ELSEVIER

Computer-Aided Design 35 (2003) 1109–1117

COMPUTER-AIDED DESIGN

www.elsevier.com/locate/cad

Knowledge capturing methodology in process planning

Sang C. Park*

Cubic Technology Research Center, AceTechno-Tower 1101, DungChon-dong, KangSeo-Ku, 684-1 Seoul, South Korea

Received 7 September 2002; received in revised form 2 November 2002; accepted 13 November 2002

Abstract

In process planning, a proper methodology for capturing knowledge is essential for constructing a knowledge base that can be maintained and shared. A knowledge base should not merely be a set of rules, but a framework of process planning that can be controlled and customized by rules. For the construction of a knowledge base, identifying the types of knowledge elements to be included is a prerequisite. To identify the knowledge elements, this paper employs a three-phase modeling methodology consisting of three sub-models: *object model*, *functional model* and *dynamic model*. By making use of the three-phase modeling methodology, four knowledge elements for process planning are derived: *facts* (from the object model), *constraints* (from the functional model), and *way of thinking* and *rules* (from the dynamic model). facts correspond to the involved data objects, and constraints to the *technological constraints* of process planning. The way of thinking is a logical procedure for quickly decreasing the solution space, and rules are key parameters to control the way of thinking. The proposed methodology is applied to the process planning of hole making.

Keywords: Knowledge capturing; Knowledge modeling; Knowledge based process planning; Rule based process planning; Hole making

1. Introduction

Process planning for manufacturing is used to determine the necessary manufacturing processes and their sequences in order to produce a particular part economically and competitively [1,6–9]. For several decades computer-aided process planning (CAPP) has received much attention from researchers because it plays a central role in manufacturing: it mediates between product design, production planning and line balancing. To perform process planning, appropriate manufacturing information needs to be generated from a design model. In this regard, the use of features has been considered to be the technology that bridges computer-aided design (CAD) and computer-aided manufacturing (CAM).

Almost all CAPP systems employ the concept of manufacturing features for part description [8,11,14,17]. Manufacturing features can identify the portions of a part that have manufacturing significance. Because manufacturing features are domain dependent, they are significant only when the domain at hand and the task to be accomplished are clearly specified. For example, different manufacturing processes such as machining and assembly have different sets of manufacturing features associated with them. For a machined part, a manufacturing feature is the portion of the raw stock removed by means of certain machining operations. In the literature [10,11,14,15], there have been two main methods of representing manufacturing features: the superficial approach in which features are defined as sets of faces having topological relationships and the volume approach in which volumes are used to define features.

Some typical issues of a knowledge-based CAPP system are shown in Fig. 1: manufacturing feature recognition, assigning machining operations to each machining feature, sequencing machining operations, set up and fixture planning, and NC generation. Beginning with the design model, process planners extract manufacturing features from the design specifications and translate them into manufacturing operations. Then they determine the optimum process sequence required to convert raw stock into finished stock. With ordered machining processes, part programmers generate NC programs that can be used to machine a particular part on an NC machine.

One of the most important issues in a knowledge-based CAPP system is the construction of a knowledge base that reflects the experience and knowledge of domain experts. The question is how to construct a knowledge base.

* Tel.: +82-2-3664-4700; fax: +82-2-3664-4701.
E-mail address: mar123@orgio.net (S.C. Park).

0010-4485/03/$ - see front matter © 2003 Elsevier Ltd. All rights reserved.
doi:10.1016/S0010-4485(02)00182-3

