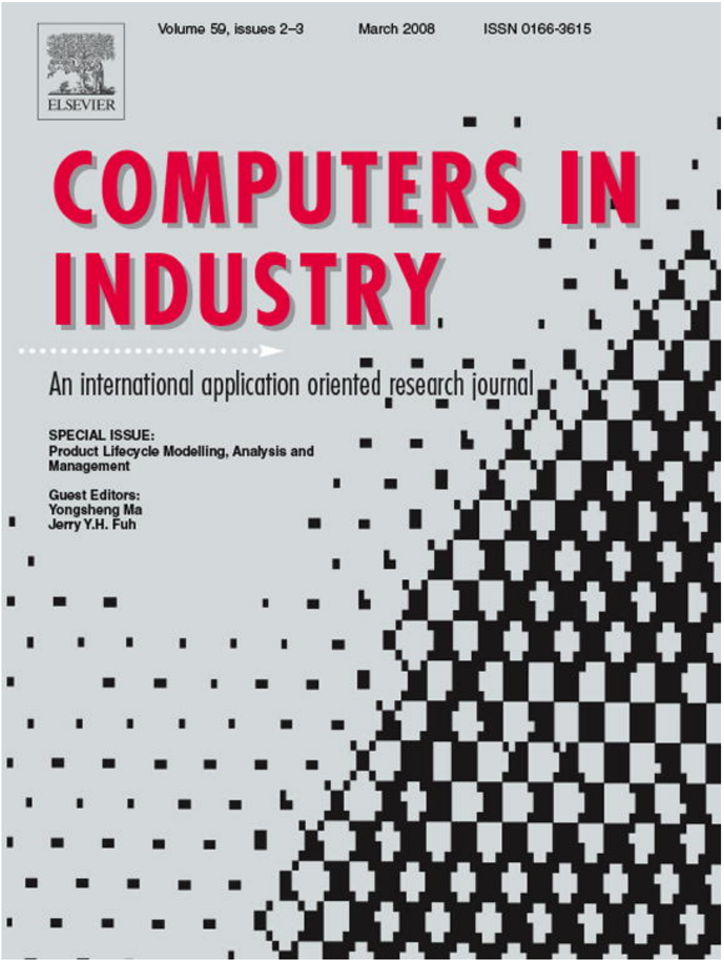
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Editorial

Product lifecycle modelling, analysis and management

Traditionally, the concept of product lifecycle management (PLM) had been applied for business planning and management. It emphasizes on the financial cash flow in an enterprise. Recently, PLM has been more broadly used as a technical term to describe a comprehensive, systematic and scientific approach in managing enterprise performance based on a coherently and consistently integrated computer system that can effectively and efficiently fulfil the product and process information requirements within a dynamic, collaborative and networked environment.This special issue of *Computers in Industry* intends to address the approaches, methodologies, and implementations of technologies throughout product lifecycles across different industrial sectors, such as aerospace, automotive, electronics, precision engineering, etc. The technological scope covers both product and process domains. The objective is to exchange research ideas and industrial practice methods on product lifecycle modelling, analysis and management (PLMAM). This special issue also includes papers focusing on computer software modelling methods, solution integration, and novel applications and tools. These papers are presented in four sections, product modelling, process modelling, system design, and application case studies.

1. Product modelling

A PLM system is supposed to support the information needs regarding products ‘‘from cradle to grave’’, along which, many engineering stages are involved, such as industrial design, conceptual design, detailed design, productization, process planning, manufacturing, assembly, sales, maintenance, and recycle or destroy. Such lifecycle stages are inter-related and mutually constraining. They also involve different computer aided application tools to carry out the processes. In the sequential product development processes, some constraints or conflicts may emerge in a later stage and require modifications on the decisions made in earlier stages. The iterations between stages are hence unavoidable and must be managed carefully to maintain the consistency, integrity, and validity of product information models. Due to the inter- or intra-stage relations, a chain of changes occurs as the consequence of an initiated change. Chen et al. suggest a unified feature-modelling scheme that could represent and manage the different application information models of different stages, and explore a propagation algorithm for the information consistency control. Geometric and non-geometric associations are handled uniformly in the scheme while the algorithm is based on a dependency network.

