A Product-Service Systems Design Method with Integration of Product Elements and Service Elements Using Affordances

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Abstract

This paper describes the systematic design method for Product-Service Systems (PSS) where service and product elements are integrated using affordances. In the PSS design method, a service element is composed of the activities from the service blueprint and the functions from the function analysis. The service elements contain the service providers and receivers and their activities and are to be connected with appropriate product elements. The integration of service elements and product elements is done by mapping service elements to product elements using the affordance. The activities of the stakeholders are the key in a service element and the product elements associated to a service element should be those that support these activities. As the affordance is defined as the property of the artifact that naturally induces certain human activities, affordances provide the means for designing product elements from service elements. The function-activity interaction method is used to identify relevant affordances and then the affordance features, structural aspects of products that provide affordance, are designed. Specific instances of those affordance features realize the relevant product elements. A case example is illustrated to demonstrate that this method can help to systematically design service elements and product elements of a PSS in a service-dominant approach.

KEYWORDS: Product Service Systems (PSS), PSS Design, PSS Representation, Service Element, Product Element, Affordance, Affordance Feature

Introduction

Product-Service Systems (PSS) have recently drawn significant attentions since it could address diverse values of consumers and create new market with more profits by providing integrated solutions of products and services. PSS has a number of diverse aspects such as stakeholders, activities, functions, product elements, service elements, and so forth. Therefore, the appropriate representation scheme for PSS should be necessary for effective designing.

For the PSS design and modelling research, the molecular modelling of service by introducing product elements, service elements, bond and essential evidence was proposed by Shostack [Shostack, 1982]. In her molecular modelling, the connection between product and service elements was made by a simple line – bond. In 1995, Congram and Epelman adopted the Structured Analysis and Design Technique (SADT) to design services [Congram and Epelman, 1995]. They claimed that SADT focused on activities which could be major building blocks of services and that SADT models could help employees at every level to understand what happens in delivering a service.

More recently, Morelli and Tollestrup have studied various service design methods such as the actor network mapping, motivation matrix, IDEF0, system platform and use cases [Morelli and Tollestrup, 2007]. Shimomura and his colleagues, in their service engineering research, proposed the service model containing several sub-models such as flow model, scope model, view model and scenario model [Sakao and Shimomura, 2007; Hara et al., 2009]. Maussang et al. proposed the functional block diagram to correlate product unit and service unit in the PSS design process [Maussang et al., 2007]. More recently, a framework of PSS design method has been proposed by the research team of Kim and his colleagues at the Creative Design Institute with emphasis on context-based stakeholder activities with association of experience values as well as economical and ecological values [Kim et al., 2010; Cho et al., 2010].

Although there have been some research efforts on PSS design and modelling, the systematic and detailed framework to define and associate service and product elements has not been substantially studied. The previous research on the PSS design and modelling has dealt with simple gathering of product and service elements, and their relations were not

systematically addressed. Besides, the linkage among stakeholders, activities, and service/product elements was not studied, which is very significant to design PSSs.

The research in this paper aims to study the PSS design method where service elements are mapped to product elements with the usage of affordances. The activities of the stakeholders are the key in a service element and the product elements associated to a service element should be those that support these activities. The case study on the urban umbrella rental PSS is conducted to examine its effectiveness.

Affordances and Function-Task Interaction Method

Affordance was coined by perceptual psychologist James J. Gibson as follows: The affordances of the environment are what it offers to the animal, what it provides or furnishes, either for good or ill [Gibson, 1979]. It implies the interaction of the animal and the environment. Gibson's essential concept of affordance is that relationship exists in a pair of animal and environment and some parts of this relationship are the invariant features of the environment permitting the animal to do things. According to Norman, the affordance refers to the perceived and actual properties of the things, primarily those fundamental properties that determine just how the thing could possibly be used [Norman, 2002]. In other words, the affordance is the message which could be perceived by a human user so that the product or service function can work with user's activities naturally induced with the help of such messages.

