

Research on auto-reasoning process planning using a knowledge based semantic net

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Received 16 September 2004; accepted 4 June 2006

Available online 25 July 2006

Abstract

A process-planning model (PP model) is proposed to convert the geometric features into manufacture machining operations and sequence the machining operations of the part in a feasible and effective order. The process-planning model (PP model) construct a feature framework that makes a mapping from geometric features into machining operations. A semantic net named the Precedence-Relations-Net is established to reflect the precedence relationships among the machining operations. The vectors and the matrixes are employed to construct a mathematical sequencing model. A part is decomposed into several basic geometrical units, namely, U_1, U_2, \dots, U_N . For each unit U_i , two vectors, named F_i and P_i , represent the features and machining operations of U_i . Finally, a matrix named PP is used to memorize the process plan, and a matrix – PO (performing objects) – represents the object of machining operations. © 2006 Elsevier B.V. All rights reserved.

Keywords: Knowledge; Semantic net; Manufacturing features; Precedence-Relations-Net; Sequencing mathematical model

1. Introduction

Manufacturing process planning is the method to get the necessary manufacturing process and their acceptable sequence in order to produce a given part in an economical and competitive way (a good way by some standards) [3–7]. In order to obtain the process planning, the process planner derives some appropriate information from a design model such as the design profile, accuracy, surface roughness, material and so on. All of those information are defined as manufacturing features. Therefore, most of computer-aided process planning (CAPP) systems uses the concept of manufacturing features to describe a part [6,8–10]. In this regard, manufacturing features link the computer-aided design (CAD) and computer-aided manufacturing (CAM). But the problem is how to build the bridge that can translate the manufacturing features into the machining operations sequence.

For several years, this problem has received more and more attention from researchers because it is the essential for generating an optimal process planning. Many researchers construct a knowledge base [1,2,11,13]. Sang C. Park [1] constructs a knowledge base that consists of three sub-models: the object model, the function model, and the dynamic model. Although he gives us a methodology on process planning, it is not a systematic model of process planning. In this paper, we will construct a process-planning model (PP model) that has three parts: the Features Framework, the Precedence-Relations-Net and the Sequencing Mathematical Model and can be illustrated by Fig. 1. First, a design model should be decomposed into several units in according with its geometrical profile. Each unit has its features. Then features of each unit were input a knowledge base, which was expressed by framework, and the output is the final operation of each unit. Second, a semantic net, namely PR-net, will be build to reflect the precedence relations among machining operations. The final operation of each unit is input PR-net, and then a vector, which consists of operations, is output. The counter-order of this vector is an acceptable sequence for each unit.

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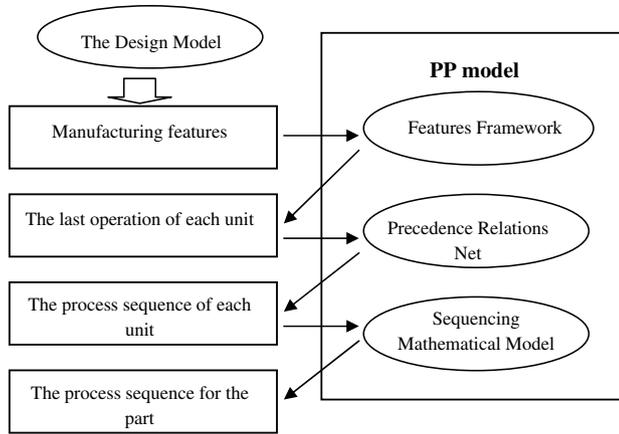


Fig. 1. Expert system.

All of those vectors are input a sequencing mathematical model to obtain an acceptable and competitive process plan.

2. Construction of the process-planning model

In this section, we will build a process-planning model (PP model). At first, a features framework will classify features of the parts and build a mapping from features to machining operations. Then, a semantic net will be build to reflect the precedence relations among machining operations. At last, a sequencing mathematical model will sequence an acceptable and feasible process planning.

