Book of Abstracts

16. – 17.09.2020

SYMPOSIUM Design for X 2020

Book of Abstracts

Symposium Design for X

16. and 17. September 2020

virtual conference

Greeting

Prof. Dr.-Ing.
Sandro Wartzack

Seit März stellt uns das neuartige Coronavirus immer wieder vor neue Herausforderungen. Auch das DfX-Symposium bleibt nicht unverschont. Um die Sicherheit der Teilnehmer sowie eine seriöse Planung der Veranstaltung gewährleisten zu können, haben wir uns letztlich dazu entschlossen, das Symposium einmalig als Webkonferenz durchzuführen. Dabei liegt es mir besonders am Herzen, den einzigartigen Charakter des DfX-Symposiums zu erhalten, nämlich den intensiven wissenschaftlichen Diskurs zwischen Jungwissenschaftlern und Professorinnen und Professoren. In diesem Zusammenhang freue ich mich, dass einige meiner Kolleginnen und Kollegen den Weg nach Erlangen antreten werden, um in reduzierter „Professorenrunde“ die virtuellen Beiträge live zu diskutieren.

In dieser schnelllebigen Zeit geht mein Dank insbesondere an meine beiden Mitveranstalter und Kollegen Kristin Paetzold und Dieter Krause für das eingebrachte Engagement und die Flexibilität, das Symposium dieses Jahr neu zu erfinden. Darüber hinaus möchte ich meinen Mitarbeitern Herrn Christoph Zirngibl, Frau Kathrin Koppenwallner und Frau Tina Schröppel für die Organisation und das Einbringen neuer Ideen und deren kompetente Umsetzung danken. Zuletzt möchte ich natürlich auch allen Teilnehmerinnen und Teilnehmern für ihre Beiträge danken.

In diesem Sinne freue ich mich auf viele interessante Vorträge und eine sicher spannende und lebhafte Diskussion.

Prof. Dr.-Ing. Sandro Wartzack

Topics

- Digital Engineering / Systems Engineering
- Augmented Reality / Virtual Reality
- User-Centred Design
- Lightweight Design in Product Design
- Design for X

Program

16. September 2020

Time	
09:00 - 09:10	Technical Setup
09:10 - 10:30	**Welcome reception & session 1 „User-Centred Design und Lightweight Design“**
	Patient-specific modelling of the passive musculoskeletal system as a basis for the preoperative assessment of postoperative effects of endoprosthetic hip joint replacement; *David Scherb; FAU Erlangen-Nürnberg*
	An approach to compare tension chording concepts by using combined multibody and finite element simulation; *Eike Uttich; Ruhr-Universität-Bochum*
	Human factors for the evaluation of the user expertise in the usage of power tools; *Sebastian Helmstetter; Karlsruher Institut of Technology*
10:30 - 10:45	Coffee break
10:45 - 10:55	Technical Setup
10:55 - 12:15	**Session 2 „Systems Engineering “**
	Enhanced System Modelling - Integration of Tacit Knowledge Elements into the Creation of Technical System Models; *Fabian Wilking; FAU Erlangen-Nürnberg*
	Representation of the connection between product architecture design and production system design in SysML; *Lea-Nadine Schwede; Hamburg University of Technology*
	Challenges and requirements for integrated architecture modeling of mechatronic systems; *Thomas Schumacher; Technische Universitaet Clausthal*
12:15 - 13:15	Lunch break
13:15 - 13:25	Technical Setup
13:25 - 14:45	**Session 3 „Digital Engineering “**
	MBSE as a databasis to support configuration systems and digital twins of modular product families; *Fabian Laukotka; Hamburg University of Technology*
	Potentials of data-based methods for the design and optimization of mechanical joints; *Christoph Zirngibl; FAU Erlangen-Nürnberg*
	Requirements for a data backend system to support industrial data analysis applications in digital engineering processes of dynamic value networks; *Andreas Eiden; University of Kaiserslautern*
14:45 - 15:00	Coffee break
15:00 - 15:10	Technical Setup
15:10 - 16:30	**Session 4 „Topology Optimisation “**
	Multi-Objective Topology Optimization of Heat Conduction and Linear Elastostatic using Weighted Global Criteria Method; *Martin Denk; University of Federal Armed Forces Munich*
	Topology Optimization by Means of Deep Learning Without Pre-Optimized Training Data; *Alex Halle; Chemnitz University of Technology*
	Investigation of surface skeletonization methods for reconstruction of topology optimized structures; *Johannes Mayer; FAU Erlangen-Nürnberg*
16:30 - 16:45	Coffee break
16:45 - 16:55	Technical Setup
16:55 - 17:45	**Session 5 „Lightweight Design“**
	Designing Lightweight Structures under Consideration of Material and Structure Uncertainties on Different Levels of the Building Block Approach *Tobias S. Hartwich; Hamburg University of Technology*
	Concept of a CAE-based method for the optimisation and systematic design of lightweight short fibre reinforced, additively manufactured nodes for highly optimised truss systems ; *Michael Jäger; FAU Erlangen-Nürnberg*

