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Another Look towards Product Cost Estimation using Feature Techniques

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Abstract

The modern era of manufacturing sector and industrialization mainly focuses on the productivity improvement. To achieve the same the manufacturing cost of the various products of the industry has a profound impact. Many companies face the problems of quoting prices of their products in the competitive market which is due to lack of efficient and effective cost estimation. Therefore, in this review paper author aims to study the various methods for early cost estimation during the design and development stage. Feature based techniques have also been employed recently for early estimation. Hence the author's intentions here are to use the amalgamation of the methods employed for cost estimation and feature techniques.

Keywords: *Early cost estimation, productivity, feature based techniques*

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INTRODUCTION

The demand of modern business era and the business applications is the effective and accurate cost estimation. Judicious cost estimation is the basic requirement of the global manufactory's success. The demand of the global market is high quality products with lower costs which can be achieved through appropriate planning and scheduling in cost estimation. Efficient business operation can be assured through quick and accurate estimation of product cost and gain a competitive edge over the competitors. Manufacturing cost estimation can be carried at three stages of the product life cycle: conceptual stage, design stage and manufacturing stage.

Numerous amount of research work has been done on how to accurately estimate the manufacturing cost which is a subpart of the cost engineering. Cost engineering also defines the process and conditions for forecasting a product's price [1]. There are basically two approaches to cost estimation methods: traditional approach and advanced approach. Traditional cost estimation approach includes bottom-up engineering, analogy, and parametric methods. Advanced cost estimation approach includes expert judgment, feature-base evaluation, fuzzy logic, neural networks and data mining (DM) methods [2]. Although the profitability is dependent on the accuracy of cost estimation, most of the companies fail to do so due to complexities in the various stages of the manufacturing process. In this paper we conduct a review on the various research works being carried out in this field and understand the development of a semantic model for the estimation of cost. Many manufacturers used to do their cost estimation at the manufacturing process level which belongs to the traditional way like engineering bottom-up method [2].

According to J. J. Shah, a feature represents the engineering meaning or significance of the geometry of a part or assembly. Features can be thought of as building blocks for the product [3]. Also features are generic shapes useful in some computer aided application, such as; geometry construction, process planning, and design for X. It also includes manufacturing features containing information related to geometry and topology of the product.

Following are the various methods of cost estimation explained by various authors:
The authors Peter Leibl, Guenther Hoehne described a procedure for estimating the costs concurrent with the design process using the feature based CAD system [4]. An IKF i.e., modules of computer program have been included. These modules consist of calculation

of costs, comparison and estimation. Features are used for developing the part models and these features are used for cost forecasting by including them in the process planning. The geometric data are taken from these form features and the time for each feature has been estimated. From the time estimation results and machine rates the cost estimation will be calculated. The authors performed test results on sheet metal operations and the results were found to be promising and accurate.

The authors Z. Bouaziz, J. Ben Younes, A. Zghal developed a cost estimation system of dies using the complex machining features [5]. The system developed by the author applies the semi analytical approach which is based on the analogic and parametric approach. This principle has recourse to the analogic approach to search for analogies between the shapes to be machined before grouping them into complex machining features [6]. For each identified feature the system develops the process plan and hence obtains the time. In the next stage the machining time is obtained using analytical approach. The system developed by the author uses a database which helps in better evaluation of the parameters of cost estimation.

Authors Y.F. Zhang, J.Y.H. Fuh, W.T. Chan developed a system for feature based cost estimation using back propagation neural network system for packaging products [7]. The cost related features from the design and manufacturing stages were identified and extracted and quantified for their costs. The relation between the features and the cost was established by performing back propagation by neural network and validating the results for 60 existing products. To validate the results the system has been adopted for 20 present products and the results were compared with the company's method and linear regression model. The experiments show that the results of the developed system were far better than the existing system.

The authors Miko Balazs, Novak Krisztian, Toth Gabor Andras developed a computer program for early cost estimation and time estimation for the products during the process planning itself [8]. The program developed is called ECoTEst. The developed program has two models. The first model defines the feature based model of the part. The second model called the feature based estimator will estimate the time and cost of the each identified feature in the previous model.