Galvao and Sato introduced the Function-Task-Interaction (FTI) method to provide an effective guidance to reasonably implement the concept of affordances in the product architecture [Galvao and Sato, 2005; 2006]. Their method is composed of following four phases: 1) User and product studies, 2) Affordance investigation, 3) Interaction exploration, and 4) Simulation and evaluation.

In the phase of user and product studies, the collection and organization of information on users' activities and on product architecture are included. The task analysis and functional modelling approach are conducted in this phase to increase the understanding about users' activities and products. The second phase is the affordance investigation where the essential relationships between the users and products are investigated. The definition of these relationships can be accomplished by two steps: 1) understanding user requirements, and 2) interpreting them in terms of required, desirable or undesirable affordances. The third phase, interaction exploration, the FTI matrix is created by relating user tasks and product functions. While associating user tasks and technical functions, three types of interactions are considered such as physical interactions, cognitive interactions, and both. The groupings of these interaction elements are followed to produce the functional affordances. Finally, in the last phase of simulation and evaluation, the designers explore provisional affordance recommendations and options based on the relationships identified in the matrix.

PSS Design with Affordances

The flowchart describing the PSS design method using the affordance concept is shown in Figure 1. The activities from the service blueprint and the functions from the PSS function modelling are combined in the service blueprint with function in the first stage. From the service blueprint with function, the target pair of function and activities should be selected, and then the service element is defined. After defining the service element, the function-activity interaction analysis is conducted to identify essential affordances and affordance features. An affordance feature represents the structural elements that provide the affordance [Kim et al., 2009; Kim et al., 2011]. The morphological matrix approach is also used to explore the possible solution instances for the required affordance features. Finally, the product elements are determined and their conceptual sketches can be generated to come up with the alternative PSS concepts.

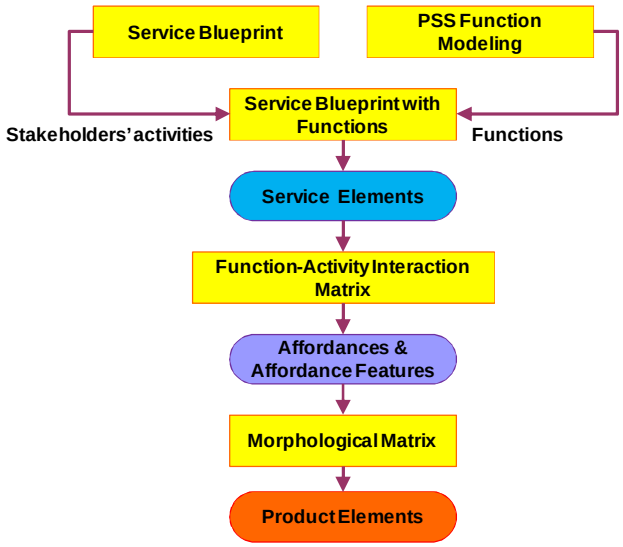

Figure 1 Flowchart of PSS design method with affordance

The overall schematic diagrams of the PSS design method with affordances are also given in Figures 3 and 4. In Figure 2, the service element can be schematically expressed as the block which resembles the function block with input and output flows. There are three nodes for stakeholders (circular node), activities (square node) and linkage with product elements (diamond node). The stakeholders – service provider and service receiver – and the activities come from the service blueprint.

The snapshot of the function-activity interaction (FAI) matrix is also shown in the bottom part of the Figure 2. The form of FTI which was originally proposed by Galvao and Sato was borrowed for building up the FAI matrix as a task is composed of activities.