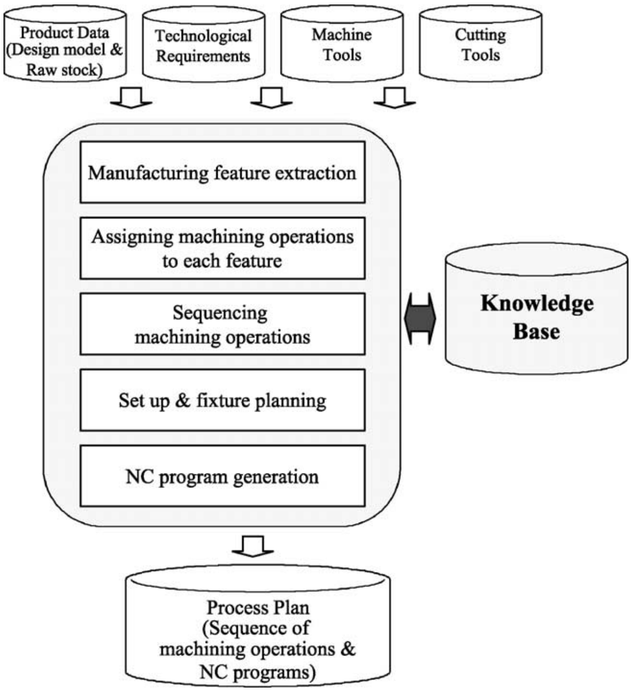

Fig. 1. Issues in a knowledge-based CAPP system.

Probably the most intuitive idea would be to visit domain experts and gather *rules* by interviewing them without any knowledge capturing methodology. In this case, some serious problems may arise because every process engineer may think in a different way. As shown in Fig. 2, some engineers may start with given cutting tools while others start from the geometry of a design model. Those rules cannot belong to the same knowledge base because they might assume implicit situations and contexts that are totally different. Consequently, we need a more formalized knowledge capturing methodology.

There have been plenty of prior studies on knowledge-based process planning (or feature-based process planning). For knowledge handling, artificial intelligence techniques such as the expert system, rule-based inference, the neural network and the blackboard method are mostly employed. However, since the development of the knowledge capturing methodology has rarely been brought into focus, motivation exists for exploring its development in process planning. The objective of this paper is to suggest a knowledge capturing methodology in process planning. By making use of the methodology, we construct a model of process planning and identify knowledge elements that represent the domain knowledge. The rest of this paper is organized as follows: in Section 2 a knowledge capturing methodology in process planning is presented; in Section 3, we apply the proposed methodology to the machining process planning of a hole; and finally, discussion and conclusions are given in Section 4.

2. Knowledge capturing methodology

The desirable properties of a knowledge base are shown in Fig. 3: (1) transparency: if it is not transparent (or understandable), users may not accept it (*for user acceptance*); (2) knowledge sharing: to achieve consistency in process planning, knowledge must be shared among

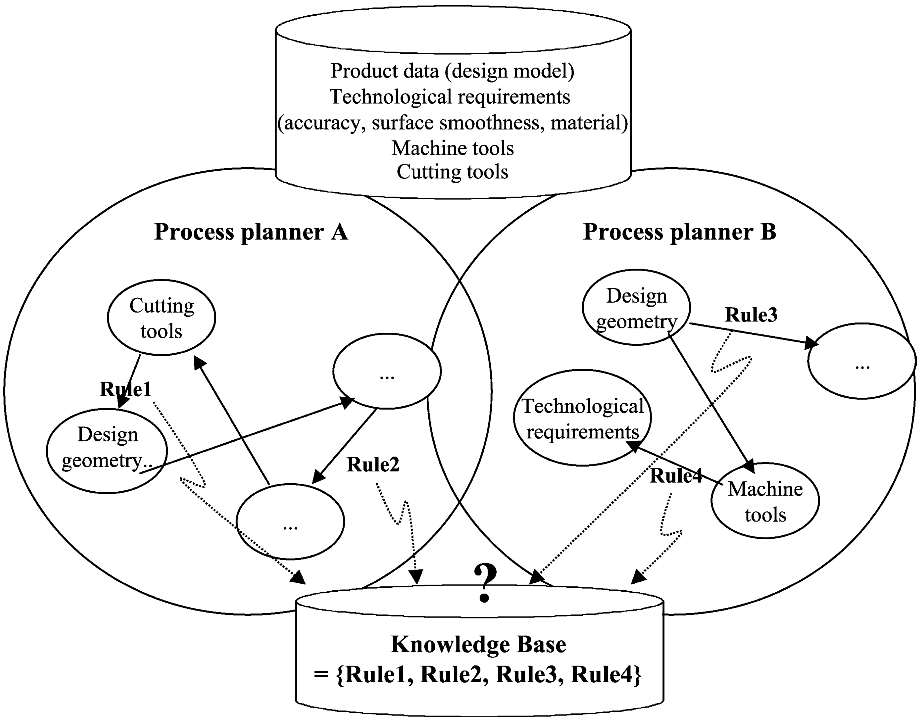

Fig. 2. Different ways of thinking of process engineers.