

Application of multiple domain feature mapping in Design For Cost(DFC)⁺

Chen Xiao-chuan , Fang Ming-lun

CIMS & Robotics Center, Shanghai University, Shanghai, China

Feng Xin-an

The Laboratory of Advanced Manufacturing Technology, Dalian University of Technology, Dalian, China

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ABSTRACT: Design For Cost (DFC) is a embranchment of Design For X (DFX). Using multiple domain feature mapping theory, we decompose the DFC's feature domain. It includes four design feature domains (concept design domain, initial general design domain, general design domain and detail design domain) and six cost feature domains (manufacturing cost domain, assembly cost domain, sale cost domain, usage cost domain, repair cost domain, recycle and disposal cost domain). Then we establish multiple domains feature mapping relations that the design domain is the core in DFC. Using artificial neural network (ANN), simulation and grey system theory, we initially attain that the design parameters can be mapped to the cost parameters. This paper presents work is a base of estimating the LCC in DFC.

1 INTRODUCTION

Nowadays, with the development of world market, modern manufacturing technologies are emerging rapidly toward flexible, agile, intelligent and integrated direction. Many manufacturing theories are developed, for example, concurrent engineering, virtual manufacturing, agile manufacturing and so on.

Concurrent engineering (CE) is a concurrent work model for many applications in manufacturing process. It needs to be supported by a whole product information model having great consistency and integrality. The special information model of each application areas are extracted and they can form the whole product information model. The special model translates information with the whole product information model directly and translates information with other areas' model by the whole product information model. Feature technology was born from the different demands on different application areas in product information. Feature information expression and conversion is the key of more development of feature technology on the condition of different engineering applications. And that is a basis that makes product information integrate and share in CE. Currently, knowledge-based feature mapping methods have been applied in the product concurrent design system (Yuyin, 1997). Design features are a basis in multiple domain feature mapping (MDFM) theory. By feature mapping, design features export information to the other application domain. Then design model's information was selected and used in all kinds of application domains according to themselves needs. Those works satisfied CE's demands. Now either theory system or application technology is at the beginning stage in MDFM research (Lim, 1995) (Detao

et al., 1996). In this paper, we research on the feature mapping between design domain and cost domain initially.

Design For Cost (DFC) is a design method which analyzed and evaluated the product's life cycle cost(include manufacturing cost, sale cost, usage cost, repair cost, recycle cost, etc.) ,then modified the design to reduce the life cycle cost. Its characters can be concluded as followed:

- 1) In tradition, designers attached importance to the other parameters, but not cost. In product design ~~process of DFC, the~~ LCC must be an equivalent parameter as performance, schedule and reliability.

- 2) Product designers consider the reduction of product cost in the whole life cycle.

- 3) In DFC we need confirm parameters of manufacturing, usage, maintenance phases, for example, assembly cost percent unit, usage cost percent unit. Designer should balance the performance, schedule, reliability, LCC and so on.

- 4) Designers and their related personnel need communicate and feedback cost information in time each other, so they can use some effective methods to control product LCC.

DFC is one of the support tools for CE and an important part of DFX. But DFC is very different from DFM and DFA. DFM (Design For Manufacturing) or DFA (Design For Assembly) is one link (Manufacturing or Assembly) in product life cycle, but DFC faced the whole life cycle of product. It says that costs exist in design, manufacturing, assembly, testing, use, maintenance, recycling phases.

In this paper, we established multiple domains feature mapping relations that design domain was the core in

DFC. Using artificial neural network (ANN), we initial attained that design parameter can be mapped to cost parameter.

