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BOOK OF ABSTRACTS

17TH INTERNATIONAL DESIGN CONFERENCE

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EDITORS Mario Štorga, Stanko Škec, Tomislav Martinec, Marija Majda Perišić, Dorian Marjanović

BOOK OF ABSTRACTS

DESIGN 2022

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17th INTERNATIONAL DESIGN CONFERENCE
ONLINE MAY 23-26, 2022 - DESIGNCONFERENCE.ORG

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All the papers submitted for the DESIGN 2022 conference have been reviewed by at least two members of the Scientific Advisory Board.

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DESIGN 2022 – BOOK OF ABSTRACTS

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Stanko Škec
Tomislav Martinec
Marija Majda Perišić
Dorian Marjanović

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It has been four years since our last meeting in Dubrovnik. We hoped that the previous – virtual - conference would be an anomaly. But unfortunately, we were in the same uncertain position this year and had to make the difficult decision to host the conference online one more time. We hope to go back to our usual way of running DESIGN conferences in 2024, providing networking opportunities and a friendly, community-building atmosphere that has always been a trademark of the DESIGN conferences.

Most of the discussions of the organising team and the Programme Chairs in the past two years have been centred around pandemics, changing our way of working, doing research, networking, and communicating. Although some positive trends will probably stay with us in the post-pandemic period, what cannot be overlooked is that as a research society, we are missing social engagement. Since we last met onsite, we have witnessed the generation change - retirements of several of our regular participants, members of the scientific advisory board, and programme chairs. We have also missed the whole generation of new PhD students that will finalise their thesis without participating in onsite international events and being able to present their work to the broader community.

More than 15% of DESIGN 2022 participants are from the Americas, Asia, or Australia. Thus, we tailored the programme to accommodate the many American delegates at the one end of the time spectrum and the Asian and Australian delegates at the other end. We are delighted to welcome them all to the conference, making it a truly global event.

When preparing the conference programme, we also noticed shifts in research focus. The topics that were emerging two or four years ago now are represented with a respectable number of contributions. In addition to the traditional themes like design theory, design support tools and methods, human behaviour in design, and design education, we have AI and data-driven design, design for additive manufacturing, design for sustainability, and design for healthcare as dominant topics for DESIGN 2022. These topics align with the general trends we are witnessing where digitalisation, digital technology and digital transformation are the underlying factors for many public sectors and industries focused on technology that works for people, a fair and competitive economy and an open, democratic and sustainable society. It is great to see that the research to be presented at DESIGN 2022 reflects those goals. We are looking forward to the transformation of the research papers into presentations, discussions and building new knowledge during conference sessions.

The papers presented at DESIGN 2022 Online are published with open access in the Proceedings of the Design Society: DESIGN Conference, ISSN: 2732-527X by Cambridge University Press.

On behalf of the DESIGN 2022 organising team, thank you for staying with the conference and for your support and participation.

Mario Štorga
DESIGN 2022 Conference Chair


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CONFERENCE VENUE

The DESIGN 2022 Online conference will take place at the hopin.to virtual event service.

GENERAL SCHEDULE

DESIGN 2022 WORKSHOPS

MONDAY, MAY 23RD, 2022 — 13:15 – 17:15 CET

DESIGN 2022 MAIN EVENT

TUESDAY, MAY 24TH – THURSDAY, MAY 26TH, 2022 — 12:15 - 17:30 CET

SPECIAL EVENTS

with pre-recorded video messages

OPENING SESSION — MONDAY, MAY 23RD, 2022 — 12:45-13:15 CET

A Word Before
Mario Štorga, University of Zagreb (HR), DESIGN 2022 Conference Chair

The Design Society Welcome Address
Tim C. McAloone, Technical University of Denmark (DK),
President of the Design Society, DESIGN 2022 Programme Chair

Presentation of the DS Fellow 2022 Award

PRE-SESSION GATHERING — TUESDAY, MAY 24TH, 2022 — 12:00 – 12:15 CET

Introduction to Conference Day
P. John Clarkson, University of Cambridge (UK), DESIGN 2022 Programme Chair

PRE-SESSION GATHERING — WEDNESDAY, MAY 25TH, 2022 — 12:00 – 12:15 CET

Introduction to Conference Day
Julie Stal-Le Cardinal, CentraleSupélec (FR), DESIGN 2022 Programme Chair

PRE-SESSION GATHERING — THURSDAY, MAY 26TH, 2022 — 12:00 – 12:15 CET

Introduction to Conference Day
Sandro Wartzack, Friedrich-Alexander-Universität Erlangen-Nürnberg (DE),
DESIGN 2022 Programme Chair

CLOSING — THURSDAY, MAY 26TH, 2022 — 17:30 – 18:00 CET

A Word After
Dorian Marjanović, University of Zagreb (HR),
DESIGN 2022 Programme Chair

Closing Remarks
Mario Štorga, University of Zagreb (HR),
DESIGN 2022 Conference Chair

SOCIAL EVENTS

Virtual social events will take place after the last session of the day on Tuesday to Thursday in gather.town! Time zone: Zagreb local time - CET!

PROGRAMME

MONDAY, MAY 23, 2022

CET 12:45 — D1-O: DESIGN 2022 OPENING - VIRTUAL STAGE

CET 13:15 — D111: BRIDGING CREATIVITY PRACTICE AND THEORY: OPPOSITES ATTRACT VR 1 | D112: CHANGING PARADIGMS FOR MANAGING PRODUCT DEVELOPMENT PROCESSES VR 2 | D113: SUSTAINABLE DESIGN FOR ADDITIVE MANUFACTURING VR 3 | D114: UNDERSTANDING SCIENTIFIC AND PRACTICE-BASED QUESTIONS FOR DESIGN NEUROCOGNITION RESEARCH VR 4

CET 16:30 — D121: RESEARCH AND TEACHING WITH ONSHAPE - VR 10

CET 17:15

TUESDAY, MAY 24, 2022

CET 12:00 — D2-O: PRE-SESSION GET-TOGETHER - VIRTUAL STAGE

CET 12:15 — D211: DATA-DRIVEN METHODS FOR EARLY DESIGN PHASES VR 1 | D212: DESIGN PROCESS TRANSFORMATIONS FOR INDUSTRY 4.0 VR 2 | D213: SYSTEM APPROACH TO HEALTHCARE DESIGN VR 3

CET 13:30 — REFRESHMENT BREAK

CET 13:45 — D2-P: PLENARY SESSION I - VIRTUAL STAGE

CET 14:30 — REFRESHMENT BREAK

CET 14:45 — D221: AI ROLE IN DESIGN TEAMS VR 1 | D222: PROJECT MANAGEMENT VR 2 | D223: HEALTHCARE DESIGN PROCESSES VR 3

CET 16:00 — REFRESHMENT BREAK

CET 16:15 — D231: DESIGN CHANGE MANAGEMENT VR 1 | D232: DESIGN PROCESS MODELS VR 2 | D233: HEALTHCARE CASE STUDIES VR 3

CET 17:30 — D2-S: SOCIAL GATHERING I - SOCIAL EVENT ROOM

CET 19:00

WEDNESDAY, MAY 25, 2022

CET 12:00 — D3-O: PRE-SESSION GET-TOGETHER - VIRTUAL STAGE

CET 12:15 — D311: DIGITAL TWIN VR 1 | D312: COGNITIVE STUDIES IN DESIGN VR 2 | D313: CIRCULAR ECONOMY: METHODS AND TOOLS - VR 3

CET 13:30 — REFRESHMENT BREAK

CET 13:45 — D321: AUTOMATED DESIGN OPTIMISATION FRAMEWORKS VR 1 | D322: DISTRIBUTED COLLABORATION VR 2 | D323: CIRCULAR ECONOMY: DESIGN FOR LONGEVITY VR 3

CET 15:00 — REFRESHMENT BREAK

CET 15:15 — D3-P: PLENARY SESSION II - VIRTUAL STAGE

CET 16:00 — REFRESHMENT BREAK

CET 16:15 — D331: APPLICATION OF MACHINE LEARNING METHODS - VR 1 | D332: AGILE MANAGEMENT APPROACHES VR 2 | D333: SUSTAINABILITY TRANSITION VR 3

CET 17:30 — D3-S: SOCIAL GATHERING II - SOCIAL EVENT ROOM

CET 19:00

THURSDAY, MAY 26, 2022

CET 12:00 — D4-O: PRE-SESSION GET-TOGETHER - VIRTUAL STAGE

CET 12:15 — D411: DESIGN DIGITALISATION APPROACHES VR 1 | D412: DESIGN FOR ADDITIVE MANUFACTURING I VR 2 | D413: PRODUCT-SERVICE SYSTEMS VR 3

CET 13:30 — REFRESHMENT BREAK

CET 13:45 — D4-P: PLENARY SESSION III - VIRTUAL STAGE

CET 14:30 — REFRESHMENT BREAK

CET 14:45 — D421: REQUIREMENTS AND CHALLENGES IN DEVELOPING COMPLEX SYSTEMS VR 1 | D422: DESIGN FOR ADDITIVE MANUFACTURING II VR 2 | D423: SUSTAINABILITY AWARENESS VR 3

CET 16:00 — REFRESHMENT BREAK

CET 16:15 — D431: AUTONOMOUS VEHICLES AND ELECTROMOBILITY VR 1 | D432: DESIGN FOR ADDITIVE MANUFACTURING III VR 2 | D433: SYSTEM DESIGN TOOLS VR 3

CET 17:30 — D4-C: DESIGN 2022 CLOSING - VIRTUAL STAGE

CET 18:00 — D4-S: SOCIAL GATHERING III- SOCIAL EVENT ROOM

CET 19:00

PROGRAMME

MONDAY, MAY 23, 2022

CET 12:45

CET 13:15

D115: HOW TO 'INTENTIONALLY DESIGN' PSS TO FOSTER RESPONSIBLE CONSUMPTION? VR 5

D116: A MODEL FOR SUCCESSFUL COLLABORATIVE ENGINEERING DESIGN: COMPLETING THE CAUSAL LOOP VR 6

D117: DIGITAL TWINS VR 7

D118: HEALTH SYSTEMS DESIGN: PEOPLE, INFORMATION AND TECHNOLOGY VR 8

D119: EXPLORING MODALITIES OF MUTUAL LEARNING FOR GLOBAL SUSTAINABLE DEVELOPMENT VR 9

CET 16:30

CET 17:15

TUESDAY, MAY 24, 2022

CET 12:00

CET 12:15

D214:DESIGN CREATIVITY STUDIES VR 4

D215: SOCIAL RELATIONSHIPS AND EMOTIONAL DESIGN VR 5

D216: DESIGN FOR X VR 6

CET 13:30

CET 13:45

CET 14:30

CET 14:45

D224: FINDING NEW PATHS IN DESIGN RESEARCH - VR 4

D225: VISUAL AND HAPTIC INTERACTIONS WITH PRODUCTS - VR 5

D226: TOPOLOGY OPTIMISATION AND SIMULATION - VR 6

CET 16:00

CET 16:15

D234: DESIGN EVALUATION CRITERIA VR 4

D235: CO-DESIGN AND CO-CREATION VR 5

CET 17:30

CET 19:00

WEDNESDAY, MAY 25, 2022

CET 12:00

CET 12:15

D314: SYSTEMS ENGINEERING PROCESSES VR 4

D315: ENGINEERING DESIGN CASE STUDIES - VR 5

D316: USER-CENTRED DESIGN VR 6

CET 13:30

CET 13:45

D324: MODEL-BASED SYSTEMS ENGINEERING VR 4

D325: DESIGN FOR PRODUCT FAMILIES VR 5

D326: PROTOTYPING TOOLS VR 6

CET 15:00

CET 15:15

CET 16:00

CET 16:15

D334: INDUSTRIAL CASE STUDIES VR 4

D335: MODULARISATION STRATEGIES AND EXAMPLES - VR 5

CET 17:30

CET 19:00

THURSDAY, MAY 26, 2022

CET 12:00

CET 12:15

D414: KNOWLEDGE-BASED DESIGN VR 4

D415: ANALYSING AND TEACHING SKILLS/COMPETENCIES VR 5

D416: SEMANTICS AND PERCEPTION IN INDUSTRIAL DESIGN VR 6

CET 13:30

CET 13:45

CET 14:30

CET 14:45

D424: KNOWLEDGE-BASED APPLICATIONS VR 4

D425: ADAPTATION OF EDUCATION TO PANDEMIC AND OTHER CHALLENGES - VR 5

D426: MODEL-BASED ERGONOMICS VR 6

CET 16:00

CET 16:15

D434: EXPLORING TECHNICAL AND CUSTOMER DATA FOR IMPROVED PRODUCTS VR 4

D435: NEW TRENDS IN DESIGN EDUCATION VR 5

D436: INDUSTRIAL DESIGN CASES VR 6

CET 17:30

CET 18:00

CET 19:00

12:45 CET

D1-O: DESIGN 2022 OPENING - VIRTUAL STAGE

A Word Before: Mario Štorga, University of Zagreb (HR), DESIGN 2022 Conference Chair

The Design Society Welcome Address: Tim C. McAloone, Technical University of Denmark (DK), President of the Design Society, DESIGN 2022 Programme Chair

Presentation of the DS Fellow 2022 Award

13:15 CET

D111 BRIDGING CREATIVITY PRACTICE AND THEORY: OPPOSITES ATTRACT

Virtual Room 1

Chairs:
Milene Gonçalves
with the participation of Ir. Katrina Heijne, as the creative facilitator

D112 CHANGING PARADIGMS FOR MANAGING PRODUCT DEVELOPMENT PROCESSES

Virtual Room 2

Chairs:
Kilian Gericke
Claudia Eckert

D113 SUSTAINABLE DESIGN FOR ADDITIVE MANUFACTURING

Virtual Room 3

Chairs:
Yuri Borgianni
Jeremy Faludi
Sophie Hallstedt
Steven Hoffenson
Daniela Pigosso
Serena Graziosi
Tino Stanković

D114 UNDERSTANDING SCIENTIFIC AND PRACTICE-BASED QUESTIONS FOR DESIGN NEUROCOGNITION RESEARCH

Virtual Room 4

Chairs:
Laura Hay
Phillip Cash

16:30 CET

D121: RESEARCH AND TEACHING WITH ONSHAPE

Virtual Room 10

Chair: Stanko Škec
Session facilitator: Matthew Mueller

17:15 CET

12:45 CET

13:15 CET

D115 HOW TO 'INTENTIONALLY DESIGN' PSS TO FOSTER RESPONSIBLE CONSUMPTION?

Virtual Room 5

Chairs:
Marco Bertoni
Yong Se Kim

D116 A MODEL FOR SUCCESSFUL COLLABORATIVE ENGINEERING DESIGN: COMPLETING THE CAUSAL LOOP

Virtual Room 6

Chairs:
Robert Ian Whitfield
Ross Brisco

D117 DIGITAL TWINS

Virtual Room 7

Chairs:
Ola Isaksson
Eckhard Kirchner

D118 HEALTH SYSTEMS DESIGN: PEOPLE, INFORMATION AND TECHNOLOGY

Virtual Room 8

Chairs:
P. John Clarkson
Anja Maier

D119 EXPLORING MODALITIES OF MUTUAL LEARNING FOR GLOBAL SUSTAINABLE DEVELOPMENT

Virtual Room 9

Chairs:
Panos Y. Papalambros
Margareta Norell Bergendahl
Susanne Carin Nilsson
Bernard Shibwabo Kasamani

16:30 CET

17:15 CET

D111: WORKSHOP 1

BRIDGING CREATIVITY PRACTICE AND THEORY: OPPOSITES ATTRACT

Chair:
Milene Gonçalves (Delft University of Technology, NL)
with the participation of Ir. Katrina Heijne, as the creative facilitator (Delft University of Technology, NL)

Organised by: DS Design Creativity SIG

We can trace the origins of scientific creativity research back to the moment when Guilford gave his acceptance speech as the new president of the American Psychological Association. From that speech onwards, the study of creativity has become a respectable scientific field and sparked the interest of many researchers, including us in the present moment. Surprisingly, it is also from that point onwards that a divide started to emerge between the theoretical study of creativity and its practice and implementation. On one hand, scientific research, first on Psychology, then in Engineering and Design (among many other fields), has been very prolific in understanding, describing and explaining phenomena related to the creation of ideas; on the other hand, the American Buffallo Creative Problem Solving Institute (CPSI) and the subsequent European Integrated Creative Problem Solving (ICPS) have burst forward with their own developments on practical approaches to come up with ideas.

However, very little overlap exists between these two communities. Even though they had the same starting point, theory and practice tend to distance themselves, sometimes even disagreeing on certain topics, or not keeping updated on the other community's developments. This results in a potentially enormous loss of shared knowledge.

The motivation for this workshop is then to bridge creativity practice and theory, by facilitating in a creative session the translation of commonalities and differences that might exist in the two communities. Creative facilitation is a particularly relevant topic to focus on, considering that very few studies have shed light in understanding the nuances of facilitation and its influence on the creation of ideas in teams.

As such, we have the following goal: Explore in which ways can creativity theory and practice learn from each other, specifically during creative facilitation practices.

Workshop activities:

- Creative facilitation session: A number of participants (the resource group) will experience first-hand a creative session, ran by a professional facilitator, while others will take the role of observers, highlighting creativity phenomena that emerges. Special attention should be taken on the role and behaviour of the creative facilitator and the resource group.
- Group reflection: depending on the number of participants, the size of the groups will be formed accordingly.
- Plenary discussion, to define a research agenda

Expected outcome: The potential outcome of the workshop is three-folded:

- Creation of a research agenda, which pinpoints possible gaps in knowledge coming from theory and practice.
- A report with the main findings and recommendations for following workshops.
- A follow-up publication, to be submitted in the IJDCI.

D112: WORKSHOP 2

CHANGING PARADIGMS FOR MANAGING PRODUCT DEVELOPMENT PROCESSES

Chairs:
Kilian Gericke (University of Rostock, DE)
Claudia Eckert (Open University, UK)

Organised by: DS Design Process SIG

In the last decades product development processes were dominated by a stage-gate paradigm. As technology and products have evolved, the composition of teams and required expertise have changed and many company think that stage-gate processes are no longer appropriate or sufficient to manage design processes in the available time and with the available resources.

New management approaches such as agile development, scaled agile, dev-ops seem to offer solutions to problems encountered in stage-gate environments. However, they also have their own limitations especially when used in a new context.

We would like to invite practitioners and researchers to participate in this workshop to discuss the future trends of product development processes. We aim to initiate an exchange between participants and want to discuss experiences and observations. The workshop will address our current understanding of different approaches for managing product development processes including their individual strengths and limitations.

Workshop plan:

- Presentation of SIG activities
- Introduction
- Presentations and discussion
- Challenges of current process modelling and management paradigms
- Workshop on experiences and trends in industry
- Conclusions & next steps

D113: WORKSHOP 3

SUSTAINABLE DESIGN FOR ADDITIVE MANUFACTURING

Chairs:
Yuri Borgianni (Free University of Bozen|Bolzano, IT)
Jeremy Faludi (Delft University of Technology, NL)
Sophie Hallstedt (Blekinge Institute of Technology, SW)
Steven Hoffenson (Stevens Institute of Technology, US)
Daniela Pigosso (Technical University of Denmark, DK)
Serena Graziosi (Politecnico di Milano, IT)
Nicholas Alexander Meisel (The Pennsylvania State University, US)
Tino Stanković (ETH Zurich, CH)

Organised by: DS Sustainable Design and Design for Additive Manufacturing SIGs

Session D113

Virtual Room 3

CET 13:15
CET 16:30

23 May

MON

Recent advances in digital fabrication are expanding the limits of fabricable real-world designs. They also strengthen the need for novel Additive Manufacturing (AM) technologies for applications across all length scales and fields, from fundamental science to engineering practice. However, although AM technology development is gaining attention, how designers should exploit the advancements in digital fabrication to design for sustainability has not yet been sufficiently explored in the design research field. So far, the literature limits itself mostly to successful applications of AM technologies and computational approaches to design complex lightweight parts, where AM provides an environmental benefit.

This lack of emphasis on sustainability is also a consequence of AM materials and technologies' rapid and continuous evolution. We are more focused on exploring their design potential rather than understanding when it is worth adopting them and how much resources are necessary. Besides, the digital transformation, where AM plays a fundamental role, has shortened development processes: making informed design decisions is becoming even more challenging. In such an era of responsibility, how should design tools evolve to support Design for AM experts in understanding the environmental impact of their choices?

The key questions:

- How should we redesign AM processes and materials for sustainability?
- How should we track impacts of AM, sustainable design approaches? How do we know (predict) whether our decisions are beneficial?
- Do we need new design tools to support sustainable Design for AM decisions?
- What is the role of the designer in AM for sustainable design?

With these key questions in mind, we have structured the workshop in order to:

- Provide the collaboration points for both Sustainable Design and DfAM SIG communities, as well as other interested members of the DS
- Discuss the opportunities to design for sustainability using AM.
- Discuss a reference point to establish the requirements needed to support sustainable Design for AM.
- Gather and process data from a case study in which the workshop participants will be asked to redesign (or assess) AM parts from a sustainability point of view.

During the workshop, the participants will discuss and propose answers to the guided questions. The discussion will be fostered by a series of design talks on the state-of-the-art in related topics.

D114: WORKSHOP 4

UNDERSTANDING SCIENTIFIC AND PRACTICE-BASED QUESTIONS FOR DESIGN NEUROCOGNITION RESEARCH

Chairs:
Laura Hay (University of Strathclyde, UK)
Phillip Cash (Technical University of Denmark, DK)

Organised by: DS Cognitive Design Science SIG

Increasing attention is being paid to the potential of neurocognitive methods for analysing design work, reflected in a proliferation of 'neuro-' articles, special issues, conference tracks, and Special Interest Groups. However, while enthusiasm for such novel methods is evident, and their potential distinct from traditional approaches, a critical lack of clarity remains regarding what scientific and design practice questions such methods can and should be used to answer.

Such methods face major challenges in their implementation, interpretation, and cost. These demand robust justification for their efficacy, beyond traditional approaches, and pose a question of when and where such methods can best be used to contribute to design knowledge. Without this clarity in when, where, and how neurocognitive methods can best contribute to advancing design knowledge they run the risk of becoming a methodological novelty that does not deliver on its potential, and hinders rather than helps efforts to translate design insights into scientific and real-world impact. Thus, to realise the full potential of these methods it is necessary to, as a community, take a step back from questions of implementation and description, and seek to identify where best such methods can be used to create scientific and real-world impact.

Given the above need, this workshop aims to identify the major practice-based and scientific challenges where neurocognitive methods could allow for paradigm shifts in understanding not achievable via traditional approaches. The workshop will open with four short provocative presentations from experts in neurocognitive methods, design theory and practice, as well as from the neurocognition community. This will then be used as the basis for three facilitated discussions: identification of major scientific questions; identification of major practice-based questions; and distillation of the implications these pose for the future of neurocognitive methods in design research. These will be hybrid in-person/online to allow international participation and widespread impact within the community.

The target audience is both design cognition/neurocognition researchers, as well as design researchers dealing with human focused processes and theory, such as creativity and teamwork, where neurocognitive methods could disrupt current understanding.

The expected outcome of the workshop is a Miro board and encapsulation of key questions to be addressed by the field. It is envisaged that this could provide a jumping off point for further workshops, as well as potential for future special issues or thematic collections. Further, the outcome will provide a concrete foundation for future SIG activities.

D115: WORKSHOP 5

HOW TO 'INTENTIONALLY DESIGN' PSS TO FOSTER RESPONSIBLE CONSUMPTION?

Chairs:
Marco Bertoni (Blekinge Institute of Technology, SW)
Yong Se Kim (University of Turku, FI)

Organised by: DS Design of Product-Service Systems SIG

PSS are often celebrated for their potential to reduce environmental impacts by diminishing resource consumption, raw material extraction and waste generation. By transitioning from to selling the benefits of a product rather than the actual product, some claim that companies are naturally eager to design for longevity, repair, recycling and remanufacturing - all of which entail improved overall environmental performance. Yet, PSS solutions do not always render such sustainability 'gains'. For instance, many have observed that, when placed in a Product-as-a-Service business, products tend to last much less than their 'one-sale' counterpart, e.g. due to misuse and vandalism. Take-back systems have also been observed not to work as expected, often because the value of returning the hardware to the provider is not clear to the user.

The main goal of this workshop is to investigate the issue of how to 'intentionally design' PSS in a way to promote responsible consumption and resource preserving behaviours among consumers – two aspects that are discussed today by the research community as being the most significant contributors to sustainable development. The workshop targets both senior researchers and young investigators, featuring a mix of activities in a plenary session and in smaller groups. The workshop will kick-off with a keynote reviewing the concept of 'responsible consumption', showing examples of unsustainable PSS, followed up by a panel discussion on how PSS design activities are seen to affect consumer behaviour (alternatively, on how PSS can be designed to affect consumer behaviour and to provide consumer-led experiences that will foster responsible consumption with active engagement). Participants will be then divided in smaller groups – and provided with prototypical PSS 'cases' – to discuss more in detail how Product-Service Systems shall be 'intentionally designed' to foster responsible consumption. The results of the workshop will be summarized in form of a short white paper, as well as in form of a video that will be shared on YouTube and on the SIG webpage (pss.designsociety.com).

