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METHOD OF DESIGN THROUGH STRUCTURING OF MEANINGS

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ABSTRACT

This paper discusses a new approach to conceptual design. The presented methodology is based on the structure of meanings in the design process. The search and evaluation of meanings form the foundations of developing this structure of meanings. In order to facilitate the use and operation of the meanings, the WordNet lexical database is used. An existing visualization of WordNet is used for the process of meaning search. The WordNet::Similarity software for the measure of the relatedness of meanings in this database is the basic tool used for the evaluation process. The concept of similarity is concerned with the degree of interconnections between different meanings. Such search and evaluation techniques are later on incorporated into our methodology of the structure of meanings to support the design process. The measures of relatedness of meanings are developed as convergence criteria for application in the evaluation processes. Further on, the methodology for the structure of meanings presented here is used to construct meanings in a case study of product design. All the steps of the design methodology, including the search and evaluation processes involved in developing the structure of the meanings, are elucidated. The designer's choice of meanings is supported by consequent searches and evaluations of meanings to be implemented in the designed product. Finally, the paper presents directions for developing and further extensions of the proposed design methodology.

1. INTRODUCTION

When designers create products, they are taking meanings into consideration. Moreover, people recognize products of design as meanings. Thus far, meanings have been considered to be an important prospective for design, such as product semantics (Petiot and Yannou, 2004, Butter, 1989). In recent times, designers have been increasingly taking into account the important role played by meanings. Therefore, there exist some design-supporting approaches that aim to connect design processes with meanings. So far, a sensitive topic on the agenda has been an understanding of the meaning of products. Designers need methods that support meanings incorporated in them, and those methods should have the ability to explicitly operate the meanings.

1.1. Meanings in Design

Meanings in design can be approached from two different perspectives – functional application of the design and impressions of the design created in the user. The applied methodologies are also diverse. Both approaches are important to support of creativity involved in the design process.

1.2. Functional Meanings

The following are the meanings based on the functional and physical phenomena of design. Functional meanings are approached through different methodologies and theories.

Ontology is one of the methodologies, used for support of functional meanings in conceptual design. Such methodology is described in Horvath (1998), which focused on the modeling and representation of concepts for the computational support of the design process. The study elaborated on the ontology theory for formalizing the design concepts. This methodology successfully utilized the ontology paradigm in descriptions and the structuring of design concepts.

Moreover, Gero and Kannengiesser's (2004) design method emphasizes the function-behavior-structure framework

and its ontological approach. The representation of design process of this framework involves the interaction of making and seeing. This interaction between the designer and the representation determines the direction of the design process. This approach explores the functional properties and meanings of the designed product.

The methodological approach of Chakrabarti and Bligh (2001) focuses on the physical descriptions of the design; these descriptions provide the intended functions of the design problem. It involves mapping natural language representations to the function structure and solution concept. This model is transferred to the knowledge-base of mechanical structures. The model proposed in this paper guarantees a search in the entire range of known solutions. IDEA-INSPIRE tool by Chakrabarti (2005) provides support of functional meanings by search of an analogy with natural phenomena. This is a systematic approach to biomimetics based on function, behavior and structure descriptions of natural and artificial structures elaborated in product design development.

Moreover, Sarkar and Chakrabarti (2007) highlight the role of the exploration of concepts in creativity. The enhancement of this exploration contributes to design creativity from the viewpoint of relations between the design function and natural phenomena.

1.3. Impression Meanings

On the other hand, the viewpoint of impression meanings of the design is researched from different approaches. These approaches emphasize the user requirements for user-oriented design. These refer to the meanings of the product, based on the impression in the user's mind, i.e. the user's cognitive interpretation of the designed product.

The concept of emotional design emerges from such a linkage. Norman (2004) highlights the interaction between affect, emotion and cognition. An emotional response to a product design that is in agreement and does not conflict with its efficiency is the major attribute for success of a product. Furthermore, Norman (2004) also associates this viewpoint to the perceived functional use of the products, based on visual impression. This example of the user's impression of a product design creates meaning for that product.

Another example is the meanings surveyed by the semantic differential method, which is based on work of Osgood et al., (1957). The semantic differential method focuses on measuring the connotative meanings of designs. Such research was carried out by Hsiao and Chen (1997), who proposed a semantic recognition and rule-oriented approach for developing a product design. A number of referential products are used to quantify partial contributions to the impression of a product in terms of its image; this is done by using the semantic differential method. The results are implemented in models of products, which can be constructed by inputting words and their corresponding functions. A new product form can further be generated from a basic model of the product by regulating the shapes of the components using rules. This approach is based on the assessment reflected to design and not the design process of using meanings.

The product semantics approach has been discussed by Krippendorff (2006) and Krippendorff (1989) as impression meanings. This approach takes into account the relationship between the user's cognitive models and the perceivable features of the concerned product. By a sequence of activities, semantic considerations are incorporated into the design process. Some of the activities include establishing the semantics to be communicated, outlining the attributes to be expressed and searching for the manifestations to project the semantic considerations in shape (Krippendorff, 1989). This approach is centered on symbolic associations and meanings and is generated by design features during the process of designing. It establishes the meanings embodied in design in the form of design semantics.

In recent times, both viewpoints – functional and impression – are required by designers, in terms of creative methodology involved in design. However, thus far, there has been no successful application methodology to explicitly process and operate all types of meanings, during designing.