2 MULTIPLE DOMAIN FEATURE MAPPING (MDFM) THEORY

2.1 the conceptual definition of feature and its classification

Research on feature identified technology and feature-based product model had many fruits, but mostly research results were on the special applications and it is difficult for definition of feature to be applied to other areas. In 1985, Pratt and Wilson gave a widely conceptual definition of feature: A feature is a local interested configuration on the surface of a manufactured part (Pratt & Wilson, 1985). Namely, a feature is part information that is useful for research or operation of the different application areas. For example, design domain are concerned of geometric model information of parts: point, line, face, loop, body and other low geometry and topology information; manufacturing process domain concern about feature semanteme and function information, process parameters and materials information, but not the geometry information. It is interested in size tolerance and semantic information that is translated from geometry information. Manufacturing domain need design domain provide geometry information and machining information in manufacturing process, then CNC program will be automatically finished. On the basis of the above discussion that have been discussed, we proposed the conceptual definition of feature as following:

The feature is a model that has been made beforehand for an application and it can describe a part's geometric configuration and engineering significance.

This definition gave a general description for feature, then we can conveniently classify feature in terms of the definition. It is an important definition for MDFM methodology.

According to the conceptual definition of feature, we classified feature domains into the followings in CE (Wangfeng et al., 1998):

(1)Design feature domain: it describes features information on design. It includes parts' figure features, precision features, material features, technology features and management features. This domain provided a foundation for MDFM because the information of other domain's feature must be translated from design feature information.

(2)Customer needs feature domain: it describes product performance that was demanded by customers. It includes performance index (power, life, etc.), product exterior effect and so on.

(3)Analysis feature domain: it describes the information that is needed by mechanical performance, dynamic performance and manufacturing analysis. For instance, we need geometric and topology information in

order to automatically plot out the griddings in finite element analysis; system imitation need geometric restriction relation among parts.

(4)Process feature domain: it describes figure that are associated with group technology (GT) and process information (tolerance, material, surface roughness, etc.) and their semantic relation that was reflected in the engineering. For example, cutting tools' types and cutting numbers were selected according to geometric information, size tolerance and materials of parts. According to technology conditions, surface roughness and hardness, heat treatment methods are confirmed.

(5)Manufacturing feature domain: it is associated with manufacturing information of workpiece. It is part figure and precision areas that are built by a metal cutting model. For instance, hole, groove, sidestep and their associated size and direction information needed in manufacturing. Machining methods are decided on those information according to reasoning and match.

(6)Assembly feature domain: it describes parts assembly information that includes assembly types, assembly directions, assembly orders, collaboration relation and so on. For instance, links structure and links type between parts and parts unit features (seal, screw thread links, etc.) are applied to select assembly methods and tools.

(7)Cost feature domain: it includes life cycle cost information that is applied to analyze and calculate parts or products cost from design to sale, use, maintenance and disposal.

(8)Quality feature domain: product reliability, life cycle, etc.

In addition, feature domains include clamp feature domain, mould feature domain, etc. except for the above features classes.

2.2 the concept of multiple domain feature mapping (MDFM)

The concept of MDMF was derived from the conceptual definition of feature and its classification. Because features are understood in the different applications and the interested areas are different for the same part, it is different to completely unify features in different domains. The concept of MDMF described feature mapping in different domain, then necessary relations were set up among different applications. Those methods provide a new way in CE research and applications.

The mathematical expression of transformation or mapping V can be expressed as follows:

$$V: F \rightarrow G \quad (1)$$

where F and G are two feature sets in different spaces.

In different applications, some features can be fit together from other domains' features. Thus Eq. (1) is extended as:

$$\left\{ \begin{array}{l} V_1 : F_1 \rightarrow G_1 \\ V_2 : F_2 \rightarrow G_2 \\ \vdots \\ V_n : F_n \rightarrow G_n \\ G = G_1 \cup G_2 \cup \dots \cup G_n \end{array} \right. \quad (2)$$

where $F_1, F_2, \dots, F_n$ are the feature sets in different domains, which are related to the feature set $G_1, G_2, \dots, G_n$ in the stated domain G ; and $V_1, V_2, \dots, V_n$ are the elements of mapping. These relationships can be expressed by a mapping function V as follows:

$$V = V_{ag}(V_{aq}(V_{ab}(F))) \quad (3)$$

where V_{ab} is abstraction function for selective discarding of information, V_{aq} acquisition function, and V_{ag} aggregation function.