Session D115

Virtual Room 5

CET 13:15
CET 16:30

23 May

MON

D116: WORKSHOP 6

A MODEL FOR SUCCESSFUL COLLABORATIVE ENGINEERING DESIGN: COMPLETING THE CAUSAL LOOP

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

Organised by: DS Collaborative Design SIG

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 run a series of workshops over recent years that have focussed on eliciting the factors that influence success within collaborative engineering design. The output of these workshops reflected the opinions of attendees that were grouped together, and more recently consolidated across all of the output into themes and contributing elements.

The focus of this series of workshops was to work towards the development of a causal loop diagram to illustrate the interconnectivity of the elements that have been captured to date. A draft causal loop of the factors that influence successful collaborative engineering design has been developed using the output from these workshops. The focus of the proposed workshop for DESIGN'22 will be to share this causal loop diagram within the workshop, and then critique and validate the relationships that it contains.

The workshop will consist of the following activities:

- Brief introduction to the CDSIG and overview of the focus and outcome of previous workshops.
- Presentation of the consolidated and themed influencing factors, and draft causal loop.
- Splitting into groups to critically assess proposed relationships, validating where appropriate, and identification and proposal of gaps.
- Identification of balancing and reinforcing loops.
- Wrap up and conclusion.

Participation will be entirely voluntary, and ethical data collection practices will be adopted throughout the experiment.

D117: WORKSHOP 7

DIGITAL TWINS

Chairs:
Ola Isaksson (Chalmers University of Technology, SW)
Eckhard Kirchner (Technical University of Darmstadt, DE)

Organised by: DS Design Practice SIG

Agenda:

- Inspiration Talks: SEW AG (Germany), Volvo Trucks (Sweden), :em AG (Germany), FAU Erlangen (Germany), University of Bristol (UK), Chalmers (Sweden)
- Workshop in groups
- Plenary discussion on the outcome
- Follow Up
- Expected Take Away: …publication, plan for conference, round table, potential partnerships

The workshop will address the current 'hot topic' of Digital Twins. This is of great interest to researchers and practitioners alike.

The goal of the workshop is in line with the SIG mission and that is to bring academics, practitioners and students together to determine the current benefits and challenges of digital twins in practice, and to reveal the most pressing research questions to be addressed by academics. Some candidate questions include:

- What is a Digital Twin? Definition
- Current Research?
- How is it used and what are the current needs in industry?
- Opportunities and Challenges
- Evidence and best practices
- Gaps and way forward
- Getting into application of Digital Twins

The workshop will be moderated and facilitated by Design Practice SIG members.

A panel of distinguished and active researchers and practitioners will give a short presentation and then be asked to address pressing questions on this topic. Groups of attendees will be formed to address specific questions with a view to bring back a report to the group. The feedback will be synthesized into an article that will be published in an appropriate form. Continue the discussion in the DS Design Practice SIG.

D118: WORKSHOP 8

HEALTH SYSTEMS DESIGN: PEOPLE, INFORMATION AND TECHNOLOGY

Chairs:
P. John Clarkson (University of Cambridge, UK)
Anja Maier (University of Strathclyde, UK)
Maaike Kleinsmann (Delft University of Technology, NL)

Organised by: DS Health Systems Design SIG

This workshop will explore the nature of health systems from the perspective of different national examples. With a focus on people, the discussions will be on the roles of information, technology and their relation to people and implications for a systems approach to design. The workshop will draw on the abundance of design knowledge and expertise within the Design Society and the clinical and health perspectives of non-DS members attending from our international meetings on Health Systems Design Research (HSDR). The workshop will be a combination of presentations, activities, and discussions. Plenty of time will be allowed for useful dialogue between the multiple disciplines and perspectives that we anticipate in attendance.

The Health Systems Design SIG was launched at DESIGN2020. The SIG is motivated by the fact that health is a critical component of every society and faces important challenges across the globe. Like the Design Society, the SIG embraces The United Nations Sustainable Development Goals (SDGs). The work of the SIG is in line with the third SDG on ensuring healthy lives and promoting well-being for all at all ages. However, our interest in a systems approach, technology, people, and information means that we see several of the SDGs as interconnected. For example, good health is fundamental to one's ability to get the needed education (SDG 4) and therefore have access to a meaningful occupation (SDG 7), leading to reduced poverty (SDG 1) and hunger (SDG 2). This understanding drives our desire to engage with a wide range of disciplines as exemplified in our international meetings and the Africa Design initiative within the Design Society. Such collaborations are also in line with SDG 17.

Agenda for the workshop is as follows:

- Welcome and introduction
- SIG update from the steering committee
- Presentation 1: Health Systems Design - Exploring perspectives
- Activity 1
- Presentation 2: Health Systems Design - People, Information & Technology
- Activity 2
- Open discussions
- Summary and next steps

Expected outcome of the workshop:

- A better understanding of the variations in health systems
- Valuable insights relevant to the opening chapters of the SIG book on Health Systems Design

Session D118

Virtual Room 8

13:15 CET
16:30 CET

23 May

MON

D119: WORKSHOP 9

EXPLORING MODALITIES OF MUTUAL LEARNING FOR GLOBAL SUSTAINABLE DEVELOPMENT

Chairs:
Panos Y. Papalambros (University of Michigan, US)
Margareta Norell Bergendahl (KTH Royal Institute of Technology, SW)
Susanne Carin Nilsson (KTH Royal Institute of Technology, SW)
Bernard Shibwabo Kasamani (Strathmore University, KE)

Organised by: DS Africa-Design Initiative

Session D119
Virtual Room 9
CET 13:15
CET 16:30
23 May
MON

The proposed workshop builds on a particular finding of previous workshops at ICED 2019, DESIGN 2020, and ICED 2021: the need for mutual learning activities on design for sustainable development across countries and regions. As an example, previous workshop discussions led to the launch of Barazas, community-driven series of regular events where members of the design community take the leading role to plan out and hold a baraza (Swahili word for a public meeting place) in their own style. The first Baraza is on Health Care Systems Design for Sustainability on 10 Nov. 2021. Other modalities of mutual learning have been discussed including workshops, short courses, on-site local events, knowledge repositories, and leveraging multi-society activities where the design Society is a partner. The emphasis is on two-way learning across all participants in such events.

The workshop's objectives are: (i) brainstorm different modalities of mutual learning, from traditional education modes to innovative ones that make use of community resources and evolving technologies; (ii) prioritize such event modalities for the short and long term; (iii) develop an actionable plan and identify global teams that can undertake specific learning events.

Preceding the workshop, we will invite the community to submit ideas in the form of short presentations or white papers. These will be incorporated into the program to seed discussions and brainstorming sessions.

Some specific topics to be addressed are:

- Learning experiences from Barazas conducted prior to the DESIGN workshops
- Topics for future Barazas and events in other modalities
- Coordinating with DS SIG events such as webinars and workshops
- Taking advantage of the new DS Exchange of instructional design modules
- Joint events between the DS and INCOSE
- Connecting, coordinating and co-sponsoring events by other organizations, such as academic institutions, business groups, and non-profits.

D121

RESEARCH AND TEACHING WITH ONSHAPE

Chair:
Stanko Škec (University of Zagreb, HR)
Session facilitator: Matthew Mueller, Manager of Education Innovation (PTC Education, US)

Organised by: PTC Education

In addition to enabling teachers and students to access a professional CAD system on any device, Onshape's cloud-native architecture allows researchers to access data about CAD models and how designers create them in a way that has never been possible before. In this session, you'll learn more about how Onshape is fundamentally different than any other CAD platform and how engineers and scientists are leveraging newly accessible data to drive innovation. We will then lead an interactive demonstration and discussion to explore how cloud-native technology is revolutionizing design.

The workshop will include:

- Introduction presentation
- Demonstration
- Discussion

12:00 CET

D2-O: PRE-SESSION GET-TOGETHER - VIRTUAL STAGE

INTRODUCTION TO CONFERENCE DAY
P. John Clarkson, University of Cambridge (UK), DESIGN 2022 Programme Chair

12:15 CET

D211	D212	D213
DATA-DRIVEN METHODS FOR EARLY DESIGN PHASES	DESIGN PROCESS TRANSFORMATIONS FOR INDUSTRY 4.0	SYSTEM APPROACH TO HEALTHCARE DESIGN
Virtual Room 1	*Virtual Room 2*	*Virtual Room 3*
Chair: Tobias Larsson	*Chair: Åsa Ericson*	*Chair: Dorian Marjanović*

13:30 CET

REFRESHMENT BREAK

13:45 CET

D2-P: PLENARY SESSION - VIRTUAL STAGE
Chair: P. John Clarkson, University of Cambridge (UK)

AI, MACHINE LEARNING, ROBOTICS: TRENDS, CHALLENGES, OPPORTUNITIES
Danica Kragic, Professor, School of Computer Science and Communication
KTH Royal Institute of Technology (SW)

14:30 CET

REFRESHMENT BREAK

14:45 CET

D221	D222	D223
AI ROLE IN DESIGN TEAMS	PROJECT MANAGEMENT	HEALTHCARE DESIGN PROCESSES
Virtual Room 1	*Virtual Room 2*	*Virtual Room 3*
Chair: Binyang Song	*Chair: Neven Pavković*	*Chair: Alexander Komashie*

16:00 CET

REFRESHMENT BREAK

16:15 CET

D231	D232	D233
DESIGN CHANGE MANAGEMENT	DESIGN PROCESS MODELS	HEALTHCARE CASE STUDIES
Virtual Room 1	*Virtual Room 2*	*Virtual Room 3*
Chair: James Gopsill	*Chair: Joshua Summers*	*Chair: Anja Maier*

17:30 CET

D2-S: SOCIAL GATHERING I
SOCIAL EVENT ROOM

19:00 CET

12:00 CET

12:15 CET

D214
DESIGN CREATIVITY STUDIES
Virtual Room 4
Chair: Philip Cash

D215
SOCIAL RELATIONSHIPS AND EMOTIONAL DESIGN
Virtual Room 5
Chair: Monica Bordegoni

D216
DESIGN FOR X
Virtual Room 6
Chair: Stephan Husung

13:30 CET

13:45 CET

14:30 CET

14:45 CET

D224
FINDING NEW PATHS IN DESIGN RESEARCH
Virtual Room 4
Chair: Susanne Carin Nilsson

D225
VISUAL AND HAPTIC INTERACTIONS WITH PRODUCTS
Virtual Room 5
Chair: Stanko Škec

D226
TOPOLOGY OPTIMISATION AND SIMULATION
Virtual Room 6
Chair: Christian Weber

16:00 CET

16:15 CET

D234
DESIGN EVALUATION CRITERIA
Virtual Room 4
Chair: Peter Törlind

D235
CO-DESIGN AND CO-CREATION
Virtual Room 5
Chair: Tomislav Martinec

17:30 CET

19:00 CET

Mehlstäubl, Jan[1]; Braun, Felix[2]; Denk, Martin[1]; Kraul, Ralf[2]; Paetzold, Kristin[3]
1: Universität der Bundeswehr München, Germany; 2: MAN Truck & Bus SE, Germany; 3: Technische Universität Dresden, Germany

USING MACHINE LEARNING FOR PRODUCT PORTFOLIO MANAGEMENT: A METHODICAL APPROACH TO PREDICT VALUES OF PRODUCT ATTRIBUTES FOR MULTI-VARIANT PRODUCT PORTFOLIOS

To satisfy customer needs in the best way, companies offer them an almost infinite number of product variants. Although, an identical product was not built before, the values of its attributes must be determined during the product configuration process. This paper introduces a methodical approach to predict the values of product attributes based on customer feature configurations using machine learning. Machine learning reduces the effort compared to rule-based expert systems and is both, more accurate and faster. The approach was validated by predicting vehicle weights using industrial data.

https://doi.org/10.1017/pds.2022.168

Bisang, Ursina[1]; Brünnhäußer, Jörg[1]; Lünnemann, Pascal[1]; Kirsch, Lucas[2]; Lindow, Kai[1]
1: Fraunhofer IPK, Germany; 2: CONTACT Software GmbH, Germany

EVALUATE SIMILARITY OF REQUIREMENTS WITH MULTILINGUAL NATURAL LANGUAGE PROCESSING

Finding redundant requirements or semantically similar ones in previous projects is a very time-consuming task in engineering design, especially with multilingual data. Due to modern NLP it is possible to automate such tasks. In this paper we compared different multilingual embeddings models to see which of them is the most suitable to find similar requirements in English and German. The comparison was done for both in-domain data (requirements pairs) and out-of-domain data (general sentence pairs). The most suitable model were sentence embeddings learnt with knowledge distillation.

https://doi.org/10.1017/pds.2022.153

Rädler, Simon[1,2]; Rigger, Eugen[1]
1: V-Research GmbH, Austria; 2: TU Wien, Austria

A SURVEY ON THE CHALLENGES HINDERING THE APPLICATION OF DATA SCIENCE, DIGITAL TWINS AND DESIGN AUTOMATION IN ENGINEERING PRÁCTICE

Digital Engineering is an emerging trend and aims to support engineering design by integrating computational technologies like design automation, data science, digital twins, and product lifecycle management. To enable alignment of industrial practice with state of the art, an industrial survey is conducted to capture the status and identify obstacles that hinder implementation in the industry. The results show companies struggle with missing know-how and available experts. Future work should elaborate on methods that facilitate the integration of Digital Engineering in design practice.

https://doi.org/10.1017/pds.2022.172

Zhu, Qihao; Luo, Jianxi
Singapore University of Technology and Design, Singapore

GENERATIVE PRE-TRAINED TRANSFORMER FOR DESIGN CONCEPT GENERATION: AN EXPLORATION

Novel concepts are essential for design innovation and can be generated with the aid of data stimuli and computers. However, current generative design algorithms focus on diagrammatic or spatial concepts that are either too abstract to understand or too detailed for early phase design exploration. This paper explores the uses of generative pre-trained transformers (GPT) for natural language design concept generation. Our experiments involve the use of GPT-2 and GPT-3 for different creative reasonings in design tasks. Both show reasonably good performance for verbal design concept generation.

https://doi.org/10.1017/pds.2022.185

Wagenmann, Steffen; Bursac, Nikola; Rapp, Simon; Albers, Albert
Karlsruhe Institute of Technology, Germany

SUCCESS FACTORS FOR THE VALIDATION OF REQUIREMENTS FOR NEW PRODUCT GENERATIONS – A CASE STUDY ON USING FIELD GATHERED DATA

This paper investigates which activities and success factors can be identified for the data-driven validation of functional requirements. For this purpose, a case study is conducted at a machine tool manufacturer. To validate functional requirements by analyzing data of reference products, these activities must be performed iteratively: basic work, interdisciplinary work, programming and check results. For the successful execution of data-driven validation, the success factors: data origin, acceptance, data quality, knowledge about data and combination of domain knowledge must be considered.

https://doi.org/10.1017/pds.2022.183

Trauer, Jakob[1]; Schweigert-Recksiek, Sebastian[1]; Schenk, Tim[2]; Baudisch, Thomas[2]; Mörtl, Markus[1]; Zimmermann, Markus[1]
1: Technical University of Munich, Germany; 2: Siemens AG, Germany

A DIGITAL TWIN TRUST FRAMEWORK FOR INDUSTRIAL APPLICATION

A reason for the slow adoption of digital twins in industry is a lack of trust in the concept and between the stakeholders involved. This paper presents a Trust Framework for Digital Twins based on a literature review and an interview study, including seven recommendations: (1) explain your twin, (2) create a common incentive, (3) make only one step at a time, (4) ensure IP protection and IT security, (5) prove your quality, (6) ensure a uniform environment, and (7) document thoroughly. Together with 20 concrete measures it supports practitioners in improving trust in their Digital Twin.

https://doi.org/10.1017/pds.2022.31

Castagnoli, Rebecca[1]; Stal-Le Cardinal, Julie[2]; Büchi, Giacomo[1]; Cugno, Monica[1]
1: University of Turin, Italy; 2: CentraleSupélec, France

INDUSTRY 4.0 MANAGEMENT: PRELIMINARY DESIGN IMPLICATIONS

Industry 4.0 is expected to change competitiveness of manufacturing firms. However, to completely achieve this goal, firms should manage barriers and complexity issues that my hinder its adoption or its effects. For this reason, the study explores, through a literature review, whether and how design theory may be a supporting theory to manage Industry 4.0 adoption and implementation to maximise the opportunities and minimise the risks. The results shows that these research questions require a design approach to innovate not only adopting technologies but reinventing the business practices.

https://doi.org/10.1017/pds.2022.13

Guertler, Matthias R.[1]; Adams, Nico[2]; Caldwell, Glenda[3]; Donovan, Jared[3]; Hopf, Andreas[1]; Roberts, Jonathan[3]
1: University of Technology Sydney, Australia; 2: James Cook University, Australia; 3: Queensland University of Technology, Australia

A LIFE-CYCLE FRAMEWORK TO MANAGE COLLABORATION AND KNOWLEDGE EXCHANGE IN OPEN ORGANISATIONS

Successful research and development requires interdisciplinary collaboration, often across organisational boundaries and for extended timeframes, such as in innovation networks or ecosystems. Open Organisation (OO) research can support collaboration and knowledge exchange in such situations. It builds on established concepts of Open Innovation through enhancing the exchange of knowledge by the exchange of humans. This paper contributes to OO research by presenting an OO lifecycle framework, which analyses evolving organisational and collaboration characteristics and resulting management needs.

https://doi.org/10.1017/pds.2022.20

Brisco, Ross
University of Strathclyde, United Kingdom

UNDERSTANDING INDUSTRY 4.0 DIGITAL TRANSFORMATION

The concept of Industry 4.0 has motivated large engineering sectors towards a common focus for improvement. Academics have capitalised on the common language, shared motivation and marketability of Industry 4.0. The potential and perceived benefits of Industry 4.0 are clear within academia and beyond. However, are engineering companies ready for the digital transformation associated? and, can Industry 4.0 be achieved by SMEs? In this paper, we investigate these questions through activity on project road mapping with 4 Scottish companies to reveal Industry 4.0 readiness and literacy.

https://doi.org/10.1017/pds.2022.245

Schneider, Martin; Hellweg, Talea; Menzefricke, Jörn Steffen
Paderborn University, Germany

IDENTIFICATION OF HUMAN AND ORGANIZATIONAL KEY DESIGN FACTORS FOR DIGITAL MATURITY – A FUZZY-SET QUALITATIVE COMPARATIVE ANALYSIS

This paper examines how human and organizational factors need to be designed to achieve strong technological maturity of either the products or the production process. In a fuzzy-set qualitative comparative analysis (fs/QCA), a combination of intensive training and strong worker participation is found to be associated with strong technological maturity in the two organizational contexts: firms with a strong entrepreneurial culture and in large firms oriented towards customer-oriented innovation. Overall, the paper uncovers designs or causal recipes for a successful digital transformation.

https://doi.org/10.1017/pds.2022.81

Feldman, Alix [1]; Patou, François[2]; Maier, Anja[1,3]
1: Technical University of Denmark, Denmark; 2: Oticon Medical, Denmark; 3: University of Strathclyde, United Kingdom

DRIVING CHANGE IN COMPLEX SOCIAL SYSTEMS: HOW TO DESIGN HEALTHCARE PATHWAYS

How does change occur in healthcare settings? In this paper, we take a design-based approach to healthcare research. From researcher-patient interactions to information sharing between practitioners, we examine how clinical research can mediate a change of routines and illuminate potential new system structures. Using a hospital-based cognitive care clinic as an example, we demonstrate how the inclusion of new actors, tools and resources was able to shed light on the prevalence of hearing loss among mild cognitive impairment (MCI) patients and lay the framework for new care pathways.

https://doi.org/10.1017/pds.2022.128

Lamé, Guillaume[1]; Huynh-Dagher, Solène[1]; Komashie, Alexander[2,3]; Jankovic, Marija[1]; Duong, Tu-Anh[4,5]
1: CentraleSupélec, France; 2: University of Cambridge, United Kingdom; 3: THIS Institute, University of Cambridge, United Kingdom; 4: AP-HP. Université Paris-Saclay, France; 5: Université Paris Est Créteil, France

IS ANYBODY LISTENING? A CITATION ANALYSIS OF HEALTHCARE DESIGN RESEARCH ARTICLES PUBLISHED IN DESIGN JOURNALS

Citation is a key metric in academia, and it can help to understand how ideas travel between disciplines. In this article, we report on a citation analysis of forty-four articles identified during a systematic literature review of healthcare design research published in six leading design journals. Using the Web of Science's categorisation of journals, we analyse which disciplines cite these forty-four articles. We find that these articles are much more cited in technology and engineering journals than in health sciences. We discuss these findings and the limitations of the study.

https://doi.org/10.1017/pds.2022.131

Nagarajan, Kamya; Koronis, Georgios; Subburaj, Karupppasamy; Silva, Arlindo
Singapore University of Technology and Design, Singapore

ATYPICAL USE SCENARIOS AS DESIGN INTERVENTION IN HEALTHCARE PRODUCT DESIGN APPLICATION

User experiences of atypical conditions leading to adverse events have the potential to discover latent user needs and improve usability in design outcomes. This study introduces atypical scenarios as a design intervention to student designers working on healthcare product design projects. These atypical scenarios are framed from real-world clinical experience related to individual projects. 40 participants from a healthcare product design course comprising of 8 teams were involved in this study. Results indicate a positive influence on design and designers in terms of usability in the design process.

https://doi.org/10.1017/pds.2022.134

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THE ROLE OF SYSTEMS APPROACHES IN HEALTH AND CARE

The concept of Health Systems is ubiquitous in the healthcare literature. However, the question 'what is a Health System' is not easy to answer. The emerging field of Health Systems Design is by nature multi-disciplinary, involving several disciplines with different ontological commitments and diverse perspectives and interpretations of health and system. To avoid confusions in communication and facilitate engagement between the design and health communities, it is important to begin an open exploration of the fundamental concepts of Health Systems. This paper is a first step in that endeavour.

https://doi.org/10.1017/pds.2022.130

Abela, Edward; Farrugia, Philip; Gauci, Maria Victoria; Vella, Pierre; Cassar, Glenn; Balzan, Emanuel
University of Malta, Malta

A NOVEL USER-CENTRED FRAMEWORK FOR THE HOLISTIC DESIGN OF THERAPEUTIC MEDICAL DEVICES

Numerous and complex sequence of activities in medical device development often result in time consuming and expensive engineering processes. In this study, patient and designer requirements were identified and integrated within a novel framework which supports medical device design through a consolidated understanding of user-experience whilst directly coalescing the applicable regulatory requirements in terms of product compliance and certification. This assists in the development of safe and reliable products which reflect the need for increased usability considerations during design.

https://doi.org/10.1017/pds.2022.122

Coustillac, Lili[1,2,3]; Bazzaro, Florence[2]; Lobbé, Justine[1]; Meyer, Yann[3,4]
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HOW TO ASSESS A CREATIVITY SESSION

To renew their innovation and creativity practices, companies are now equipping themselves with new specific places: innovation laboratories. These laboratories support project teams during creativity sessions to generate ideas. In order to improve these practices, it is necessary to be able to assess and compare the different sessions organised. By joining the Clean Mobility Lab of Faurecia, we were able to analyse, observe and participate in creativity sessions. This immersion allowed us to develop an assessment grid of forty-eight indicators covering the entire creativity process.

https://doi.org/10.1017/pds.2022.87

Session D214
Virtual Room 4
CET 12:15
CET 13:30

Raafat, Omar; Becattini, Niccolò
Politecnico di Milano, Italy

TESTING THE USABILITY OF GUIDELINES FOR THE DESIGN OF SURPRISING PRODUCTS

The paper introduces guidelines to support designers to generate ideas for the development of surprising products. The guidelines are structured coherently with the concept of sensory incongruity and the Function-Behaviour-Structure framework to create a mismatch between previously conceived expectations and product features. The usability of the interactive presentation is checked with an experiment that involved more than 30 subjects with a background in product design (mechanical engineers and industrial designers), which demonstrated to be capable of generating ideas using the same.