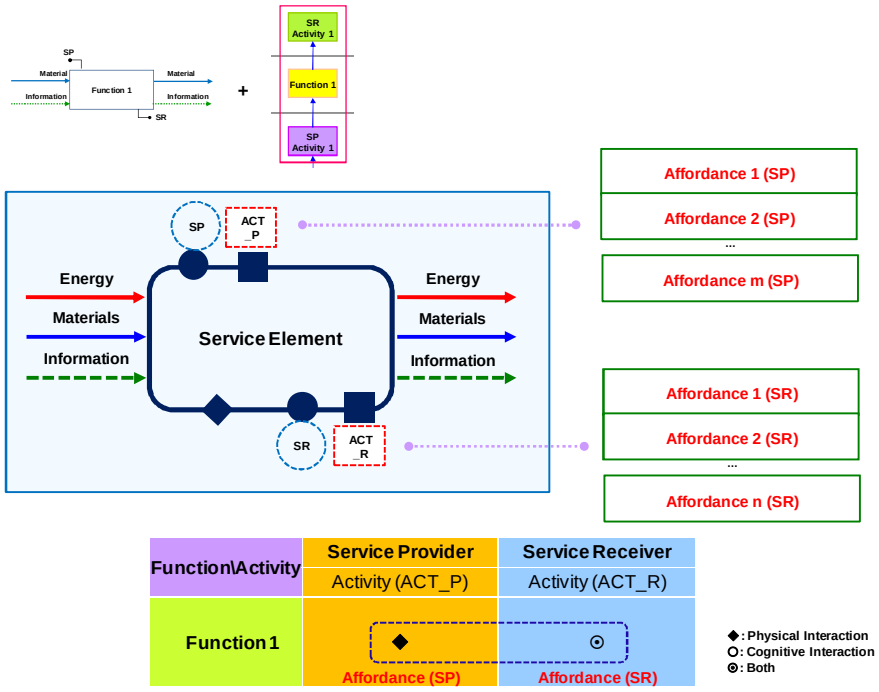

Figure 2 Overall schematic diagrams of the PSS design method with affordances

When considering the interactions among functions and activities, those activities are classified into those of service provider and service receiver, respectively. Three interactions such as physical, cognitive and both interactions are considered. Then, the critical affordances can be identified and assigned to the single interaction or the group of

interactions. Those affordances can also be classified as those for service provider and service receiver. Once the affordances are identified, the product elements having the required affordance features are conceived and their conceptual sketches may also be generated. In the schematic diagram of PSS representation given in Figure 3, the identified product elements are linked with the service element thorough the affordances.

Case Example: Urban Umbrella Rental PSS

In the case study, the urban umbrella rental PSS at the subway station was considered. Figure 4 shows the possible scenario associated with umbrellas in urban life. People might need the umbrellas at the public place in the case of sudden raining. In addition, the floors of a public transportation place such as a subway station could be very slippery due to water dropped from the umbrellas.

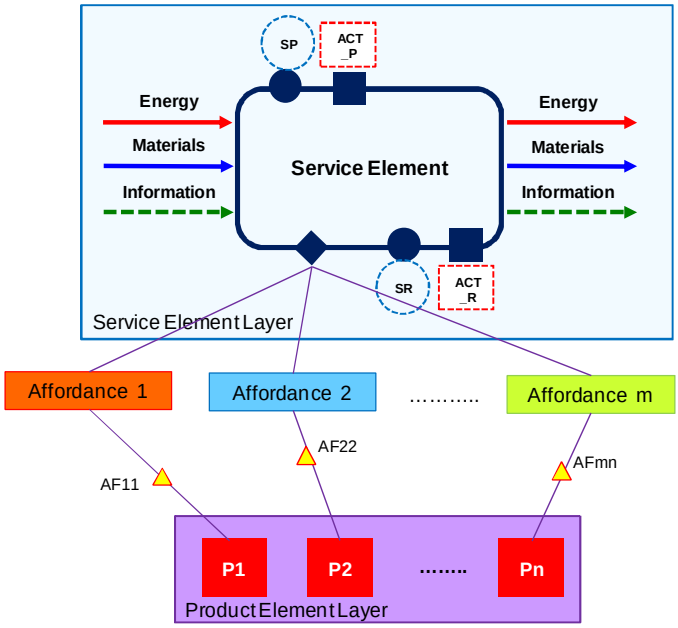

Figure 3 Schematic diagram of PSS representation

To solve the problems generated from the above scenario, the urban umbrella rental PSS at the subway station was designed based on the proposed method in this paper. Figure 5 shows the service blueprint of the new urban umbrella rental PSS at the subway station. For the case example, the functions of 'provide umbrella' and 'return umbrella' were selected for the study. In the case of the function of 'provide umbrella', the associated activities are 'make umbrella available' of the umbrella provider (service provider) and 'access umbrella', 'take umbrella' and 'move away with umbrella' of the user (service receiver). The service element was defined as 'provide umbrella service' and the associated flows were assigned to the block of the service element.