The authors Nagahanumaiah, B. Ravi, N.P. Mukherjee presented an integrated model for die and mold manufacturing using design features [9]. The model developed uses the concept of cost drivers and cost modifiers. Cost drivers consider the geometric features of the cavity and core and handles by the analytical cost. The cost modifiers consider the tool parameters such as; parting line, core area, die material which add to the material cost. The framework has been implemented and tested on 13 industrial products. The results show that the model is flexible and can widely be accepted.

The author H.S. Wang proposed a cost estimation model based on the back propagation methodology on the feature models to simplify the existing methods of cost estimation [10]. The model was implemented for the plastic injection products. The results indicate that the efficiency and effectiveness of the model is adequate to estimate cost at the development stage.

The authors Jung Hyun Hana, Mujin Kang, Hoogon Choi proposed to integrate feature recognition and process planning domain [11]. The input is the steps to manufacture the part. Now a two layered strategy is adopted, first layer refers to a specific setup and the node of the lower layer refers to the processes of the feature. The system presented in this paper uses STEP as input and output formats, and therefore, can be ported to arbitrary CAD and planning systems.

METHODOLOGY

The feature technologies have been successfully employed in many areas of the engineering works such as; modelling, manufacturing, time estimation, assembly and many further. These methods have been very important in the integration of CAD and CAM. Feature is a kind of data structure that can describe more information related to all aspects of the product that was not described in traditional semantic attributes [12]. Various

design and manufacturing features have been successfully developed and implemented. The features contain information regarding the geometry, geometry process information, material properties, manufacturing methods etc.

The feature based cost estimation method covers to identify the manufacturing features that are associated to the cost of the product which is linked to certain manufacturing processes. Cost can also be linked to manufacture features to estimate the machine utilization and process time cost [13]. However, to identify and define the dependencies of the various cost features for a complex part is a very challenging and complex task. The authors contemplate to define a new type of features that is 'Cost Feature', a feature object class, aiming to cluster, encapsulate, update and manage those cost-related dependencies, rules, constraints and referenced features defined from other domains, such as; those related to design functions and machining processes [12].

For identifying and developing cost features various types of information is required such as; historical data, manufacturing conditions and many further. Knowledge-based technique like Data Mining (DM) can identify all the product information from historical data such as; their attributes and the correlations and relationship patterns among their attributes. The next phase is cost feature establishment with attribute selection that is one of the most important steps. Given the fact that not all the information of the product is useful for cost estimation, most effective features have to be selected for this purpose [14]. This information includes the geometry process information and topology of the cost features.