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24 May
TUE

Hart, Edward; Hay, Laura
University of Strathclyde, United Kingdom

DO YOU SEE WHAT I SEE? EXPLORING VIVIDNESS OF VISUAL MENTAL IMAGERY IN PRODUCT DESIGN IDEATION

This paper reports a preliminary study (N=16) exploring vividness of visual mental imagery in product design ideation. Vividness was observed to vary across designers in the study, from high (68.8% of participants) to moderate (18.8%) to low (12.5%). A significant, strong positive relationship was found between vividness and creativity. Most participants reported using imagery always or sometimes, except one who has difficulties forming mental images. The results have several implications, including the possibility of other 'ways of imagining' not captured by visual reasoning models of design.

https://doi.org/10.1017/pds.2022.90

Matsumae, Akane; Hirasawa, Hikari
Kyushu University, Japan

THE RELATION BETWEEN THE CHARACTERISTICS OF INDIVIDUAL AND COLLABORATIVE CONCEPT GENERATION

The purpose of this study is to investigate the effect of the concept generation process on metacognition, and the relation between individual concept generation characteristics and the nature of collaboration. The results of the experiment revealed that the attitude affects individual concept generation characteristics, the meta-cognition developed and the quality of the concepts generated. In paired concept generation, the awareness and the attitude toward the partner and individual concept generation characteristics affect the nature of both the collaborative process and generated concepts.

https://doi.org/10.1017/pds.2022.93

Bartz, Marcel[1]; Uttich, Eike[2]; Wanieck, Kristina[3]; Bender, Beate[2]; Wartzack, Sandro[1]
1: Friedrich-Alexander-Universität Erlangen-Nürnberg, Germany; 2: Ruhr-Universität Bochum, Germany; 3: Deggendorf Institute of Technology, Germany

AN APPROACH TO TRANSFER BIOLOGICAL SOLUTIONS BASED ON THE INTERACTION OF MECHANISMS TO TECHNICAL PRODUCTS

Biological solutions are often used for developing technically innovative products in a biomimetic process. However, biological solutions do not always make it into a successful technical product, e.g. due to a lack of knowledge on the mechanisms of action. A new approach is presented for transferring biological solutions based on complex mechanisms of action. It is based on mathematical optimization methods and applied to the lightweight design of the musculoskeletal system. Finally, first technical implementations in the field of robotics, among others, will be presented.

https://doi.org/10.1017/pds.2022.85

Trondsen, June; Boks, Casper
Norwegian University of Science and Technology, Norway

EXPLORING THE ROLE OF SHAME IN DESIGN STRATEGIES

Shame is an emotion most of us are well familiar with and has taken an increasing role in public discourse in the last couple of years. While design literature has seen a strong tradition for evoking positive emotions, shame seems to be somewhat neglected. As a step towards a more practical understanding of shame in design, this article combines design literature with studies from other disciplines in an attempt to give an overview of designers' current notion of shame, and discuss if and how this notion could be further explored into concepts and tools that may benefit future designers.

https://doi.org/10.1017/pds.2022.226

Ramírez Galleguillos, María Laura; Eloiriachi, Aya; Serdar, Büşra; Coşkun, Aykut
Koç University, Turkey

DESIGN STRATEGIES TO PROMOTE INTERCULTURAL MEANINGFUL SOCIAL INTERACTIONS

Intercultural interactions encourage social inclusion and diversity, but they are often avoided due to prejudices. Intercultural Meaningful Social Interactions (IMSI) can overcome such prejudices; still, the literature lacks guidelines on how to promote them by Design. In this study, we propose eight design strategies to facilitate these interactions, which were originated by bridging four theories for prejudice reduction and exemplar IMSI experiences of 15 intercultural participants. This paper presents the strategies and discusses their use to inspire new design concepts for promoting IMSI.

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De Boeck, Muriel; Vleugels, Jochen; Van Rooy, Dirk; Vaes, Kristof
University of Antwerp, Belgium

ASSESSING SOCIAL BEHAVIOUR TOWARDS NEAR-BODY PRODUCT USERS IN THE WILD: A REVIEW OF METHODS

Prior to wide adoption, a product must find social approval, which is especially true for near-body products as they are considered part of the human body. Based on a theoretical foundation, this study aims to provide an overview of methods to assess natural behaviour towards users of visible near-body products in uncontrolled environments, i.e. in the wild. Approaching the matter from a product design perspective, this article is primarily intended for designers of near-body products who wish to gain insights into the social behaviour of people towards users wearing their design proposals.

https://doi.org/10.1017/pds.2022.212

Ito, Akira; Taoka, Yuki; Saito, Shigeki
Tokyo Institute of Technology, Japan

ANALYSIS DESIGNERS' PROCESS OF INSIGHT GENERATION THROUGH EMPATHY WITH USERS

This study aims to investigate the good way to generate insight through empathy with users. The fifteen experiment participants drew thinking processes of understanding users and defining insight statements while generating insight statements based on a given interview transcript. The thinking processes were assessed by qualitative coding, and the insight statements were evaluated. The results identified the types of thinking that should be avoided when gaining insights. This paper proposes a framework to categorise designers' process of gaining insight.

https://doi.org/10.1017/pds.2022.91

Ortega Alvarado, Isaac Arturo
Norwegian University of Science and Technology, Norway

AN EXPLORATION OF SOME ASPECTS TO CONSIDER WHEN OPENING FUTURES

This paper follows the form of an essay, it offers a narrative review inquiring conceptually about opening futures. The main research question is: What concepts could help elucidate the new position of designers when futures are open? Four branches of literature from design are addressed, considering their core approaches: participation, infrastructures, systems thinking, and narratives. Focus on these four approaches could lead to profound discussions about what it means to open futures and the current relevance of expert design.

https://doi.org/10.1017/pds.2022.218

Hommel, Patrick; Roth, Daniel; Binz, Hansgeorg; Kreimeyer, Matthias
University of Stuttgart, Germany

TOWARD A METHOD FOR EVALUATING THE APPLICABILITY OF ALUMINUM FOAM SANDWICH

Aluminum foam sandwich (AFS) is an innovative material for lightweight structures due to its various advantages (e.g. low specific mass). Today, many material properties (e.g. strength) are still not well researched, which is why AFS is not yet considered in current material selection processes. Therefore, AFS has rarely been used in the past and its application potential remains unused. This paper presents an approach toward an appropriate method for considering AFS in material selection processes to assist designers in evaluating whether the use of AFS in an application is profitable.

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USE OF MARGIN TO ABSORB VARIATION IN DESIGN SPECIFICATIONS: AN ANALYSIS USING THE MARGIN VALUE METHOD

Predicting the impact of changes in a design can be challenging, especially for complex designs. Margins are often built into the designs which can absorb the knock-on effect of such changes, erroneously allocating which can however, lead to propagation. A method for localising and sizing margins in an incremental design context is the Margin Value Method. This paper adapts MVM in the context of uncertainty in input specifications. It discusses possible ways to allocate them in a design such that undesirable effects of margins are minimised while preventing change propagation.

https://doi.org/10.1017/pds.2022.34

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UNCERTAINTY ANALYSIS OF A CALCULATION MODEL FOR ELECTRIC BEARING IMPEDANCE

The integration of Sensing Machine Elements (SME) is a promising approach to obtain reliable data about relevant process and state variables of technical systems. However, the quality and reliability of the provided data strongly depends on the corresponding calculation model of the SME and the therein included uncertainty. Consequently, in this contribution, the calculation model of a sensory utilized rolling bearing, as exemplary SME, is systematically analyzed using existing methods and tools to identify uncertainty that critically affects the quality and reliability of the data provided.

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MODEL-BASED DEFINITION ACCELERATES PRODUCT LIFE CYCLE IN MANUFACTURING AND INSPECTION PHASE – EXPERIMENT OF MACHINED ONE-OFF PRODUCTION

The paper focuses on comparative experiment on manufacturing and inspection of two different prismatic one-off parts, which have different complexity. Our experiment shows that transforming product definition method from the Drawing Centric Definition (DCD) to the Model Centric Definition (MCD) enables 28% - 29% time savings in manufacturing and inspection phases of machined one-off part's life cycle. Furthermore, transition from MCD to Model-Based Definition (MBD) enables 5% - 9% time savings, respectively. Applying of MBD enables more time savings in complex part compared to a less complex part.

https://doi.org/10.1017/pds.2022.66

Strauß, Lea[1]; Montero, Joaquin[2]; Weber, Sebastian[1]; Brenner, Stefan[1]; Höfer, Philipp[1]; Paetzold, Kristin[2]; Löwisch, Günther[1]
1: Universität der Bundeswehr München, Germany; 2: Technische Universität Dresden, Germany

EFFECT OF HEAT TREATMENT ON THE HARDNESS OF UNCONVENTIONAL GEOMETRICAL FEATURES FOR LASER POWDER BED FUSED ALSI10MG

The adoption of Design for Additive Manufacturing (DfAM) practices brought new industrial components embedding unconventional shapes such as lattice structures or freeform surfaces resulting from topological optimisations. As a drawback of design freedom, designers need to use thermal post-processing to achieve homogeneous properties in metal 3D printing. This contribution analyses the effect of T6-like heat treatment on the hardness of a complex component. Hardness values are reported along with good design practices for effective thermal post-processing to complement the DfAM knowledge base.

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DESIGN
2022

AI, MACHINE LEARNING, ROBOTICS: TRENDS, CHALLENGES, OPPORTUNITIES

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KTH Royal Institute of Technology (SW)

Building machines that are autonomous and intelligent, taking over dirty, dull and dangerous jobs, has been an integral part of human history for a long time. Recent advances in robotics, artificial intelligence and machine learning have demonstrated how these can be utilized in development of technologies that exhibit rather advanced capabilities. In integration with human decision making and experience, artificial systems are today used to make diagnostics in health application, make estimations of weather conditions to secure crops, provide more informed predictions of potential earthquakes, and more. Apart from purely software solutions, we are also seeing the beginning of more advanced hardware solutions, robotic systems that are equipped with various sensor technologies and are built to physically interact with humans at workplaces, and sometimes in the future, even our homes. Humans poses a fantastic ability to acquire complex behaviors from watching another person. Initial observations are needed to understand goals of complex behaviors but repeated, extensive interactions with the physical world are necessary to ground the behaviors in own sensing and reuse these in new situations. Robots acquiring behaviors solely from human demonstrations and unstructured videos rather than through explicit programming has been a research vision for a long time – probably even from the time a first robot was built. But still, having a robot that is able to adapt and enrich its knowledge through self-supervised learning remains one of the open challenges. Thus, to be deployed in natural environments, robots need the ability to learn skills autonomously, through continuous interaction with the environment, humans and other robots. Although classically built on rigorous control theory, mathematical and theoretical computer science methodologies, more recently data-driven learning methods, such as Deep Learning and Reinforcement Learning have been demonstrated as powerful technologies for developing robotic systems. Still, most of the practical applications exist in solely carefully structured settings where there exists enough data to train the models.

BIOGRAPHICAL SKETCH

Danica Kragic is a Professor at the School of Computer Science and Communication at the Royal Institute of Technology, KTH. She received MSc in Mechanical Engineering from the Technical University of Rijeka, Croatia in 1995 and PhD in Computer Science from KTH in 2001. She has been a visiting researcher at Columbia University, Johns Hopkins University and INRIA Rennes. She is the Director of the Centre for Autonomous Systems. Danica received the 2007 IEEE Robotics and Automation Society Early Academic Career Award. She is a member of the Royal Swedish Academy of Sciences, Royal Swedish Academy of Engineering Sciences and Young Academy of Sweden. She holds a Honorary Doctorate from the Lappeenranta University of Technology. She chaired IEEE RAS Technical Committee on Computer and Robot Vision and served as an IEEE RAS AdCom member. Her research is in the area of robotics, computer vision and machine learning. In 2012, she received an ERC Starting Grant and 2020 ERC Advanced Grant. Her research is supported by the EU, Knut and Alice Wallenberg Foundation, Swedish Foundation for Strategic Research and Swedish Research Council. She is an IEEE Fellow.

Gyory, Joshua T.; Kotovsky, Kenneth; Cagan, Jonathan
Carnegie Mellon University, United States of America

IS IT HUMAN OR IS IT ARTIFICIAL INTELLIGENCE? DISCERNING THE IMPACT AND EFFECTIVENESS OF PROCESS MANAGERS BASED ON THE MANAGER'S IDENTITY

This work studies the perception of the impacts of AI and human process managers during a complex design task. Although performance and perceptions by teams that are AI- versus human-managed are similar, we show that how team members discern the identity of their process manager (human/AI), impacts their perceptions. They discern the interventions as significantly more helpful and manager sensitive to the needs of the team, if they believe to be managed by a human. Further results provide deeper insights into automating real-time process management and the efficacy of AI to fill that role.

https://doi.org/10.1017/pds.2022.160

Tufarelli, Margherita; Cianfanelli, Elisabetta
University of Florence, Italy

GENERATIVE PRODUCT DESIGN PROCESSES: HUMANS AND MACHINES TOWARDS A SYMBIOTIC BALANCE

Design processes managed by algorithms provide solutions and improvements in terms of efficiency, performance, choice of materials, and cost optimization. It is a whole new approach to industrial design in which artificial intelligence participates directly in the design processes. The paper aims to investigate the way we design through algorithms, and consequent changes in thoughts, approaches, and generation of ideas that are rising determining new ways of defining things and their relations.

https://doi.org/10.1017/pds.2022.181

Patel, Apurva Rajesh; Summers, Joshua D.
The University of Texas at Dallas, United States of America

STUDENT VS MACHINE: COMPARING ARTIFICIAL NEURAL NETWORK PREDICTIONS WITH STUDENT ESTIMATES OF MARKET PRICE USING FUNCTION STRUCTURE MODELS

This paper investigates the use of ANNs to model human behaviour in design by comparing the predictive capability of ANNs and engineering students. Function structure models of 15 products are used as input for prediction. The type of information provided varied between topology and vocabulary. Analysis of prediction accuracy showed that ANNs perform comparably to students. However, students are more precise with their predictions. Finally, limitations and future work are discussed, with research questions presented for subsequent research.

https://doi.org/10.1017/pds.2022.169

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1: CentraleSupélec, France; 2: IRT SystemX, France

MATCHING SYNTHETIC POPULATIONS WITH PERSONAS: A TEST APPLICATION FOR URBAN MOBILITY

Design is increasingly influenced by digitalisation yet differs largely across domains. We present synergies between the works of UX designers and data scientists. We can utilise personas to represent users and their behaviours, or synthetic populations to represent agent groups. Despite sharing characteristics, their synergies have not been explored so far. We propose a workflow and test it in the urban mobility context to link a synthetic population of Paris with a set of contextual personas. This builds the basis for an integrated approach for designing urban mobility across fields.

https://doi.org/10.1017/pds.2022.182

Chong, Leah; Kotovsky, Kenneth; Cagan, Jonathan
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ARE CONFIDENT DESIGNERS GOOD TEAMMATES TO ARTIFICIAL INTELLIGENCE?: A STUDY OF SELF-CONFIDENCE, COMPETENCE, AND COLLABORATIVE PERFORMANCE

For successful human-artificial intelligence (AI) collaboration in design, human designers must properly use AI input. Some factors affecting that use are designers' self-confidence and competence and those variables' impact on reliance on AI. This work studies how designers' self-confidence before and during teamwork and overall competence are associated with their performance as teammates, measured by AI reliance and overall team score. Results show that designers' self-confidence and competence have very different impacts on their collaborative performance depending on the accuracy of AI.

https://doi.org/10.1017/pds.2022.155

Ammersdörfer, Theresa; Inkermann, David
Technische Universität Clausthal, Germany

A PROCESS MODELLING MORPHOLOGY TO SUPPORT PROCESS ANALYSIS AND DEVELOPMENT IN CHANGE PROCESSES

Process modelling (PM) is used to support designers by providing guidance on what needs to be done. Change processes in development organizations accompany introduction of new procedures, new methods (also digital form), tools that have to integrated into existing processes. Objective of this paper is to provide guidance to designers in selecting the appropriate PM language to support structured changes in processes. Requirements are derived from frequent change needs in SME and a PM morphology is provided assisting the selection and use of suitable PM languages for change processes.

https://doi.org/10.1017/pds.2022.10

Riesener, Michael; Kuhn, Maximilian; Keuper, Alexander; Lender, Benjamin; Schuh, Guenther
RWTH Aachen University, Germany

FRAMEWORK FOR FAMD-BASED IDENTIFICATION OF RCPSP-CONSTRAINTS FOR IMPROVED PROJECT SCHEDULING

Product development in today's manufacturing companies is characterized by multiple development projects under intense time constraints. This means that the success of projects impacts the company's success significantly. However, industrial practices show that many projects fail to meet their time targets. This paper presents a methodology to systematically improve project schedule adherence of development projects by combining exploratory data analysis of historic project data with project scheduling optimizations to enhance the project schedules and enable more successful projects.

https://doi.org/10.1017/pds.2022.27

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A LONGITUDINAL STUDY OF TEAMWORK QUALITY IN DESIGN TEAMS

Teamwork quality (TWQ) is often associated with project success. Therefore, understanding TWQ is crucial to have better design project outcomes. Since most of the studies in the past have presented a cross-sectional analysis of TWQ, the current work focuses on capturing TWQ in a longitudinal way for a project-based learning (PBL) course. The results showed that the 6 facets differed significantly during the first half of the course than towards the end. In later phases of the PBL, TWQ and team performance were positively correlated than at the beginning.

https://doi.org/10.1017/pds.2022.241

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THE COLLABORATIVE IRON TRIANGLE: A NEW TOOL FOR SUPPORTING A PROJECT-CULTURE-AWARE MANAGEMENT IN INTERORGANIZATIONAL R&D PROJECTS

Since project managers still face problems in managing interorganizational R&D projects, it is a promising approach to manage these projects project-culturally-aware. However, an important prerequisite for a project-culture-aware management is that the involved individual organizations pursue a collaborative strategy. Therefore, our article provides a conceptual approach including a new tool, the Collaborative Iron Triangle, which supports both project sponsors and managers in different phases of the collaboration process to pursue a collaborative strategy in interorganizational R&D projects.

https://doi.org/10.1017/pds.2022.15

Karia, Deval[1]; Shah, Komal[1]; Venkatesh, Kavyashree[1]; Acharya, Shakuntala[2]; Arora, Manish[1]
1: Indian Institute of Science, India; 2: Indian Institute of Technology Guwahati, India

A COMPARATIVE ANALYSIS OF THE ENGINEERING DESIGN AND LEAN START-UP INNOVATION METHODOLOGIES

Innovation is a key driver for product success. Engineering design and lean start-up are prominent innovation methodologies well accepted and widely used. There is a lack of availability of pragmatic reflections for innovators to put into practice. The paper addresses this need by undertaking a comparative analysis of the two methodologies, using three case studies of medical device innovation. Directions and insights on how innovators may employ one or both approaches at different stages of their innovation are presented.

https://doi.org/10.1017/pds.2022.4

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SERVICE DESIGN APPROACH TO ELEVATE THE PATIENT EXPERIENCE DURING HOME X-RAYS

Healthcare services have evolved with advances in science, technology and societal needs. Despite being around for two decades, 'X-ray at Home' has seen limited adoption. Understanding its enablers and disablers can lead to insights to develop an accessible healthcare service ecosystem. Healthcare organisations have adopted design thinking to develop new products but healthcare service design is still in its introductory phase. This qualitative study describes the current state of home X-ray services in Mumbai and proposes touchpoints for raising awareness, acceptance and patient experience.

https://doi.org/10.1017/pds.2022.135

Glazkova, Natalia[1]; Menshenin, Yaroslav[1]; Vasilev, Dmitry[2]; Fortin, Clement[1]
1: Skolkovo Institute of Science and Technology, Russia; 2: Karfidov Lab, Russia

MEDTECH PRODUCT DEVELOPMENT FRAMEWORK FOR POST-PANDEMIC ERA

A case study during pandemic revealed the major drawbacks of the traditional product development process for MedTech industry. Disruption of conventional manufacturing, urgent need for accelerated design and production, faster regulatory approval have challenged the industry. In this paper the conventional medical product development process is explored based on the intramuscular injector case study. The study revealed core areas for improvement of the medical devices development process. The paper proposes the Lean-Agile methodology with the incorporated elements of Concurrent Engineering.

https://doi.org/10.1017/pds.2022.129

Lauer-Schmaltz, Martin Wolfgang[1]; Cash, Philip[1]; Hansen, John Paulin[1]; Maier, Anja[1,2]
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DESIGNING HUMAN DIGITAL TWINS FOR BEHAVIOUR-CHANGING THERAPY AND REHABILITATION: A SYSTEMATIC REVIEW

REVIEWERS FAVOURITE

One of the most promising trends in healthcare digitalisation is the personalisation and individualisation of therapy based on virtual representations of the human body through Human Digital Twins (HDTs). Despite the growing number of articles on HDTs, to-date no consensus on how to design such systems exists. A systematic literature review for designing HDTs used for behaviour-changing therapy and rehabilitation resulted in eight key design considerations across four themes: regulatory and ethical, transparency and trust, dynamism and flexibility, and behaviour and cognitive mechanisms.

https://doi.org/10.1017/pds.2022.132

Ege, Daniel Nygård; Auflem, Marius; Steinert, Martin
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LOST IN TRANSIT: IMPLICATIONS AND INSIGHTS FOR MAKING MEDICAL TASK TRAINER PROTOTYPES WITH AN OPEN SOURCE HARDWARE PARADIGM

This paper presents an open-source novel intravenous cannulation task trainer developed during the Covid- 19 pandemic for unsupervised clinical skill practice. Multiple user errors were uncovered when observing 13 registered nurses using the task trainer during a two-hour unsupervised skill training session. These insights raise the question of how OSH needs to share more than just device descriptions and assembly instructions- as designs are being shared only in its current state of an ongoing project, sharing insights, user errors and test results should be encouraged and prioritized.

https://doi.org/10.1017/pds.2022.127

Liaw, Tiffany Sun; Gehlenborg, Nils
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USER-CENTRIC PROCESS OF DESIGNING A MOLECULAR & CELLULAR QUERY INTERFACE FOR BIOMEDICAL RESEARCH

There is a growing demand for the adoption of user-centric design processes for the development of computational biology software as usability becomes a major concern. Our team develops interfaces for a human biomolecular data portal with user-centered design, so we present a case study of the design process of a molecular and cellular query to emphasize the importance of user-centric design and reveal the complications that arise in a complex software development environment. The study follows the design process from user requirement gathering to the prototyping of a minimum viable product.

https://doi.org/10.1017/pds.2022.24

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UNVEILING THE CONSTRUCT OF DESIGN THINKING: AN EXPLORATORY STUDY

Design thinking does not have a consensually defined construct in the academic literature. This foundational fragility hinders theory building in the field. This study addresses this gap by providing a construct of design thinking following guidelines for developing theory-building instruments. We propose a non-normative, comprehensive construct composed of a conceptual definition and a subset of properties that portray tangible design thinking expressions. The proposed construct aims to provide a grounded foundation to support the advancement of design thinking theory building and testing.

https://doi.org/10.1017/pds.2022.5

Session D224

Virtual Room 4

CET 14:45
CET 16:00

Sviridova, Aleksandra; Stokhuijzen, Drim; Verlinden, Jouke
University of Antwerp, Belgium

ACCESSING THE INACCESSIBLE: DEMONSTRATORS AS SOURCES OF TACIT KNOWLEDGE

This paper highlights a recently identified by the community perspective of design research, so far described as "inaccessible", discusses the potential of "designerly" way of approaching it in order to let designers excavate tacit knowledge from their own finished projects. We frame demonstrators as a category of design outcomes that can be a great source of such knowledge. Skills of empathy and intuition are called crucial for researchers to position themselves inside the design system looking inwards.

https://doi.org/10.1017/pds.2022.6

24 May

TUE

Goudswaard, Mark[1]; Kent, Lee[1]; Giunta, Lorenzo[1]; Gopsill, James[1]; Snider, Chris[1]; Valjak, Filip[2]; Christensen, Kim A.[3]; Felton, Harry[1]; Ege, Daniel Nygård[3]; Real, Ricardo M.[1]; Cox, Chris[1]; Horvat, Nikola[2]; Kohtala, Sampsa[3]; Eikevåg, Sindre Wold[3]; Martinec, Tomislav[2]; Perišić, Marija Majda[2]; Steinert, Martin[3]; Hicks, Ben[1]
1: University of Bristol, United Kingdom; 2: University of Zagreb, Croatia; 3: Norwegian University of Science and Technology, Norway

VIRTUALLY HOSTED HACKATHONS FOR DESIGN RESEARCH: LESSONS LEARNED FROM THE INTERNATIONAL DESIGN ENGINEERING ANNUAL (IDEA) CHALLENGE 2021

This paper provides an overview and appraisal of the International Design Engineering Annual (IDEA) challenge - a virtually hosted design hackathon run with the aim of generating a design research dataset that can provide insights into design activities at virtually hosted hackathons. The resulting dataset consists of 200+ prototypes with over 1300 connections providing insights into the products, processes and people involved in the design process. The paper also provides recommendations for future deployments of virtual hackathons for design research.

https://doi.org/10.1017/pds.2022.3

Bangle, Chris Edward[1]; Rosso, Marco[1]; Montagna, Francesca[2]; Cantamessa, Marco[2]
1: Chris Bangle Associates, Italy; 2: Politecnico di Torino, Italy

