PERGAMON

Robotics and Computer Integrated Manufacturing 16 (2000) 259–266

Robotics and Computer Integrated Manufacturing

www.elsevier.com/locate/rcim

Modelling for process planning: the links between process planning entities

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Abstract

In an integrated design framework, each actor of the design process must have his own view of the product to efficiently participate and co-design. The product model used by the process planner is presented here: it is in fact extracted from the global product model of the whole design system by filtering. The links of dependence among the different entities of the model – links of availability, accessibility and quality – are particularly emphasised in this text. Their efficiency has been tested in process planning and product designing. © 2000 Elsevier Science Ltd. All rights reserved.

Keywords: Product modelling; Process planning

1. Introduction

In an integrated design framework, all the actors of the product life cycle must cooperate all along the design process in order to define the best design, in the sense it satisfies all their constraints. Each of them brings competence and skills of his domain: he works with his own culture, reasoning and rationales, and uses data, knowledge and tools in his own environment. An efficient work of each actor needs a specific structure of a product model split in different views [1,2]. A view is dedicated to the work of an actor, expert in one particular domain. In this paper, the machining process planner's point of view is particularly emphasised. A product model useable by the experts in machining and process planning is proposed. It permits them to elaborate reliable process plans. The model is implemented in the CasCade environment [3].

Present CAD-CAM systems are geometrical-modelling-based. But product models required by the actors of the product life cycle are specific domain-feature-based. Three tracks have been explored until now to build product models (MAR 96). Design by features permits to design the product directly by handling functional features generally pre-defined and parameterised. Those functional features are generally geometrical features like form-features specially built for a particular domain. The main disadvantage comes from the fact that the model cannot support simultaneously all the life cycle points of view. The product must be re-defined for each domain [4]. The feature recognition permits to classically design from geometrical CAD-CAM modellers. Then domain features must be extracted from the geometrical representation of the product by applying domain expert rules. The difficult formalisation of the expertise from a given point of view and the poorness of available information in the geometrical data base lead to an incomplete recognition [5]. Those two approaches are widely exploited and are not sufficient. The most promising approach is a product model including one model for the design solution and several models of domain applications like for example one for process planning [6]. The expert person of the domain must exploit the design features to obtain a product model based on his domain features and from which he can work efficiently. This specific model is dependent on the way it can be used by specialists, the process planner for example. The whole product model is a multiple view and multiple actor model; the product model for the process planning point of view is extracted from this global model by filtering information useful in this view.

The specifications for the product model in a process planning point of view have been studied. It has been pointed out, on the one hand the machining feature

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PII: S0736-5845(99)00056-3

concept, particularly to obtain the form and the intrinsic quality of the form, and on the other the role of the tolerances on the geometrical relations between features. The product model must explicitly support these relations and the machining features. Rough features (pieces of part remaining rough in the finished part) must be added to have a complete description of the part. Locating-clamping features are capable of being either the location or the clamp for the part while machining is also necessary. It is the set of these four concepts that defines a product model in a machining process planning point of view. The models developed for a specific view are of course dependent of the models of the other views. In particular, the models of the machining process planning and rough obtaining views are strongly coupled.

The aim of this paper is to show how a product and its environment are modelled in order to be efficient in a process planning point of view. The fact that the entities used in product and process planning modelling are not independent is particularly emphasised. The product model for a process planning point of view, then the resources for machining are reminded in Section 2. The mapping between those entities and the different entities used in process planning are presented in Section 3. The core of the paper in Section 4 deals with the links of dependence between these entities. A coherency between the product definition and the behaviour of the product process plan is ensured by these links. In conclusion, the implementation of the model and its usage in a multi-view system of design is discussed.

2. Product model for process planning and resources for machining

The product model for process planning is composed of four types of specific features: machining features, rough features, relations between features and locating-clamping features [7].

2.1. The machining feature model

It has been studied for a long time [8–10]. A machining feature is defined, for example in GAMA's book [9], by a geometrical form and a set of specifications for which a machining process is known. A machining process is an ordered sequence of machining operations. Machining operations depending on another machining process can come in between two machining operations of the considered machining process.

The attributes associated to the machining feature entirely define the geometry and the technological properties required by the feature. Some of the attributes have a particular interest here:

- *The type*. The expertise is largely contained in the feature type, particularly on the relevance of geometrical parameters and machining processes.
- *The machining directions*. They talk about the possible orientations of the part relative to the machine-tool spindle axis and the machining process.
- *The intrinsic tolerance on the form to achieve*. A state of a feature is characterised by a geometrical form and a realisation quality (tolerance) associated to the form. At each step of the machining process and from the rough state of the feature, the geometrical form gets closer to the required final form and the quality improves until the required final quality.
- *The estimating of the material to remove*. It can be done by a "rough state" attribute of a feature defined by a machining allowance, a plain material state or a state roughed before by forging, casting, etc.

2.2. The rough feature model

A rough feature is a feature belonging to the final part that is never machined. It remains in a rough state and was obtained by a rough technique like forging, casting, stretching, etc. It is defined like a machining feature by a geometrical form and a set of specifications for which a technique for obtaining the rough state is known.

Here, these features are essentially of use to participate to, on the one hand a location and/or a clamp of the part while machining, and on the other hand an active surface belonging to a relation between features (in this case of course, the second feature of the relation is a machining feature).

2.3. The model of a relation between features

It is composed of two categories of relations: (i) the topological and the (ii) geometrical ones.

(i) *The topological relations*. The topological relations express the associativity of a feature with the neighbour features. They are classically defined in terms of "opens-onto", "opens-into" whether a feature opens onto (or into) another feature, "intersects-with" whether two features intersect each other. These relations are considered as attributes of a machining feature.

(ii) *The geometrical relations*. The geometrical relations are either dimensional tolerances or tolerances on the position or the orientation of the geometrical bodies of the features. These relations locate the machining features among themselves or relative to the rough features. They are defined by:

- A type that expresses the orientation, the position or the distance between the two concerned features.