DESIGN 2018

BOOK OF ABSTRACTS

excellence in design

15TH INTERNATIONAL DESIGN CONFERENCE
MAY, 21 - 24, 2018 - DUBROVNIK, CROATIA

PROGRAMME CHAIRS
P. John Clarkson, Udo Lindemann, Tim McAloone
Christian Weber, Dorian Marjanović

ISSN 1847-9162

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All the papers submitted for the DESIGN 2018 conference have been reviewed by at least two members of the Scientific Advisory Board.

Authors were asked to submit manuscripts electronically. In some instances, the layout of the manuscripts has been redone where the layout did not correspond to the conference manuscript style standard. The readers are therefore asked to excuse any deficiencies that may have arisen due to the above. If you have any difficulty interpreting the text or diagrams, please contact the corresponding author of the article directly.

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www.designconference.org

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Faculty of Mechanical Engineering
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Mechanical Engineering Design

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The Information Era has reached a tipping point, a moment where digital technologies have irreversibly permeated all facets of products and society, with design as the linchpin of this change. After a century of design research, pluralism and imagination define the way of thinking and the way forward. Design encapsulates the knowledge within and across disciplines, with overlapping theories and models of design. The DESIGN Conference proceedings present an essential collection of design research as a broad, multidisciplinary area that evolved from a consolidation of problem-solving methodologies and became a scientific domain in itself. Design research redefines the processes, the products and our behaviour in a whole host of applications, ranging from simple one-time-use products to complex systems-of-systems, services and the society at large. The move towards new business models like PSS, the trend to sharing products and the new, innovative products redefine users' behaviour on an individual level, but the interconnectedness of products and society imbues this process with a greater social impact than ever before. At the same time, the speed of change and turnover, never before seen in production processes, makes design research more demanding and broader than ever. Data Analytics and the Internet of Things allow for a dialogue between designer, production and users in real time. Advances in AI research and progress in additive manufacturing present the design process and design research with new challenges. In response, design research is becoming not only more fundamental, but also more applicable. Within this dichotomy lie the keys to reshaping our presence and charting a path to our future.

The design research presented at the DESIGN 2018 conference reflects predominantly the interests and experiences of design researchers and practitioners connected with academia. The papers presented epitomise the current state-of-the-art in design research. In places, they also re-examine questions that have been discussed before but in new contexts. And some of the papers readdress those questions that have been answered only partially. Understanding that design cannot, in all its complexity, be modelled or formally designated within one autonomous theory or model,

the research results presented will be subjected to constant examination and redefinition. Through papers selected for the DESIGN conference, the authors strive to improve design projects and processes with new methods, practices, competencies, information and communication technologies. A question that permeates all the work selected is how the changing landscape of production and product use influences engineering design methodologies and tools, both in practice and in the science of design. The programme of DESIGN 2018 is the result of a joint effort between authors, Programme Chairs, Organising team, and the reviewers in the Scientific Advisory Board. This year, Professor John Clarkson from the University of Cambridge joined the Programme Chairs, sharing his knowledge and expertise. We would like to express our gratitude to all the authors who have submitted their papers and all the reviewers who have helped Programme Chairs to select the submitted research reports to ensure an outstanding conference experience for all the participants. A special thank you goes to all authors and Session Chairs, who will make this experience possible. The DESIGN 2018 proceedings are structured in six virtual volumes, according to research topics. Design theory and research methods and Design support tools are clustered in the first volume. The next two volumes, with potential for practical impact, cover research in Design organisation and management, Design processes, Design practice and Design methods. Design information and knowledge and Innovation are the topics of the fourth volume. Research in Human behaviour in design, Industrial design and Design education are collected in the fifth volume while the Sociotechnical issues in design and System engineering design topics complete the six-volume DESIGN 2018 proceedings. Social sciences provide us with the notion of a 'tipping point' as a moment at which a series of small changes or incidents become significant enough to cause a larger, more important change. DESIGN 2018 aims to provide participants with a series of insights into design research and practice that will help them navigate and shape the tipping point of the information age.

Dorian Marjanović
P. John Clarkson
Udo Lindemann
Tim McAloone
Christian Weber

CONFERENCE VENUE

The conference will take place at the Hotel Dubrovnik Palace Conference Center.

REGISTRATION DESK WORKING HOURS

Sunday, 20th May:	18:00 - 20:00
Monday to Thursday, 21st – 24th May:	08:00 - 18:00

SPECIAL EVENTS

MONDAY, 21st May	
09:00 - 17:00	CONFERENCE WORKSHOPS
09:00 - 12:15	PHD FORUM
WEDNESDAY, 23rd May	
11:30 - 12:45	DESIGN DEBATE
16:30 - 18:00	SPECIAL INTEREST GROUPS MEETINGS

OPENING SESSION

Conference Hall Mare – SECTION I

MONDAY, 21st May

17:30 - 18:00

THE DESIGN SOCIETY WELCOME ADDRESS
Panos Y. Papalambros – President of the Design Society (University of Michigan, United States of America)

A WORD BEFORE
Dorian Marjanović – Conference Chair (Unversity of Zagreb, Croatia)

CLOSING SESSION AND AWARDS

Conference Hall Mare – SECTION I

THURSDAY, 24th May

17:15 - 18:00

DESIGN SCIENCE JOURNAL DISTINGUISHED PAPER AWARDS

CONFERENCE REFLECTION
Udo Lindemann - Programme Chair (Technical University of Munich, Germany)

REFRESHMENTS AND LUNCHES

Refreshments and lunches will be served in the Hotel Dubrovnik Palace from 21st – 24th May.

SOCIAL EVENTS

MONDAY, 21st May	19:00 - 20:00	WELCOME COCKTAIL - TERRACE OF THE CONFERENCE HALL MARE
WEDNESDAY, 23rd May	20:00 - 23:00	CONFERENCE GALA DINNER - RESTAURANT KLARISA, DUBROVNIK OLD TOWN
THURSDAY, 24th May	20:00 - 22:00	FAREWELL PARTY - BEACHFRONT OF THE HOTEL DUBROVNIK PALACE

GUEST PROGRAMME

Information, schedule and reservations about excursions are available at the desk. Accompanying guests are very welcome to attend.

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● Mare SECTION 1 ● Mare SECTION 2 ● Mare SECTION 3 ● Mare SECTION 4 ● Dubrava SECTION 1 ● Dubrava SECTION 2

MONDAY, MAY 21

8:00 – 8:15 – 8:30 – 8:45 – 9:00 – 9:15 – 9:30 – 9:45 – 10:00 – 10:15 – 10:30 – 10:45 – 11:00 – 11:15 – 11:30 – 11:45 – 12:00 – 12:15 – 12:30 – 12:45 – 13:00 – 13:15 – 13:30 – 13:45 – 14:00 – 14:15 – 14:30 – 14:45 – 15:00 – 15:15 – 15:30 – 15:45 – 16:00 – 16:15 – 16:30 – 16:45 – 17:00 – 17:15 – 17:30 – 17:45 – 18:00 – 18:15 – 18:30 – 18:45 – 19:00 – 19:15 – 19:30 – 19:45 – 20:00 – 20:15 – ...

REGISTRATION

D111	D112	D113	D114	D115	D116
PHD FORUM	WORKSHOP 1: TACKLING TOUGH DESIGN CHALLENGES TOGETHER	WORKSHOP 2: MAPPING SUCCESS IN COLLABORATIVE ENGINEERING	WORKSHOP 3: EXPLORING THE FUTURE OF DRAW/SKETCH CONTEXTS IN DESIGN EDUCATION	WORKSHOP 4: PERCEIVED QUALITY - QUALITY IS IN THE EYE OF THE BEHOLDER	WORKSHOP 5: SIMPLICITY: A CHALLENGE FOR IMPROVING PRODUCTS AND THEIR APPLICATIONS

LUNCH

D132	D133	D134	D135	D136
WORKSHOP 6: LET'S GENERATE ECO-INNOVATIVE CONCEPTS: EXPERIMENTING AN ECO-IDEATION TOOLBOX	WORKSHOP 7: METHODS FOR MODELLING AND MANAGEMENT OF ENGINEERING PROCESSES	WORKSHOP 8: VALIDATE THE V-MODEL FOR NEW VDI 2206	WORKSHOP 9: THE CREATIVE MOMENT(S): CHARACTERISATION AND ENABLERS OF DESIGN CREATIVITY	WORKSHOP 10: NEW RESEARCH TOPICS IN DESIGN FOR ADDITIVE MANUFACTURE

● D1-O OPENING

● D1-P PLENARY SESSION I

WELCOME COCKTAIL
(19:00-20:00)
Terrace of the Conference Hall Mare

TUESDAY, MAY 22

REGISTRATION

D211	D212	D213	D214	D215	D216
APPLICATIONS OF DESIGN METHODS	DESIGN CREATIVITY AND COGNITION STUDIES	DESCRIPTIVE AND EXPERIMENTAL RESEARCH APPROACHES	INFORMATION MANAGEMENT IN PRODUCT DEVELOPMENT	KNOWLEDGE BASED DESIGN SUPPORT TOOLS	SYSTEMS MODELLING

REFRESHMENT BREAK

● D2-P PLENARY SESSION II

LUNCH

D231	D232	D233	D234	D235	D236
PROCESSES IN DESIGN	CREATIVITY APPROACHES AND METHODS	COMPUTATIONAL APPROACHES TO DESIGN RESEARCH	ANALYSING COURSES AND METHODOLOGIES IN EDUCATION	APPLICATIONS OF DESIGN SUPPORT TOOLS	UNDERSTANDING HEALTH AND INCLUSION

REFRESHMENT BREAK

D241	D242	D243	D244	D245	D246
SUPPORTING CREATIVITY IN DESIGN	INNOVATION ALLIANCES	DESIGN FOR ELDERLY AND USER CENTRED DESIGN	KNOWLEDGE MANAGEMENT IN DESIGN	DESIGNERS' IDENTITY, SKILLS AND MINDSET	SYSTEMATIC APPROACH TO AUTONOMOUS SYSTEMS

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WEDNESDAY, MAY 23

REGISTRATION

- D311 EVALUATION AND RISK ASSESSMENT METHODS
- D312 TOOLS FOR EARLY PHASES OF DESIGN
- D313 DEVELOPING PRODUCT -SERVICE SYSTEMS
- D314 SUPPORTING SUSTAINABLE DESIGN AND FRUGALITY
- D315 CUSTOMER AND USER INTEGRATION
- D316 DATA-DRIVEN DESIGN

REFRESHMENT BREAK

- D3-P PLENARY SESSION III
- D3-D DESIGN DEBATE

LUNCH

- D331 IDEA GENERATION AND INNOVATION ASSESSMENT
- D332 COLLABORATION IN DESIGN
- D333 DESIGN PRACTICE THINKING
- D334 STRATEGIC SUSTAINABILITY AND CIRCULAR ECONOMY
- D335 AGILE PRODUCT DEVELOPMENT
- D336 MULTI SENSORIAL AND USER CENTRED DESIGN

REFRESHMENT BREAK

- D341 D341-YOUNG DS MEMBERS IN INDUSTRY - EXPECTATIONS MEETING
- D342 DESIGN CYBER-PHYSICAL SYSTEMS DS SIG MEETING
- D343 HUMAN BEHAVIOUR IN DESIGN DS SIG MEETING
- D344 JOINT UTILISATION OF RESEARCH INFRASTRUCTURE MEETING
- D345 MECHATRONIC COLLABORATION DESIGN MEETING

CONFERENCE GALA DINNER
(20:00-23:00)
Restaurant Klarisa Dubrovnik Old Town

THURSDAY, MAY 24

REGISTRATION

- D411 ADDITIVE MANUFACTURING
- D412 APPLIED DESIGN PROCESSES KNOWLEDGE
- D413 TOOLS FOR LATE PHASES OF DESIGN
- D414 EXPERIMENTS IN DESIGN EDUCATION
- D415 CHANGE AND RISK MANAGEMENT
- D416 DESIGN AUTOMATION TOOLS

REFRESHMENT BREAK

- D421 PROTOTYPING AND DIGITAL PRODUCTION
- D422 DESIGN PROCESS EVALUATION
- D423 TOOLS FOR COLLABORATIVE DESIGN
- D424 TOOLS AND FRAMEWORKS IN EDUCATION
- D425 PARTICIPATORY DESIGN / CODESIGN
- D426 SHAPING PRODUCTS AND NEEDS

LUNCH

- D431 DESIGN FOR X
- D432 LEAN AND AGILE TO SUPPORT INNOVATION
- D433 ARCHITECTURE, PLATFORMS, MODULARITY
- D434 CASE STUDIES OF SYSTEMS ENGINEERING
- D435 DESIGN KNOWLEDGE DESCRIPTIONS
- D436 ERGONOMIC AND INCLUSIVE DESIGN

REFRESHMENT BREAK

- D4-P PLENARY SESSION IV
- D4-C CLOSING AND AWARDS

FAREWELL PARTY
(20:00-22:00)
Beachfront of the Hotel Dubrovnik Palace

8:00 8:15 8:30 8:45 9:00 9:15 9:30 9:45 10:00 10:15 10:30 10:45 11:00 11:15 11:30 11:45 12:00 12:15 12:30 12:45 13:00 13:15 13:30 13:45 14:00 14:15 14:30 14:45 15:00 15:15 15:30 15:45 16:00 16:15 16:30 16:45 17:00 17:15 17:30 17:45 18:00 18:15 18:30 18:45 19:00 19:15 19:30 19:45 20:00 20:15 ...

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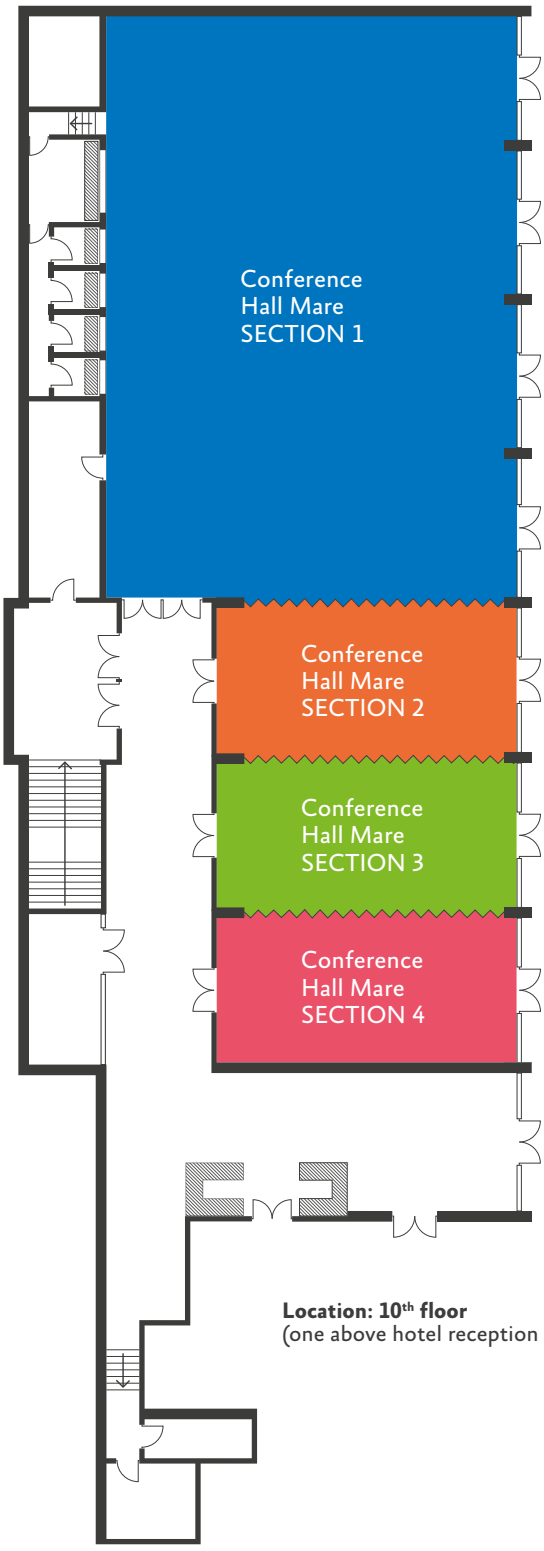

Terrace of the
Conference
Hall Mare

Location: 10th floor
(one above hotel reception level)

Location: 9th floor
(hotel reception level)


DESIGN
2018

MONDAY, MAY 21

● Mare SECTION 1 ● Mare SECTION 2 ● Mare SECTION 3 ● Mare SECTION 4 ● Dubrava SECTION 1 ● Dubrava SECTION 2

8:00						8:00
8:15	REGISTRATION					8:15
8:30						8:30
8:45						8:45
9:00	● D111	● D112	● D113	● D114	● D115	● D116	9:00
9:15	PHD FORUM	WORKSHOP 1: TACKLING TOUGH DESIGN CHALLENGES TOGETHER	WORKSHOP 2: MAPPING SUCCESS IN COLLABORATIVE ENGINEERING	WORKSHOP 3: EXPLORING THE FUTURE OF DRAW/SKETCH CONTEXTS IN DESIGN EDUCATION	WORKSHOP 4: PERCEIVED QUALITY - QUALITY IS IN THE EYE OF THE BEHOLDER	WORKSHOP 5: SIMPLICITY: A CHALLENGE FOR IMPROVING PRODUCTS AND THEIR APPLICATIONS	9:15
9:30							9:30
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12:30	LUNCH						12:30
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13:30							13:30
13:45		● D132	● D133	● D134	● D135	● D136	13:45
14:00		WORKSHOP 6: LET'S GENERATE ECO-INNOVATIVE CONCEPTS: EXPERIMENTING AN ECO-IDEATION TOOLBOX	WORKSHOP 7: METHODS FOR MODELLING AND MANAGEMENT OF ENGINEERING PROCESSES	WORKSHOP 8: VALIDATE THE V-MODEL FOR NEW VDI 2206	WORKSHOP 9: THE CREATIVE MOMENT(S): CHARACTERISATION AND ENABLERS OF DESIGN CREATIVITY	WORKSHOP 10: NEW RESEARCH TOPICS IN DESIGN FOR ADDITIVE MANUFACTURE	14:00
14:15							14:15
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17:30	● D1-O OPENING						17:30
17:45							17:45
18:00							18:00
18:15	● D1-P PLENARY SESSION I						18:15
18:30							18:30
18:45							18:45
19:00							19:00
19:15	WELCOME COCKTAIL (19:00-20:00) *Terrace of the Conference Hall Mare*						19:15
19:30							19:30
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20:00							20:00
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D111: PhD FORUM

Conference Hall Mare SECTION 1

Chairs: Philip Cash (Technical University of Denmark, Denmark), Kilian Gericke (University of Luxembourg, Luxembourg)

Research within the DESIGN community offers many possibilities of exchange and collaboration between fellow researchers. While these opportunities cover a broad scope from young researchers to senior members of the community with a range of research interests, we aim to support the specific needs of PhD students. Therefore, the DESIGN 2018 conference offers a PhD Forum.

The aims of the PhD Forum are:

- To foster the exchange of ideas and research approaches between younger researchers
- To provide opportunities for discussing personal research topics, methodologies and potential problems with experts
- To enhance networking and collaboration

The forum will be an opportunity for PhD students to discuss their research questions and ideas with their peers and experienced researchers to support their research. Small discussion groups will be organised in which individual research topics are presented to and discussed within the group. Discussion groups will consist of 5-6 PhD students and 1-2 experts.

The PhD Forum is aimed at PhD students. To facilitate meaningful discussion, it is essential that potential participants should already have defined their PhD research topic, undertaken an initial literature study and formulated aims and objectives.

D112: WORKSHOP 1

Conference Hall Mare SECTION 2

TACKLING TOUGH DESIGN CHALLENGES TOGETHER

Hosted by The Design Society SIG DESIGN PRACTICE

Chairs: Ola Isaksson (Chalmers University of Technology, Sweden), Oscar Nespoli (University of Waterloo, Canada)

The workshop intends to support the goals of the Design Practice SIG, namely, to capture, study and share authentic, relevant and tough design challenges in their contexts. A new SIG sub-theme to capture design activity in-situ (industry and practice contexts) or in-vitro (laboratory or non-practice contexts), will be investigated.

We invite you to share your most interesting design challenges with us at the Design Practice Special Interest Group (SIG) workshop. We invite challenges in all areas of design practice, including those from industry, government, healthcare, and start-up communities.

We are interested in fostering collaboration, cooperation and interdisciplinary learning by practitioners, academics and students alike, through the presentation, formulation and solving of these challenges. We are also very interested in having you share your strategies, models, techniques you used in addressing them to share with our community. We offer design challenge sponsors an opportunity to access the collective mind of our Society through this unique workshop format.

We expect that the design challenges will vary, spanning many application domains, disciplines, challenge type, scale and potential impact.

D113: WORKSHOP 2

Conference Hall Mare SECTION 3

MAPPING SUCCESS IN COLLABORATIVE ENGINEERING

Hosted by The Design Society SIG COLLABORATIVE DESIGN

Chairs: Robert Ian Whitfield (University of Strathclyde, United Kingdom), Ross Brisco (University of Strathclyde, United Kingdom)

Successful collaborative engineering practices have demonstrated significant benefits to industry: improving efficiency; eliminating rework due to information inconsistencies; managing complexity and automating parts of the collaborative design process. Despite these benefits, collaborative endeavours fail due to obstacles such as: sharing knowledge through ineffective communication methods; co-ordinating stakeholders with divergent objectives; managing teams with cultural and leadership differences; and configuring collaborative networks towards a long-term and strategic vision. Changing innovation landscapes have the potential to radically advance collaborative practices to develop more user-centred, innovative and customised products in a timelier manner.

The Collaborative Design SIG has been working to define the characteristics of successful collaborative practices through previous workshops exploring the changing innovation landscape. These characteristics present complex challenges to conventional industrial practice and confound the benefits gained from wide-spread implementation. These challenges could, for example, relate to the complexities of extending knowledge management practices beyond the boundaries of the organisation and the subsequent manipulation of this knowledge; the opera on of formal and informal collaborative networks that manages ambiguity, equivocality, and conflicting constraints; the adaptation of organisational structures to become more flexible, agile and open; and the ownership of the product development process.

D114: WORKSHOP 3

Conference Hall Mare SECTION 4

EXPLORING THE FUTURE OF DRAW/SKETCH CONTEXTS IN DESIGN EDUCATION

Hosted by The Design Society SIG DESIGN EDUCATION

Chairs: Bryan Howell (Brigham Young University, United States of America), Jan Willem Hoftijzer (Delft University of Technology, The Netherlands)

Ever since the emergence of the Industrial Design profession and field, sketching has always played an important part in practice and design education. Sketching is the designer's language. At the same time, the field is changing; expanding, and the design sketching discipline is expanding likewise. The design sketching discipline becomes broader since designers' activity covers a larger share of the process, and because design projects tend to show increasingly more variation in what is designed: services, systems, experience (Sander and Stappers 2013), next to products and spaces.

We believe the role of sketching and drawing has evolved and that there is an inadequate platform to explore and collaborate with academics, researchers and practitioners in this field. We propose that a new special interest group on Design Sketching and Drawing be created to fill this need.

To deliver meaningful sketching and drawing instruction in higher education, we should be exploring existing and emerging draw/sketch contexts and contemporary research efforts to understand the evolving domain of design sketching. As well, we should be exploring how emerging technologies used to disseminate design drawing knowledge might be best utilized in this new world of design. We also suspect that the traditional written paper about drawing is not the optimal methods of peer review, collaboration or pedagogy.

In a brainstorming session with design educators across the world, the workshop participants will explore, discuss and identify content and boundaries of the potential Design Draw SIG.

D115: WORKSHOP 4

Conference Hall Dubrava SECTION 1

PERCEIVED QUALITY - QUALITY IS IN THE EYE OF THE BEHOLDER

Chairs: Monica Rossi (Politecnico di Milano, Italy), Konstantinos Stylidis (Chalmers University of Technology, Sweden), Antonia Fels (RWTH Aachen University, Germany)

Successful products are not simply the result of developing unique features but much more often the result of a reasonable price-performance ratio from the customers' point of view. In addition to functional and performance aspects, this ratio comprises quality as the basis for evaluation. But how can quality be conveyed? It is no longer just about reliability and error-freeness, but rather about immediate perception. High-quality materials and processing serve as substitute indicators for the concept of quality, which is difficult to grasp from the customer's point of view. Moreover, materials of a product can enable an individual to resourcefully situate the product in multiple contexts and as part of multiple practices. As a result, a product will remain appropriate and will continue to generate value for a longer time.

For this purpose, problems and solutions are presented and illustrated in this workshop by practical examples and methods, including but not limited to:

- Brand impact on quality perception - How does evaluation change due to the product brand?
- Sensory assessment - How do customers perceive products?
- Customer-needs profiling - How do different customer needs correlate with different product attributes?
- Social Media Analysis - How to learn from and use Social Media for customer-oriented product development?

The workshop aims at increasing awareness regarding Perceived Quality for designers and practitioners. It will actively involve the audience in the process of Perceived Quality quantification as well as present showcases of various design activities along the product development process.

Session D115 D116

09:00 12:15

21 May

MON

D116: WORKSHOP 5

Conference Hall Dubrava SECTION 2

SIMPLICITY: A CHALLENGE FOR IMPROVING PRODUCTS AND THEIR APPLICATIONS

Chairs: Sándor Vajna (Otto von Guericke University Magdeburg, Germany), Julie Le-Cardinal (CentraleSupélec, France), Jonathan Borg (University of Malta, Malta), Kristin Paetzold (Bundeswehr University Munich, Germany)

Everyone expects simplicity, whether in operating a mobile phone, using a printer or a household appliance, or handling a car or a machine tool. Unfortunately, complexity builds barriers nowadays and prevents us from understanding the full potential of a product. Thus, the goal-oriented design of simple products is more important than ever. But, what makes a product simple? And does "simple utilisation" mean simple functionality at the same time? Are easy-to-use products easy to manufacture at the same time? Which criteria create and contribute to simplicity?

When developing innovative products, three design principles claim that a product has to be "unambiguous", "simple", and "safe" (Pahl and Beitz 1977). Unambiguousness can be described consistently; safety is defined following guidelines and rules. But requirements and conditions for simplicity don't seem to be palpable. Descriptions of the characteristics of simplicity and how to get there seem to be relative and speculative.

In this workshop, we would like to examine and discuss possible characteristics and properties (differentiation according to Weber (Weber 2005)) of simplicity by examining different mechatronic products. We therefore kindly invite you to participate and share your scientific and industrial experience with us.

D132: WORKSHOP 6

Conference Hall Mare SECTION 2

LET'S GENERATE ECO-INNOVATIVE CONCEPTS: EXPERIMENTING AN ECO-IDEATION TOOLBOX

Hosted by The Design Society SIG SUSTAINABLE DESIGN

Chairs: Benjamin Tyl (APESA, France), Daniela C.A. Pigosso (Technical University of Denmark, Denmark), Flore Vallet (University of Technology of Compiègne, France)

New knowledge on eco-innovation processes to support small businesses (startups and SMEs) is the objective of the ALIENNOR project that aims to the development of an eco-innovation toolkit. This toolkit is based on Eco-ideation Stimulation Mechanisms (ESM) that are both didactic and accurate. The mechanisms explore systemic dimensions of Sustainable Development, poorly exploited so far but yet very promising.

A toolbox of 7 ESM has been developed and covers the whole eco-innovation space. Compared to the well-known Life Cycle Design Strategy Wheel (LiDS), the mechanisms include more than guidelines, but elemental creative processes in the spirit of the TRIZ method.

This goal of the workshop is to test the ESM approach within the Design Society community and to discuss it as an opportunity to better support companies during eco-innovation processes.

