Case Reasoning Based Design System for Product Packaging

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Abstract. The overall design procedure of product packaging is divided into 2 phases: generation of packaging design scheme and detailed design scheme, based on which, overall structure of design system for product packaging PACKAGING is designed. By using CBR technology, generation of product design scheme in PACKAGING is achieved, Meanwhile, each key technological step in generating procedure of design scheme for product packaging is discussed in detail.

1. Introduction
In Chinese national standard GB 4122-83, packaging is defined as a general name of containers, materials, auxiliaries and others used for protecting products, facilitating storage and transportation, as well as promoting sales during circulation, which are based on certain technological methods. "Protecting products, facilitating storage and transportation, as well as promoting sales" is summarized as 3 functions of packaging, and a good packaging design is the key enabling product packaging to achieve its function. Packing design is obtained by focusing on characteristics of products to be packed, as well as considering raw material, structure, decoration, production, circulation, price and other factors of packaging comprehensively. With the continuous emerging of new packaging material and technology, and increasingly improved user's requirement and expectation toward product packaging, amounts of information necessary for packaging design is greatly increased, and difficulty of packaging design is correspondingly enhanced. Generally speaking, the more knowledge and stronger analysis and comprehensive abilities the packaging designer possesses in packaging and related area, the better the designed packaging meets user's requirement. In a developed e-commercial economy nowadays, packaging design could affect competitiveness of the packaged product to a large extent. To this end, how to deal with knowledge of packaging and related area, thus to effectively accomplish packaging design of products has turned to be a hot issue in the field of commodity production and circulation.

2. Design system for product packaging
In view of complexities and uncertainties in design of product packaging, computer aided designing technologies are merely used by most traditional design system for product packaging in a certain step of the design (such as decoration design of packaging, selection of a crash pad), or applied to a certain packaged product (such as paper box, glass bottle), so as to improve quality and efficiency of the design. Currently, mature design system for product packaging including: design system for corrugated case, wooden case, and trap loading of Japanese Mitsubishi, design system for bottled container of Sharp Corporation.

Design of product packaging is a materialization procedure for interaction of a packaging designer’s creativity and design condition, which is also an intelligent behavior. In many steps of
design of product packaging (such as determination of design scheme for product packaging, establishment of a buffer model, determination of main structural parameter, evaluation and excellence selection), considerable work could not be solved by establishing accurate mathematical model and applying a numerical calculation, but requiring the designer to exert his own creativity, use multi-disciplinary knowledge and practical experience to analyze & reason, operate & decide, as well as evaluate comprehensively, thus to get the rational result. Although existed design systems for product packaging have humans’ capacities extended both in numerical calculation and graphic plotting, they could not generate packaging design scheme of a specific product without intelligent support and lacking of introduction of specialized knowledge.

The design system for product packaging (PACKAGING) studied in this paper is such a system that when facing products to be packed, it sorts them (drinking, pot foods and medicine for example) firstly according to specific condition of which, then fully consider each function of the packaging, and design the product packaging. By referencing practical design procedure of product packaging, PACKAGING divides overall design procedure of product packaging into two phases: generation of scheme for packaging design and detailed packaging design. PACKAGING firstly utilizes a case reasoning based method to accomplish design of product packaging scheme, and use the determined design scheme of product packaging to get the specific design drawing. Among which, generation of scheme for packaging design references to proposing of brief packaging design scheme on the basic of knowing product feature and packaging requirement, which includes whether to employ inner packaging, intermediate packaging or exterior packaging, which materials to be employed by packaging of each layer, and main functions that should be included. The design scheme of product packaging here is reasoned and obtained by PACKAGING to interact with users to get product features as well as its packaging and transportation requirement, as well as combining the system itself possessed design knowledge for product packaging. Detailed packaging design could include generation of packaging structural drawing and decorating drawing. If paper boxes are included in a packaging design scheme, die cutting layout, printing layout of the paper boxes, and other producing drawings which could be directly used by a paper box factory shall also be included. Furthermore, at the detailed design phase of product packaging, PACKAGING also provides some other dedicated design tools, such as decoration design plates for OTC (Over the Counter) medicine specific to OTC medicine. Overall structure of PACKAGING could be illustrated by Fig. 1.

