Assistance to support the Self-Maintenance between Models and Documents in the Development and Use Phase of PSS

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Introduction

Mass customization and innovative technologies result in the modernization and individualization of *automated Production Systems* (aPS) and *Cyber Physical Productions Systems* (CPPS). Regular innovations often imply changes, to improve a system while these systems become increasingly complex.

To cope with these challenges, different discipline-specific (e.g. CAD, Simulation, etc.) and interdisciplinary (e.g. structural and behavioral systems models based on SysML) are used. During the development of an aPS and a CPPS, various disciplines collaborate and have to exchange these models. If these models are not or cannot be exchanged; instead, exported documents are often used as information and knowledge carriers [1].

Since changes occur regularly due to innovations, the development is not straightforward, and thus, model and documents with overlapping information become inconsistent. Commonly applied methods for inconsistency management are not applicable due to the use of documents if they have a limited machine-interpretable structure such as PDFs or hard copies [1;2]. Such so-called *unstructured documents* become difficult to maintain.

To support the *Self-Maintenance* between models and documents during the entire lifecycle of a PSS, subproject A6 looks at how models and documents can be systematically coupled; and how reverse engineering of changed documents can be technically assisted.

Information Retrieval of Redlining and Model-Document Coupling

For coupling models and documents, we propose a bidirectional *Model-Document Coupling* framework (see figure 1).

Within the *Model Environment*, various engineering domains, e.g. requirements, mechanics, electrics/electronics, software and systems, are involved in the development of the investigated system. These models can be linked if they are associative or contain overlapping information, e.g. to trace requirements.

To share specific model information with third parties by the means of documents, two options can be applied: (a) If the model environment tool offers export functions, it has to be considered whether these functions should be used. If not or individualized documents are desired, (2) we propose a *transformation engine* that uses predefined *layout templates* and generates a corresponding document. In [1], we demonstrate the latter option based on the

exchange of functional specification documents (i.e. requirements) between various stakeholders. We show another example for document generation in [3]: Modular PLC control software within the standardized PLCopen format is generated out of *piping and instrumentation diagrams* (P&IDs), which were initially drawn as SVG-based documents.

However, as mentioned in the introduction, the development process of systems is an innovative process, i.e. characterized by fast occurring changes of the system, its associated models and corresponding documents. As depicted in figure 1, we intend a *Reverse Engine* to reverse engineer changed documents. The *Reverse Engine* is completely independent from the *Transformation Engine* since we assume that during the reverse engineering of document changes not the entire background knowledge is available. A representative case study from industry comes from the electrical engineering domain: Therein, it is common to export ECAD models into circuit diagrams as hard copies or PDFs. These circuit diagrams often serve as installation manual during the commissioning of an aPS or a CPPS and are often changed during the installation process [4]. We call this *redlining* (of engineering documents). To provide an approach for reverse engineering, we integrate *Image Processing* techniques with *Model-Based Engineering* techniques [4]. By doing so, we allow first to retrieve information from changed documents and then to represent these within machine-interpretable models.

In [5], we have integrated the experiences and findings from our preparatory work by deriving (a) a classification scheme for changes in engineering documents and (b) a systematic Text-to-Modell approach (T2M) for reverse engineering of changed documents.

Outlook on the Assistance System for Reverse Engineering of changed Engineering Documents

After examining the applicability of our concepts on the basis of various case studies from different disciplines (cf. [1;3;4;5]), we aim at developing a flexible, adaptive and modular assistance system (see figure 1) in the near future. On the one hand, this assistance system will support engineers in generating documents from models. On the other hand, it will support the reverse engineering of altered information due to document changes to the original model. Here, it becomes obvious that the interactive assistance system aims not at replacing engineers. Rather, it allows engineers to focus on the essential tasks during the reverse engineering of document changes.

We encourage interested scientists and industry representatives to contact the responsible project staff to derive synergies in future cooperation. We are interested in the (1) exchange experience regarding methods and their applicability as well as in the (2) evaluation of our approaches at the hand of industrial case studies in order to prepare our solutions for transfer into industrial practice.

References

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