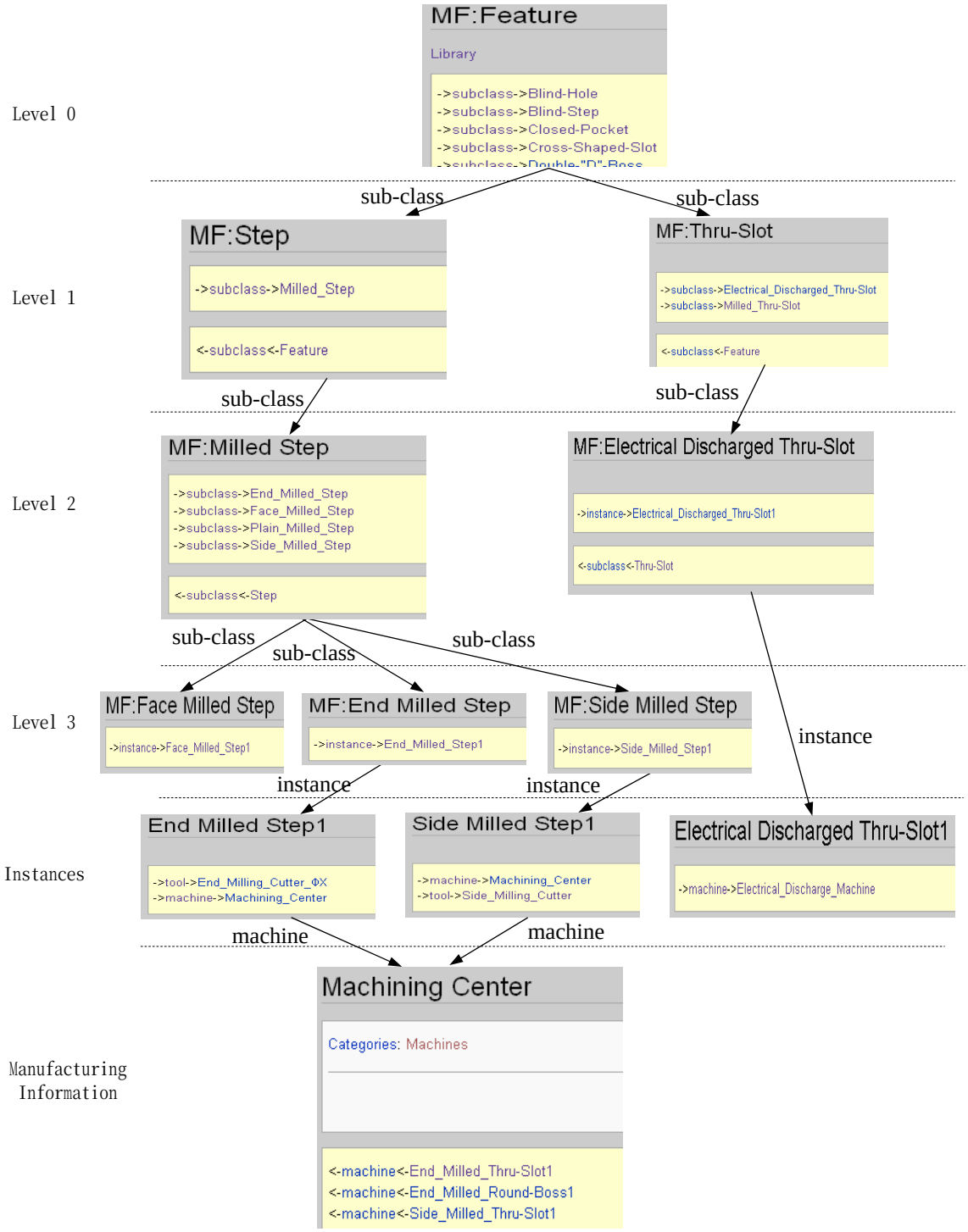


Fig. 7 Illustration of the manufacturing feature library.