1.4. Issues to be Addressed

It is necessary to have a new user-oriented methodology that focuses on both types of meanings – functional and impression. With aid of this methodology it should be possible to rationally support these meanings. For this purpose, it is necessary to elaborate on the explicit representation of meanings that reflect complex human knowledge. Moreover, the methodology should be easily operable by the designer. In addition, in order to support the designers' creative process, it is necessary to consider the early stages of process. From the viewpoint of creativity, the exploration, synthesis, search and finding (Finke, 1996, Nagai and Taura, 2006 and Sarkar and Chakrabarti, 2007) of new concepts and meanings are critical for design achievements. Creative design entails the creation a new structure of meanings by the designer. Existing methods can not address all these issues in their complexity and are not universally applicable beyond the original designation of methodology.

The early stages of design entail the following requisites:

- Control and construction of meanings
- Explore the meanings search in favor of the choice of the meanings
- Enhance and support the choice of the meanings. Use a systematic approach to meanings on the basis of their evaluation
- Use more complex and objective information concerning meanings; these should be consistent with human knowledge
- Improved designer control over the structure of the meanings

Currently, the search and evaluation of meanings in the conceptual phase of design rely only on the ability of the designer. These abilities are not sufficient for an objective

search and evaluation of meanings; moreover, they are not entirely effective for conceptual design.

2. AIM OF THIS RESEARCH

The present research introduces a methodology with above described features and proposes the structuring of the meanings in the process of conceptual design.

Hence, we term it as the structure of meanings. Our approach is based on the notion that the design process can be considered as the developing structure of meanings.

The goal of this research is to support the development of this structure in conceptual design. This structure of meanings is achieved by the search and evaluation of meanings. In order to propose a method for supporting the design process from the perspective of meaning, we focus on the relations of words enabling those meanings and involve these words in the construction of a network of meanings.

The tool for analysis of meaning relations has two requirements: it should be searchable and should facilitate the evaluations of meanings in it. Quality requirements constitute the number of meanings represented and their interconnections in such network.

2.1. WordNet Database

The domain of natural language processing provides tools that can be applied for such meaning analyses. WordNet represents knowledge in the form of a structured interconnected concept dictionary that is applicable for design support. The WordNet database satisfies all the basic requirements for a tool to be implemented in such a methodology; it can address and describe both functional and impression meanings. This database covers the requirements mentioned in the previous chapter. The aim of WordNet is to serve as a database system, consistent with the knowledge about the manner in which human beings process language and concepts.

More than 20 years of development of WordNet has resulted in creation of a network database comprising over 150,000 words and 207,000 word–meaning connections. Words are organized in hierarchies and are interconnected by different kinds of semantic relations. Semantic relatedness refers to the human judgments of relationships between pairs of concepts. It is also used as lexical ontology in computer science (Pedersen et al., 2004).

The advantages of WordNet as humanly constructed database and having an extended network between concepts are that it is practically useful for searches and evaluations of connections between concepts. Different types and lengths of interconnections are comparable in the network. Thus, it is usable as a structure for connecting concepts and representing the human mind, not only for linguistic analysis but also as an evaluation tool.

2.2. Concept Evaluation Tools

Pedersen et al. (2004) describe the practical application of measures of concepts within WordNet. The measures are domain independent. The developed WordNet::Similarity tool has been used in recent approaches in different domains (Pedersen et al., 2007). This approach is practically applicable as a concept evaluation tool. It allows the measure of the semantic relatedness and the similarity between concepts found in the WordNet lexical database.

This research assumes that meaning structure and relations are applicable as criteria to support design choices and exploration.

The domain of design support already has some examples in which WordNet has been applied. Restrepo (2007) uses the semantic similarity approach for contributing to the searches of conceptual designs. Although the work is focused on the conceptual design phase, it only has an application for comparison of the design under consideration with database descriptions of previous designs.

In a different approach, meanings have been researched as the semantics of product design, and this approach was extended to the view that similarity of language bridges the designers' knowledge (Dong 2005).

However, this research uses WordNet in a different manner, namely to search for meanings. Moreover, the WordNet::Similarity tool is used for the evaluation of meanings in the methodology of design.

3. STRUCTURE OF MEANINGS

3.1. Framework

This framework is established as a description of application of the structure of meanings in the design process.

Basically, in our framework, we distinguish between two domains – shape domain and meaning domain. Additionally, we describe the designer and WordNet database, i.e. either they act independently or they are connected to these domains, interacting with the domains or intermediating interactions between them. We divide the process into the conceptual, emergence, prototyping and detail phases (Figure 1).

In this framework, the design process is presented as a progressive transfer between meanings and shapes. In the initial stages, the meanings are searched, evaluated and expressed (emerged) in shapes; then the prototype of the shape is developed through iterations into the final product. In the twelve stages of this framework of meaning structure (Figure 1), the designer can refer back to any stage of the process. The steps are described as follows:

Conceptual Phase

At a fundamental level, the designer's work entails the translation between objectives (concepts or meanings), and the visualization of that concept in the form of a shape. In the first and second stages (Design task and Meanings abstraction) of the conceptual phase, the designer extracts (abstracts) the initial set of meanings (Meaning Set in Step 3) based on the description of design goals.

