What is a Feature and what is its use?
- Results of FEMEX Working Group I

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Abstract

The result of a survey concerning the definition of the term feature which was realized by the chair of engineering design/CAD of the university of the Saarland and several other statements about this topic in discussions and publications show that there are a lot of different opinions about the meaning of the term feature. Therefore working group I („Feature Definition and Classification“) of FEMEX (FEature Modelling EXperts) tried to work out a definition of this term to reduce the problem of „What ist a feature and what is its use?“.

In the beginning of this report the authors want to give a short overview of different definitions about the term feature to show the necessity of a general definition. Thereafter they present the definition of the term feature and of some other important terms as it was elaborated by FEMEX working group I. Furthermore they want to explain the use of features which enable some sort of „high-level“ communication between the user and the CAx-system.

1 Introduction, Importance of a Feature Definition

Research in feature technology has been conducted for more than 15 years in order to improve state of the art CAx-systems. Nowadays features are used in several commercial and research CAx-systems. But there is still a lack of a common understanding of the term feature. The result of a survey concerning the definition of the term feature which was realized by the chair of engineering design/CAD of the university of the Saarland and several other statements about this topic in discussions and publications show that there are a lot of different opinions about the meaning of the term feature. This shows the necessity of a feature definition. Therefore FEMEX Working-Group I *„Feature Definition and Classification“* worked out a frame of a general feature definition.

FEMEX (FEature Modelling EXperts) is an international and interdisciplinary group of experts in the area of feature-based modeling. The primary goal of FEMEX is to provide a broad theoretical, conceptual and practical background for the development and evaluation of a new generation of tools and systems for feature-based product development. FEMEX is devided into three sub-groups (Working-Group I *„Feature Definition and Classification“,* Working-Group II *„Feature Modelling Methods and Application Areas“,* Working-Group III *„Feature Modelling Tools and Systems“*).

The following tasks are within the scope of the FEMEX Working-Group I:

- Common understanding of the term feature
- Unified feature definition
- Application specific definition derived from the application area
- Feature classification based on a unified and clear vocabulary

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2 Several Definitions of the Term „Feature“

In the following there are listed some interesting definitions of the term „feature“ known from literature or discussions, which had been the base of the beginning of the work of FEMEX Working-Group I.

Pratt, Wilson 1985 [PrWi85]:

„A feature is a region of interest on the surface of a part.“

Luby, Dixon, Simmons 1986 [LuDS86]:

„A feature is a geometric form or entity

- whose presence or dimensions are relevant to one or more CIM functions (graphics, analysis, process planning, the manufacturability evaluation, etc.) or
- whose availability to a designer as a primitive facilitates the design process.“

Krause et al 1987/1990 [KrVY87, KrUV90]:

„A feature is defined by the following equation:

Feature = Form Feature & Semantic

Shah 1989 [Shah89]:

„Many definitions have been offered in the literature. Some are very general: ‘Any entity used in reasoning of design, engineering, or manufacturing’; some are rather esoteric: ‘a region of of interest’; and some are specific to geometric modeling: ‘a collection (set) of faces in a boundary model’. ... All these definitions imply that a feature is something physical, something discernible, on an object. So an engineering feature is a portion of a shape, form, or make (of an object) that has some engineering significance.“

Shah 1991 [Shah91]:

„Features are generic shapes with which engineers associate certain properties or attributes and knowledge useful in reasoning about the product (‘engineering primitives’).“

Shah, Rogers et al 1991 [SRSH91]:

„A form feature is a physical element of a part that can be identified by some generic shape and attributes. A form feature has significance in design, analysis, manufacturing, or some other engineering domain. Thus, a feature can be formalized in terms of its generic shape, attributes, and behavior.. . .

Assembly feature = relationship between two mating features on different parts, specifying the shape, dimension, and location constraints required for proper assembly.“

Henderson et al 1990:

„Features are defined as geometric and topological patterns of interest in a part model and which represent high level entities useful in part analysis.“

Wierda 1991 [Wier91]:

„A feature is a partial form or a product characteristic that is considered as a unit and that has a semantic meaning in design, process planning, manufacture, cost estimation or other engineering disciplines.“

Shah, Mäntylä, Nau 1994 [ShMN94a]:

„There are many published definitions of the concept of a feature. Even though these definitions seem to be dissimilar, they all consider features as entities which are of semantically higher level than the pure geometric elements typically used in solid modeling systems."