Figure 4 Scenario associated with umbrellas in urban life

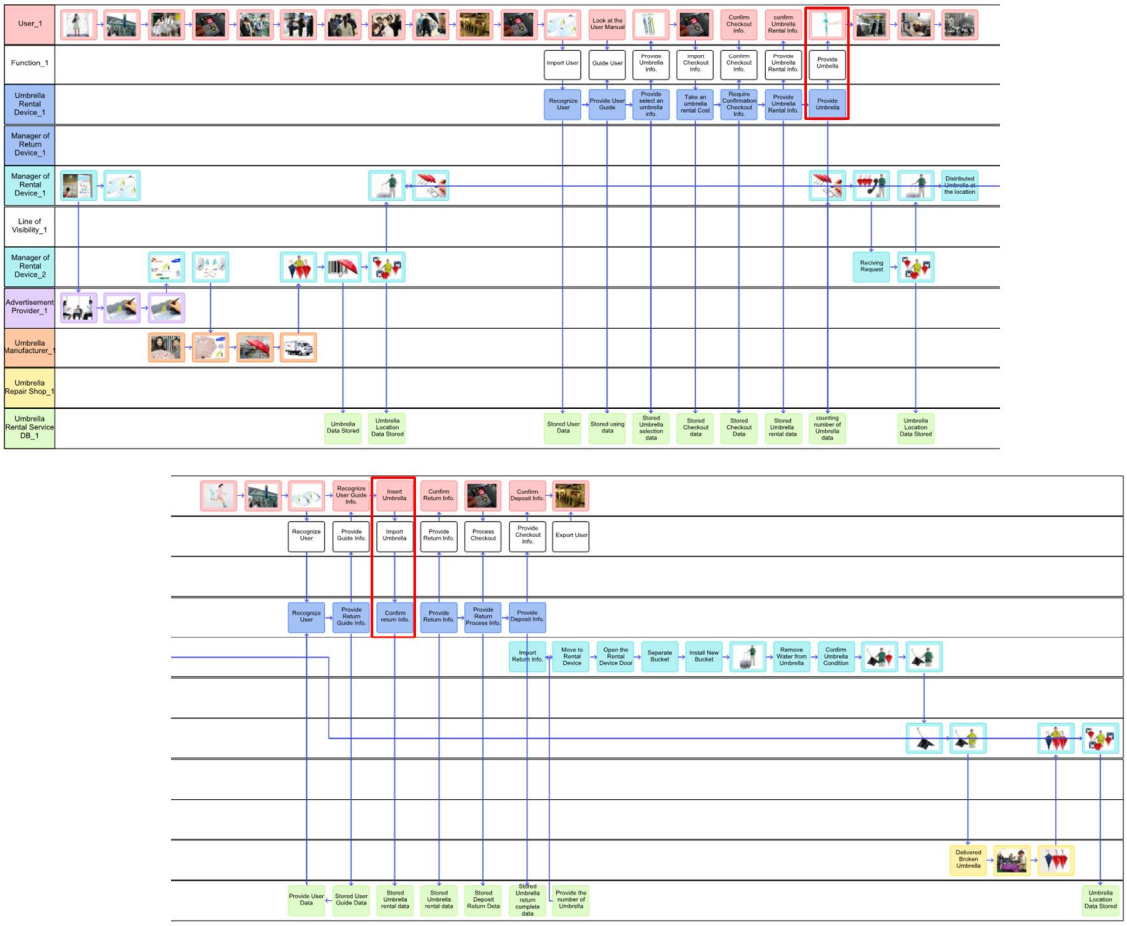

Figure 5 Service blueprint of the urban umbrella rental PSS at the subway station

Figure 6 shows the FAI matrix to identify the affordances. As can be seen in Figure 6, the identified affordances were 'provide-ability', 'access-ability', 'grasp/take-ability' and 'move-ability'. To satisfy the required affordance features, the product elements of 'umbrella handle', 'umbrella output structure' and 'passage structure' were conceived.