Program

17. September 2020

Time	
09:00 - 09:10	Technical Setup
09:10 - 10:30	**Session 6 „Design for X and User-Centred Design“**
	SMART assistive systems in power tools - Identification of product requirements in application studies; *Sven Matthiesen; Karlsruher Institut of Technology*
	Information Exchange in Prototyping Processes: Determination and Description of Disturbance Variables; S*imon Nicklas; University of the Bundeswehr Munich*
	Prototyping Strategies for the Agile Development of Additive Manufactured Products: A Case Study from the COVID-19 Pandemic; *Daniel Omidvarkarjan; inspire AG*
10:30 - 10:45	Coffee break
10:45 - 10:55	Technical Setup
10:55 - 12:15	**Session 7 „Virtual Reality and User-Centred Design“**
	Linking a game-engine with CAD-software to create a flexible platform for researching extended reality interfaces for the industrial design process; *Jakob Harlan; FAU Erlangen-Nürnberg*
	Increasing the utility value of exoskeletal systems by integrating an active element into existing back structures; *Jonas Klabunde; Helmut-Schmidt-University*
	A posture prediction method for ergonomic assessment of user-product interactions while grasping using musculoskeletal human models; *Carla Hartmann; FAU Erlangen-Nürnberg*
12:15 - 13:15	Lunch break
13:15 - 13:25	Technical Setup
13:25 - 14:45	**Session 8 „Design for X“**
	Automated Identification and Characterization of Requirement Dependencies - Literature Study to Compare Solution Approaches; *Daniel Preuß; Paderborn University*
	A methodology for the systematic identification of market uncertainties to support the development of the system of objectives; *Valentin Zimmermann; Karlsruher Institut of Technologie*
	Method for cross-brand product design using the example of a battery module; *Florian Reichelt; University of Stuttgart*
14:45 - 15:00	Coffee break
15:00 - 15:30	Farewell with award ceremony

Wednesday, 16.09.2020, 9:10 - 10:30 o‘clock

Patient-specific modelling of the passive musculoskeletal system as a basis for the preoperative assessment of postoperative effects of endoprosthetic hip joint replacement

David Scherb[1]*, Marlene Kurz[1], Christopher Fleischmann[2], Alexander Wolf[1], Stefan Sesselmann[2], Jörg Miehling[1], Sandro Wartzack[1]

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During preoperative planning of total hip arthroplasty, the patients’ biomechanics is widely reduced to geometrical parameters. To provide the orthopedist more functional biomechanical parameters, a method is shown to model a patient-specific musculoskeletal human model via CT-/MRI-images in OpenSim. Main focus of this contribution is the setup of the passive musculoskeletal system. A generic human model and a segmented dataset of bones from the hip area serve as the basis for the modelling process. During the method the generic model is processed by scaling it to the anthropometry of the patient and adjusting subject-specific kinematics and shapes gathered from the segmented data. Finally, to reach the patient-specific representation the segmented bones are integrated into the model.

Keywords: *Patient-specific modeling, Image-based model, Musculoskeletal human model, OpenSim, Total Hip Arthroplasty*

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Wednesday, 16.09.2020, 9:10 - 10:30 o'clock

An approach to compare tension chording concepts by using combined multibody and finite element simulation

Eike Uttich[1]*, Beate Bender[1]

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The tension chording principle is a biomimetic lightweight design principle for kinematic chains. A great number of conceivable actuation concepts exist for specific applications that use the tension chording principle. Their effect on the system weight cannot yet be evaluated without calculating structural stress and movement. When comparing the effects on system weight of different actuation concepts, modelling the concepts can be time-consuming. We present an approach that uses a modeling system combining multibody and finite element simulation. Thus, stress and movement are calculated in the same model. We successfully test the approach for a simple system.