2.3 Features' relations among different domains

The totality of information related to every kind of product, in all its aspects over its entire life cycle, and for all conceivable applications, defines a domain called a feature hyperspace. Then actual feature spaces for a given product or application are subsets of the hyperspace. These sub-sets are lower in dimension; i.e., they contain less information. The following kinds of relationships can exist between two sub-spaces, which may be of the same dimension or of different dimensions (Ke-Zhang et al, 2000).

1) Projective spaces: Information from a higher-dimensional domain (A) with n -dimensions can be selectively abstracted to suit a lower-dimensional domain (B) with $(n-m)$ dimensions. The mapping from n to $(n-m)$ space is unique and the inverse, $(n-m)$ to n , is not. This projection relation is denoted by the symbol $(B \ll A)$ and illustrated in Fig.1.

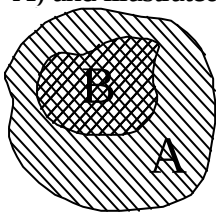


Fig. 1 Projective spaces

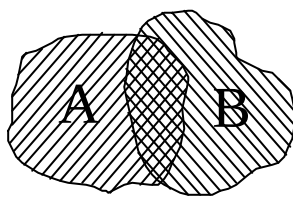


Fig. 2 Overlapping spaces

2) Overlapping spaces: Feature spaces of the same dimension can be partially overlapping as shown in Fig.2. In the overlapping regions, the features have the same semantics. In regions that do not overlap, features are meaningful in only one domain, and there is no transformation available. For conjoint regions of overlapping spaces, an identity transformation is used for the sub-space formed by intersection.

$$\text{Conjoint}(A,B) = \text{common feature in A and B} \quad (4)$$

$$\text{Disjoint}(A,B) = \text{feature in A not found in B} \quad (5)$$

$$\text{Disjoint}(B,A) = \text{feature in B not found in A} \quad (6)$$

3) Conjugate spaces: The sub-spaces may contain features that are composed of different variations of the same elements. These are created when model elements are grouped in different ways to obtain different form features depending on the user's different point of views. For instance, two ribs can be described as a slot as shown in Fig.3. The ribs and slots are complementary features because they are different groupings of the same set of underlying geometric elements. Conjugate transformations require reasoning.

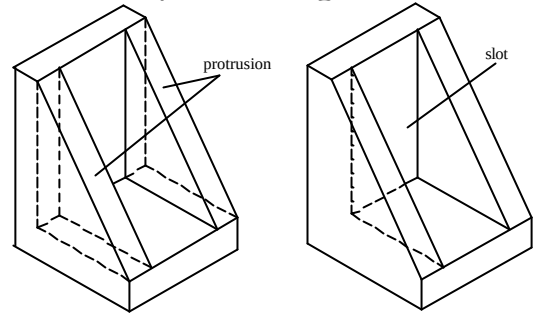


Fig. 3 Conjugate spaces

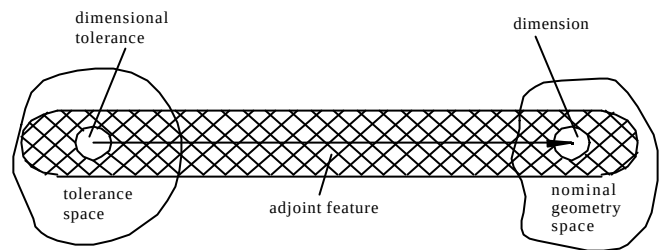


Fig. 4 Adjoint spaces

4) Adjoint spaces: Adjoint spaces are created by associating elements in one sub-space to certain elements in another subspace. For instance, dimensional tolerances in tolerance space are associated with dimensions in geometry space as shown in Fig.4. Adjoint transformations require the creation of pointers to link related elements.