DESIGN METHODS REVIEW FOR SMART PRODUCT: OBJECTOMY, A NEW APPROACH

Digital artefacts call for new design challenges: they enable services, technology-driven and multidisciplinary never ended processes, uncouple form-function, in a social relationship that must be ecosystem-framed. Then, the usual design mindset is not proper and expected vs unexpected outcomes must be equally studied. A framework of methods, in view of the usual design variables and the new ones called by design of smart objects, is here offered. From that the seeds for the future aid to the design process of smart objects result. Then, Objectomy and one real application case are described.

https://doi.org/10.1017/pds.2022.207

Mesa, David; Tan, Linus; Ranscombe, Charlie
Swinburne University of Technology, Australia

A CASE STUDY EXPLORING THE ROLE OF DESIGN IN MATURING UNIVERSITY-DEVELOPED TECHNOLOGY

Universities struggle to commercialise scientific research. However, designers can help scientists bridge the research-market gap in different ways. Although the value design can bring to science is understood, how design outputs deliver value to scientific research remains unexplored. Our paper reports findings from a designer-scientist collaboration developing a graphene-based water desalination technology. By reflecting on this case study, we found that design outputs serve different purposes in developing technology and assist in progressing technology maturation efficiently.

https://doi.org/10.1017/pds.2022.237

Angeleska, Elena; Aleksovska, Aleksandra; Avramov, Nikola; Sidorenko, Sofija; Rizov, Tashko; Jankovic, Aleksandar
Ss. Cyril and Methodius University in Skopje, North Macedonia

DESIGN AND EVALUATION OF AN INCLUSIVE AUTONOMOUS VEHICLE USER INTERFACE DEVELOPED FOR PERSONS WITH VISUAL ACUITY LOSS

This research focuses on evaluating a user interface (UI) for an autonomous vehicle (AV) with the goal to determine the most suitable layout for persons with visual acuity loss. The testing procedure includes a Wizard of Oz AV for simulating an automated ride. Several participants are included in the study and the visual impairments are simulated by specially designed glasses. The conclusions help to determine the optimal graphic design of the UI that can be independently used by persons with blurred vision. The results can be applied to improve the inclusiveness and ergonomics of vehicle UIs.

https://doi.org/10.1017/pds.2022.206

Basak, Abhinav; Roy, Shatarupa Thakurta
Indian Institute of Technology Kanpur, India

VISUAL ERGONOMICS FOR COLOURBLINDNESS: APPLYING UNIVERSAL DESIGN PRINCIPLES IN GRAPHICAL USER INTERFACE TO PROVIDE AFFORDANCE TO THE COLOURBLIND USERS

With evolution of Graphical User Interface, the access to the computer interface was expanded to cater to the extreme user categories by providing accessibility features and making the computer interface more inclusive. One such extreme user category is colourblind, which has a special accessibility requirement from the GUI. This paper studies the iconography of the Microsoft Windows operating system interface with an objective to develop an inclusive icon design solution that is visually ergonomic for colourblind users to include them as a mainstream user category in a computer interface.

https://doi.org/10.1017/pds.2022.208

Balzan, Emanuel; Farrugia, Philip; Casha, Owen
University of Malta, Malta

EVALUATION OF AN AFFORDANCE-BASED REQUIREMENTS GENERATION TOOL FOR SPEECH AND LANGUAGE THERAPEUTIC TOYS

Task clarification poses various challenges to designers as they need to understand the different needs of users before translating the requirements into specifications and aptly conceiving product concepts in the subsequent design stage. This paper presents a descriptive study for the evaluation of a framework and its implementation as a computer-based prototype tool, proposed to assist designers in generating and understanding affordance-based requirements for speech and language therapeutic toys. Results show that early design support is beneficial to both experienced and novice designers.

https://doi.org/10.1017/pds.2022.124

Quattelbaum, Bastian[1]; Wolter, Stephanie[1]; Stylidis, Kostas[2,3]
1: Niederrhein University of Applied Sciences, Germany; 2: University West, Sweden; 3: Chalmers University of Technology, Sweden

PRELIMINARY STUDY ON HAPTICS OF TEXTILE SURFACES VIA DIGITAL VISUAL CUES

Humans perceive through various sensory impressions, including the five senses. Not only the number of different stimuli in everyday life increase, but also the degree of assessment of urgent and irrelevant information. But online it is not possible for the customer to physically perceive and assess the haptics of a product. This paper focus on the questions if it is possible for humans to perceive and identify surface properties without using their sense of touch and if humans can judge and classify the haptics of a textile materials via digital channels through a purely visual perception?

https://doi.org/10.1017/pds.2022.221

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1: Indian Institute of Technology Hyderabad, India; 2: Osmania University, India

UNDERSTANDING THE ROLE OF PERCEPTUAL HAPTIC CONDITIONS ON DESIGN DECISION

The haptic propositions derived from the textile prototypes often allow for more than one interpretation. It impacts the decision on design alternatives during the phase of design evaluation and validation. The present study aims to conquer this challenge with a haptic design case study of automotive upholstery fabric. It links experimental psychophysics with design decision-making. The study results show that visual cues influence haptic detection accuracy and constancy to choose a final design option.

https://doi.org/10.1017/pds.2022.222

Sauer, Christopher[1]; Gerschütz, Benjamin[1]; Bernsdorf, Jörg[2]; Schleich, Benjamin[1]; Wartzack, Sandro[1]
1: Friedrich-Alexander-Universität Erlangen-Nürnberg, Germany; 2: CADFEM GmbH, Germany

A MACHINE LEARNING-BASED APPROACH FOR QUICK EVALUATION OF LIVE SIMULATIONS IN EMBODIMENT DESIGN

Supporting product developers in early design phases with Live-Simulation can enhance the quality of early product designs. Live-Simulation can also facilitate a democratization of simulation and puts away pressure from simulation experts. In this paper, a machine learning based quick evaluation tool is proposed to support product developers in interpreting Live-Simulation results. The proposed tool enables a quick evaluation of the Live-Simulation results and enables product developers to further enhance their simulations. The tool is shown within a use case in bike rocker switch design.

https://doi.org/10.1017/pds.2022.178

Session D226
Virtual Room 6
CET 14:45
CET 16:00

Krischer, Lukas; Vazhapilli Sureshbabu, Anand; Zimmermann, Markus
Technical University of Munich, Germany

ACTIVE-LEARNING COMBINED WITH TOPOLOGY OPTIMIZATION FOR TOP-DOWN DESIGN OF MULTI-COMPONENT SYSTEMS

In top-down design, optimal component requirements are difficult to derive, as the feasible components that satisfy these requirements are yet to be designed and hence unknown. Meta models that provide feasibility and mass estimates for component performance are used for optimal requirement decomposition in an existing approach. This paper (1) extends its applicability adapting it to varying design domains, and (2) increases its efficiency by active-learning. Applying it to the design of a robot arm produces a result that is 1% heavier than the reference obtained by monolithic optimization.

https://doi.org/10.1017/pds.2022.165

24 May
TUE

Dausch, Valesko; Kröger, Jan; Kreimeyer, Matthias
University of Stuttgart, Germany

AN AI-BASED APPROACH TO OPTIMIZE STRESS IN SHRINK FITS

The present analytical design of shrink fits typically results in an uneven stress condition that can lead to failure in a variety of manners. With increasing loads and the use of brittle materials, the optimization of the stresses in the shrink fit hence becomes increasingly necessary. Currently existing approaches do not solve the problem satisfactorily or increase the manufacturing and design effort. This paper therefore considers the implementation of an AI-based stress optimization using reinforcement learning, which performs stress optimization by geometrically contouring the interstice.

https://doi.org/10.1017/pds.2022.157

Halle, Alex; Campanile, Lucio Flavio; Hasse, Alexander
Chemnitz University of Technology, Germany

AN AI-ASSISTED DESIGN METHOD FOR TOPOLOGY OPTIMIZATION WITHOUT PRE-OPTIMIZED TRAINING DATA

Engineers widely use topology optimization during the initial process of product development to obtain a first possible geometry design. The state-of-the-art method is iterative calculation, which requires both time and computational power. This paper proposes an AI-assisted design method for topology optimization, which does not require any optimized data. The presented AI-assisted design procedure generates geometries that are similar to those of conventional topology optimizers, but require only a fraction of the computational effort.

https://doi.org/10.1017/pds.2022.161

Denk, Martin[1]; Rother, Klemens[2]; Paetzold, Kristin[3]
1: Universität der Bundeswehr München, Germany; 2: Munich University of Applied Sciences, Germany; 3: Technische Universität Dresden, Germany

TRUSS PARAMETRIZATION OF TOPOLOGY OPTIMIZATION RESULTS WITH CURVE SKELETONS AND META BALLS

Truss-like shapes can occur in topology optimization described by an assembly of finite elements or its boundary represented as a polygon mesh. Such shape description does not cover a common engineering parametrization like the lines of a frame structure and its corresponding cross-section. This article addresses the truss-parametrization of such optimization using curve skeletons and Meta Balls. While the curve skeleton is common in the truss-parametrization, including Meta Balls can lead to an overall implicit and smooth shape description.

https://doi.org/10.1017/pds.2022.38

Capistrano Burgos, Raquel[1]; Sippl, Fabian[1]; Radisic-Aberger, Ognjen[2]; Weisser, Tim[2]
1: Technical University of Munich, Germany; 2: University of Siegen, Germany

DATA-BASED METHOD FOR THE IMPLEMENTATION PLANNING OF ENGINEERING CHANGES IN THE AUTOMOTIVE INDUSTRY

Each year, automotive OEMs implement a variety of Engineering Changes (ECs) in their production. In the timing of ECs, different KPIs are often in conflict with one another or even unknown to the OEMs. Therefore, OEMs struggle to identify the optimal date to implement an EC. This paper presents a method to determine the cost-optimal implementation date for each EC, considering time, cost, and quality KPIs based on a new EC classification rule-set. To evaluate the presented method, case-studies at a German automotive OEM were performed, two of which are discussed.

https://doi.org/10.1017/pds.2022.36

Albers, Albert[1]; Altner, Moritz Magnus[1,2]; Rapp, Simon[1]; Valeh, Benjamin[2]; Redinger, Hans[2]; Winter, Roland[2]
1: Karlsruhe Institute of Technology, Germany; 2: Mercedes-Benz AG, Germany

EVALUATION OF ENGINEERING CHANGES BASED ON VARIATIONS FROM THE MODEL OF PGE – PRODUCT GENERATION ENGINEERING IN AN AUTOMOTIVE WIRING HARNESS

Engineering change management is a central part of the product development process. This paper investigates how variations from the PGE - Product Generation Engineering can improve the evaluation of engineering changes from the wiring harness. Engineering changes that occur in an automotive wiring harness development process are analysed in a case study, evaluated in expert interviews with regard to the risk and effort connected to the implementation and compared to the types of variations. Additional influencing factors are discussed. The variations provide an indication on risk and effort.

https://doi.org/10.1017/pds.2022.32

Horber, Dennis; Schleich, Benjamin; Wartzack, Sandro
Friedrich-Alexander-Universität Erlangen-Nürnberg, Germany

IDENTIFICATION OF PROPERTY CHANGE IMPACTS BASED ON REQUIREMENTS-ORIENTED, MULTI-CRITERIA DECISION MODELS

As an outcome of the multi-criteria evaluation of different alternatives, product developers receive information on whether the evaluation alternatives meet the demanded property profile. If not, product characteristic and property changes are required, which can have desired and undesired effects. This contribution presents an MBSE-based approach, which extends the relational requirement model by value functions and product properties. Its novelty can be found in the integration of multi-criteria decision models, which are used to improve alternatives based on property change impact analyses.

https://doi.org/10.1017/pds.2022.48

Radisic-Aberger, Ognjen; Weisser, Tim; Saßmannshausen, Till; Wagner, Johannes; Burggräf, Peter
University of Siegen, Germany

CONCEPT OF A MULTI-AGENT SYSTEM FOR OPTIMISED AND AUTOMATED ENGINEERING CHANGE IMPLEMENTATION

Engineering changes are necessary to stay competitive, unavoidable and occur more frequently with increased product complexity. Currently, scheduling of engineering changes into production and supply chain is a manual process. With new possibilities in the field of artificial intelligence, this publication presents the vision of a flexible multi-agent system with four agents and a single shared database. By autonomously scheduling changes and predicting KPI impacts of implementation dates, the agent-system provides additional capacity and decision-making support to the organisation.

https://doi.org/10.1017/pds.2022.171

Vieira, Sonia[1]; Kannengiesser, Udo[2]; Benedek, Mathias[3]
1: Politecnico di Milano, Italy; 2: Johannes Kepler University, Austria; 3: University of Graz, Austria

INVESTIGATING TRIPLE PROCESS THEORY IN DESIGN PROTOCOLS

This study presents a coding scheme for design protocols that is derived from Triple Process Theory postulating the existence of three categories of cognitive processes: spontaneous, deliberate, and metacognitive. We applied the coding scheme to think-aloud protocols of designers engaged in an open design task. Results show that all three types occur during designing. The scheme we propose has the potential to ground accounts of Triple Process Theory for design in empirical studies. We explore the relation between design sessions outcomes and shifts between cognitive processes.

https://doi.org/10.1017/pds.2022.7

Wong, Yvonne Yu Bing; Joyce, Sam Conrad; Blessing, Lucienne
Singapore University of Technology and Design, Singapore

Session D232

Virtual Room 2

CET 16:15
CET 17:30

SELECTING DESIGN PROCESS MODELLING APPROACHES FOR BUILDING DESIGN: A REVIEW

Design process modelling is well-founded in fields of mechanical engineering, and product design and development but not in Building Design (BD). This paper looks at the selection process when choosing appropriate models for specific BD processes. The paper adapts process model selection criteria from Trauer's work and combines it with anecdotal evidence from the authors to select these models. The selection criteria were ranked, categorised, and applied to BD processes explained. Process models related to each selection criteria were then selected from backward snowballing of literature.

https://doi.org/10.1017/pds.2022.8

24 May

TUE

Campean, Felician[1]; Uddin, Amad[1,2]; Bridges, Jonathan[1]; Fannon, Steven[1]; Yildirim, Unal[1,3]
1: University of Bradford, United Kingdom; 2: Jaguar Land Rover, United Kingdom; 3: Hubei University of Automotive Technology, China

EVALUATION OF THE IMPACT OF COLLABORATIVE RESEARCH ON ROBUST DESIGN METHODOLOGIES: A LARGE SCALE EMPIRICAL CASE STUDY WITH AN AUTOMOTIVE OEM

The evaluation of impact of collaborative research on robust design methodologies and methods is important to both academic and industry stakeholders. This paper introduces a framework for impact evaluation which combines the broader framework adopted for the academic research impact assessment with the organisation viewpoint centred on business results, process improvement and product development teams capability improvement. A large scale empirical study conducted with evidence from technical reports on workplace projects from an automotive OEM proved the validity of the proposed framework.

https://doi.org/10.1017/pds.2022.1

Zallio, Matteo; Clarkson, P. John
University of Cambridge, United Kingdom

THE INCLUSIVE DESIGN CANVAS. A STRATEGIC DESIGN TEMPLATE FOR ARCHITECTURAL DESIGN PROFESSIONALS

Designing accessible and inclusive buildings is essential if they are to provide enjoyable and inspiring experiences for all their occupants. Research revealed that many architectural design professionals perceive a lack of awareness of the aspects to consider when designing to be a limiting factor in the uptake of Inclusive Design. By involving expert stakeholders this study provides evidence for the demand to create an Inclusive Design Canvas, a strategic design template offering an educational springboard for building industry professionals to embed Inclusive Design in the design process.

https://doi.org/10.1017/pds.2022.9

Colombo, Samuele[1]; Montagna, Francesca[1]; Cascini, Gaetano[2]; Palazzolo, Virginia Flavia[1]
1: Politecnico di Torino, Italy; 2: Politecnico di Milano, Italy

DIGITAL ARTEFACTS AND THE ROLE OF DIGITAL AFFORDANCE

This work investigates how the concept of affordance should be revised following the digital evolution. Starting from a review of the literature about affordance, the most acknowledged constructs are compared with the variegated definitions of digital artefacts. The paper proposes a definition of digital affordance, overcoming the inconsistencies identified in the literature. The study is enriched by a series of interviews to investigate the final users' perception of affordance. Finally, the paper shows the application of the proposed model with a case study related to food delivery services.

https://doi.org/10.1017/pds.2022.2

Bonello, Matthew; Farrugia, Philip
University of Malta, Malta

A DESIGNERS' PERSPECTIVE ON ADDITIVE MANUFACTURED SMART WEARABLES FOR PAEDIATRIC HABILITATION

The aim of the paper is to identify from the perspective of designers, what is required to optimally design smart habilitation devices for additive manufacturing, whilst ensuring a high quality multi-user experience. Semi-structured interviews were conducted with designers to identify the key requirements to develop such devices. The outcome of this study will provide a preliminary framework for designers to take advantage of the state-of-the-art of design for additive manufacturing in order to meet the expectations of multiple users of smart devices for pediatric occupational therapy.

https://doi.org/10.1017/pds.2022.126

Pystina, Xeniya; Gomes Lisboa de Souza, Adriana; Thomann, Guillaume
Grenoble INP, France

SERIOUS GAME DESIGN PRINCIPLES FOR MOTOR EVALUATION OF PATIENTS WITH NEUROLOGICAL DISEASES

The use of serious games is more and more popular in the medical filed, mainly for home-based rehabilitation therapy. In this context, some design principles were already proposed. Designing serious game for evolution diseases assessment is challenging and necessitates a new approach of this principles. Working with physiotherapists at the origin of the Motor Function Measurement assessment scale, the development of a dedicated serious game is proposed based on new contextual principles.

https://doi.org/10.1017/pds.2022.137

Aflatoony, Leila[1]; Kolarić, Siniša[2]
1: Georgia Institute of Technology, United States of America; 2: Simon Fraser University, Canada

ONE SIZE DOESN'T FIT ALL: ON THE ADAPTABLE UNIVERSAL DESIGN OF ASSISTIVE TECHNOLOGIES

Occupational therapists modify mass-produced and universally-designed assistive technologies (ATs) to fulfill the specific needs of people with disabilities. We interviewed ten occupational therapists with experience in modifying ATs in order to understand adaptation processes. Our findings reveal the reasoning behind adaptation, common ATs that require adaptation, as well as the collaborative nature of adaptation. We propose a new framework called Adaptable Universal Design (AUD) that blends Universal Design with the need to adapt ATs in order to fulfill unique and specific user needs.

https://doi.org/10.1017/pds.2022.123

Mishra, Soumya Ranjan; Behdinan, Kamran
University of Toronto, Canada

CARDINAL MATURITY DETERMINATION OF TECHNOLOGY DEVELOPMENT: MEDICAL DEVICE DEVELOPMENT CASE STUDY

A novel application of Best Worst Method (BWM) enables one to incorporate the complexity of specific sub-criteria of technological development to assess its maturity with the pre-established Technology Readiness Level (TRL) framework. It utilizes the concept of Multi-Criteria Decision Making (MCDM) methods to determine the cardinality of endpoint quantitative processes. The model is used to determine the maturity of Class II Ventilators and to detect the consistency aspects for their selection.

https://doi.org/10.1017/pds.2022.133

Patiniott, Nicholas[1]; Borg, Jonathan C.[1]; Francalanza, Emmanuel[1]; Gatt, Alfred[1]; Vella, Pierre[1]; Zammit, Joseph[1]; Paetzold, Kristin[2]
1: University of Malta, Malta; 2: Technische Universität Dresden, Germany

TOWARDS A PRODUCT SERVICE SYSTEM FRAMEWORK FOR LOWER LIMB PROSTHETIC DEVICES

Amputees face challenges with prosthesis such as cost, long delivery periods, as well as social discomfort. Simultaneously, the prosthetists and manufacturers have a difficulty to handle such diverse issues. We thus contribute a Prosthetic Life-Cycle Service System (ProLiSS) Framework, prescribed to involve amputees in different life phases. From an evaluation of ProLiSS, we conclude that it influences how prosthetics need to be designed and that it is beneficial to perform further research to provide manufacturers with a systematic, amputee-centered development and servicing framework.

https://doi.org/10.1017/pds.2022.136

Hausmann, Maximilian; Häfner, Luca; Kirchner, Eckhard
Technical University of Darmstadt, Germany

A PROCEDURE MODEL FOR THE SYSTEMATIC SENSOR SELECTION AND INTEGRATION INTO TECHNICAL SYSTEMS

New sensor solutions are under development in the context of digitalization in order to integrate sensory functions into systems. When integrating sensors, the three domains of mechanical, electrical and information engineering must be considered. This results in complex development processes that require suitable procedure models. However, specific procedure models for sensor selection and integration are missing. This contribution proposes a procedure model for sensor selection and integration on the basis of the Munich Procedure Model (MPM) and gives an outlook on open research questions.

https://doi.org/10.1017/pds.2022.46

Fröhlich, Tim; Vietor, Thomas
Technische Universität Braunschweig, Germany

DESIGN PRINCIPLES AND MULTI-LEVEL STRUCTURES FOR MULTI-FUNCTIONAL AND MULTI-MATERIAL DESIGN

Multi-functional design has high potential to overcome e.g. increasing weight and costs of products. However, the possible solution space for integrating functions is hardly manageable. This paper presents an approach to assist in the identification of multi-functional approaches. Therefore, hybrid design principles are developed that are combinable to complex structures including specific manufacturing routes. By this, multi-functional solutions can be provided on different resolutions in order to identify the most promising approach and position for the integration of additional functions.

https://doi.org/10.1017/pds.2022.41

Stelvaga, Anastasia; Fortin, Clement
Skolkovo Institute of Science and Technology, Russia

DEVELOPMENT OF A METHODOLOGY FOR TECHNOLOGY DEMONSTRATION PROJECTS EVALUATION

To ensure optimal resource allocation in technology demonstration projects, the evaluation of demonstrators of various maturity, scale, and nature has to be carried out. Most of the existing approaches focus on risk assessment or projected financial return; the need for a tool supporting multi-facet projects evaluation has been identified. This paper presents R2L framework based on three major criteria, defined in detail: Leap Potential, Learning, and Risk. The framework was applied to a real flight-test demonstrator project during workshops in a major aerospace company.

https://doi.org/10.1017/pds.2022.29

Inkermann, David
Technische Universität Clausthal, Germany

LIFECYCLE OPTION SELECTION IN EARLY DESIGN STAGES BASED ON DEGRADATION MODEL EVALUATION

Components of modern systems are characterised by differing lifetimes. The resulting lifetime heterogeneity (LTH) is a core criteria to determine life cycle options (LCO) for more sustainable products, e.g. by upgrading or reuse. Estimating the lifetimes is challenged by a lack of suitable degradation models (DM) describing the detrimental change performance of components during the use phase. This paper expands the state of the art in LCO selection by a method to evaluate fitness and sensitivity of DM based on the similarity of use cases, environments and operation profiles of the system.

https://doi.org/10.1017/pds.2022.49

Stetter, Ralf[1]; Witczak, Marcin[2]; Till, Markus[1]
1: University of Applied Sciences Ravensburg-Weingarten, Germany; 2: University of Zielona Góra, Poland

CYBER-SECURITY AWARE DESIGN OF AUTOMATED SYSTEMS

One of the main current threats for producing companies is the possibility of cyber-space attacks. Due to several reasons, industrial companies need to connect their plants over some kind of networks. Obviously, today many approaches from information technology (IT) exist which will greatly reduce the danger of attacks. Still, no producing company can completely rely on these IT solutions. This paper proposes a systemic approach to design processes and products for increased cyber security. This approach is based on an attack model and is explained based on an automated storage system.

https://doi.org/10.1017/pds.2022.201

Aranda-Muñoz, Álvaro[1,2]; Florin, Ulrika[1]; Yamamoto, Yuji[1]; Eriksson, Yvonne[1]; Sandström, Kristian[2]
1: Mälardalen University, Sweden; 2: Research Institutes of Sweden, Sweden

CO-DESIGNING WITH AI IN SIGHT

Artificial Intelligence offers a wide variety of capabilities that can potentially address people's needs and desires in their specific contexts. This pilot study presents a collaborative method using a deck of AI cards tested with 58 production, AI, and information science students, and experts from an accessible media agency. The results suggest that, with the support of the method and AI cards, participants can ideate and reach conceptual AI solutions. Such conceptualisations can contribute to a more inclusive integration of AI solutions in society.

https://doi.org/10.1017/pds.2022.11

Hansen, Andreas Claus[1,2]; Willumsen, Pelle Lundquist[1]; Oehmen, Josef[1]
1: Technical University of Denmark, Denmark; 2: Bygningsstyrelsen, Denmark

TAILORING A PROJECT RISK MANAGEMENT TOOL THROUGH CO-DESIGN: MANAGING RISK IN THE FUZZY FRONT-END OF CONSTRUCTION PROJECT DESIGN