Keywords: *Biomimetics, Lightweight design, Simulation, Tension chording principle*

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Wednesday, 16.09.2020, 9:10 - 10:30 o'clock

Human factors for the evaluation of the user expertise in the usage of power tools

Sebastian Helmstetter[1], René Germann[1], Moez Abbes[1], Sven Matthiesen[1]*

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In order to optimize the use of hand/ power tools, user differences such as the influence of user expertise must be considered in product design. Therefore, product-independent non-application-specific variables are needed to objectively capture user expertise. In sports science, the characteristics of movement are used to evaluate the training level. To what extent these variables can be used for product development is unknown. Therefore, a study with 6 male subjects was carried out to analyze correlations between efficiency and characteristics in the movement behavior of the subjects when hammering. Results indicate a clear difference between experienced and less experienced users. Moreover, the movement of the more efficient subjects was spreading less than those of the less efficient ones.

Keywords: *User-centered Design, Human-Machine System, Human Factors, User Expertise*

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Wednesday, 16.09.2020, 10:55 - 12:15 o'clock

Enhanced System Modelling - Integration of Tacit Knowledge Elements into the Creation of Technical System Models

Fabian Wilking[1]*, Leonie Walter[1], Benjamin Schleich[1], Sandro Wartzack[1]

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The increasing complexity of technical consumer products has led to the integration of Model-Based Systems Engineering (MBSE) approaches into sectors that are not viewed as classic users of Systems Engineering. The approach helps grasping the complexity and keeping costs at a low level. However, many companies struggle with the implementation of the approach into their processes. A regularly mentioned reason for this is a missing visibility of a clear benefit. Especially smaller enterprises are facing these problems within the value chain. This paper presents an approach to contribute towards the enhancement of MBSE accessibility. It shows different strategies for the integration of tacit knowledge into system models and discusses their feasibility and contribution towards this enhancement.

Keywords: *Systems Engineering, Model-Based Systems Engineering, System Model, Knowledge Management, Tacit Knowledge*

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Wednesday, 16.09.2020, 10:55 - 12:15 o'clock

Representation of the connection between product architecture design and production system design in SysML

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The product standardization favors the design of production systems in terms of automation. This is contrary to the strategy of product differentiation, which serves external market variety. The goal of this paper is the design of an overall system that leverages product differentiation while not derogating the production efficiency. For this purpose, module drivers are recorded in a literature research and examined with regard to their relevance for production. In a next step, the module drivers are linked to the impact model of modular product structures in a SysML-model, which is then examined with regard to indirect connections.

Keywords: *Product Architecture, Production Systems, MBSE*

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Wednesday, 16.09.2020, 10:55 - 12:15 o'clock

Challenges and requirements for integrated architecture modeling of mechatronic systems

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Architectural models serve to generate a cross-domain understanding of system behaviour and relationships between subsystems within the development process. Various architectural models are described in literature and used in practice, differing in the level of concretion as well as the modelling purpose and representation. In order to structure these architectural models, a framework is derived from established and modern development models. The analysis of the architectural models using the model morphology indicates that architectural models have a large diversity and are often domain-specific. Consequently, the need of cross-domain architecture models are derived. Based on the analysis result and specific use cases requirements for cross-domain architecture modelling are defined.

Keywords: *Model-based Systems Engineering, cross-domain architectural model, product architecture, model morphology, RFLP*

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Wednesday, 16.09.2020, 13:25 - 14:45 o'clock

MBSE as a databasis to support configuration systems and digital twins of modular product families

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Today more products are developed in the form of modular productfamilies with similar, but slightly different product variants. To improve the development process but also the use and lifespanning service of product families and individual products the usage of MBSE has been an uprising trend. Using system models implicate another benefit: The stored information can be accessed by applications and be used to improve the userinteraction. One example are product configurators allowing the user to create a product variant according to individual requirements. This link to the product family's information can also be used in later lifecycle phases, as it enables an ongoing information flow about existing products into a digital representation, preparing the development and use of digital twins.