This set is searched and evaluated with the core design methodology described in the following chapter. With support of this design methodology we achieve the appropriate (improved) meaning structure in Stage 5. The improved

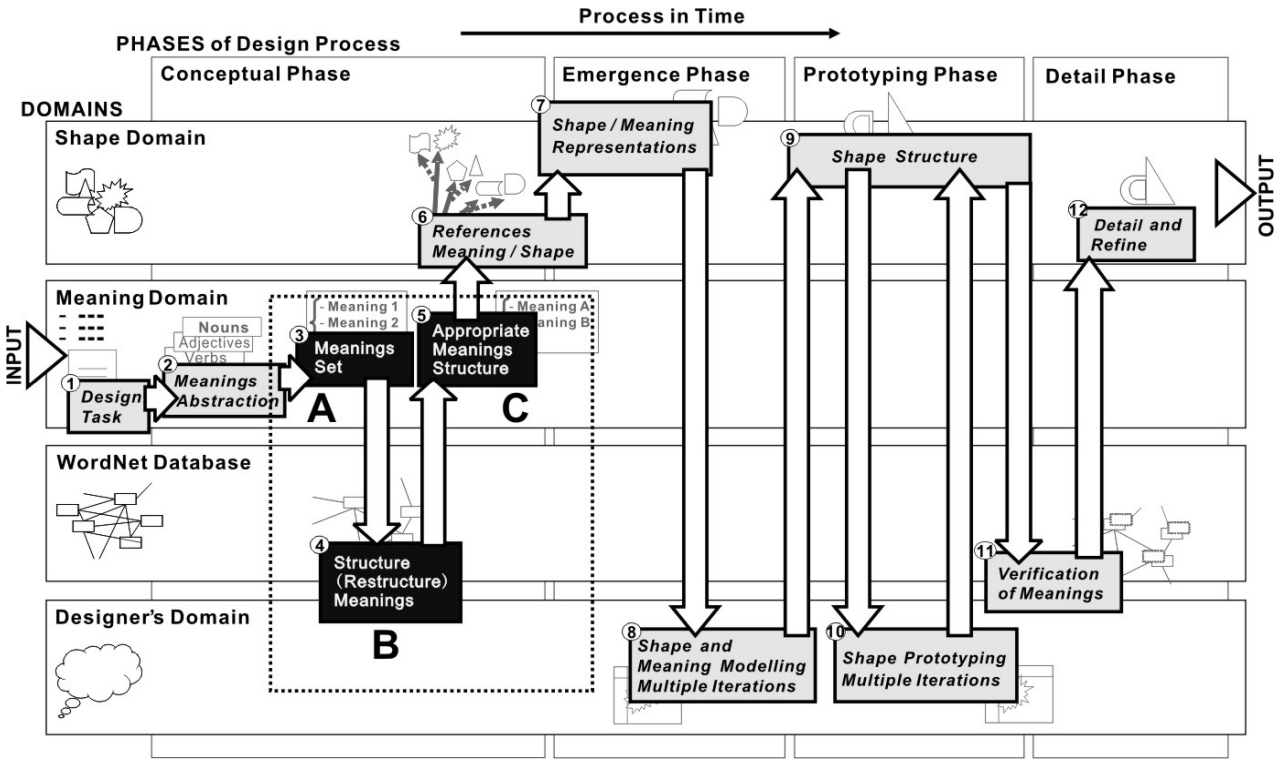


Figure 1. Location of our methodology placed in the entire framework of meanings in the design process. Stages marked as A-B-C in the conceptual phase are in the focus of the design methodology presented in a later chapter.

structure of meanings from Stage 5 is expressed in the form of a shape in the design prototype in Stage 6.

Emergence Phase

This phase refers to the emergence or visualization of a shape from the meanings (concepts). The meanings are translated into shapes. Here (stages 7 and 8 in Figure 1), the shape and meaning structure are modeled. The process primarily involves sketching and multiple iterations by the designer.

Prototype Phase

The structure of the shape is expressed in the design prototype. This phase results in a structured shape (Stage 9, Figure 1), that is again prototyped in multiple iterations by the designer (stages 10 and 11).

Detail Phase

The meanings are verified and evaluated using an approach similar to that used in the conceptual phase. All the details are finalized and the shape is refined.

Outline of the Framework

By the way of a conclusion, we provide an outline of the framework. It describes the design process as a transition between meanings and shapes. Through this, the framework outlines the important points connected with meanings for the creative design process (Figure 1). This paper focuses on the conceptual phase of design, which is considered as the most important in design (Finke, 1996). Further, the proposed design methodology focuses on achieving the structure of meanings in stages A-B-C. Using this framework, the methodology supports the effective exploration and evaluation of meanings. This contributes to conceptual exploration and synthesis. The latter is the key to creativity in the design process (Nagai and Taura, 2006).

3.2. Search and Evaluation in Design Methodology

The steps of design methodology described below are part of the structuring the meanings phase of conceptual design in the framework, which is the focus of this study.

Steps

The design methodology uses the following precise procedures for meaning search and evaluation (Figure 2). It corresponds to the stages A-B-C in the framework presented in the previous figure. Stage A involves the meaning set used in the design methodology; Stage B entails building the structure of meaning using search and evaluations and Stage C is the resulting, appropriate meaning structure (Figure 2). The steps are:

- Meanings set refers to the starting point of initial concepts (meanings) that relate to the design task and abstracted meanings from the task (A)
- Search in WordNet with these meanings (B1)
- Visualization of WordNet as a network neighborhood of searched meanings (example is provided in Figure 3) (B2)
- Designer selects new meanings (concepts) from this neighborhood network (Figure 3) (B3)

- New meanings are evaluated by convergence criteria from WordNet::Similarity (B4)
- If the meanings do not show sufficient convergence, the designer returns to one of the previous steps, i.e. the designer selects new meanings (concepts) or searches using new input (B5)
- The process continues until a good score on convergence criteria is achieved or until the designer decides that the meanings are appropriate (B1–B5). The steps are repeated until an improved and appropriate structure of meanings is attained.