3 THE APPLICATION OF MDFM THEORY IN DFC

3.1 feature domains' classification in DFC

Product design is a process of feature mapping among feature spaces. Feature mapping plays an important role in product concurrent design. The deep analysis described in Refs (Xiao-chuan et al., 1999,2000,2001) for cost and design problems, so we can divide feature domain into two domains (design feature domain and cost feature domain) in DFC. According to different design stages, we divided design feature domain (DFD) into four domains: concept design domain, initial general design domain, general design domain and detail design domain; According to product life cycle and feature extraction, we divided cost feature domain (CFD) into six domains: manufacturing cost domain, assembly cost domain, sale cost domain, repair cost domain, usage cost domain, recycle and disposal cost domain (see Fig.5).

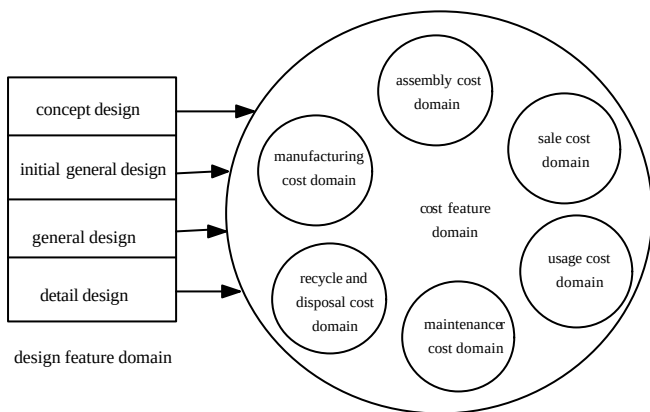


Fig.5 Design feature domain and cost feature domain

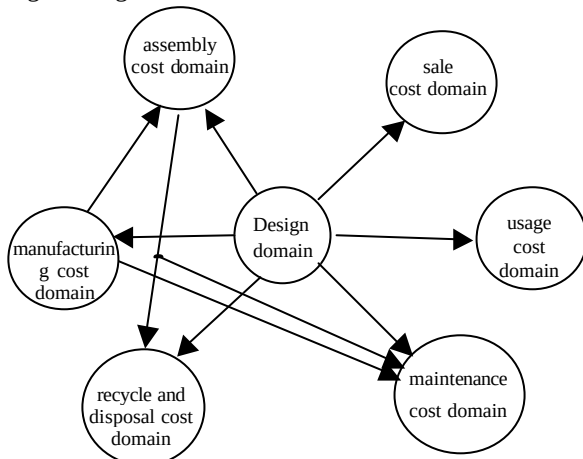


Fig.6 Relationships of MDFM in DFC

The above feature domains can be continually divided into some son feature domains. For example, manufacturing cost domain can be divided into heat machining cost domain, cold machining cost domain, heat treatment cost domain and so on; assembly cost domain also can be divided into handwork assembly cost domain, automatic assembly cost domain; the other divisions were omitted in this paper. Some son feature domain can be continually divided.

Figure 6 shows the different relations among features in product life cycle. Product design feature domain is a core in many feature domains because the partial features in the other feature domains can be translated from it. With the development of design, product design model are improved. Then design features are also increased. By using the feature mapping methods, we can translate design features into the information that other domains need in time. And at the different design stages costs are estimated in the other domain. Then the cost information feeds back to designers and the design is improved. Figure 6 shows the first level relation of feature mapping in many feature domains. Each domain also includes feature mapping relation, then multiple level feature mapping relations are consisted of them in MDFM.

Product design feature domain lays particular stress on describing function demands of parts or product and technic conditions that must be guaranteed in order to satisfy function demands. Currently, finite element analysis was applied to analyze products. The analysis & optimization son domain describes loads, restriction conditions and symmetry in parts.

Manufacturing cost domain: it is made of parameters that is associated with manufacturing cost (for example, material feature, machinery feature and so on). The information is derived from the design domain.

Assembly cost domain: it is made of features that is associated with assembly cost (for instance, joint parts quantity, assembly unit quantity and so on). The information is derived from the design domain and manufacturing cost domain.

Sale cost domain is made of features that is associated with sale cost. The information is mainly derived from the design domain.

Usage cost domain need the information about consuming power, maintenance work and so on. Its information is mainly derived from the design domain.