Keywords: *MBSE, modular product families, product generator, digital twin*

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Wednesday, 16.09.2020, 13:25 - 14:45 o'clock

Potentials of data-based methods for the design and optimization of mechanical joints

Christoph Zirngibl[1]*, Benjamin Schleich[1], Sandro Wartzack[1]

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Due to the increasing requirements on lightweight constructions, the demands for efficient joining processes are constantly rising. Therefor cold forming processes provide a faster and less expensive alternative to established thermal joining methods. In order to guarantee the joining reliability, not only the selection of a suitable process, but also the design and dimensioning of the joint is crucial. As a possible solution, data-driven methods offer procedures for the structuring of data and the targeted analysis of product features and key variables. Motivated by this, the paper shows a literature-based approach by using the example of clinching to illustrate the potentials and limits of data-based methods for the design and optimization of mechanical joining processes.

Keywords: *Clinching, Data-driven optimization, Multiobjective Optimization*

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Wednesday, 16.09.2020, 13:25 - 14:45 o'clock

Requirements for a data backend system to support industrial data analysis applications in digital engineering processes of dynamic value networks

Andreas Eiden[1]*, Jonas Gries[1], Thomas Eickhoff[1], Jens C. Göbel[1]

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Industrial data analytics needs well-structured and linked data from different data sources. The increasing mass of data, scattered IT-structures and a lack of knowledge, especially in small and medium-sized companies (SMEs) are factors that hinder the usage of data analytics. The goal of the research project AKKORD is to build a toolkit for companies to facilitate distributed and integrated industrial data analytics inside value-adding networks. A core part of this toolkit is a data backend system, which collects and links data from different source systems together in a single meta-model. This paper describes the requirements analysis of the data backend system by conducting structured interviews and workshops.

Keywords: *Digital Engineering Processes, PLM, Product Data Integration; Interoperability in Product Design; Digital Product Twin*

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Wednesday, 16.09.2020, 15:10 - 16:30 o'clock

Multi-Objective Topology Optimization of Heat Conduction and Linear Elastostatic using Weighted Global Criteria Method

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Multi-Objective Topology Optimization is a tool for finding low-weight solutions using a discretized geometry of several objective functions. In this contribution, the coupling of heat conduction and elastostatics is covered using the global criteria method. For the comparison of the different objectives and objective distributions typically the single target optimized solutions are selected as normalization criteria [1], [2]. The use of these optimized results requires additional calculation effort, so that this work uses the objective distribution of full material properties instead. For the normalization, the objective distributions will be standardized, and quantile normalized. The normalization strategies are compared to each other by the number of iterations and the resulting objective value.

Keywords: *Multi Objective, Topology Optimization, Global Criteria, Heat Conduction, Elasto Static*

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Wednesday, 16.09.2020, 15:10 - 16:30 o'clock

Topology Optimization by Means of Deep Learning Without Pre-Optimized Training Data

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Here a method for topology optimization is presented which is able to obtain optimized geometries without iterative optimum search. The optimized geometries are provided by an artificial neural network, the predictor, on the basis of boundary conditions and degree of filling as input data. In the training phase, geometries generated on the basis of random input data are evaluated with respect to given criteria and the results of those evaluations flow into an objective function which is minimized. Other than in state-of-the-art procedures, no pre-optimized geometries are used during training.

The trained predictor supplies geometries which are similar to the ones generated by conventional topology optimizers, but requires only a small fraction of the computational effort.

Keywords: *deep learning, topology optimization, artificial neural networks, AI in design*

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Wednesday, 16.09.2020, 15:10 - 16:30 o'clock

Investigation of surface skeletonization methods for reconstruction of topology optimized structures

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By showing where to place material in a specified design space, the continuous topology optimization is very useful in product development of structural loaded components. However the optimizations design proposal is far from being a parametric CAD-model. Instead it usually consists of a tesselated surface, that has to be re-engineered. As this is often done manually, it takes a lot of time and expert knowledge. Curve skeleton algorithms have proven their ability to support the restructuring of truss-like design proposals by providing references for construction elements. To investigate a similar design concept for general optimization results, showing truss-like structures as well as surface-like sections, the suitability of surface skeletons for topology reconstruction is examined.

Keywords: *Computational Geometry, Topology Optimization, Medial Axis Transform, Surface Skeleton*

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Wednesday, 16.09.2020, 16:55 - 17:45 o'clock

Designing Lightweight Structures under Consideration of Material and Structure Uncertainties on Different Levels of the Building Block Approach

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Lightweight design is an important aspect in the development of components to reduce material use and obtain energy-efficient structures. Frequently, lightweight structures are designed for one or a few load cases. Therefore, optimized designs can be less robust against changes in boundary conditions, scattering material parameters or deviating tolerances. Thus, these structures must be designed with safety factors that counteract the targeted lightweight design goal. In this article, an approach for the consideration of uncertainties is presented. The approach allows evaluating potentials of the accurate consideration of uncertainties. Finally, the developed approach is implemented for the calculation of the buckling load and torsional strength of thin-walled CFRP cylinderical shells.