Function|Activity	SP	SR		
	Make umbrella available	Access umbrella	Take umbrella	Move away with umbrella
Provide umbrella	◎ (Provide-ability)	◎ (Access-ability)	◆ (Grasp/take-ability)	◆ (Move-ability)

Figure 6 Function–activity interaction matrix for 'provide umbrella'

The PSS representation diagram is given in Figure 7. As can be seen in Figure 7, the identified affordances played a role of linking the product elements to the service element. The conceptual sketch given in Figure 7 could be the best solution among a number of possible solutions obtained from the morphological matrix. It included the required affordance features. With the PSS concept given in Figure 7, the user can easily access to the umbrella output device and conveniently pick up the umbrellas by pulling out their handles. Since the subway station is usually very crowded, the passage structure that allows the users to smoothly move away with umbrella was also needed.

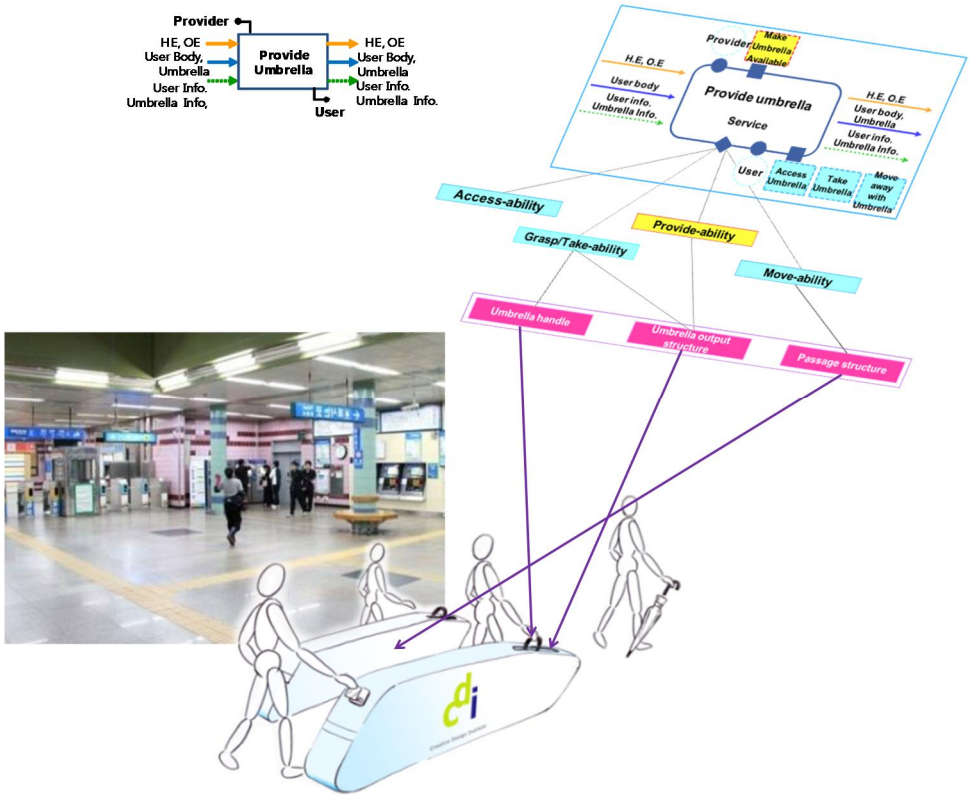

Figure 7 PSS representation for the function of 'provide umbrella' and the concept sketch of the product elements

In the second case example, the function of 'return umbrella' was considered. In this case, the associated activities were 'recognize umbrella', 'receive umbrella', 'arrange umbrella' and 'store umbrella' for the umbrella receiver and 'remove water', 'leave umbrella' and 'move away' for the returning user. Similar to the first case, the FAI matrix was generated and the affordances were identified, which is given in Figure 8. The identified affordances were 'identify-ability', 'receive-ability', 'arrange-ability' and 'store-ability' for the umbrella receiver and 'water remove-ability', 'leave-ability' and 'move-ability' for the returning user.