3.3. Search Method

The essential aim of the meaning search (B1) is to find more applicable meanings on the basis of the input meaning, which is a judgment call taken by the designer. WordNet release 2.1. (<http://wordnet.princeton.edu/>) is used for the complete exploration of concepts associated with the initial searched concept. The visualization of WordNet facilitates the meaning choice of the designer and the search for adequate meaning or concept.

Such a search can be utilized by the visualization (B2) of WordNet, as shown in Figure 3. It is limited to the representation of the network neighborhood (only directly connected) to the input meaning search. The designer chooses to judge and select the meanings from this visualization that are to be evaluated with the help of the example method described in the next section.

3.4. Evaluation Method

The evaluation of meanings (B4) is based on measures implemented in WordNet::Similarity software release 2.01. (<http://search.cpan.org/dist/WordNet-Similarity/>). There exist a number of measures, and the relatedness based on path is the most general one among these. Relatedness by path length is based on the principle of counting edges between concepts (Pedersen, 2007). It is a relatively simple measure in WordNet's noun hierarchy. Relatedness by path (similarity) can be defined as follows:

$$Sim_{path}(Meaning_1, Meaning_2) = \frac{1}{Path} \quad (1)$$

The measure results in a number between 0 and 1, evaluating the degree of similarity between the two meanings. Although, it has the relative advantage of simplicity, it is restricted to only nouns and the "is–a" relation.

Our methodology uses this measure as the evaluation criteria (B5) of the set of meanings. Since relatedness (similarity) refers to the degree of similarity between a pair of words, we summarize this relatedness as the convergence criteria. Previous research has pointed out that relatedness contributes to evaluation (Georgiev et al., 2007). The results from this research indicate the significance of relatedness by path as a factor contributing the higher assessment of designs. Thus, higher relatedness corresponds to higher evaluated designs. The relatedness of meanings is applicable as comparative criteria between the pairs of meanings. Thus,

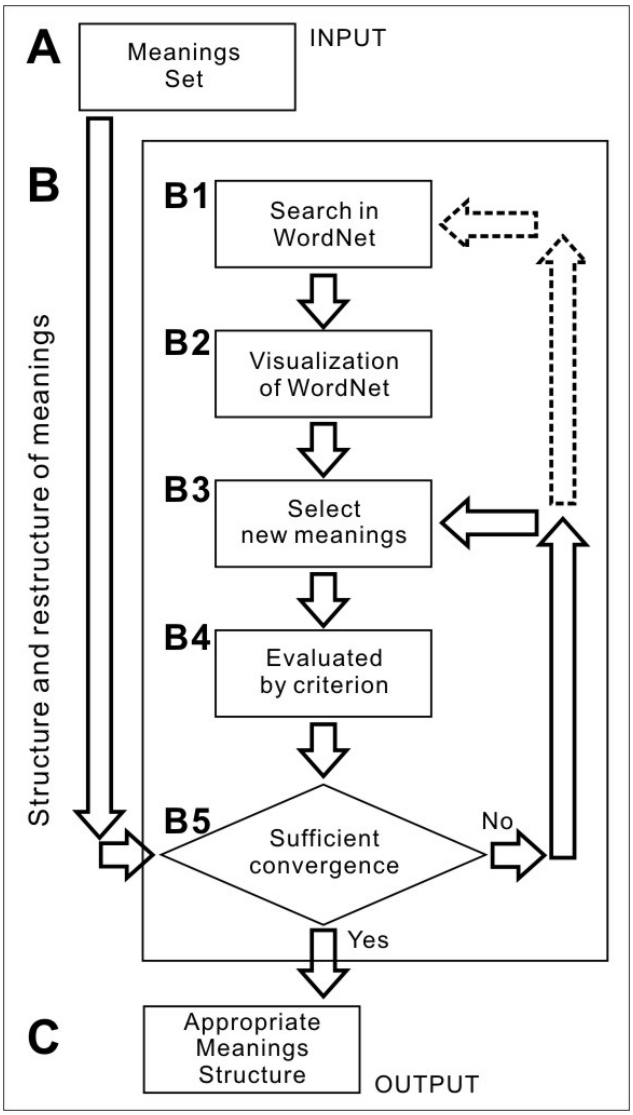


Figure 2. Flowchart of steps in the design methodology. Stages A to C correspond to those in Figure 1. Stage B, the structuring of the meanings, is described in detailed steps, B1 to B5, according to the methodology.

convergence is the evaluation of relatedness or similarity of a limited set of meanings, as follows:

$$Convergence = \frac{\sum_{i=1}^{N} Sim_{path_i}}{Number_{SimPath}} \quad (2)$$

Characteristics

In terms of applicability, the general characteristics and advantages in terms of applicability of our methodology are as follows:

- It directly operates the structure of meanings and explicitly explores meanings.