Repair cost domain need the information that is associated with maintenance (easy damage parts, maintenance tools and so on). Its information is derived from the design domain, manufacturing cost domain and assembly cost domain.

Recycle & disposal cost domain need the information about material recycle methods, disassembly process, disposal states and so on. Its information is mainly derived from the design domain and assembly cost domain.

3.2 Feature mapping and LCC estimation in conceptual design

In the conceptual design stage, design information is not integrated and is uncertain highly. For example, material information is not decided basically; machining process is considered roughly and is not include detail information. In this case it is difficult for us to translate highly uncertain design feature into detail cost feature. In this paper, we consider design feature parameter as cost feature and estimate LCC using ANN. Then we can know which design is better than the other about LCC. Using ANN we provide some reasons as follows:

1) Traditionally we described a twodimension figure with product type and cost value, we got a variety on cost. In fact, using regression method estimation a product cost, in practice ANN is better than regression method.

2) ANN has good non-line mapping ability and self-study ability.

3) At conceptual design stage, design information has highly uncertainty, usually methods are not easily used.

The mainly steps of LCC estimation using ANN proposed are the following:

1) Select important factors that affect LCC to quantity.

2) Select number of ANN's layers and nodes.

3) Train the ANN using value in fact.

In order to illustrate ANN's application steps, an example that BP ANN was applied in feature mapping was given.

3.2.1 ANN's application in LCC estimation

Table 1 Machining center parameters (400 series)(Huifang, 1994)

Machine tool type		MH-40	CMH-45	DC30
Product country		Japan	Spain	Germany
Manufacturer		MORI SEIKI	SORALUCE	DECKEL
Exchanging worktable number		2	2	2
Worktable size(mm)		400×400	450×450	400×400
Three directions stroke number	X(mm)	550	500	500
	Y(mm)	450	455	400
	Z(mm)	500	400	500
Rotating speed of principal axis (r/min)		45~6000	45~4500	1~4000
Power of principal electric machinery (kw)		7.5	15	11.8
Feed speed(mm/min)		0.1~4000	1~10000	1~4000
Fleetness feed(m/min)		12	12	15
Cutter base volume		32	30	40/60/80
Emale cone of principal axis (7:24)		40	40	40
Carrying capacity of worktable (kg)		400	400	300
Machine weight(kg)		7500	6800	7200
Control system		MORI-FANUC-H2	SINUMERIK 3M	SINUMERIK 8M
Controlled axis number		3	4	4
Setting accuracy (mm)		0.01	± 0.01	± 0.0075
Repeatability precision (mm)		± 0.003	± 0.005	± 0.0025
Rotating precision		± 3"	± 3"	± 3"
Equally division of worktable (degrees)		5	1	1

In machine system function design includes: power system design, implement system design, transmission system design and control system design (Shenghai, 1997). According to four design systems parameters in Table 1 was classified as follows:

- 1) Power system: mainly electromotor power.
- 2) Drive system: Rotating speed of principal axis, emale cone of principal axis, rotating precision, repeatability precision, setting accuracy and feed speed.

3) Executive system: cutter base volume, worktable size, equally division of worktable, carrying capacity of worktable, exchange workbench numbers and three directions stroke.

4) Control system.

5) Other parts: machine weight.

Addition to the above mentioned systems' information, we must pay a tension to the structure and process information in design from a machinery product because they can be used in LCC estimation.

Using such feature parameters and some factors which are associated with LCC, the ANN can be trained. Fig. 7 shows BP ANN's example. The explanation of Fig.7 is presented as follows:

Based on the analysis of machinery product, it includes four systems (power system, drive system, executive system and control system) and design features can be obtained from four systems. Then those design features are quantity as the input of ANN directly. The general factors that were not included in four systems' factors are selected. For example, fittings provision model and product service model, they are directly associated with maintenance or repair cost. The transportation model and transportation cost have a relationship. The manufacturing capability, product batch and delivery time relate to production status in an enterprise. And those factors affect manufacturing cost of a product in the enterprise. Namely, we must consider the practical situations in the enterprise when LCC is estimated.