Krause, Rieger 1994 [Workshop „Feature Technology in Design and Manufacturing", Universität des Saarlandes, Saarbrücken 29.-30.08.1994]:

„Feature = Form Feature and/**or** Semantic."

de Martino 1994 [Workshop „Feature Based Modeling in the Product Development", FhG–IGD, Darmstadt 10.-11.11.1994]:

„A feature is a group of topological and geometric entities which have a functional meaning in a given context. ... Several semantics can be applied to the same part."

Meerkamm, Bachschuster 1994 [Fragebogen/Questionnaire on Feature-Technology]:

„Feature = technische Bedeutung (Semantik) + **eventuell** Gestalt."

Ehrlenspiel 1995 [Ehrl95]:

„Features ... sind Objekte, die zur Beschreibung der geometrischen und zusätzlichen, nicht geometrischen Eigenschaften von Produkten, Baugruppen, Einzelteilen und Gestaltzonen dienen. ... Die in diesen Objekten verwalteten Eigenschaften richten sich nach den Anforderungen aus den Programmen, die auf diese Produktbeschreibung zugreifen oder Daten in ihr speichern."

3 Definition of the Term Feature by FEMEX Working-Group I

A feature is an information unit (element) representing a region of interest[1] within a product[2].

A feature is described by an aggregation of *properties* of a product. The description contains the relevant properties including their values and their relations (*structure* and *constraints*).

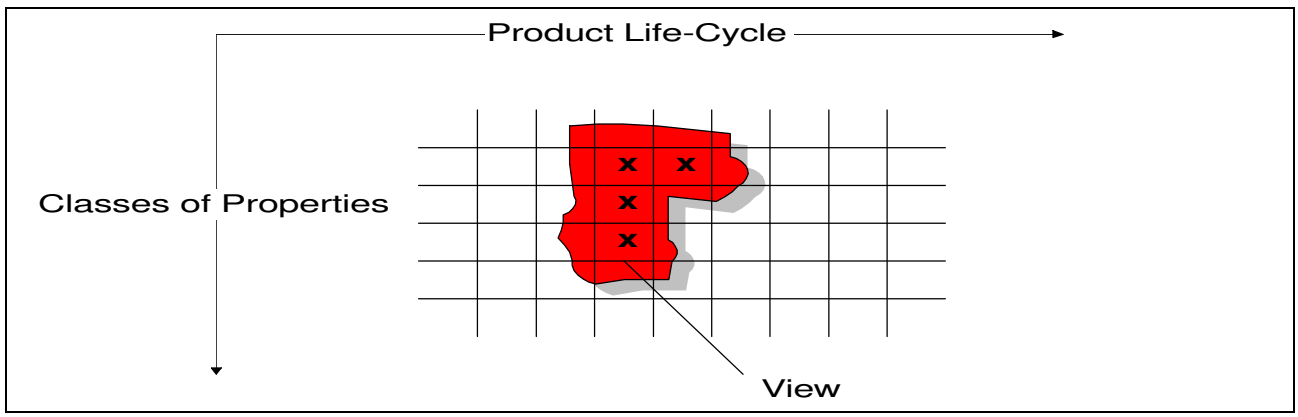

Figure 1: Matrix representation of the different stages of the product life-cycle, the different classes of properties and views

A feature is defined in the scope of a specific *view* onto the product description with respect to the *classes of properties* and to the phases of the *product life cycle* (Figure 1).

A feature can be described by properties out of several different classes of properties, thus relating these (classes of) properties to one another.

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1 The expression „region of interest" does not necessarily mean geometry.

2 According to STEP [ISO93] „product" means a physically realizable object that is produced by a natural process or manufacture.

There are three special aspects in the definition above:

– A feature is no physical element. Features only exists in the world of information models.