Based on this approach, the workshop is aimed at participants interested in or familiar with innovation and eco-sustainable design. It is built on an industrial case that will be challenged in groups. This workshop structure will be governed by:

- Presentation of the ESM approach, the eco-innovation toolbox and the case study
- Eco-ideation: choice of the appropriate set of ESMs according to the case study and generation of eco-innovative concepts
- Debriefing: perspectives for future development of the toolbox

D133: WORKSHOP 7

Conference Hall Mare SECTION 3

METHODS FOR MODELLING AND MANAGEMENT OF ENGINEERING PROCESSES

Hosted by The Design Society SIG MODELLING AND MANAGEMENT OF ENGINEERING PROCESSES

Chairs: Kilian Gericke (University of Luxembourg, Luxembourg), Claudia Eckert (The Open University, United Kingdom)

In this workshop, we will analyse which methods are used for modelling and management of engineering and innovation processes. The focus is on understanding and managing the process as a whole; rather than on methods supporting particular tasks or steps in the process. We will therefore not look at creativity techniques and other design methods.

We aim to create an overview of methods that are widely used in our community and want to exchange experiences in using them. We are particularly interested in understanding what makes the method suitable for a particular context and what are reasons that the same method might not work in a different context.

D134: WORKSHOP 8

VALIDATE THE V-MODEL FOR NEW VDI 2206

Conference Hall Mare SECTION 4

Chairs: Michael Dattner (BST eltromat International GmbH, Germany), Iris Graessler (Paderborn University, Germany)

The Core Team of VDI Guideline revision 2206 invites you to participate in this workshop and bring in your scientific expertise or industrial experience in Systems Engineering, Mechanical Engineering, Electric/Electronic Engineering, Software Development and Requirements Engineering. Together we will critically discuss the call for action and pursued goals of modelling mechatronic engineering and thus validate the actual revision status of the V-Model. Exemplary enhancements of the proposed V-Model are the representation of:

- Digital Business Models running in eco systems: enabling engineers to give impulses for new business models originating from new technologies,
- Requirements Engineering including stakeholder analysis and operation scenarios:
  - Continuous model-based engineering,
  - Product architecture,
  - Networked discipline specific implementation,
  - Holistic view on the entire product life cycle in order to retrieve all relevant restrictions.

In preparation for this workshop, a thesis paper will be provided to registered participants. Thus, we will dive into a deep discussion right away from the start, and you will profit from new insights and solution approaches. Together, we will provide a clear orientation on how IoT-systems will affect our cross-disciplinary engineering work.

Session D134

13:45 17:00

21 May

MON

D135: WORKSHOP 9

Conference Hall Dubrava SECTION 1

THE CREATIVE MOMENT(S): CHARACTERISATION AND ENABLERS OF DESIGN CREATIVITY

Hosted by The Design Society SIG DESIGN CREATIVITY

Chairs: Milene Gonçalves (TU Delft, The Netherlands), Niccolò Becattini (Politecnico di Milano, Italy)

Can we recognise the instant when one gets inspired and generates a creative idea? Does it happen in an instant, as a sudden insight, as creative literature claims? Or is it composed of a combination of semi-creative moments, which ultimately evolves into a creative idea? Can we, as researchers, be aware of these creative moments when they occur? And how are these ideas supported, shared and represented? These are some of the questions that motivate this workshop. We aim to identify and characterise the moment(s) when a creative idea occurs and discuss the role of possible shared design representations in creativity.

The research questions that guide this workshop are the following:

RQ1: What characterises the creative moment(s) prior and during ideation in teams?

RQ2: How do shared design representations support the generation of creative moments?

This workshop differs from previous SIG workshops in how it is set up and carried out. During the workshop, part of the participants will be asked to face a design task while some others will be invited to observe and analyse their activities and their creative process. Therefore, differently, from a passive workshop, participants will be divided into relatively small design teams to explore and generate ideas for a given design problem, as an actual creative workshop. Each design team will be partnered by a smaller observation team to analyse the former's creative process, by trying to capture and identify what inspired them, what was behind those creative moments, and to what extent design representations supported ideation and creativity. Due to time limitations, we cannot expect a full analysis, but rather a discussion within the design teams and the observation teams about the critical insights they might have when looking back at their creative process. At a later stage, with the support of recording tools (we expect to use some personal device to audio and/or video record what is going on during the workshop) and by capturing their pen and paper results, we will be able, together with each team, to elaborate a more in-depth analysis of the creative sessions.

Finally, the workshop will be concluded with a final discussion involving all the design and observation teams of their main observations and triggers for future research.

Session D135 D136

13:45 17:00

21 May

MON

D136: WORKSHOP 10

Conference Hall Dubrava SECTION 2

NEW RESEARCH TOPICS IN DESIGN FOR ADDITIVE MANUFACTURE

Hosted by The Design Society SIG DESIGN FOR ADDITIVE MANUFACTURING

Chairs: Kristina Shea (ETH Zurich, Switzerland), Yuri Borgianni (Free University of Bozen-Bolzano, Italy), Anna B. Öhrwall Rönnbäck (Luleå University of Technology, Sweden), Peter Törlind (Luleå University of Technology, Sweden)

The workshop will explore two new research topics in DfAM: 1) design heuristics for AM that can be used in conceptual design and re-design to explore new concepts possible through AM and 2) human acceptance of artefacts manufactured by AM, instead of traditional technologies. These two topics will be explored through active design experiments involving the workshop participants and the outcome discussed to identify future research directions. The workshop will end with a general discussion of a future PhD school in DfAM offered by the SIG.

OPENING SESSION
Chair: Dorian Marjanović (University of Zagreb, Croatia)

Session D1-O

Conf. Hall Mare Section 1

17:30 18:00

21 May

MON

THE DESIGN SOCIETY WELCOME ADDRESS

Panos Y. Papalambros
President of the Design Society
(University of Michigan, United States of America)

A WORD BEFORE

Dorian Marjanović
(Unversity of Zagreb, Croatia)

A NEW DESIGN VISION: COGNITIVE DRIVEN DESIGN

Alex Duffy
University of Strathclyde (United Kingdom)

Currently, both commercial and state-of-the-art Computer Aided Design (CAD) systems are limited in how intuitive and conducive they are to the engineering design process. They are continually advancing but in an incremental fashion and by adapting to established design processes. Professor Alex Duffy currently leads a multidisciplinary team of scientists and engineers from the University of Strathclyde, Ulster University, and University College London, adopting a radically different perspective on design. In this keynote, he will present a new vision for design creativity. Using brain imaging and cognitive psychology techniques, this vision seeks to open up possibilities for a new generation of design tools, surpassing the traditional CAD approach of mouse and keyboard interaction through a scientific understanding of the cognitive and neural processes underlying creative design activities.

Mapping the cognitive and neural basis of design is a complex, multi-faceted challenge that requires the integration of design, psychology, and neuroscience research. Professor Duffy will discuss state of the art methods for measuring cognitive and neural processing in design, and present findings from a recent functional magnetic resonance imaging (fMRI) study of creative ideation involving professional designers. He will outline the potential implications of the work for design research and practice, as well as key challenges for advancing cognitive design science.

BIOGRAPHICAL SKETCH

Alex Duffy is Professor of Systems Design and currently Head of Department of Design Manufacture and Engineering Management, at the University of Strathclyde. He was previously the Vice-Dean of Research in the Faculty of Engineering and a past Vice President and President of the Design Society, an international body encompassing all aspects and disciplines of design. He is the editor of the Journal of Engineering Design, an Associate Editor of Design Science, a Strategic Advisory Board member for the International Journal of Design Creativity and Innovation, and on the editorial boards of the journals of Artificial Intelligence in Engineering Design Analysis and Manufacture, the International Journal of Engineering Management and Economics, and Research in Engineering Design.


DESIGN
2018

● Mare SECTION 1 ● Mare SECTION 2 ● Mare SECTION 3 ● Mare SECTION 4 ● Dubrava SECTION 1 ● Dubrava SECTION 2

TUESDAY, MAY 22

8:00 – 8:15 REGISTRATION

8:15 – 10:00	D211	D212	D213	D214	D215	D216
	APPLICATIONS OF DESIGN METHODS	DESIGN CREATIVITY AND COGNITION STUDIES	DESCRIPTIVE AND EXPERIMENTAL RESEARCH APPROACHES	INFORMATION MANAGEMENT IN PRODUCT DEVELOPMENT	KNOWLEDGE BASED DESIGN SUPPORT TOOLS	SYSTEMS MODELLING

10:15 – 10:30 REFRESHMENT BREAK

10:45 – 12:15 D2-P PLENARY SESSION II

12:30 – 13:45 LUNCH

14:00 – 15:45	D231	D232	D233	D234	D235	D236
	PROCESSES IN DESIGN	CREATIVITY APPROACHES AND METHODS	COMPUTATIONAL APPROACHES TO DESIGN RESEARCH	ANALYSING COURSES AND METHODOLOGIES IN EDUCATION	APPLICATIONS OF DESIGN SUPPORT TOOLS	UNDERSTANDING HEALTH AND INCLUSION

16:00 – 16:15 REFRESHMENT BREAK

16:30 – 18:15	D241	D242	D243	D244	D245	D246
	SUPPORTING CREATIVITY IN DESIGN	INNOVATION ALLIANCES	DESIGN FOR ELDERLY AND USER CENTRED DESIGN	KNOWLEDGE MANAGEMENT IN DESIGN	DESIGNERS' IDENTITY, SKILLS AND MINDSET	SYSTEMATIC APPROACH TO AUTONOMOUS SYSTEMS

INVESTIGATING ON THE RE-USE OF CONCEPTUAL DESIGN REPRESENTATIONS

Cascini G., Fiorineschi L., Rotini F.
University of Florence, Italy

Systematic conceptual design approaches foresee the realization of abstract representations, according to their specific formalisms and rationales. Therefore, even if not explicitly conceived for this purpose, they implicitly allow to store information about the explored design space. Unfortunately, the effectiveness of the re-use of the recalled representation is unclear, especially if reused by designers not comprehensively learned about the original method. This paper shows an experimental investigation on this argument, where a sample of thirty-five MS engineering students is involved.

HOW TO DESIGN METHODS FOR APPLICATION - EMPIRICAL INSIGHTS FROM INDUSTRY

Guertler M. R.
University of Technology Sydney, Australia

Methods support designers in systematically developing new or improving products and processes. Despite their benefits, the use of methods in industry is still limited. Methods are often perceived as too abstract and not suitable by industry users. Research has tended to focus on the selection and application of methods. This paper proposes to extend the scope and include the design of methods themselves. Based on literature and empirical insights from research projects in industry, it derives a first set of requirements for designing new methods and increasing their usability and acceptance.

DEVELOPMENT OF A BIOINSPIRED APPROACH FOR THE DESIGN OF KINEMATIC CHAINS

Bartz M., Gößling R., Remus R., Bender B.
Ruhr-Universität Bochum, Germany

In recent years, bioinspired lightweight design has become a high priority in technology. An important source is the musculoskeletal system, which achieves a light construction by the interplay of different effects, which have the aim of minimizing bending stresses. In this paper the potentials for technology and the challenges for a transfer are discussed using kinematic chains as an example. An iterative approach is presented, which represents a solution to integrate the simultaneous optimization process of the musculoskeletal system into the technical product development process.

AN EXPLORATORY STUDY ON THE USE OF NEW DESIGN METHODS IN DESIGN CONSULTANCIES

Filippi A., Suarez Madrigal A., Eisenbart B., Gericke K.
Delft University of Technology, The Netherlands

This paper explores the uptake of design methods in design consultancies. Our results show that new methods are primarily used in the initial phases of the design process for specific problems. The main motive for doing so is to enhance creativity and understanding of the user. Many participants modify methods to fit specific needs or develop own methods. These findings highlight the need to improve the link between industry and academia in order to increase method awareness and use. Potential ways to improve this include better descriptions of methods and the benefits provided.

ROLE OF BIOLOGISTS IN BIOMIMETIC DESIGN PROCESSES: PRELIMINARY RESULTS

Graeff E., Maranzana N., Aoussat A.
Arts et Métiers ParisTech, France

Although biomimetic design practice becomes more and more common, some methodological aspects are still under development. More especially, this article aims at dealing with biologist's role and integration during the design process and its construction. After an introduction of the context and the protocol of our experiment on a case study about the insulation of containers housing, our preliminary results will be presented. Through the use of the biomimetic tool AskNature, we will wonder about the differences between the approach of biomimetic processes by students in biology or engineering.

WHEN LIFECYCLE COST ANALYSIS ENABLES STRATEGIC DESIGN CONSIDERATIONS

Altavilla S., Montagna F.
Politecnico di Torino, Italy

The literature on cost-estimation is full of examples that methodologically explain the construction of models. In this paper, we showed how such methods when correctly implemented represent a source of structured information for in-depth design decisions. We investigated the impact of variety proliferation overall lifecycle costs, assessing differences in product architectures using a cluster analysis. The evidence collected serves as validation of a cost model approach and provides a decision-making support for choosing between platform solutions against a knowledge of costs consequences.

MEASUREMENT OF BRAIN ACTIVITIES OF IDEA GENERATION (SKETCH)

Kato T., Okada H., Izu Y.
Keio University, Japan

This study analyzed the correspondence between the brain activities and some types of the idea generation by sketching. To compare the types on the basis of the brain activities, this study employed a NIRS apparatus which measures the change in concentration of oxygenated hemoglobin in cerebral blood flow and detects the activated areas in the prefrontal cortex. The result suggests the idea generation with the sketch based on long term memory activates the prefrontal cortex more than that based on a previous sketch.

COMPREHENDING THE DESIGNER'S SKETCH & IMPLICATIONS FOR COMMUNICATION

Self J. A.
Ulsan National Institute of Science and Technology, Republic of Korea

Communication between stakeholders during design ideation is important due to growing product complexity. We examine how sketches implicate stakeholder response. Eye-tracking data revealed designers attended to visual representation, while managers focused on diagrammatic elements. Cognitive workload suggested designers adopt a holistic frame-of-reference in comprehending design through sketches. Managers and engineers understand sketches as concrete solutions, leading to increased cognitive workload. Implication for communicated through sketch representation are finally discussed.

THE BEHAVIOURAL DESIGN SOLUTION SPACE: EXAMINING THE DISTRIBUTION OF IDEAS GENERATED BY EXPERT BEHAVIOURAL DESIGNERS

Bay Brix Nielsen C. K. E., Cash P., Daalhuizen J.
Technical University of Denmark, Denmark

Understanding how human behaviour can be influenced through design is an increasingly important topic in research and industry. Despite distinct theoretical recommendations for behavioural design ideation there is little research examining the solution space. Thus, this research provides an in depth examination of the distribution of intervention ideas generated by expert behavioural designers in five brainstorming sessions. The findings show a distribution of ideas often at odds with theoretical expectations. As such, this study contributes important implications for research and practice.

INSIGHTS INTO DESIGN CONCEPT SIMILARITY JUDGEMENTS

REVIEWERS FAVOURITE

McTeague C. P., Duffy A., Hay L., Vuletic T., Campbell G., Choo P. L., Grealy M.
University of Strathclyde, United Kingdom

Similarity has been shown to influence various measures of outcome creativity in combinatorial design tasks, but the role of similarity during the combination of design concepts is unknown. As an initial step towards understanding design concept similarity we review prominent models of similarity in psychology and carry out an exploratory experimental investigation of design concept similarity judgements. Results suggest that as per non-design stimuli, similarity may be the result of structural alignment processing and similarity ratings may be related to the degree of common features.

EXPLORATION OF COGNITIVE DESIGN BEHAVIOUR DURING DESIGN CRITIQUES

Milovanovic J., Gero J. S.
UMR AUU-CRENAU, France

The design studio pedagogy fosters a learning by designing model for students to develop designing skills. A methodology, based on protocol analysis and the FBS framework, is proposed to measure actors' design cognitive behavior and interaction throughout design critiques. Those metric measurements provide a quantitative understanding of their design activity during the critiques. A case study of four architectural critiques of a team of two students, across a semester, illustrates our methodology. The results point out differences in each actor's behavior, and their evolution across sessions.

ANALYZING RID METHODOLOGY THROUGH THE LENS OF INNOVATIVE ABDUCTION

Lamé G., Yannou B., Cluzel F.
CentraleSupélec, France

The literature reports that abduction is inherent to design reasoning. The Radical Innovation Design methodology is analyzed using the lens of Kroll and Koskela's two-step innovative abduction. In the first phase (Problem Setting), the Knowledge Design process follows a two-step selective abduction and the Problem Design process comprises abduction followed by deduction. This illustrates the specific reasoning employed when identifying the right problem on which to innovate. In the second phase (Problem Solving), the reasoning follows two-step innovative abduction.

DESIGN METHODOLOGY: WHERE DO YOU GO?

Badke-Schaub P., Voute E.
Delft University of Technology, The Netherlands

Currently society undergoes disruptive changes so that the pressure on the designer in terms of MORE/BETTER/FASTER seems to be much higher than the centuries before. This contribution aims to initiate a discussion on how to gain a better understanding of what kind of design methodology should be offered to the designer to make him answer to these challenges. Especially the statement is made that there are so many empirical results about design behaviour which are not used - but would be useful to be implemented in design methodology - instead, we always start from the scratch again.

A PRODUCT SUCCESS SCALE FOR SUPPORTING RESEARCH IN ENGINEERING DESIGN

Maccioni L., Borgianni Y.
Free University of Bozen-Bolzano, Italy

Although product design targets success, the achievement of success is rarely verified or insightfully explored because of difficulties in measuring this term. The present paper addresses design research by proposing a procedure to extrapolate success of products by means of the vast knowledge made available by the scientific literature and the Internet at large. The final achievements are constituted by an algorithm to perform information search about product success and a success scale to be used as an ordinal variable in a posteriori studies involving large numbers of products.

UNCOVERING DESIGN TOPICS BY VISUALIZING AND INTERPRETING KEYWORD DATA

Lei N., Faust O., Rosen D. W., Sherkat N.
Sheffield Hallam University, United Kingdom

This paper presents a bibliometric keyword analysis for the international DESIGN conference. We combined related keywords to form DESIGN topics. After that, we visualized the connections between the topics. Our analysis shows that the web of science database does not contain the DESIGN 2012-14 proceedings. That is relevant for the conference organizers, because content visibility is important. The topic visualization benefits both contributors to and organizers of the international DESIGN conference, because it shows trending topics and it indicates areas with room for improvement.

LIVE-LABS AS REAL-WORLD VALIDATION ENVIRONMENTS FOR DESIGN METHODS

Albers A., Walter B., Wilmsen M., Bursac N.
Karlsruhe Institute of Technology, Germany

Laboratory studies and field studies make a major contribution to the validation of new design processes, methods and tools, but are confronted with limited transferability of validation results to corporate practice. In contrast, Live-Labs are validation environments that promise a high degree of external validity, but have not yet been able to systematically justify it. This article presents a procedure model and a categorisation framework that allows existing Live-Labs to be designed in such a way that the transferability of the results of Live-Lab studies to companies can be optimised.

LIVING LABS AS A METHODOLOGY FOR SERVICE DESIGN - ANALYSIS BASED ON CASES AND DISCUSSION FROM THE VIEWPOINT OF SYSTEMS APPROACH

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Recently “Living Labs (LLs)” have attracted attentions as a method which aims at actively involving citizens for longer term to co-create service. Despite its increased interests, there is no unified definition of what LLs are. In order to develop a service successfully by utilizing this approach, it is of critical importance to understand the methodology in depth, and then localize them to fit to conditions in practice. In this paper, we investigated preceding LL cases in Japan and Scandinavia, depict the methodological features of LL, and review them from the systems approach perspective.

A QUALITATIVE INVENTORY OF USER INTEGRATION METHODS AND THEIR USAGE IN PRODUCT DEVELOPMENT RESEARCH AND PRACTICE

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In the field of human-centred design, user experience (UX) is one of the key factors that make similar products differ in popularity among users. The more holistic one can depict UX, the more specific one can derive product requirements. One promising way to achieve good UX is user integration into product development. However, this is an open concept. By analysing recent research papers, this exploratory study gives some clues to understand the reality of UX research and practice in product development. It turns out that user integration is not necessarily the same as integrating users.

INFORMATION FEEDBACK IN PRODUCT DEVELOPMENT: ANALYSING PRACTICAL CASES

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BIBA - Bremer Institut für Produktion und Logistik GmbH, Germany

Information feedback is an important driver of iteration in development projects. Feedback emerges for various reasons and from different information sources and channels. This paper seeks to support the systematic exploration of information feedback in development. It identifies characteristics of iterative situations through literature analysis and proposes a classification schema. The identified characteristics relate to projects, processes, products and product life cycle management. Future research topics are the detailed analysis of information sources, channels and information quality.

A NEW MODEL FOR CAPTURING DESIGN INFORMATION WITH AN AIM TO AID CHANGE PROPAGATION ASSESSMENT AND SUBSEQUENT REDESIGN

Brahma A., Wynn D. C.
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A new model is developed to investigate the causes of change propagation and guide the redesign process. The model offers a micro-level perspective on the mechanisms through which changes propagate or are absorbed. Extending the Information Structure Framework (ISF) reported by Ahmad et al. (2013), the model uses a multi-domain approach combined with a reformulated detail design process layer. It is illustrated through a desk-based case study of routine mechanical design. Advantages and limitations are discussed along with possibilities for further work.

GRAPH DATABASES FOR EXPLOITING USE PHASE DATA IN PRODUCT-SERVICE-SYSTEM DEVELOPMENT: A METHODOLOGY TO SUPPORT IMPLEMENTATION

Hollauer C., Shalumov B., Wilberg J., Omer M.
Technical University of Munich, Germany

Factors such as cost reductions in sensors lead to an increase of use-related data of Product-Service-Systems (PSS) users. PSS use data is a challenge as well as competitive advantage, enabling companies to better understand customers. Graph databases can be used to amange and analyze highly connected data. However, their implementation is a complex process, with low dissemination and few documented experiences for PSS companies. Consequently, we present a methodology supporting their implementation, which has been evaluated in a qualitative interview study as well as an industrial case study.

A NORMATIVE APPROACH FOR IDENTIFYING DECISION PROPAGATION PATHS IN COMPLEX SYSTEM

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University of Cambridge, United Kingdom

In real-world, making the right decision at the right time is very challenging. Additional complexity is related to the fact that, a change in one part may propagate across multiple subsystems and therefore, it is very difficult to predict how decisions behave. To respond this need, this paper contributes a conceptual framework to present a novel perspective on modelling decisions, so-called Decision Propagation System – DPS. It is an intelligent approach to reflect how organisational dynamics and information dependencies can affect decision propagations, thus helping make Smart decisions.

EXECUTABLE COST-SENSITIVE PRODUCT DEVELOPMENT OF A SELF-BALANCING TWO-WHEEL SCOOTER WITH GRAPH-BASED DESIGN LANGUAGES

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This paper deals with the integration of cost considerations into the technological design process of a product. As an example serves a self-balancing two-wheel scooter. The design process of that scooter is expanded with aspects from the cost-domain so that the design can be enhanced with economic knowledge. Methods of modern software engineering are applied onto classical engineering. For this purpose so called graph-based design languages are used. Through the representation as an UML-model, the realization of interfaces to antecedent and subsequent systems can be eased.

THE DESCRIPTIONS AND ABSTRACTIONS OF A MULTIDISCIPLINARY SYSTEM: FROM GOALS TO STRUCTURE VIA COUPLING FRAMEWORK

Uddin A.
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In engineering design, there is a need for consensus to be developed on full descriptions and abstractions of a multidisciplinary system. The system's descriptions belong to its different abstractions. This paper introduces a structured coupling matrix (CM) framework that aids the practitioners to model and couple the system's descriptions from goals to structure via functions at its abstractions from black-box to white-box. The CM framework is built upon limitations in existing frameworks and is illustrated with an example. It provides structured guidelines for system analysis and design.

AN INITIAL PROTOTYPE OF A TOOL FOR DEFINING VALUE PROPOSITION IN THE PRODUCT-SERVICE SYSTEM (PSS) DESIGN

Fernandes S. d. C., Rosa M., Queiroz C., Rozenfeld H.
University of São Paulo, Brazil

The design of product-service systems (PSS) requires a complete reformulation of the company's business model. A central aspect of business models is the value proposition, which is commonly created with tools such as the Value Proposition Canvas (VPC). However, problems were identified during the application of the VPC in the context of a PSS design. This work aims to create and test an initial prototype of a value proposition tool for PSS. Both tools were submitted to controlled experiments, providing an evaluation of the VPC's problems and insights for further development of the new tool.

DEVELOPMENT OF A NEW SIMULATION-BASED PLATFORM FOR PRODUCT AND SERVICE CUSTOMER CO-DESIGN USING AI

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This paper describes our new simulation-based platform for the customer co-design of products and service. This platform is based on the concept model that builds integrated digital models from the real world and analyzes from the simulation results. It explores and maximizes customer value using machine learning algorithms. The platform consists of a workflow constructor and a GUI builder with reusable nodes and templates. An example is given in the oil & gas filed. The customer co-design GUI is built in 5 minutes and can be used to assess the business feasibility of the oil & gas devices.

CONCEPTION OF A CROWDSOURCING TOOL TO SUPPORT INDUSTRIAL DESIGN DECISIONS

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Otto von Guericke University Magdeburg, Germany

Industrial Design is still seen as a "soft" factor without big influence within the most product development decisions, because of the low measurability (Kohler, 2003). Therefore it is necessary to develop a tool which enables Industrial Designers to make design preferences empirically measurable. This paper will provide first insights to relevant theories, perspectives and a comprehensive methodology overview for implicit and explicit measuring methods, which will be implemented in future steps in the emerging crowdsourcing approach to support Industrial Design decisions.

GOAL SETTING IN SUSTAINABLE BUILDING RENOVATION – EARLY PROTOTYPE DESIGN AND TESTING OF A NEW DECISION SUPPORT TOOL

Gade A. N., Jensen R. L., Larsen T. S., Nissen S. B.
University College of Northern Denmark, Denmark

This paper presents an early prototype of a new value-based decision support tool that can support building owners in setting goals for sustainability in renovation projects. The prototype includes the main functionalities of choosing and weighting criteria. Five users tested the prototype using think-aloud testing. The results showed that providing a pre-defined set of criteria for the goal setting made the users feel locked in their choices, and challenged in weighting criteria using the analytical hierarchy process. The results have informed the further design iterations of the prototype.

ON KNOWLEDGE MATURITY AND BIASED NATURE OF STAGED DECISION MAKING IN A HIGH CONSEQUENCE INDUSTRY

Svensson M., Bertoni A., Lanander M.
Blekinge Institute of Technology, Sweden

This paper explores and problematizes decision-making in a high-consequence industry which is characterized by the stage-gate process. We showcase that decision-makers do not differentiate between the types of knowledge used for modelling decisions and calculation of risks. This makes them susceptible to incorporating cognitive distortions—biases—into the stage-gate process. We conclude by amending the risk for certain kinds of biases with a knowledge maturity framework in order to outline conditions for pragmatic decision making.

A METAHEURISTIC FOR SOLUTION SPACE MODELLING

REVIEWERS FAVOURITE

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CentraleSupélec, France

To confront current market changes, Set-Based Design (SBD) should help carmakers improve time, cost and quality in early design phase. In a development process using ever more computer experiments, building predictive models of the solution space is key to implementing SBD. The present article proposes a new algorithm to build high quality predictive metamodels efficiently and tests it on several benchmark problems. Promising results are obtained. We believe such models could be used for several purpose in design: implementing SBD, optimisation and generating feasible concepts, among others.

