Chapter 19
Semantic Description Framework of Product Concept Based on How Net

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Abstract To reduce ambiguities and misunderstandings in product design and promote information communication, this paper attempted to utilize and combine the intuitiveness of visible model and the richness of product concept in semantic, proposing a semantic description framework based on How Net. The framework could comprehensively take structure, function, and behavior into account. Application-specific dictionary construction method was proposed to prepare standard taxonomy for the framework; then the framework is finally established through the dynamic roles in How Net. Using a central wing panel assembly fixture as an example, the effectiveness of the framework was verified.

Keywords Semantics description framework · Product concept · How Net

19.1 Introduction

Generally speaking, there are two most direct representations of product in modern product design: visible models and invisible naming concepts (referred to "product concept" for short). Product concept implies abundant engineering semantic information, including function, behavior, structure, etc. [1, 2]. By applying

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constructive strategy, How Net builds concept definition with a closed sememe set, organizing the concepts which are static and isolated into a network structure by adopting dynamic concept descriptions [3, 4]. The constructive strategy of How Net allows for defining concepts expressed by Chinese characters as they are one-syllable words, the meaning of which could be conveyed [5]. This paper hence proposes a concept semantic description framework for product design based on How Net, integrating the structure, function, and behavior of products in a unified way [6].

19.2 Introduction of How Net and Product Information Model

19.2.1 How Net

In How Net, the semantic of words are described by "concept" and a word could be expressed as several concepts. The minimum meaning unit of a "concept" is "sememe". How Net designs the knowledge database markup language (KDML). KDML adopts semantic expressions to describe knowledge through a series of restrictions and symbols. With the help of "dynamic role" in How Net, semantic expressions describe the complex relationship between "concept" and "sememe", forming a complicated network structure.

19.2.2 Product Information Model

Product information model is the base for establishing the semantic description framework of product concept, which clarifies the roles of elements and the relationships between them in the description framework [7]. The product design process is generally driven by functional requirements and targeted by obtaining the structures which meet the function needs; On the other hand, the purpose of the structures is to represent some certain products, the shape and size of which are required for accomplishing the functions of products; while the satisfaction of such demands is realized by some certain behaviors (indicates "how to realize the function of the structures"). As function and behavior of products are usually implicit, the structure becomes the only one which could be seen intuitively among the three; meanwhile, except for the representation in the visual aspect, the structure is able to convey information through the term which names it. Therefore, the terms which are used to name products are also regarded as a part of product information in this paper. For establishing semantics description framework of product concept, the paper focuses on two aspects:

1. Determine the taxonomy which are universally recognized in relevant field and guarantee correct semantic analysis of product concept by establishing "taxonomy dictionary" for design with the help of How Net.

2. Establish semantic description framework of product concept based on standard taxonomy.

19.3 The Development of Taxonomy Dictionary in Product Design Field

The development of taxonomy dictionary mainly focuses on the retrieval of sememes. According to the product information model, the taxonomy dictionary in product design will mainly include dictionaries in the domain of structure, behavior, and function. As behavior and function usually relate with each other, the taxonomy dictionaries of the both are merged here, which are collectively called function/behavior taxonomy dictionary. Generally speaking, structure, behavior, and function all have corresponding attribute and attribute value, so corresponding taxonomy dictionaries of these attributes and attribute values should be established as well.

19.3.1 Structure Sememes

Structural information is the core in product information model. In 3D product design platform, product structure includes two aspects: organization structure and geometry structure. As it is hard to form an independent semantic structure unit by those geometry elements such as point, line, and face, the taxonomy dictionary of geometry structure in the paper mainly focuses on geometrical features.

In order to obtain the specific structure sememes from the product design, this paper puts forward some guiding principles as follows:

1. For the terms which have been generalized out by experts and used as basic component classes, the closer they are away from the root nodes in the classification tree, the higher priority they will have to become sememes; otherwise, the lower priority they will have.
2. Specific terms could be considered as sememes.
3. Those terms which are synonyms of sememes (such as “fixtures”, “technological equipment”, etc.) could be regarded as sememes.

19.3.2 Function/Behaviors Memes

Function/behavior terms belong to “event” in How Net. Sememes of event class are mainly used to describe inter-concept relations as well as inter-attribute relations. There are more than 1,700 sememes of event class in How Net, which could

basically meet the requirements in product design. In order to obtain the specific function/behavior terms in product design, the paper proposes several guiding principles too, which is similar to the structure sememe:

- Terms of function basis could be considered as sememes.
- Those terms which are synonyms of sememes.

19.4 Semantics Description Framework of Product Concept

Terms which are used to name products could be described in a standard way after obtaining the sememes in product design. The semantic description framework of product concept establishes semantic relationships of terms through making use of the relationship of function, behavior, and structure. This paper defines the description framework of the terms which name products in How Net as follows:

DEF = {Structure Type | type of structure: {behavior | behavior}, {function | function}, {attribute | attribute}}.

Function/behavior description framework is mainly used to express the semantics of verbs. According to the theory of role framework of How Net, function/behavior description framework should reflect those roles which may involve in the events described by the framework, such as the purpose of function/behavior, the agent of behavior, the instrument, the patient of behavior, and the relevant attribute.

