A METHOD OF CREATING NEW SCENES IN WHICH PRODUCTS ARE USED BY FOCUSING ON THEMATIC RELATIONS

N. Sumitani[1], T. Taura[2] and G. V. Georgiev[2]

[1]Department of Mechanical Engineering, Kobe University, Kobe, Japan
[2]Organization of Advanced Science and Technology, Kobe University, Kobe, Japan

Abstract: This study aims to develop a method that creates new scenes in which a new product may be used. This method is developed by focusing on thematic relations, which are the relations between two concepts through a thematic scene. Thematic relations enable us to represent the functions and structure of a product, as well as the scenes in which the product are used. We propose a specific method for constructing a database of thematic relations and creating a new scene using this database. This method is implemented in a computer system and a case study demonstrates the use of this system.

Keywords: design, scene, thematic relations

1. Introduction

In the modern era of manufacturing, the creation of novel and attractive products is expected. The design of new functions plays an important role in the production of such novel and attractive products. There are two primary types of methods for approaching the design of new functions. One type of method approaches function design from inside the product, examining its physical properties and creating new functions based on the mechanisms and structure of the product. An example of this type of method is described in a study on functional reasoning (Chakrabarti & Bligh, 2001). The second type of method approaches function design from outside the product, investigating and creating the "scenes" (context) in which the product may be used. For example, the portable audio player is a product that was designed to satisfy a particular function that was identified by examining the scene, "listening to music while walking outside the house."

In this study, we develop a method in which a new function is generated based on analysis of the context outside a product: a new scene is created based on a user's everyday life, and particularly the user's actions and product usage in the scene. This method focuses on the thematic relations (the relations between the concepts, Shoben & Gagné, 1997) and how they can be applied to create a new scene. Extending our previous studies on the use of thematic relations for design (Nagai & Taura, 2006; Nagai & Taura, 2009), this paper reports a method for constructing a database of thematic

relations and subsequently for creating a new scene using this database. The idea involved in this method can also be applied to software engineering and HCI scenarios.

Furthermore, the discussion of this method involves a general problem that extends beyond the domain of natural language processing and intelligence. It is an ambitious attempt to extend the scope of design research in the pre-design stage that occurs prior to the clarification of specification normally provided as the starting point of the design process. In other words, this study focuses not only on the product itself but also on the situation surrounding the product.

2. Thematic relations

We have previously defined the concept in design as that which refers to the figure of an object along with other representations (such as attributes or functions of the object) which have existed, are existing, or might exist in the human mind as well as in the real world (Taura et al., 2012). Generally, with respect to the relations between concepts, two types of relations have been identified: taxonomic relations and thematic relations (Nagai & Taura, 2006). A taxonomic relation is a relation that represents the physical resemblance between two concepts, and it is linked with concept classification based on a superordinate-subordinate relation. In Figure 1(a), for example, "apple" and "orange" are subordinate concepts included in the superordinate concept "fruit." They involve many common features, such as being "edible" and "growing on a tree." This type of relation between concepts is a taxonomic relation. By contrast, a thematic relation represents the relation between two concepts through a thematic scene. In Figure 1(b), for example, there are few resemblances between "apple" and "knife." However, we can recognize that "apple" and "knife" are still closely related to each other, because the scene of "cutting an apple with a knife" represents this connection. As this example shows, even when a taxonomic resemblance between concepts cannot be found, a strong relationship may exist; such a relationship is called a thematic relation.