SYSML BEHAVIOUR MODELS FOR DESCRIPTION OF VIRTUAL REALITY ENVIRONMENTS FOR EARLY EVALUATION OF A PRODUCT

Mahboob A., Husung S., Weber C., Liebal A., Krömker H.
Technical University of Ilmenau, Germany

Virtual Reality (VR) can help designers to realise later life phase situations of a product in presence of a specific actor (or actors) in a specific environment by building product use-cases in VR, thus facilitating an early evaluation of a design. In this paper, we present a model-based approach that uses SysML behaviour models to describe and control VR environments. The behaviour modelling process with SysML and the simulation results obtained using these behaviour models are discussed. An overview over simulation processes is provided by constructing an example product use-case in VR.

SYNTHESIS OF FUNCTIONAL MODELS FROM USE CASES USING THE SYSTEM STATE FLOW DIAGRAM: A NESTED SYSTEMS APPROACH

Campean F., Yildirim U., Henshall E.
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The research presented in this paper addresses the challenge of developing functional models for complex systems that have multiple modes of operation or use cases. An industrial case study of an electric vehicle is used to illustrate the proposed methodology, which is based on a systematic modelling of functions through nested systems using the system state flow diagram (SSFD) method. The paper discusses the use of SSFD parameter based state definition to identify physical and logical conditions for joining function models, and the use of heuristics to construct complex function models.

MATURITY MODEL-BASED PLANNING OF CYBER-PHYSICAL SYSTEMS IN THE MACHINERY AND PLANT ENGINEERING INDUSTRY

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Cyber-physical systems (CPS) are networked, intelligent technical systems that interact with the physical and digital world alike. Companies now increasingly face the challenge of rapidly and consistently exploiting the emerging opportunities of this development. A prerequisite for this is a clear picture of the current position of products, the target position and first concrete steps towards the target projection. The contribution at hand shows an approach for the maturity model-based planning of cyber-physical systems in the machinery and plant engineering industry.

DETAILED CONCEPT OF THE SYSML LIGHTWEIGHT VISUALIZATION IN PDM SYSTEMS

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Cyber-Physical Systems (CPS) are prime examples for the ongoing trend of increasing product complexity within technical systems. Abstract modelling languages like the Systems Modelling Language (SysML) provide a solid basis to handle cross-domain complexity, but have weaknesses concerning data exchange. The paper presents a detailed concept of a lightweight visualization approach of SysML models in Product Data Management Systems. This approach allows SysML model visualization without using specific authoring tools, resulting in a more flexible model data exchange between development partners.

IMPLEMENTATION OF SYSTEMS MODELING LANGUAGE (SYSML) IN CONSIDERATION OF THE CONSENS APPROACH

Salehi V., Florian G., Taha J.
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The following paper, which is based on the design research methodology (DRM) according to Blessing and Chakrabarti, will first make a literature survey related to MBSE approaches in general. Based on the literature survey this paper will demonstrate the combination of SysML and MBSE in an industrial context by means of Cameo Systems as a MBSE-Modeler. Especially at the use of modeling tools, like Cameo Systems Modeler, users often have to create a completely new model draft.

EMPIRICAL STUDY OF REQUIREMENTS ENGINEERING IN CROSS DOMAIN DEVELOPMENT

Nilsson S., Buffoni L., Sandahl K., Johansson H., Tahir Sheikh B.
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Shortened time-to-market cycles and increasingly complex systems are just some of the challenges faced by industry. The requirement engineering process needs to adapt to these challenges in order to guarantee that the end product fulfils the customer expectations as well as the necessary safety norms. The goal of this paper is to investigate the way engineers work in practice with the requirement engeneering processes at different stages of the development, with a particular focus on the use of requirements in cross domain development and to compare this to the existing theory in the domain.

DESIGN RESEARCH IN, WITH AND FOR COMPANIES: HOW TO JOINTLY SHAPE INNOVATIONS TO CREATE BENEFIT FOR SOCIETY

Albert Albers
Karlsruhe Institute of Technology (Germany)

Mobility, urbanisation and globalisation, but also world food and health. All major issues of the future have one thing in common: Civil society is increasingly demanding technical solutions to solve its problems, rather than social or moral ones. Increased mobility needs, for example, cannot be met by appeals to reduce mobility demands, but only with technically intelligent and ecologically sustainable mobility concepts. The consequence of this is that on the one hand, the importance and influence of engineers and on the other hand, their social responsibility has grown and will continue to grow.

Against this backdrop, the orientation and self-image of the design research community are also changing more and more: In many cases, the collaboration between design researchers, companies and civil society is intensifying. This development is very welcome. However, there is still great untapped potential for cooperation, which is necessary, because only this way real-world problems can be solved.

BIOGRAPHICAL SKETCH

Professor Albert Albers, head of the IPEK - Institute of Product Engineering at the Karlsruhe Institute of Technology (KIT), has been researching processes, methods and tools of product generation engineering for more than 20 years. As part of the keynote, he evaluates current developments in design research in a critical and constructive manner. He points out that excellent research, economic benefits and social added value are not mutually exclusive but require each other. Using current case studies, he shows ways in which the collaboration between design research, companies and civil society can be put into practice in concrete terms so that everyone involved can work together successfully.

FROM TECHNICAL DRAWING TO VIRTUAL PRODUCT DEVELOPMENT: HOW TO REORGANIZE THE PROCESSES ACCORDING TO THE AVAILABLE TECHNOLOGIES

Mauro Faccin
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Starting from the technical drawings of Leonardo da Vinci, which were the direct expression of the design intents, we arrive at what, today, we call virtual twin, which is the exact virtual replication of a physical object including the behaviours. After many years, the purpose of designing is the same: communicating the aesthetical, functional, economic, and socio-political dimensions of an idea. The major changes have been developed regarding technologies that support the design process. Actually, the acceleration and continuous emergence of innovative technologies have changed and still are influencing the way of doing design.

However, technologies are just tools, tools that have been developed for supporting specific activities and improving design performances. Nowadays many different technologies are available thanks to visionary people and forerunners that based on their needs dared to innovate their way of doing. The multi-body simulation, the connected PLM, the virtual twin, AR/VR they are just examples of how the design processes are evolving beyond mere modelling products. The main question now is no longer about the design accuracy, but how technologies are adopted. The challenge now is to rethink completely the processes according to the available technologies proposing new design models that can leverage the digital continuity in the virtual product development.

BIOGRAPHICAL SKETCH

Mauro Faccin is the EUROMED Director, 3DS Value Solution Business Development Executive at Dassault Systemes. His career started in 1979 as Mechanical Designer using the first CAD Workstation. He covered different position in particular as Designer, Business Process analyst, IT architect, Project Manager, Service Director and finally Business Development Director. He has over 30 years of experience in requirements analysis and IT tools definition to support the Product Development Process from CAD to Digital Manufacturing. His main expertise is Digital Manufacturing where he defines different solutions to manage the Production Processes and new work methodologies to satisfy customers' requirements. He managed many PLM systems implementation in different sectors including Automotive, Aerospace, Industry Equipment, Heavy transportation, Shipbuilding, Consumer Packaged Goods and Consumer Goods.

MAKING PARTNERSHIPS WORK: INTEGRATIVE OPEN SYSTEM DESIGN FOR A NEW GENERATION OF COMPLEX INFRASTRUCTURE SCHEMES

Witz P., Oehmen J.
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With the financial crisis having casted doubt on many standard business models a search for adaptations began. Infrastructure investments around the world have produced rather mixed results. Previous research identified the main success/failure factors. At the same time, stakeholders' perception of risks has evolved having unforeseen implications. Our findings indicate that in order to bring risks under control and to secure a wider value creation, a new open system design needs to be applied in the process of planning, funding and managing complex transport infrastructure schemes.

AUGMENTED DSM SEQUENCING TO SUPPORT PRODUCT DEVELOPMENT PLANNING

Göhlich D., Hildebrand S., Schellert D. D.
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The Sequencing of product DSMs has been proposed for the identification of interdependencies and for product development planning (PDP) including components and subsystems. But, due to little exploitable outcome, this approach is hardly used in practice. A new method using an augmented DSM Sequencing algorithm with a gradient based optimizer is presented. The method considers Product Architecture Drivers to derive a suggestion for an efficient planning process and is integrated in a DSM software. Furthermore, it is validated using a combustion engine as a typical engineering product.

A-POSTERIORI NOVELTY ASSESSMENTS FOR SEQUENTIAL DESIGN SESSIONS

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Among the various novelty metrics available in literature, those developed by Shah and Vargas-Hernandez are frequently used for academic purposes. More precisely, their "a-posteriori" version is often used for assessing ideation effectiveness of idea generation methods. We observed that when in presence of sequential idea generation sessions of the same task, the application of the recalled metric could lead to misleading results. In this paper, we argue about this problem, and we also provide useful suggestions for a correct "a-posteriori" assessment for sequential idea generation sessions.

EVALUATION OF TAF AGILE FRAMEWORK BASED ON THE DEVELOPMENT OF AN INNOVATIVE EMERGENCY WEARABLE FOR SENIORS

Spreiter L., Böhmer A. I., Lindemann U.
Technical University of Munich, Germany

Due to shortened technology lifecycles and changing customer needs, companies are forced to get their products to the market quicker. To overcome these challenges, agile product development methods have been developed. After being widely prevailed in software development, agile methods find their way into hardware development. The TAF Agile Framework provides a procedural model specifically for developing mechatronic products. In this paper TAF is used for the development of an innovative emergency wearable for seniors and is evaluated using an adaption of the 4-Dimensional Analytical Tool.

RE-DESIGN AND RE-MANUFACTURING OF DISCONTINUED SPARE PARTS IMPLEMENTING ADDITIVE MANUFACTURING IN THE MILITARY FIELD

Montero J., Paetzold K., Bleckmann M., Holtmannspoetter J.
Bundeswehr University Munich, Germany

In military systems, usually the repair of deployed equipment can become impossible due to the lack of a spare, either due to logistical problems or because said component is no longer in production. Thus, arises the need to manufacture the spare in the place where the equipment needs it, this gives an interesting opportunity to implement the techniques of additive manufacturing in the field. In this article a case study of a required spare of the German Federal Armed Forces is presented, with a methodology to deal with the data in the integrated process of design and manufacturing.

INTEGRATING SUSTAINABILITY IN PRODUCT REQUIREMENTS

REVIEWERS FAVOURITE

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Trade-offs between sustainability criteria and engineering design variables can lead to sub-optimisations and costly short-term priorities. This study explores how sustainability requirements can be identified and integrated in product requirements to guide strategic and tactical decisions in product development including sustainability perspectives. Literature review and action research resulted in a proposed systematic approach that: define sustainability criteria and indicators; use correlation analysis with QFD; and adds identified specific sustainability requirements to requirement list.

DESIGN PRINCIPLES FOR CREATIVE SPACES

Thoring K., Mueller R. M., Desmet P., Badke-Schaub P.
Delft University of Technology, The Netherlands

Work and study environments that facilitate creative design processes—so called creative spaces—have gained an increased interest in the past years. This paper contributes to this emerging field by providing a set of guidelines for creating such environments. We developed a set of 49 abstracted design principles (patterns) that are empirically developed, embedded in the broader system of creative spaces, and supplemented by examples. The suggested principles provide concrete, yet adaptable, guidelines for designers, educators, and spatial planners who want to redesign their creative environments.

RE-USE OF ENGINEERING DESIGN RATIONALE IN FINNISH SME PROJECT BASED INDUSTRY

Ellman A., Paronen J., Juuti T. S., Tiainen T.
Tampere University of Technology, Finland

This study presents views on barriers of re-use of engineering design rationale. The research data was gathered by interviewing 29 persons who work in 19 different Finnish SME engineering project based companies. The topic was studied on three main levels: due to actions of business management, due to actions of project team and due to individuals own action. From this perspective, six categories of barriers of tacit knowledge re-use were found: Time management, Tools and documentation practices, Working methods, Validity of information, Well-being at work and Distinction in competence.

A COMPUTATIONAL APPROACH FOR COMBINATIONAL CREATIVITY IN DESIGN

Chen L., Wang P., Shi F., Han J., Childs P. R. N.
Imperial College London, United Kingdom

Creativity is essential for innovative design. As an important topic in computational creativity research, how to model and generate creativity has sparked much interest. In this paper, combinational creativity is explored to provide potential semantic solutions and to generate visually synthesized solutions based on a given combination. This is achieved by a data-driven module and an artificial intelligence module respectively, which have been implemented as a creativity tool used in a design case study to demonstrate their effectiveness for assisting combinational creativity design.

STEERING A SHIP - INVESTIGATING AFFECTIVE STATE AND WORKLOAD IN SHIP SIMULATIONS

Dybvik H., Wulvik A., Steinert M.
Norwegian University of Science and Technology, Norway

We present an experiment investigating concepts of affective state and workload in a large ship manoeuvring context. It is run on a consumer ship simulator software where student participants (N=31) perform two ecologically valid scenarios: sailing on open sea and in a harbour. Results from surveys show highly significant changes in terms of both affect and workload between the scenarios. Thus, one should consider varying affects and workloads from users in varying contexts, consequently demanding new design paradigms for product development, such as dynamically adaptive interfaces.

IDENTIFYING DISRUPTIVE TECHNOLOGIES: HORIZON SCANNING IN THE EARLY STAGES OF DESIGN

Ernstsen S. K., Thuesen C., Larsen L. R., Maier A.
Technical University of Denmark, Denmark

Technology development is accelerating, driving disruption. Design is seen as key differentiator in creating innovative offerings but few design methods consider future technologies explicitly. In this article, we explore how a foresight method, namely horizon scanning, may be applied in a design context to anticipate disruption of construction. By means of a 3-step horizon scan, we identify 133 potentially disruptive technologies from across industries. We find that when preparing for disruption, design may benefit from the future-oriented and technology-focused features of horizon scanning.

GETTING INSPIRATION OR CREATING INSPIRATION? THE ROLE OF KNOWLEDGE STRUCTURES IN IDEA GENERATION

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Earlybird, United States of America

Every designer - experienced or not - aspires to live Aha! moments, but how to favor these moments, where original ideas emerge, is not always obvious. While design methods often focus on the concept space, this article highlights the role of knowledge structuration in idea generation. By analyzing two cases of idea generation sessions with C-K theory, we show that generativity relies on the designers' ability to reorganize their own knowledge basis and thus create new design rules. "Incompatible knowledge" especially helps fostering such restructuration, and therefore, provoking inspiration.

THE WORLD IS COMPLEX THEREFORE OUR RESEARCH IS NEEDED - USING DATA MINING FOR LITERATURE REVIEWS

Albers A., Bursac N., Butenko V., Marthaler F., Zhang Q.
Karlsruhe Institute of Technology, Germany

Using current data-mining technologies, we analyzed 3712 papers submitted from 2002-2017 at the International Conference on Engineering Design and International Design Conference. We have explored various research questions and propose an approach for analyzing a great number of papers on product engineering and use them for respective research. Here, we show examples of how data mining can be used to support the user in carrying out literature research. However, one is particularly clear: The user must always critically question the results with his intelligence in order to derive findings.

COMPARATIVE ANALYSIS OF RESEARCH FOR INDUSTRIAL DESIGN AND ENGINEERING DESIGN BASED ON MULTISPACE DESIGN MODEL

Sakae Y., Mukai S., Sato K., Matsuoka Y.
Keio University, Japan

This research conducts comparative analysis of domestic and international articles for industrial design and engineering design domains to clarify the characteristics of the two design domains, as well as to derive the future issues for design integration. Various articles from the domestic and international societies were extracted and were evaluated from the viewpoint of multispace design model. In addition, the future issues for facilitating the design integration between industrial designers and engineering designers were investigated.

USE OF ANALOGY IN DESIGN TEAMS: STEPS TOWARDS A COMPUTATIONAL MODEL AND CONCEPTUAL INSIGHTS

Singh V., Casakin H.
Aalto University, Finland

This paper presents a computational framework to study the effects of the use of analogy in design teams on team cohesion and team collaboration. The paper also reports on the new conceptual insights and lessons learnt while developing the model. The lessons learnt are particularly useful, because the use of computational models to study social aspects of team work in design research is still a fairly recent development, and the challenges and benefits in the process of formalizing abstract concepts into computational details are rarely discussed in the literature.

REAL-TIME CODING METHOD FOR CAPTURE OF ARTEFACT-CENTRIC INTERACTIONS IN CO-CREATIVE DESIGN SESSIONS

REVIEWERS FAVOURITE

Ben Guefrache F., Masclet C., Prudhomme G., Cascini G., O'Hare J. A.
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This paper proposes a method to speed up the quantitative description of interaction occurrences during co-creative design sessions. Protocol analysis is traditionally used for such studies but it requires capturing video and cumbersome post session analyzing – making it too time consuming for analyzing a large number of sessions. We developed a new 'on the fly' method based on direct observation and compared the results obtained by this method to those obtained with traditional post-session coding method. Results were found to be very similar, whilst analysis time was significantly reduced.

NATURAL AND INTUITIVE GESTURE INTERACTION FOR 3D OBJECT MANIPULATION IN CONCEPTUAL DESIGN

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Gesture interaction with three-dimensional (3D) representations is increasingly explored, however there is little research present on the nature of the gestures used. A study was conducted in order to explore gestures designers perform naturally and intuitively while interacting with 3D objects during conceptual design. The findings demonstrate that different designers perform similar gestures for the same activities, and that their interaction with a 3D representation on a 2D screen is consistent with that which would be expected if a physical object were suspended in air in front of them.

FORMAL SYSTEM FOR THE EXPRESSION OF TARGET-ORIENTED DESIGN HEURISTICS

REVIEWERS FAVOURITE

Bonvoisin J., Buchert T., Stark R.
University of Bath, United Kingdom

In design, it is generally neither possible to list all solutions to a given problem nor to prove whether a solution is optimal. In this context, guidance can be provided to designers in the form of heuristics, i.e. solutions validated by practice which have proven to lead towards satisfactory solutions but which are not guaranteed to be optimal or perfect. This article contributes to the development of supportive design tools by providing a first formal system for the expression of target-oriented design heuristics and their collection in consistent sets.

REFLECTING ON THE EMPLOYABILITY ADEQUACY OF COMPETENCIES TAUGHT IN DESIGN HIGH EDUCATION SYSTEM

Almendra R. A., Falcão G. A.
Universidade de Lisboa, Portugal

This paper exposes a clear reflection about design competencies, addressing the ones academia finds necessary to be acquired by design students and the ones the market requires from designers. Besides the identification of those competencies an analysis is done considering the similarities and the differences between these two "worlds." Finally, the paper proposes a set of recommendations on how to work into education a set of competencies that better match the needs both students/designers and the markets.

ANALYSIS OF ECODESIGN AND SUSTAINABLE DESIGN IN HIGHER EDUCATION

Kattwinkel D., Song Y.-W., Bender B.
Ruhr-Universität Bochum, Germany

To respond to environmental sustainability challenges, many industries request that future engineers need to be sensitized and educated in the context of sustainability. This paper analyses if today's courses and degree programs meet these expectations by examining the curricula of 120 German and 50 international higher education institutions in the field of engineering. At first, it was investigated, if these institutions offer courses and degree programs covering Ecodesign and Sustainable Design, then it was analysed which specific topics and life cycle phases those courses address.

INSIGHTS ON HOW METACOGNITION INFLUENCES KNOWLEDGE APPLICATION IN PRODUCT DESIGN EDUCATION

Zhang Y., Bohemia E., McCardle J.
Loughborough University London, United Kingdom

An empirical study investigating creativity relevant factors that impact on knowledge application within the context of Product Design Education has been undertaken in the form of survey. The principal creativity relevant factor is identified as metacognition, which is related to creative thinking. Different kinds of knowledge applied in Product Design students' final year design projects (FYDPs) have been assembled and arranged into three categories. Possible ways of categorising knowledge according to the influences of metacognition are proposed that may inform design education practices.

FAIL EARLY, FAIL OFTEN: EXPLORING STANFORD'S ME310 COURSE AS A BASIS TO IMPROVE INNOVATION OUTPOST EFFICACY

Stenholm D., Moore D., Leifer L., Bergsjö D.
Chalmers University of Technology, Sweden

In this case study, we compare knowledge transfer between innovation teams in two contexts: an industry-sponsored graduate student capstone course to their corporate sponsors, and innovation outposts (IOs) to their parent companies. Through interviews with different stakeholders, we identified best practices for and challenges to innovation transfer, with personal relationships and tangible communication of ideas through prototypes being key to success. We call for more longitudinal studies to explore both the soft and hard benefits of innovation outposts.

THE CHALLENGES OF TEACHING SUSTAINABLE SYSTEM DESIGN

Pineda A. F. V., Jørgensen U.
Aalborg University, Denmark

We present the program Sustainable Design Engineering, where Science and Technology Studies theories are a core element among design and engineering approaches. Our main claim is that existing product centred and short-term oriented solution tools and knowledges are inadequate for system design in a sustainable transition perspective. To achieve this goal, design theory and practices need to be further improved to be able to tackle controversies and engage in proposing how to navigate conflicting matters of concern and partial systemic clashes with a long-term scope.

INTRODUCING SUSTAINABILITY IN ENGINEERING DESIGN EDUCATION: A CASE STUDY USING ANALYSIS OF IMPACTS DURING THE DESIGN FOR SUSTAINABILITY (AID-DS)

Esparragoza I. E., Mesa J. A., Maury H. E.
The Pennsylvania State University, United States of America

This work presents an academic initiative to introduce sustainability in engineering design education based on a case study approach that uses indicators to measure the sustainability performance of a product. The proposed approach uses strategic actions to redesign the product and to measure the sustainability performance under the new conditions. The performances of different alternatives resulting from the strategic interventions are compared to determine the most sustainable solution considering the effect of the strategic actions on the three pillars of sustainability.

MODEL-DRIVEN DECISION ARENA: AN AEROSPACE CASE STUDY

Bertoni M., Wall J., Bertoni A.
Blekinge Institute of Technology, Sweden

The concept of Decision Theatre (DT) is of great interest to leverage knowledge sharing in early stage design decision events. Yet, few contributions show how to configure a DT to support design space exploration and concept selection in cross-functional teams. This paper describes the development of a model-driven decision arena (MDDA) for aero-engine sub-system design. After presenting the descriptive study findings, it illustrates the overall logic of the MDDA environment and exemplifies its use in a case study related to the design of a turbine real structure (TRS) for commercial use.

PERCEIVED QUALITY OF THE SPLIT-LINE DESIGN AND QUALITY

REVIEWERS FAVOURITE

Striegel S. S., Zielinski D.
BMW Group, Germany

Increasing customer expectations towards high product quality and shorter product development cycles require new and standardized methods to asses a product's quality on an objective level. The split-line's design and its quality assessment correlates with the perceived quality of a product. The definitions of perceived quality are quite detailed. A lack of knowledge is the assessment process of perceived quality. Therefore, the assistance of Augmented Reality to acuire empirical data is specified. In conclusion, the overall assessment heat map is deducted and resulting standards are derived.

DEVELOPMENT OF A METHODOLOGY FOR ROBUST EVALUATION OF PERCEIVED QUALITY OF VEHICLE BODY PANEL GAPS

REVIEWERS FAVOURITE

Duraiswamy V., Campean F., Harris S., Munive-Hernandez J. E.
University of Bradford, United Kingdom

This paper presents research into perceived quality of vehicle body split lines / gaps. The survey based methodology combined direct attribute evaluation and choice experiments with multiple test cases, based on static images generated from parametric CAD virtual prototypes of a specific vehicle. The study systematically tested for perception without and with awareness and the Hawthorne bias, showing significant effects. Statistical analysis provided clear evidence of the user preference for smaller gap size, and as such supports target and tolerance setting for the body gap.

AN ASSESSMENT OF METHODS TO SUPPORT THE DESIGN OF FUTURE ROBUST MODULAR PRODUCT ARCHITECTURES

Greve E., Krause D.
Hamburg University of Technology, Germany

Modular product architectures enable not only a trade-off between the external variety demanded by the customer and the cost-causing internal variety, but also facilitate the ability to react on future requirement changes with less effort. This work concentrates on the investigation of design support, which address both objectives at once. For this purpose relevant criteria for a successful design of the so called future robust modular product architectures are derived and used to gain and evaluate the existing design methods. The results are used to describe the further research focus.

TRACEABILITY OF DECISIONS IN PRODUCT REALIZATION PROCESSES OF CUSTOM ENGINEERED PRODUCTS

Elgh F. P. W., Johansson J., Pookrkiany M., Stolt R., Raudberget D.
Jönköping University, Sweden

Custom engineered products require an engineer-to-order approach in development, quotation preparation and order processing. This work reports the result of a three-and-a-half-year project were the objective was to develop means for implementation and management of computer support for engineering design and production engineering of customized products. Efficient re-use is essential for success and decision is identified as the core concept to trace tasks executed, knowledge used, design rationale and artefacts developed throughout the product realization process.

SUPPORT OF SEARCHING FOR SOLUTIONS BY AUTOMATED STRUCTURAL OPTIMIZATION

Meyer A. W., Vajna S.
Otto von Guericke University Magdeburg, Germany

In the early stages of product development, engineers search for several different solutions to a design problem, which can then be further detailed and evaluated. This is due to little or fuzzy information about the product at this early phase of product development. The aim of this paper is to support this searching process with automated structural optimization. This is achieved by a combined approach of continuous topology optimization and stochastic algorithms. Computational results are presented and compared with results obtained by pure topology optimization.

DESIGNING MENTAL HEALTH DELIVERY SYSTEMS: DESCRIBING THE RELATIONSHIP BETWEEN SYSTEM COMPONENTS

Komashie A., Clarkson P. J.
University of Cambridge, United Kingdom

A challenging area of healthcare delivery in the UK is mental health. There is a growing need to improve outcomes of care. This research is part of an ongoing study that brings Design and Systems Engineering approaches into mental health service design. The focus is on how to understand and describe the architecture of delivery systems. Results from earlier stages of the work, looking at the identification of system components, have been reported previously. In this paper, we report the findings from empirical work on understanding the nature of the relationships between system components.

A KNOWLEDGE-BASED AND MULTI-USER PLATFORM FOR PRESCRIBING CUSTOM-MADE INSOLES

Brunzini A., Mandolini M., Germani M., Nester C. J., Williams A. E.
Università Politecnica delle Marche, Italy

This paper presents a knowledge-based method and relative multi-user web platform to prescribe Custom Made Insoles (CMI) involving the various stakeholders (patients/customers, practitioners, manufacturers and controllers) in an integrated approach that covers the entire process. The CMI prescription and design are carried out by using configuration rules, which combine foot parameters with insoles features. The platform also offers functionalities to collect and monitor the patients feedbacks, to control the clinician work and to obtain an electronic insole order used by manufactures.

POSITION PAPER: ON DESIGN RESEARCH ENGAGING WITH HEALTHCARE SYSTEMS

Lamé G.
University of Cambridge, United Kingdom

This position paper intends to trigger a debate on the engagement of the design research community with healthcare systems. We analyse the specificities of healthcare systems design and of healthcare organisations. We discuss the focus on evaluation and the evidence-based paradigm in healthcare, and argue that design research currently is ill-prepared to meet such expectations. Dedicated research attention in healthcare seems necessary to bridge this gap. It could enrich design research through multidisciplinary collaborations, and enable design to make a precious contribution to healthcare.

DESIGN FOR HEALTH: TOWARDS COLLABORATIVE CARE

Valentin-Hjorth J. F., Patou F., Syhler N., Dominguez H., Maier A.
Technical University of Denmark, Denmark

The design of novel healthcare delivery models better suited to address the burden of chronic diseases requires a thorough understanding of the foundational concepts of patient and healthcare provider collaboration. Reviewing the literature, we propose a taxonomy towards collaborative care: a generic term characterising healthcare delivery models that focus on the importance of patient-provider interactions, support safe patient participation in their own care, and redefine the balance of decision-power and accountability between patient and provider in health and care management.