The objectives and scope of a construction project is defined in the early design stage, the fuzzy front-end. This stage is crucial for project risk management and success, but traditional risk management tend to focus on operational risk in later design stages. This action research study leverages co-design methodology and the project management actuality perspective to tailor a risk management process for the fuzzy front-end of construction projects in a large client organization. The co-design process help enchance stakeholder value perception of the designed solution.

https://doi.org/10.1017/pds.2022.21

Ericson, Åsa; Lugnet, Johan; Silawiang, Hatharat; Eliasson, Lisa; Wenngren, Johan
Luleå University of Technology, Sweden

USER-CENTRED CO-DESIGN IN THE PANDEMIC – A REINDEER CASE

An innovative design process which has been conducted under the restrictions during the covid-19 pandemic is in focus in this study. Visits were banned so user-centred design activities were particularly challenged by the necessity to meet and work online. The purpose of the study is to present and reflect on how user-centred design was done under those conditions. The potential users, the reindeer herders, were merely contacted online, the user investigation were supported by for example using videos and storytelling. Also, the final concept is presented.

https://doi.org/10.1017/pds.2022.18

Innella, Giovanni[1]; Gatto, Gionata[2]
1: Virginia Commonwealth University School of the Arts in Qatar, Qatar; 2: Dubai Institute of Design and Innovation, United Arab Emirates

SPECULATING ON NATURE, TECHNOLOGY AND FINANCE. GEOMERCE AS A CASE STUDY FOR RESEARCH THROUGH DESIGN

This paper chronicles and reflects on the processes and the meanings of a project of speculative design that creates a narrative based on the scientific notion of phytomining, the activity of extracting metals from the soil using plants. The paper reflects on the ability of the project of bringing together people from different expertise, as a successful case study of Speculative Design and Research through Practice. Besides the scientific and technical challenges posed by GeoMerce, the authors of this paper reflect on the critical framework that set the basis for such a complex project.

https://doi.org/10.1017/pds.2022.213

12:00 CET

D3-O: PRE-SESSION GET-TOGETHER - VIRTUAL STAGE

INTRODUCTION TO CONFERENCE DAY
Julie Stal-Le Cardinal, CentraleSupélec (FR), DESIGN 2022 Programme Chair

12:15 CET

D311 DIGITAL TWIN	D312 COGNITIVE STUDIES IN DESIGN	D313 CIRCULAR ECONOMY: METHODS AND TOOLS
Virtual Room 1	*Virtual Room 2*	*Virtual Room 3*
Chair: Benoit Eynard	*Chair: Sonia Vieira*	*Chair: Casper Boks*

13:30 CET

REFRESHMENT BREAK

13:45 CET

D321 AUTOMATED DESIGN OPTIMISATION FRAMEWORKS	D322 DISTRIBUTED COLLABORATION	D323 CIRCULAR ECONOMY: DESIGN FOR LONGEVITY
Virtual Room 1	*Virtual Room 2*	*Virtual Room 3*
Chair: Markus Zimmermann	*Chair: Laura Hay*	*Chair: Sophie Hallstedt*

15:00 CET

REFRESHMENT BREAK

15:15 CET

D3-P: PLENARY SESSION - VIRTUAL STAGE
Chair: Julie Stal-Le Cardinal, CentraleSupélec (FR)

TOWARD AI-HUMAN HYBRID LEARNING
Jonathan Cagan, George Tallman and Florence Barrett Ladd Professor in Mechanical Engineering Carnegie Mellon University (US)

16:00 CET

REFRESHMENT BREAK

16:15 CET

D331 APPLICATION OF MACHINE LEARNING METHODS	D332 AGILE MANAGEMENT APPROACHES	D333 SUSTAINABILITY TRANSITION
Virtual Room 1	*Virtual Room 2*	*Virtual Room 3*
Chair: Marija Majda Perišić	*Chair: Kristin Paetzold*	*Chair: Tim C. McAloone*

17:30 CET

D3-S: SOCIAL GATHERING II
SOCIAL EVENT ROOM

19:00 CET

12:00 CET

12:15 CET

D314
SYSTEMS ENGINEERING PROCESSES

Virtual Room 4
Chair: Beate Bender

D315
ENGINEERING DESIGN CASE STUDIES

Virtual Room 5
Chair: Asko Uolevi Ellman

D316
USER-CENTRED DESIGN

Virtual Room 6
Chair: Philip Farrugia

13:30 CET

13:45 CET

D324
MODEL-BASED SYSTEMS ENGINEERING

Virtual Room 4
Chair: Felician Campean

D325
DESIGN FOR PRODUCT FAMILIES

Virtual Room 5
Chair: Ola Isaksson

D326
PROTOTYPING TOOLS

Virtual Room 6
Chair: Niccolò Becattini

15:00 CET

15:15 CET

16:00 CET

16:15 CET

D334
INDUSTRIAL CASE STUDIES

Virtual Room 4
Chair: Oscar Gabriel Nespoli

D335
MODULARISATION STRATEGIES AND EXAMPLES

Virtual Room 5
Chair: Iryna Mozgova

17:30 CET

19:00 CET

Wilking, Fabian; Sauer, Christopher; Schleich, Benjamin; Wartzack, Sandro
Friedrich-Alexander-Universität Erlangen-Nürnberg, Germany

SYSML 4 DIGITAL TWINS – UTILIZATION OF SYSTEM MODELS FOR THE DESIGN AND OPERATION OF DIGITAL TWINS

The implementation of Digital Twins has become a common task for many industrial companies to ensure a sufficient digitization of their products and maintain competitiveness. This results in the question of how to compensate additional effort caused by designing Digital Twins. With this paper, an approach for this compensation is presented by creating Digital Twin behaviour through utilizing SysML diagrams and directly derivate usable code from them for a further implementation. This offers a part solution of lowering the threshold for using MBSE and increasing its benefits.

https://doi.org/10.1017/pds.2022.184

Laukotka, Fabian N.; Rennpferdt, Christoph; Krause, Dieter
Hamburg University of Technology, Germany

DIGITAL TWINS AND PRODUCT-SERVICE SYSTEMS: A SYNERGY WITH CHALLENGES AND OPPORTUNITIES

Digital Twins and Product-Service Systems are just two of the recent trends in product development. While many presented approaches seem promising, their implementation often face challenges. This is especially true if existing approaches are transferred onto new applications. Diving into these topics this paper presents the basics but also challenges as well as synergies emerging between them. The objective is set, to move from specialised applications to broader approaches that can provide benefit to a range of applications and ease the entrance, particularly, for smaller enterprises.

https://doi.org/10.1017/pds.2022.166

Snider, Chris; Kent, Lee; Goudswaard, Mark; Hicks, Ben
University of Bristol, United Kingdom

INTEGRATED PHYSICAL-DIGITAL WORKFLOW IN PROTOTYPING – INSPIRATIONS FROM THE DIGITAL TWIN

REVIEWERS FAVOURITE

Prototyping uses many models over its process, with varying strength and weakness offered by those in the physical vs digital domains. Working across domains is necessary but introduces a transition cost, process complexities, and risks lost learning. Drawing from Digital Twinning, this work explores the creation of integrated physical-digital prototyping workflows, where technology enables simultaneous cross-domain working. It contrasts four case-study implementations of integrated prototyping workflow to current practice, exploring feasibility, value, and implementation challenges.

https://doi.org/10.1017/pds.2022.179

Eickhoff, Thomas; Forte, Sven; Göbel, Jens Christian
Technische Universität Kaiserslautern, Germany

APPROACH FOR DEVELOPING DIGITAL TWINS OF SMART PRODUCTS BASED ON LINKED LIFECYCLE INFORMATION

The ongoing digitization of engineering processes and the increasing prevalence of smart products create possibilities for new business models and services. Digital twins enable the collection of all required data about a smart product in order to make these possibilities a reality. This paper describes a flexible approach towards a digital product twin that is tightly integrated with existing product models while being lightweight and easy to integrate with existing IT solutions.

https://doi.org/10.1017/pds.2022.158

Koch, Yanik[1]; Husung, Stephan[2]; Röhnert, Felix[2]; Mahboob, Atif[2]; Frank, Michael Georg[1]; Kirchner, Eckhard[1]
1: Technical University of Darmstadt, Germany; 2: Technische Universität Ilmenau, Germany

A METHOD FOR THE SUPPORT OF THE DESIGN FOR DIGITAL TWIN SOLUTION AND ITS APPLICATION ON A GEARBOX SYSTEM

The information from Real Twins are increasingly used to construct Digital Twins. Acquisition of information from the Real Twin or in other words performing measurements on the Real Twin may lead to effects in the working of Real Twin. For instance, the introduction of sensors may impair certain functions of a Real Twin. Therefore, it is important to analyse the effect of any change that is performed on the Real Twin for achieving the Digital Twin. In this paper, a method for Digital Twin solution is presented that address these aspects as well as its use is demonstrated by a case example.

https://doi.org/10.1017/pds.2022.163

Berni, Aurora; Altavilla, Stefania; Ruiz-Pastor, Laura; Nezzi, Chiara; Borgianni, Yuri
Free University of Bozen|Bolzano, Italy

AN EYE-TRACKING STUDY TO IDENTIFY THE MOST OBSERVED FEATURES IN A PHYSICAL PROTOTYPE OF A TINY HOUSE

This exploratory work aims to understand which elements of a building mostly attract visitors' attention. An experiment was conducted to allow participants to visit a prototype tiny house while wearing eye-tracking glasses. Identified gazed elements of the prototype were selected and the corresponding dwell times used as variables. The limited dwell times on structural elements show that they can be easily overshadowed by other features present in the building. This leads to a design problem when the novelty and the quality of a new product, markedly a building, reside in the materials used.

https://doi.org/10.1017/pds.2022.86

Vuletic, Tijana; Duffy, Alex; McTeague, Chris; Hay, Laura; Campbell, Gerard; Grealy, Madeleine
University of Strathclyde, United Kingdom

INTERACTION AND PERCEPTION OF INTERACTION WITH 3D OBJECTS DURING DESIGN ACTIVITIES

Post study questionnaires are used in design studies to uncover data about design reasoning and intent. A study was conducted where activities the study participants performed were compared to the participants' statements about those activities, collected immediately after the study via a questionnaire. The goal was to explore the reliability of post study evaluations. Disagreements between performed and reported activities were identified, and recommendations made to, where possible, include more objective measures of design activity.

https://doi.org/10.1017/pds.2022.97

Matsumae, Akane; Shoji, Keisuke; Motomura, Yuki
Kyushu University, Japan

AN ATTEMPT TO GRASP RESONANCE DURING CO-CREATION WITH BIOSIGNAL INDICATORS

Resonance is known as an important phenomenon where individual creative moments resonate with each other during co-creation. The purpose of this study is to capture this co-creative moment as a resonant cognitive status with biosignal indicators. The authors conducted an experiment in which pairs of participants work on concept generation from two nouns and measured their dynamic creative status both subjectively and objectively with biosignal indicators fEMG and EOG. This study will help to understand co-creative cognitive phenomena and to improve the co-creative design process.

https://doi.org/10.1017/pds.2022.94

Dybvik, Henrikke[1]; Abelson, Filip Gornitzka[1]; Aalto, Pasi[1]; Goucher-Lambert, Kosa[2]; Steinert, Martin[1]
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INSPIRATIONAL STIMULI IMPROVE IDEA FLUENCY DURING IDEATION: A REPLICATION AND EXTENSION STUDY WITH EYE-TRACKING

We replicate a design ideation experiment (Goucher-Lambert et al., 2019) with and without inspirational stimuli and extend data collection sources to eye-tracking and a think aloud protocol to provide new insights into generated ideas. Preliminary results corroborate original findings: inspirational stimuli have an effect on idea output and questionnaire ratings. Near and far inspirational stimuli increased participants' idea fluency over time and were rated more useful than control. We further enable experiment reproducibility and provide publicly available data.

https://doi.org/10.1017/pds.2022.88

Lukačević, Fanika[1,2]; Li, Shumin[2]; Becattini, Niccolò[2]; Škec, Stanko[1]
1: University of Zagreb, Croatia; 2: Politecnico di Milano, Italy

COMPARING EEG BRAIN POWER OF MECHANICAL ENGINEERS IN 3D CAD MODELLING FROM 2D AND 3D REPRESENTATIONS

Using the EEG features extracted from the EEG signals, the presented study investigates differences in the cognitive load posed on engineers while 3D CAD modelling in two different conditions, depending on the visual representations used as stimulus - a 2D and a 3D technical drawing of parts. The results indicate a higher cognitive load during the 2D drawing task. In addition, common indicators of the ongoing spatial information processing were recognised - a suppression of parietal and occipital alpha power, a higher frontal theta, and differences in theta power between the hemispheres.

https://doi.org/10.1017/pds.2022.92

Mallick, Pravin Kumar[1]; Pigosso, Daniela C.A.[1]; Salling, Kim Bang[2]; McAloone, Tim C.[1]
1: Technical University of Denmark, Denmark; 2: Novo Nordisk A/S, Denmark

DESIGNING CONFIGURATOR FOR TAKE-BACK FOR A CIRCULAR ECONOMY – A CONCEPTUAL FRAMEWORK

Closing the material loop is fundamental to circular economy (CE). However, significant quantities of resources are currently landfilled. Today, companies realise the importance of take-back for CE but face several barriers in implementing it, lack of knowledge, being one such barrier. To address this, a proposal is presented for the design of a configurator to support companies evaluate different approaches, as well as opportunities and challenges for designing and implementing take-back. The paper presents a conceptual framework for the configurator, based on a systematic literature review.

https://doi.org/10.1017/pds.2022.106

Xia, Hanbing; Han, Ji; Milisavljevic-Syed, Jelena
University of Liverpool, United Kingdom

FORECASTING THE NUMBER OF END-OF-LIFE VEHICLES: STATE OF THE ART REPORT

Academics and practitioners have shown a growing interest in automobile reverse supply chain (RSC) management as a result of the rise of circular economy and the development of Industry 4.0. Accurate quantity prediction enhances the efficiency of all decision levels in automobile RSC, not only the recovery of end-of-life vehicles (ELVs). Therefore, a comprehensive state-of-the-art review, evaluating ELVs quantity forecasting methodologies and summarizing the main variables influencing forecasting outcomes, is conducted to throw shed light on future research directions.

https://doi.org/10.1017/pds.2022.119

Schweitzer, Gregor M.[1]; Mörsdorf, Simon[2]; Bitzer, Michael[1]; Vielhaber, Michael[2]
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DETECTION OF CAUSE-EFFECT RELATIONSHIPS IN LIFE CYCLE SUSTAINABILITY ASSESSMENT BASED ON AN ENGINEERING GRAPH

Although Life Cycle Sustainability Assessments (LCSA) are important in evaluating the sustainability of complex products and services, there is no sufficient support for engineers performing LCSA. The concept of an Engineering Graph focuses on the relations of data within engineering. It provides a model that leverages existing data in engineering and extendibility to include specialized databases and open and public data from the semantic web. This paper proposes a concept of how Engineering Graphs can be used to address the issues of LCSA and support engineers.

https://doi.org/10.1017/pds.2022.115

Cappelletti, Federica; Rossi, Marta; Germani, Michele
Università Politecnica delle Marche, Italy

CLOSING THE LOOP VALORIZATION OF INDUSTRIAL WASTE OF COMPOSITE MATERIALS THROUGH RE-DESIGN OF PRODUCTS FROM DETACHED VALUE CHAINS

The literature lacks methodologies to make supply chains of composite materials circular. The proposed approach aims to transform scraps and off-specification products into secondary raw materials. Its novelty is to find innovative applications, instead of re-introducing scraps in the loop they come from. The case study investigates how scraps can be re-worked and re-used as raw material. First, the processes are analyzed; some components are then re-designed to be made of the discarded scraps (composites material). Results reveal that the symbiosis can ensure green, high performing products.

https://doi.org/10.1017/pds.2022.100

Gräßler, Iris; Hesse, Philipp
Paderborn University, Germany

APPROACH TO SUSTAINABILITY-BASED ASSESSMENT OF SOLUTION ALTERNATIVES IN EARLY STAGES OF PRODUCT ENGINEERING

Sustainable product engineering is becoming increasingly important. This includes the development of environmentally friendly products and the design for recycling. In this paper a holistic method for the assessment of solution alternatives is presented, in which the stakeholder perspectives along the generic product lifecycle are taken into account. Finally, a new visualization is presented. By visualizing the results in the integrated sustainability triangle, decision-makers in product development can holistically assess the sustainability of the solution alternatives.

https://doi.org/10.1017/pds.2022.102

Gräßler, Iris; Thiele, Henrik; Grewe, Benedikt; Hieb, Michael
Paderborn University, Germany

RESPONSIBILITY ASSIGNMENT IN SYSTEMS ENGINEERING

Increasing system complexity can be controlled by using systems engineering processes. INCOSE defines processes with inputs and outputs (artifacts) for this purpose. Specific SE roles are used to organize the tasks of the processes within the company. In this work, the responsibilities for artifacts are evaluated by means of the RACI scheme and examined by a cluster analysis and discussed for a SE transformation project with a German automotive OEM. As a result of the study, the optimal composition for systems engineering teams is identified and the systems engineering roles are prioritized.

https://doi.org/10.1017/pds.2022.190

Korsunovs, Aleksandrs[1]; Doikin, Aleksandr[1]; Campean, Felician[1]; Kabir, Sohag[1]; Hernandez, Eduardo Munive[1]; Taggart, Darren[2]; Parker, Sophie[2]; Mills, Gavin[2]
1: University of Bradford, United Kingdom; 2: Arrival Ltd, United Kingdom

TOWARDS A MODEL-BASED SYSTEMS ENGINEERING APPROACH FOR ROBOTIC MANUFACTURING PROCESS MODELLING WITH AUTOMATIC FMEA GENERATION

The process of generating FMEA following document-centric approach is tedious and susceptible to human error. This paper presents preliminary methodology for robotic manufacturing process modelling in MBSE environment with a scope of automating multiple steps of the modelling process using ontology. This is followed by the reasoning towards automatic generation of process FMEA from the MBSE model. The proposed methodology allows to establish robust and self-synchronising links between process-relevant information, reduce the likelihood of human error, and scale down time expenses.

https://doi.org/10.1017/pds.2022.193

Sakao, Tomohiko; Neramballi, Abhijna; Matschewsky, Johannes
Linköping University, Sweden

AVOID SERVICE DESIGN TRAP BY GUIDING PRODUCT/SERVICE SYSTEM DESIGN WITH PRODUCT-SERVICE DEPENDENCY KNOWLEDGE BASE

This article aims to contribute to the knowledge on product/service system (PSS) design practice as follows. First, a new rationale for why PSS design in practice often does not exploit its full potential is given based on a theory on inseparability of services. Second, a representation of the dependencies between product design parameters (DPs) and service DPs in a form of potential-dependency knowledge base is proposed as a remedy. Third, reusability of the knowledge captured from product-service integration across sectorial borders is shown with PSS design at a complex product manufacturer.

https://doi.org/10.1017/pds.2022.198

Stetter, Ralf[1]; Pulm, Udo[2]
1: University of Applied Sciences Ravensburg-Weingarten, Germany; 2: University of Applied Sciences Hamburg, Germany

FAULT-TOLERANT FUNCTION DEVELOPMENT FOR MECHATRONIC SYSTEMS

The main focus of this paper is the exploration of fault accommodation possibilities in the context of function development. Faults occur in complex technical systems and may lead, if no accommodation entities or processes are present, to catastrophic failure. Several entities and processes exist and are applied, but mainly on the concrete levels. Faults very often concern more than one physical domain and accommodation possibilities are present in many physical or even non-physical domains. This paper explores this specific challenge and proposes an initial collection of countermeasures.

https://doi.org/10.1017/pds.2022.200

Dreesbeimdiek, Kaya M.; von Behr, Carl-Magnus; Brayne, Carol; Clarkson, P. John
University of Cambridge, United Kingdom

TOWARDS A CONTEMPORARY DESIGN FRAMEWORK FOR SYSTEMS-OF-SYSTEMS RESILIENCE

In an increasingly interconnected world, changes of uncertain nature and impact affect the functioning of human societies that depend on health, ecological, and economic systems. The proposed framework for systems-of-systems resilience explains ways of accommodating and responding to these challenges while encompassing the interfaces of the health, environment, and economy domains and their effect on communities. Resilience is defined as a continuous process and we distinguish between four system properties, five resilience capacities, and a variety of system activities.

https://doi.org/10.1017/pds.2022.186

Voigt, Michael P.; Roth, Daniel; Kreimeyer, Matthias
University of Stuttgart, Germany

MAIN CHARACTERISTICS OF ADAPTIVE FAÇADES

Adaptive façades (AF), unlike conventional façades, respond to their environment to reduce energy consumption while increasing comfort. The planning of AF presents architects and engineers with a variety of challenges. One central challenge is the specification of the right planning goals in the early phases. This paper identifies in a systematic literature review the main characteristics which were crucial in previous realizations of AF. Due to the comprehensive approach it provides a reference for the goal definition of subsequent projects and the development of further methodical support.

https://doi.org/10.1017/pds.2022.257

Session D315
Virtual Room 5
CET 12:15
CET 13:30

Vazhapilli Sureshbabu, Anand; Martins Pacheco, Nuno Miguel; Duran Noy, Laura Isabel; Zimmermann, Markus
Technical University of Munich, Germany

DESIGN OF AN AUTONOMOUS TRASH-PICKING SERVICE ROBOT FOCUSSED ON HUMAN-ROBOT INTERACTION

The design of service robots is typically treated as a mechatronic design problem aimed at implementation of its core technical functionalities. Intuitive operation and usability are ignored. We developed a trash-picking service robot with a strong focus on human-robot interaction (HRI) using the double diamond framework. The HRI-focussed hardware features were successfully implemented and tested. The results were shown to satisfy the ease of operation and usability requirements set as development goals for the robot.

https://doi.org/10.1017/pds.2022.255

Hayashi, Natsumi; Matsumoto, Yuma; Wesugi, Shigeru
Waseda University, Japan

25 May
WED

DESIGNING A CONVERSATION SUPPORT TOOL FOR QUIET ENVIRONMENTS BY FOCUSING ON THE CHARACTERISTICS OF ULTRASONIC WAVES

In a quiet environment, even a small noise attracts the attention of the people around. In order to reduce the stress of speakers, listeners, and other people around them, we devised a tool to support conversation by converting voice into ultrasonic waves and outputting them from parametric speakers to deliver the sound to the conversation partner. Since light materials can be used for soundproofing ultrasonic waves, we used cardboard and newspaper as soundproofing materials. We confirmed that the sound converted by the tool can be used for conversation and soundproofed.

https://doi.org/10.1017/pds.2022.248

Ehlers, Tobias; Lachmayer, Roland
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DESIGN RULES FOR LASER BEAM MELTED PARTICLE DAMPERS

By means of additive manufacturing, especially laser powder bed fusion, particle dampers can be integrated locally into structural components and thus significantly reduce component vibrations. However, detailed design recommendations for additively manufactured particle dampers do not yet exist. The research question in this paper is: How can the effect of particle damping be described as a function of excitation force, cavity width and cavity length? For beams made of AlSi10Mg, it is shown that a powder-filled cavity of 2.5% to 5% is sufficient to increase the damping by more than x10.

https://doi.org/10.1017/pds.2022.247

Jäger, Michael; Wartzack, Sandro
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STRENGTH ANALYSIS OF STRUCTURALLY OPTIMIZED ALUMINIUM-COMPOSITE TUBULAR LAP JOINTS

Truss structures are a stiff, economical, and efficient lightweight design, the limiting factor of these structures are usually the load transfer elements. This paper presents an analytical design method for optimized adhesive tubular lap joints between CFRP tubes and aluminium inserts. The analytically optimized design agrees very well with the numerical simulations and experimental results. Although the experiments show a highly non-linear behaviour, where a linear elastic correlation is expected, the total load capacity is only reached when the adhesive is fully plasticised.

https://doi.org/10.1017/pds.2022.250

Rautray, Priyabrata[1]; Mathew, Deepak John[1]; Eisenbart, Boris[2]; Kuys, Jo[2]
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UNDERSTANDING WORKING SCENARIOS OF URBAN AIR MOBILITY

Urban Air Mobility (UAM) can provide new air mobility faster and avoid city traffic with the growth of new technologies. But they need to be co-developed with the city infrastructure. Thus, understanding the working scenarios of UAM and how they will interact with the city and the other modes of transport systems is vital. Storyboarding helps policymakers, city planners, designers, and investors better understand the product's contextual interaction over time. This process allows the design team to be implicit or express a design that is easy to understand, reflect upon, or modify.

https://doi.org/10.1017/pds.2022.58

Tanaka, Tomoyuki; Taoka, Yuki; Saito, Shigeki
Tokyo Institute of Technology, Japan