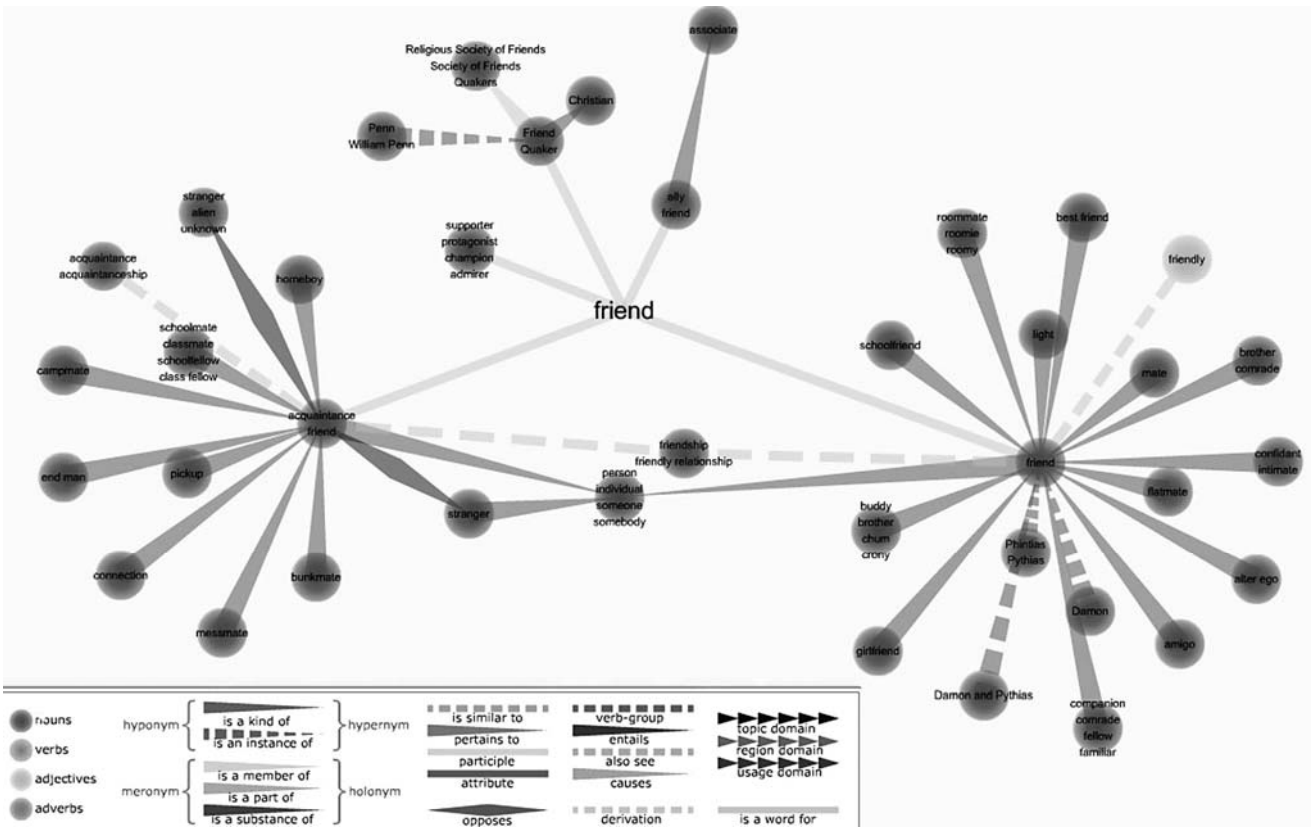


Figure 3. Graph visualization of the local WordNet structure for word "friend". Nodes represent words (concepts) and the different connections represent different dependencies between the words. Source: < www.visuwords.com>

- It uses WordNet as an explicit representation of the human mind. WordNet is a very complex knowledge-based structure that has a broad coverage and is domain independent.
- It implements criteria that are easy to judge and evaluate.
- It can be calculated and evaluated in real time, during the design process.
- It is possible to be conducted at an early design stage.

4. CASE STUDY OF DESIGN METHODOLOGY

The practical implications are clarified with a design case study of the methodology. We focused on the structure of meaning, applied to the case of product design.

The application of relatedness by path (Georgiev et al., 2007) is done by using convergence criteria, as described in Section 3.4. Support role of convergence criteria is used in addition to the decisions of designer.

The further described case study is a demonstration of the design methodology implications. Further, we discuss a case trial that covers difficult meaning inputs from a design task. In the case study presented here, the methodology of and application of meaning criteria in design tasks is described.

The trial in 2-dimensional design (Georgiev et al., 2007) showed the applicability of the methodology to impression meanings in that domain.

Because the design area is different from that case, the convergence criteria here receive a little broader interpretation. It is not focused on achieving a specific value of the convergence criteria (Georgiev et al., 2007), but on use as a **relative** or **comparative evaluation** of interconnection strength of a given **sets of the meanings**.

4.1. Design Task

The example discussed focuses on designing a light system, with specific requirements concerning functional and impression meanings. In this study, both are focusing only on meanings from nouns.

The client is a hospital, concerned with specific problems of their patients – injured people who as a result of an accident have to change and adapt their lifestyles for the period of hospital stay. Such patients – usually in active working age – often have to stay for 1 to 3 months in the hospital. The design task is focused on improving the environment for such patients in hospital bedrooms.