Keywords: *CFRP, Uncertainties, Lightweight Design, Buckling, Building Block Approach*

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Wednesday, 16.09.2020, 16:55 - 17:45 o'clock

Concept of a CAE-based method for the optimisation and systematic design of lightweight short fibre reinforced, additively manufactured nodes for highly optimised truss systems

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Trusses represent an economical, rigid and effective lightweight construction method. However, the connecting parts (nodes) between the struts are a design challenge, especially in highly optimized trusses. Several struts with different geometries (diameter, cross-sections) must be connected at any spatial angle in one point in a manner that is suitable for the load. The use of fibre-reinforced materials for the struts is common practice, for the nodes, metals are usually used. However, these do not exploit the full lightweight construction potential of the truss. The proposed method allows the design of truss nodes using fibre-reinforced materials and additive manufacturing, while taking into account the geometric boundary conditions of the connection points for the struts.

Keywords: *Structural optimization, CFRP truss, lightweight design, short fibre reinforced plastics*

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Thursday, 17.09.2020, 09:10 - 10:30 o'clock

SMART assistive systems in power tools – Identification of product requirements in application studies

Jürgen Wilwer[1], René Germann[1], Philipp-Tobias Dörner[1], Sven Matthiesen[1]*

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The use of miniaturized sensor and actuator technology makes it possible to develop smart assistive systems in power tools for user support. For this purpose, not only the understanding of the power tool, but also the understanding of the user and the user's behavior are important. Furthermore, the resulting interactions between the user and power tool are indispensable. For the identification of product requirements for smart power tools, this paper presents a methodical approach to analyze the user behavior of non-professionals when assembling a birdhouse. From this analysis, first findings for the need and the added value in the use of smart assistive systems are derived. As a result of this paper first requirements for the development of smart cordless screwdriver can be identified.

Keywords: *Power tools, user-centered design, assistive technology, end user studies*

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Thursday, 17.09.2020, 09:10 - 10:30 o'clock

Information Exchange in Prototyping Processes: Determination and Description of Disturbance Variables

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Innovation requires methodologies that enable the continuous development of effective and context-relevant solutions. Thus, the frequent comparison of development goals and actual user needs is of crucial importance. Prototyping is a widely used tool for User Integration that supports the mutual process of understanding between designer and user. Yet, this usage of nonverbal communication in the course of the process is ambiguous and brings along its specific challenges for the designer. An enhanced system description of the prototyping process seems necessary to provide the developer with well-founded and comprehensible guidelines. Therefore, the present work analyses the similarities and differences of disturbance variables the designer may encounter in different prototyping processes.

Keywords: *prototyping, user integration, communication gap, design theory, cybernetics*

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Thursday, 17.09.2020, 09:10 - 10:30 o'clock

Prototyping Strategies for the Agile Development of Additive Manufactured Products: A Case Study from the COVID-19 Pandemic

Daniel Omidvarkarjan[1]*, Ralph Rosenbauer[2], Daniel Kirschenbaum[3], Daniele Cipriano[2], David Ochsner[2], Harry Woodfin[2], Christoph Klahn[1], Mirko Meboldt[4]

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Frequent validations of physical product increments play an essential role for Agile Hardware Development (AHD). This paper presents practices for the accelerated embodiment of increments based on the analysis of an AHD project. It describes adaptations of established prototyping strategies for the use of Additive Manufacturing (AM), covering iterative refinement, parallel development, prototyping media change and scheduling of build phases. The application of the practices led to an accelerated embodiment process with mean iteration lengths of 6 days and a first release of a viable product increment within 18 days. By enabling early and frequent validations with tangible increments, the practices facilitate the effective application of AHD in practice.

Keywords: *Agile hardware development, prototyping strategies, design for additive manufacturing*

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Thursday, 17.09.2020, 10:55 - 12:15 o'clock

Linking a game-engine with CAD-software to create a flexible platform for researching extended reality interfaces for the industrial design process

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Driven by the need to develop highly complex products in short development cycles, many companies are aiming at fully digitized design workflows and continuous data and information flow. XR-interfaces can extend current CAD-functionality to allow the usage of CAD-data in more stages of the product design process. In this paper, a platform linking a game-engine and CAD-software to efficiently explore XR-CAD Interfaces is presented. An architecture meeting the requirements of research environments is designed and implemented using the unreal engine and Siemens NX. The proposed system allows to efficiently explore interfaces for design sketch creation using different hardware setups.