ENHANCING THE QUALITY OF USER RESEARCH USING EMBEDDED IOT SENSORS FOR COLLECTING LIFE INFORMATION

This study aims at developing a new user research method that uses IoT sensors embedded at users' homes to enable users to recall their memories. The proposed method was evaluated by experiments where four participants individually created user journey maps with quantity data that was collected for seven days. The results showed that IoT sensor data increased the quantity, clarity, and accuracy of recalled memories. This study argues that IoT sensors can be an effective approach to increasing user research quality by triggering users' memories without interfering with users' ordinary lives.

https://doi.org/10.1017/pds.2022.63

Nesheim, Ole S.; Bentengen, Dag Håkon; Eikevåg, Sindre Wold; Steinert, Martin
Norwegian University of Science and Technology, Norway

HUMAN GEOMETRIES AS KEY STARTING POINT IN SPORTS PERFORMANCE – DESIGNING EQUIPMENT FOR INDIVIDUAL PERFORMANCE IN PARALYMPIC SIT-SKI

This article investigates human geometry in design, allowing exploration of unknown geometries in Paralympic sports equipment. By creating a configuration map exploring the solution-space, optimal sit-ski seating positions–in the sense of performance and ergonomics–can efficiently be found for individual athletes. A physical prototype was developed, and an experiment was designed to identify changes in performance due to different geometries. The design method and application make it possible to translate critical angles onto geometries, and test individuals for optimal work ergonomics.

https://doi.org/10.1017/pds.2022.217

Chaturmutha, Ketan Madan; Mathew, Deepak John
Indian Institute of Technology Hyderabad, India

FACTORS INFLUENCING THE EXTERIOR DESIGN OF AUTONOMOUS PASSENGER DRONES: LITERATURE REVIEW

Electric vertical take-off and landing aircraft (eVTOLs) have been accessed on various configurations over the past decade. This literature review deals with the issue of determining the appropriate design for an Autonomous Passenger Drone (APD). APDs have been compared with VTOLs on their pros and cons. The authors analysed aerodynamics and propulsion systems of multiple APDs. Further, the comparative analysis aids in designing the best framework for the exterior form of APDs based on human capacity, flying technology, fuel type, travel distance, door type, size, material, safety, cost, etc.

https://doi.org/10.1017/pds.2022.211

Lee, Haebin[1]; Tufail, Muhammad[2]; Kim, KwanMyung[1]
1: Ulsan National Institute of Science and Technology, South Korea; 2: The Hong Kong Polytechnic University, Hong Kong

EXPANDED PHASE MODEL FOR TRANSFORMABLE DESIGN IN DEFINING ITS USAGE SCENARIOS FOR MERITS AND DEMERITS

The product's transformation is considered for its fascination but it is not studied for its usage scenario. This study proposes an expanded phase model that can evaluate the usefulness of transformable products from the perspective of form, function and user scenario of a transformable product. We analyzed purpose of transformation, and identified user benefits from existing transformable products. This model allows designers/ team to evaluate usefulness of transformable products by comparing user benefits of the product with appropriateness of form and function in a given usage scenario.

https://doi.org/10.1017/pds.2022.215

Osman, Altun; Kutay, Yinanc; Mozgova, Iryna; Lachmayer, Roland
Leibniz Universität Hannover, Germany

PROCEDURE TO CREATE AN AUTOMATED DESIGN ENVIRONMENT FOR FUNCTIONAL ASSEMBLIES

Manually exploring the solution space for different variants of a product for a given set of requirements is ineffective regarding product development time and adaptation to dynamic customer requirements. Variant generation coupled to optimization algorithms offers possibilities to search the solution space in an automated way. This paper provides a framework to build a generative parametric design environment for functional assemblies by implementing analysis as well as synthesis methods in computer-aided tools. The procedure is presented using the example of a coffee machine.

https://doi.org/10.1017/pds.2022.57

Dickopf, Thomas; Apostolov, Christo
CONTACT Software GmbH, Germany

CLOSED-LOOP ENGINEERING APPROACH FOR DATA-DRIVEN PRODUCT PLANNING

This contribution introduces an approach for data-driven optimization of products and their product generations through a Closed-Loop Engineering approach resulting from the German research project DizRuPt. The approach focuses on data-driven product planning by ensuring data consistency and traceability between product planning, product development, and product operation by combining aspects and functions from Product Lifecycle Management (PLM) and the Internet of Things (IoT). The presented approach is illustrated and validated by pilot applications from the research project.

https://doi.org/10.1017/pds.2022.39

Nambiar, Sanjay[1]; Albert, Albin Parappilly[1]; Rimmalapudi, Veeravenkatamanikanta Virupaksh Raja Chowdary[1]; Acharya, Vinayak[1]; Tarkian, Mehdi[1]; Kihlman, Henrik[2]
1: Linköping University, Sweden; 2: Prodtex AB, Sweden

AUTOFIX – AUTOMATED DESIGN OF FIXTURES

This paper presents a framework to develop the automated design of fixtures using the combination of design automation (DA), multidisciplinary optimization and robotic simulation. MDO necessitates the use of concurrent and parametric designs which are created by DA and knowledge-based engineering tools. This approach is designed to decrease the time and cost of the fixture design process by increasing the degree of automation. AutoFix provides methods and tools for automatically optimizing resource-intensive fixture design utilizing digital tools from different disciplines.

https://doi.org/10.1017/pds.2022.56

Gopsill, James[1,2]; Hicks, Ben[1]
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THROUGH-LIFECYCLE WHOLE-DESIGN OPTIMISATION USING SOFTWARE DEPLOYMENT TOOLCHAINS

Through-Lifecycle Whole Design Design Optimisation is widely considered one of the future approaches to solving design problems featuring prominently in Model-Based Systems Engineering, Set-Based Design and Digital Twins. Yet, design optimisation remains siloed optimising for design subsets. In this paper, we review academic literature and a series of case studies to uncover the challenges in achieving Through-Lifecycle Whole Design Design Optimisation. This is followed by action research that has investigated the application of software deployment toolchains to overcome the challenges.

https://doi.org/10.1017/pds.2022.188

Rosich, Albert; López, Carlos; Dewangan, Prakash; Abedrabbo, Gabriel
Flanders Make, Belgium

ROBUST DESIGN OPTIMIZATION OF MECHATRONICS SYSTEMS: PARALLEL ELECTRIC DRIVETRAIN APPLICATION

This paper addresses the problem of finding a robust optimal design when uncertain parameters in the form of crisp or interval sets are present in the optimization. Furthermore, in order to make the approach as general as possible, direct search methods with the help of sensitivity analysis techniques are employed to optimize the design. Consequently, the presented approach is suitable for black box models for which no, or very little, information of the equations governing the model is available. The design of an electric drivetrain is used to illustrate the benefits of the proposed method.

https://doi.org/10.1017/pds.2022.175

Martins Pacheco, Nuno Miguel[1]; Vazhapilli Sureshbabu, Anand[1]; Dieckmann, Elena[2]; Apud Bell, Maria[2]; Green, Stephen[2]; Childs, Peter[2]; Zimmermann, Markus[1]
1: Technical University of Munich, Germany; 2: Imperial College London, United Kingdom

CHALLENGES AND OPPORTUNITIES IN REMOTE PROTOTYPING: A CASE-STUDY DURING COVID-19

Collaboration is common practice within design disciplines and beyond. Brainstorming, discussions, and prototyping tend to occur within the same physical space. The reduction of human interaction during the COVID-19 pandemic disrupted these practices. In this paper, we focus on the possibilities and challenges of remote prototyping of four student teams by combining a double diamond approach with tools to overcome remote work challenges. The results were analyzed to understand crucial tools, advantages, and obstacles. The key challenges and opportunities were then identified and examined.

https://doi.org/10.1017/pds.2022.25

Session D322
Virtual Room 2
CET 13:45
CET 15:00

Horvat, Nikola; Brnčić, Marko; Perišić, Marija Majda; Martinec, Tomislav; Bojčetić, Nenad; Škec, Stanko
University of Zagreb, Croatia

DESIGN REVIEWS IN IMMERSIVE AND NON-IMMERSIVE COLLABORATIVE VIRTUAL ENVIRONMENTS: COMPARING VERBAL COMMUNICATION STRUCTURES

The paper explores the differences between immersive and non-immersive collaborative virtual environments (CVEs) during design reviews. Based on ten reviews with one designer and two reviewers, the study shows that CVEs affect verbal communication structure. More specifically, teams usually talked less, and reviewers exchanged significantly more turn sequences in immersive than in non-immersive CVEs. Regardless of the environment, most turn sequences were related to the designer, who usually talked the most. These findings contribute to the understanding of CVEs in virtual teams.

https://doi.org/10.1017/pds.2022.23

25 May
WED

Dekoninck, Elies Ann; Brenninkmeijer, Charlotte
University of Bath, United Kingdom

TESTING TYPICAL CHALLENGES AFFECTING IDEA SHARING IN DISTRIBUTED DESIGN TEAMS TODAY

The aim of this study was to compare behaviours in distributed design teams today to the existing literature to see if previously identified challenges faced by distributed teams have been overcome. Recordings of teams' online idea sharing sessions were transcribed and split into idea sharing instances (units). A scoring system analysed the effectiveness of each unit. Having a clear structure with formal idea discussion, an assertive leader, and no time limits led to higher scores. Whilst instances of informal speaking and the wide variety of tools used had no link to the unit scores.

https://doi.org/10.1017/pds.2022.14

Bisson, Isaline[1,2]; Mahdjoub, Morad[1]; Zare, Mohsen[1]; Bluntzer, Jean-Bernard[1]; Sagot, Jean-Claude[1]; Goutaudier, Frédéric[2]; Ravier, Franck[2]
1: UTBM-University of Bourgogne Franche-Comte, France; 2: Stäubli, France

PROPOSAL OF A CONCEPTUAL FRAMEWORK FOR COLLABORATIVE DESIGN OF IMMERSIVE PROFESSIONAL TRAINING: APPLICATION TO THE TEXTILE INDUSTRY

Immersive technologies have an increasing use in professional training. However, the usability of applications has limits due to a lack of consideration of end users in the design of these new supports. This paper reviews the literature and discovers that few approaches offer to include different collaborators' work, or the end user, in the design process. This study proposes a conceptual framework design for immersive professional training (IPT) and its application in the textile industry.

https://doi.org/10.1017/pds.2022.12

Duehr, Katharina[1]; Grimminger, Jana[2]; Rapp, Simon[1]; Albers, Albert[1]; Bursac, Nikola[2]
1: Karlsruhe Institute of Technology, Germany; 2: TRUMPF GmbH + Co. KG, Germany

ENABLING DISTRIBUTED TEAMS – A PROCESS MODEL FOR EARLY AND CONTINUOUS METHOD VALIDATION

Neglecting challenges of distributed collaboration can lead to significant efficiency and effectiveness losses in agile, distributed development teams. The EDiT method provides support for improving distributed collaboration of development teams. To ensure acceptance, applicability, and contribution to success in industrial development practice, it is necessary to validate the EDiT method. The goal of this contribution is the development of a process model for early and incremental validation of the EDiT method in the field finally leading to a validation of the EDiT method itself.

https://doi.org/10.1017/pds.2022.17

Bendixen, Andreas Fenger; Jensen, Carina Nørtoft; Schmidt, Frederik; Laursen, Linda Nhu
Aalborg University, Denmark

DESIGNING LONG-LASTING PRODUCTS: BARRIERS FOR DESIGN CONSULTANCIES

Past research shows there are significant barriers for creating long lasting products. In this paper we examine, the distinct collaborative barriers design consultancies face when striving to design long-lasting products for client firms. Data is collected through case studies (four months of observations and interviews) from three projects. Through the study we find indications, that the value chain intricacies, provide distinct interfirm barriers for creating long lasting products. These barriers include vision clashes, misalignment in the aspired manufacturing quality and price position.

https://doi.org/10.1017/pds.2022.99

Session D323
Virtual Room 3
CET 13:45
CET 15:00

Pucci, Elena; Tufarelli, Margherita; Giliberti, Leonardo
University of Florence, Italy

SLOW FASHION ACCOMPANIES DIGITAL TOWARDS A SUSTAINABLE FUTURE: FROM QUANTITY TO QUALITY. REFLECTIONS ON THE NEW PARADIGM OF SUSTAINABLE FASHION

The negative social and environmental impacts of the fashion industry refer to a global industry, with its ubiquitous supply chains driven by big brands that determine what to produce, where to produce, and at what prices to sell. Do we want to continue to keep fashion as a beautiful artifact? If so, we need to consider how resources are deployed. Accelerating climate change is looming, portending an uncertain and damaging future. Can fashion be sustainable? Why is sustainability in fashion seen as an oxymoron? Can a return to slow fashion accompany digital towards a sustainable future?

https://doi.org/10.1017/pds.2022.111

25 May
WED

Gurel, Rengin[1,2]; Merzali Celikoglu, Ozge[1]
1: Istanbul Technical University, Turkey; 2: Fatih Sultan Mehmet Vakıf University, Turkey

PRODUCTS THAT AGE WITH US: CARPET IN THE TURKISH HOUSEHOLD

This paper explores carpet, an intergenerational product, that lives and ages with its users. An ethnographic study was conducted through participant observation and in-depth interviews to understand why carpet matters in Turkish homes. Exploring material culture of carpet unfolds its meaning as a signifier of culture in second-order semiological systems. Study finds carpet has socializing traits, is the maker of home, needs maintenance and can be an artwork or object. Examining a product's importance and emotional durability can enable new understandings of product meaning and sustainability.

https://doi.org/10.1017/pds.2022.103

Srivastava, Vishal; Singh, Sumer; Das, Dipayan
Indian Institute of Technology Delhi, India

PARAMETERS PROPOSED FOR SUSTAINABILITY ASSESSMENT OF BIOCOMPOSITE BASED RIGID PACKAGING

The sustainability of rigid packaging can be increased by using biocomposites in packaging. Existing frameworks have some limitations such as are made to assess a few aspects, conventional packaging parameters are considered, etc. Biocomposite has a slightly different scenario at various life cycle stages, like the end-of-life cycle process. To assess the sustainability of biocomposite rigid packaging, we must consider parameters related to the biocomposite-based rigid packaging materials life cycle. These are categorised into different aspects of sustainability and life cycle phases.

https://doi.org/10.1017/pds.2022.116

Metic, Julija[1]; Klose, Svenja[2]; McAloone, Tim C.[1]; Fröhling, Magnus[2]; Pigosso, Daniela C. A.[1]
1: Technical University of Denmark, Denmark; 2: Technical University of Munich, Germany

PROPOSAL OF A DUAL CIRCULARITY CONCEPT FOR SUSTAINABLE DESIGN

Current CE approach, and its many definitions, does not explicitly consider the interconnectedness of the biological and technological cycle. This paper uses state-of-the-art to articulate nuances of the CE to encourage a more comprehensive understanding of the concept from a perspective of both cycles. The results address that acknowledged sustainably driven shifts of resources between cycles are neglected in most state-of-the-art. Therefore, the Dual Circularity (DC) definition is proposed and further evaluated by three examples.

https://doi.org/10.1017/pds.2022.107

Zech, Andreas[1]; Stetter, Ralf[2]; Rudolph, Stephan[3]; Till, Markus[2]
1: EKS InTec GmbH, Germany; 2: University of Applied Sciences Ravensburg-Weingarten, Germany; 3: University of Stuttgart, Germany

CAPTURING THE DESIGN RATIONALE IN MODEL-BASED SYSTEMS ENGINEERING OF GEO-STATIONS

The design rationale describes the justification of design decision or selection. To avoid unnecessary design iterations, a capturing and documentation of this rationale is highly desirable. In digital engineering processes it is of imminent importance not only to document the evaluation processes behind this rationale but to make them repeatable and digitally executable. This allows to design a variety of product variants within an engineering framework. This paper explains an approach based on graph-based design languages and presents it based on a section of an automotive assembly system.

https://doi.org/10.1017/pds.2022.204

Session D324
Virtual Room 4
CET 13:45
CET 15:00

Husung, Stephan; Weber, Christian; Mahboob, Atif
Technische Universität Ilmenau, Germany

INTEGRATING MODEL-BASED DESIGN OF MECHATRONIC SYSTEMS WITH DOMAIN-SPECIFIC DESIGN APPROACHES

In addition to the known approaches for product development new or supplementary approaches have emerged. An important approach in this field is Systems Engineering (SE) and Model-Based Systems Engineering. Through these approaches, new procedures, level-focused description concepts and terms come into product development. However there are still some uncertainties as to how the known approaches of product development can be combined with the SE approaches. This paper aims to show how the known development approaches can be extended by and integrated with SE approaches.

https://doi.org/10.1017/pds.2022.192

25 May
WED

Pinquié, Romain; Romero, Victor; Noel, Frédéric
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SURVEY OF MODEL-BASED DESIGN REVIEWS: PRACTICES & CHALLENGES?

The design of large-scale engineered systems relies on the extensive use of models. Although there are few papers that study design review practices, we did not find any on model-based design reviews. Thus, we undertook a survey to collect current practices and challenges. We found that reviews are mainly synchronous co-located or remote meetings that involve various profiles who need to access and share models, but that they pragmatically give them up and prefer to comment on PowerPoint-like slides containing screenshots of models except when the meeting gathers only experts in model-based design.

https://doi.org/10.1017/pds.2022.197

Gräßler, Iris; Wiechel, Dominik; Koch, Anna-Sophie; Preuß, Daniel; Oleff, Christian
Heinz Nixdorf Institute, Paderborn University, Germany

MODEL-BASED EFFECT-CHAIN ANALYSIS FOR COMPLEX SYSTEMS

Effect chain modeling approaches are applied to model cause-effect relations and analyze affected elements and dependencies. In this paper a systematic literature research is conducted to derive main characteristics and limitations of existing approaches. Then, the Model-based Effect Chain Analysis (MECA) method is introduced. Evaluation proves applicability of the method by means of a case example. This is done in the context of a project with a German automotive company. In the project 66 workshops were conducted to model certification-compliant effect chains in accordance to the UN ECE 156.

https://doi.org/10.1017/pds.2022.191

Valdivia Dabringer, Martin Leo; Dybov, Anton; Fresemann, Carina; Stark, Rainer
Technische Universität Berlin, Germany

TOWARDS INTEGRATED SAFETY ANALYSIS AS PART OF TRACEABLE MODEL-BASED SYSTEMS ENGINEERING

Currently systems grow in complexity and more aspects, such as socio-technical aspects or the obligation to produce proof become more important. Both require a safety analysis on the system level early in the design process. System overview is provided by MBSE, while safety analysis is provided for example by FMEA. Both processes are executed organizationally and timely separated from each other. This research proposes a concept and a tool integration at the concept design phase, during system definition and functional decomposition and evaluates the effect and its potential applicability.

https://doi.org/10.1017/pds.2022.203

Küchenhof, Jan; Berschik, Markus Christian; Heyden, Emil; Krause, Dieter
Hamburg University of Technology, Germany

METHODICAL SUPPORT FOR THE NEW DEVELOPMENT OF CYBER-PHYSICAL PRODUCT FAMILIES

The new development of cyber-physical product families currently lacks a methodically supported modularisation approach. This paper provides an approach for module-based mechatronic development, which provides design for future product variety. The state of the art in terms of mechatronic system design and modular product architecture design is presented. A modified V-model is then shown that integrates initial product architecture design and life phase modularisation. The method is applied and evaluated for the development of product family generations of robot units in a teaching course.

https://doi.org/10.1017/pds.2022.51

Session D325
Virtual Room 5
CET 13:45
CET 15:00

Molina, Veronica Rocio; Reyes Rey, Luis; Werner, Sebastian; Göhlich, Dietmar
Technische Universität Berlin, Germany

METHOD FOR FUNCTION-BASED IDENTIFICATION OF POTENTIAL AM COMPONENTS IN CONVENTIONAL PRODUCT ARCHITECTURES

The implementation of additive manufacturing enables the the re-thinking of a product towards function-oriented design. This study proposes a method, which uses a set of rules and indicators to implement functional integration, part consolidation, part separation and on-demand manufacturing onto a conventional prodcut architecture to restructure it into an AM-oriented product architecture. The feasibility of the method is demonstrated on an assembly from the field of high temperature applications.

https://doi.org/10.1017/pds.2022.52

Schaffers, Michel; Rosseel, Eveline; Burggraeve, Sofie; Pelfrene, Joren; Gadeyne, Klaas; Petré, Frederik
Flanders Make, Belgium

25 May
WED

METHODOLOGY FOR EARLY DESIGN PHASE COST AND PERFORMANCE TRADE-OFF ANALYSIS OF A NEW VARIANT IN A PRODUCT FAMILY

Given the Industry 4.0 trend towards smaller lot sizes and large product families, there is a need to increase the design efficiency in terms of cost and lead time. Design decisions taken in the early or conceptual design phases are shown to have the greatest impact on the final product cost, however the choices and trade-offs are often made in an ad-hoc way. This paper presents a structured methodology for formalizing early stage product design knowledge, which is key for designing and evaluating new variants in a product family in the early stages of the design process.

https://doi.org/10.1017/pds.2022.61

Rötzer, Sebastian[1]; Berger, Vincent[2]; Zimmermann, Markus[1]
1: Technical University of Munich, Germany; 2: DeepDrive GmbH, Germany

COST OPTIMIZATION OF PRODUCT FAMILIES USING SOLUTION SPACES: APPLICATION TO EARLY-STAGE ELECTRIC VEHICLE DESIGN

Companies offer products in different variants to reach more customers. This increases internal variety and cost. However, reducing those cost is difficult due to complexity. Complexity arises from: combinatorics; many design variables interacting with each other; coupling of technical and economical perspectives. This paper presents an approach based on (1) building a complex system model of modular models; (2) identifying the potential for standardization from a technical perspective; (3) cost-optimizing the degree of standardization. A product family of electric vehicles was optimized.

https://doi.org/10.1017/pds.2022.60

Hanna, Michael; Schwenke, Johann; Schwan, Lukas; Krause, Dieter
Hamburg University of Technology, Germany

METHODICAL APPROACH FOR THE MODEL-BASED DEVELOPMENT OF AIRCRAFT CABIN PRODUCT FAMILIES UNDER CONSIDERATION OF LIGHTWEIGHT AND COST-BASED DESIGN

Aircraft cabin monuments must be optimized in terms of lightweight design, cost structure and variance. Model-based approaches support the aircraft data and help to modify them consistently during further development. In this paper, a holistic methodological approach for product families of aircraft cabin development is shown, which integrates lightweight and cost-efficient aspects, in addition to the variance focus. For this purpose, the development of cost-efficient and ligthweight optimized cabin modules is supported in a model-based way.

https://doi.org/10.1017/pds.2022.45

Giunta, Lorenzo; Gopsill, James; Kent, Lee; Goudswaard, Mark; Snider, Chris; Hicks, Ben
University of Bristol, United Kingdom

PRO2BOOTH: TOWARDS AN IMPROVED TOOL FOR CAPTURING PROTOTYPES AND THE PROTOTYPING PROCESS

The act of prototyping is a key element of the design process. However, capturing information on how prototypes evolve and influence one another is a complex problem. This paper presents an iterative evolution to a prototyping capture platform, termed Pro2Booth, designed to address the shortcomings encountered in previous systems. The Pro2Booth hardware and online software described in this paper provide a new baseline for future innovation and exploration of the prototype capture process.

https://doi.org/10.1017/pds.2022.43

Session D326
Virtual Room 6
CET 13:45
CET 15:00

Gutiérrez Morales, Felipe[1]; Osorio Gómez, Gilberto[1]; Córdoba Morales, Jorge[2]
1: EAFIT University, Colombia; 2: EIA University, Colombia

PROTO-ARCH: GUIDANCE TOOL FOR PROTOTYPING OF MECHANICAL SYSTEMS AT THE EMBODIMENT DESIGN PHASE

Prototypes are a critical aid in the product development process, allowing designers translate concepts to reality. However, the execution of prototypes depends heavily on the designer experience, evidenced in research in the need of creating design support tools to establish a standard for a prototyping effort. To improve on these findings, the Proto-Arch is introduced as a partial result of creating a standard for executing prototypes in each product development phase based on the prototyping roles and purposes. Proto-Arch defines the prototyping activities in the embodiment design phase.

https://doi.org/10.1017/pds.2022.44

Wang, Jing; Ranscombe, Charlie; Eisenbart, Boris
Swinburne University of Technology, Australia

25 May
WED

PROTOTYPING IN SMART PRODUCT DESIGN: INVESTIGATING PROTOTYPING TOOLS TO SUPPORT COMMUNICATION OF INTERACTIVE AND ENVIRONMENTAL QUALITIES

The increasing availability of smart products creates a more pronounced need for designers to prototype and communicate interactive and environmental qualities of product during their design process. This paper explores which elements of User journey, Storyboards and Wireframes contribute to communicating these qualities, and how they might integrate with sketching. Results show depictions of user and temporal elements alongside low fidelity sketches are deemed most important. Our findings form the basis to propose and subsequently test combined prototyping approaches in future research.

https://doi.org/10.1017/pds.2022.227

Buker, Tina[1]; Endress, Felix[1,2]; Miehling, Jörg[1]; Wartzack, Sandro[1]
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THE INTERPLAY OF SUBJECTIVE QUALITY EVALUATION, PROTOTYPING TECHNOLOGIES AND THE USER'S TECHNOLOGY ACCEPTANCE

Subjective product quality is a fundamental aspect to maintain a high level of user acceptance and to provide a good user experience. Prototypes can be used to evaluate subjective product quality in early design phases. We conducted an empirical study to examine the influence of different (re)presentations of prototypes determined by the chosen technology (2D image, VR, AR, 3D print) and the user's technology acceptance. Based on the results we recommend 2D images as most reliable for evaluating subjective product quality.

https://doi.org/10.1017/pds.2022.210

Real, Ricardo M.; Snider, Chris; Hicks, Ben
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EXPLORING THE BENEFITS OF REMANUFACTURE DURING PRODUCT PROTOTYPING: A COST AND TIME BASED ANALYSIS

Whilst remanufacture is identified as a key enabler for sustainable manufacture in future industry, its role within the context of new product development remains unclear. Where prototypes often go through multiple iterations with varying degrees of change, could remanufacture be adopted to reduce the time and cost components of design iteration? This paper presents a computational study to explore the potential savings afforded by remanufacture across stages of a rapid prototyping process. Results suggest significant reductions to development time and cost can be achieved.

https://doi.org/10.1017/pds.2022.59


DESIGN
2022

TOWARD AI-HUMAN HYBRID LEARNING

Jonathan Cagan

George Tallman and Florence Barrett Ladd Professor in Mechanical Engineering, Carnegie Mellon University (US)

Teams are a core part of the engineering design process. Prior computational design tools have served to support the human team, applied to distinct tasks to output specific information or calculations. As smart (AI) agents emerge, their role has the potential to be different, contributing to teams as a proactive partner or even manager of the human design process. This talk will examine engineering teaming and ways that AI is evolving to change the performance and dynamics of teams. AI agents that assimilate historical and real time data are proving to impact team output, communication efficiency, and group behavior during problem solving. The talk will illustrate recent results and motivate future research in this emerging area of study and practice.

