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THE POTENTIAL OF RELATIONAL DATABASE FRAMEWORK SUPPORTING KNOWLEDGE-BASED DESIGN

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ABSTRACT
Complexity in product development is essentially caused by product-related interdependencies between different engineering departments and disciplines. To face this challenge, knowledge-based design (KBD) methods are applied in modern product development processes, reaching from the application of template models to computer-aided design (CAD)-based virtual prototyping, where product and process knowledge is typically stored in elementary databases. Those databases are often provided as relatively simple data sheets, like text files or xml files with limited functionalities, which may decrease productivity and effectivity in design. Data structures should be stored and connected to each other for easy, flexible and effective management of information between engineering teams. In a new approach, the application of relational databases allows new potentials for KBD-methods in simulation and design. Besides, the use of relational databases offers huge possibilities with CAD, computer-aided engineering (CAE) and data management systems. The challenge is to find higher stability and integration of KBD - methods into modern design processes which often requires handling of product structures and effective interfaces to traditional product data management (PDM) systems. In addition, collaborative development environments require simultaneously data sharing in KBD - tools. The present research treats the implementation of relational databases supporting KBD - methods with CAD environments through interfaces and several functionalities. Finally, an exemplary application of a database framework for a selected KBD - tool in combination with a commercial CAD system is presented to show the potential of relational database frameworks supporting KBD.
Keywords: knowledge-based design, relational database, CAD, KBE

1. INTRODUCTION
Sharing information across different engineering departments and disciplines makes it widely hard to manage product development. The wide spectrum of available design information such as CAD models, simulation results, databases and specific know-how, increases the complexity in virtual product development. Nowadays, manufactures have radically transformed their development process and design decisions to virtual prototypes, because of reduced time, improved quality and lowered costs. Besides, the trend is to improve product – related knowledge with frontloading methodology in the early phases to handle the product complexity, costs and the fulfillment of development targets. The potential of knowledge-based engineering (KBE) in the field of engineering provides increasing management-related efficiency in the product development process, because KBE deals with the storage and reuse of knowledge in product development processes. A comprehensive definition of KBE was elaborated by La Rocca [1]: the technology is based on the use of dedicated software tools called KBE systems, which are able to capture and systematically reuse product and process engineering knowledge, with the final goal of reducing time and costs of product development by automation of repetitive and non-creative design tasks and by support of multidisciplinary design optimization in all the phases of the design process. More in detail, knowledge-based design (KBD) is focused on product design and its related procedures. The KBD-tools handle problems and

complexity in design process from different knowledge domains. In general, knowledge-based methods are used to capture and reuse knowledge of a company. The enormous potential of KBD regarding cost and time reduction and the simultaneous improvement of quality and increasing efficiency leads to a continuous development and research in this area. Mainly, KBD-tools are software applications with a typical methodology that require an identification, acquisition and codification of the relevant knowledge within the applications. These software applications have aspects of object-oriented and functional programming, applied from template models to CAD-based on virtual prototyping, where product and process knowledge are stored in elementary databases. Those databases are often provided as relatively simple data sheets, like *.txt, *.xlsx or *.xml files with limited functionalities, which decrease productivity and efficiency. Those limited functionalities can be attributed to the complex distribution, access, management and maintenance of simple 2D databases or list of information like Microsoft® Excel files, also so called simple datasheets files. The typical databases in Excel files do neither deliver the flexibility nor the effective management of simultaneous user accessibility, being often empty cells found. For these reasons external relational databases management systems (RDBMS) are introduced as solution to handle the complexity and data amount.
Several additional modules, applications and functionalities can be implemented in the early design definition of the product. This development implementation uses global-network-based data within PDM systems. PDM includes all organizational tasks for the identification, the supply and the archival storage of product related data during the product development. PDM helps to organize the data and information flow throughout the development process. The management of the entire data flow, processes and documents during the development or modification of products across the products lifecycle states the basis for an efficient virtual product development. While, a PDM system offers easy sharing, it does not guarantee a useful data management due to the complexity of data and different data sources, which may result in a reduced flexibility in concept development. In this direction, collaboration with PDM systems has information gaps in the concept phase of the design. Due to this, a goal is proposed to find higher stability and integration of KBD-methods into modern design processes, which requires handling of flexible product structures in early concept phases (e.g. styling development) and effective interfaces to traditional PDM systems. The challenge is focused on the use of external RDBMS supported by application programming interfaces (API), which offer new potentials for KBD-methods in data management systems.