CORPORATE REQUIREMENT CULTURE IN DEVELOPMENT OF A LARGE SCALE MEDICAL SYSTEM: A CASE STUDY

DelSpina B., Gilliam S., Summers J., Morkos B.
Florida Institute of Technology, United States of America

This case study explores requirements evolution of a medical device system. The study focuses on the analysis of requirements via interviews and document analysis. The mechanical, software, and systems engineering directors were interviewed regarding eight revisions to the design specifications (>1000 total design requirements). Findings suggest 1) change in requirements leadership, 2) market strategy, and 3) requirements writing may lead to requirements change. From analysis, a requirements culture emerged highlighting a need for greater understanding of company requirements cultures in situ.

PERSONAS FOR POLICY-MAKING AND HEALTHCARE DESIGN

Gonzalez de Heredia A., Goodman-Deane J., Waller S., Clarkson P. J., Justel D., Iriarte I., Hernández J.
Mondragon Unibertsitatea, Spain

Personas are widely used in design, and have recently spread to other fields such as policy-making and healthcare, where they help to convey the complexities of an ageing population. Policies and healthcare systems should rely on quantitative data to ensure the best impact on society, but no database exists that represents the aging population in a holistic and deep way, making it difficult to create effective personas. In this paper, we review the available surveys on the effects of aging, and propose three approaches that use these surveys to create better quantitative personas.

SUPPORTING SYSTEMATIC CONCEPTUAL DESIGN WITH TRIZ

Fiorineschi L., Frillici F. S., Rotini F.
University of Florence, Italy

Most acknowledged systematic conceptual design (SCD) methods are based on Functional Decomposition and Morphology (FDM). However, since some of the observed FDM flaws concern a non-comprehensive support to creativity, some scholars attempted to fill this gap by integrating FDM with the TRIZ body of knowledge. Unfortunately, non-negligible issues arise in these cases, hindering a comprehensive exploitation of TRIZ in SCD. This paper proposes an alternative way for exploiting the TRIZ potentialities within SCD, and three academic application examples are reported to show how the proposal works.

DESIGN EXPLORATION OF BIOMORPHIC FREEFORM UNIT CELLS FOR ADDITIVELY MANUFACTURED LATTICE STRUCTURES UNDER COMPRESSIVE LOADS

Thallemer A., Kostadinov A., Fam A., Teo A.
National University of Singapore, Singapore

Additive manufacturing methods facilitate the production of complex cellular materials. Commonly, their designs are based on primitive solids using linear struts without curvature continuous joints which results in notch stress. This study presents cellular material units with biomorphic features. The employed method allows us to design lattices with geometrical optimization and varying lattice morphology. The compression test results show that this method allows us to achieve a spectrum of mechanical properties for improving existing 3D printed lattice materials.

DEVELOPMENT OF A CATALOGUE SUPPORTING IDEA GENERATION FOR INTERNET OF THINGS USE CASES

Wilberg J., Lau K., Nützel T., Hollauer C., Omer M.
Technical University of Munich, Germany

Offering connected products that are part of the Internet of Things (IoT) enables new product functionalities and services, which creates additional revenues. Despite these new possibilities, engineering companies struggle to identify IoT use cases. Available publications mention many different use cases, but a structured overview is missing. This paper thus introduces a structured catalogue with 245 use cases. The catalogue provides a starting point to derive use cases based on analogy building. Initial case studies indicate that the catalogue assists in identifying new ideas for use cases.

TOP-DOWN DESIGN COMPUTING BASED ON NON-MANIFOLD POLYHEDRA FROM FUNCTION-TO-FORM MAPPING

Xu Z.-G., Zhu J.-F., Su K.-Y., Liu W.-M.
Shandong University, People's Republic of China

In this paper, our research works are reported from requirement management to functional design, from automatic function-to-form mapping to shape decomposition and synthesizing, from traditional AI technologies to geometric reasoning etc. It is concluded that, management of creative process is the key issue to develop creative computational design tools; and the modelling of design tools could facilitate the creative thought processes. Several packages of design tools have been developed to testify creativity in design practices, and the relationship between creativity and automation.

INVENTIVE PRODUCT DESIGN FOCUSING ON PHYSICAL CAUSAL RELATIONSHIPS CAUSING TRADE-OFFS BETWEEN FUNCTIONS

Oizumi K., Aoyama K.
The University of Tokyo, Japan

Development of fascinating products has always been aspired by product designers. Trade-offs are one important aspects to consider improving a product functionality. When significant trade-off is relieved by a sort of invention, functionality of a product reaches new frontier. This paper proposes a method to support ideation of inventive solution based on analysis of trade-offs and physical contradictions in a product, which are mapped to contradiction matrix of TRIZ. Validity of the proposed method was confirmed through a demonstration with Continuous Variable Transmission.

HOW TO SELECT APPROPRIATE STIMULATION MECHANISMS TO PERFORM AN ECO-IDEATION SESSION?

Tyl B., Vallet F., Pialot O.
APESA, France

The generation of eco-innovative ideas requires the development of specific heuristics or stimuli. If several types of heuristics have been elaborated in innovation -and eco-innovation-, the selection of appropriate heuristics adapted to an industrial problem for ideation -and eco-ideation- have not been addressed. This paper explores three methods for selecting heuristics called Eco-ideation Stimulation Mechanisms (ESM) for an energy-based case: (1) an examination of environmental issues; (2) a direct screening of the problem through the ESMs; (3) an examination of inspiring cases.

HOW TO FOSTER INNOVATION? FINDINGS AND HYPOTHESES FOR COLLABORATIONS BETWEEN RESEARCH AND INDUSTRY

Şahin T., Cudok A., Rapp S., Inkermann D., Albers A., Wattenberg F., Bursac N., Vietor T.
Technische Universität Braunschweig, Germany

This paper stresses the importance of collaborations to foster innovation and highlights the need for a shared understanding of innovation. To support successful collaboration we outline essential success factors and formulate hypotheses to improve collaborations focussing on SMEs. A model is introduced, allowing the identification of fields and measures to foster innovation. In addition, the concept of Product Generation Engineering is proposed to analyse past and plan future innovation activities. The discussion and hypotheses are addressed to researchers in the field of product engineering.

Session D242

Conf. Hall Mare Section 2

16:15 18:15

INTEGRATING INDIVIDUAL KNOWLEDGE INTO INNOVATION PROCESSES OF R&D ALLIANCES

Canik Y., Fain N., Bohemia E., Telalbasic I., Tewes V.
Loughborough University London, United Kingdom

Innovation processes involve individuals from different disciplines within and across organisations, who exchange knowledge to undertake tasks. Exchanged knowledge is tacit in nature and, for an organisational benefit, it needs to be integrated into innovation processes. To achieve this, this paper proposes a conceptual framework based on the literature, suggesting a circle of retrieving, creating, validating, codifying, storing, communicating and coaching new individual knowledge mitigated by boundary objects including design artefacts from the case of innovation processes of R&D alliances.

22 May

TUE

ANALYSING OPEN INNOVATION INTEGRATION TO PRODUCT DEVELOPMENT PROCESSES WITHIN THE BRAZILIAN AUTOMOTIVE INDUSTRY

Marin R. O., Kaminski P. C.
University of São Paulo, Brazil

The purpose of the present study is to analyze how different Open Innovation (OI) activities occur in Product Development Processes (PDP) from the Brazilian automotive industry. From conceptual frameworks unifying both OI and PDP, the study presents the main OI practices that are applicable to the PDP, as well as four constructs regarding that interrelationship. A case study approach is taken in 7 companies with 11 interviews, and a comparative and critical analysis is made, providing insight into how OI and PDP literature relate to the actual work being done in the automotive industry.

FRAMING STRATEGIC VALUE THROUGH DESIGN-LED INNOVATION PRACTICE

Bailey M., Spencer N., Smith N., Aftab M., Knott C., Sams P.
Northumbria University, United Kingdom

In university/industry collaborative projects, full project value is often overlooked and such projects can be viewed simply as contributing to student employability agendas. Initially, collaborators tend to place value solely on the projects' created outputs. This paper reveals how strategic value evolves during such projects and identifies frame creation as a means of highlighting additional values in design-led innovation projects. Identifying 'value-frames' allows the academic team to be more purposeful in aligning project focus to partner objectives, thereby increasing impact potential.

PRODUCT DEVELOPMENT CHALLENGES FOR SPACE SUB-SYSTEM MANUFACTURERS

Öhrwall Rönnbäck A. B., Isaksson O.
Luleå University of Technology, Sweden

Space industry undergoes a transformation where new business interests affect manufacturers of space subsystems and equipment. This paper investigates consequences on development and design capabilities following the increased competition and market volumes, towards emphasis on commercial values, seeking adaptable, flexible and production efficient design solutions.

INDUSTRY-LED CORPORATE START-UP ACCELERATOR DESIGN: LESSONS LEARNED IN A MARITIME PORT COMPLEX

Garcia-Herrera C., Perkmann M., Childs P. R. N.
Imperial College London, United Kingdom

Given the increasing disruption in every industry, firms can design new interfaces to further their strategic exploration efforts in order to remain competitive. Based on an inductive multi-case study research in a leading maritime port complex, we devised an actionable framework to design and run an industry-led accelerator through four steps: ecosystem orchestration, innovation funnel generation, flexible matching and scaling corporate start-up recurrent engagement. This framework can guide managerial practice and inform corporate start-up acceleration design in similar industrial contexts.

APPROXIMATION OF THE USER BEHAVIOUR IN A FULLY AUTOMATED VEHICLE REFERRING TO A STATIONARY PROTOTYPE-BASED RESEARCH STUDY

Fitzen F., Amereller M., Paetzold K.
BMW Group, Germany

The technological progress of automated driving fundamentally affects the starting situation for developing the automotive interior. As the driver will not be occupied with driving tasks, a self-driving car should enable him and all passengers to productively shape their driving time in a new way. Basing on previous approaches of deriving interior functional requirements a literature review as well as a research study in a stationary prototype regarding relevant secondary activities have been conducted. The outcome is exemplified, embedded in a methodical approach and next steps are deduced.

SETTING THE SCENE: A NEW PROPOSAL FOR VISUALIZING AND ESTABLISHING 3-DIMENSIONAL PERSONAS AS A MANAGEMENT TOOL

Koscher A., Dittenberger S.
New Design University St. Pölten, Austria

Experiences drawn from former projects indicate a gap concerning the creation and the perpetual use of Personas throughout a project development process. This gap builds the focus of this paper. In order to develop a new approach to create a possibility for all team members to actively get involved in the Persona creation and further evolvement over the project duration, this paper offers a new option for using Personas dynamically for communication and visualization of product development stages.

WORKSHOP METHOD FOR EARLY SUSTAINABLE PRODUCT DEVELOPMENT

Schulte J., Hallstedt S. I.
Blekinge Institute of Technology, Sweden

It is in the early phases of product development that most of a product's life-cycle sustainability impact is determined. This study presents a workshop method that has the purpose to support multi-disciplinary teams in sustainable product development, focusing on early phases. The workshop method aims to map the sustainability challenges and opportunities of a concept at an overarching level, utilizing backcasting from sustainability principles in three steps: create vision, assess current state, derive strategies. Testing and validation was done at two companies and with one academic group.

MATCHLINK - A MULTI-SENSORIAL GAME FOR PERSONS WITH DEMENTIA

Seah C. E. L., Tan M. T. K. B.
Nanyang Technological University, Singapore

Sensory, cognitive and motor stimulation can enhance the wellbeing of people with dementia and their caregivers by reducing their susceptibility to developing behavioural or psychological symptoms. This project led to the development of a multi-sensorial game (MatchLink) for use by occupational therapists and caregivers to engage and stimulate people with dementia, with the intention to increase functional ability and prevent decline. Primary information was collected through an ethnographic observation at Ng Teng Fong Hospital with the guidance of an occupational therapist.

ASSESSING USER NEEDS BY EXPLORING DAILY ACTIONS OF ELDERLY PEOPLE IN THEIR HOME ENVIRONMENT IN CHILE

Wallisch A., Stieg T., Paetzold K., Briede J. C.
Bundeswehr University Munich, Germany

Despite their increasing need for assistance, technical assistance systems for the elderly often fail. The aim of this study is to investigate the human-technology interaction in the everyday life of older Chileans. It focuses on household technology, which subsumes technical devices that are used to simplify and manage daily routine. The aim of the investigation is to identify the technology used and the usage practices. By conducting interviews with observational parts, some special characteristics of the target group are revealed and general implications for product development are derived.

RESEARCH FOR RELIEF OF DISCOMFORT OF SOUND USER INTERFACE (SUI)

Yang W.
Shibaura Institute of Technology, Japan

Bicycle bells are often used for avoiding danger and can serve as a warning. It seems that psychological displeasure is pronounced when the pedestrian suddenly hears a loud high frequency alarm from the back. In this study, we investigate the conditions of sounds causing little psychological displeasure as a signature needed for interactions informing pedestrians of a bicycle's approach. For this purpose, we analyzed the sounds of existing bicycle horns and investigated factors that concluded to be unpleasant in previous studies and experiments.

A PROPOSITION OF A KNOWLEDGE ELICITATION METHODOLOGY FOR CRASH SIMULATION DIAGNOSIS SUPPORT SYSTEM

Rousselon Fatfouta N., Stal-Le Cardinal J., Royer C.
CentraleSupélec, France

Crash simulation analysis process is a complex task because of the enormous data to analyse and the integration of different disciplines. This paper is integrated within a research about developing a diagnosis support system of car crash simulation. The overall purpose is, based on organisational and individual knowledge, to provide diagnostic support for experts. This paper only focuses on early difficulties encountered within this research. The knowledge about car crash simulation process is implicit. The objective is to build a methodology for eliciting implicit knowledge from experts.

SCALING OF STRUCTURAL COMPONENTS BY KNOWLEDGE-BASED ENGINEERING METHODS

Wolniak P., Sauthoff B., Lachmayer R.
Leibniz Universität Hannover, Germany

Decreasing the development time is a significant mean for a company operating in the technical area to lower the development cost. Effort invested into developing a given product can be used to derive following variants of the same product by applying a scaling method. Common scaling methods are created in a means of a geometrical scaling without the option of a flexible change of geometry, while maintaining the concept in the main. Therefore a method is proposed for deriving a knowledge based engineering system which ensures the beforehand mentioned characteristics of the scaling process.

CHOOSING THE RIGHT TOOLS AND PRACTICES TO DESIGN A KNOWLEDGE MANAGEMENT SYSTEM IN A SME

Tapissier E., Mantelet F., Aoussat A.
Arts et Métiers ParisTech, France

The aim of this paper is to propose a knowledge management system (KMS) design methodology for small and medium enterprises (SMEs) that address the problems encountered on the existing ones, such as the high amount of resources or the KMS sustainability. To solve these problems, we created a KMS design methodology that uses the SMEs characteristics, needs and problems to select adapted KM tools and practices and offer a tailor-made KMS. This methodology was used to design a KMS for a high-tech SME and write a set of requirements to ease its implementation and ensure its sustainability.

KNOWLEDGE-BASED SUPPORT DURING DESIGN OPTIMIZATION USING FLANGES AS AN EXAMPLE

Loibl A., Andrae R., Köhler P.
University of Duisburg-Essen, Germany

In today's interdisciplinary environment, design engineers are facing increasing market demands for faster product cycle times. This implies that product-lifecycle processes need to be performed parallelly and faster. Repetitive processes should be questioned. To support the designer, processes can be automated by using clever linking software, Knowledge-Based Engineering (KBE), and a central knowledge base. This paper demonstrates an approach by giving examples of bolted and flange connections. The result supports the user, by providing simulation templates and optimization algorithms.

THE DESIGN OF VISUAL INFORMATION OBJECTS IN THREE-DIMENSIONAL VIRTUAL ENVIRONMENTS FOR ENGINEERING INFORMATION NAVIGATION

Jones D. E., Snider C., Yon J., Gopsill J., Xie Y., Chanchevrier N., Hicks B.
University of Bristol, United Kingdom

Product Life-Cycle Management (PLM) and Product Data Management (PDM) systems aim to facilitate the capture and dissemination of information throughout the product life-cycle by providing an artefact-centric approach to Information Management. Work is progressing in providing three dimensional artefact-based user interfaces to PLM/PDM and in contribution to this field, this paper describes the design and verification or a number of Visual Information Objects (VIO), visual markers that indicate the presence of information within the three dimensional artefact space.

HOW MUCH KNOWLEDGE MANAGEMENT IS HIDDEN IN DESIGN METHODS?

Laukemann A., Roth D., Binz H.
University of Stuttgart, Germany

The focus of this paper is to provide a beneficial insight into knowledge-management-specific analysis of the design activities involved in design methods. Therefore the objective is to present an approach that outlines how knowledge-management-specific sections of a design method can be identified by means of the modeling language KMDL. This paper is based on the ongoing research results of a product-development-specific knowledge-management approach for SME, and serves as a continuation of research into the influence of information flows and knowledge transformations for design activities.

VERBAL ENGAGEMENT IN TEAMS SOLVING A CONCEPTUAL DESIGN TASK

Martinec T., Horvat N., Škec S., Štorga M.
University of Zagreb, Croatia

The paper represents an explorative step in studying the effect of problem-solving styles on verbal engagement in teams solving a conceptual design task. The selection of VIEW problem-solving style assessment framework provided assumptions on how different style dimensions could affect verbal engagement. The assumptions were tested by setting up a protocol study where teams composed of members with different problem-solving styles solved a conceptual design task. The results of the protocol analysis have revealed the potential effects and provided directions for further research steps.

Session D245
Conf. Hall Dubrava Section 1
16:15 18:15

DESIGNERS' IDENTITY: SKILLS' SELF-PERCEPTION AND EXPECTATION IN DESIGN STUDENTS

Kunrath K., Cash P., Li-Ying J.
Technical University of Denmark, Denmark

Designers' Professional Identity (DPI) combines social- and self-perceptive awareness through which one is able to identify as a designer. However, self-perception can be different from the expectations associated with an ideal designer, especially during education. Thus, this paper reports a survey where self-perceived design skills and expectation are compared at different points in a design education. Findings indicate that changes in mindset modify the alignment between self-perception and expectations, which provides implications for education and for a broader understanding of DPI.

22 May
TUE

THINKING STYLES IN PRODUCT OPPORTUNITY RECOGNITION - A RATHER ENTREPRENEURIAL POINT OF VIEW

Zagorac Z., Marxt C.
ETH Zurich, Switzerland

Actual cognitive strategies in relation to identifying new business opportunities have rarely been researched. This paper investigates the roles of a pair of cognitive strategies – divergent and convergent thinking – in the context of the type and process of the product opportunity recognition.

NOVICE DESIGNER'S LACK OF AWARENESS TO CYBERSECURITY AND DATA VULNERABILITY IN NEW CONCEPT DEVELOPMENT OF MOBILE SENSING DEVICES

Kim E., Jensen M. B., Poreh D., Agogino A. M.
University of California, Berkeley, United States of America

As more mobile sensing devices are introduced in the market, the risks associated with cybersecurity increase. Our research goal is to shed light on novice designers' awareness to these risks with a focus on the sensing device design. We coded qualitative data from design thinking student teams at the University of California, Berkeley to see how carefully they took data vulnerability of their created solutions into account. The results reveal that novice design students did not pay much attention to the data vulnerability of their new solutions, in spite of numerous prompts for them to do so.

MEASURING DESIGN THINKING MINDSET

Dosi C., Rosati F., Vignoli M.
University of Modena and Reggio Emilia, Italy

This article describes the development and validation of a questionnaire designed to measure the Design Thinking Mindset self-awareness. A comprehensive review of the relevant literature revealed 19 constructs. An exploratory factor analysis of the responses of two samples (N = 307) of Design Thinking professionals with some level of experience resulted in a 71-item instrument to assess DT Thinking Mindset based on 22 constructs. A measure of DT Mindset is relevant for research and practice, i.e. measuring the impact of different variables and designing more balanced and complete design teams.

USING THE FIVE FACTOR MODEL TO STUDY PERSONALITY CONVERGENCE ON STUDENT ENGINEERING DESIGN TEAMS

Stidham H., Summers J., Shuffler M.
Clemson University, United States of America

The goal of this work is to identify changes in self and peer evaluations of personality among team members using the Five Factor Model. Multidisciplinary teams of five students in an undergraduate research design project-based course were used to evaluate their own and their peer's personalities over the course of one semester. Results show that team members' evaluations of their own personalities did not change significantly through four iterations. Team member's evaluations of their peers did change for Neuroticism, Agreeableness, and Extraversion.

THE KSCM AS PART OF A HOLISTIC METHODOLOGY FOR THE DEVELOPMENT OF CYBERTRONIC SYSTEMS IN THE CONTEXT OF ENGINEERING 4.0

Dickopf T., Eigner M., Apostolov H.
Technische Universität Kaiserslautern, Germany

With today's increased level of product complexity concerning the development of so-called cybertronic or cyber-physical systems, a rethinking of current design methodologies, processes, and IT solutions is required. After a short introduction of relevant work in the field of cybertronic systems design, this paper proposes a novel design methodology based on the MVPE Model and the newly introduced Kaiserslautern System Concretization Model for the model-based development in the context of Engineering 4.0.

TOWARDS A DESIGN-METHOD SELECTION FRAMEWORK FOR MULTIDISCIPLINARY PRODUCT DEVELOPMENT

Guérineau B., Rivest L., Bricogne M., Durupt A., Eynard B.
University of Technology of Compiègne, France

Within product development, software and connectivity are playing an ever-increasing role, driven by information and communication technologies, part of the Industrie 4.0 paradigm. Product development has evolved accordingly to integrate new disciplines. Multidisciplinary product development (MPD) is supported by a variety of approaches, processes, methods and tools that should be carefully chosen and combined. This paper investigates MPD-oriented criteria that will lead to selecting appropriate concepts and techniques, proposing criteria that illustrate the features and considerations of MPD.

FRAMING THE CONCEPT OF AUTONOMY IN SYSTEM DESIGN

Beernaert T. F., Bayrak A. E., Etman L. F. P., Papalambros P. Y.
Eindhoven University of Technology, The Netherlands

Advancements in multiple domains have led to a focus on autonomy in engineered systems. This focus necessitates a clear definition of the term 'autonomy' and its implications for system design. To this end, we present a framework that defines autonomy mathematically as a function of independence and task complexity. A deeper understanding is established by generating design principles that can be used to influence autonomy. We illustrate these concepts on autonomy quantification for a coffee machine and on a qualitative retrospective assessment of the evolution of autonomy for the automobile.

ANALYSIS OF SAFETY REQUIREMENTS EVOLUTION IN THE TRANSITION OF LAND TRANSPORTATION SYSTEMS TOWARD AUTONOMY

Damak Y., Jankovic M., Leroy Y., Yannou B.
CentraleSupélec, France

Autonomous Vehicles (AV) are the future evolution of Land Transportation Systems (LTS). They promise an improvement in road safety. However, safety requirements stay a big challenge for their development. The literature presents a lack of insight on the way LTS safety requirements will evolve. This paper proposes an analysis method of LTS safety requirements evolution toward AV. The ASIL metric is used to evaluate the safety criticality. The application on two case studies, the steering by wire and platooning systems, results in a better understanding and characterization of this evolution.

SYSTEM OF SYSTEMS APPROACH FOR THE DESCRIPTION AND CHARACTERIZATION OF VALIDATION ENVIRONMENTS

Albers A., Mandel C., Yan S., Behrendt M.
Karlsruhe Institute of Technology, Germany

Validation reveals differences between created objects and their objectives. The increasing number of mechatronic systems drives the interdisciplinary approach of Systems Engineering for product development and thus also validation. Complexity and scale of the individual subsystems of a system may increase to such an extent, that the system can be considered a "System of System" (SoS). These SoS can also be found in validation systems. To establish a common understanding, this contribution describes an approach to transfer Systems- and SoS Engineering to the domain of system validation.


DESIGN
2018

● Mare SECTION 1 ● Mare SECTION 2 ● Mare SECTION 3 ● Mare SECTION 4 ● Dubrava SECTION 1 ● Dubrava SECTION 2

WEDNESDAY, MAY 23

8:00	REGISTRATION					
8:15	● D311 EVALUATION AND RISK ASSESSMENT METHODS	● D312 TOOLS FOR EARLY PHASES OF DESIGN	● D313 DEVELOPING PRODUCT -SERVICE SYSTEMS	● D314 SUPPORTING SUSTAINABLE DESIGN AND FRUGALITY	● D315 CUSTOMER AND USER INTEGRATION	● D316 DATA-DRIVEN DESIGN
8:30						
8:45						
9:00						
9:15						
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9:45						
10:00						
10:15	REFRESHMENT BREAK					
10:30						
10:45	● D3-P PLENARY SESSION III					
11:00						
11:15						
11:30	● D3-D DESIGN DEBATE					
11:45						
12:00						
12:15						
12:30						
12:45	LUNCH					
13:00						
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13:45						
14:00						
14:15	● D331 IDEA GENERATION AND INNOVATION ASSESSMENT	● D332 COLLABORATION IN DESIGN	● D333 DESIGN PRACTICE THINKING	● D334 STRATEGIC SUSTAINABILITY AND CIRCULAR ECONOMY	● D335 AGILE PRODUCT DEVELOPMENT	● D336 MULTI SENSORIAL AND USER CENTRED DESIGN
14:30						
14:45						
15:00						
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15:30						
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16:00	REFRESHMENT BREAK					
16:15						
16:30	● D341 D341: YOUNG DS MEMBERS IN INDUSTRY - EXPECTATIONS MEETING	● D342 DESIGN CYBER-PHYSICAL SYSTEMS DS SIG MEETING	● D343 HUMAN BEHAVIOUR IN DESIGN DS SIG MEETING	● D344 JOINT UTILISATION OF RESEARCH INFRASTRUCTURE MEETING	● D345 MECHATRONIC COLLABORATION DESIGN MEETING	
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20:00	CONFERENCE GALA DINNER (20:00-23:00) *Restaurant Klarisa Dubrovnik Old Town*					
20:15						
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MEET AURA: A STUDY ON HOW ITERATIVE DESIGN METHODOLOGIES AND USER PARTICIPATION HELP IMPROVE RESULTS IN TECHNOLOGY DRIVEN PILOT PROJECTS

Pérez García M., Saffón López S.
Telefónica I+D, Spain

Design is an essential aspect of developing successful products and services in technology-driven scenarios. This study emphasizes on exploring how iterative design methodologies and user participation in service design can help shape a better user experience and maximise learnings when working on technology-driven pilot projects. This research study will focus on a pilot project called Meet Aura involving Artificial Intelligence, cognitive capabilities and multi-interface interaction. It specifically seeks to generate a conceptual framework that can be replicated in future pilot projects.

HOW DO C&C²MODELS IMPROVE EFFICIENCY, COMPREHENSIBILITY AND SCOPE IN FAILURE ANALYSIS - AN EMPIRICAL STUDY BASED ON TWO LIVE-LABS

Gladysz B., Albers A.
Karlsruhe Institute of Technology, Germany

In this article, the authors evaluate a newly-developed method, which is based on the Contact and Channel Approach (C&C²A) and uses models integrating embodiment design and functions for supporting the collaborative failure analysis in product development. Previous interview-based investigations of the method have already showed a potential regarding comprehensibility, extension of the analysis scope and improvement of efficiency. To quantify the effects, a two-study comparison with conventional models and approaches was conducted and the results are introduced and discussed.

SUSTAINABILITY RISK MANAGEMENT FOR PRODUCT INNOVATION

Schulte J., Hallstedt S. I.
Blekinge Institute of Technology, Sweden

Social and environmental issues are directly connected to many of the most important risks that product development companies are facing. Based on literature review and interviews, this study investigates risk management practices on the strategic, tactical, and operational levels of companies. The findings are used to identify preconditions for integrating sustainability into risk management processes and support tools. The results show that sustainability risks need to be connected to company objectives through internal and external stakeholder value creation.

