# OntoGear: A Platform for Externalization of Functional Knowledge and its Interoperability

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**Abstract.** This paper discusses a functional modeling platform named OntoGear for externalization and utilization of functional knowledge. OntoGear enables users to effectively describe functional structure of any artifacts in the form of function decomposition trees, to organize generic way knowledge, and to visualize the whole processes in manufacturing in a 3D form. It contributes to engineering knowledge management for all manufacturing companies.

**Keywords:** Ontology, Functional Modeling, Knowledge Management, XML

## 1 Introduction

Sharing functional knowledge, which shows a part of designer's intention (so-called design rationale), is increasing its importance for collaborative work among engineers who have different skill levels and backgrounds in the global manufacturing age. However, well-handling of such knowledge is not easy because of lack of sufficient modeling frameworks and appropriate tools. In order to improve the situation, we have proposed a functional knowledge systematization framework based on ontology engineering [1] and developed a functional modeling tool [2]. In our framework, functional knowledge is represented as function decomposition trees and way knowledge that represents how to achieve a function (called *generic ways of function achievement*). Although the framework has advanced in several aspects, the original tool has not been able to catch up with the advancement due to its rigid system architecture. Therefore we reformed the tool, which is called *OntoGear*, based on an extensible architecture and furthermore developed a useful set of tools for enhancing interoperability of functional knowledge.

## 2 Implementation and Features of OntoGear

The flexible extensibility of a system plays a crucial role in both practical use and rapid follow-up of the evolution of theoretical study of functional ontology. Also reducing modeling cost is required. For the former issue, OntoGear system adopts XML-centric architecture which can combine any XML vocabularies in a single

platform. For the later issue, it is equipped with pre-defined way knowledge base (hereafter WKB) that has been built by the authors, referring to patents and technical documents. The number of the generic *ways of function achievement* in the knowledge base is approximately 120. OntoGear also incorporates with the specific sub-system called SAFFRON (Smart Assist for Functional Term Conceptualization). SAFFRON helps users' conceptualization of functionality from superficial term representation to a functional concept (*verb*): e.g. from *weld* to *join* by detaching *Fusion way*, from *filter* to *separate* by detaching *Filtering way*, etc. Furthermore it automatically separates everyday-terms into two elements which consist of non-functional element and functional one with two language resources and one additional resource: functional concept ontology which has about 220 concepts (lexical labels), a dictionary of about 1000 everyday functional terms, and a repository that includes supplemental information (e.g., functional image).

As shown in Fig.1, OntoGear system is composed of several functional modules−OntoGear FKE (Functional Knowledge Externalization), OntoGear WKE (Way Knowledge Editor) and OntoGear FFN (Functions' Forest Navigator). OntoGear FKE is a tool for externalizing functional knowledge, and extended for functional modeling of product life cycle of artifacts as multiple function decomposition trees. OntoGear WKE is a new module to build generic WKB to share and reuse *way knowledge*. In addition, OntoGear FFN provides users 3D view of the multiple function decomposition trees reflecting product life cycle of artifacts.

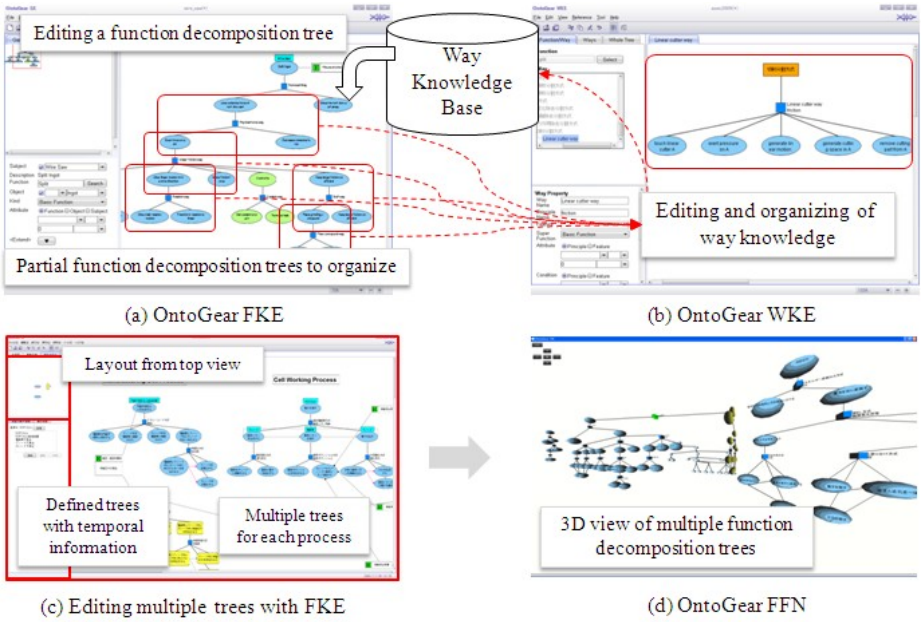


**Fig.1.** Snapshots of OntoGear system

Fig.1(a) and (b) show the combinatorial use of FKE and WKE. After a function decomposition tree is described in FKE, way knowledge as the partial tree in the whole tree can be passed to WKE and organized as reusable knowledge into WKB.

Thus it will be available for designers to use the way knowledge stored the way knowledge base interoperably.

In functional modeling for production processes, multiple function decomposition trees are described. In contrast to single modeling of working process of an artifact, integrated process modeling has two temporal axes: temporal axis of function in which the target objects of function change and the other in which functional structures change. Also there are relationships among trees. An extended version of FKE enables designers to attach temporal data and relationship information to multiple function decomposition trees. Once they are outputted in the specific data format, FFN reads them and internally constructs a 3D model. Eventually a 3D view of multiple function decomposition trees is displayed in the screen.

We applied OntoGear to support design of an SOFC (Solid Oxide Fuel Cell) power generation system. According to the advice of SOFC experts, we described the function decomposition trees that correspond to processes in the product life cycle of the SOFC system using FKE (see Fig.1(c)). Then FFN generates a 3D view after incorporating those data from OntoGear FKE (see Fig.1(d)). The SOFC experts gave us positive comments on the usefulness of the prototype system to support the SOFC design. Their comments include “the consistent externalization of SOFC knowledge facilitates comprehension of the system” and “the bird’s-eye view over the SOFC life-cycle clarifies relationships among several processes”.

## 3 Conclusion and Future Work

We have developed OntoGear to externalize, share, and reuse functional knowledge embedded in artifacts. OntoGear achieved its extensibility by an XML-centric architecture, and reduces modeling cost by providing pre-defined WKB and equipment of SAFFRON sub-system. According to the preliminary evaluation of OntoGear in Japan, combinatorial usage of the system will be useful for managing functional modeling of products or integrated process modeling of the whole productive activities, and for handling a variety of knowledge about failure. For example, there is a use case of OntoGear for supporting an SOFC power generation system design with valuable comment by the SOFC experts. Future work includes completing some extended functionalities of OntoGear system and its evaluation. Furthermore its English version is under development.

## References


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