4.2. Interview

For the purpose of the design we conducted an interview with a doctor and two nurses. The main concerns of

interviewed subjects were connected with negative influences of lifestyle change on the patients' health improvement. The aim was to identify specific issues of these kinds of patients, and to explore possibilities to improve the environment in hospital bedrooms.

They gave examples of the problems from patients' viewpoint – "I feel difficulty in sleeping". Furthermore, statements such as "They miss their families" were often observed. In other cases it was stated – "The patient wants to go back to work" and "He feels bored and misses his life before the accident … doesn't like the room environment".

4.3. Identified Issues

The results of the interview show concerns about vital energy of the patients. The requirements are in connection with: room environment (stress and isolation of these patients); night period (insufficient sleeping and boring) and vitality (feeling of loneliness and missing families, friends and pets, missing active movement). The identified issues as keywords are:

From patients' side:

- Isolation and Loneliness – Friendship
- Sleepless – Sleep
- Vitality (Movement, Active)

From client's side:

- Health

From designer's side:

- Light – achieving more friendly light – based on the idea from designer

As a result of the investigation it was decided for the design should be focused on a new light system for hospital bedroom. This new proposal for a light system focused on improving current tungsten lights of the rooms. Potential of new materials for design of night light stand was investigated. New concept of light stand was aimed at using OLED (organic electro-luminescence display) as a light source.

4.4. Basic Keywords

The design task is analyzed in the first stage of the design process (Figure 1). The meanings conveyed from this task result in four input keywords – **Friendship, Sleep, Vitality** and **Health** – to be considered further in the process. This set is directly extracted from interviews as explicit goals of the design. These meanings are decided to be the meaning set, further structured in the design methodology.

4.5. Design Methodology

The next process according to the design methodology (according to the flow-chart in Figure 2) is the evaluation of the whole initial meaning set (B5 in Figure 2). The convergence of meanings for keywords Sleep, Vitality and Health, and Friend is shown in Table 1. This value of 0.207 indicated relatively low relatedness between meanings. The aim is to improve the relatedness (convergence) of the meaning set during the steps of meaning exploration, search and visualization.

Figure 4 shows further involvement of the design methodology in the form of consequent searches and visualizations (steps B2 and B3) which led designer from keyword **Friendship** to **Dolphin and Wave** and from keyword **Light** to **Moon and Moonlight.** The replacements were made by the designer and they led him to a final improved meaning set.

Table 1 Calculations of the path relatedness matrix of meanings for the words **Friendship, Sleep, Vitality** and **Health**.

Friendship	Sleep	Vitality	Health	*Convergence* **0.207**
	0.2	0.143	0.2	Friendship
		0.25	0.25	Sleep
			0.2	Vitality
				Health

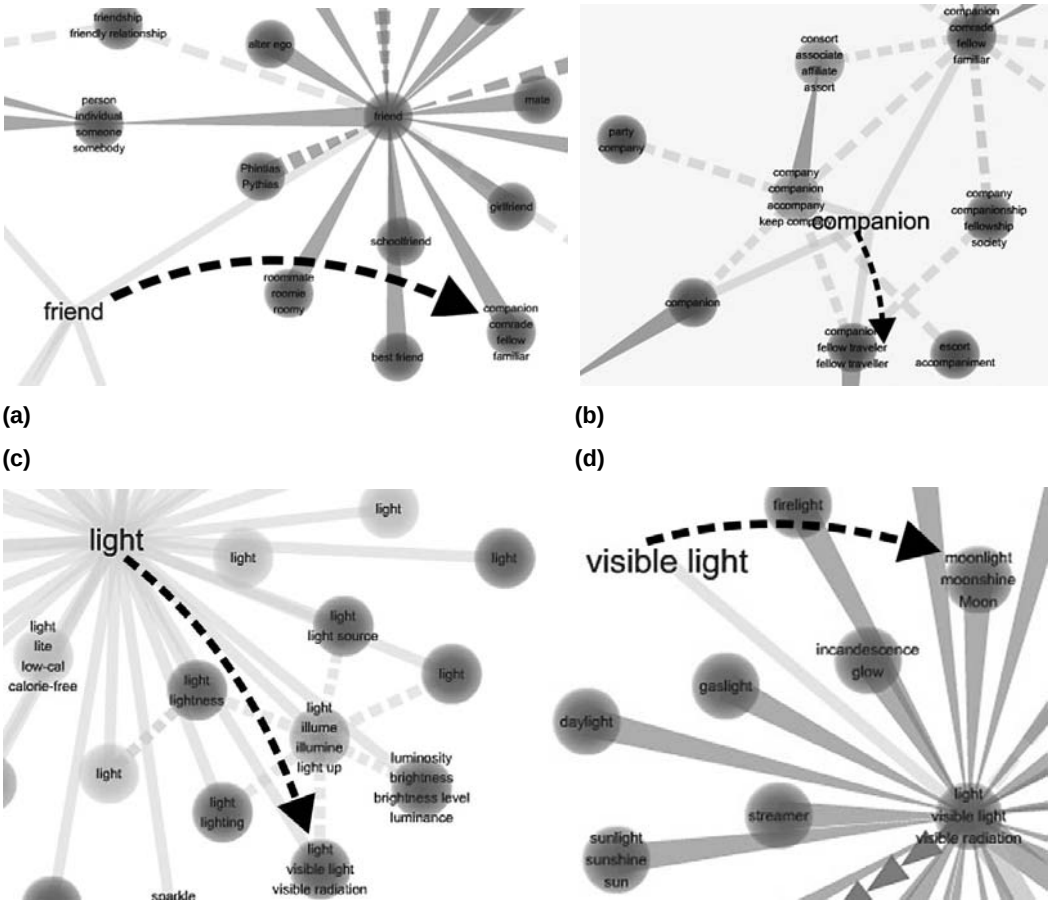
The evolution of meanings is shown in Figure 5, describing steps and replacements of all keywords. Functional notion of meaning of word "light" was developed to impression meaning of "visible light", further substituted by "moonlight" ("moon"), which is also an impression meaning. Impression notion of meaning of word "friendship" was developed to "companion" and "fellow traveler" and later to "dolphin" ("wave"). The impression meaning of "sleep" corresponds to the meaning of "moonlight" ("moon"), while "dolphin" corresponds to the meaning to "vitality". Correspondence of meanings, decided by the designer, help fictional meanings to be transferred to impression such. Meanings of "vitality" and "health" are transferred to the final improved meanings set not directly, however by this correspondence.