BIOGRAPHICAL SKETCH

Jonathan Cagan is the George Tallman and Florence Barrett Ladd Professor in Engineering, Department of Mechanical Engineering, at Carnegie Mellon University, with courtesy appointment in Design. His research focuses on engineering design automation and methods, merging AI, machine learning, and optimization with cognitive science problem solving. With nearly 300 peer-reviewed publications and multiple patents, both his design methods and computer-based design research have been applied in a variety of industries. A Member of the Design Society and Fellow of the American Society of Mechanical Engineers, Jon is recipient of the ASME Design Theory and Methodology, Design Automation, and Ruth and Joel Spira Outstanding Design Educator Awards.

Rahman, Molla Hafizur[1]; Bayrak, Alparslan Emrah[2]; Sha, Zhenghui[3]
1: University of Arkansas, United States of America; 2: Stevens Institute of Technology, United States of America; 3: The University of Texas at Austin, United States of America

A REINFORCEMENT LEARNING APPROACH TO PREDICTING HUMAN DESIGN ACTIONS USING A DATA-DRIVEN REWARD FORMULATION

In this paper, we develop a design agent based on reinforcement learning to mimic human design behaviours. A data-driven reward mechanism based on the Markov chain model is introduced so that it can reinforce prominent and beneficial design patterns. The method is implemented on a set of data collected from a solar system design problem. The result indicates that the agent provides higher prediction accuracy than the baseline Markov chain model. Several design strategies are also identified that differentiate high-performing designers from low-performing designers.

https://doi.org/10.1017/pds.2022.173

Bickel, Sebastian; Schleich, Benjamin; Wartzack, Sandro
Friedrich-Alexander-Universität Erlangen-Nürnberg, Germany

A NEW PROJECTION BASED METHOD FOR THE CLASSIFICATION OF MECHANICAL COMPONENTS USING CONVOLUTIONAL NEURAL NETWORKS

Digital engineering is increasingly established in the industrial routine. Especially the application of machine learning on geometry data is a growing research issue. Driven by this, the paper presents a new method for the classification of mechanical components, which utilizes the projection of points onto a spherical detector surfaces to transfer the geometries into matrices. These matrices are then classified using deep learning networks. Different types of projection are examined, as are several deep learning models. Finally, a benchmark dataset is used to demonstrate the competitiveness.

https://doi.org/10.1017/pds.2022.152

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ASSESSING MACHINE LEARNABILITY OF IMAGE AND GRAPH REPRESENTATIONS FOR DRONE PERFORMANCE PREDICTION

Deep learning (DL) from various representations have succeeded in many fields. However, we know little about the machine learnability of distinct design representations when using DL to predict design performance. This paper proposes a graph representation for designs and compares it to the common image representation. We employ graph neural networks (GNNs) and convolutional neural networks (CNNs) respectively to learn them to predict drone performance. GCNs outperform CNNs by 2.6-8.1% in predictive validity. We argue that graph learning is a powerful and generalizable method for such tasks.

https://doi.org/10.1017/pds.2022.180

Franz, Michael[1]; Pfingstl, Simon[2]; Zimmermann, Markus[2]; Wartzack, Sandro[1]
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ESTIMATION OF COMPOSITE LAMINATE PLY ANGLES USING AN INVERSE BAYESIAN APPROACH BASED ON SURROGATE MODELS

A digital twin (DT) relies on a detailed, virtual representation of a physical product. Since uncertainties and deviations can lead to significant changes in the functionality and quality of products, they should be considered in the DT. However, valuable product properties are often hidden and thus difficult to integrate into a DT. In this work, a Bayesian inverse approach based on surrogate models is applied to infer hidden composite laminate ply angles from strain measurements. The approach is able to find the true values even for ill-posed problems and shows good results up to 6 plies.

https://doi.org/10.1017/pds.2022.159

Cobb, Adam; Roy, Anirban; Elenius, Daniel; Koneripalli, Kaushik; Jha, Susmit
SRI International, United States of America

ON DIVERSE SYSTEM-LEVEL DESIGN USING MANIFOLD LEARNING AND PARTIAL SIMULATED ANNEALING

The goal in system-level design is to generate a diverse set of high-performing design configurations that allow trade-offs across different objectives and avoid early concretization. We use deep generative models to learn a manifold of the valid design space, followed by Monte Carlo sampling to explore and optimize design over the learned manifold, producing a diverse set of optimal designs. We demonstrate the efficacy of our proposed approach on the design of an SAE race vehicle and propeller.

https://doi.org/10.1017/pds.2022.156

Rößler, Lisa; Gericke, Kilian
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ANALYSING PARADIGMS FOR MANAGING PRODUCT DEVELOPMENT: CONVENTIONAL, AGILE AND HYBRID APPROACHES

As the complexity of products and their development processes increases, a trend emerged where companies try to manage the complexity through implementing agile practices on all or on some levels of the development process. It is not yet clear if an agile approach is the solution or under which circumstances it can be most effective in the development of physical products. This paper aims to compile the information from existing empirical and meta-studies to give an overview of the strengths and weaknesses of conventional, agile and hybrid paradigms.

https://doi.org/10.1017/pds.2022.28

Drutchas, Jake; Eppinger, Steven
Massachusetts Institute of Technology, United States of America

GUIDANCE ON APPLICATION OF AGILE IN COMBINED HARDWARE AND SOFTWARE DEVELOPMENT PROJECTS

Agile has its roots in software, improving the pace and quality of development projects. The application of Agile to hardware is less mature, and anecdotal evidence suggests there are specific challenges in this space. Based upon qualitative interviews with organizations working simultaneously across hardware and software applications, this paper presents three key challenges we identified. We also document several useful adjustments to Agile practice which provide a toolset that teams can use to more successfully apply Agile to hardware projects.

https://doi.org/10.1017/pds.2022.16

Heimicke, Jonas; Czech, Christiane; Schoeck, Moritz; Mueller, Johannes; Rapp, Simon; Albers, Albert
Karlsruhe Institute of Technology, Germany

INTRODUCING AGILITY INTO THE PROCESSES OF MANUFACTURING COMPANIES: A METHOD FOR EVALUATING SUCCESS, SUPPORT AND APPLICABILITY

Agile approaches are increasingly being used in appropriate use cases for the development of mechatronic systems.In the process of implementing agile elements in the development processes, the question of the success of the transformation often arises. In order to support the agile transition in measuring process improvement, a framework was developed that evaluates the success of the implementation process by means of interviews at 4 maturity levels in the transformation. The method was evaluated in 3 use cases. On this basis, continuous adaptations can be made to the implementation process.

https://doi.org/10.1017/pds.2022.249

Hansen, Camilla Arndt; Arlitt, Ryan; Eifler, Tobias; Deininger, Michael
Technical University of Denmark, Denmark

DESIGN BY PROTOTYPING: INCREASING AGILITY IN MECHATRONIC PRODUCT DESIGN THROUGH PROTOTYPING SPRINTS

This paper adapts the agile scrum sprint, typically used in software development, to a prototyping sprint for mechatronic product design. The Design by Prototyping framework describes how the prototyping sprint can be used to manage the prototyping process in design projects through an agile-stage-gate hybrid model. A comparison of 18 student projects using either prototyping sprints or a traditional iterative prototyping approach shows that prototyping sprints helped students make more deliberate, strategic decisions about their use of prototypes.

https://doi.org/10.1017/pds.2022.22

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1: University of Stuttgart, Germany; 2: Scania CV AB, Sweden

NEW HOLISTIC APPROACH TOWARDS A TECHNOLOGY-DRIVEN DEVELOPMENT-MODEL IN AUTOMOTIVE

The use of agile methods can also be advantageous in the development of physical products, as pilot projects have shown so far. However, the transfer of agile methods to the entire organisation is difficult, due to the different, prevailing circumstances of the various development activities. We have therefore defined a new approach subdividing product development into agile technology-driven and traditional product-oriented development. This model considers the methodological characteristics and thus enables the combination of the benefits of both agile and traditional development methods.

https://doi.org/10.1017/pds.2022.26

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DESIGNING INNOVATION – THE ROLE OF ENGINEERING DESIGN TO REALISE SUSTAINABILITY CHALLENGES

Sustainability challenges drive innovation, yet few studies attend to the role of design to realise innovation. This paper report from a full day workshop and panel discussion with 100 delegates at the ICED 2021 conference. Industrialists, academics and societal representatives discussed how to deal with five conflicting themes. It is argued that innovation actors will need to take a joint action to the problem, industrial value chains need to co-innovate and that long term challenging targets are powerful metrics to drive transformation.

https://doi.org/10.1017/pds.2022.104

Session D333
Virtual Room 3
CET 16:15
CET 17:30

Nielsen, Brita Fladvad; Bjerck, Mari
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RELATIONAL DESIGN

There is a mismatch between the way public services are designed, and the chronic dilemmas of the welfare state. Through two case studies we show how tool-dependent, instrumental and systems-oriented approaches fall short in tackling these dilemmas, and how the there is a need for a new, relational turn in design. Relational design takes into account interdependencies and dynamic situation of society, and calls for a new design vocabulary that discusses and approaches the relational aspects and opens up for a more situational and sensitive design agency.

https://doi.org/10.1017/pds.2022.108

Rajski, Pauline; Sicko, Anabel J; Papalambros, Panos Y.
University of Michigan, United States of America

MODELING SOCIAL BENEFITS IN SYSTEM DESIGN OPTIMIZATION OF INTEGRATED NATURAL RESOURCES CONSERVATION AND DEVELOPMENT (INRCD) PROJECTS: IDENTIFICATION AND QUANTIFICATION OF DESIGN ATTRIBUTES FROM EXTANT LITERATURE

25 May
WED

Integrated Natural Resource Conservation and Development (INRCD) Projects promote community economic development consistent with natural resource conservation. Such projects are studied analytically as system design optimization problems comprising engineering, economic, and social considerations. Modeling social benefits as objectives or constraints requires proper quantification. From the extant literature, we decompose the social benefits concept into quantifiable INRCD attributes and point to further quantification efforts needed to capture the system design's impact on local communities.

https://doi.org/10.1017/pds.2022.112

van der Marel, Floris; Björklund, Tua
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DESIGNERS AS CHANGE AGENTS: PERCEIVED ROLES IN ADVANCING SUSTAINABILITY IN ORGANIZATIONS ON DIFFERENT DESIGN UTILIZATION LEVELS

Design scholarship has long roots in tackling wicked problems and sustainability, yet less is known about how professional designers interact with sustainability issues in practice. Based on interviews with 104 designers in 101 organizations in Finland, this study compares designer perceptions on the role of design in advancing sustainability. We identify six common roles, each with various foci on different design maturity levels in organisations. The findings support managers and designers in understanding which capabilities might be needed in advancing the role of design and sustainability.

https://doi.org/10.1017/pds.2022.117

Zomer, Thayla; McAloone, Tim C.; Pigosso, Daniela C. A.
Technical University of Denmark, Denmark

TO WHAT EXTENT IS CIRCULAR PRODUCT DESIGN SUPPORTING CARBON REDUCTION STRATEGIES? AN ANALYSIS OF NORDIC MANUFACTURING FIRMS WITHIN THE SCIENCE-BASED TARGETS INITIATIVE

Corporate climate action is critical in supporting the transition towards a low-carbon economy. This paper explores what design practices have been adopted by manufacturing companies that have committed to science-based emission reduction targets and are making progress towards those targets. We contribute to the existing literature by providing empirical evidence of circular economy (CE) actions related to product design supporting firms in reaching their emission reduction targets, contributing to the calls for more research showing evidence between CE adoption and emissions reduction.

https://doi.org/10.1017/pds.2022.121

Vidner, Olle; Wehlin, Camilla; Wiberg, Anton
Linköping University, Sweden

DESIGN AUTOMATION SYSTEMS FOR THE PRODUCT DEVELOPMENT PROCESS: REFLECTIONS FROM FIVE INDUSTRIAL CASE STUDIES

This paper presents five industrial cases where design automation (DA) systems supported by design optimization has been developed, and aims to summarize the lesson learned and identify needs for future development of such projects. By mapping the challenges during development and deployment of the systems, common issues were found in technical areas such as model integration and organizational areas such as knowledge transfer. The latter can be seen as a two-layered design paradox; one for the product that the DA system is developed for, and one for the development of the DA system.

https://doi.org/10.1017/pds.2022.256

Cudok, Anja[1]; Lutz, Thorsten[2]; Vietor, Thomas[1]
1: Technische Universität Braunschweig, Germany; 2: Michael Weinig AG, Germany

TRANSFORMATION TOWARDS PRODUCT-SERVICE SYSTEMS AT THE EXAMPLE OF THE WOOD-PROCESSING INDUSTRY

Offering product-service systems instead of technical products is one way for companies to achieve a competitive advantage and stay viable in the future. This paper presents a workshop series created in cooperation between a manufacturer of wood processing production lines and a research institute for engineering design to develop PSS concepts for a plant. Using the finger jointing line as an example, the progress and results of the workshops are presented. Furthermore, it is discussed whether the workshop series is transferable to other products and industries.

https://doi.org/10.1017/pds.2022.246

Stulga, Paulius[1]; Whitfield, Robert Ian[1]; Love, Jaki[2]; Evans, Dorothy[1]
1: University of Strathclyde, United Kingdom; 2: UK Fashion & Textile Association, United Kingdom

TOWARDS SUSTAINABLE MANUFACTURING WITH INDUSTRY 4.0: A FRAMEWORK FOR THE TEXTILE INDUSTRY

Due to increasing sustainability demands, textiles manufacturing, an industry that uses substantial amounts of natural resources, energy and labour, are facing tough challenges in the years ahead. One of the more overlooked concepts with great potential for sustainable manufacturing is Industry 4.0. This paper addresses how the textile industry is engaging with Industry 4.0 technologies and applications in the context of sustainable manufacturing. A proposal for an implementation framework is introduced based on a literature review within this field.

https://doi.org/10.1017/pds.2022.30

Page, Jonathan Edward[1]; Higgins, Christopher J[1]; Seering, Warren Paul[2]
1: United States Navy, United States of America; 2: Massachusetts Institute of Technology, United States of America

STARTING AND SCALING A SET-BASED DESIGN METHOD FOR A MARITIME SYSTEM OF SYSTEMS: DESIGNING A MODERN WARSHIP

There has been a growing body of literature and use cases for set-based design since its introduction in the 80s. Few studies or use cases involve highly complex systems, though, except for the hallmark work regarding Toyota in the late 90s. Over the last three years, the US Navy used set-based methods to design a complex system of systems: a warship. Their experience provides insight into the scalability of the method and design management considerations relevant to the start of similar projects.

https://doi.org/10.1017/pds.2022.253

Opiyo, Eliab[1]; Jagtap, Santosh[2]; Keshwani, Sonal[3]
1: St. Joseph University in Tanzania, Tanzania; 2: Blekinge Institute of Technology, Sweden; 3: Dayananda Sagar University, India

CONCEPTUAL DESIGN IN METALWORKING MICROENTERPRISES: AN EMPIRICAL STUDY IN TANZANIA

Product design is a key aspect of human intelligence and creativity, attracting not only experts but also workers and self-employed without any formal design training. Although numerous people in developing countries design and manufacture simple products in metalworking microenterprises, there is very little systematic knowledge about their design process. This paper aims to fill this gap in design knowledge. We aim at investigating some aspects of design process in the metalworking microenterprises in Tanzania. The findings reveal how they identify needs, and generate and evaluate concepts.

https://doi.org/10.1017/pds.2022.252

Zuefle, Marc[1,2]; Muschik, Sabine[2]; Bursac, Nikola[2]; Krause, Dieter[1]
1: Hamburg University of Technology, Germany; 2: TRUMPF GmbH + Co. KG, Germany

COPING ASYNCHRONOUS MODULAR PRODUCT DESIGN BY MODELLING A SYSTEMS-IN-SYSTEM

This paper analyzes the potential of crossdisciplinary collaboration in the methodical development of Modular Design by harmonization asynchronous mechatronic system structures. Subsystem boundaries in multidisciplinary development processes are set disciplinespecific, resulting in inconsistencies in module fitting. Based on a case study, harmonization of disciplines is elaborated as a solution. This aligns discipline structures and reduces effects on the variety in system structures. This implementation shows support for modular design and enables an integrated view as a systems-in-system.

https://doi.org/10.1017/pds.2022.258

Session D335
Virtual Room 5
CET 16:15
CET 17:30

Lennartsson, Dan; Raudberget, Dag; Sandkuhl, Kurt; Seigerroth, Ulf
Jönköping University, Sweden

MODULARISATION METRICS – CONTRASTING INDUSTRIAL PRACTICE AND STATE-OF-RESEARCH

In many industrial sectors, modularization of products and services is considered as an important contribution to increased efficiency and competitiveness. Research has developed many modularization approaches, however, there is a gap between industrial practice in modularization and state-of-research in this field, which partly is due to shortcomings in “measuring” the value and state of modularization. This papers contribution is an analysis of industrial real-world cases to contrast practice and research, and a compilation of metrics in the context of modular product design from research.

https://doi.org/10.1017/pds.2022.251

Agergaard, Julie Krogh; Sigsgaard, Kristoffer Vandrup; Mortensen, Niels Henrik; Ge, Jingrui; Hansen, Kasper Barslund
Technical University of Denmark, Denmark

25 May
WED

MODULARIZING MAINTENANCE FOR IMPROVED PRODUCTION IMPACT CLARIFICATION

Maintenance is an essential aspect to keeping production facilities running and safe. However, without an overview of the maintenance impact on production, gaining clarification of the impact of maintenance is difficult. This paper introduces modularization of maintenance based on the dimensions of maintenance: physical, action, and process. The approach is applied in a case study where maintenance decisions are improved and faster than prior to the introduction of the modularized maintenance.

https://doi.org/10.1017/pds.2022.244

Asión-Suñer, Laura; López-Forniés, Ignacio
Universidad de Zaragoza, Spain

VALIDATION AS A NEW EVALUATION METHOD OF MODULAR DESIGN FOCUSED ON THE PROSUMER

The modular design harbors a potential development in the prosumer scope that has hardly been previously exploited. Their joint application can lead to products focused on user participation through modular design. This work proposes and validates a concept evaluation metric in the design phases that meet these characteristics. To do this, 24 external designers and prosumers evaluate five products using this method. The results and conclusions contribute to the improvement of the method and provide information on how to approach it to the prosumers.

https://doi.org/10.1017/pds.2022.33

Seidenberg, Tobias[1]; Disselkamp, Jan-Philipp[1]; Schräder, Elena[2]; Anacker, Harald[1]
1: Fraunhofer IEM, Germany; 2: Technische Universität Berlin, Germany

TOWARDS AN OPTIMISED VALUE CREATION NETWORK FOR MODULAR INVESTMENT GOODS

Companies are under increasing pressure from global competition while at the same they need to offer flexible products to meet individual customer requirements. Therefore, modularised capital goods are designed and manufactured to meet both challenges. This paper presents an approach to identify necessary changes in the production process and summarises the changes in the automotive and aerospace industries due to modularisation. Three key findings are identified: increased outsourcing potential, production in a value creation network with specialised manufacturers and joint investments.

https://doi.org/10.1017/pds.2022.254

12:00 CET

D4-O: PRE-SESSION GET-TOGETHER - VIRTUAL STAGE

INTRODUCTION TO CONFERENCE DAY
Sandro Wartzack, Friedrich-Alexander-Universität Erlangen-Nürnberg (DE), DESIGN 2022 Programme Chair

12:15 CET

D411	D412	D413
DESIGN DIGITALISATION APPROACHES	DESIGN FOR ADDITIVE MANUFACTURING I	PRODUCT-SERVICE SYSTEMS
Virtual Room 1	*Virtual Room 2*	*Virtual Room 3*
Chair: Marco Bertoni	*Chair: Tino Stanković*	*Chair: Jeremy Faludi*

13:30 CET

REFRESHMENT BREAK

13:45 CET

D4-P: PLENARY SESSION - VIRTUAL STAGE
Chair: Sandro Wartzack, Friedrich-Alexander-Universität Erlangen-Nürnberg (DE)

WHICH WAY I OUGHT TO GO?
Zrinka Čorak, Dr., Vicepresident, INETEC (HR)

14:30 CET

REFRESHMENT BREAK

14:45 CET

D421	D422	D423
REQUIREMENTS AND CHALLENGES IN DEVELOPING COMPLEX SYSTEMS	DESIGN FOR ADDITIVE MANUFACTURING II	SUSTAINABILITY AWARENESS
Virtual Room 1	*Virtual Room 2*	*Virtual Room 3*
Chair: Steven Eppinger	*Chair: Serena Graziosi*	*Chair: Daniela C. A. Pigosso*

16:00 CET

REFRESHMENT BREAK

16:15 CET

D431	D432	D433
AUTONOMOUS VEHICLES AND ELECTROMOBILITY	DESIGN FOR ADDITIVE MANUFACTURING III	SYSTEM DESIGN TOOLS
Virtual Room 1	*Virtual Room 2*	*Virtual Room 3*
Chair: Tim C. McAloone	*Chair: Georges Fadel*	*Chair: Clement Fortin*

17:30 CET

D4-C: DESIGN 2022 CLOSING - VIRTUAL STAGE

A Word After: Dorian Marjanović, University of Zagreb (HR), DESIGN 2022 Programme Chair

Closing Remarks: Mario Štorga, University of Zagreb (HR), DESIGN 2022 Conference Chair

18:00 CET

D4-S: SOCIAL GATHERING III
SOCIAL EVENT ROOM

19:00 CET

12:00 CET

12:15 CET

D414
KNOWLEDGE-BASED DESIGN
Virtual Room 4
Chair: Nenad Bojčetić

D415
ANALYSING AND TEACHING SKILLS/COMPETENCIES
Virtual Room 5
Chair: Elies Ann Dekoninck

D416
SEMANTICS AND PERCEPTION IN INDUSTRIAL DESIGN
Virtual Room 6
Chair: Akane Matsumae

13:30 CET

13:45 CET

14:30 CET

14:45 CET

D424
KNOWLEDGE-BASED APPLICATIONS
Virtual Room 4
Chair: Ben Hicks

D425
ADAPTATION OF EDUCATION TO PANDEMIC AND OTHER CHALLENGES
Virtual Room 5
Chair: Josef Oehmen

D426
MODEL-BASED ERGONOMICS
Virtual Room 6
Chair: Gaetano Cascini

16:00 CET

16:15 CET

D434
EXPLORING TECHNICAL AND CUSTOMER DATA FOR IMPROVED PRODUCTS
Virtual Room 4
Chair: Francesca Montagna

D435
NEW TRENDS IN DESIGN EDUCATION
Virtual Room 5
Chair: Robert Ian Whitfield

D436
INDUSTRIAL DESIGN CASES
Virtual Room 6
Chair: Mario Štorga

17:30 CET

18:00 CET

19:00 CET

Bleisinger, Oliver[1]; Malek, Christian[1]; Holbach, Stefan[2]
1: Fraunhofer IESE, Germany; 2: BorgWarner Turbo Systems Engineering GmbH, Germany