(a)   (b)
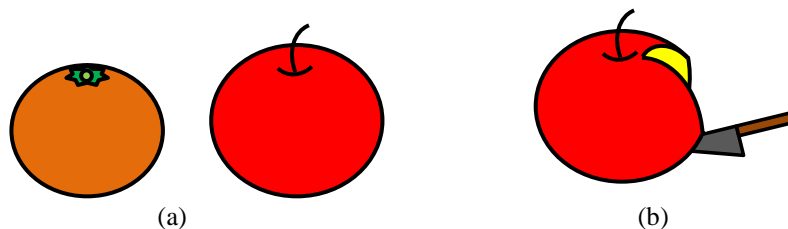
Figure 1. Examples of a taxonomic relation (a) and a thematic relation (b)

2.1. Classification of thematic relations

Thematic relations are expressed by three concepts: two concepts relate to each other in a scene, and one of the three concepts relates the other two to each other, explaining the scene. For example, the three concepts could be described as <car, listen, music>, in which "car" and "music" are related by the concept "listen" or <apple, cut, knife>, in which "apple" and "knife" are related by the concept "cut." Thematic relations can be classified as follows:

- A relation between an object and a place
  This is a thematic relation between an object and a place where the object exists. Examples are <car, listen, music> and <train, listen, announcement>.
- A relation between an object and time
  This is a thematic relation between an object and the time when the object exists. Examples are <winter, warm up, heater> and <night, switch on, light>.
- A relation between the whole of an object and one of its parts
  This is a thematic relation between a concept and one of the parts which comprise it. Examples are <cow, milking, milk> and <sheep, shear, wool>.
- A relation between a product and its material

This is a thematic relation between a product and one of the materials of which it is made. Examples are <bread, made, flour> and <coffee, brew, coffee beans>.

- A relation between a subject of usage and its object
  This thematic relation occurs when a concept is used by a particular subject. Examples are <dog, eat, dog food> and <vacuum cleaner, consume, electricity>.
- A relation between causes and effects
  This thematic relation occurs when one concept causes another. Examples are <fire, yield, burn> and <electricity, supply, heat>.
- A relation between a tool or method and its object
  This thematic relation occurs when an object (e.g., a tool or method) affects another object. An example is <apple, cut, knife>.

2.2. Role of thematic relations in function design

In the field of design, the following situations can be expressed by thematic relations:

- A scene in which a product is used by a user
  For example, <train, listen, music> describes a scene in which a portable music player is used.
- A user's interface with a product
  For example, <screen, scroll, hand＞ describes the operation method of a touch panel.
- The function of a product
  For example, <engine, rotate, shaft> describes the function of an engine.
- The structure of a product
  For example, <car, run, tire> describes the structure of car.

This range of situations that can be represented by thematic relations encompasses almost all the phases of function design. Here, it should be noted that the thematic relations can represent not only the scenes in which a product is used, but also the states (structure or function) of a product.

3. Creation of a new scene using thematic relations

We can identify a process for generating a concept for a new product, based on the use of thematic relations to express both the scenes in which a product will potentially be used and the states of the product. First, a new scene is created; next, a concept for a new product is generated based on analysis of this newly created scene. The above-mentioned example of developing a portable audio player can be explained according to this same process. First, the new scene of "listening to music anywhere outside the house (e.g., on a train)" is created as an extension of the existing scene of "listening to music in a room." Then, a concept is generated for a new product that is "movable and compact," and which can realize the newly created scene. The general method of concept generation discussed here can be summarized into the following process:

Step 1: A new scene is created.
Step 2: A concept for a new product is generated based on consideration of this newly created scene, and then the concept is embodied into a product.

This paper focuses on Step 1. We propose two specific methods to achieve Step 1: a method for creating a new scene by combining two thematic relations, and a method for creating a new scene by replacing one of the words in a thematic relation. Both of these methods follow the method of concept generation (Taura & Nagai, 2012).

