Chapter 6
Feature Recognition and Datum Extraction for Setup Planning and Operation Sequencing for Prismatic Parts

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ABSTRACT

An automated planning system extracts data from design models and processes it efficiently for transfer to manufacturing activity. Researchers have used face adjacency graphs and volume decomposition approaches which make the feature recognition complex and give rise to multiple interpretations. The present work recognizes the features in prismatic parts considering Attributed Adjacency Matrix (AAM) for the faces of delta volume that lie on rawstock faces. Conceptually, intermediate shape of the work-piece is treated as rawstock for the next stage and tool approach direction is used to recognize minimum, yet practically feasible, set of feature interpretations. Edge-features like fillets/undercuts and rounded/chamfer edges are also recognized using a new concept of Attributed Connectivity Matrix (ACM). In the first module, STEP AP-203 format of a model is taken as the geometric data input. Datum information is extracted from Geometric Dimension and Tolerance (GD&T) data. The second module uses features and datum information to arrive at setup planning and operation sequencing on the basis of different criteria and priority rules.

1. INTRODUCTION

In a Computer Integrated Manufacturing system (CIM), Computer Aided Process Planning (CAPP) plays a major role in bridging the gap between Computer Aided Design (CAD) and Computer Aided Manufacturing (CAM) systems. If CAD addresses 'what to build', a planning system addresses the most critical issue of 'how to build'. However, the geometric model of a part designed in a conventional CAD system is not adequate for an automated planning system. First basic requirement in any automated planning system is to obtain the feature data from geometric data. This

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feature data has to be effectively be transferred in an explicit form to the planning modules. Problems still exists in the existing feature extraction systems particularly while dealing with the interacting features because of the feature representations and methodologies adopted.

A survey of literature shows that various methodologies like object oriented models, feature-based models, feature recognition methods have been proposed earlier. In object oriented models (Beg & Shunmugam, 2002; Bhaskara Reddy et al., 1999), feature data is entered interactively for inspection planning and operation sequencing respectively. Though the data entry can be made error-free, it requires high-level intelligence and takes considerable time. Feature based modeling systems (Lin et al., 1997; Harun & Case, 2000; Kim et al., 2001; Patil & Pande, 2002; Faraj, 2003; Liu & Wang, 2007) require the part model in terms of manufacturing features rather than design features so that the feature data can directly be used in the downstream applications. They are limited by the number of manufacturing features one can include in a predefined library and it is essential that the designer should also have a thorough knowledge of manufacturing features, in order to use them effectively.

Feature recognition overcomes the above mentioned limitations of interactive data entry and feature-based design approaches. It deals with interpretation of given geometric data by implementing specific algorithms. In other words, it can be considered as a 'virtual eye' that looks at the model and recognizes the manufacturing features present in it. Of various methodologies reported for its development, prominent ones are graph based methods and volume decomposition methods.

In Graph based methods (Joshi & Chang, 1988; Gavankar & Henderson, 1995), boundary model of a part is represented as a graph-based structure such as face-adjacency graph. This graph is then searched for sub-graphs or feature-graphs where each sub-graph represents a feature. Concepts of sub-graph isomorphism are used in these approaches. These graph-based representations become very complex for parts with complex geometry and topology due to the complex feature representation adopted.

Volume decomposition approaches (Tseng & Joshi, 1994; Sakurai, 1995; Woo & Sakurai, 2002) have been proposed to deal with interacting features, where volume to be removed from the rawstock to produce the part, referred to as delta volume, is decomposed into small blocks. They are then combined in such a way that the recognizable features are reconstructed. They require a large number of Boolean operations. However, these approaches give large number of interpretations, sometimes ambiguous ones, to which machining heuristics are applied subsequently to arrive at those interpretations that give the machining sequence. Most of the researchers dealing with prismatic parts have considered initial rawstock to be a rectangular block, but the initial shape cannot be ignored, as the amount of material to be removed and the production time are dependent on it (Khailash et al., 2001).

Edge-features like fillets, undercuts, rounded and chamfered edges may also be present in the part. Rahmani and Arezoo (2006) and Zhu and Menq (2002) have proposed the suppression of fillets to convert them into sharp edges to reduce the complexity during feature recognition. The sharp edges, fillets, rounded edges etc, specifically introduced by the designer cannot be neglected and additional operations may be required to get those features which will lead to a considerable change in the process plan.

Literature study on feature recognition reveals that (1) complex methodologies have been followed to obtain interacting features (e.g. volume decomposition methods); (2) a large number of interpretations of features are obtained initially without considering practical aspects of machining and additional heuristics are used later to arrive at proper interpretations, thus making the systems cumbersome; (3) feature representations adopted