Keywords: *Virtual Reality, Extended Reality, Computer-Aided-Design, Natural-User-Interface*

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Thursday, 17.09.2020, 10:55 - 12:15 o'clock

Increasing the utility value of exoskeletal systems by integrating an active element into existing back structures

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The use of exoskeletal systems has become an important approach to facilitate manual tasks e.g. in manufacturing industry. Depending on the addressed areas of application and activities, these systems can support or relieve different parts of the body. Due to overloading or incorrect posture, a high number of back disorders may occur. Exoskeletons are often used for muscular support and not primarily for correcting posture or gaining body muscle force. The base structure of a support system is capable of connecting different components like actuators or sensors. However, the high potential of this structure is often underemployed and could be improved by a functional integration of active components. An example to increase the support potential for the user is presented in this study.

Keywords: *Exoskeleton, Active Structures, Back Support System, User-centered Development*

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Thursday, 17.09.2020, 10:55 - 12:15 o'clock

A posture prediction method for ergonomic assessment of user-product interactions while grasping using musculoskeletal human models

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Using digital human models (DHMs) as the virtual representation of the human body enables the integration of ergonomic assessments in the product design process. Especially the use of DHMs in the early phases of product design can be decisive for competitive factors such as ergonomics or usability. Therefore, we present a method for automatic posture generation for grasping tasks using a musculoskeletal human model. This method enables ergonomic analyses without ergonomic knowledge of the product designer or subject tests. We implemented the presented method for a cylinder grasping scenario using the open source software OpenSim. Subsequently, we evaluated the implementation by means of a parameter study.

Keywords: *Posture prediction, musculoskeletal simulation, digital human model*

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Thursday, 17.09.2020, 13:25 - 14:45 o'clock

Automated Identification and Characterization of Requirement Dependencies - Literature Study to Compare Solution Approaches

Iris Gräßler[1], Daniel Preuß*[1], Christian Oleff[1]

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Many development projects of complex, interdisciplinary products fail due to an inefficient handling of requirement changes. One reason for this is that requirement dependencies and the resulting change propagation are not sufficiently recognized and considered by existing approaches. Based on a literature study and two industry workshops, approaches of automated dependency analysis of requirements for interdisciplinary development are evaluated. The result is that ontology-based approaches are particularly suitable for the automated dependency analysis of requirements due to the use of expert knowledge and the possibility of automation. On this basis, subsequent research activities can further develop the handling of requirements changes in interdisciplinary projects in a targeted manner.

Keywords: *Requirements Engineering, Requirements Change Management, Dependency Detection, Interdisciplinary Product Development, Literature Study*

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Thursday, 17.09.2020, 13:25 - 14:45 o'clock

A methodology for the systematic identification of market uncertainties to support the development of the system of objectives

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Product development and the associated processes are characterized by uncertainties. Thus, the elements of the system of objectives are also subject to uncertainties, which influence the product, its development and its success on the market. The systematic handling of these uncertainties is crucial for the success of product development. Uncertainty can be reduced by validation. However, validation has only a low priority, since, among other things the awareness of the necessity of validation and the uncertainties is only partly existing. In the course of this publication, a method to systematically evaluate the elements of the system of objectives concerning market uncertainty to increase the awareness of the uncertainties and to support the planning of validation activities is proposed.

Keywords: *System of Objectives, Product Engineering, Validation, Market Uncertainty*

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Thursday, 17.09.2020, 13:25 - 14:45 o'clock

Method for cross-brand product design using the example of a battery module

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Replaceable products for changing use in machines from different manufacturers confront industrial designers with new challenges. In contrast to classic products, a strong product uniqueness must be created here for the recognition of the functional system and an individually modifiable brand allocation so that the product does not look like a foreign body in the application machine. The three-stage design method to solve this problem is placed before the concepts are created. This includes the analysis of the technical degree of freedom of the design, an analysis of the competition and the definition of a design target. In addition to the integration of the method into the product development process, the development of a cross-brand battery module is described as an example.

Keywords: *Design Method, Industrial Design, Brand Design, Product Uniqueness, Brand Allocation*

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