A METHOD FOR A DETAILED ANALYSIS OF VERIFICATION AND VALIDATION PROCESSES IN PRODUCT DEVELOPMENT

Schönwald J., Fleskes J., Forsteneichner C., Paetzold K.
Bundeswehr University Munich, Germany

In this paper a method is described to analyse data and information flows in product development processes. It combines two perspectives (BOTTOM UP and TOP DOWN) and three analysing methods (BPMN, coordination and graph theory). Detailed processes and interdependencies are illustrated, networks formed, process parameters defined and evaluation and interpretation potentials described. Problems and abnormalities are clustered and action recommended. The method can be used to support communication, cooperation and collaboration as well as to improve processes incremental and problem orientated.

CAN DESIGN THINKING MITIGATE CRITICAL STRATEGY IMPLEMENTATION RISKS?

Lund Strøm L. C., Willumsen P. L., Oehmen J., Heck J.
Technical University of Denmark, Denmark

Failed strategy implementations are a key business risk, and we explore how applying design thinking can mitigate key risks in strategy implementation. Based on a literature review and exploratory interviews, we identify a set of key strategy implementation risks, and map these risks against the key principles of the design thinking methodology. We discuss the usage of design thinking capabilities to tackle key strategy implementation risks and call for a situation-specific adaptation of strategy implementation. The paper concludes with an outlook on future research activities.

USING THE NEW WORKING SPACE MODEL FOR THE DEVELOPMENT OF HYGIENIC PRODUCTS

Beetz J.-P., Schlemmer P. D., Kloberdanz H., Kirchner E.
Technische Universität Darmstadt, Germany

Hygienic design is of fundamental importance in the development of food processing machines. A hygiene appropriate design leads to lower maintenance work for machine operators and to clean food free of contamination. Designers have access to plenty of guidelines that support the embodiment design and detailing of specific equipment. The Working Space Model is a suitable adaptation of the well-known and established Contact & Channel Model, which aids designers in systematically considering hygiene-relevant requirements during the conceptual design.

SEMI-AUTOMATIZED ASSESSMENT OF REQUIREMENT INTERRELATIONS

Graessler I., Scholle P., Hentze J., Oleff C.
Paderborn University, Germany

Changing requirements have a broad impact on product development processes. In this paper, a novel approach towards structuring requirements is proposed. Based on a requirements list, interrelations of requirements are assessed semi-automatically by a rule basis. Here, generic interrelations funded on either physical fundamentals or working principles are recorded. By this approach, requirements structure matrices are derived semi-automatically. Combined with selecting critical requirements based on structured criterions, iterations due to changing requirements will be reduced.

SUPPORTING DESIGN TASKS THROUGH CONSTRAINT SATISFACTION TOOLS

Nardelli M., Cicconi P., Raffaeli R., Germani M.
Università Politecnica delle Marche, Italy

Nowadays, different commercial tools are available to support engineers during optimization tasks in engineering design; however, many researches have been still studying tools and methods to improve the design process and overcome some limits related to configuration and design optimization. This paper proposes a methodological approach to highlight how a CSP analysis can support the first phase of an optimization analysis, to reduce the design space of solutions to be investigated and subsequently optimized. A test case shows a CSP study applied to steel structures for oil & gas applications.

INTEGRATING THE KNOWLEDGE ABOUT FUNCTIONAL INTERDEPENDENCIES INTO A PARAMETER MANAGEMENT APPROACH

Toepfer F., Naumann T., Anderer J., Vajna S.
Daimler AG, Germany

Based on an approach which uses the description of functional interdependencies to resolve multi-criterial goal conflicts this paper addresses the challenge of formalizing the complex knowledge about functional interdependencies and making this knowledge broadly retrievable and applicable in engineering processes. Therefore a second approach, designed to foster transparency and consistency of engineering parameters, is used to integrate this knowledge and to make it applicable based on a concept of target value management and information flow.

MODEL-DRIVEN VALUE ASSESSMENT: A CASE FROM THE FOOD PACKAGING INDUSTRY

Bertoni M., Chowdhery S. A., Bellini A.
Blekinge Institute of Technology, Sweden

Consumer perception of food packaging solutions is driven by early design decisions on paperboard configuration and manufacturing technologies. Simulation Driven Design is common to frontload design activities, but is confined to the engineering field and fails to capture higher-level value aspects. This paper presents an assessment framework connecting customer value dimensions with simulations conducted on the mechanical properties of the packaging material, and discusses how value modelling results can be visualised to support collaborative decision making in cross-functional teams.

GEOMETRIC SUBSTITUTE MODELS FOR EFFICIENT SCALING OF DIMENSIONS DURING VEHICLE ARCHITECTURE DESIGN

Felgenhauer M., Angerer C., Marksteiner R., Schneider F., Lienkamp M.
Technical University of Munich, Germany

The scaling of component sizes and distances between them, during the early stage of Vehicle Architecture Design, is time- and cost-consuming, due to numerous requirements as well as component and position alternatives. To enable fast scaling of dimensions, this paper introduces the development of empirical and semi-physical geometric substitute models. For over 25 components and distances between them, over 300 vehicles of the A2Mac1 benchmarking database serve as main data source. The resulting accuracies range from 80 % to 97 % and are applicable for initial architecture investigations.

EXAMINING THE SOLUTION BIAS OF CONSTRUCTION KITS

Gopsill J.
University of Bath, United Kingdom

Prototyping is a fundamental activity across design with one of the most common types of tool used during prototyping sessions are construction kits. These kits have of a number of bricks that designers are able to construct designs from. Meeting the constraints within a kit ensures a valid solution. With the advent of high-performance computing, this paper computes the solution space that is represented by construction kits and investigates the number of pathways to potential solutions and reveals that construction kits have an inherent bias to particular solutions.

SPECIFICATION TECHNIQUE FOR AUGMENTED REALITY BASED PRODUCT SERVICE SYSTEMS

Röltgen D., Wortmann F., Anacker H., Dumitrescu R.
Fraunhofer IEM, Germany

As one of the key technologies of digitalization, Augmented Reality (AR) provides significant innovation potentials for the product service business. However, the design of AR-based product service systems proves to be challenging due to interdependencies of product, service and AR functionalities. In this paper, a semi-formal, domain-spanning specification technique is presented. It helps companies to systematically create concepts for product service systems, taking into account the technology-specific requirements of AR, and enables a transparent communication between the domains involved.

TOWARDS SYSTEMATIC DESIGN OF CYBER-PHYSICAL PRODUCT-SERVICE SYSTEMS

Rizvi M. A. K., Chew E.
University of Technology Sydney, Australia

Modern businesses are servitizing their offerings into product-service system to achieve customized value co-creation and superior customer satisfaction. PSS are evolving to incorporate cyber-physical capabilities to form a CPPSS. It enables real-time sensing, networking, and decision-making to enhance customization, sustainability, flexibility, and profitability. This paper presents a systematic literature review of CPPSS from which basic building blocks and principles are derived for the synthesis of a proposition for a new integrated definition and meta-model of its holistic design process.

TOWARDS SYSTEMATIC INCONSISTENCY IDENTIFICATION FOR PRODUCT SERVICE SYSTEMS

Basirati M. R., Zou M., Bauer H., Kattner N., Reinhart G., Lindemann U., Böhm M., Krcmar H., Vogel-Heuser B.
Technical University of Munich, Germany

Value shift towards services led to emergence of product-service systems (PSS) as intertwined products and services. PSS development requires collaborating teams with higher domain diversity to tackle service side as well as product side. Since every domain employs a particular set of tools and models, it is challenging to manage consistency among them. However, the PSS literature lacks approaches for managing inconsistency among various type of models. This study proposes a framework that supports establishing a systematic solution for inconsistency identification during PSS development.

PRODUCT SERVICE SYSTEM DESIGN IN A SYSTEM OF SYSTEMS CONTEXT: A LITERATURE SURVEY

Hein A. M., Poulain B., Jankovic M., Chazal Y., Fakhfakh S.
CentraleSupélec, France

Product service systems (PSS) can be understood as an innovation / business strategy that includes a set of products and services that are embedded into an actor network. This paper presents the concept of PSS-System of Systems. We present how existing PSS and system of systems design approaches can be applied to PSS-SoS design.

A DESIGN PROCESS MANAGEMENT METHOD FOR PRODUCT-SERVICE SYSTEMS

Minato S., Idei Y., Mitake Y., Shimomura Y.
Tokyo Metropolitan University, Japan

Product-Service Systems (PSS) has been regarded as an attractive business concept that create high added value by integrated provisions of products and services. Since both products and services are included in the design object, the PSS design process has become increasingly complicated. To support such PSS design process, this paper proposes a design process management method for PSS. The proposed method uses “PSS design cards” which organize the tasks in PSS design and enables designers to grapple what they need to focus on during PSS design process in a tangible way.

PRODUCT DESIGN FOR A CIRCULAR ECONOMY: FUNCTIONAL RECOVERY ON FOCUS

REVIEWERS FAVOURITE

Pozo Arcos B., Balkenende A. R., Bakker C. A., Sundin E.
Linköping University, Sweden

This paper explores existing design strategies, guidelines and product features that enable functional recovery operations like repair, refurbishing or remanufacturing. A circular economy demands for products to be kept as valuable as possible for as long as possible. Therefore, recovery operations should be easy to perform in an efficient manner, which is influenced by product design. As a result of the literature review conducted, this paper presents a categorization of functional recovery guidelines for product design and identifies the need to plan for recovery at early design stages.

WHAT DESIGN PRACTICES DO PROFESSIONALS USE FOR SUSTAINABILITY AND INNOVATION?

Faludi J., Agogino A. M.
Dartmouth College, United States of America

Interviews with 27 professionals were performed to investigate what designers, engineers, and their managers value in sustainable design practices, and see how sustainable design practices might also provide innovation. Quantitative and qualitative analysis found that only 1/6th of design practices were valued for both sustainability and innovation; two often-mentioned practices were systems thinking and The Natural Step. Providing a new lens, broadening scope, and problem redefinition were some of the reasons these and other design practices were valued for both sustainability and innovation.

DECISION SUPPORT TOOL TO DERIVE SUSTAINABLE PRODUCT CONFIGURATIONS AS A BASIS FOR CONCEPTUAL DESIGN

Buchert T., Stark R.
Technische Universität Berlin, Germany

Developing sustainable products requires a thorough understanding of the product and its environmental, economic and social impact. In particular decision-making in conceptual design has a large influence on sustainability performance of the final product but still remains widely unsupported. Hence, an Engineering Decision Support System (EDSS) and a corresponding method is proposed which assists system engineers in evaluating and comparing various product concepts in early design phases. In this paper the EDSS concept is elaborated and demonstrated on the example of a pedelec drive system.

THE APPRAISAL OF SUSTAINABLE MATERIALS

Bahrudin F. I., Aurisicchio M.
Imperial College London, United Kingdom

This paper seeks to understand how users appraise sustainable materials. Using think-aloud sessions, appraisals of sustainable materials embodied in products were collected from users and categorised. To account for the appraisal of aspects such as origin, use and end of life of materials, we have extended a previous categorisation of material appraisals to include a systemic theme. The results stress the importance of the sensorial and semantic themes and the existence of relationships between appraisal themes. This understanding is useful to facilitate the uptake of sustainable materials.

DESIGN AND FRUGAL INNOVATIONS: THREE ROLES OF RESOURCE-POOR PEOPLE

Jagtap S., Larsson T.
Blekinge Institute of Technology, Sweden

Design is imperative to satisfy needs of people in resource-limited societies. Many design studies have been carried out in the context of such societies in developing countries, and are discussed under names such as humanitarian engineering, frugal innovations, appropriate technology, design at the Base of the Pyramid, design for development, etc. In this paper, we review a wide range of literature, with close analysis of 30 design studies in this field to understand how marginalised people were engaged and positioned in those studies and to plan for future research in this field.

FRUGAL INNOVATION IN COMPLEX SYSTEMS: EVIDENCE FROM NUCLEAR REACTOR DESIGN AND DEVELOPMENT IN INDIA

Verma A.
Massachusetts Institute of Technology, United States of America

Frugal innovation has typically been observed in the design of relatively simple artifacts and systems.This work finds evidence of in a 'complex' setting: the design and development nuclear reactors in India. Drawing on more than 40 interviews with reactor designers and equipment manufacturers, this paper describes the improvisational design practices that led to a localization of reactor technology in India. These findings are significant because they suggest the possibility of an alternate home-grown technology development paradigm for resource-constrained designers in developing countries.

LINKING ECODESIGN CAPABILITIES TO CORPORATE PERFORMANCE: PROPOSAL OF A SIMULATION-BASED APPROACH

Rodrigues V. P., Pigosso D., McAloone T.
Technical University of Denmark, Denmark

The absence of mechanisms to evaluate the potential benefits of ecodesign prior to implementation is a major barrier to wider adoption. There is a need to understand how the development of ecodesign capabilities affect corporate performance considering its dynamic complexity. Drawing upon the Ecodesign Maturity Model, this paper systematically reviews the literature on relevant applications of dynamic modeling and develops the foundations of a simulation framework, aimed at deriving business cases for ecodesign implementation. Preliminary results and streams of future research are discussed.

THE IMPLEMENTATION OF AN INDUSTRIAL ROBOT DESIGN TEMPLATE FOR CUSTOMER PARTICIPATION DESIGN

Li J., Nie Y., Zhang X., Wang K., Tong S., Eynard B.
Northwestern Polytechnical University, People's Republic of China

Customer participation design plays an important role in achieving high degree of customization. Complex product such as robot has complicated structure and strong professionalism, the design is hard for users who are lack of professional knowledge. So an industrial robot design template is proposed. Base on composition structure of robot, four elements of the template are analysed. According to relationships and interactions among the four, the design template is established to guide users with a simple design method. This study provides references for the design of other complex products.

Session D315
Conf. Hall Dubrava Section 1
08:15 10:15

DERIVING A USE PHASE DATA STRATEGY FOR CONNECTED PRODUCTS: A PROCESS MODEL

Wilberg J., Fahrmeier L., Hollauer C., Omer M.
Technical University of Munich, Germany

Data from connected products provides additional value because it enables companies to better understand their customers and their products' usage. However, companies struggle to identify use cases and derive a clear use phase data strategy. Existing process models for data analytics projects focus mainly on technical aspects and do not address strategy development. Thus, this paper presents a six step process model that assists companies in developing a use phase data strategy that turns data into value. An initial evaluation shows that the process model addresses important industry needs.

EIGHT KEY STRATEGIES FOR SUCCESSFUL STAKEHOLDER INVOLVEMENT IN DESIGN

23 May
WED

Manrique S. W., Simons D. P., Eisenbart B., Gericke K.
Delft University of Technology, The Netherlands

Design professionals work often in multi-stakeholder environments. This research aims to understand how design practitioners deal with challenges resulting from stakeholder involvement in design activities. In this exploratory study, ten interviews were conducted with design practitioners from design agencies in the Netherlands. Eight key strategies were identified that are considered for successful stakeholder involvement. The findings can help the field of DTM to develop methods and tools that fit better with the needs of design professionals.

LESSONS LEARNT IN DESIGNING TRANSPORTATION SOLUTIONS FOR ELDERLY PEOPLE FOLLOWING A PARTICIPATORY APPROACH

Wallisch A., Maccioni L., Trautmann L., Ostermeyer E., Borgianni Y., Borg J. C.
Bundeswehr University Munich, Germany

Aging societies have an extended need for transportation solutions that enhance elderly's independence. However, the solutions needed are as manifold as the elderly's lifestyles are. This study uses User-centred Design principles as a structuring tool to manage this complexity of requirements. By not just focusing on specific functionalities but also reflecting product life cycle and usage context, new types of requirements can be revealed. Through a case study, this article shows how a participatory design approach can lead to integrated solutions that better fit the user's needs.

CHALLENGES IN THE DEFINITION AND PRIORITISATION OF REQUIREMENTS: A CASE STUDY

Song Y.-W., Windheim M., Bender B.
Ruhr-Universität Bochum, Germany

A big challenge in the definition and prioritisation of requirements for a new product is to find compromises when conflicts arise. What is the best compromise depends on the objectives of the specific development context. After developing an explanation based on literary theory, the here presented case study describes an exemplary development context to better understand the correlating influencing factors in this decision process in real development projects. Based on the findings, three hypotheses are developed and requirements for a methodical support are derived.

ISSUES RELATED TO MISSING ATTRIBUTES IN A-POSTERIORI NOVELTY ASSESSMENTS

Fiorineschi L., Frillici F. S., Rotini F.
University of Florence, Italy

Novelty assessment is a fundamental activity for creativity evaluation of ideas or concepts. Accordingly, literature acknowledges a variety of suitable metrics, among which some "a-posteriori" versions are often used for assessing idea generated in experimental sessions. We observed that when in presence of tasks requiring multiple functions, the application of the metric becomes problematic. In this paper, we argue about the recalled issue, providing detailed suggestions for a correct "a-posteriori" novelty assessment of ideas generated from tasks with multiple required functions.

DATA OBJECTS: DESIGN PRINCIPLES FOR DATA PHYSICALISATION

Sosa R., Gerrard V., Esparza A., Torres R., Napper R.
Auckland University of Technology, New Zealand

This paper describes the principles, methods and strategies for the design of everyday objects that embody data – or Data Objects. The work presented in the paper connects the fields of industrial design and data physicalisation to introduce the concept of using data as a design material. To support the creative synthesis of Data Objects the paper provides a literature review, methods and guidance on the creation of Data Objects alongside examples - and possible opportunities, challenges, and future scenarios - for the practice, use and the study of Data Objects.

Session D316

Conf. Hall Dubrava Section 2

08:15 10:15

DATA DRIVEN DESIGN SELECTION AND GENERATION - AN INDUSTRIAL CASE STUDY ON ELECTRIC MOTORS

Tüchsen J., Pop A. C., Koch M., Schleich B., Wartzack S.
Brose Fahrzeugteile GmbH & Co. KG, Germany

This paper presents a novel design selection and generation mechanism for fast and efficient solution-finding based on the knowledge-based systems concept. Such a mechanism can be fully exploited in the early design phases (i.e. quotation phase), when the supplier has to propose both a technically feasible and pricewise attractive solution to the OEM's request. The benefits of the presented method are a massive time reduction from several weeks to less than one day as well as an improvement of the overall solutions quality as all possible technologies are evaluated parallel.

TOWARDS A FRAMEWORK FOR ENGINEERING BIG DATA: AN AUTOMOTIVE SYSTEMS PERSPECTIVE

Byrne T. J., Campean F., Neagu D.
University of Bradford, United Kingdom

Demand for more sophisticated models to meet big data expectations require significant data repository obligations, operating concurrently in higher-level applications. Current models provide only disjointed modelling paradigms. The proposed framework addresses the need for higher-level abstraction, using low-level logic in the form of axioms, from which higher-level functionality is logically derived. The framework facilitates definition and usage of subjective structures across the cyber-physical system domain, and is intended to converge the range of heterogeneous data-driven objects.

23 May

WED

A DIGITAL TWIN FOR ROOT CAUSE ANALYSIS AND PRODUCT QUALITY MONITORING

Detzner A., Eigner M.
Technische Universität Kaiserslautern, Germany

Mass customization and increasing product complexity require new methods to ensure a continuously high product quality. In the case of product failures it has to be determined what distinguishes flawed products. The data generated by cybertronic products over their lifecycle offers new possibilities to find such distinctions. To manage this data for individual product instances the concept of a Digital Twin has been proposed. This paper introduces the elements of a Digital Twin for root cause analysis and product quality monitoring and suggests a data structure that enables data analytics.

CROWD-BASED DATA-DRIVEN HYPOTHESIS GENERATION FROM DATA AND THE ORGANISATION OF PARTICIPATIVE SCIENTIFIC PROCESS

Sitruk Y., Kazakçi A.
Mines ParisTech, France

In scientific process, hypothesis generation is one the most important steps where creativity is needed most. As the science becomes more open and data-driven, it becomes interesting to analyse whether a crowdsourcing approach might be beneficial in this step. First, we characterize the process as a design process. Then, based on a real-life case study, we analyse and highlight difficulties and challenges for crowd-based hypothesis generation. Last, we give a generic process model for organizing in similar challenges in other data-based scientific hypothesis generation contexts.

PREDICTION OF THE RESIDUAL LIFE OF A COMPONENT UNDER INTENSIVE RANDOM DYNAMIC LOADING WITHIN THE SCOPE OF TECHNICAL INHERITANCE

Mozgova I., Yanchevskyi I., Lachmayer R.
Leibniz Universität Hannover, Germany

An important part of the Technical Inheritance approach are suited methods and algorithms for analyzing the data of manufacturing and usage of components, as well as methods for assessing the current state of the component during operation and predicting its residual life. In this paper we are going to describe the concept of TI as a process model and the main challenge of how to collect and analyse data, paying special attention to one aspect of the approach - forecasting the residual resource of a component under conditions of intense random loading.

PSYCHOLOGY OF DESIGN: AN INTERDISCIPLINARY FIELD OF PERCEPTION, EMO-COGNITIVE PROCESSING AND THE CHARACTERISTICS OF DESIGN

Claus-Christian Carbon
University of Bamberg, Germany

When we talk about design, most discussions will circulate the physical objects of design, and subsequently the invention, development, production and marketing of design objects. Corresponding research areas have been developed to address these topics. While most approaches do indeed also cover the side of human interaction, a systematic way of understanding human perception and emo-cognitive processing when attending to design objects is still lacking. Under the umbrella term "psychology of design" I will introduce, demonstrate and explain the power of these processes in modulating the appreciation, acceptance and usage of design goods. This includes top-down-processes such as framing, expectation, knowledge, habituation or Gestalt qualities overwriting mere physical design properties, but also Zeitgeist-dependent processing further modulating the interpretation, value and function of design. In extreme cases, such psychological effects decide whether the same physical design is aesthetically appreciated or rejected in the end. The psychology of design has a tremendous influence on the success and sustainability of design, especially because it intentionally uses associations with design characteristics in a multimodal way to induce certain psychological properties which are crucial for purchase and maintaining decisions later on. The talk is based on fundamental psychological theories and empirical evidence which are linked to applied examples from the world of art and design.

BIOGRAPHICAL SKETCH

Christian Carbon studied Psychology (Dipl.-Psych.), followed by Philosophy (M.A.), both at University of Trier, Germany. After receiving his PhD from the Freie Universität Berlin and his "Habilitation" at the University of Vienna, Austria, he worked at the University of Technology Delft, Netherlands and the University of Bamberg, Germany, where he currently holds a full professorship leading the Department of General Psychology and Methodology and the "Forschungsgruppe EPAEG" - a research group devoted to enhancing the knowledge, methodology and enthusiasm in the fields of cognitive ergonomics, psychological aesthetics and design evaluation (see www.experimental-psychology.com and www.epaeg.de for more details). He is editor-in-chief of the scientific journal Art & Perception, section editor of Perception and i-Perception, Associate Editor of Frontiers in Psychology and Frontiers in Neuroscience and a member of the Editorial Boards of Advances in Cognitive Psychology, Psihologija, Open Psychology and Musicae Scientiae.

TOPIC OF THE DESIGN 2018 DEBATE:

"THIS HOUSE BELIEVES THAT DESIGN RESEARCH SHOULD FOCUS ITS EFFORTS IN LEARNING FROM REAL PRACTITIONERS AND STOP RUNNING MEANINGLESS EXPERIMENTS WITH INEXPERIENCED STUDENTS."

Proposed by: *Anja Maier (Technical University of Denmark, Denmark) and Ola Isaksson (Chalmers University of Technology, Sweden)*

Opposed by: *Joshua Summers (Clemson University, United States of America) and Phil Cash (Technical University of Denmark, Denmark)*

Organizers and debaters expect the audience will actively and lively participate in this event that was introduced successfully for the first time during DESIGN 2012 conference. The purpose of the debate is to investigate forensically some key topics that affect the engineering design research community. This will be achieved by key players in the community presenting evidence for or against a particular topic.

FORMAT

- The topic will be proposed and then opposed (approx 8 minutes each)
- Supporting statements, seconding the two viewpoints will then be given (4 minutes each)
- The floor (the audience) will then be asked to question the proposers and opposers
- A single final statement will be given
- A vote will then be taken to see which side has "won" the debate

DERIVATION OF CRITERIA FOR RADICAL PRODUCT IDEAS

REVIEWERS FAVOURITE

Herrmann T., Roth D., Binz H.
University of Stuttgart, Germany

One of the most important problems concerning the management of radical innovations is that companies do not differentiate between radical and incremental ideas within the design process. Thus companies often do not have an understanding of which product ideas constitute radical product ideas and may result in a radical innovation. This paper analyses relevant literature's perspective on criteria for defining radical product ideas. A basic criteria set is provided and can be used to develop a company-specific definition.

THE CONCEPTUAL DISTANCES BETWEEN IDEAS IN COMBINATIONAL CREATIVITY

REVIEWERS FAVOURITE

Han J., Shi F., Park D., Chen L., Childs P. R. N.
Imperial College London, United Kingdom

Combinational creativity plays a significant role in design for supporting designers in producing creative ideas at early phases of design. This study provides insights into conceptual distances for forming combinational ideas. The results from a case study indicate that far-related ideas are used more often than closely-related ones to produce creative combinational designs and that far-related ideas could lead to more creative outcomes. The study provides new insights to aid designers in understanding the value of combinational creativity, and support in the production of creative designs.

COMPETITIVE CAPABILITY ASSESSMENT OF INDUSTRIAL COMPANIES WITHIN THE FRAMEWORK OF ADVANCED INNOVATION DESIGN APPROACH

Livotov P.
Offenburg University of Applied Sciences, Germany

The comprehensive assessment method includes 80 innovation performance parameters and 10 key indicators of innovation capability, such as innovation process performance, innovating system performance, market and customer orientation, technology orientation, creativity, leadership, communication and knowledge management, risk and cost management, innovative climate, and innovation competences. The cross-industry study identifies parameters critical for innovation success and reveals different innovation performance patterns in companies.

PROPOSITION OF GUIDELINES FOR ASSESSING INNOVATION IN THE DESIGN AND PRODUCTION OF PAPERBOARD CONSUMER PACKAGING

Sastre R. M., de Paula I. C., Echeveste M. E. S.
Universidade Federal do Rio Grande do Sul, Brazil

When thinking of innovation applied to packaging, it becomes evident that there is a profusion of propositions of an applied nature to improve and benefit. However, the literature does not present guidelines that help assessing the main innovation factors applied to paperboard packaging. This article aimed to identify guidelines for assessing innovation in the design and production of paperboard consumer packaging which could be used to identify the type and intensity of incident innovation factor(s). The study used a qualitative/descriptive methodological approach and literature review.

THE FUNCTION OF CO-CREATION IN DYNAMIC MECHANISM OF INTERSUBJECTIVITY FORMATION AMONG INDIVIDUALS

Matsumae A., Nagai Y.
Kyushu University, Japan

This study aims to elucidate the dynamic mechanism of formation process of inter-subjectivity among individuals in various contexts: how a design process affects formation of intersubjectivity among individuals involved and also their co-creativity, motivation toward realization of the co-designed concept. The authors have defined key terms and proposed methodologies to evaluate fundamental factors of co-creation dynamics, intersubjectivity, context, and co-creativity. Then to examine them, an experimental study was conducted concerning the type of collaborative design process.