When BP ANN has been trained, they can provide LCC estimation result. In order that LCC's constitutions parts were gained to be low or high, different BP ANN can be built and trained according to different cost structure. For instance, if we need estimate manufacturing cost, the input of ANN may be instead of some features that are associated with manufacturing cost and the output of ANN (LCC) may be instead of manufacturing cost. Using ANN must provide a lot of data, if we can't collect enough data, we can't use ANN.

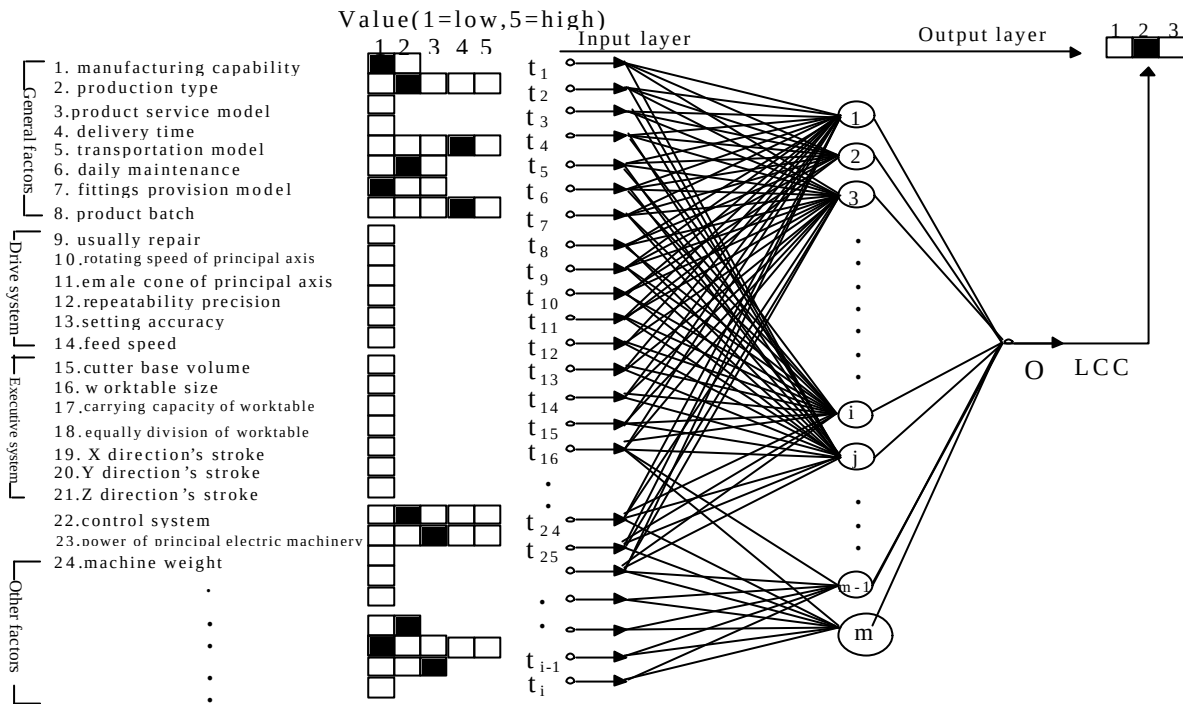


Fig. 7 estimation LCC using ANN

3.3 feature mapping and LCC estimation in initial general design

At initial general design stage, design feature are gradually increase, but there are some uncertain factors and new structure of the design was not decided. Because some design features have been decided and the other were not decided at conceptual stage, we propose that the information of not deciding can be supposed in reason or ignored. Then the known design features can be mapped into the cost features with direct mapping, projective mapping and conjugate mapping. For some parts that have been manufactured in the past detail cost estimation method is used directly to obtain the cost value. Mapping analysis of cost features were given in the following.

1) feature mapping of manufacturing cost

Table 2 feature mapping table of manufacturing cost

Cost feature	Design feature and its mapping methods on similar product
Structure sizes	Product structure sizes have been known on the whole at this design stage, direct mapping is selected.
Product batch	This information has been known at conceptual design stage, direct mapping is selected.
Material information	The information has been known, direct mapping is selected. The unknown information can be supposed or ignored.