3.1. A method for creating a new scene by combining two thematic relations

This method is based on creating a new scene by combining two thematic relations. In order to combine thematic relations, some kind of resemblance between them is required. For example, a shared or similar word among these different relations is useful to bring them together. Generally, thematic relations can be combined freely: a thematic relation can be combined with any other thematic relation. However, we focus on combinations in which one thematic relation represents everyday life, because a new scene is thought to have a traditional background or precursor in everyday life, even though the new scene itself is beyond our everyday life. Figure 2 illustrates an example of combining the following thematic relations: "listening to the announcement on the train" <train, listen, announce> and "listening to music on a CD" <music, listen, CD>. In this example, "listen" is the shared concept found in both of the thematic relations. As a result of their combination, the new scene <train, listen, music> is created.

commonality

<train, listen, announcement>   <music, listen, CD>

combine

<train, listen , music >
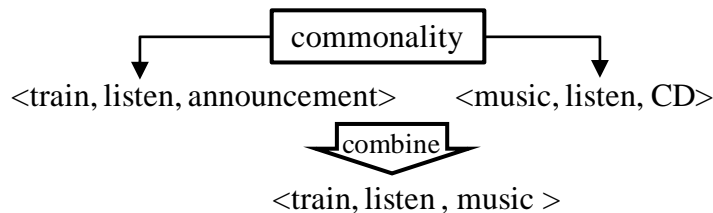
Figure 2. Example of combining thematic relations

3.2. A method for creating a new scene by replacing one of the words in a thematic relation

This method is based on replacing one of the words in a thematic relation with another word. Figure 3 illustrates an example of creating the scene of "sending a landscape photograph by mobile phone" by replacing the word "mail" with "landscape photograph" in the pre-existing scene, "sending mail by mobile phone." This method is a type of analogy.

<mobile phone, send, mail>

replace

<mobile phone, send, landscape photograph >
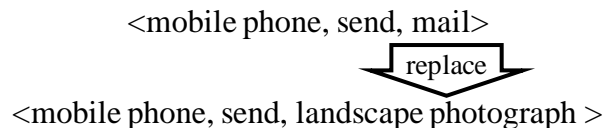
Figure 3. Example of replacing a word in a thematic relation

4. A method for constructing a database of thematic relations

A database in which many different situations are stored is required to enable the creation of a new scene according to the methods described in Section 3. In this study, we believe that everyday life is expressed in documents that are published in public, and we extracted thematic relations from those documents. The origin of the corpus is a large-scale corpus that consists of 470 million sentences (Kawahara & Kurohashi, 2006). A set of concepts that can be expressed as a thematic relation can be obtained from the grammatical dependency relations present in the structure of sentences. Figure 4 illustrates examples of two types of grammatical dependency relations, represented in tree structures. Figure 4(a) depicts a structure in which three words are connected to each other by virtue of one word being connected both the other words. Figure 4(b) illustrates a structure in which the three words are connected to each other in a series. These structures can also be represented as thematic relations. The structure presented in Figure 4(a) is described in the form <apple, cut, knife> and the structure presented in Figure 4(b) is described in the form <CD, listen, music>. In this study, these grammatical structures of thematic relations were obtained using "The Stanford Parser" (Klein & Manning, 2003). The procedure of extracting thematic relations is as follows (illustrated in Figure 5):
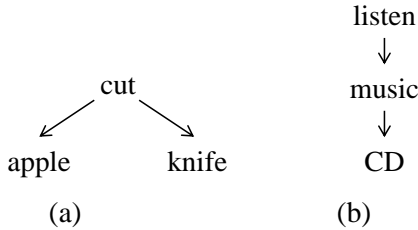
Step 1: Sentence structures are analyzed using a Parser. The example in Figure 5 shows the process in which a sentence ("He listens to his favorite music with a CD player") is divided into eight words and expressed in a tree structure.