2.1. Features framework

In the literature [8,9,13,14], there have two main methods to representing manufacturing features: one is the superficial approach in which features are defined as sets of faces having topological relationships, and the other is the volume approach in which volumes are used to define features [1]. In this paper, we use the latter to define features.

Parts have many kinds of features such as the design profile, accuracy, surface roughness, material and so on.

Therefore, parts can be classified by one kind of features. For example, because parts can be classified by its design profile such as hole, slot ware, sidestep. . . , a design profile framework is built. So, we can build a framework for each kind of features. It can be shown in Fig. 2. The last level of each framework is corresponding machining operations to the feature in the framework. For example, from Fig. 2b, a circle hole has three corresponding machining operations – Boring, Drilling, and Reaming.

A part always consists of several basic geometrical figures. A basic geometrical figure is a geometrical unit. So the design model can be decomposed into several basic geometrical units. A unit has several features, namely, feature 1, feature 2, feature 3, feature 4, . . . Each feature has a corresponding operation set generated from features framework. The final operation of this unit can be obtain by intersect those sets. Then we can derive the final operation of one geometrical unit from the features framework. As Fig. 3 shows, feature 1 is the geometrical feature; feature 2 is the accuracy feature and feature3 is the surface

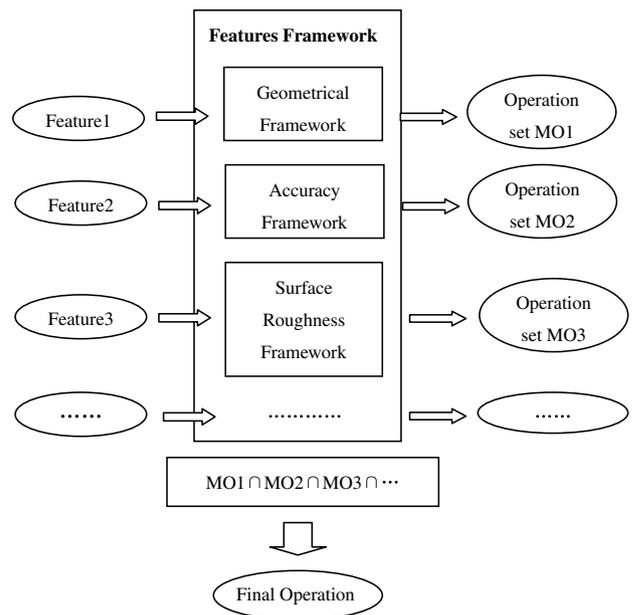


Fig. 3. Process of obtaining the final operation.

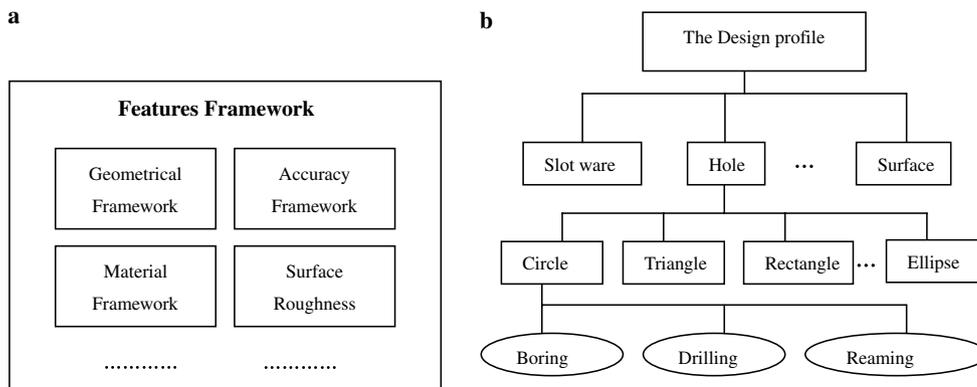


Fig. 2. (a) Features framework. (b) Geometrical framework.

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