THE CHARACTERISTICS OF SUCCESSFUL MEANING CONSTRUCTION IN DESIGN TEAMS

Knudsen L. S., Tollestrup C., Haase L. M.
Aalborg University, Denmark

Creation of new meanings of products and services is acknowledged as the key skill of designers today. Still, it is also recognised as a difficult competence to acquire and moreover, there is very little guidance for novice designers or non-designers on how to practice this creation of new products meanings. In this study, we explore the meaning construction process in four novice design teams. The study reveals a remarkable difference between high-grade and low-grade students related both to their approach to a design problem as well as their prioritisation of aspects in the design process.

MARGINS LEADING TO OVER-CAPACITY

Jones D. A., Eckert C. M., Gericke K.
The Open University, United Kingdom

This paper categorises and describes the design stages, stakeholders and decision processes of an overcapacity boiler upgrade that came about from the excessive use of design margins. Using a hospital case study, the reason behind the overcapacity and excessive margins is explored using semi-structured interviews, document analysis and process modelling. Design margins arise from a lack of systemic thinking during the design and installation phases. It is likely that margins are added as a matter of habit with no real thought to their applicability, calling into question the design process.

ADDRESSING TEAM BASED INNOVATION FOR SMALL FIRMS - CREATE, BUILD, TEST & LEARN

Lugnet J., Wenngren J., Ericson Å.
Luleå University of Technology, Sweden

The Create-Build-Test-Learn supports toolbox for engineering concept development motivates not only experimentation, but also instils design thinking in teams. By offering tools and methods for reconstruction of the design challenge, the approach prevents teams to jump into a solution too quickly. When using prototyping as a team resource, reframing of the problem becomes part of the process, ensuring that efforts are put on solving the right problem. The article describes the contents of the toolbox as well as exemplifies how to use it. CBTL has been designed in particular to support SMEs.

EXPLORING THE PERFORMANCE OF AUGMENTED REALITY TECHNOLOGIES IN CO-CREATIVE SESSIONS: INITIAL RESULTS FROM CONTROLLED EXPERIMENTS

O'Hare J. A., Dekoninck E., Giunta L., Boujut J.-F., Becattini N.
University of Bath, United Kingdom

Co-creation can offer business benefits such as increased speed to market, increased product quality, and a reduced risk of market failure. However, co-creative design sessions can be challenging due to communication barriers between designers and non-designers that can result in misunderstandings and inhibit the efficient exchange of ideas. The potential for augmented reality-based design representations to overcome these challenges and support more effective co-creation sessions is explored through controlled experiments conducted with professional designers and end users.

CHANGES AND SENTIMENT: A LONGITUDINAL EMAIL ANALYSIS OF A LARGE DESIGN PROJECT

Piccolo S. A., Wilberg J., Lindemann U., Maier A.
Technical University of Denmark, Denmark

Changes are part of any project. Although previous research provides methods to deal with changes, understanding of changes in relation to sentiment is still unclear. This is important as people's mood can affect performance and decisions. We implement an approach to quantify "change language" in emails and study its relation to sentiment. We find that sentiment decreases when problems or changes emerge, and increases when changes are implemented successfully. We discuss the implications of our findings for research and project engineering practice, providing avenues for further work.

DEEP LEARNING IN SHEET-BULK METAL FORMING PART DESIGN

Sauer C., Schleich B., Wartzack S.
Friedrich-Alexander Universität Erlangen-Nürnberg, Germany

Within the Transregional Collaborative Research Centre 73, a self-learning engineering workbench is being developed. It assists product developers in designing sheet-bulk metal formed (SBMF) parts by computing the effects of given product and process characteristics on the product properties. This contribution presents a novel approach to using deep learning methods for the properties prediction. By making use of a parameter study of 20 SBMF part designs, a metamodel is trained and used to predict the total equivalent plastic strain on local level as an indicator for part manufacturability.

RESEARCH ON INTELLIGENT DESIGN AND ACCURATE MODELLING OF SPIRAL BEVEL GEARS BASED ON FUNCTION-TO-FORM MAPPING

Xu Z.-G., Su K.-Y., Zhu J.-F., Liu W.-M.
Shandong University, People's Republic of China

A design method of function-to-form mapping is proposed for spiral bevel gear. The rules are established. The mathematical model of tooth surface of the spiral bevel gear is deduced, the boundary of the tooth surface is determined. The intelligent design system of spiral bevel gears is developed on a commercial CAD software SINOVATION. The surface deviation method is used to test the solid model of the spiral bevel gear. The results show that the tooth surface model is accurate, the modeling method are feasible, intelligent and efficient.

BALL BEARINGS AS SENSORS FOR SYSTEMATICAL COMBINATION OF LOAD AND FAILURE MONITORING

Schirra T., Martin G., Vogel S., Kirchner E.
Technische Universität Darmstadt, Germany

In modern machine architecture, complex mechanical components guarantee the function of the system. Specific maintenance rates reduce maintenance effort and cost. The combination of load and failure monitoring provide data to establish an individual maintenance rate depending on component specific remaining lifetime. In addition, algorithms can optimise the operation strategy to relieve the weakest components and extend the system lifetime. Adapted ball bearings contain a sensor mechanism depending on the relation of beating load and electric bearing impedance to measure load and failure data.

WORLDS APART AND CLOSE TOGETHER: RELATING MECHATRONICS AND PROJECT MANAGEMENT RESEARCH

Flening E., Jerbrant A.
KTH Royal Institute of Technology, Sweden

While they originate from different contexts and values, the Mechatronic and Project Management research communities are both committed to the study of the process of complex engineering systems design. These two fields have generally been engaged in their research separated from each other. Recently, calls have been heard from both to end such disciplinary separation. This paper seeks to conceptually relate the two research communities, seeking to understand how they can be seen as different, related and inclusive of each other through offering three conceptual models of their relationships.

A NEW FRAMEWORK FOR CONSTRUCTION PROJECT DEFINITION STAGE

Pikas E., Oehmen J., Koskela L., Thuesen C.
Technical University of Denmark, Denmark

One major reason for the poor performance of construction project delivery is related to the 'ill'-performed project definition stage. The emphasis on rational decision-making and methods have stifled the creativity important to problem structuring and solution generation. Problem is in the poor conceptualization of the project definition stage in construction. Taking the design literature as starting point, the intent here is to clarify the underlying concepts and principles related to project definition stage, and propose a simplified prescriptive framework for the project definition stage.

UNDERSTAND SUSTAINABLE PACKAGING DESIGN IN PRACTICE

Ma X., Moultrie J.
University of Cambridge, United Kingdom

Packaging waste is known to be a significant problem for firms and society. Packaging materials constitute 65% of global solid waste. Increasingly, the cost of processing packaging waste is being directed to firms through legislation and stricter regulations. However, the sustainable packaging work in practice remains unclear and the packaging waste is still an issue. To solve this problem, seven interviews were conducted with the sustainable packaging tool users and tool providers. The interviews were transcribed and analyzed. It is clear that there are gaps between tool providers and users.

EXPLORING THE SYNERGISTIC RELATIONSHIPS OF CIRCULAR BUSINESS MODEL DEVELOPMENT AND PRODUCT DESIGN

Pieroni M., Pigosso D., McAloone T.
Technical University of Denmark, Denmark

Circular economy is a key approach for promoting a sustainable society. The design of innovative circular business models is critical and potentially leads to changes in strategies during product design and development. Systemic approaches relating business models and product design should be reflected in the methodological support for circular transformation. This article investigates this synergistic relationship and, by means of literature review, discusses how circular business modelling approaches address the integration with product design. Gaps and future improvements are outlined.

TOWARD A SUPPORTIVE ECO-INNOVATION PLATFORM BASED ON ECO-IDEATION STIMULATION MESO-MECHANISMS AND ECO-INNOVATION CASES

Pham C. C., Vallet F., Tyl B., Pialot O., Eynard B.
University of Technology of Compiègne, France

This paper presents the ALIENNOR platform that is developed within French research project ALIENNOR to promote eco-innovation by providing different kinds of users with a rich base of eco-innovation cases and seven eco-ideation stimulation meso-mechanisms (ESMs). With two main modules “Methodology” and “Community”, the proposed platform focuses mainly on how to explore seven ESMs and the base of eco-innovation cases and how to facilitate the tagging process (associate one or many mechanisms to an eco-innovation case and vice versa) of experts.

MODEL-BASED DECISION SUPPORT FOR VALUE AND SUSTAINABILITY ASSESSMENT: APPLYING MACHINE LEARNING IN AEROSPACE PRODUCT DEVELOPMENT

REVIEWERS FAVOURITE

Bertoni A., Dasari S. K., Hallstedt S. I., Andersson P.
Blekinge Institute of Technology, Sweden

This paper presents a prescriptive approach toward the integration of value and sustainability models in an automated decision support environment enabled by machine learning (ML). The approach allows the concurrent multidimensional analysis of design cases complementing mechanical simulation results with value and sustainability assessment. ML allows to deal with both qualitative and quantitative data and to create surrogate models for quicker design space exploration. The approach has been developed and preliminary implemented in collaboration with a major aerospace sub-system manufacturer.

SUPPORTING PRODUCT DEVELOPMENT AT TECH STARTUPS WITH LEAN PRODUCT DEVELOPMENT: CHALLENGES AND OPPORTUNITIES

Van Der Braak M., Jauregui Becker J. M., Pessoa M. V. P.
University of Twente, The Netherlands

Startups and Small and Medium Enterprises (SME) are the backbone of the European society, accounting for 67.1% of the total employment. One of the main common challenges for startups is product development (PD). While the Lean PD (LPD) approach has been proved effective in bigger companies, very few work was done related to SME and particularly to startups. In this work, a survey was sent to 104 Dutch tech startups. The results from the 26 respondents supported identifying a set of opportunities and challenges on reframing lean to startups.

FURTHER DEVELOPMENT OF AN AGILE TECHNIQUE TOOLBOX FOR MECHATRONIC PRODUCT DEVELOPMENT

Goevert K., Lindemann U.
Technical University of Munich, Germany

Agile development gets more and more into the focus of mechatronic product development. They will solve existing chalenges e.g. digitalization with the dynamic and flexible approach of agile development. This paper focus on agile techniques, how they can be presented and linked to each other to develop an agile technique toolbox. For this nine different agile processes are analyzed and different workshops with industrial companies are implemented to meet the industrie needs. With the toolbox different possibilities are prepared to combine different techniques depending on the user needs.

DEFINING AGILE CULTURE USING TOPIC MODELLING

Rebentisch E., Schuh G., Dölle C., Mattern C., Abel H.
RWTH Aachen University, Germany

The implementation of Agile Methods is often subject to failure, with cultural issues being the most commonly named reason. The purpose of this paper is to analyse the relationship between organizational culture and the deployment of Agile Methods. Built from a combination of systematic literature review and Latent Dirichlet Allocation, it presents a set of cultural characteristics that constitute a successful Agile organization. The results serve as a more robust definition of Agile Culture and help to assess an organization's cultural readiness for the implementation of Agile Methods.

EXPECTED VS. REAL EFFECTS OF AGILE DEVELOPMENT OF PHYSICAL PRODUCTS: APPORTIONING THE HYPE

Schmidt T. S., Weiss S., Paetzold K.
Bundeswehr University Munich, Germany

Agile development of physical products is on the rise. But can it live up to its promise? This study investigates and opposes expected (reasons for adopting) and actual effects (real value) of agile development specifically of physical products. By conducting an online survey, it turns out that primarily improvements in soft factors like communication, reaction time to changes, transparency and flexibility are associated with agile development. It has less positive effects on hard controlling KPI's such as project lead time or costs. A means-end analysis helps to explain why.

AGILE BEYOND SOFTWARE - A STUDY OF A LARGE SCALE AGILE INITIATIVE

Lindlöf L., Furuhjelm J.
Chalmers University of Technology, Sweden

Central to the effectiveness of design teams is how the planning of the design work is organized and coordinated. This paper describes how Saab Aeronautics, a large Swedish developer of jet fighter airplanes, has adopted an agile methodology on a large scale. The paper discusses central mechanisms of agile methodology including development of both software and hardware. The findings indicate two main factors that play an important role in reaching the benefits of agile in a large organization: setting up a system allowing focused team-work and giving the teams an empowered role in planning.

CPM/PDD AS AN INTEGRATED PRODUCT AND PROCESS MODEL FOR A DESIGN-THINKING BASED, AGILE PRODUCT DEVELOPMENT PROCESS

Luedeke T. F., Köhler C., Conrad J., Grashiller M., Ruf T., Sailer A., Vielhaber M.
csi entwicklungstechnik GmbH, Germany

This contribution describes an approach for an agile product development process for technical products considering the outputs of Design Thinking. As backbone serves the integrated product and process modelling theory CPM/PDD. The overall process reflects three different perspectives: stakeholder, product owner and development team. The approach transfers the agile development from software to hardware and focuses on solving the problems within the perspectives observed in practice.

EXPLORING NEW FUNCTIONALITIES IN CULTURAL HERITAGE SPACES - DESIGNING DIFFERENT MUSEUM TRAILS WITH LOW COST TECHNOLOGIES

Khan S., Rosa S., Germak C.
Politecnico di Torino, Italy

Different museums and cultural heritage institutions are seeking new ways to improve access to their artefacts and collections. The huge impact of the digital revolution shed some light on diverse approaches to minimize the visitor's museum experience disruption and enhance the accessibility to the exhibits. This paper describes the design of a sensor system by improving the access to the cultural resources adopting a non invasive and low cost technology. The study will provide new suggestions to analyze visitors' behaviour and their needs and design new visiting trails for the museum.

DESIGNING A LIFE SITUATION TOOL IN CO-CREATIVITY: PROPOSAL FOR A TOOL ADAPTED TO FABLABS

Lobbé J., Bazzaro F., Sagot J.-C.
Université de Technologie de Belfort-Montbéliard, France

Today, in user-centred design, the user is integrated alongside the design team. In our work, we propose to go further and to integrate the user in the phases of co-creativity. Indeed, the user could be considered an expert of his life situation, so that his participation in all phases of the product design process is also essential. We propose to explore the very specific world of FabLabs. In particular, we will ask how to enable design experts and Makers to work around the life situation. We propose to apply user-centred methodologies to design a life situation tool in co-creativity.

TOUCH, TOUCH, TOUCH, SENSORIAL COGNITIVE SKILLS SENSITIZED THROUGH TACTILITY AND TANGIBILITY

Wendrich R.
University of Twente, The Netherlands

This paper presents the development and testing of a tangible user interface (TUI) project that includes the exploration of haptics, design processes, hybrid design tools and unconventional user interfaces (NUI) that focus essentially on the tangible bits, embodiment, meta-cognitive and user interaction (IxD) on concrete devices designed to explore sensorial feedbacks (e.g. sense of touch, tactility etc.). We include preliminary user-testing with a heterogeneous group of 24 participants and show initial results and findings based on usability, interaction modality and user experience (UX).

MUSEUM EXPERIENCE DESIGN BASED ON MULTI-SENSORY TRANSFORMATION APPROACH

Harada T., Hideyoshi Y., Gressier-Soudan E., Jean C.
Arts et Métiers ParisTech, France

Museums' main functions are to preserve pieces of art, transmit and share knowledge. They are proposing more and more solutions to address the access to information. In this paper, our main purpose is to improve visitors' learning experience and knowledge transfer in museums. First, we did theoretical background review about museum experience and multi-sensory experience. Then, we propose a new method based on "Multi-sensory transformation matrix". Finally, we design the initial concept of a brand new multi-sensory solution that we plan to experiment with visitors in real museum environments.

THE ROLE OF USER-CENTRED DESIGN IN SMART WEARABLE SYSTEMS DESIGN PROCESS

Francés-Morcillo L., Morer-Camo P., Rodríguez-Ferradas M. I., Cazón-Martín A.
University of Navarra, Spain

Wearable electronics make possible to monitor human activity and behaviour. Most of these devices have not taken into account human factors and they have instead focused on technological issues. This fact could not only affect user acceptance and user experience but also the devices' use cycle. This leads us to formulate our research question: How can a user-centred design process deal with this situation? This study answers this question by reviewing the design requirements found in the literature and providing a map of design requirements to design wearable devices.

D341: YOUNG DS MEMBERS IN INDUSTRY - EXPECTATIONS MEETING

Conference Hall Mare SECTION 1

Chair: Udo Lindemann (Technical University of Munich, Germany)

The Design Society wants to learn more about the expectations of young members / PhD's to be motivated being a DS-member after starting their career outside academia.

The illustrative list of ideas and thoughts to be addressed includes:

- hints towards actual research topics and trends
- networking with senior DS-members
- networking with next-generation members
- networking within a global society
- early information about events of the DS
- required changes to the DS or of its focus

Especially PhD's and young industry members are invited to participate and help the Design Society in further positive development!

Session D342 D343

16:30 18:00

D342: DESIGN CYBER-PHYSICAL SYSTEMS DS SIG MEETING

Conference Hall Mare SECTION 2

Hosted by The Design Society SIG DESIGN OF CYBER-PHYSICAL SYSTEMS

Chair: Benoit Eynard (University of Technology of Compiègne, France)

This SIG meeting provides an overview of different kinds of systems and focuses on the transition process from mechatronics to CPS and cloud-based (IoT) systems. Main criteria are the classification of the driving forces and necessary technologies. So a cyber-physical system is a system of collaborating computational elements controlling physical entities. These systems can be found in areas such as aerospace, automotive, energy, healthcare, manufacturing, entertainment, and consumer appliances. With the consideration of several case studies we deal with the main research questions, identifies in the last workshops.

D343: HUMAN BEHAVIOUR IN DESIGN DS SIG MEETING

Conference Hall Mare SECTION 3

Hosted by The Design Society SIG HUMAN BEHAVIOUR IN DESIGN

Chair: Kristin Paetzold (Bundeswehr University Munich, Germany)
Yvonne Theresia Eriksson (Mälardalen University, Sweden)

Digitalization will change society, work life, activities, technology use and new business conditions that arise from the possibilities that technology provides. The digital technology allows us to do things in completely different ways than we could have before, and gives us the opportunity to do brand new things. We will use such VR, AI and robotics for designing, planning and performing. At the same time, we have to deal with the physical environment, interact with artefacts and build environments. The technology is in many ways mature regarding VR, AI and robotics, but questions remain on how to use and implement the technology in, for example, small and medium manufactory industry and health care.

- How can Human Behavior in Design (HBiD) contribute to a better and deeper understanding of how to design the interface of VR, AI and robots to better suit the user?
- What do we need to know about human behavior in various situations to develop support for different users (employees, managers, end user, etc.)?

About the content:

- Start with two very short impulse speeches to
  - Human Behavior in the field of digitalisation
  - How to identify user needs in this context
- Short contributions of every participant asking, where they see the problems and challenges
- Discussing main challenges (collection at a wall)
- Clustering and identifying research questions for the future

Session D344 D345

16:30 18:00

23 May

WED

D344: JOINT UTILISATION OF RESEARCH INFRASTRUCTURE MEETING

Conference Hall Mare SECTION 4

Chair: Peter Törlind (Luleå University of Technology, Sweden)

Within the Design society, there are a variety of research labs, such as manufacturing, testing, virtual reality and observation of human behaviour. In other areas, such as physics, it is very common to see expensive infrastructure as an international resource, which can be used by a larger group of researchers, such as CERN, Max IV, ESS. The basic idea of these major efforts is that the infrastructure is too expensive to replicate in several places. By bringing together strong infrastructure investments, there is the opportunity to maintain, develop and improve the infrastructure in a sustainable way.

Now, there is a trend to do this even in much smaller labs. These labs act as a strong research resources, but usually, the use is limited to the local research group. Here we see that there is an untapped potential for international cooperation where external researchers can rent the lab to conduct experiments and use the equipment.

In this meeting, we want to meet and discuss this issue and hopefully, identify and visualize existing labs within the Design society (and are open for sharing the facilities with other researchers) or are interesting of using shared infrastructures as well as meet researchers that need certain infrastructures to conduct their research.

Session D342 D343

16:30 18:00

D345: MECHATRONIC COLLABORATION DESIGN MEETING

Conference Hall Dubrava SECTION 1

Chair: Zlatko Šimunec (CADCAM Group, Croatia)

In conventional design approach using ECAD and MCAD authoring tools, electro-mechanical product are designed with many separate rework iterations in each tool. When the design is finished, independently in each tool, the process continues to the design phase where the MCAD and ECAD designers collaborate to produce the final electro-mechanical product. The mechatronic approach is quite different since there are no separate design phases in each of the authoring tools. Instead, there are many common rework iterations with no distinct boundaries between electrical and mechanical design. The nature of common rework iterations implies that real mechatronic collaboration must be integrated into the CAD tools to enable engineers to work across boundaries of their working domain. MECODES interest group meeting is introducing a new methodology for multi-domain collaboration during the design of electromechanical products.

23 May WED

THURSDAY, MAY 24

8:00	REGISTRATION					8:00
8:15	D411 ADDITIVE MANUFACTURIN	D412 APPLIED DESIGN PROCESSES KNOWLEDGE	D413 TOOLS FOR LATE PHASES OF DESIGN	D414 EXPERIMENTS IN DESIGN EDUCATION	D415 CHANGE AND RISK MANAGEMENT	D416 DESIGN AUTOMATION TOOLS	8:15
10:15	REFRESHMENT BREAK						10:15
10:45	D421 PROTOTYPING AND DIGITAL PRODUCTION	D422 DESIGN PROCESS EVALUATION	D423 TOOLS FOR COLLABORATIVE DESIGN	D424 TOOLS AND FRAMEWORKS IN EDUCATION	D425 PARTICIPATORY DESIGN /CODESIGN	D426 SHAPING PRODUCTS AND NEEDS	10:45
12:45	LUNCH						12:45
14:15	D431 DESIGN FOR X	D432 LEAN AND AGILE TO SUPPORT INNOVATION	D433 ARCHITECTURE, PLATFORMS, MODULARITY	D434 CASE STUDIES OF SYSTEMS ENGINEERING	D435 DESIGN KNOWLEDGE DESCRIPTIONS	D436 ERGONOMIC AND INCLUSIVE DESIGN	14:15
16:00	REFRESHMENT BREAK						16:00
16:30	D4-P PLENARY SESSION IV						16:30
17:15	D4-C CLOSING AND AWARDS						17:15
18:00							18:00
20:00	FAREWELL PARTY (20:00-22:00) *Beachfront of the Hotel Dubrovnik Palace*						20:00

● Mare SECTION 1 ● Mare SECTION 2 ● Mare SECTION 3 ● Mare SECTION 4 ● Dubrava SECTION 1 ● Dubrava SECTION 2

USING THE POTENTIALS OF ADDITIVE MANUFACTURING BY A SYSTEMATIC LINKAGE OF THE MANUFACTURING PROCESS TO PRODUCT DESIGN

Würtenberger J., Reichwein J., Kirchner E.
Technische Universität Darmstadt, Germany

This paper shows a way for a systematic linkage of knowledge about additive manufacturing to the development process using a design pattern matrix. The potentials of additive manufacturing are demonstrated by defining manufacturing induced properties. These properties gives the designer new stimulations to extend potential solution variants to concretize function carriers for a given task during the development process.

EVALUATING DESIGN HEURISTICS FOR ADDITIVE MANUFACTURING AS AN EXPLORATIVE WORKSHOP METHOD

Lindwall A., Törlind P.
Luleå University of Technology, Sweden

It is suggested that the space industry is an ideal case for Additive Manufacturing (AM), with a low production volume and need for complex geometries. However, few engineers have experience of AM design. One way to support design engineers with limited experience of AM is the use of design heuristics, to enhance variety, quality and creativity of potential designs. This paper is based on literature studies and observations of creative workshops with companies from the space industry. Results showed that heuristics assisted designers and 8/10 heuristics was utilised during the ideation phase.

DESIGN FOR ADDITIVE MANUFACTURING: MAPPING OF PRODUCT FUNCTIONS

Valjak F., Bojčetić N., Lukić M.
University of Zagreb, Croatia

In this paper, authors present a new approach for supporting design process for additive manufacturing. The purpose of the method is to support structured process for the conceptual design phase and help designers utilise the unique possibilities of additive manufacturing with mapping of product functions and design principles through additive manufacturing ontology. The method is still in early research phase and therefore lacks a necessary computational framework. The paper presents the preliminary validation of the method through a case study.

ADDITIVE MANUFACTURING FROM A STRATEGIC SUSTAINABILITY PERSPECTIVE

Villamil C., Nylander J., Hallstedt S. I., Schulte J., Watz M.
Blekinge Institute of Technology, Sweden

There are high expectations of additive manufacturing (AM) as a technology to improve manufacturing efficiency and reduce material waste. This study aims to clarify the sustainability advantages and challenges of AM technologies used in industry by testing and applying a strategic sustainability life cycle assessment in the early development stage. The result showed possibilities from using the tool and some areas of certain interest regarding improvement potentials of the AM technologies, i.e. value chain management, concept design, optimized material usage, and social sustainability.

EARLY PHASE EVALUATION OF ADDITIVE MANUFACTURING TECHNOLOGIES WITHIN AN INTEGRATED PRODUCT AND PRODUCTION ENGINEERING APPROACH

Kaspar J., Stoffels P., Schneberger J.-H., Vielhaber M.
Saarland University, Germany

Today, an essential challenge lies in a holistic as well as integrated assessment and selection of an adequate manufacturing technology bearing in mind a tailored product design along with a further optimized material selection, particularly with respect to the emerging potentials of the increasingly industrialized application of additive manufacturing (AM). Therefore, this contribution presents a scientifically detailed view on a methodological set-based product and production engineering approach dealing with technical, economic and ecological aspects in an aggregated, tool-based manner.

IMPACT ON DESIGN WHEN INTRODUCING ADDITIVE MANUFACTURING IN SPACE APPLICATIONS

Borgue O., Panarotto M., Isaksson O.
Chalmers University of Technology, Sweden

This paper studied how the introduction of additive manufacturing (AM) in space applications impacts the design phases. Together with three manufacturers of space applications, the potential benefit as well as constraints are studied to identify design gaps. A literature survey is conducted to match the needs and following an analysis the impact on design practice is formulated. Results show the need to combine a wider design exploration capability, in combination with comparative modelling strategies.

KNOWLEDGE IN ENGINEERING DESIGN: A SYSTEMATIC LITERATURE REVIEW ON ARTIFACTS AND IT SYSTEMS

Preidel M., Wang W. M., Exner K., Stark R.
Technische Universität Berlin, Germany

Intense collaboration within networks of stakeholders characterizes current engineering design processes. In these, engineers use IT systems to create artifacts, which manifest their knowledge allowing its circulation. Still, a research gap exists regarding the understanding of kinds, relations and interdependencies between IT systems, artifacts and knowledge types. This article addresses this gap by presenting results of a systematic literature review. The results contribute to close the mentioned gap, give insight on focusses of current research and identify further need for investigations.

Session D412
Conf. Hall Mare Section 2
08:15 10:15

AGILITY FACTORS AND THEIR IMPACT ON PRODUCT DEVELOPMENT PERFORMANCE

Rebentisch E., Conforto E. C., Schuh G., Riesener M., Kantelberg J., Amaral D. C., Januszek S.
Laboratory for Machine Tools and Production Engineering (WZL), Germany

Agile product development is popular but still not well understood beyond its methodological implications. This paper reports an identification of agility factors enabling teams to make and communicate decisions more quickly in product development. On this basis, a quantitative System Dynamics (SD) model is developed and analyzed to explore the impact of the identified agility factors on the product development performance. The results show that both methodological and team factors do not only influence agility but can also significantly improve the project completion time and product quality.

SUPPORTING ENGINEERS IN LIGHTWEIGHT DESIGN: THE ENERGY DISTRIBUTION ANALYSIS (EDA)

Laufer F., Roth D., Binz H.
University of Stuttgart, Germany

Lightweight design methods help the engineer to design lighter products. However, none of the existing methods support lightweight design with regard to the state of motion of mass and the mass distribution. This paper presents an analytic method to fill this gap. The method uses kinetic and potential energies to determine an energy level factor. This factor enables the engineer to derive an optimization potential and order of all different product assemblies. Finally, a case study is performed on a processing machine to illustrate the effectiveness of the developed method.