	SP				SR		
Function|Activity	Recognize umbrella	Receive umbrella	Arrange umbrella	Store umbrella	Remove water	Leave umbrella	Move away
Return umbrella	Identify-ability ◆	Receive-ability ◆	Arrange-ability ◆	Store-ability ◆	Waterremove-ability ◆	Leave-ability ◆	Move-ability ◆

Figure 8 Function–activity interaction matrix for 'return umbrella'

The PSS representation schematic diagram for the function of 'return umbrella' is given in Figure 9. The defined service element was 'return umbrella service', and the conceived product elements were the user identifier, umbrella input structure, umbrella waterspout, umbrella storage and passage structure. The conceptual sketch including the above product elements is also given Figure 9, which was considered to be the best solution among many alternatives. With the concept given in

Figure 9, the returning user could simply dry and insert the wet umbrella to the umbrella input structure without blocking the stream of other returning users. The inserted wet umbrella would be properly arranged and stored inside the device.

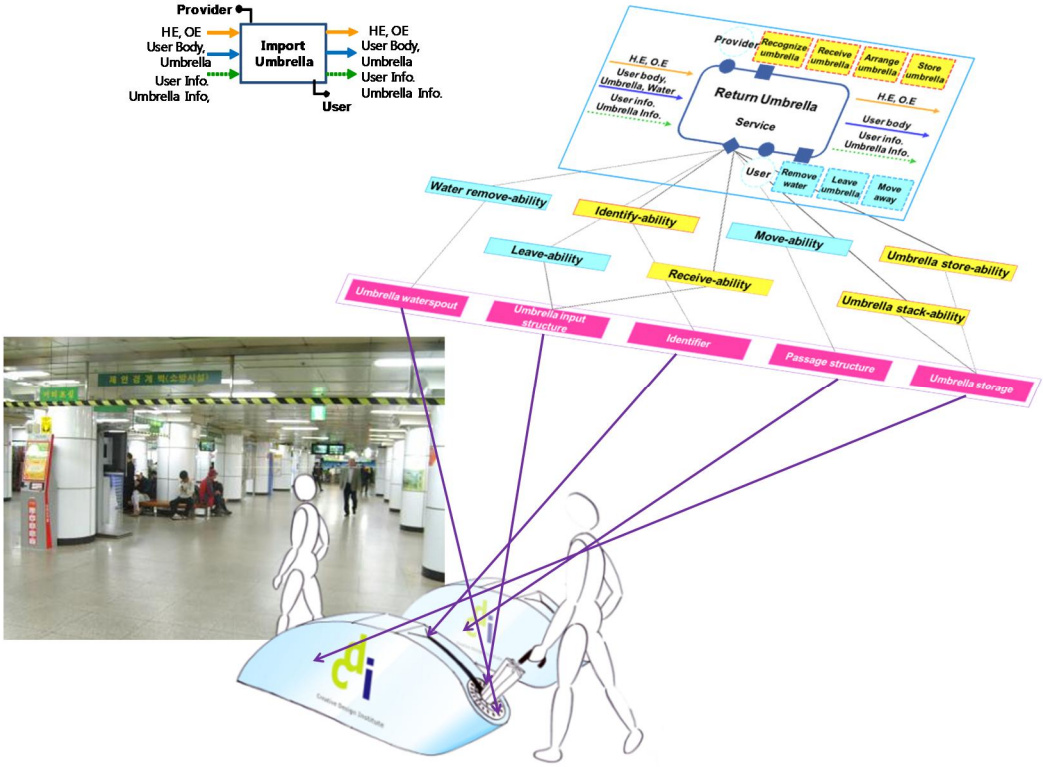

Figure 9 PSS representation for the function of 'return umbrella' and the concept sketch of the product elements