The new challenges for product modelling in PLM are the increasing coordination and management complexity of organizational information, responsibilities, schedules, deliverables, product information, and business processes that are involved in collaborative product development due to outsourcing and economic globalization. Shiau and Wee propose a distributed change control workflow method to maintain the consistency among designs and to speed up the decision-making of trusted partners, employees, suppliers, and customers in design chains. The two-layer approach is derived from the principles of configuration management and routing algorithm. It has been validated that the consistencies of designs from each participants in design chain is maintained by applying the proposed distributed control of workflow change.

2. Process modelling

PLM defines both the product as a central element to aggregate enterprise information and the lifecycle processes with an evolving time dimension for information integration and analysis. As indicated by the definition of PLM given at the beginning, PLM has to emphasize the generic process modelling in a reusable and scalable manner. From this angle, Yan et al. look into the integration of bidding-oriented product conceptualization and supply chain formation whereby both technical activities, e.g., product platform definition, and commercial activities, to be coordinated. For product platform generation, a general sorting is used. For eliciting bidding criteria, a self-organizing map (SOM) of neural network is suggested while analytic hierarchy process (AHP) technique is employed for finalizing the product concept and supply chain. They commented that when implemented using Internet and object-oriented database technology, their method is effective in linking and managing product conceptualization and bidding processes across organizations, during the early stage of product development.

Considering product manufacturing, Tong et al. present a product lifecycle oriented and agile digitization process preparation system with functions of providing computer-aided advisory tools and database systems for product structure manufacturability evaluation, rapid process planning, tooling

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design, process consumption determination as well as field process preparation. This research is expected to facilitate the rationalization of process preparation and thus, shorten the preparation time. From a similar angle, Ming et al. propose a framework for effective collaboration in process planning and manufacturing, where customers, developers, suppliers, and manufacturers are involved throughout the entire product lifecycle for the most advanced competitiveness. They identify the development of collaboration protocols as the future work, including semantic and mathematical models, heuristics, business rules, and optimization algorithms, to improve the performance of dynamic collaboration along a business value chain.

In the aspect of quality assurance in PLM, Tang and Hu develop a UML data model for quality management, which is aimed for seamlessly integrating all the quality data produced throughout the life of a product. The proposed multi-layered data model framework supports the evolution procedures of quality control. The model consists of six layers: general bill of material (GBOM), quality data carrier, quality processes, quality activities, quality objects, and physical data. Evolution relationship of quality data along the product evolution chain is discussed.

Du et al. apply stream of variation (SoV) methodology to analyze and predict product quality during the product design phase and identify root causes of faults for productivity improvement during ramp-up and production time in complex and multistage manufacturing systems. The methodology integrates multivariate statistics, control theory and design/manufacturing knowledge into a unified framework and is useful in eliminating costly trial-and-error fine-tuning of new-product manufacturing processes throughout product design and manufacturing.

Ha and Suh define a timed and colour Petri-nets model for dynamic workflow in product development process considering the uncertain and dynamic characteristics. Transition behaviours and functional primitives are represented to support the construction of workflow patterns. These semi-structured patterns can accommodate appropriate variations that are common in the implementation of system dynamic workflows. Practically, such process templates can be microscopically handled and adapted for the dynamic and uncertain environment related to data and time. Errors or abnormal executions of workflow can be analyzed and the lead-time of product development is then evaluated.

3. System design

An important aspect that has to be addressed is how a PLM solution can be designed and implemented in order to support enterprises' goals. Since strategic and operational excellence depend on many company and branch-specific conditions and constraints, a universal PLM solution cannot exist. PLM has to be aligned to boundary conditions and must support a company's strategy. Schuh et al. suggest a process-oriented framework to support PLM implementation. The framework's central point consists of a set of lifecycle-oriented business process reference models which link the necessary fundamental concepts, enterprise knowledge and software solutions to effectively deploy PLM.

To achieve the effective software system design and specification, Huang and Li adopt XML and develop the *ppXML* (platform product eXtensible Markup Language), a generic and extensible language for lifecycle modelling of platform products. It is designed to provide a set of constructs that are consistent with concepts and methods. Further it is dedicated for the modelling of product variants and platforms reflecting commonality, modularity, scalability and other strategies. The *ppXML* also serves as a standard interface with the product platform repository and platform development web service registry, together with a set of online facilities for data representation and transformation between different components and parties involved in the web services.

