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# A framework for similarity recognition of CAD models

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**Abstract**

A designer is mainly supported by two essential factors in design decisions. These two factors are intelligence and experience aiding the designer by predicting the interconnection between the required design parameters. Through classification of product data and similarity recognition between new and existing designs, it is partially possible to replace the required experience for an inexperienced designer. Given this context, the current paper addresses a framework for recognition and flexible retrieval of similar models in product design. The idea is to establish an infrastructure for transferring design as well as the required PLM (Product Lifecycle Management) know-how to the design phase of product development in order to reduce the design time. Furthermore, such a method can be applied as a brainstorming method for a new and creative product development as well. The proposed framework has been tested and benchmarked while showing promising results.


*Keywords:* Design classification; Opitz coding system; Similarity retrieval

## 1. Introduction

Market competition and constantly changing customer demands yield to massive production. Consequently a huge amount of information is produced and archived every day. Reusing such information can reduce the product cost and time; along with optimizing the product design. There is no doubt that the dimension of reusing such know-how greatly affects the designing of new products in the conceptual design phase. Different information could be derived and learnt from the already existing design including geometry, material, process planning, manufacturing, price and generally Product Lifecycle Management (PLM) information. It is possible to become skilled at PLM knowledge by knowing the similar cases, therefore making better design decisions. In this regard, an efficient similarity recognition algorithm is a fundamental prerequisite which assists in providing an automated and intelligent decision making.

Alongside all research developed by engineers on decision making and Decision Support Systems (DSS) [1–3] and models [4], psychologists suggest four essential techniques for improving the problem of decision making and choice overload [5–7] listed in following:

(1) *Cut:* get rid of the extraneous alternatives
(2) *Concretize:* Make it real
(3) *Categorize:* more categorization, fewer choice
(4) *Condition:* for complexity, it is easier to make complex decisions by gradually increasing the complexity

The above mentioned techniques have been considered in the current research aiming for modeling a knowledge-based framework. Such a structure guides the designer to an optimized decision making with respect to reuse of the existing similar artifacts data, Fig. 1.

A CAM-based classification system was applied and developed further intended for automatic extraction of the design information from STEP file. In addition, an infrastructure was designed and developed for a comprehensive retrieval, i.e.

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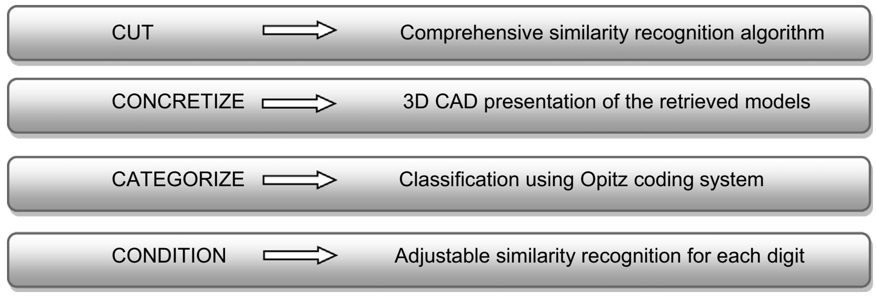


Fig. 1. Comparable techniques of better decision making and the developed system.

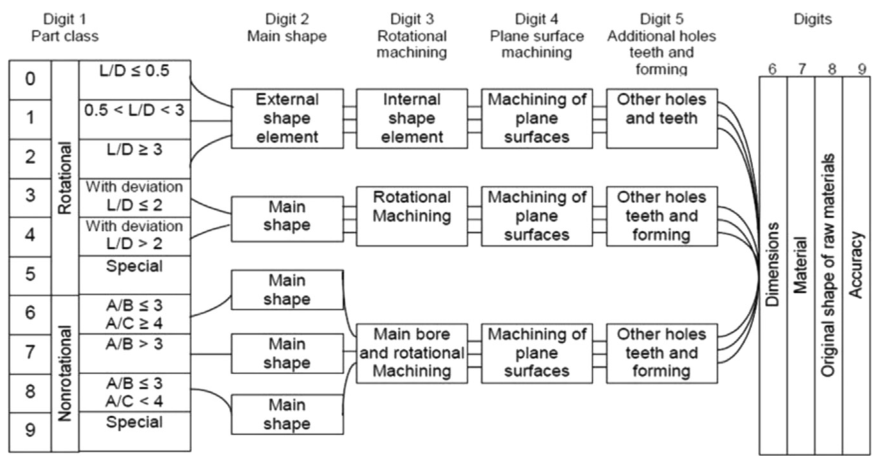


Fig. 2. The Opitz code's main structure [8,9].

selective similarity recognition and part retrieval. The following paragraphs explain these phases briefly.

- *Comprehensive similarity recognition algorithm:* A comprehensive similarity recognition algorithm has been developed to calculate distance function. A distance function is applied to measure the similarity and accordingly to discard the dissimilar cases and retrieve only the similar models. The percentage of total similarity can be tuned by the designer.
- *3D CAD presentation of the retrieved models:* To make the retrieved similar models more tangible, all the related 3D CAD models are also represented to the user in addition to STEP files and the classification codes (Opitz codes).
- *Opitz coding system:* For categorization and classification, Opitz coding system as a successful method of group technology (GT) in manufacturing has been applied.
- *Adjustable similarity recognition for each digit:* The similarity setting for each digit can vary from 0 to 100 percent. 0 indicates dissimilar features and 100 for identical models and the required weight for each digit step-by-step can be adjusted between these two numbers by the user.

Opitz coding system is a method of group technology which is applied in Computer Aided Manufacturing (CAM) for part classification. It is a well-known method for classification of manufacturing features and is named after Herwart Opitz who originally proposed this coding system [8]. Opitz coding system consists of alphanumerical digits, each presenting a feature and its type. In the other words, a digit is the aggregation of all the feature conditions it is composed of according to the code's definition. Created by Herwert Opitz in 1970, Opitz code is a hybrid code consisting of a maximum of 14 digits. The code itself is divided into 3 sections. The first section consists of five digits which are dubbed the “form code” and describe the geometry and topology of the product/part. The second section, also called the “supplementary code” was added later and consists again of four digits that represent the dimensions, material, original shape of raw stock, and accuracy of the product/part. Each digit in these two sections may contain 10 different values ranging from 0 to 9. The third section consists of only four characters; A, B, C, and D. It is called the “secondary code” and allows for organization customization of the code. Here, organizations can include proprietary and organization-specific information regarding the product/part. The Opitz code's structure is given below in Fig. 2.

The first five digits of the code are referred to manufacturing features and highlight the manufacturing features such as bore, step, forming, etc. and their specifications. As an instance if the discussed manufacturing feature is bore, blind bore, through bore, number of the bore/s, position/s and main/axial bore are specifically pointed and highlighted in the code.

The number of digits or the size of Opitz code is fixed for all parts and it is independent of complexity of a part. The current research incorporates feature recognition and the translation of such features into a model's group comparison functions code,