Step 2: Specific words are connected. For example, the specific combination "noun + noun" is connected into one word. In the example presented in Figure 5, the individual words "CD" and "player" are combined into "CD player."
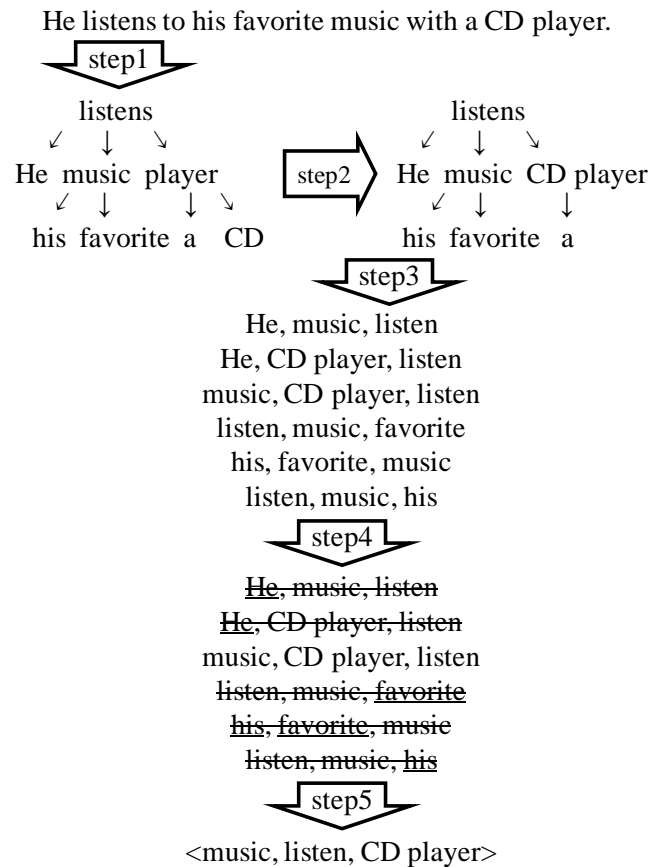
Step 3: The structures by which three words are connected to each other (either one word being connected to the other two words or all three words being connected in series) are extracted. Figure 5 depicts how the sets "He, music, listen," "He, CD player, listen," "music, CD player, listen," "listen, music, favorite," "his, favorite, music," and "listen, music, his" are all extracted from the structure that was obtained in Step 2.

Step 4: Among the sets of three words that were obtained in Step3, those which include words that are unnecessary for thematic relations (e.g., pronouns or emotional expressions) are removed.

Step 5: The sets of three words that have been identified as thematic relations are stored in the thematic relation database. In Figure 5, "music, CD player, listen" is identified as "a relation between a tool or method and its object." Currently, this identification is performed by a system user.


Figure 4. Examples of modification structures

He listens to his favorite music with a CD player.

step1

```
          listens                               listens
        ↙   ↓   ↘                             ↙   ↓   ↘
   He  music  player      step2 →      He  music  CD player
  ↙  ↓      ↓  ↘                      ↙  ↓      ↓
his favorite a   CD                  his favorite a
```

step3

He, music, listen
He, CD player, listen
music, CD player, listen
listen, music, favorite
his, favorite, music
listen, music, his

step4

~~He, music, listen~~
~~He, CD player, listen~~
music, CD player, listen
~~listen, music, favorite~~
~~his, favorite, music~~
~~listen, music, his~~