Before design features are mapped into cost features, we must select cost estimation methods because the different cost estimation methods need the different cost features. For instance, if material cost estimation method is selected, we only need material information in order to estimate manufacturing cost. But in fact the method can't be used in the majority of the cases. As an example of feature mapping method, we select analogy cost method

for similar parts or products. Generally, if products' geometry or structure is similar, we need structure size, product batch and material information to estimate manufacturing cost. Structure size and product batch can be obtained at the initial general design stage. Material information have been known partly and the unknown part maybe be supposed or ignored. In table 2 the situation of design feature and its mapping methods on similar product is shown.

2) feature mapping of assembly cost

In general, assembly cost is estimated according to statistic method. The mainly assembly cost features include parts size, parts weight, son assembly number, total assembly operation number, parts number, interface number, assembly time, assembly efficiency and so on. The total assembly number, son assembly number, interface number and parts number can be deduced from design information. The conversion method is related to design method. For example, if feature-based model is adopted, the needed features can be extracted from the model on computer directly. But assembly time and efficiency can't be obtained from design feature domain. To get the information, we use simulation or analogy way. At initial general design stage, some information hasn't been decided, for instance, parts number, interface number and assembly operation number. Those cost features will be confirmed at later general design stage.

3) feature mapping of sale cost

Sale cost is most related to packing, depositary and transportation. Packing material and process is decided in packing design. We can get the packing information at general design stage, so they is ignored at initial general design stage. Product size is associated with packing area, depositary volume and transportation distance. Much bigger product will increase corresponding fee

obviously. Product weight is a key factor in transportation and move actions.

4) feature mapping of usage cost

Usage cost includes energy expense, environmental protection fee and daily maintenance cost. At initial general design stage, power system has been decided, so energy expense can be obtain; daily maintenance cost is related to the special product, if for a machine tools it is fewer but for a plane it is not fewer; environmental protection fee is paid according to a country's law because the product made the pollutions. In table 3 the mapping between cost features and design features about usage cost is shown.

Table 3 feature mapping table of usage cost

Cost feature	Design features and its mapping method
Energy expense	Energy expense can be obtained from drive system parameters, direct mapping is selected.
Daily maintenance	This information can't be obtained from design features, but we can obtain some of them from technology demand on the technic drawing.
Environmental protection fee	The expense is paid according a country's law.

5) feature mapping of repair cost

At initial general design stage, some special structures in parts have not decided completely. So it is difficult to confirm the number of easy damage parts and repair tools; because basic structure of the product has been decided, assembly time and disassembly time approximately are known and estimate repair cost partly. Assembly time and disassembly time can't obtain from design features directly. To get the information, we use simulation or analogy way.

6) feature mapping of recycle and disposal cost

At this design stage, a majority of parts in a product are not decided, a few parts that have been confirmed can be considered on reused and material recycle by the end of product life cycle. Recycle cost is mostly effected by disassembly cost and carriage. Disassembly cost and carriage is associated with component total number, fastener total number, disassembly time of component, disassembly time of fastener, joint total number of fasten process and so on.

3.4 feature mapping and LCC estimation in general design

At general design stage, key structures and parts of product have been decided and minor parts of product are not confirmed. The known design features can be mapped into the cost features with direct mapping, projective mapping and conjugate mapping at this design stage. Detail cost estimation can be used in some parts or structures to get their cost value. We gave an analysis on different feature mapping from initial general design stage as follows:

1) feature mapping of manufacturing cost

Feature mapping of manufacturing cost at general design stage is the same way at initial general design stage. Because design information increase and uncertainty reduce, more mapping methods can be adopted.

2) feature mapping of assembly cost

The great mass of exact information of assembly cost features can be obtained at general design stage, so assembly cost is accurately evaluated. If feature-based assembly model is used in product design, the cost features mapping were given in table 4.