– „Properties“ are the base in the definition, because they can be represented in CAx-systems quite easilly.[3]

– „Classes of properties“ and „product life-cycle phases“ are distinguished in the definition above. For instance, geometry – in different phenotypes – is considered in nearly every phase of the product life-cycle One potential classification of the „classes of properties“ and the „product life-cycle phases“, in this case stemming from design methodology, is shown in Figure 2. Talking about a special product within an individual company there may be a different classification.

phases of the product life cycle / classes of properties	recognition of need/ clarifikation of the task	preliminary design	detail design	production planning and tool design	production	distribution and sale	usage	replacement/recycling/ deposition
requirements								
functions and their structure								
solution principles and their structure								
geometry								
material properties								
tolerances								
strength								
durability								
corrosion resistance								
manufacturing methods and parameters								
economic properies								
conformance to standards, laws etc.								
distribution properties								
aesthetic properties								
ergonomic properties								
operational properties								
enviromental properties								

Figure 2: Matrix representation of the different stages of the product life-cycle and the different classes of properties (scheme according to [HuEd88])

[3] „Properties“ can be the base of the definition of the term „product model“.This, however, is beyond the scope of FEMEX. The term „product model“ as it is used within this paper consists of a selection of properties and their values of the product to be described.

4 Definition of the main Terms used in the Feature Definition of FEMEX Working-Group I

Property: Every notion that can be used to characterize an object (here: a product) and to distinguish it from other objects (products). Properties used to describe an object (a product) can be very concrete (e.g. load capacity of an individual shaft) or rather abstract (e.g. reliability of a motor car), dependent on the view that is the base of the description. It should be emphasized that it is neither possible nor even feasible to consider **all** properties of an individual object (product); the context determines which selection of properties is adequate.

Static/dynamic properties: Static properties are properties which do not change, while dynamic properties do. Looking at the complete product life-cycle, we cannot think of any property that remains static. However, when working within an specific phase of the product life-cycle some properties usually are assumed as static.

Classes of properties: A class of properties is a combination of properties, which can be logical structured. One potential classification of properties that stems from design methodology [HuEd88] was already shown in Figure 2. The different classes of properties are essential for the (correct) definition of different feature types. The classes of properties which a special feature definition is based on determine the feature´s application area.

Product life-cycle: The product life-cycle is a model to distinguish between specific (significant) phases of product creation, usage and replacement[4] or more detailed according to Figure 2. In some disciplines relevant to Feature Technology (e.g. design methodology, quality management) there are similar, but not quite identical frameworks for product life-cycle definitions (phase models). In practise, each product - most probably even a given product within each company - has to follow its own product life-cycle which easily can get quite complicated if written down in detail. The different phases of the product life-cycle together with the classes of properties usually are the base of different views from which to look at the product.

View: A view describes the way to look at a product and its classes of properties during the product life-cycle according to Figure 1. In many cases one phase of the product life-cycle (e.g. „manufacturing“) is splitted up into several, more detailed views (e.g. „turning“, „milling“, ...), which may themselves be structured. In such a special view not all of the product´s (known) properties are relevant. The names of some properties as well as the structure of objects and their properties may change from view to view.

Structure: A structure of objects is a scheme to show the relations between these objects systematically. A similar (maybe the same?) selection of objects can be structured in different ways, dependent on the view from which to look at this objects. To establish a structure of given objects from a special view, one first has to decide which properties of the objects are relevant and then use the relevant properties to group the objects systematically. In CAx-systems, Feature Technology and product modelling one very often finds hierarchical structures (e.g. „body – faces – edges – vertices“ in geometric modelling, „compound features– single features“ in Feature Technology, „product – sub-assembly – component“ in product modelling). That may be the result if the objects are grouped very strictly according to identical and diverse properties. In some cases (hierarchical) structures are differentiated dependent on the type of relations used (e.g. „part-of-relation“, „numerical relation“, „parent-child-relation“).

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[4] „Product creation“, „product usage“ and „product replacement“ are themselves phases of the product life cycle, albeit in a very coarse specification.

Constraint: Relation between two or more properties of an object additional to the relations that are implied in the underlying (often hierarchical) structure of objects and their properties. (Maybe: Relations that „bypass“ the relations in a systematical/hierarchical structure.)

5 Requirements of Features

- The representation of features, their behaviour and processing must be formalized[5] (to be exchangable).
- The user must be able to extend a given set of features according to his own needs.
- Features can also be encapsulated to another features („nesting“, hierarchy of features).

6 Use/Benefits of Features

The use of features is:

- to formalize knowledge related to the product,
- to represent and store the meaning of a region of interest („semantic“) in a computer model,
- to improve the communication throughout the product life-cycle,
- to permit a „high-level“ communication between the user and the CAx-system which is simular to the communication betwen humans (that means: using/considering abstraction, context, implicit information, relevance, engineering language),
- to improve the communication between different CAx-systems,
- to be the base of simulating the human way of reasoning on the computer,
- to reduce development time,
- to re-use information.