In the next step the resulting meanings were evaluated (B4). Table 2 shows evaluation of the meanings of the final keyword set – **Dolphin, Wave, Sleep, Moonlight** and **Moon** – the convergence score for meanings is improved compared to the initial – 0.222>0.207. The designer used these meanings to further construct the shape of the bedroom light stand.

4.6. Prototype of Shape

The design task in this stage was transferring those meanings to the idea shape of the product. The stage after application of the core methodology continued with sketches shown in Figure 6.

Decided shape layout has characteristics of and resembles the dolphin from meaning perspective (phenomena). The OLED light source has color of and serves as meaning of "moonlight" (Figure 6). The hemisphere part has the shape of and transfers the meaning of "moon" and "dolphin". The wavy reflective surface of base and wave like shape are spreading the light from the OLED source, contributing to the impression of "moonlight", its reflection and the whole impression meaning of "sleep".



Friend is replaced (by designer) by **Companion** using visualization of the local WordNet structure for the word "**Friend**".

Companion is replaced (by designer) by **Fellow Traveler** using visualization of the local WordNet structure for the word "**Companion**". From **Fellow Traveler** designer came up with concepts for **Dolphin** and **Wave.**

Light is replaced (by designer) by **Visible light** using visualization of the local WordNet structure for the word "**Light**".

Visible light is replaced (by designer) by **Moon** and **Moonlight** using visualization of the local WordNet structure for the word "**Visible light**".

Figure 4 Search and visualization of WordNet for the meanings **Friend (a), Companion (b),** and **Light (c)** and **Visible light (d).**

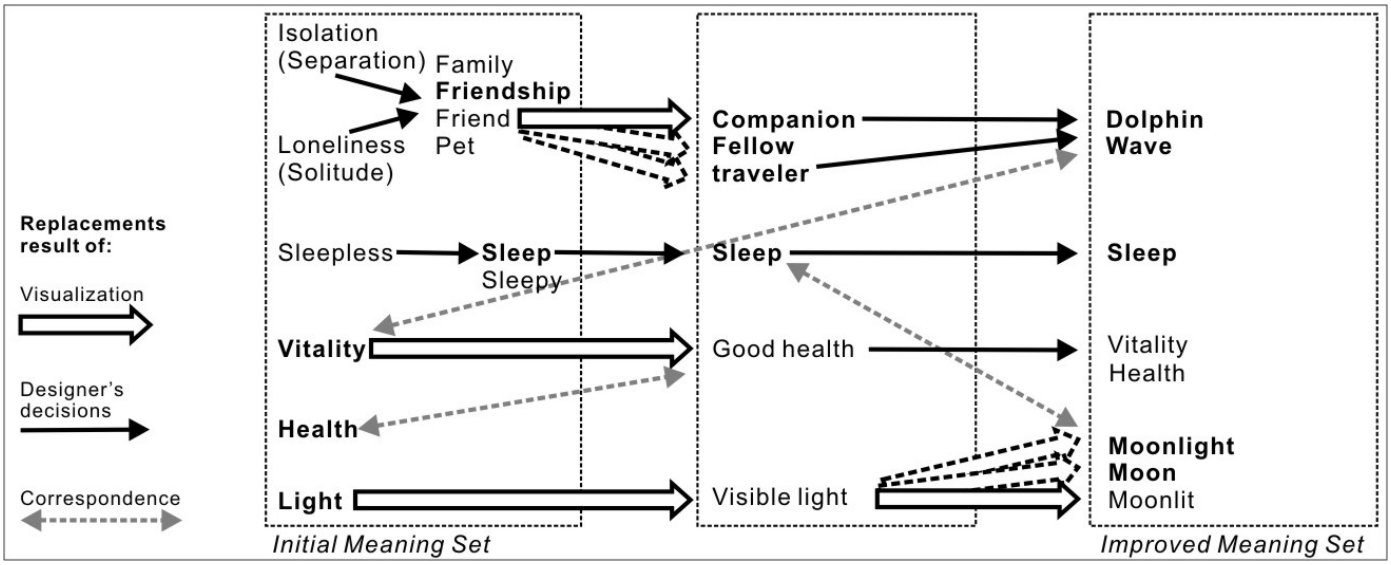
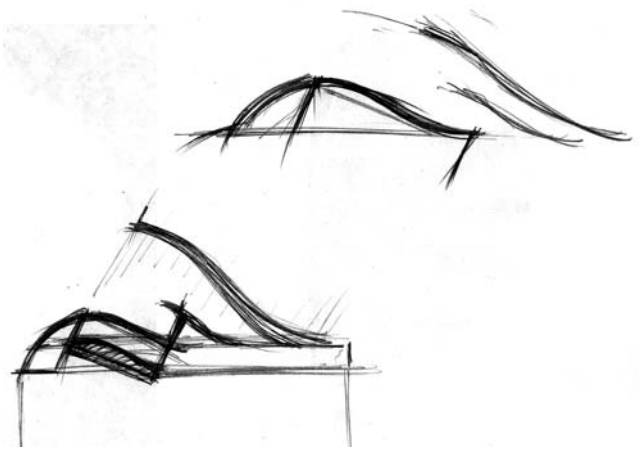