step5

<music, listen, CD player>

Figure 5. Process of extracting thematic relations

5. A system to generate new scenes

Figure 6 presents a flow chart illustrating the creation of a new scene by combining thematic relations. The system in which we have implemented this flow chart searches the thematic relation database by referring to the keywords that are input by a user. Currently, the thematic relation database contains nearly three million relations, which have been obtained by following Step 1 to Step 4 of the process proposed in Section 4; this means that the relations have not yet been identified as thematic relations, because the procedure involved in Step 5 is still performed manually. Figure 7 shows the interface of a prototype of a computer system that illustrates the situation in which thematic relations are combined. Figure 8 depicts some of the search results obtained by inputting the keyword "car." In this case, the thematic relations <map, look, car> and <map, look, display> are selected from the displayed list, and buttons that correspond to these thematic relations are pushed. The outcome of the above procedures, the combined thematic relations, is displayed in Figure 9. Among them, the new thematic relation <car, look, display> can be selected.
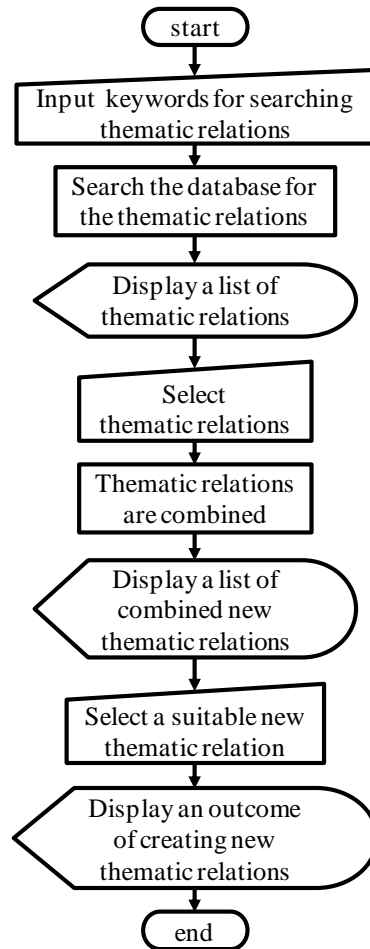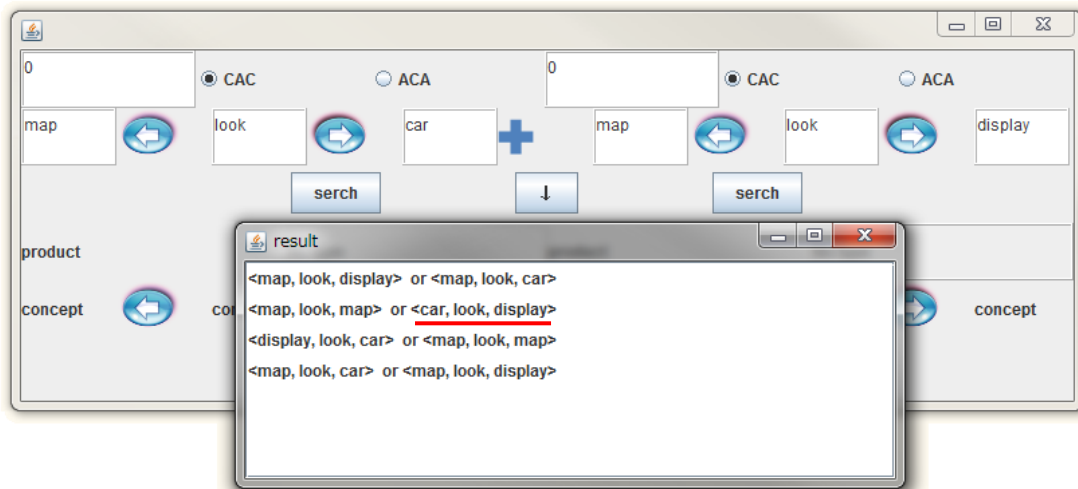
Figure 6. Flow chart to create a new scene by combining thematic relations
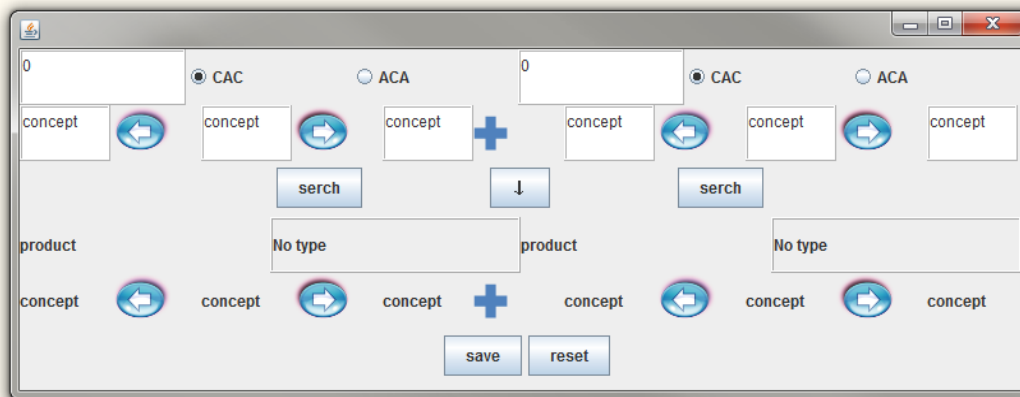
Figure 7. Interface that illustrates the situation in which the thematic relations are combined
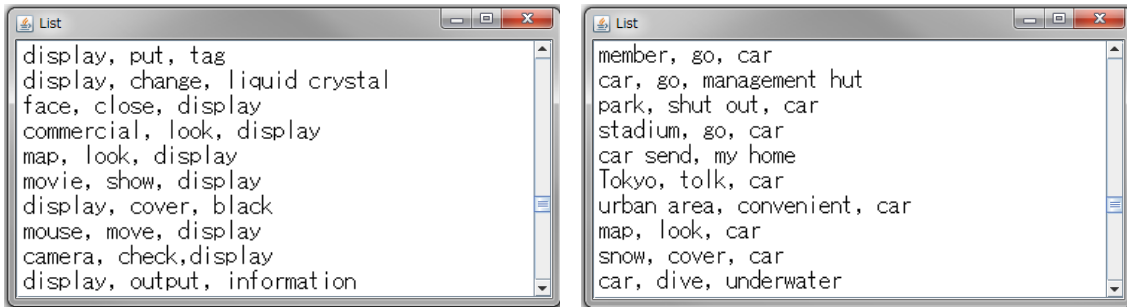
Figure 8. Some results of searching thematic relations