2. THE IDEA

In early phases of a product development process, an optimal interaction between the styling process and technical engineering operations is required. Data structures should be stored and connected to each another for easy, flexible and effective management of information between engineering teams. Conventional ways of PDM systems have reduced flexibility in the concept design development. Engineers use typical databases such as Excel files or simple text files, which are ineffective and inflexible as mentioned before.

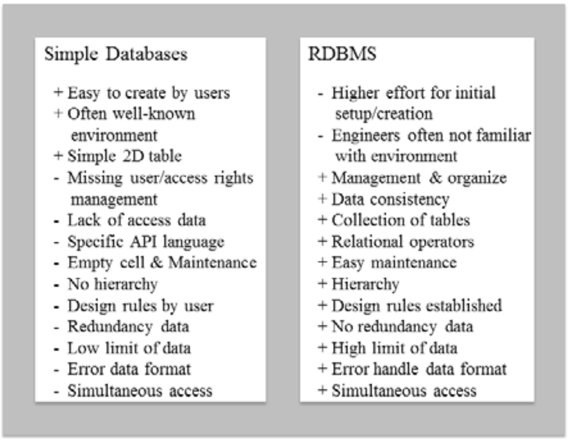

Figure 1. Advantages and disadvantages of simple and relational databases.

Some literature [2], [3] provides good approaches of improvement in the concept phase, using graphical user interfaces to control the data flow between 3D-CAD models and simple two dimensional databases (sheets). The goal is to have databases with easy maintenance as well as quick and easy handling concerning modifications. Those issues are solved by relational databases storing influencing parameters with a hierarchy and giving a direct access to the relevant information. Figure 1 shows a comparison of advantages and disadvantages between simple databases as Excel files or text files, and relational databases management system. The idea proposed uses a graphical user interface (GUI) taking data from the RDBMS to handle data easier and offering more capabilities.

3. EXAMPLE OF KBD USING RDBMS

The combination of external RDBMS with computer-aided) software applications allows new potentials for KBD-methods in engineering design. An exemplary challenge is the development of a dynamic vehicle structure for the early concept phase in automotive engineering. In reference [4], a GUI of software application is developed to automatize processes with AutoCAD. Based on this approach, looking for an effective and flexible data management, a relational database is created as shown in Figure 2. This Figure illustrates how a few tables which are in relation together are able to represent the full vehicle structure including several metadata. Then, influencing parameters predefine the structure to be used in a 3D-CAD model. The application of RDBMS and problem-oriented software solutions are integrated into the design environment.

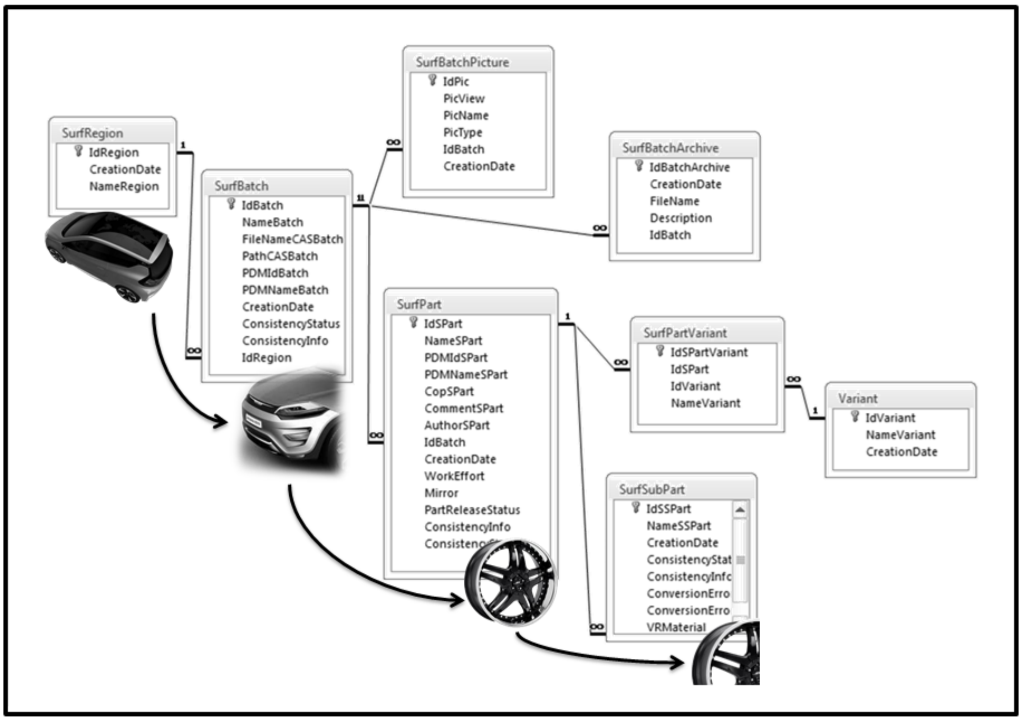

Figure 2. Relational database with predefined car structure in hierarchy, parameters and geometrical metadata.