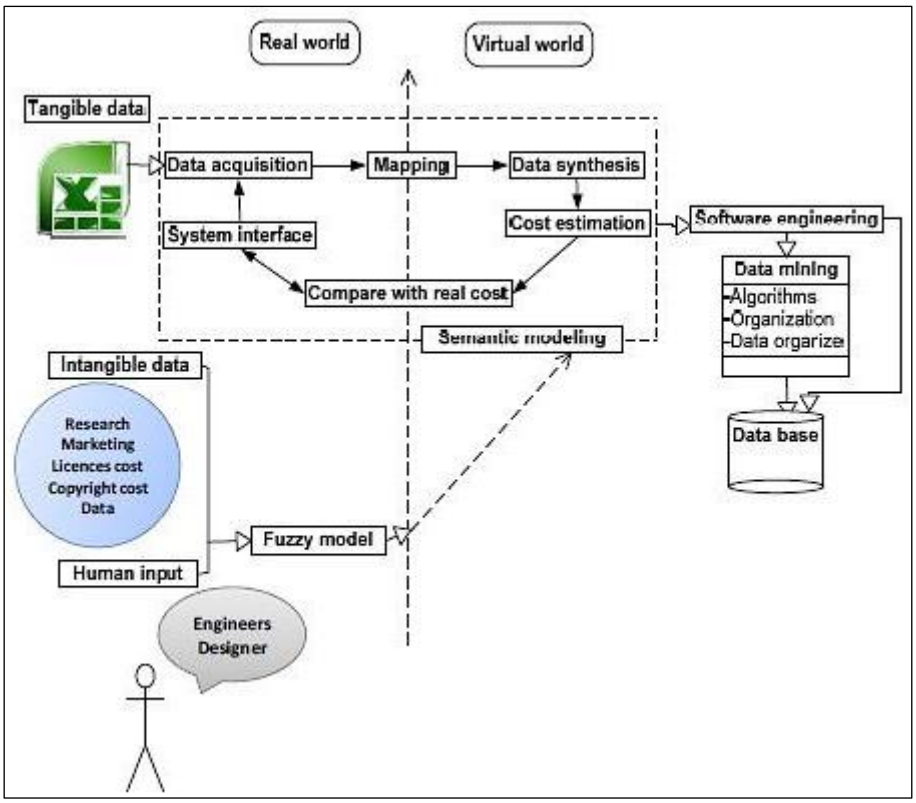

Fig. 1: *Concept of Semantic Modelling for Cost Estimation.*

In the next step, the rules for data analyses and weight of importance are set. Finally, DM can present the data pattern that can predict the future information from historical data. These algorithms are built into the methods of cost feature class and derivatives of their object instances. The next step which is the most vital step is the identification of cost feature with

the additional attribute selection. It should be noted that all the information stored in the product feature is not useful for the cost estimation therefore, it is necessary to find those attributes which really have an impact on the product cost. Finally the DM can be developed algorithms that can predict the cost based on the historical data. These algorithms are developed in cost feature models. Other supporting functions and factors affecting the cost feature are also included in the algorithm.

To identify and understand the situations where the cost features can be implemented, semantic modelling technique is used. Semantic modelling is a new data representation approach that states real world objects in the form of predefined terms and entities that are interpretable by modern computer program such that the real world entities and their dynamic behaviour can be consistently described, modified and persistently reused within the prescribed scope of application [12]. It is one kind of knowledge modelling that describes the meaning of data from the point view of the computer entities with interactions and user interfaces. Figure 1 shows the entire concept of semantic modelling. The main objective of semantic modelling is to extract the data and read the information that is provided in the data. The other aim of semantic modelling is implementing the high cohesive model [15].

Everyone can develop their personalized semantic model. However, it has to follow some simple rules:

I. All the steps of semantic modelling have to be defined clearly.
II. The abstract model should create relations for mapping the information between the real and the virtual worlds.
III. The modelling objects have to be generically defined and directly mapped into class diagram.
IV. A semantic model has to specify the relationships and interactions among the modelling objects to describe the logics.

Three types of data are studied, understood, analysed in the semantic modelling and relationship among them is established. The first type of data is the concrete and real data related to the attributes of the cost features which include physical properties. The first kind describes the properties such as; physical, natural and economic data. The second type of data is the intangible data which is not directly affecting the cost features but are useful in establishing relation among the different cost features. It is defined dynamically like the data describing context, background, social status, organizational attributes and cultural data. The third kind of data is information developed from the human inputs which includes engineering feedbacks from marketing managers, designers, process engineers, and purchasers. The third kind of data actually does the work of bridging the gap between the tangible and intangible data. In the next step, the conceptual semantic relations illustrating the dependencies between cost features and other engineering information entities are to be defined and some elementary and nonexhaustive relations are shown in Figure 2.

Cost features, supported with a template library, is a conceptual class of objects that has to define the road map for doing the cost estimation within a specific scope. It has to define cost constituents, searching mechanisms and target elements in the scope and a sound cost structure. To interact with other types of features which are used for constraining the cost elements and rules, a unified feature scheme can be used. Such a unified feature system model covers a multifaceted feature-oriented platform which defines the basic referencing mechanisms and information inference scope which can include concept features, machining features, user-defined face-cluster features, design features or any other kind of features.