Conclusions

This paper presented the systematic design method for Product-Service Systems (PSS) by integrating service and produce elements using affordances in a service-dominant approach. In the PSS design method, the activities from the service blueprint and the functions from the PSS function modelling were combined in the service blueprint with function. Then, the pair of function and activities was selected, and the service element was defined. After defining the service element, the function-activity interaction analysis was conducted to identify essential affordances and affordance features. The morphological matrix approach was also used to explore the possible solutions including the required affordance features. Finally, the product elements were determined and their conceptual sketches could be generated to come up with the alternative PSS concepts.

In order to examine the effectiveness of the PSS design method, the case study of the urban umbrella rental PSS was conducted. In the case studies, the functions of 'provide umbrella' and 'return umbrella' were considered as representative examples, and the possible PSS concepts allowing the users to conveniently pick up and return the umbrella by including the essential affordances which were extracted from the FAI matrices were generated.

The PSS involves a number of stakeholders and their various activities. Therefore, it was confirmed that the usage of the affordances for integrating service elements and product elements was effective, since the affordance was the key property of the product elements that allows stakeholders' activities by its definition.

References

Shostack, G.L. (1982): How to Design a Service, European Journal of Marketing, 16(1): 49-63.

Congram, C. and Epelman, M. (1995): How to describe your service: An invitation to the structured analysis and design technique, International Journal of Service Industry Management, 6(2): 6-23.

Morelli, N. and Tollestrup, C. (2007): New Representation Techniques for Designing in a Systematic Perspective, Proc. Nordic Design Research Conference, Stockholm.

Sakao, T., and Shimomura, Y. (2007): Service Engineering: a Novel Engineering Discipline for Producers to Increase Value Combining Service and Product, Journal of Cleaner Production, Vol. 15, pp. 590–604.

Hara, T., Arai, T., and Shimomura, Y. (2009): A Method to Analyze PSS from the Viewpoints of Function, Service Activity, and Product Behavior, Proc. CIRP Industrial Product-Service Systems Conf., Cranfield.

Maussang, N., Sakao, T., Zwolinski, P., and Brissaud, D. (2007): A Model For Designing Product-Service Systems Using Functional Analysis and Agent Based Model, Proc. Int'l. Conf. on Engineering Design, Paris.

Kim, Y. S., Lee, S. W., Maeng, J. W., and Cho, C. K. (2010): Product-Service Systems Design with Functions and Activities: Methodological Framework and Case Studies, Proc. Design & Emotion Conference, Chicago.

Cho, C. K., Kim, Y. S., and Lee, W. J. (2010): Economical, Ecological and Experience Values for Product-Service Systems, Proc. Design & Emotion Conference, Chicago.

Gibson, J. J. (1979): The Theory of Affordances in the Ecological Approach to Visual Perceptual, Houghton Mifflin.

Norman, D. D. (2002): The Design of Everyday Things, Basic Books, New York, NY.

Galvao, A. B. and Sato, K. (2005): Affordances in Product Architecture: Linking Technical Functions and Users' Tasks, Proc. of Int'l Conf. on Design Theory and Methodology, Long Beach, CA, DETC2005-84525.

Galvao, A. B. and Sato, K. (2006): Incorporating Affordances into Product Architecture: Methodology and Case Study, Proc. of Int'l Conf. on Design Theory and Methodology, Philadelphia, PA, DETC2006-99404.

Kim, Y. S., Lim, J. S., and Park, J. A. (2009): Affordance Feature Reasoning: A Case Study for Human-Product Interaction, Proc. of Int'l Conf. on Engineering Design, Stanford.

Kim, Y. S., Cho. Y. C., and Kim, S. R. (2011): A Case Study of Design for Affordance: Affordance Features of a Simple Medical Device, Proc. of Int'l Conf. on Engineering Design, Copenhagen.