3. Use a case reasoning based method to generate design scheme for product packaging
The world “case-based reasoning” (CBR for short) was firstly put forward by Professor Janet L.Kolodner led researchers mid-1980s, which is an analogic reasoning method. As such reasoning method could effectively solve many assignments that could not be accomplished by regular-based reasoning, it is widely used by AI staffs to solve each kind of practical problems. Core thought of case-based reasoning lies in: when solving a problem, experience in solving similar problems previously could be used for reasoning, rather than solving it from scratch. Map such ideology to design of product packaging is to apply existed design scheme for product packaging to product packaging to be designed when design a product packaging. Such design thought for product packaging is on one hand similar to practical design procedure of product packaging, which could on the other hand make full use of previous design experience and tactfully avoid some reparative work when designing product packaging. Therefore, in the design system for product packaging PACKAGING, a case reasoning base method is selected to get design scheme of product packaging.

4. Key steps for CBR generating design scheme for product packaging
CBR simplifies task of knowledge engineering to determine appropriate case characteristics, define proper nouns of the field and collect classified case before from specialists. Difficulties for technological implementation of applying CBR technology to generation of design scheme of product packaging is firstly expression of packaging design scheme; furthermore, case retrieval, case management, and other steps involved in the CBR procedure is of significance for generating design
scheme of product packaging correctly, such important technological steps will be respectively described below.

![Overall structure of PACKAGING](image)

**Fig.1 Overall structure of PACKAGING**

4.1. Case expression of design scheme of product packaging

CBR technology is used by PACKAGING for determining design scheme of product packaging, and case expression of packaging design is an important factor that determines design quality. In PACKIMG, expression for design scheme of product packaging not only influences whether practical packaging design scheme could be rationally and easily converted to a case pattern, but also influences efficiency of case-base reasoning and case library management system.

Expression of packaging case in PACKAGING almost involves all relevant content of packaging design, which shall also be convenient for subsequent reasoning design. Information used in the design determines that expression of design case shall embody certain hierarchy. Medicine packaging is taken as an example below to explain case expression in PACKAGING.

A packaging design scheme for medicine stored in case library could be divided into 2 parts according to its content, the previous part is descriptions for characteristics of the medicine itself, such as name, status, and usage, purpose of which is to distinguish different medicines. For a same medicine, as its specification, packaging dimension, especially the intermediate packaging and exterior packaging scheme may differ, packaging schemes of which will be treated as different ones. The later part is descriptions for packaging design scheme of the medicine, packaging contact with medicine directly is called inner packaging, and the outermost packaging when the medicine leaves factory is
called exterior packaging, other packaging is called intermediate packaging 1, intermediate packaging 2 etc. in turn from inside to outside. While inner, intermediate and exterior packaging of products is all specific packaging types incorporated in the finished packaging library. Except for the packaging itself, appendage, such label and sealing will be included in each kind of specific packaging pattern. A specific content of design case for medicine packaging could be summarized as in table 1.

| Case for design scheme of product packaging | Product description |
|------------------------------------------|---------------------|
|                                          | 1. Name (trade name, brand, OTC or not) |
|                                          | 2. Characteristics [solid (powder, particle, capsule, dimension), liquid (compressed, viscosity, half-viscosity, low-viscosity, or ordinary), others] |
|                                          | 3. Usage (oral, externally, injection, inhale, suppository) |
|                                          | 4. Chemical characteristics (packaging material prohibited, inflammable or not, keep in dark or not) |
|                                          | 5. Specification |
|                                          | 6. Circulating procedure and requirement |
|                                          | 7. Price |
|                                          | 8. Others |

| Packing design scheme |
|-----------------------|
| 1. Inner packaging [material code (from the packaging material library), pattern (bag, bottle, box, from the packaging material library), main dimension and accessory] |
| 2. Intermediate packaging 1 |
| 3. Intermediate packaging 2 |
| 4. Intermediate packaging 3 |
| 5. Exterior packaging |
| 6. Others |

4.2. Retrieval of packaging design case

Retrieval and matching of cases are important steps of case-based reasoning, which is related to what cases to be supplied to the design system, so as to be referenced or rewritten. It thus determines the design quality to some extent.