According to the scope and level of features, then the cost feature can be defined by identifying appropriate attributes and a set of constraints. Next, the tangible and intangible data sets are to be associated by identifying their various referencing sources, for instance, from CAD/CAM data, product configurations, ERP data tables as well as references to licenses, product models, historical data and suppliers' data. A design feature includes all the information about the material requirement, functional assembly features, functional part features and part geometry constriction features. Machining features

includes all the information about the machines that are to be used to produce the specific product, such as; a water jet machine, surface grinding machine, a welding machine, CNC turning or milling centres. For accurate and efficient cost estimation all the three kinds of data are required.

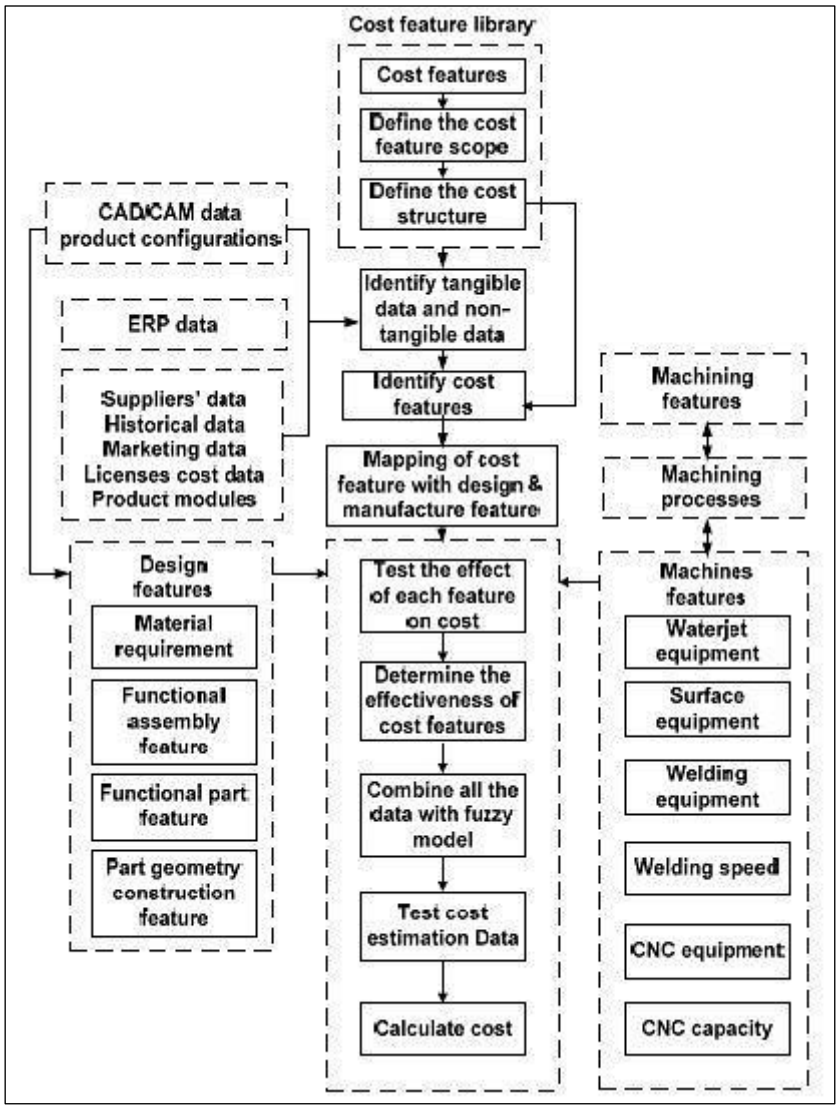

Fig. 2: *Cost Feature Related Elementary Semantics with Some Nonexhaustive Relations.*

CONCLUSION

In this paper author has considered all the methods used for early cost estimation which can be employed for the industrial products. These methods have been linked with the feature models and a semantic feature model has been developed to efficiently and effectively predict the cost of a product. The method is based on three types of data: tangible data, intangible data and the data obtained from the human experience. All the tree types of data have been combined and the cost of the product is estimated. The model suggested by the author is efficient and applicable for the industrial products.

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