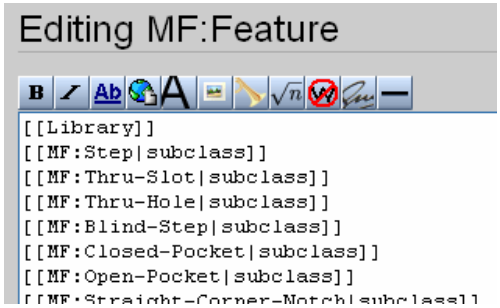


Fig.8 Writing the Wiki syntax: [[MF:feature_subclass|subclass]]

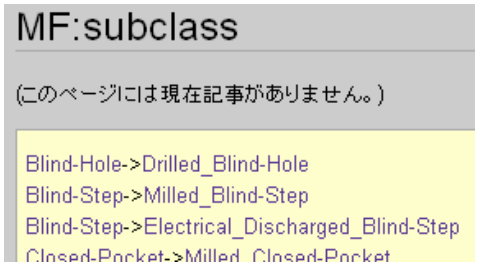


Fig.9 MF:subclass page

Fig.10 Writing the Wiki syntax: [[Term:instance_page|instance]]

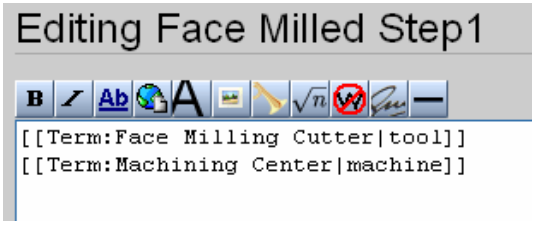


Fig.11 Writing the Wiki syntax: [[Term:manufacturing_information|property]]

3.3 Discussion

As shown in Section 3.2, the modified MewKISS provides an environment where users can manage the relation between manufacturing features and manufacturing information in the manufacturing feature library easily. The modified MewKISS also provides a collaborative environment where many people can work together to manage the manufacturing feature library.

Displaying labeled link relation allows users to navigate the relation between pages easily. This navigation support may assist users to collect manufacturing information for the generation of process plans.

And since users can write page relations in RDF triple representation, even though they have no knowledge about it, the page relation can be processed and manipulated by other Semantic Web applications or other computer applications. In other words, by storing the metadata in RDF triples, the

metadata can also be mapped easily to other applications. Further work needs to be done on how the mapping to other Semantic Web applications may benefit the realization of automatic process planning.

4 Conclusions

This paper described the implementation of Semantic Wiki for the development of manufacturing feature library. By enabling the writing of labeled link, class-sub-class relation and the class-instance relation of the manufacturing feature ontology, and the relation between manufacturing feature and manufacturing information can be easily constructed in the modified MewKISS environment. And since the page relation is written in RDF triple representation, the metadata can be mapped to other applications.

MewKISS provides a collaborative and easy-to-use environment for users to manage the manufacturing feature library. User friendliness of a tool is very important to foster the participation of skilled engineers to store their knowledge in the manufacturing feature library. Thus, the manufacturing feature library can be useful for the management of manufacturing information for the generation of process plans.

References

Broekstra, J., Kampman, A. (2004). RDF(S) manipulation, storage and querying using Sesame. In: Demo Proceedings of the 3rd International Semantic Web Conference. Hiroshima

Butterfield, W.R., Green, M.K., Scott, D.C., Stoker, W.J. (1988). Part Features for Process Planning. Document R-86-PPP-01. Arlington, TX: Computer Aided Manufacturing International (CAM-I).

Elmaraghy, H.A. (1993). Evolution and future perspectives of CAPP. Annals of CIRP, 42(2), 739-751.

Halevi, G. (2003). Process and operation planning. Kluwer Academic Publishers.

Han, J.H., Rosen, D. (1998). Special panel session for feature recognition at the 1997 ASME Computers in Engineering Conference. Computer-Aided Design, 30(13), 979-982.

Kanamaru, M., Ando, K., Muljadi, H. & Ogawa, M. (2004). Manufacturing feature library for the machining process planning. In: Proceedings of the Japan Society of Precision Engineering Autumn Conference (CD-ROM C-74). Shimane: JSPE (in Japanese).

Luttervelt, K. (2003). Report on the CIRP Working Group CAPP 2000-2003

Miller, E., Swick, R., Brickley, D. (2004). Resource Description Framework (RDF). http://www.w3.org/RDF/

Muljadi H., Takeda H. (2005). Semantic Wiki as an integrated content and metadata management system. In: Poster & Demonstration Proceedings of the 4th International Semantic Web Conference (PID-44). Galway.

Scallan, P. (2004). Process planning: the design/manufacture interface. Oxford: Butterworth-Heinemann

Subrahmanyam, S.R. (2002). A method for generation of machining and fixturing features from design features. Computer in Industry, 47(3), 269-287.

Takeda, H. (2004). Semantic Web: A Road to the Knowledge Infrastructure on the Internet. New Generation Computing, 22(4), 395–413.