Table 4 feature mapping table of assembly cost

Cost feature	Design features and its mapping method about feature-based assembly model
Son assembly number	Son assembly number can be extracted from assembly model, direct mapping is selected.
Interface number	Interface number is identified from assembly model.
Total assembly operation number	Total assembly operation number is identified from assembly model.
Assembly time and assembly efficiency	Assembly time and assembly efficiency can't be directly obtained from assembly model, but it can be obtained using imitate.
Fastener number	Fastener number can be extracted from assembly model, direct mapping is selected
Inspect methods and tools	Inspect methods and tools can be obtained from design feature, direct mapping is selected.
Parts number	Parts number can be obtained from assembly model using statistics.
Parts weight	Parts weight can be calculated from material density and parts size.
Parts size	Parts size that has been known can be directly mapped and the unknown parts size maybe be supposed or ignored.

3) feature mapping of sale cost

Sale cost is most related to packing, depositary and transportation. Packing material and process is decided in packing design. We can get sale cost features from packing design directly. Because product size and weight information at general design stage is more accurate than at initial general design stage, sale cost can be estimated more accurately than before. In table 5 the mapping between cost features and design features about sale cost is shown.

Table 5 feature mapping table of sale cost

Cost feature	Design features and its mapping method
Packing material	Packing material can be directly obtained from packing design.
Packing process	Packing process can be directly obtained from packing design.
Product weight	Product weight have known at initial design stage, direct mapping is selected.
Product size	Product size can be directly obtained from product design.

4) feature mapping of usage cost

Usage cost estimation is more accurate than before, but the feature mapping methods at general design stage are same as initial general design stage.

5) feature mapping of repair cost

Because product structures have been decided completely at general design stage, the number of easy damage parts and repair tools are confirmed. So repair cost can be estimated completely. In table 6 the

mapping between cost features and design features about repair cost is shown.

Table 6 feature mapping table of repair cost

Cost feature	Design features and its mapping method
Easy damage parts	Easy damage parts can't be directly obtained from design feature, but experts can deduce the information from design.
Repair tools	Repair tools were not included in design features, but experts can deduce the information from design.
Failure finding time	Failure finding time were not included in design features, but experts can deduce the information from design.
Assembly time and disassembly time	Assembly time and disassembly time can't be directly obtained from design feature, but it can be obtained using imitate.

6) feature mapping of recycle and disposal cost

At this design stage, a few parts in a product are not decided, a majority of parts that have been confirmed can be considered on reused and material recycle by the end of product life cycle. We specially point out that packing material must be considered recycling. Recycle cost is mostly effected by disassembly cost and carriage. Disassembly cost and carriage is associated with component total number, fastener total number, disassembly time of component, disassembly time of fastener, joint total number of fasten process and so on. At general design stage, we can get those information and disassembly cost can be evaluated completely. The features mapping of recycle and disposal cost were given in table 7.

Table 7 feature mapping table of recycle and disposal cost

Cost feature	Design features and its mapping method
Transportation	Product size
	Product weight
	Material information
Disassembly	Component total number
	Total number of fastener
	Disassembly time of component
	Disassembly time of fastener
	Joint total number of fasten process
	Disassembly time of fasten process

At detail design stage, product design parameters and structures have been decided completely. But opportunity of reducing LCC also reduced and design changes will make a lot of expense. The detail will be discussed in other paper because this paper's length is limited.

4 CONCLUSIONS

In this paper, we decompose the DFC's feature domain using multiple domain feature mapping theory. It includes four design feature domains (concept design domain, and construction design domain) and five cost feature domains (manufacturing cost domain, assembly cost domain, sale cost domain, repair cost domain, usage cost domain, reclaim and reject cost domain). Then we establish multiple domains feature mapping relations that design domain was the core in DFC. Using artificial neural network (ANN), simulation and group technology (GT), we initial attain that design parameter can be mapped to cost parameter. Our work is a base to estimate life cycle cost (LCC) in DFC.

Currently, we are developing the prototype system of LCC estimation in DFC according the structure that is provided in this paper. In the future the prototype system will be established to prove the feasibility of the overall concept of the DFC model.

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