Figure 9. Outcome of creating new thematic relations

6. Conclusion

In this study, we have proposed methods for expressing and creating a new scene in which a product may be used by focusing on thematic relations between concepts. We have developed specific methods for operating with thematic relations and constructing a database of thematic relations. We intend to extend the methods developed in this study in order to integrate methods to design new functions, incorporating approaches that work from both inside and outside the product by examining both the internal states (structure or function) and external scenes (context).

References

Chakrabarti, A., & Bligh, T.P. (2001). A scheme for functional reasoning in conceptual design. *Design Studies, 22*(6), 493–517.

Kawahara, D., & Kurohashi, S. (2006). Case frame compilation from the Web using high-performance computing. In *Proceedings of the 5th International Conference on Language Resources and Evaluation (LREC2006)* (pp. 1344-1347).

Klein, D., & Manning C. D. (2003). Accurate unlexicalized parsing. In E. W. Hinrichs & D. Roth. (Eds.), *Proceedings of the 41st Annual Meeting of the Association for Computational Linguistics – Volume 1* (pp. 423–430). Stroudsburg, PA: Association for Computational Linguistics.

Nagai, Y., & Taura, T. (2006). Formal description of concept-synthesizing process for creative design. In J. Gero (Ed.), *Design computing and cognition* (pp. 443–460). London: Springer-Verlag.

Nagai, Y., & Taura, T. (2009). Concept blending and dissimilarity: Factors for creative concept generation process. *Design Studies*, *30*(6), 648–675.

Shoben, E. J., & Gagné, C. L. (1997). Thematic relation and the creation of combined concepts. In T. B. Ward, S. M. Smith, & J. Vaid (Eds.), *Creative thought: An investigation of conceptual structures and processes* (pp. 31–50). Washington, D.C.: American Psychological Association.

Taura, T., & Nagai, Y. (2012). *Concept generation for design creativity: A systematized theory and methodology.* London: Springer-Verlag.