An exemplary KBD application for data management in vehicle structures is developed within the programming environment Microsoft® Visual Studio 2012 and uses the CAD software CATIA® V5. The developed KBD application combines expert design knowledge together with integration of calculation and simulation procedures. This KBD application uses a relational database in background to create the full vehicle structure, imported by *.xml files optionally. Figure 3 illustrates a screenshot of the GUI of the software prototype. A flexible vehicle structure can be seen on the left side of the GUI. Each element of this structure can be set in context together or can be enriched with several process- or product-related metadata. To enable this functionality in KBD software, the usage of simple datasheets as databases would be ineffective. Due to this, the presented application of Figure 3 is connected to a RDBMS system using the layout of Figure 2. In this way, the KBD application for example can be run on a server to connect several clients to a common database. In particular, Figure 3 shows on the right side the result of a data quality checking procedure for the preselected elements of the structure on the left side. Several results can be stored on a centralized relational database and thus shared with other designers or monitored by project engineers for example.

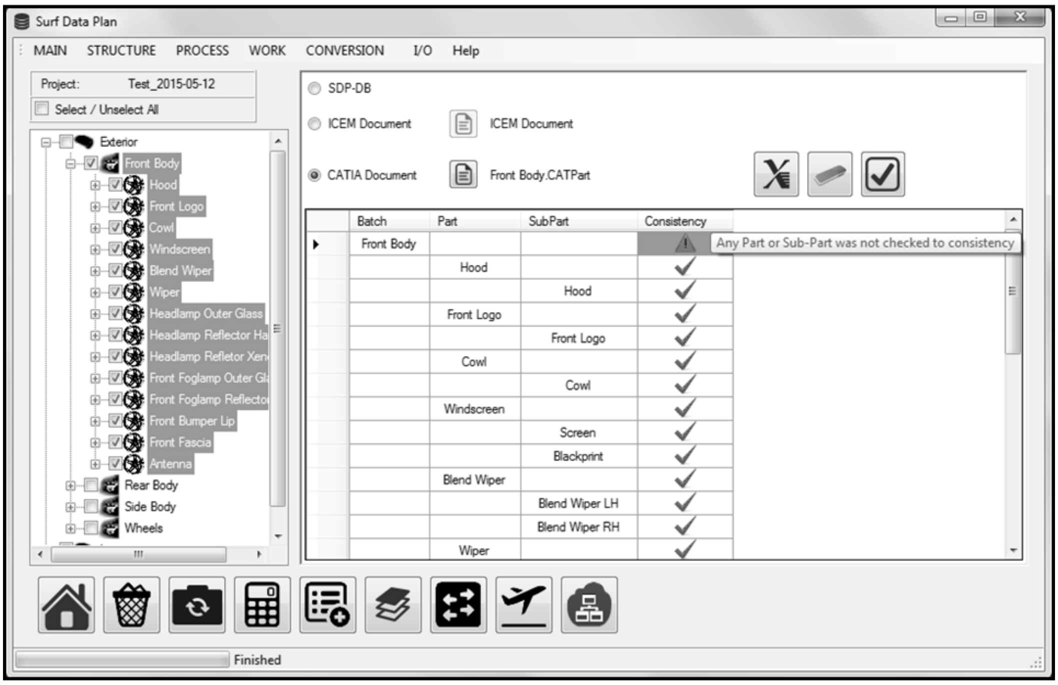

Figure 3. KBD application prototype for automotive styling checking the consistency using RDBMS.

4. CONCLUSION

Nowadays, improving quality, reducing costs and fulfilling delivery time are considered as main challenges in product development. To face product complexity in automotive industry, KBD-methods are used to develop products with increased flexibility and availability. The application of relational databases management systems (RDBMS) enables management and maintenance freedom and thus it offers more open solutions. The standards and user tools in RDBMS are more stable than simple datasheets, nevertheless initially a higher effort is required for efficient usage. The environment of RDBMS is not often known as easy simple datasheets, but relational databases can be managed by any engineer, and also can be created and shared between different teams and engineering departments. Besides, the use of those databases involved in KBD-methods and tools reduces data redundancy, repetitive tasks and mistakes within the design and styling development.

5. REFERENCES

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