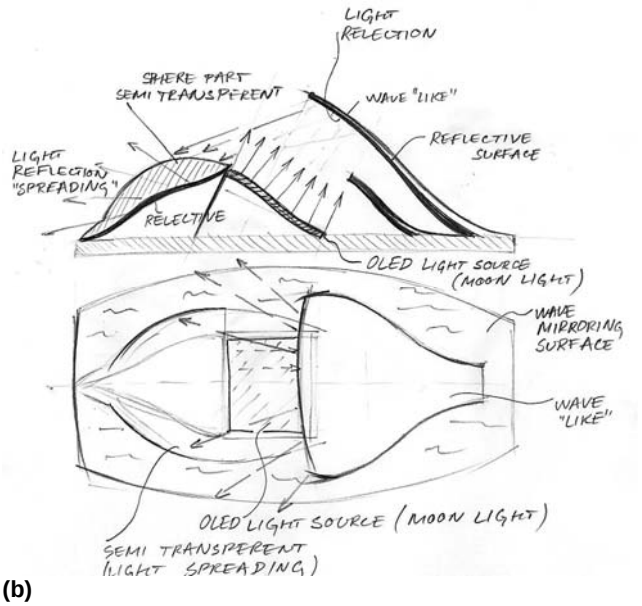
Figure 5 Steps to find meanings. Initially analyzed meanings **Friendship, Sleep, Vitality** and **Health** are developed with design methodology to **Dolphin, Wave, Sleep, Moonlight** and **Moon**. The improved meaning set found is the result of methodology and designer's decisions about meaning replacements, and correspondence between initial functional and final impression meanings.

Table 2 Calculations of the path relatedness matrix of meanings for the words **Dolphin, Wave, Sleep, Moonlight** and **Moon**.

Dolphin	Wave	Sleep	Moon	Moonlight	*Convergence* **0.222**
	0.067	0.048	0.067	0.04	Dolphin
		0.2	0.2	0.2	Wave
			0.2	0.2	Sleep
				1	Moon
					Moonlight



(a)



(b)

Figure 6 Shape idea sketches by designer (a) and layout of designer's decision (b) for the product shape.

5. CONCLUSION

In summary, this example of design methodology application shows search, evaluation and building of meanings structure using WordNet and similarity measures in the WordNet database. These processes of search and evaluation use initial meaning set from the design task and develop this set to form an appropriate meaning structure in the conceptual design phase.

This research established a framework of meanings that can support different aspects of meanings in design support methodology. It is conducted by a meaning search and the evaluation of the structure of meanings according to criteria. The search and evaluation of meanings are key stages in the proposed design methodology. The structure of meanings – that can be directly operated and developed by the designer – on the design conceptual level is applied. Confirmation of changes and development of the structure of meanings by the designer is done by the presented case study.

The design methodology advantages can be considered to have the following:

- The search for meanings is enhanced in a systematic manner, by using the complex WordNet knowledge database for objective representation of the meanings.
- The evaluations of the designer in terms of meanings are enhanced by the introduction of the convergence criteria, which can be easily evaluated for sets of meanings.
- There is improvement in the designer's control and in the building of the structure of meanings.

The described convergence criteria provide qualitative criteria in addition to that of the designer. With the use of WordNet in the search of new meanings that are closely related to the initial meaning, we can achieve a better exploration of the concepts.

The discussed design task case study is used for verification of the design methodology in terms of features and activities of the designer. The practical development of the structure of the meanings is done. The case study discloses the importance of search and evaluation of meanings in the conceptual phase of design. In this way, the development of this structure supports the efforts of the designer. The methodology is applied to create impression meanings using nouns hierarchies from WordNet, and similarly applied to functional meanings.

6. FUTURE WORK

Considering this methodology, further refinement of the process is required. The steps of search and evaluation of the convergence criteria have not yet been integrated into a single system. An improved integrated functionality is required to facilitate easy application in the design conceptual phase.

There is a possibility that other more complex criteria can be described for structure of meanings in WordNet. We will identify such criteria in future studies through the exploration of different measures of relatedness.

The future aim of this methodology is to support both functional meaning and impression meanings based not only on nouns. The possibility for the extension of the methodology, including other hierarchies in WordNet is a factor for covering the product design domain. It is not limited to a specific design area or type of design tasks.

The support of the product design necessarily involves (and considering functional meanings possibly, predominantly focuses on) the verb and adjectives sub-networks of WordNet. It is possible that this extension will reflect on the criteria for evaluation. Additional research in this direction is needed. Functional meanings can be analyzed by the measures in these sub-networks.

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