A Visualization System of Design Information for Locally-oriented Sustainable Product

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Abstract

One of the practical approaches to environmental issues in developing countries is introducing eco-products made in developed countries. However, such products are not always acceptable due to differences of various contexts in the different regions. It is necessary to understand how such local conditions are related with product function and structure. The aim of this study is to develop a design support system for visualizing design information for locally-oriented product design. The system aids users in understanding relationship among product specifications and local information. The authors show a case study on home electric appliances in Vietnam and Japan to validate the system.

1. Introduction

After the industrial revolution, the living standards of people have been improved particularly in developed countries in which modernization and industrialization advanced. However, the majority of people in the world is still living in developing or emerging countries. In the economic pyramid of the world population, there are 5.1 billion people who belong to the Base of the Economic Pyramid (BOP) group with an annual income of less than 3,000 dollar as of 2015. Furthermore, the population in the BOP is expected to increase by 6.5 billion in 2050 [1]. Under the circumstances, the BOP group has high Engel’s coefficient. However, it is assumed that their consumption patterns will change and purchasing power will increase with the increase of their income. In such a situation, companies in developed countries focus on the potential market size of developing and emerging countries in the BOP group, and try to develop new products for them. If each company develops them in order just to expand the sales of them, there is a possibility that pollution or waste problems are getting worse. Therefore, each company must concern for not only economic but also environmental aspect.

The United Nations General Assembly set 17 Sustainable Development Goals (SDGs) in September of 2015. One of them is Sustainable Consumption and Production (SCP) which shows the importance of issues related to consumption and production. Traditionally, producers have made efforts on sustainable production such as the development of eco-products. In addition, consumer’s acceptability becomes more important. In the current situation, industrial products designed by manufacturers in developed countries are not always acceptable for developing or emerging countries. One of the reasons is that the social contexts are different from developed countries in addition to the problem that the price of the products from developed countries is relatively high. The authors call such local specific needs and constraints “local information”. It is important to understand the local information and to reflect it in product design. Instead of technology imitation and transfer from developed countries,
developing appropriate technology (AT) which is suitable and acceptable for each local condition and culture is required [2]. In this study, we focus on the function-structure of a product in order to reflect differences of local information in the product design. The aim of this study is to develop a design support system for visualizing the relationship of local information and product function-structure for locally-oriented design. With this system, we compare home appliances designed and manufactured in a developing country with those of Japan in order to clarify the differences in their local information based on function and structure of the products.

2. Related work

2.1. Product development for locally-oriented design

One of the existing approaches for locally-oriented product design is “glocalization” which is a portmanteau of “globalization” and “localization”. In most cases, glocalization is achieved by minor change or customization of world standard products into localized products [3]. A problem in glocalization is that it heavily depends on the manufacturer’s ability of marketing. As a methodology of creating localized products, co-design by engineers of global manufacturer and users of local community is a promising approach. Although the co-design process introduces the needs of local people into product development, it could be insufficient depending on the knowledge and experience of users participating in the co-design. To avoid such misunderstandings, it is necessary to employ “gatekeepers” as specialists who connect local people with engineers for efficient communication [4]. Furthermore, co-design is a low reproducible methodology because the local information acquired in the design process is shared only among project members. Meanwhile, field observation is an effective method of understanding local conditions. However, it is also unreplicable at product design due to the difficulty of systematic usage of the information obtained from the field observation. High reproducible methods for locally-oriented product design have not been established.

Local Oriented Manufacturing map (LOMmap) as a design support system focusing on locality at manufacturing and use stages has been proposed [5]. The aim of the LOMmap is to understand information on local circumstances that influences product life cycles. Reverse engineering is a systematic methodology for taking advantages in product development by analyzing competitor’s products [6]. The process of the reverse engineering includes customer needs investigation and function-structure analysis through product teardown and comparison. The authors have proposed an analytical methodology with an extended function-structure map (EFSM) which relates design information obtained from reverse engineering and field observation with a product function-structure map [7].

2.2. Visualization of environmentally-oriented design information

As a visualization tool for various stakeholders including design engineers to access environmentally conscious design information, Green Browser has been proposed [8]. In this tool, product concept, life cycle and attributes are represented as strategy model, process model and object model respectively, and the design information is connected with each of the model. The main aim of this tool is to visualize trade-off relationship among the models. As another interactive visualization tool for eco-conscious redesign, ViSER has been proposed [9]. This tool represents a supply chain and a product system network by a graph of nodes and links. The aim of the ViSER is to mitigate environmental impact efficiently by using an indicator for the effect of design change propagation by the redesign. A major problem in the both tools is the difficulty for designer in accessing appropriate design information due to a large amount of data held in the database of these visualization tools.

3. Visualization system for locally-oriented design information

3.1. Architecture of the system

Fig. 1 shows the architecture of the visualization system proposed in this study. Designers edit the EFSM on the map editor by referring to information stored in the Reverse engineering information database. The Evaluation module calculates the value of each evaluation index and shows designers the result of the evaluation. The Evaluation module refers to information stored in each database and EFSM for the calculation. The Reverse engineering information database stores product information obtained from reverse engineering, such as product function-structure maps, pictures of components, records of electricity consumption and videos of operation. The Local information database stores local information obtained from field observation, such as product usage styles, surrounding environment and requirements for products. The Embodied-intensity database stores data on environmental load units collected from existing life cycle assessment.

3.2. Evaluation index

We propose carbon dioxide emission, localizable ratio and perceived price as evaluation indices for comparing target products from environmental, social and economic aspects.

![Fig. 1 Architecture of the visualization system](image_url)
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