DEF = {Type | Type: purpose = {*}, agent = {*}, instrument = {*}, patient = {*}, attribute = {}}

19.5 Examples

This paper explains the semantic description framework by taking the assembly fixture of an aircraft central wing panels as an example.

Taxonomy dictionary is the basis of establishing semantics description framework of concepts in this paper. Based on the construction methods of taxonomy dictionary mentioned before, this paper establishes corresponding taxonomy dictionaries for structure, function/behavior, and attribute in Protégé according to the knowledge of the aircraft tooling design and some general knowledge in mechanical design. As shown in Table 19.1.

Table 19.1 Descriptions of main nomenclatures in fixtures

Term	How Net describe
Aircraft central wing panel	DEF = {fixture, purpose = {install: location = {~}, patient = {part: whole = {part: Part position = {centre}, whole = {wing}}}}
Bone base beam	DEF = {part: Isa = {beam}, Part Position = {base}, whole = {bone}, modifier = {horizontal}}
Bone column	DEF = {part: Isa = {column}, whole = {bone}, modifier = {vertical}}
Bone beam	DEF = {part: Isa = {beam}, Part position = {capstone}, whole = {bone}, modifier = {horizontal}}
Clip board subassembly	DEF = {subassembly: purpose = {position: agent = {locator}, cogent = {auxiliary device}, patient = {product}, instrument = {~}}{clamp: agent = {locator}, cogent = {auxiliary device}, patient = {product}, instrument = {~}}}
Channel steel	DEF = {Profile: material Of = {beam}}
Sleeve	DEF = {sleeve: purpose = {fasten: patient = {ear}, location = {~}}}
One aperture ear	DEF = {ear: Of part = {aperture: quantity = {one¯}}}
Reinforcing plate	DEF = {stiffener : purpose = {strengthen: patient = {?}, method = {~}}}
Long ear	DEF = {ear: modifier = {long}}}
Two big ear	DEF = {ear: of part = {aperture: quantity = {two}}, modifier = {big}}
Screw sleeve	DEF = {sleeve: purpose = {protect: patient = {screw}}
Stent	DEF = {part: purpose = {prop up: patient = {?}}, part position = {base}, whole = {implement}
Left mainstay	DEF = {mainstay, purpose = {prop up: patient = {?}, instrument = {~}}, modifier = {lefl}}
Right mainstay	DEF = {mainsta: purpose = {prop up: patient = {?}, instrument = {~}}, modifier = {right}}
Top beam	DEF = {part: Isa = {beaml}, part position = {capstone}, whole = {bone}, modifier = {horizontal}}
Clip board	DEF = {locator: purpose = {position: part of touch = {part: part position = {skin}, whole = {product}}, modifier = {form value: board}}
Form value bolt	DEF = {bolt: modifier = {form value}}
Double screw bolt	DEF = {double screw bolt}
Lugs	DEF = {tool: purpose = {join: instrument = {~}, patient = {locator}}}
Knurled nut	DEF = {nut: {knurled}}
Front locator	DEF = {locator: purpose = {position}, modifier = {Form Value: block}{front}}
Angle section	DEF = {Profile}
Position Subassembly	DEF = {subassembly: purpose = {position: agent = {locator}, cogent = {auxiliary device}, patient = {product}, instrument = {~}}
Shape locator	DEF = {locator: purpose = {position: part of touch = {part: part Position = {skin}, whole = {product}}, modifier = {form value: block}}
Binding clasp	DEF = {clamper: purpose = {clamp agent = {~}, patient = {product}, instrument = {~}}, modifier = {fast}}

(continued)

Table 19.1 (continued)

Term	How Net describe
Substructure	DEF = {part: purpose = {Prop Up: patient = {?}}, Part Position = {base}, whole = {implement}}
Handle	DEF = {fittings: whole = {implement}, purpose = {alter state good: state fin = {difficult}, state in = {easy}, content = {operation}}
Compression bar	DEF = {part: whole = {implement}, purpose = {press: patient = {?}, method = {lever}}}
Pin	DEF = {pin: purpose = {fasten: instrument = {~}}}
Washer	DEF = {washer: purpose = {spread: patient = {force}, instrument = {~}}}
Bolt	DEF = {bolt: purpose = {join: partner = {nut}{washer}, patient = {?}}}
Cushion block	DEF = {cushion block: purpose = {prop Up: patient = {?}, instrument = {~}}{spread: patient = {force}, instrument = {~}}, modifier = {thick}}

19.6 Conclusion

With the purpose of improving the information communication in product design and reducing semantic misunderstandings and ambiguities, this paper proposed semantic description framework of product concept, based on How Net. The framework simultaneously took the structure, function, and behavior of products into consideration, which was beneficial to combine the intuitiveness of visible model with the rich semantic of concept. Based on product information model and How Net, we established taxonomy dictionaries of structure, function/behavior in product design, and built the semantic description framework of product concept by adopting dynamic roles in How Net, according to the relationship of function, structure, and behavior. Finally, this paper described the concepts of the names in assembly fixtures of an aircraft central wing panel certainly, using the taxonomy dictionaries and semantic description framework which have been established, verifying the feasibility of the technologies proposed.

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