Jiménez et al. describe an extension of the product data framework based on an original product ontology, which establishes a common formal vocabulary to be used for each stakeholder of an extended supply chain. The extended model provides the foundation for a distributed product data management system and is consistent with the idea of managing product information according to the abstraction hierarchy and the structural hierarchy. They formalize the data aggregation and 'disaggregating' processes required by logistics planning activities.

4. Application case studies

Chen et al. make use of knowledge-based methods in networked new product development process management. They adopt analytical network process (ANP) with sensitivity analysis to prioritize the relative importance of multiple criteria and the preferences of new product mixes by generalizing experts' opinions. This method is claimed to be better than the fuzzy AHP model, which cannot deal with the inter-relationship among factors or the usually imprecise and vague human judgment.

Zheng et al. report a web-based machining parameter selection system for turning process planning and optimization. Using this system, engineers at geographically distributed sites can select adequate machine tools, cutters, and cutting parameters for the turning process. They can also evaluate the machining performance by obtaining the turning force, power consumption, vibration status, and work piece distortion from this system. This system is expected to reduce the product life cycle cost, enhance the product quality, and decrease the product lead-time significantly.

Nagahanumaiah et al. present a computer-aided rapid tooling process selection and manufacturability evaluation methodology for injection moulding, supported by mould cost estimation models and a rapid tooling process capability database. This system is aimed to overcome inconsistent or inappropriate rapid tooling process selection and mould design incompatibility. In their method, process capability is mapped in quality function deployment (QFD) against a set of tooling requirements that are prioritized through pair-wise comparison using analytical hierarchal process (AHP). The mould manufacturability for the selected process is evaluated out using fuzzy-analytic hierarchy process (Fuzzy-AHP) to identify problem features.

Automotive industry is more than ever obliged to improve its development strategy in response to the pressure of product innovation and complexity, the emergence of new technology, the changing market demands and increasing level of customer awareness. Trappey and Hsiao apply collaborative design and modularized assembly for automotive supply chain integration and focus on supporting quick-to-market and mass-customization. A plug-in system, called advanced production quality planning (APQP) hub is designed and developed to enhance the efficiency of automotive ODM supply chain, which assume both design and production responsibilities for the primary manufacturing company. The system can also provide e-solutions for SMEs to participate in the global automotive supply networks and fulfil the prime enterprise's real-time information requirement for their ODMs. Coincidently, Tang and Qian also study supplier integration in automotive development but emphasize on OEM supply chain. Two ways of supplier integration, quasi and full, are defined enabling different levels of supplier integration and partnership management. Aiming at the increase of efficiency and the reduction of the expenditure for partnership, the automotive OEM, system suppliers and sub-suppliers are managed and coordinated with different strategies.

Lee et al. present their insight on product lifecycle management in aviation maintenance, repair and overhaul (MRO) via two study cases. The study is unique because in comparison with the design of aircraft, PLM is used nearly 10 times less frequently in this industry sector. Because of the long lifespan of aircrafts, this means that the potential of PLM in aviation MRO activities has not been realized. Ideally, PLM provides reliable and accurate information among partners in extended enterprises and at various lifecycle stages of a product; in addition, it could optimize inventory levels and improve the efficiency of scheduled or unscheduled maintenance by cutting down on non-value add tasks.

Danesi et al. present a methodology for the management of projects, products, processes, proceeds on a digital mock-up platform. The aim is to allow high-level semantic knowledge definition for different partners involved so that the target corporation could improve on the time to market, cost, and quality. The methodology has a specific architecture for the functional refinement which links high semantic representation to geometric representation. Their methodology allows the partners to define different information about their resources – human resources, equipment – on a collaborative portal. Users can also define their collaborative scenarios, rules and graphonumerical parameters either in private or public spaces.

Since the ''call for papers'' was published in November 2005, this special issue has drawn much attention from the research community. Thirty-three papers have been received and out of them, only 18 dedicated ones are selected according to the merits identified by reviewers. Hope this special issue will provide resourceful information for researchers in this emerging field. At this junction, the guest editors would like to express their sincere appreciation to the authors, reviewers, and the editorial office for their kind support and assistance throughout the editing process.

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