7 Some additional Explanations

Features have found use in a wide range of applications: part and assembly design, design for manufacturing, process planning and many other areas.

Based on the definition mentioned before Figure 3 tries to explain the terms „Feature Recognition“, „Feature Based Modelling“ and „Feature Mapping“.

- *„Feature Based Modelling“* (top-down-approach)
  „Feature Based Modelling“ describes the way to go down within one class of properties and define some other properties related to another class of properties.
  Example: Modelling geometry from functional considerations.
- *„Feature Recognition“* (bottom-up-approach)
  „Feature Recognition“ means finding some properties in one class which lead to a „higher“ meaning in another class.
  Example: Recognizing manufacturing elements from geometric properties.
- *„Feature Mapping“*
  „Feature Mapping“ is the translation of a „high-level“ meaning within one class of properties to the meaning within anotherclass of properties.
  Example: Translation of functional elements to manufacturing elements.

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[5] Independent of the system, there must be an adjusted logical structure. The implementation and the logical structure are not subject of this definition.

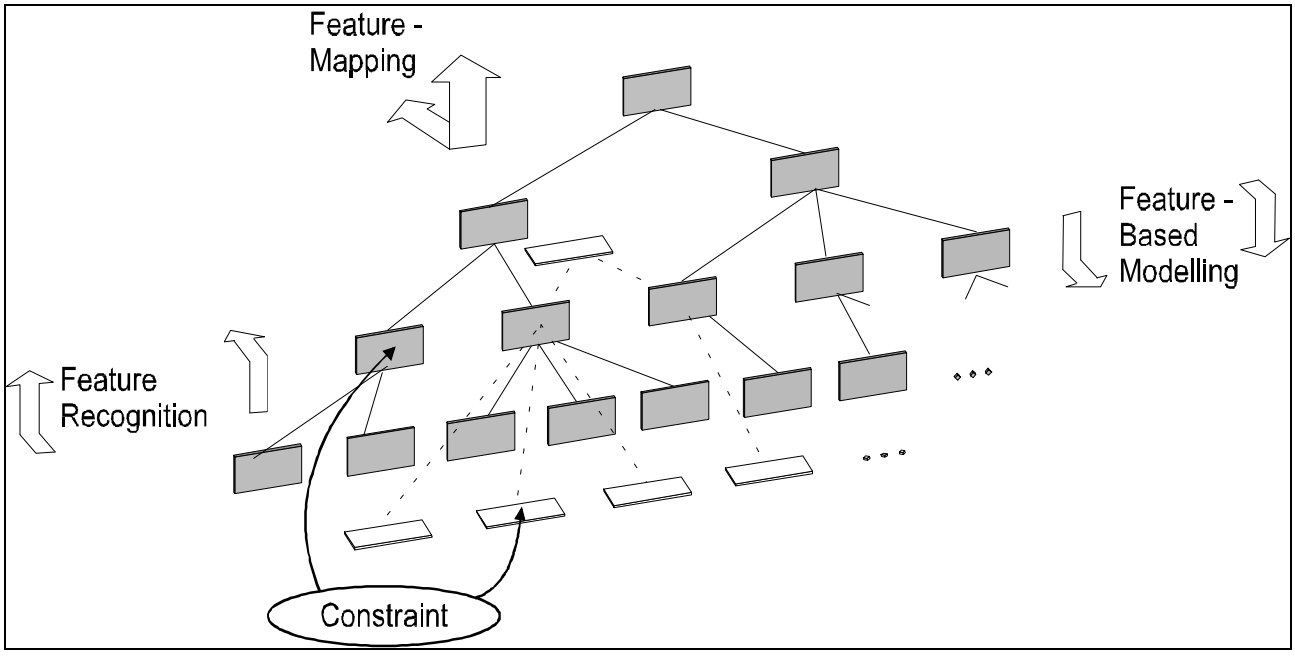

Figure 3: Combination of different classes of properties

Figure 3 also tries to explain the term „constraint“ as it is widely used in feature technology.

- *„Constraint“*

  Relation between properties belonging to different classes of properties outside the formalized structures of these properties.

