Systematization of Nanotechnology Knowledge Through Ontology Engineering
- A Trial Development of Idea Creation Support System for Materials Design based on Functional Ontology -

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Abstract

The research of nanotechnology is extended in various domains, and each domain intertwines with each other closely. The objective of our re-search is to systematize fundamental knowledge using ontology engineering to fill the gap between materials and devices through establishment of common concepts across various domains. We also aim at building a creative design support system using the systematized knowledge. In this paper, we outline a prototype of a support system for innovative nanotech-made device design based on functional ontology and functional de-composition tree which helps developers' crea-tive design processes.

1 Introduction

The research of nanotechnology is extended in various domains, and each domain intertwines with each other closely. Therefore, sharing the knowledge in common among different domains contributes to facilitate research in each domain through cross fertilization. In this back-ground, the Structuring Nanotechnology Knowledge pro-ject, which is a NEDO (Japanese New Energy and Indus-trial Technology Development Organization) funded na-tional project, has been carried out. The goal of the project is to build a material-independent platform for supporting development of innovative nano-materials. It is not a da-tabase, a set of simulation tools or a knowledge base, but is an integrated environment composed of structured knowledge supported by advanced IT.

Among many factors, the authors have been involved in building ontology of nanotechnology and its application to knowledge systematization. The key issues of knowledge structuring include how to harmonize different terminol-ogies and viewpoints of the respective domains and how to interface end users with the platform. Ontology of nanotechnology plays a role of glue for seamless connec-tion between different domains and between users and the platform, since it provides us with a conceptual infra-structure of nanotechnology and with a unified framework in which functional knowledge for conceptual design of nanotechnology-made materials and devices and their realization processes.

In this paper, we outline a prototype of a support system for innovative nanotech-made device design based on functional ontology and functional decomposition tree which helps developers' creative design processes.

2 A System for Supporting Creative De-sign of Nanomaterials

Aiming at bridging required functions stated by engineers in industries and basic functions (or quality) and at fa-cilitating the creative design, systematization of function achievement ways in a particular domain and development of a support system of functional design of materials are currently conducted in parallel (Figure.1).

2.1 Idea Creation Support by Providing Alternative Function Achievement ways

In general, a function is achieved by performing multiple sub-functions. For example, a function of incandescent lamp "emit light" is achieved by sub-functions "apply a current to a filament", "the filament heats up", and "emit light". The achievement is supported by a physical prin-ciple and/or structure of the device or materials which is conceptualized as *Function achievement way*. (In this example, the principle is "radiation".) The decomposition is continued concerning each sub-function until it reaches a basic function or quality of a material to eventually form
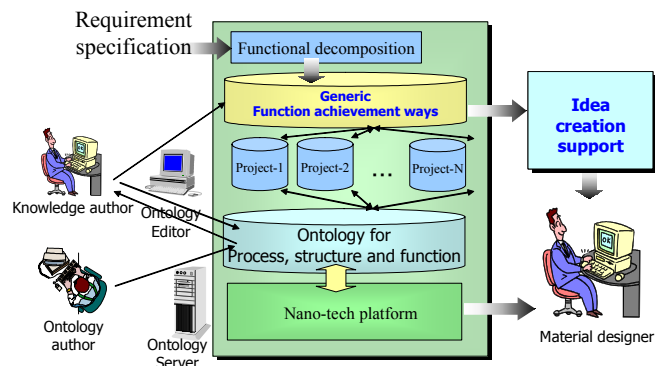

Figure.1. Idea creation support system for materials design

a function decomposition tree for each device/material. In this way, the gaps between required functions and basic functions (or quality) are bridged. There exist multiple ways of functional decomposition so that the computer can help device/material designers to help their design process by giving possible alternative ways stored in a function achievement way server.

2.3 Development of Functional Ontology and Idea Creation Support System

We developed a functional ontology containing such concepts that are used in describing requirement specification for devices together with a set of functional decomposition knowledge which bridges the gap between requirement specification of a device and fundamental properties of materials.

Then we stored some common knowledge represented based on the ontology in the ontology server and investigated the performance of the ontology server. And we built a creative design support system based on the functional ontology and a formalism of functional decomposition tree. It is considered as a prototype system for an intelligent support system for designing nanotech-made materials.

Figure.2 shows a snapshot of the system. It supports the user's creative design process by the following steps:

(1) The system displays the lists of functions, and the user selects one function as a requirement function
(2) The system searches the function achievement ways which can realize the selected function and show the results.
(3) The user selects an achievement way.
(4) Then the system expands the functional decomposition tree based on the selection.
(5) Continue functional decomposition of sub-functions

Our system is developed as a web-based application which is connected our ontology sever. And we realized the cooperation mechanism with other subsystems developed by other group in our project and confirmed it works well using the result explained in the item.
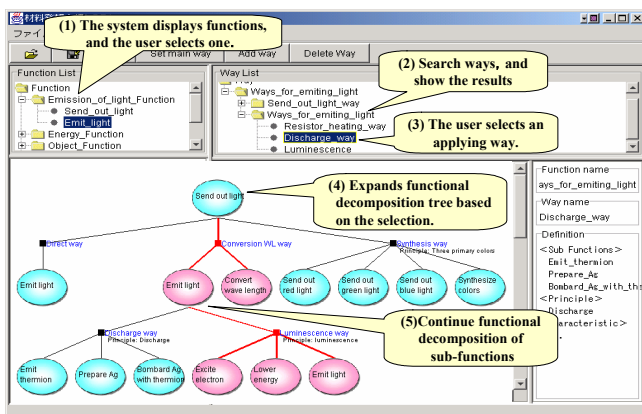

Figure.2. a snapshot of Idea creation support system

3.3 Advantages of Our System

The system supports the idea creation by allowing to replace alternative ways of function achievement, and the user's selection results are preserved. The selection from alternatives is regard as an explication of design decisions so that recording past design processes might be effective to facilitate idea creation. Moreover, the function decomposition tree is very useful to compare between past designs. And it is effective analysis of patents because improvement factors are expressed explicitly as the replacement of ways.

3 Concluding Remarks and Future work

In this paper, we summarized an idea creation support system for materials design based on the functional ontology and a formalism of functional decomposition tree as a part of systematization of nanotechnology knowledge with ontology engineering. Improvement of the prototype system through the applications to several examples with augmentation of the ontology and knowledge is the important future work. It is based on the evaluation of them and includes the following research items:

- Design of upper ontology for nanotechnology
- Augmentation of the function achievement way knowledge for function decomposition tree building
- Improvement of the nanotech-ontology server.

Acknowledgments

References

[Kitamura *et al*., 2003] Kitamura, Y. and Mizoguchi, R.: Ontology-based description of functional design knowledge and its use in a functional way server, *Expert Systems with Applications*, Vol.24, pp.153-166, 2003.

[Kozaki et al., 2000] Kozaki, K., et al: Development of an Environment for Building Ontologies which is based on a Fundamental Consideration of "Relationship" and "Role":PKAW2000, pp.205-221, Sydney, Australia, December, 2000

[Kozaki et al., 2002] Kozaki, K., et al: Hozo: An Environment for Building/Using Ontologies Based on a Fundamental Consideration of "Role" and "Relationship", Proc. of the 13th International Conference Knowledge Engineering and Knowledge Management(EKAW2002), pp.213-218, Sigüenza, Spain, October 1-4, 2002