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Decision support in the quotation process of engineered-to-order products

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ABSTRACT

Sub-suppliers acting in the supply chain of the car industry have to adopt a strategy of products customization to be at the competitive edge. This is caused by the diversity of client's requirements that entails customer engineered products with a high level of variety. A business strategy based on engineered-to-order products requires systems for efficient generation of product variants. This also includes a need of decision support in the order preparation process as well as in the quotation preparation process. Decision support that gives access to detailed and accurate information in the quotation preparation enables a high level of product adaptation while ensuring company efficiency. By the introduction of a design automation system, this can be achieved. However, means to manage different application domains, projects, task knowledge and design information are required together with a possibility to perform detailed analyses on the system generated information. The objective of this work is to contribute in that area. Initially, a number of success criteria were identified and explorative work was conducted for the purpose to develop a conceptual model and principles that an application system would reside upon. The result is a framework consisting of an information model and underlying principles to be used when developing a design automation system for quotation preparation. A system founded on the framework supports management and analysis of quotations and product variants. The functionality and usefulness has been demonstrated and validated by a system implementation developed in collaboration with an industry partner.

1. Introduction

Many companies base their business strategy on an engineer-to-order approach providing product concepts that are highly adaptable to different customer specifications. These product concepts appear frequently in the business-to-business market and range from discrete parts to complex products. The companies providing these products are commonly involved in many quotation processes and to be able to respond quickly with competitive prices and a short product delivery time while ensuring company profitability, these companies have to introduce design automation. This implies the deployment of a process view of the product concept and the definition of a product platform for variant designs incorporating engineering knowledge (e.g. mechanical design, production engineering, and cost engineering). Automation of product design, process planning, and cost estimation integrated in a system enable design proposals to be generated in a short time with minor effort. Different product variants can be evaluated while cutting off delivery time of products and offers [7], while guaranteeing consistent design calculations. One task suited for automation is quotation preparation including the definition of principle product design, process planning and cost estimation.

The advantages to gain by introducing design automation to support the quotation process are not difficult to see. What become a lot more difficult to answer are the issues related to how it should be realized. The scope and the purpose of this research originate from industrial problems and needs which have been identified within research projects carried out in near collaboration with five industrial partners.

The main objective of this work is to provide a system foundation for automated quotation preparation. The focus is on a solution that enables generation of different product variants based on varying customer requirements as well as changes in product and manufacturing properties. Management of different application domains, projects, task knowledge and design information should be supported together with the possibility to perform detailed analyses on the data generated by a system implementation. Collaboration and decision-making in the quotation processes should be supported by the possibility to easily evaluate different solutions and their effects on different technical and economical aspects. The industrial and scientific objective is to provide concepts and principles supporting application system development and utilization for both practitioners and researchers.

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2. Research methodology

This work is associated with research in design automation. There, the four domains – domain knowledge, process character, tools and computer implementations – are considered as base elements for system realization, and their combinations into design automation systems in an industrial environment are studied. The aim of the research in this field is to derive new knowledge including descriptive statements gained by analyzing existing solutions and industrial practice, or prescriptive statements by synthesizing new solutions and their utilization in an industrial environment. The statements address strategies, methods, models, and processes for planning, developing, implementing, and utilization of design automation systems.

The starting-point in industrial problems is in accordance with problem-based research as described by Blessing's research methodology for the development of design support [1]. The system development method [2] has been deployed as research methodology for the purpose to explore the research issue including the introduction, evaluation, and refinement of new concepts which are perceived as prescriptive models in accordance with the design modeling approach [3]. This evolutionary research process is depicted in Fig. 1. Conceptual phenomena principles and models are used as a basis for the development of an application system. The applicability and utilization of the application system are explored and evaluated. Then the principles and methods encapsulated by the system are formalized. These principles and models are representations of the conceptual phenomena of principles and models. The process is of iterative nature, where the experiences from the system evaluation serve as input to the refinement of the conceptual phenomena principles and models. The different parts evolve over time and the framework goes from tentative to final. The development of the research object is an intrinsic part of the research method and the tasks of research inquiry and system development are intertwined. The generalization aspects together with the related theories of the introduced principles and models are continuously considered throughout the work. The level in the generalization effort and the adoption of related theories are increasing as the knowledge about the research issues are increasing. Earlier works of others are continuously sought for with the purpose to reveal: if the research issues previously have been addressed, if there exist theories (e.g. principles and models) proposed by others, and if there is a knowledge gap in these proposed theories, if any.