SIMULATION-SUPPORTED PARTICIPATIVE PROCESSES IMPROVEMENT IN ENGINEERING DESIGN

Becerril L., Lindemann U.
Technical University of Munich, Germany

In today's dynamic environment, companies need to adapt their design processes faster than ever. Lack of employee involvement has been highlighted as a main issue during the adoption of new processes in R&D. Existing participatory methods, e.g. in ergonomics, contribute to ease organizational changes. However, their applicability on complex processes is limited. By combining methods from ergonomics and user experience with dynamic process models, we propose an approach that enables process stakeholders (e.g. engineers) to give feedback and to test the planned process in a range of scenarios.

AGILE METHOD DEVELOPMENT: A LIVE-LAB CASE STUDY ON PRODUCT PROPERTIES FOR PROCESS PLANNING

Albers A., Bursac N., Eckert C. M., Walter B., Wilmsen M., Heimicke J.
Karlsruhe Institute of Technology, Germany

Developing design methods can be described as a process similar to product development processes. Following agile approaches is worthwhile in order to identify relevant requirements of potential users at early stages of method's maturity. Live-Labs, as a controllable research environment located between laboratory and field studies, provide an environment whose results are neither too specific nor too generic. In this paper, an agile development of a method for process planning depending on product attributes is presented. The research took place in a Live-Lab with industrial participation.

ECO-DESIGN IN THE PUPPET WORLD, A CO-LEARNING PROCESS

Allais R., Tyl B., Postel J., Fleury R.
APESA, France

Ecodesign has been widely explored in the development process of consumer and capital goods. This study focuses on the environmental assessment of puppets. The methodological approach is inductive and propose to adapt analytical tools from ecodesign to cultural goods specificities. First, a generic puppet design process emerged from interviews of 6 puppet makers. Then, a life cycle inventory study is performed and main environmental issues are discussed. Finally, crossfertilization between puppet design and engineering design are highlighted in research perspectives.

NEW INTEGRATIVE APPROACH TO EXISTING DESIGN FOR ASSEMBLY (DFA) METHODOLOGIES: APPLICATION ON ELEVATOR COMPONENTS

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This paper presents an integrative approach to the design for assembly (DfA) methodologies, adapting these to the particularities of the elevation industry. A friendly design tool in form of software has been developed implementing the proposed approach and methodology. A study case for an elevator counterweight design has been presented to show and test the advantages of the new approach and developed tool. Improvements of approximately 7.9 percentage points in the assembly effort of the elevator counterweight have been obtained following the proposed approach.

A METHODICAL APPROACH FOR THE TECHNOLOGICAL ASSESSMENT OF JOINING TECHNOLOGIES - OPTIMIZED DECISION-MAKING IN CAR BODY DEVELOPMENT

Choudry S. A., Haass S., Alber U., Landgrebe D.
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Lightweight solution lead to a diversity of joining technologies in car body development. To date, the decision-making for joining technologies is based on the expertise of the developer; a standardized selection procedure does not exist. The focus of the extant literature mostly lies on economic criteria. Thus, an assessment of the technological potential of the technologies cannot be made. This research presents an approach for the technological assessment. By considering besides economic also technological criteria, the approach allows an optimized selection-process of joining technologies.

KNOWLEDGE-BASED MANUFACTURING: A PROPOSAL TO MANAGE MANUFACTURING RULES

Marra M., Pascarelli C., Lazoi M., Corallo A., Micchetti F.
University of Salento, Italy

In manufacturing companies, technologists use CAD/CAM tools for NC programming. Feature based approaches enable to faster programming, but require advanced competences and a standardization too rigorous for real machining practices. It is necessary a data and manufacturing rules management environment, in which knowledge engineer can define the rules based on industrial best practice and CAM Experts can customize them for production requirements. A possible solution is to extend the FBM software module with an easy-to-use system that simplifies feature based rules management and deployment.

DESIGN FOR COMPOSITES: TAILOR-MADE, BIO-INSPIRED TOPOLOGY OPTIMIZATION FOR FIBER-REINFORCED PLASTICS

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A bio-inspired topology optimization approach with simultaneous fiber orientation optimization for fiber-reinforced plastics is introduced. To scrutinize the optimization potential of the new approach when compared to methods not considering fiber orientation during the optimization process, a case study using a bike rocker arm is presented. In this study, slightly better stiffness behavior of the new approach compared to its counterparts could be observed. However, as far as strength behavior (matrix failure) is concerned, significant gains could be achieved, both in numbers and visually.

A TOOL FOR IDEALISATION OF CAD MODELS

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The idealisation of CAD models for FEA purpose is an iterative and time consuming process. In order to automate and speed it up, the present paper introduces a geometry simplification tool named CAD Idealiser, which has been developed using CATIA V5 automation. The macro is able to detect geometric details such as fillets, chamfers, holes & notches, and visualize them by means of different colors. In addition, it supports the user in suppression of detected geometric details. In order to verify the efficiency of the algorithm, several different CAD models have been subjected to idealisation.

MANUFACTURING TECHNOLOGY-BASED APPROACH TO TEACHING ENGINEERING DRAWING

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Engineering drawing is of vital importance to the designer since it enables sharing the design solution with the rest of the team. Even though recommendations for the dimension arrangement are provided in the national standards, general solutions are not offered. For this reason, dimensioning strategy in teaching technical drawing is required. In this article, the authors studied the manufacturing technology-based teaching approach by analysing the learning outcomes and the feedback from the students. During the time span of five years, 814 students responded to the student questionnaire.

DO BETTER SKETCHERS BECOME BETTER PRODUCT DESIGNERS?

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University of Antwerp, Belgium

The importance and value of sketching as part of the creative design process has already been extensively argued. Not only the act of sketching and the number of sketches made have a positive effect on the quality of the design outcomes, also sketch quality has an influence. The correlational study presented in this paper explores the relationship between the students' sketch courses grades and the grades for their individual design outcomes. The results show that students with better sketch competences are more likely to score higher for their product design projects.

CREATIVITY UNDER PRESSURE: USING DISTANT SEMANTIC FIELDS FOR FAST ACTIVATION OF DIVERGENT THINKING IN ENGINEERING STUDENTS

Beghelli A., Prieto P.
Universidad Adolfo Ibañez, Chile

Creativity is one of the most valued professional skills. However, creativity-training opportunities are scarce in engineering programs. In this paper we present an interventional study for fast activation of divergent thinking in non-trained people. Based on the associative creativity theory, we force the participants to connect semantically distant concepts to generate divergent ideas in a short time. The effect was evaluated using a pre-post test (n=27). We found a significant increase in the number of creative ideas generated after a 2.5-hour intervention.

ENGAGING STUDENTS WHILE TEACHING DESIGN TOPICS ACROSS DIVERSE PROJECTS

Benjamin S., Anderson J.
Northwestern University, United States of America

We present an approach for integrating design topics in an undergraduate capstone design course. In addition to project work, students learn design topics, such as IP, robust design and DFMA. However, they struggle to integrate these into their project. To address this we require teams to explore connections between their project and a topic of our choosing and to present their findings to the class together with ideas for applying the topic to other projects. We find students engage better with these topics and are better able to articulate questions and concerns about what they are learning.

THE IMPACT OF DESIGN BRIEFS ON CREATIVITY: A STUDY ON MEASURING STUDENT DESIGNERS OUTCOMES

Koronis G., Silva A., Kang J.
Singapore University of Technology and Design, Singapore

This study is based on an interdisciplinary project aimed at ways to improve creativity among student designers. We examine the influence of different kinds of stimuli and relationships between ideas generation in product design creative outcomes. This entails a design of experiments approach to measure and determine whether factors as quantitative requirements, visual and physical stimuli can affect creativity scores. The statistical analysis suggests that briefs of no quantitative data without additional stimuli produce high scored ideas and minimize the variability of all three factors.

TAILORING RISK MANAGEMENT IN DESIGN

Tegeltija M., Oehmen J., McMahon C. A., Maier A., Kozin I., Škec S.
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While risk quantification research has grown over the last few decades, only a limited number of studies have addressed the overall process integration of these approaches in design risk management. This paper argues that the choice of risk quantification method has strong implications for several process aspects. We investigate current risk management maturity models and suggest an expansion to accommodate requirements originating from the choice of quantification method, and to inform the choice of quantification method, based on other process parameters, validated through 3 case companies.

ENGINEERING CHANGE MANAGEMENT FROM THE VIEWPOINT OF CORPORATE REPUTATION

Honkisch C. A., Pessoa M. V. P., Henseler J.
University of Twente, The Netherlands

Engineering change management (ECM) decisions affect the corporate reputation (CR) either valuable or up to total destruction. This work investigates the gap between ECM and CR for decision making. This literature grounded study decomposes and synthesizes diverging aspects in both ECM and CR: focus, execution, participants, motivation, timing, process design, decision assessment, and decision options. Merging and comparison identified traditional understandings and combination requirements implying that CR-based ECM may control the intangibles. Further research is suggested.

ANALYSIS OF ENGINEERING CHANGE REQUESTS USING MARKOV CHAINS

Arnarsson Í. Ö., Gustavsson E., Malmqvist J., Jirstrand M.
Chalmers University of Technology, Sweden

Engineering change requests are important and plentiful in the product development process to enhance a product. In this paper we use Markov chains on ECRs in a large product development project and display the results in a Markov chain DSM. The DSM shows statistical probability of a transition pathway for an industrial design process and together with engineering domain knowledge we identify patterns and improvement opportunities. It turns out that 8% of ECRs are closed directly after creation, most common pathway is not followed in early statues and status iterations are seen in the DSM.

APPLICATION OF KNOWLEDGE MANAGEMENT SYSTEM TO INJECTION MOLD DESIGN AND MANUFACTURING IN SMALL ENTERPRISES

Vukašinović N., Vasić D., Tavčar J.
University of Ljubljana, Slovenia

This paper present the solutions that a company introduced to tackle the problems that it faced during the engineering design and manufacturing of plastic injection molds. The company took an approach of introducing knowledge management system for risk reduction and avoiding problems that had already been recognized in the past. Based on preliminary analysis, knowledge management system model has been developed and potential solutions have been tested with respect to identified requirements. The most suitable system was later implemented in the company.

A METHOD FOR FUNCTION INTEGRITY DIAGNOSIS AND DOCUMENTATION: FIDD

REVIEWERS FAVOURITE

Wichmann R. L., Gericke K., Eisenbart B., Moser H.
Swinburne University of Technology, Australia

This paper introduces a method to perform systematic diagnosis of function integrity. The proposed method advances the Integrated Function Modelling framework to extend its application to risk identification and documentation tasks. By analyzing the system model of interdisciplinary designs, this method guides the designer to explore function vulnerability by systematic decoupling of inherent design entities. Thereby it provides unique opportunities for failure mode identification in complex, interdisciplinary systems. The motivation for this method is ensuring system function integrity.

MODELLING CHANGE WITH AN INTEGRATED APPROACH TO MANUFACTURING SYSTEM DESIGN

Olmez H., Hassannezhad M., Ball N., Clarkson P. J.
University of Cambridge, United Kingdom

This paper proposes a model that integrates information from product, process and organisation domains with a view to help manage these complex interrelationships with multiple layers of interaction. This model incorporates an integrated mechanism that simulates change effects during the design of complex manufacturing system by populating a Multi-layered Domain Matrix (MDM) and applying a Change Prediction Model (CPM) propagation mechanism to interconnected elements.

DESIGN AUTOMATION STATE OF PRACTICE - POTENTIAL AND OPPORTUNITIES

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Design Automation has been in focus of research and application for several decades. This paper aims at establishing the current view of design automation and identification of potential for adoption based on a survey conducted in German speaking countries and a hypothesis based multivariate analysis based on networks. The findings show that design automation is still considered a means of automation of repetitive design tasks and potential for enhanced application exists. The necessity for methods supporting designers for identification and definition of design automation tasks is urged.

LEANIFICATION OF THE ENGINEERING PROCESS FOR CUSTOMIZED ROAD SAFETY PRODUCTS

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Lattix AS, Norway

Increasing need for customization and documentation but with deficits in a systematic product configuration strategy can result in repeated problem-solving and non-value added engineering. This is especially challenging for SMEs where resources are limited. To remain competitive, they need to gather efficient ways of providing engineer-to-order products. This paper presents a case study of the implementation of a customizable product platform combined with a web-based interface in an industrial SME for road safety products as an opportunity to increase customer value and reduce waste.

INDEATE 3.0: AN ONTOLOGY BASED, GENERIC DESIGN PROCESS GUIDANCE WEB-TOOL

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InDeaTe web-tool addresses the issues of poor incorporation of design methods and tools in design. Initially conceived with a focus on sustainability, it is supported by a comprehensive database of design methods and tools, that are mapped using an ontology developed with ACLODS framework as the basis. This paper discusses the expansion of the ontology and inclusion of multiple design methodologies within the InDeaTe 3.0 web-tool, highlights the salient features of the tool and further discusses its relevance also as a research support, to widen its applicability across domains and criteria.

CONTINUOUS INTEGRATION OF MODEL VALIDATION INTO PRODUCT DEVELOPMENT

Forsteneichner C., Paetzold K., Metschkoll M.
BMW AG, Germany

The validation of product properties is a necessary part of the product development process. Consequently, methods and models used therefor have to be validated itself in order to produce reliable results. This paper describes and exemplarily implements a process model that integrates model validation into product development. The CPM/PDD approach according to Weber (2005) provides the basic process model and the modeling procedure is based on VDI 2006 (2004) and ASME V&V 10 (2006). The focus of the introduced process model is on continuous integration, consistency of data and knowledge storage.

ANALYSIS OF CO-DESIGN SCENARIOS AND ACTIVITIES FOR THE DEVELOPMENT OF A SPATIAL-AUGMENTED REALITY DESIGN PLATFORM

Morosi F., Carli I., Caruso G., Cascini G., Dhokia V., Ben Guefrache F.
Politecnico di Milano, Italy

This paper discusses how Spatial Augmented Reality (SAR) can support design sessions in the fields of product, interface and packaging design. We analyse how the scope of a design session and the type of collaboration require different features of the SAR technology. We benchmark a SAR platform under development within the SPARK project (http://spark-project.net/) and state of the art solutions against the proposed classification framework to evaluate the current state of the platform, its limitations and to outline SAR technology requirements for future development possibilities.

THE INFLUENCE OF MATERIAL PROPERTY VARIANCES AND PRINTING TOLERANCES ON THE MECHANICAL BEHAVIOR OF AN ADDITIVELY MANUFACTURED META-MATERIAL TANK TRACK BACKER PAD

Franklin S., Fadel G., Li G., Coutris N.
Clemson University, United States of America

This paper explores the influences that potential variances in material properties and nominal dimensions have on the overall mechanical behavior of an additively manufactured meta-material. The investigation looks at deviations between expected and experimental mechanical responses obtained through performance validation testing. Three sources for discrepancies were identified through literature review and model/experimental comparison. Sensitivity analyses were employed to obtain the significance of the design parameters, and preliminary work in boundary condition improvements is discussed.

A REVIEW OF MAKING IN THE CONTEXT OF DIGITAL FABRICATION TOOLS

Corsini L., Moultrie J.
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The review considers the role of making in the context of digital fabrication tools. Digital fabrication is having significant impacts on design and is challenging traditional production paradigms. The study reviews literature on making to conceptualise the activity of design-in-making, where making becomes an integral part of the design process. The paper analyses an improvisational model of design to suggest practical ways to achieve improvisational making when using digital fabrication, with the goal of achieving creative design.

PROTOTYPING IN MECHATRONIC PRODUCT DEVELOPMENT: HOW PROTOTYPE FIDELITY LEVELS AFFECT USER DESIGN INPUT

Jensen L. S., Nissen L., Bilde N., Özkil A. G.
Technical University of Denmark, Denmark

This paper provides a study of prototyping; with the aim of understanding how the fidelity of prototypes affects inputs by users. During development of a mechatronic padlock, 4 physical prototypes at varying fidelity were fabricated. 66 interviews with users were conducted. Users were presented with 1 of the 4 prototypes. The study finds; fidelity of prototypes affects users' feedback. Though not linearly and without unambiguity. This underlining the complexity of prototyping. A better understanding of how prototypes are perceived can help designers in establishing prototyping strategies.

CONTENT AND FUNCTIONS OF AN INTERNET-BASED PLATFORM FOR SUPPORTING DEVELOPMENT OF ADDITIVELY MANUFACTURED PARTS

Weiss F., Roth D., Binz H.
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To enable efficient and effective development of additively manufactured parts, the development process can be supported by a tailored information platform. In this paper, an Internet-based information platform for this purpose is presented. A survey in an industrial environment with 35 participants was conducted to determine the beneficial functions and information on the platform. This paper presents the results of the survey and the realization of an information platform as a digital support tool for designing additively manufactured parts.

DEVELOPMENT OF A RAPID CO-PROTOTYPING ENVIRONMENT FOR INDUSTRIAL SERVICES

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Service-oriented industrial companies need to manage the complexity of developing new services (NSD) besides products. Prototyping offers a way to increase the success of NSD. There are service prototyping environments, but they fall short in effectiveness. CoProtolab concept was developed for effective, comprehensive, immersive and collaborative prototyping of industrial services in a physical and virtual environments. The research follows an axiomatic design theory and results in a theoretical model for studying and developing virtual, physical and social service prototyping environments.

METHOD FOR THE DEVELOPMENT OF EARLY PROTOTYPES OF MECHATRONIC MACHINE ELEMENTS BASED ON THEIR CRITICAL PROPERTIES

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Prototyping in general is a widely used procedure within the product development process. Prototypes help to understand different and complex phenomena, support the communication between developers and customers and lower the risk of undesirable developments. There is however a lack of described methods for the development of the prototype itself to gain a maximum of knowledge. This paper therefore postulates a method for the development of early prototypes by identification of the critical properties of the final product. These properties lead to requirements for the prototype.

CHARACTERISING THE AFFORDANCES AND LIMITATIONS OF COMMON PROTOTYPING TECHNIQUES TO SUPPORT THE EARLY STAGES OF PRODUCT DEVELOPMENT

Mathias D., Hicks B., Snider C., Ranscombe C.
University of Bristol, United Kingdom

The act of prototyping is more than the artefact produced – the process helps answer design questions. A knowledge of prototyping activities leads to better decisions in the design process. The aim of this paper is to characterise and compare prototyping techniques. A literature review explores current research into characterising prototypes, before highlighting the need for comparison. A study is reported that compares the design activity of sketching, CAD, cardboard and LEGO when used as prototypes in a group design task, showing differences in the levels of different design activities.

SUPPORTING TAILORING OF COMPLEX PRODUCT DEVELOPMENT PROCESSES: AN APPROACH BASED ON STRUCTURAL MODELLING AND ANALYSIS

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Project tailoring is discussed in academia and industry as a way to bridge the project-specific adaptation of generic organizational reference process models. Research into process tailoring in interdisciplinary product development is currently limited. We have developed a structure-based approach for supporting process tailoring, addressing limitations in existing approaches through: Concrete method support; systematic analysis of documented tailoring knowledge using structural analysis; and social aspects, e.g. stakeholder inclusion. The approach has been evaluated in eight case studies.

EXTENDED DESIGN ASSETS ENABLING AUTOMATED TOOL DEVELOPMENT AS A PART OF A PRODUCT PLATFORM APPROACH

Heikkinen T. M. D., Johansson J., Elgh F. P. W.
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Product platform development is a well-established approach for reusing product knowledge in the form of geometry and its configuration rules and constraints. Explicitly defining all platform components is not always possible however. This is why a product platform approach where the processes of realising platform components also are supported is needed, instead of exclusively relying on their results. The work presented here works toward this, with a focus on automated tool development enabled by extending design assets from different tools.

V-MODELS FOR INTERDISCIPLINARY SYSTEMS ENGINEERING

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Paderborn University, Germany

Changes in products, markets and technologies influence the development process and its approaches. The V-Model of the VDI 2206 from 2004 is an important basis for the industrial application of mechatronic product development. This paper shows which changes need to be integrated into the updated V-Model and in which areas the focused topics have to be changed to be prepared for future challenges. For this purpose, existing applied models are analyzed and the need for rework is elaborated.

PARAMETRIC MOVEMENT SYNTHESIS: TOWARDS VIRTUAL OPTIMISATION OF MAN-MACHINE INTERACTION IN ENGINEERING DESIGN

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Friedrich-Alexander-Universität Erlangen-Nürnberg, Germany

A parametric movement synthesis approach is introduced, which allows the adaptation of a synthesized movement to a specific use case by varying geometrical parameters. This parametric movement synthesis empowers the product developer to optimize products purely virtually in terms of ergonomics and (dis-)comfort by using musculoskeletal simulation. We developed such a parametric model for a lifting movement to analyse several scenarios. The results of the analyses show to what extent this procedure may support the product developer to improve the man-machine interaction of products.

EVALUATION OF PRODUCT DEVELOPMENT: A COMPARATIVE CASE STUDY

Koehler N., Močibov P., Naumann T., Vajna S.
Otto von Guericke University Magdeburg, Germany

The aim of the paper is to reveal phenomena of integrated design engineering in practice by comparing four different product developments in a case study. Based on our universal questionnaire, the product developments in the branch automotive, sports optics, power tools and camera are analyzed in terms of their abilities in the field of problem solving, complexity and traceability. With the help of the collected data, we confirm well-known product development phenomena such as the ill-definedness of goals, communication as complexity driver and the lack of traceability in design rationale.

COLOURED PETRI NETS MODEL OF DESIGNERS COLLABORATION IN ITERATIVE RESOLVING OF COUPLED DESIGN PARAMETERS

Pavković N., Vlah L., Juranić J., Kuzmić N.
University of Zagreb, Croatia

The aim of the presented research is to investigate possibilities of applying Coloured Petri Nets (CPN) modelling methodology for supporting design collaboration with a focus on iterative resolving of coupled sets of design parameters. Two case studies have been conducted aiming to build CPN based models and simulations for design development projects having several sets of not trivially coupled design parameters. Based on the results, it is concluded that CPN-based approach could bring several significant benefits comparing to common design support methods and tools.

CAPTURING SYNCHRONOUS COLLABORATIVE DESIGN ACTIVITIES: A STATE-OF-THE-ART TECHNOLOGY REVIEW

Hall M., McMahon C. A., Bermell-Garcia P., Johansson A., Ravindranath R.
Airbus, United Kingdom

This paper provides a technology-focused state-of-the-art review applied to capturing, processing and reviewing collaborative design activities. It presents a descriptive study (DS-I), which explores the landscape of relevant technologies and future trends that can be applied to improve the situation within engineering organisations.

IMPROVEMENT OPPORTUNITIES FOR THE COLLABORATION OF DESIGN AND SIMULATION DEPARTMENTS - AN INTERVIEW STUDY

Schweigert S., Lindemann U.
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As mechanical simulations of products play an increasingly important role in design processes, improving the collaboration of design and simulation departments has come into focus. In order to identify barriers and according improvement measures, semi-structured expert interviews were conducted with participants from 16 companies of different sizes and industry sectors. Building on three basic structures for the integration of simulation departments, improvement opportunities were derived consisting of an identified barrier and an associated improvement measure for each of the 20 barriers.

COLLABORATIVE DESIGN: LINKING METHODS, COMMUNICATION TOOLS AND COMPETENCIES TO PROCESSES

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Today's design processes involve various persons and disciplines. Process participants are often distributed in different sites and might have diverse cultures. Thus, collaborations are often confusing due to the different parties. This paper uses a model considering 3 layers of collaborations: process, methods & tools and competencies & qualification. Each layer is modelled or supported by existing tools but a holistic modelling approach to represent relations between the 3 layers is missing. This research work proposes a modelling approach showing design processes on all 3 layers using BPMN.

MODELLING THE RELATIONSHIP BETWEEN DESIGN ACTIVITY AND COMPUTER-SUPPORTED COLLABORATIVE DESIGN FACTORS

Brisco R., Whitfield R. I., Grierson H.
University of Strathclyde, United Kingdom

Computer-Supported Collaborative Design (CSCD) technologies can enable teams to collaborate across boundaries. Emerging research documents the potential of CSCD technologies to contribute towards successful collaborative design, however, no model exists to define the relationship between a successful design activity and CSCD factors which influence its success. This paper utilises a systematic literature review to categorise known CSCD factors, categorise and characterise them, and applies this knowledge towards developing an established design activity model to include CSCD factors.

VIRTUAL AND MIXED PROTOTYPING TECHNIQUES AND TECHNOLOGIES FOR CONSUMER PRODUCT DESIGN WITHIN A BLENDED LEARNING DESIGN ENVIRONMENT

Bordegoni M., Ferrise F., Wendrich R., Barone S.
Politecnico di Milano, Italy

Both physical and virtual prototyping are core elements of the design and engineering process. In this paper, we present an industrial case-study in conjunction with a collaborative agile design engineering process and "methodology." Four groups of heterogeneous Post-doc and Ph.D. students from various domains were assembled and instructed to fulfill a multi-disciplinary design task based on a real-world industry use-case. We present findings, evaluation, and results of this study.

IDEAL IDEATION: A FRAMEWORK FOR THE MANAGEMENT OF SKETCH INHIBITION AMONG UNDERGRADUATE DESIGNERS

Thurlow L., Ford P.
De Montfort University, United Kingdom

Sketch inhibition among undergraduates is a growing but under-researched issue. Affected students avoid engaging with sketching during concept development, they also have little understanding of the benefits it offers effective ideation as a language and a cognitive tool which in turn affects design quality and impedes commercial activity. Causes include skill-set shortage, prevalence of technology and social and educational issues. The proposed management framework aims to reduce inhibition via a three-part tool for use by higher education at strategic, pedagogic and individual levels.

DISCURSIVE ENGINEERING DESIGN: A SPECULATIVE FRAMEWORK FOR DESIGNING TECHNOLOGICAL INNOVATION

Rebola C. B., Gonsher I.
University of Cincinnati, United States of America

The productive tensions between the sciences and the arts, between disciplines that make predictions and those that permit speculation, establish a creative dialectic. This paper describes a methodological approach for examining these kinds of creative dialectics and puts forth ways in which they might be implemented as educational models for cultivating innovation. The goal is to present a framework that builds on interdisciplinary pedagogy and hybrid experimentation – a technical and artistic rigor for approaching engineering and design as a mode of inquiry for innovation.

CREATIVE PATH TO PRACTICAL KNOWLEDGE - CASE OF A TRIPLE HELIX FRAMEWORK

Čok V., Fain N., Žavbi R., Vukašinović N.
University of Ljubljana, Slovenia

The paper presents a successful Triple helix collaboration between university, industry and government that resulted in commercialisation of a sustainable new product within the aircraft industry. The case presented is a result of a government funded student project between a high-tech organisation and a mechanical engineering faculty, which fully supports the notion of how Triple helix organisations work. The solution (i.e. new product developed via Triple helix collaboration) has been prototyped, improved, manufactured and already sold to users.

FACILITATING NEED FINDING AND PROBLEM FORMULATION DURING COOPERATIVE WORK TERMS THROUGH VIRTUAL INSTRUCTION - PILOT IMPLEMENTATION RESULTS

Nespoli O., Hurst A., Russell J.
University of Waterloo, Canada

This project aimed to teach, facilitate the learning of, and assess need finding and problem formulation skills while students were immersed in an authentic practice environment during their coop work terms. An interdisciplinary team of students was placed in a manufacturing facility where they were asked to need find and propose significant problems to solve while they were taught design methods remotely. Students reported that they learned more deeply than a classroom environment because they were able to be in constant engagement with the problems they were trying to solve.