In a CBR system, there are 3 most common retrieving methods: the most adjacent strategy, inductive reasoning strategy and knowledge leading strategy. Product packaging is designed according to characteristics of the product itself, and retrieval of packaging design case also takes the principle that retrieve product packaging design case similar to packaging characteristics of products to be designed. So, PACKAGING uses a knowledge leading strategy to make case retrieval. Factors in product characteristics that will determine packaging design most will be firstly used for retrieval, and then influencing level of product characteristics to product packaging will be used for retrieval in turn, until the design scheme for product packaging that close to each characteristic of the product most is obtained. In order to improve flexibility of the retrieval, those should be determined by users themselves, i.e. which characteristic of the product shall be used for retrieval firstly, and characteristics of the product for retrieval of the next step, the system also provides recommended retrieval strategies.

4.3. Determination of design scheme for product packaging

The following 3 circumstances may occur to design scheme of product packaging obtained from retrieval step:

(1) Product characteristics of packaging to be designed completely the same to a product in the case library, and the original packaging scheme could be directly used without any modification.

(2) Product characteristics of packaging to be designed are consistent with a product in the case library, which could be used after amendment by general modification procedure of the system itself is
done. For example, for different medicine shape, just change shape of the blister packaging; for medicine need to be kept in dark, just change color of the packaging bottle.

(3) If product similar or basically similar to the product to be designed could not be retrieved in the case library by the system, then a multi-case integrating mechanism shall be utilized. The system or users will respectively make the retrieval according to main characteristic of the product and get many cases, each one will determine part of the design scheme respectively, and then the system synthesizes many cases and gets the design result.

4.4. Management and maintenance of design case of product packing
Case library in PACKAGING is the primary basis for the system to make scheme design for product packaging. Basic managerial function of the case library includes display, edit, modification, deleting, add in and others of cases. Case maintenance is relatively more complex. Although cases in the case library apply consistent expression form and unified organizational method, source and using effect of each case differ. If it is solely considered from the angel of case source, case in PACKAGING case library mainly include the following types:

(1) At the early beginning of establishment of the system, for the purpose of enabling users to use the case reasoning based method to design product packaging scheme, there is already initial case in the case library.

(2) New design schemes designed for new products via case-based reasoning by users by virtue the system will be saved in the case library, becoming system generated cases.

(3) As new progress, material and structure of product packaging emerge continuously, in order to improve design capacity of PACKAGING, new packaging design scheme will be added in the case library, thus to become newly added cases of the case library.

Except for differences in source of cases in the case library, times of case being retrieved, similarities between cases and others are also issues shall be considered when maintaining the case library. Due to complexity of cases in the case library, maintenance of case library is indispensable for maintaining an efficient and ordered case library.

Maintenance of case library is of significance for improving efficiency of case library, which will keep the case library at an optimal operating status. In order to prevent the case library from being more and more enormous, reducing managerial efficiency of the case library and efficiency of case reasoning system, reasonable maintenance to the case library is needed. Main maintaining work includes: conforming whether to keep a case or not according to similarities; set a variable record for each case to record usage of the case; amend cases with problem frequently.

5. Conclusions
The design system for product packaging PACKAGING divides overall design procedure of product packaging into 2 phases: generation of packaging design scheme and detailed packaging design, and CBR technology is utilized to complete implementation of packaging design scheme. With the help of medicine packaging cases in its own case library, and base on user input product characteristics, PACKAGING could generate packaging design scheme for medical product, and then make detailed design of medical product packaging, generating packaging structural drawing and decoration drawing, etc.

PACKAGING focuses on specific product and offers design scheme for product packaging, while there are plenty of products with packaging of which to be designed and differ greatly. Therefore, when solving design issues of product packing, PACKAGING will firstly classify products, so that packaging design of the same kind of products will be solely considered every time. The above mentioned factors make universal application of the system have certain difficulties. To this end, studying common characteristics of product packaging design systematically, and dividing design scheme for product packaging into several representative model will help PACKAGING to improve efficiency for solving packaging design issues.
Moreover, during the procedure for utilizing CBR technology to generate design scheme for product packaging, when a multi-case integrating mechanism is needed, if it is non-limited within packaging design case of this kind of product, issue solving capacity of PACKAGING will also be greatly improved.

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