3. Related work and state of the art

The research in the field of design automation has been conducted for about half a century [4]. Focus has been on both the automation of the design process and the automation of the design object during the years. The work has mainly adopted an object oriented supported by the evolution in CAD software, i.e. the rules have been defined and organized in accordance with a product structure. This has been further supported by the different commercial KBE tools available today for modeling of design knowledge (e.g. Catia KWA and UGS NX Knowledge Fusion). The process approach, on the other hand, has gained more success in the area of computing, where engineering tasks defined in different applications are connected for the purpose of simulation and optimization (e.g. ModeFrontier and Simulia Isigth). Two specific areas that have been subject for research are the development process of design automation systems and the modeling of product related information. Hvam et al. [5] describes a complete and detailed methodology for constructing configuration systems in industrial and service companies. They suggest an iterative process including the activities: analysis of product portfolio, object-oriented modeling, object-oriented design and programming, among others. Every activity results in a description of the problem domain with different levels of abstraction and formalization. Two strategies are proposed for system documentation, either by using a product variant master and associated CRC (Class Relationship Collaboration) cards or by using the class diagram of a formal model and associated CRC-cards. The original content and structure of the CRC-cards have been further developed by Haug and Hvam [6]. The layout of the CRC-card has been revised and the content has been extended. Haug et al. [7] have developed a prototype system for

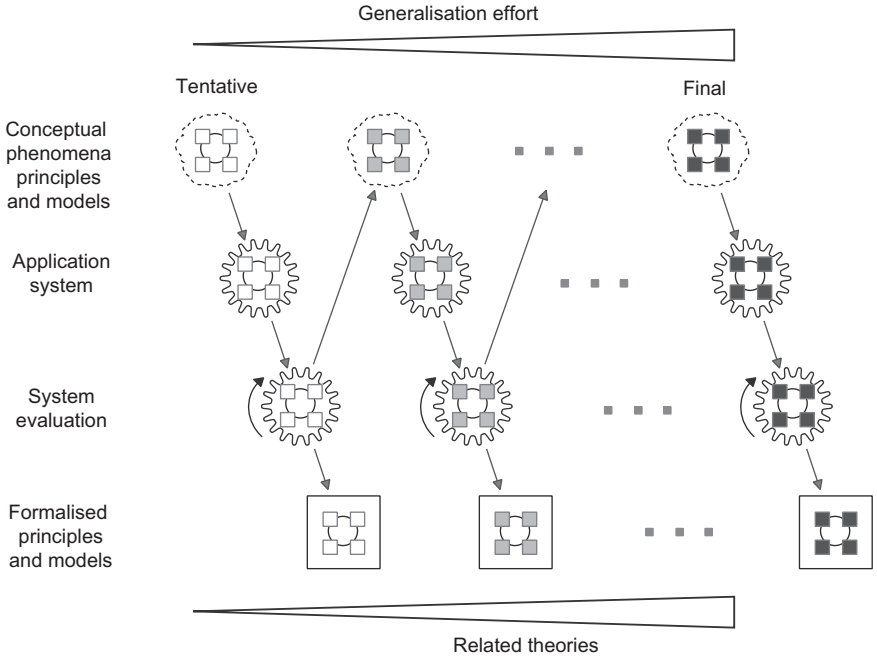

Fig. 1. Generalized model of the applied research methodology.