RETHINKING DESIGN EDUCATION FOR THE MULTICULTURAL GENERATION

Huang T., Scott A., Lu Q., Sui T.
Southern Illinois University, United States of America

The paper presents our strategies and insights for conducting a collaborative workshop of American and Chinese students and faculty in Guangzhou, China. Inspired by this experience, the authors address the challenges and opportunities of globalization and decolonization to design education. The paper emphasizes the importance of establishing strong collaborations with other countries and cultures for a truly multicultural experience for the new generations of design students.

RECONCEPTUALIZING DESIGN RISK MANAGEMENT AS A LEARNING STRATEGY

Willumsen P. L., Oehmen J., Ernstsen S. K.
Technical University of Denmark, Denmark

We observed how risk management (RM) is perceived to hinder radical innovation in companies. RM is perceived to kill good ideas too early before they were explored thoroughly or leads to cancellation of projects after several years of development time due to critical risks. This paper contributes an empirical investigation and show that a multitude of value propositions for RM exist, among them innovation. The paper proposes 5 practices to reconcile risk management and innovation, and reconceptualise risk management as a learning strategy that supports innovation.

HUMAN CENTRICITY IN INTEGRATED DESIGN ENGINEERING

Urakami J., Vajna S.
Otto von Guericke University Magdeburg, Germany

Integrated Design Engineering is a holistic approach to create products of any kind. These are created in a human-centred way, as interests, issues, and needs of people involved in any product life cycle phase are respected. Attributes that don't fix realisation issues describe neutrally the required product performance. They result from needs, desires, expectations, and conditions in relation to the capabilities of users and from the environments where the product is created and to be used. Requirements to assure human centricity add to the requirements to realise the expected performance.

CROWDSOURCING IN PRODUCT DEVELOPMENT: CURRENT STATE AND FUTURE RESEARCH DIRECTIONS

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The term crowdsourcing has been identified as a valuable paradigm in the open design movement. Despite its proven value, research focusing specifically on crowdsourcing in product development has been stagnating, with the general tone in this sector having moved from optimism to skepticism. In this paper, the authors present a literature analysis that reveals four hurdles limiting industry adoption. The authors are then able to suggest future research avenues that they anticipate will encourage adoption of crowdsourcing in professional product design and development settings in industry.

PUTTING THEORY TO PRACTICE: REFLECTIONS ON THE INTEGRATION OF PRODUCT DESIGN ASPECTS IN AAL PROJECTS

Dittenberger S.
New Design University St. Pölten, Austria

This paper discusses the question of the awareness and representation of product design aspects in the user-centred design's ISO process model applied in research projects in the realm of the Active and Assisted Living (AAL) Programme. Experience has shown that product design aspects are to date not as well integrated and applied in projects' everyday working practice as the realms usability engineering, user experience design and user interface design already are. This paper proposes refinements for the applied process as a basis for further elaborations.

CODING SCHEMES FOR THE ANALYSIS OF ICT SUPPORTED CO-CREATIVE DESIGN SESSIONS

Becattini N., Cascini G., O'Hare J. A., Masclet C.
Politecnico di Milano, Italy

The paper presents a coding scheme for design protocol analysis of collaborative sessions supported by Augmented Reality. It maps verbal interactions during creative sessions, so as to distinguish co-designers' intentions and the related contents characterizing the characteristics of the design proposal in terms of items and related parameters. Three different co-creative sessions and a tailored metrics allowed for checking the coding scheme effectiveness, showing good mapping capabilities and versatility of application also to compare similar sessions carried out with and without AR support.

DESIGNING HUMAN-ROBOT COLLABORATIONS IN INDUSTRY 4.0: EXPLORATIVE CASE STUDIES

REVIEWERS FAVOURITE

Kadir B. A., Broberg O., Souza da Conceição C.
Technical University of Denmark, Denmark

We are experiencing an increase in human-robot interactions and the use of collaborative robots (cobots) in industrial work systems. To make full use of cobots, it is essential to understand emerging challenges and opportunities. In this paper, we analyse three successful industrial case studies of cobots' implementation. We highlight the top three challenges and opportunities, from the empirical evidence, relate them to current available literature on the topic, and use them to identify key design factor to consider when designing industrial work system with human-robot collaborations.

MASTERING EXECUTION: FOUR GENERATIONS OF THINK.MAKE.START. AT A CORPORATION

Böhmer A. I., Lindemann U.
Technical University of Munich, Germany

Beyond all the tool, methods, and processes, that shall improve innovation in the organization execution is the key. Ambidexter calls for handling daily business with perfection, while simultaneously exploring new topics. However, studies and practice have shown that companies are having a hard time with both at the same time. New approaches are needed to promote the absence of thinking barriers facilitate true innovation. With Think.Make.Start. (TMS) a format was created to empower employees and give them the freedom needed to innovate. The study reflect on four generations of TMS at an OEM.

SHAPING PRODUCTS: DIFFERENCES BETWEEN EXPERT AND NOVICE INDUSTRIAL DESIGNERS

Jagtap S.
Blekinge Institute of Technology, Sweden

The process of shaping a product's visual appearance is crucial in determining consumer response. However, extant research on the nature of expertise in this process is scarce. Specifically, there is absence of studies investigating differences between how expert and novice industrial designers use information in this process. This research, using think aloud method, compared informational behaviour of an expert and a novice industrial designer in shaping products. We report rich qualitative accounts of their informational behaviour, revealing a sharp contrast between them.

INTRODUCING AN EVALUATION FRAMEWORK FOR WEARABLE DEVICES DESIGN: EXPLAIN REASONS OF LOW USER ADOPTION

Wang Y., Yu S., Wang J., Ma N., Liu Z.
Northwestern Polytechnical University, People's Republic of China

We summed up the factors and attributes affecting the success of smart wearable product design. We analysed the relations between design intention and cognitive interpretation and presented the attributes of aesthetic experience and emotional expression in wearable device. Then we propose an evaluation framework for better understanding the attributes, impact factors of successful wearable devices design. The evaluation framework can explain the reasons for low user stickiness of wearable device, and the framework can be used for determining design directions in the concept phrase of design.

AESTHETIC PRODUCT INTERACTION: THE NECESSITY OF CONSISTENCY BETWEEN FUNCTION & EMOTION

Lee K., Self J. A., Hong H.
Ulsan National Institute of Science and Technology, Republic of Korea

We investigate the application of aesthetic stimuli's influence on emotional response during product interaction; implications for novel yet acceptable product experiences. Adopting a research-through-design approach, three tape-dispenser products were designed. Together with a control, the dispensers offered visual and auditory stimulation during product use. Results indicate the importance of consistency between function and stimulus for elicitation of positive response towards novel aesthetic interventions. User profiles also appeared to implicate response to aesthetic stimuli.

AESTHETIC INTERACTION CONSISTENCY: EXPLORING THE FOUNDATION FOR STATIC AND DYNAMIC AESTHETICS

Gonzalez I., Val E., Justel D., Iriarte I., Lasa G.
Mondragon Unibertsitatea, Spain

Aesthetics is a powerful means for creating consistency across a product range. During the design process consistency is subject to risk. The existing tools do not integrate static as well as dynamic approaches. This paper explores how to integrate and combine both. The framework considers that, firstly, the users perceive the product thought all their senses (product presentation). Based on the perceptions, users will interact through gestures or movements (user action). These action will create a product reaction (product reaction). Finally, the frame has been applied in an experiment.

NEW EYES OF ID - HOW TO PREPARE NEW INDUSTRIAL REVOLUTION AS INDUSTRIAL DESIGNER

Jung E. C., Choi J. M., Sim Y.
Seoul National University, Republic of Korea

At the turning point of technological innovation, an intriguing question is how industrial designers can bridge gap between human and technology. The role of the industrial designer in the traditional view of the physical appearance of objects may be reduced, but in the future, designing meaning with object through rich interaction is becoming a wiser way of preparing for a new industrial revolution. The purpose of this paper is to discuss the changing role of designers through theoretical reviews with case studies.

FRAMING NEW PRODUCT INNOVATIONS: HOW TO MAKE SENSE OF INTERNAL AND EXTERNAL INSIGHTS?

Laursen L. N., Haase L. M.
Aalborg University, Denmark

This study examines: How experts make sense of internal and external insights when they create new product innovations. It focuses on the experts' reasoning; and suggests a model for internal/external sense-making based on framing theory. The model is tested in three emblematic cases in respectively B&O, Coloplast & Vipp. The study reveals, that experts make sense by reapplying frames from previous internal products as well as adopt frames from external inspirational products. Hereby they both create coherency with the brand, but also update the product to match new emerging values and trends.

TOWARD A DESIGN APPROACH FOR INDUSTRIAL INDOOR LOCATION-BASED SERVICES (I²LBS)

Falkowski T., Günther M., Jürgenhake C., Anacker H., Dumitrescu R.
Fraunhofer IEM, Germany

In the context of the ongoing industrial digitization, location-based services (LBS) can play a key role in improving internal company workflows and processes and the associated supporting activities. A lack of standardized indoor-positioning technologies and complex integration with the existing infrastructure are two of the main barriers for the implementation of LBS. In this paper, we present an approach for the design of industrial indoor LBS or (I²LBS), which supports companies during the early design and planning phase, taking into account their unique prerequisites.

CLASSIFICATION OF BIO-DESIGN APPLICATIONS: TOWARDS A DESIGN METHODOLOGY

Esat R., Ahmed-Kristensen S.
Imperial College London, United Kingdom

Bio-design is a novel frontier in design research. So far no methodology has been conceived for bio-design. A methodology would render the field more accessible by those without deep biology knowledge. Existing bio-design applications were reviewed and a novel classification scheme was proposed. The classification scheme forms the initial step towards the design methodology and is also a key contribution to the emerging field of bio-design.

ASSURANCE OF THE SYSTEM RELIABILITY OF A GEARBOX CONSIDERING PRIOR KNOWLEDGE

Bartholdt M., Grundler A., Bollmann M., Bertsche B.
University of Stuttgart, Germany

System reliability is predicted for the EcoLife 6-gear automatic transmission from ZF Friedrichshafen AG taking various calculations and testing procedures during product development into account at different system levels. The system reliability predicted in this way is compared to the field reliability derived from the actually observed failure behaviour. The combination of methods as developed, applied and validated in this paper aids in streamlining reliability efforts due to the fact that an updateable process of determining reliabilities at various system levels is formed.

EVALUATION METHOD IN ENERGY EFFICIENT DESIGN OF COOLING PLANTS

Osman K., Tomaš Ž., Pervan D.
Termo Servis Ltd., Croatia

The paper presents research in connection with a method of evaluating different cooling plant system architecture. This method is of analytical nature and is to be used primarily effectively solve problems regarding the selection of a cooling plant system architecture. A satisfactory solution here refers to a solution with a lower cost of total electricity consumption. The method's verification is presented by comparing two cooling plant with water cooled chillers system architecture. First of them is using cooling towers, while the other using dry coolers in the same mode.

ASSESSING THE VALUE OF RADICAL TECHNOLOGY ALTERNATIVES AT SYSTEM LEVEL

Panarotto M., Isaksson O., Asp L.
Chalmers University of Technology, Sweden

This study investigates the challenge to assess value when alternative technologies - of radical nature - are integrated on complex products. The study highlights three main challenges: 1) value depends on how the overall product platform is impacted over time 2) value depends on combination effects between technologies and 3) value depends on how the technology balances internal and external stakeholders needs simultaneously.

The paper describes how these challenges can be tackled by novel modelling methods, illustrated with an example related to structural batteries.

VALUE CREATION MECHANISMS IN PRODUCT VARIETY DEVELOPMENT

Pakkanen J. T., Juuti T. S., Lehtonen T. A.
Tampere University of Technology, Finland

The aim is to study value creation mechanisms in product variety development and to discuss how the mechanisms could be used in communicating and evaluating the business potential of product variety development. The mechanisms were recognised by studying the literature of modularisation, product platform and product family development. Mechanisms that increase and decrease profit were found. Industrial case study suggests that clarifying the important value creation mechanisms can be beneficial in negotiating the justification to invest in R&D projects in supporting the business.

LEAN OFFICE: STUDY ON THE APPLICABILITY OF THE CONCEPT IN A DESIGN COMPANY

Sastre R. M., Saurin T. A., Echeveste M. E. S., de Paula I. C., Lucena R.
Universidade Federal do Rio Grande do Sul, Brazil

This study has explored the applicability of the concepts related to Lean Manufacturing with focus on service areas, specifically in an office specialized in graphic design of packaging. Through a case study it was possible to deploy and analyse the value stream map of the company's overall processes. This map has assisted in identification of waste situations and in proposing improvements in the process. It is concluded that Lean concepts have been presented as promising in a graphic design company and are potentially applicable in creative companies.

DESIGN THINKING CAPABILITY MODEL (DTCM): A FRAMEWORK TO MAP OUT DESIGN THINKING CAPACITY IN BUSINESS ORGANISATIONS

De Paula D., Dobrigkeit F., Cormican K.
National University of Ireland Galway, Ireland

It has been suggested that organisations can derive value from a design thinking (DT) capability. However, there is still a very limited understanding of how to integrate and assess DT strategy. Our study aims to develop a conceptual framework – Design Thinking Capability Model (DTCM) - to map out the DT capability in business organisations. The model was developed based on an exploratory research design combining empirical investigations and industry practice. This study can lead to valuable insights into how having a DT strategy can support competitive advantage in organisations.

ASSESSING INCREASED PRODUCT LINE COMMONALITY'S EFFECT ON ASSEMBLY PRODUCTIVITY AND PRODUCT QUALITY

Løkkegaard M., Mortensen N. H., Jensen L. S., Christensen C. K. F.
Technical University of Denmark, Denmark

We present results of an experiment focused on quantifying effects on assembly productivity and product quality by introducing a product platform and increasing commonality between variants in a product family. The experiment was set up with 50 engineering students, who over three rounds produced a family of LEGO car models. Over the rounds a product platform was introduced and the Commonality Index was increased from 47,8% to 88,4%. Compared to productivity and quality results show an increased output of 118% and a decrease in product defects by 31% when applying a platform-based approach.

PRODUCT ARCHITECTURE TRANSITION IN AN EVOLVING MULTI-BRAND ORGANISATION

REVIEWERS FAVOURITE

Williamsson D., Sellgren U., Söderberg A.
KTH Royal Institute of Technology, Sweden

A modular architecture is a strategic means to deliver external variety and internal commonality. A methodology for product modularization that integrates complexity and strategies is proposed and logically verified with an industrial case from the heavy truck business area. The case study indicates that the new methodology is capable of identifying and proposing reasonable module candidates that address product complexity as well as company specific strategies.

A PRODUCT PLANNING FRAMEWORK FOR MASS-CUSTOMISATION IN CONSTRUCTION

Wee T. P. Y., Aurisicchio M.
Imperial College London, United Kingdom

This paper provides a framework for modular product planning in construction. It integrates tools to support quality and flexibility in design. A case study was carried out on a chilled water modular plant-room. The Quality Functional Deployment (QFD) tool was effective at capturing and analysing the requirements from multiple disciplines. Modularisation was supported by the Dependency Structure Matrix (DSM), Modular Identification Matrix (MIM) and Generational Variance Indexes (GVI). The framework's novelty lies in tools integration to achieve mass-customisation for construction.

PRODUCT VARIETY AND VARIETY IN PRODUCTION

Landahl J., Johannesson H.
Chalmers University of Technology, Sweden

Variety traditionally denotes products that serve a wide range of customer needs. However, variety in production exists too. Like products, production processes and production resources may also embody variety to serve the production fulfillment of a product variety. In this paper, product variety and variety in production are described and contrasted through a literature review. The aim is to serve the engineering design community with an elevated perspective of variety in production and its relation to product variety.

INTEGRATED SYSTEM DESIGN OF A MODULAR, AUTONOMOUS, AERIAL AND GROUND VEHICLE FLEET FOR DISASTER RELIEF MISSIONS - A CASE STUDY

Gärtner A. C., Ferriero D., Bayrak A. E., Papalambros P. Y.
University of Michigan, United States of America

We present a case study for designing a fleet of modular, unmanned aerial and ground vehicles (UAV and UGV) working cooperatively in a disaster relief mission. The study is motivated by the desire to explore the potential benefits of modularity coupled with autonomy. For example, as a result of the synergy between autonomy and modularity at the fleet level, autonomous battery replacement can extend the operation range of aerial vehicles. The study follows a simplified design process from problem definition to prototyping of the modular aerial vehicle as a first step in developing the fleet.

ROBUST DESIGN FOR MECHATRONIC MACHINE ELEMENTS - HOW ROBUST DESIGN ENABLES THE APPLICATION OF MECHATRONIC SHAFT-HUB CONNECTION

Vogel S., Martin G., Schirra T., Kirchner E.
Technische Universität Darmstadt, Germany

This paper discusses the difficulties caused by production precision for a widespread application of sensorial Mechatronic Machine Elements to expand existing machines or designs to Cyber-Physical-Systems. The production induced tolerances lead to an undetermined flow of forces in machine elements and prevent a reliable sensing of forces in Mechatronic Machine Elements. A promising approach to overcome these difficulties is Robust Design, which leads to determined mechanical functions that reduce uncertainty of force measurement in Mechatronic Machine Elements.

PLANNING OF SMART SERVICES BASED ON A REFERENCE ARCHITECTURE

Rabe M., Asmar L., Kühn A., Dumitrescu R.
Fraunhofer IEM, Germany

Smart services are digital services that use data of physical products to create value for users like automatic reordering of consumables. New capabilities of technical systems enable smart services and changing business models like pay-per-use require smart services. The reference architecture considers both and supports the planning of new services around an existing product of manufacturing companies. The contributions shows an approach of smart service building blocks and their combination based on a consistency assessment.

RESILIENT DESIGN PROPERTIES OF A DRIVERLESS TRANSPORT SYSTEM

Wied M., Oehmen J., Welo T.
Technical University of Denmark, Denmark

From its origin in ecology, resilient system properties have attracted wider interest for their applications to man-made systems. Previous research has shown that a simple conceptual model seems to capture much resilience thinking across disciplines and system types. In this paper, we apply that model to study resilient properties in the design and development of an autonomous public transport system, attempting to circumvent the problem of commitment under uncertainty. We identify a number of resilient system properties and classify them by function into six distinct categories.

AN APPROACH FOR THE IMPLEMENTATION OF THE DIGITAL TWIN IN THE AUTOMOTIVE WIRING HARNESS FIELD

Tharma R., Winter R., Eigner M.
Daimler AG, Germany

The importance of continuous and sustainable information exchange processes rises, due to the growing digitalisation in many fields of automotive area. By implementing the Digital Twin method, these challenges can be met in the future. In this paper, the Digital Twin method is discussed in the context of the automotive wiring harness. Different kinds of individual definitions of the Digital Twin are discussed and the methodical meaning is analysed. Furthermore the wiring harness specific requirements for the Digital Twin, caused by the enormous variety, is considered.

DEFICITS IN THE SELECTION OF JOINING PROCESSES FOR CAR BODY DESIGN

Garrelts E., Fabis D., Roth D., Werz M., Binz H., Weihe S.
University of Stuttgart, Germany

The number of different materials used in a single car body is growing, while the complexity involved in selecting joining processes in design is increasing. This paper will review the requirements for joining connections and for methods used to choose joining processes in car body design. Existing approaches will then be evaluated based on these requirements and the identified deficits discussed. Demonstration will be given that a new approach is needed: one which considers costs and different variants and which can estimate properties of joining processes for new material combinations.

AN ONTOLOGICAL FRAMEWORK TO LINK MARKETING AND DESIGN

Casagrande-Seretti A., Montagna F.
Politecnico di Torino, Italy

Communication issues between people with different backgrounds within the product development teams are commonplace. The causes are many, including cultural differences and language barriers. Nevertheless, cooperation between Marketing and Design was proved to be strongly correlated with product success. In this paper, we study an ontological way to overcome this problem. The framework is built on the FBS ontology and refers to Consumer Behaviour theories. It was tested on a set of 77 products.

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Conf. Hall Dubrava Section 1
14:15 16:00

ONTOLOGY-BASED APPROACH FOR THE USE OF INTENTIONAL FORGETTING IN PRODUCT DEVELOPMENT

REVIEWERS FAVOURITE

Kügler P., Kestel P., Schon C., Marian M., Schleich B., Staab S., Wartzack S.
Friedrich-Alexander-Universität Erlangen-Nürnberg, Germany

When reusing product knowledge in design processes, developers have to decide which knowledge elements are relevant for a task. Thus, mechanisms of knowledge removal are vital for a successful reuse, but are not yet assisted by procedure models. This contribution introduces Intentional Forgetting as a methodology of intelligent removal processes in ontological knowledge bases. The aim is to support developers by providing relevant contents for reuse systematically. The development process of a test-rig, that is highly based on knowledge reuse, is considered as use case.

GENERATIVE HERITAGE: DRIVING GENERATIVITY THROUGH KNOWLEDGE STRUCTURES IN CREATIVE INDUSTRIES. LESSONS FROM CUISINE

Carvajal Pérez D., Araud A., Chaperon V., Le Masson P., Weil B.
Mines ParisTech, France

Sometimes, a designer needs to share a “creation heritage” to support the generativity of his pairs, in the form of a book. What should be its content? The literature has shown that knowledge in such books might be fixating or defixating, leading to inconclusive results. Using recent advances in design theories we model the features of a heritage oriented towards generativity. Relying on the literary tradition in Cuisine, we validate our model. We show that transferring knowledge implies sharing objects structure, value criteria, desired unknowns, progress principles, and creative reasoning.

CONCEPTUAL FRAMEWORK FOR ANALYSING KNOWLEDGE DYNAMICS IN ENGINEERING SCIENCE

Märten A., Jenek J. F. W., Wang W. M., Fleck C., Meyer H., Stark R., Ammon S.
Technische Universität Berlin, Germany

Despite increasing knowledge intensity in product development, there is still a lack of understanding regarding the dynamic interrelations of knowledge types, stakeholders and artefacts in value creation processes.This dilemma counts also for engineering science as a discipline. This paper proposes a conceptual framework that allows for the analysis of dynamic knowledge flows in practical design processes and fundamental engineering research. Results from exemplary applications on two use cases will be used to illustrate its overall applicability and its potentials for science and industry.

BIG DATA ANALYSIS AS A NEW APPROACH FOR USABILITY ATTRIBUTES EVALUATION OF USER INTERFACES: AN AUTOMOTIVE INDUSTRY CONTEXT

Orlovska J., Wickman C., Söderberg R.
Chalmers University of Technology, Sweden

The growth of digital technologies dramatically increased the complexity of user interfaces in modern cars that made the usability evaluation an arduous task. Current usability evaluation methods cannot provide sufficient information about a user and system performance for such a complex and dynamic environment as automotive user interfaces. In this paper, we investigate how and to what extent the big data analysis can contribute to the usability attributes evaluation. We present the case study design for usability evaluation of Driver Support system, validated by the industry professionals.

ROBOT ERGONOMICS: TOWARDS HUMAN-CENTRED AND ROBOT-INCLUSIVE DESIGN

Sosa R., Montiel M., Sandoval E. B., Mohan R. E.
Auckland University of Technology, New Zealand

This paper presents a cross-disciplinary approach to the design of robots and the designed environments they will inhabit and the objects they will operate in applications of social and service robotics. Such an approach brings together roboticists, architects, product, and interior designers in realizing new ways of collaboration to design innovative spaces and products that are ergonomically designed for diverse users as well as for robots. A design paradigm is proposed for realizing successful robot-inclusive designs using a case study of door handles to test our robot ergonomic principles.

EVALUATING THE IMPACT OF DESIGN AFFORDANCES IN PRESCHOOL CHILDREN'S TOY PREFERENCES

Balzan E., Farrugia P., Casha O., Wodehouse A.
University of Malta, Malta

The role of toys in early childhood intervention is crucial for children to acquire and improve their skills. A study with preschool children has been carried out in order to establish, from a product design perspective, how toys' innate characteristics trigger toy preferences. It was found that children's preference is presided by the play value that is perceived. By exploiting hedonic and pragmatic qualities, designers can embed persuasive qualities in toys. A framework for toy design is proposed as a model for a computer-aided support tool that helps toy designers reach their design goal.

DESIGN OPTIMIZATION FOR INTERACTIVE PARENT-CHILD CLOTHING: INTEGRATION OF IOT TECHNOLOGY ENTITIES AND EMOTIONAL VIRTUAL BODIES

Wang W. Z., Nagai Y., Fang Y., Qiao C. X., Chen Y. P.
Japan Advanced Institute of Science and Technology, Japan

In academia, this paper expounds the development trend of the interactive clothing through the inference of the pyramid hierarchy model in psychology, sociology and the data evolution theory. In practical, through the design of prototypes and the evaluation of Kansei engineering to demonstrate the characteristics of interactive parent-child clothing, validated the necessity of combining emotional design with high-tech application, provides a practical approach to realize the IoC (internet of clothes) cycle for the coming age of ubiquitous intelligent IoT applications.

TRI-WHEEL STAIR WALKER: DESIGN PROPOSAL OF AUXILIARY WALKER USABLE AT DISTRICT INCLUDING STAIRWAY

Le M., Jung E.-C.
Seoul National University, Republic of Korea

This study is to suggest a new auxiliary walker which 1) can be used not only on flat but also in real urban environments; 2) can be used without psychological burden when going outside; and 3) can be manufactured with low cost to improve the mobility of the elderly and to lead to a healthy and pleasurable life. We investigated the characteristics of the movement of the elderly and proposed the design concept Tri-Wheel Stair Walker based on interviews with and observation of elderly users. The concept is expected to be a safe and cheap solution to the door-to-door mobility in a smart city.

SIMULATING MULTISENSORY WINE TASTING EXPERIENCE

Carulli M., Bordegoni M., Ferrise F., Gallace A., Gustafsson M., Pfuhl T.
Politecnico di Milano, Italy

In this paper, we present the development of an application that allows us to simulate the multisensory experience of tasting a glass of wine. To this end, technologies for the sense of touch, sight, hearing, and smell have been integrated, creating an interactive multi-sensory experience. The user, after picking up a glass, activates an application in which he is guided by a virtual sommelier to make a tasting, and he is able to perceive the multi-sensory experience of the wine tasting experience. The paper describes the application and its potential use in marketing.

PLENARY SESSION IV

BUILDING A DESIGN COMMUNITY: SCIENCE, RESEARCH, EDUCATION, AND PRACTICE

Panos Y. Papalambros
University of Michigan (United States of America)

The design appears in all aspects of human endeavour and has many stakeholders with diverse viewpoints. Diversity can mean division, but there is unity in our common recognition that design is how humans change the world. Design Science studies the creation of artefacts and their embedding in our physical, psychological, economic, social and digital environment.

Design science research aims to deepen our understanding of wicked problems in a technology-driven society and to contribute to their positive resolution. Design education is how we propagate such knowledge. Design practice informs, motivates, and realizes the benefits of this knowledge. We discuss some examples of design science research, education, and scholarly communication across disciplines; and we explore avenues for building a broader design community beyond traditional disciplinary boundaries.

BIOGRAPHICAL SKETCH

Panos Y. Papalambros is the James B. Angell Distinguished University Professor and the Donald C. Graham Professor of Engineering at the University of Michigan with appointments in Mechanical Engineering, Architecture and Urban Planning, Art and Design, and Integrative Systems & Design where he serves as chair. His pedagogical and research interests include design science and optimization, with applications to the sustainable design of products, automotive systems, such as hybrid and electric vehicles; design of complex engineered systems; and architectural design. With D. J. Wilde, he co-authored the textbook Principles of Optimal Design (3d Ed., 2017). He is past chief editor of the ASME Journal of Mechanical Design and currently serves as Editor-in-Chief of the Design Science journal and as President of the Design Society.

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