  Example: Restrictions of geometrical properties stemming from manufacturing aspects.

Today in CAx-practice one of the classes of properties usually is the geomtry, because geometry is the most prominent part of today`s CAx-systems data bases. Connected to the geometry one finds mostly manufacturing aspects (manufacturing features, process planning features), but also assembly, inspection, functional or calculation aspects (assembly/design/calculation features).

8 Summary

This paper is an attempt to achieve an able to work definition of the term „feature“. Besides it want to be a base of discussion, because it is important to establish a definition of features because it will obviously influence the functional specifications of feature-based modeling systems, data exchange standards, and information that various applications can expect to derive from feature modelers [Shah89].

9 References

[Ehrl95] Ehrlenspiel, K.: Integrierte Produktentwicklung. Hanser-Verlag, München–Wien 1995.

[HuEd88] Hubka, V.; Eder, E.:Theory of Technical Systems; a Total Concept Theory of Engineering Design. Springer-Verlag, Berlin 1988.

[ICEC86] Proceedings of the ASME International Computers in Engineering Conference, Chicago 1986. American Society of Mechanical Engineers (ASME), New York 1986.

[IFIP87] Yoshikawa, H.; Gossard, D. (Herausgeber): Intelligent CAD I; Proceedings of the IFIP TC 5 / WG 5.2 Workshop on Intelligent CAD, Cambridge (USA) 1987. International Federation for Information Processing (IFIP), Genf–London 1987. Elsevier-Verlag, Amsterdam–London 1987.

[ISO93] N. N.: International Standard ISO 10303-41 Industrial automation systems - Product data representation and exchange - Part 41: Fundamentals of product description and support, 1993

[KrUV90] Krause, F.-L.; Ulbrich, A.; Vosgerau, F.H.: Feature Based Approach for the Integration of Design and Process Planning Systems. In: [SATA90].

[KrVY87] Krause, F.-L.; Vosgerau, F.H.; Yaramanoglu, N.: Using Technical Rules and Features in Product Modelling. In: [IFIP87].

[LuDS86] Luby, S.C.; Dixon, J.R.; Simmons, M.K.: Designing with Features: Creating and Using a Features Data Base for Evaluation of the Manufacturability of Castings. In: [ICEC86], S. 285-292.

[NSF89] Proceedings of the NSF Design Engineering Workshop, Amherst 1989. National Science Foundation (NSF), Washington 1989.

[PrWi85] Pratt, M.J.; Wilson, P.R.: Requirements for Support of Form Features in a Solid Modelling System. CAM-I Report R-85-ASPP-01, Computer Aided Manufacturing – International Inc., Arlington 1985.

[SATA90] Proceedings of the 23rd International Symposium on Automotive Technology & Automation, 1990.

[Shah89] Shah, J.J.: Philosophical Development of Form Feature Concept. In: [NSF89], S. 317-332.

[Shah91] Shah, J.J.: Conceptual Development of Form Features and Feature Modelers. Research in Engineering Design 2 (1990/91) 2, S. 93-108.

[ShMN94a] Shah, J.J.; Mäntylä, M.; Nau, D.S.: Introduction to Feature Based Manufacturing. In: [ShMN94b], S. 1-11.

[ShMN94b] Shah, J.J.; Mäntylä, M.; Nau, D.S. (Herausgeber): Advances in Feature Based Manufacturing. Elsevier-Verlag, Amsterdam–London 1994.

[SRSH91] Shah, J.J.; Rogers, M.T.; Sreevalsan, P.C.; Hsiao, D.W.; Mathew, A.; Bhatnagar, A.; Liou, B.B.; Miller, D.W.; Tadepalli, R.; Pherwani, V.: The ASU Features Testbed: An Overview. Technical Report, Arizona State University, Department of Mechanical and Aerospace Engineering, CAE & Expert Systems Laboratory. Tempe, Arizona/ USA 1991.

[VDZS85] Vaghul, M.; Dixon, J.R.; Zinsmeister, G.E.; Simmons, M.K.: Expert Systems in a CAD Environment: Injection Molding Part Design as an Example. In: [ICEC85].

[Wier91] Wierda, L.S.: Linking Design, Process Planning and Cost Information by Feature-Based Modelling. Journal of Engineering Design 2 (1991) 1, S. 3-19.