MACHINE LEARNING BASED SIMULATION FOR DESIGN SPACE EXPLORATION

Design of software in the automotive domain often involves simulation to allow early software parametrization. Modeling complex systems or components impacted by the software in an analytical way can be time-consuming, require domain knowledge and executing the analytical models can result in high computational effort. In specific applications, these challenges can be overcome by applying machine learning based simulation. This contribution presents results of a case study in which powertrain components are modeled data-driven with artificial neural networks to support design space exploration.

https://doi.org/10.1017/pds.2022.154

Rosso, Peter[1]; Gopsill, James[1,2]; Burgess, Stuart C.[1]; Hicks, Ben[1]
1: University of Bristol, United Kingdom; 2: Centre for Modelling & Simulation, United Kingdom

DOES CAD SMELL LIKE CODE? A MAPPING BETWEEN VIOLATION OF OBJECT ORIENTED PROGRAMMING DESIGN PRINCIPLES AND COMPUTER AIDED DESIGN MODELLING

In objected-oriented design, “smells” are symptoms of code violating design principles. When a deadline is looming, decisions can affect the long-term quality of a code or CAD. Given this and the similarities between object-oriented code and CAD models, this paper introduces a set of CAD smells. These smells are derived from a top-down review of potential CAD smells mapped against the reported code smells that violate abstraction, modularity, encapsulation, and hierarchy principles. This list was further reviewed considering CAD systems and specific examples (some illustrated in the paper).

https://doi.org/10.1017/pds.2022.176

Kraus, Benjamin; Schwind, Jakob Valentin; Kirchner, Eckhard
Technical University of Darmstadt, Germany

DEVELOPMENT METHOD FOR ENABLING THE UTILISATION OF A SENSORY FUNCTION IN A CENTRAL COMPONENT BASED ON ITS PHYSICAL PROPERTIES

In the context of condition monitoring and predictive maintenance, collecting accurate data from technical systems is an important corner stone of the advancing digitalization. For gathering precise data of the current state of a system, measurements from within the process can be utilised. To measure in process without disrupting the system is a challenge that can be tackled by using the physical properties of the components of the system. In this paper a method to systematically find such possible sensory utilizable components (SuC), based on their inherent physical effects is presented.

https://doi.org/10.1017/pds.2022.164

Gerschütz, Benjamin; Bickel, Sebastian; Schleich, Benjamin; Wartzack, Sandro
Friedrich-Alexander-Universität Erlangen-Nürnberg, Germany

ENABLING INITIAL DESIGN-CHECKS OF PARAMETRIC DESIGNS USING DIGITAL ENGINEERING METHODS

The world consequently gets faster, so does product development. Therefore, the stock of development and simulation data increases continuously. Unfortunately, inexperienced users cannot cope with the rising number of simulation requests in the time needed. Digital Engineering opens potentials to support the users with newly developed methods and tools. In this contribution, we present a method to assist designers, inexperienced in finite-element simulations to perform an initial check of changed parametric designs independently, quickly and with support in interpreting the results.

https://doi.org/10.1017/pds.2022.42

Japs, Sergej[1]; Schmidt, Sebastian[1]; Kargl, Frank[2]; Kaiser, Lydia[3]; Kharatyan, Aschot[1]; Dumitrescu, Roman[4]
1: Fraunhofer IEM, Germany; 2: Ulm University, Germany; 3: Technische Universität Berlin, Germany; 4: Paderborn University, Germany

COLLABORATIVE MODELING OF USE CASE & DAMAGE SCENARIOS IN ONLINE WORKSHOPS USING A 3D ENVIRONMENT

The development of technical systems requires close cooperation of stakeholders from different disciplines. This collaboration takes place in workshops. Driven by digitalization and by the current pandemic such workshops take place primarily online. Suitable collaboration tools and methods are crucial to success. At the beginning of such workshops, use and damage scenarios are identified. In this paper, we presented a method and tool for identifying and modeling use and damage scenarios, which we evaluated in 14 online workshops with a total of 118 participants over a period of almost 3 years.

https://doi.org/10.1017/pds.2022.162

Air, Alan[1,2]; Wodehouse, Andrew[1]
1: University of Strathclyde, United Kingdom; 2: National Manufacturing Institute of Scotland, United Kingdom

DEFORMATION TAXONOMY OF ADDITIVELY MANUFACTURED LATTICE STRUCTURES

Additive manufacturing offers opportunities for designed mechanical deformation within parts by integrating lattice structures into their designs. This work re-analyses and translates data on lattice structure deformation behaviours into a novel taxonomy, enabling their actions to be understood and controlled. Parallels between these actions and the four basic types of mechanical motion are identified. Creating a taxonomy method using these motions enables the future development of a DfAM framework that assimilates controlled anisotropy via lattices and aids the design of compliant mechanisms.

https://doi.org/10.1017/pds.2022.138

Schulte, Fiona; Sauerzapf, Lisa; Kirchner, Eckhard
Technical University of Darmstadt, Germany

INFLUENCES AND EFFECTS ON SCALING THE PRESSURE STIFFNESS OF ADDITIVELY MANUFACTURED MESO STRUCTURES

AM-meso structures offer a high potential for adapted properties combined with lightweight design. To utilize the potential a purposeful design of the meso structures is required. Therefore, this contribution presents an approach for modelling their properties depending on design parameters by scaling relationships. The relationships are investigated based on grey box and axiomatic models of elementary cells. Exemplary the pressure stiffness is determined using FEM in comparison to an analytical approximation. The comparison reveals effects and influences occurring within the elementary cell.

https://doi.org/10.1017/pds.2022.147

Obilanade, Didunoluwa[1]; Törlind, Peter[1]; Dordlofva, Christo[1,2]
1: Luleå University of Technology, Sweden; 2: GKN Aerospace Engine Systems, Sweden

SURFACE ROUGHNESS AND DESIGN FOR ADDITIVE MANUFACTURING: A DESIGN ARTEFACT INVESTIGATION

Laser Powder Bed Fusion (LPBF) brings the possibility to manufacture innovative near-net-shape part designs. But unfortunately, some designed surfaces suffer from rough surface finish due to characteristics of the LPBF process. This paper explores trends in managing surface roughness and through a space industry case study, a proposed process that uses Additive Manufacturing Design Artefacts (AMDAs) is used to investigate the relationship between design, surface roughness and fatigue. The process enables the identification of design uncertainties, however, iterations of AMDA's can be required.

https://doi.org/10.1017/pds.2022.144

Rundbäck Martinsson, Oscar; Nordin, Axel; Tavčar, Jože
Lund University, Sweden

COMPOUNDING COMPOSITES FROM RAW MATERIALS WITH EXTRUSION DIRECTLY ON 3D PRINTER

The materials most commonly used in 3D-printers are in a filament form. This is a barrier for users who want to have new types of filaments with different material compositions. A 3D-printer which can extrude and print directly from the raw material was assembled. Compounding with the common additive types; fibres, and metal powders was performed. The size and volumetric output of an extruder was scaling down. Verification was done by mechanical testing, and electron microscopy. The positive result is opening the path to a more accessible composites for both researchers and home producers.

https://doi.org/10.1017/pds.2022.145

Seidler, Alexander[1]; Holtzhausen, Stefan[1]; Korn, Hannes[2]; Koch, Peter[1]; Paetzold, Kristin[1]; Müller, Bernhard[2]
1: Technische Universität Dresden, Germany; 2: Fraunhofer IWU Dresden, Germany

PROPOSAL FOR LOAD ADAPTIVE DESIGN OF MICROLATTICE STRUCTURES SUITABLE FOR PBF-LB/M MANUFACTURING

In this paper, a proposal for a new method to design load-adaptive microlattice structures for PBF-LB/M manufacturing is presented. For this purpose, a method was developed to stiffen microlattice structures in particular by using self-similar sub-cells to ensure their manufacturability. The quality of the stiffness increase was investigated and verified by finite element simulations. Subsequently, the simulation results were critically discussed with respect to their potential for future design processes for architected materials.

https://doi.org/10.1017/pds.2022.148

Sarancic, David; Pigosso, Daniela C. A.; McAloone, Tim C.
Technical University of Denmark, Denmark

DESIGNING INDUSTRIAL PRODUCT-SERVICE SYSTEM (PSS) PILOT PROJECTS IN MANUFACTURING COMPANIES: A PROPOSED PROCESS FOR PRODUCT AND CUSTOMER SELECTION

This paper proposes an approach for capital goods manufacturers to design Product-Service System (PSS) pilot projects by selecting appropriate products and customers. The authors conducted a single-case empirical study as a part of an ongoing action research project to maximise the learnings from a pilot project while minimising expenditure in extensive trial and error PSS solution testing. Two sets of criteria were elicited for product and customer selection, respectively, followed by a description of the ideal product and customer attributes for each of the three most common PSS archetypes.

https://doi.org/10.1017/pds.2022.114

Rennpferdt, Christoph[1]; Schneider, Jannik Alexander[2]; Lachmayer, Roland[2]; Krause, Dieter[1]
1: Hamburg University of Technology, Germany; 2: Leibniz Universität Hannover, Germany

DESIGNING PSS FLEETS – CONSIDERATION OF THE PRODUCT ARCHITECTURE

By transforming from a manufacturer into a PSS provider, the business model of a company changes. In particular with service-oriented business models, the importance of tangible products alters. Instead of selling products, PSS providers need product fleets that enable the provision of services. If the manufacturer of the product and the provider of the PSS fleet are identical, the products can be designed specifically for the PSS. This paper introduces a framework that supports the design of modular PSS fleets so that the product architecture is optimised for the requirements of the fleet.

https://doi.org/10.1017/pds.2022.113

Yan, Zhang[1,2]; Larsson, Tobias[1]; Larsson, Andreas[1]
1: Blekinge Institute of Technology, Sweden; 2: BIGmind Innovation, China

PSS VALUE TRANSFORMATION: FROM MASS-MANUFACTURED VEHICLES TO PROVISION OF MASS-CUSTOMIZED SERVICES – A CASE STUDY OF DESIGNING AND PROTOTYPING CUSTOMIZED DIGITAL SERVICES FOR SAIC MOTOR IN CHINA

This work focuses on exploring how to transform the PSS strategy through conceptual design and prototyping to a way in which different stakeholders in the case car company – SAIC Motor – can experience and give feedback on the PSS strategy, analyze the impact of the PSS strategy on the process of customized digital service design in a traditional Chinese car company. Also, the work discusses how to increase the service value for different stakeholders in the overall PSS system.

https://doi.org/10.1017/pds.2022.120

Janson, Debbie J.; Newman, Stephen T.; Dhokia, Vimal
University of Bath, United Kingdom

A PRODUCT-SERVICE SYSTEM FOR SAFETY FOOTWEAR

This paper proposes that safety footwear manufacture shifts towards a sustainable Product-Service System (PSS). The PSS consists of seven stages from identification of requirements through to disposal or replacement. Through this, designers and manufacturers can realise safety footwear that is customised to end user sizing, function, industry and aesthetic requirements. For end users, this PSS leads to the creation of more comfortable and practicable footwear, addressing the underlying level of acceptance of uncomfortable safety footwear, reducing waste and providing sex specific offerings.

https://doi.org/10.1017/pds.2022.105

Pizzinini, Clemens; Bercher, Jakob; Lienkamp, Markus
Technical University of Munich, Germany

FROM SUPPLY CHAIN STAKEHOLDER TO SERVICE CUSTOMER: AN ENGINEERING FRAMEWORK FOR VEHICLE-BASED SERVICES

Geographic distance between supply and demand reduces spatial accessibility. Vehicles have been contributing to improved spatial accessibility by offering transport services for people and goods. From traditional trucks to mobile health clinics, vehicles can offer a wide range of functionalities on wheels. To develop context-specific vehicles-based services, we propose a novel engineering framework based on a supply chain perspective. Requirements are derived from supply chain stakeholders and translated into vehicle-based services and vehicle components.

https://doi.org/10.1017/pds.2022.110

Schlegel, Michael; Pfaff, Felix; Rapp, Simon; Albers, Albert
Karlsruhe Institute of Technology, Germany

IMPLICATIONS OF CREATING SOLUTION CONCEPTS BASED ON THE USE OF REFERENCES

The use of already validated systems as references for the development of solution concepts offers the potential to increase process efficiency. It is important to understand how the use of references impacts the development of solution concepts. Therefore, the representation of solution concepts in an engineering project of two student cohorts are analyzed and compared. The first cohort is provided with few and the second cohort with extensive references. The results of the study show that the increased use of references leads to a higher share of embodiment and specific challenges.

https://doi.org/10.1017/pds.2022.80

Session D414

Virtual Room 4

CET 12:15
CET 13:30

Plappert, Stefan; Becker, Christian; Gembarski, Paul Christoph; Lachmayer, Roland
Leibniz Universität Hannover, Germany

FEASIBILITY EVALUATION OF MILLING DESIGNS USING MULTI-AGENT SYSTEMS

During product development, many decisions have to be made that affect the entire product life cycle and often lead to errors that cause additional effort. To proactively support the engineer in evaluating his design in a CAD program, in this paper an approach to evaluate milling designs using a multi-agent system (MAS) is presented. The CommonKADS method is used and the MAS is validated against an application example of a gearbox housing that has been checked for design guidelines, standards, and tool or machine portfolios.

https://doi.org/10.1017/pds.2022.78

Raudberget, Dag; Wlazlak, Paraskeva
Jönköping University, Sweden

KNOWLEDGE REUSE DURING NEW PRODUCT DEVELOPMENT: A STUDY OF A SWEDISH MANUFACTURER

As organisations grow, consequences of poor knowledge management are evident for new employees in product developing companies. The problem of leveraging existing knowledge between development projects and departments is still relevant. This paper presents an industrial case study of a traditional manufacturing company and extends prior research addressing the reuse of organisational knowledge in new product development. The paper outlines barriers that hinder effective reuse of codified engineering knowledge and suggest means to overcome those barriers by using A3-reports in the PLM-system.

https://doi.org/10.1017/pds.2022.79

Eder, Kevin[1,2]; Herzog, Wolfgang[1]; Altner, Moritz Magnus[1,3]; Tas, Onur[1]; Neckenich, Jonas[1]; Paetzold, Kristin[2]
1: Mercedes-Benz AG, Germany; 2: Technische Universität Dresden, Germany; 3: Karlsruhe Institute of Technology, Germany

KNOWLEDGE DOCUMENTATION BASED ON AUTOMATIC IDENTIFICATION AND CLUSTERING OF CHANGE INTENTIONS IN CAD DATA OF WIRING HARNESSES

High amount of changes and increasing complexity in CAD design of wiring harnesses result in a lack of time for documentation and transfer of acquired knowledge. To be able to transfer the gained knowledge efficiently during development automating the identification, analyzation and documentation of changes is necessary. This paper shows a methodology to address this challenge for CAD data of wiring harnesses. Thus, it is shown how interrelated change elements can be combined or separated from each other according to their change intention.

https://doi.org/10.1017/pds.2022.70

Kempf, Christoph; Sanke, Felix; Heimicke, Jonas; Rapp, Simon; Albers, Albert
Karlsruhe Institute of Technology, Germany

IDENTIFYING FACTORS INFLUENCING THE DESIGN OF A SUITABLE KNOWLEDGE BASE IN PRODUCT ENGINEERING PROJECTS

During product engineering, engineers draw on existing knowledge as a basis. This knowledge is applied in design processes either by adopting elements, alternating some attributes, or changing the solution principles. While concepts for design reuse exist, the proactive design of a suitable knowledge base is still a challenge. In this paper, we show influencing factors in engineering and their influence on the knowledge base. These factors are of the areas market, company, project, and team. Based on our results, we intent to develop a support for engineers to set up the knowledge base.

https://doi.org/10.1017/pds.2022.75

Thandlam Sudhindra, Shravya; He, Yuejun; Blessing, Lucienne; Ahmad Khan, Sumbul
Singapore University of Technology and Design, Singapore

STORIES OF DESIGN EDUCATION: AN ANALYSIS OF PRACTICES AND COMPETENCIES

Using 61 stories from design educators from different countries, this paper presents (1) the design competencies being fostered at different levels of education, (2) the practices (approaches, techniques, methods and tools) used to facilitate teaching and learning, (3) the 'non-design' competencies being fostered, and (4) the impact of COVID 19. Our findings highlight design education is not only used to teach students how to design, but also to kindle productive attitudes, behaviours and mindsets that give them the ability to address a wide range of challenges.

https://doi.org/10.1017/pds.2022.243

Leonardi, Selma[1]; Perpignan, Catherine[1,2]; Eynard, Benoit[1]; Baouch, Yacine[1]; Robin, Vincent[2]
1: Université de Technologie de Compiègne, France; 2: University of Bordeaux, France

LIFE CYCLE ASSESSMENT IN AN ECODESIGN PROCESS: A PEDAGOGICAL CASE STUDY

To face environmental requirements in the design area, it is crucial to work on the education of younger generation to sustainable design. But literature shows there is a growing need for both teachers and learners to develop pedagogical support to help the integration of sustainable concerns and tools in the education. This article focuses on Life Cycle Assessment in the scope of an ecodesign process. Through a case study, the aim is to illustrate it with firstly a succinct version of the LCA of an electric kettle and then suggestions of ecodesign strategies based on the outcomes of the LCA.

https://doi.org/10.1017/pds.2022.235

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University of Ljubljana, Faculty of Mechanical Engineering, Slovenia

STORYBOARDS AS AN ENGINEERING TOOL FOR EXTRACTION OF FUNCTIONAL REQUIREMENTS

In new product development courses, engineering students are introduced to the tools for addressing the functional or technical issues of the product. Problems arise when they need to empathise with the user to better understand how the product can be used in different contexts. To address this problem, we propose the use of storyboards as a tool to explore user behaviour and to clarify functions of the future product. The study results confirmed that storyboards are a suitable tool for understanding user-product interaction, however, the several problems encountered by the participants were outlined.

https://doi.org/10.1017/pds.2022.230

Akaki, Mayu[1,2]; Ioki, Makoto[1]; Mitomi, Keita[1,2]; Maeno, Takashi[1]
1: Keio University, Japan; 2: Tsukuru to Ugoku Design Co., Ltd., Japan

BEST PRACTICES OF TEAM-BUILDING ACTIVITIES IN A PROJECT-BASED LEARNING CLASS 'DESIGN PROJECT' IN A JAPANESE GRADUATE SCHOOL

To indicate the effective team-building activities implemented independently by the students in a project-based learning class in higher education in Japan, we conducted semi-structured interviews with the students of the Design Project class held at a Japanese graduate school in 2020 and 2021. The interviewees are 12 students belonging to the top three teams regarding the evaluation of the final presentation. Based on the classifications of the comments, we indicate the best practices of team-building activities corresponding to the timing and team characteristics.

https://doi.org/10.1017/pds.2022.229

Maheshwary, Khushbu[1]; Eisenbart, Boris[2]; Zorn, Stefan[3]; Nelius, Thomas[4]; Gericke, Kilian[3]; Matthiesen, Sven[4]; Blessing, Lucienne[1]
1: Singapore University of Technology and Design, Singapore; 2: Swinburne University of Technology, Australia; 3: University of Rostock, Germany; 4: Karlsruhe Institute of Technology, Germany

REVIEWERS FAVOURITE

ASSESSING RIGID AND NON-RIGID SPATIAL THINKING

Spatial Thinking (ST) is an important part of reasoning. In contrast to Rigid ST (R-ST), Non-Rigid ST (NR-ST) has hardly been researched and tests do not exist, even though NR-ST is crucial for professions that deal with space and time such as engineering and design. Our study at 4 different universities confirms that R-ST does not predict performance in NR-ST; that performance in Non-Rigid ST is significantly lower than in R-ST; and that performance of students in later semesters is not better than in the first semesters. These results highlight the need for further research into NR-ST.

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OLD AND APPRECIATED: EXPLORING THE INFLUENCE OF MATERIAL AGEING ON THE AESTHETIC APPRECIATION OF EVERYDAY PRODUCTS

There is a growing interest in design research to explore sustainable consumption via products that are cherished as they age. This paper presents an empirical study exploring the influence of patina (signs of surface aging) on consumers' willingness to discard products and aesthetic appreciation. Results show participants are predisposed to discard everyday products regardless aesthetic qualities (patina). This implies designers should look beyond the presence of pure aesthetic qualities of aging and emphasise symbolic qualities of aging to stimulate appreciation as products age.

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Session D416
Virtual Room 6
CET 12:15
CET 13:30

Millet, Antoine; Abi Akle, Audrey; Legardeur, Jérémy
ESTIA Institute of Technology, France

FROM THE DEFINITION OF COLOURS ATTRIBUTES TO BUILD A SEMANTIC SPACE: APPLICATION TO A SPORT-HEALTH DIALOGICAL CONTEXT OF USE

The integration of user perception into the design process has become necessary to provide the best experience to users.All methods focusing on the interpretations of products are based on the same principle: identifying relationships between a semantics and physical attributes of products within a product domain. Sometimes this domain makes the definition of these relations more complex as for a dialogic context of us due to the lack of existing product. We propose in this paper a method to define a semantics directly from products attributes in regards with a dialogic product domain.

https://doi.org/10.1017/pds.2022.216

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BIOMATERIALS IN EVERYDAY DESIGN: UNDERSTANDING PERCEPTIONS OF DESIGNERS AND NON-DESIGNERS

The application of biological materials in everyday design is gaining traction and designers are encouraged to employ biological systems through biodesign and biophilia. However, there is a deficiency in the understanding of potential consumers' perceptions. This paper compares the perception of non-designers as well as designers towards design-embedded bio-materials. Data was collected from 234 respondents using an online survey. The findings were gathered by evaluating perception in terms of desirability, practicality, aesthetically, and familiarity with living and non-living biomaterials.

https://doi.org/10.1017/pds.2022.205

Zhong, Yulan; Takawaki, Ryuta; Harada, Etsuko T.
University of Tsukuba, Japan

HOW DO SEMANTIC CLUES AFFECT PEOPLE'S PERCEPTIONS OF PRODUCTS WITH MULTIPLE MEANINGS

A psychological experiment was conducted to explore the relationship between design features of physical controllers and perceived multiple meanings or possible operations by users. In particular, we focused on affordances and informatives, two semantic clues derived from product semantics, to find out how these clues affect users' perceptions. The results indicated that both desired shapes, text, and icon could encourage and discourage the perception of specific operations. Those empirical data could be useful for product designers in communicating effectively with users through their products.

https://doi.org/10.1017/pds.2022.228

Cox, Chris; Hicks, Ben; Gopsill, James
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IMPROVING MIXED-REALITY PROTOTYPING THROUGH A CLASSIFICATION AND CHARACTERISATION OF FIDELITY

Prototyping is a vital activity in product development. For reasons of time, cost and level of definition, low fidelity representations of products are used to advance understanding and progress design. With the advent of Mixed Reality prototyping, the ways in which abstractions of different fidelities can be created have multiplied, but there is no guidance on how best to specify this abstraction. In this paper, a taxonomy of the dimensions of product fidelity is proposed so that both designers and researchers can better understand how fidelity can be managed to maximise prototype value.

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DESIGN
2022

WHICH WAY I OUGHT TO GO?

Zrinka Čorak

Dr., Vicepresident
INETEC (HR)

The journey of INETEC started as a small family business company focused on providing NDT inspection activities of nuclear power plants 30 years ago. We have grown into a renowned company active in developing robots, scanners, control units, probes and software for navigation, as well as performing the NDT inspection. We continue to provide the NDT inspection within the scope our operations. With innovation as one of our core values, we have brought forth innovative solutions in technology and business models. We have strived to balance between short-term exploitation of existing markets and long-term exploration of new opportunities. This presentation outlines how an innovation-driven company has evolved throughout the years across product ranges and business models.

BIOGRAPHICAL SKETCH

Zrinka Čorak is Vice-Chairman of INETEC. She completed a Master of Electrical Engineering at the University of Zagreb and earned PhD at University of Zagreb. She graduated from Harvard Business School, Executive Education Program. She is one of the founders of the family foundation Iter Meum Illumina.

Gräßler, Iris; Oleff, Christian; Hieb, Michael; Preuß, Daniel
Paderborn University, Germany

AUTOMATED REQUIREMENT DEPENDENCY ANALYSIS FOR COMPLEX TECHNICAL SYSTEMS

Requirements changes are a leading cause for project failures. Due to propagation effects, change management requires dependency analysis. Existing approaches have shortcomings regarding ability to process large requirement sets, availability of required data, differentiation of propagation behavior and consideration of higher order dependencies. This paper introduces a new method for advanced requirement dependency analysis based on machine learning. Evaluation proves applicability and high performance by means of a case example, 4 development projects and 3 workshops with industry experts.

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Saab AB, Sweden

HARNESSING THE COMPLEXITY FOR VEHICLE SYSTEM DESIGN AT THE CONCEPT DESIGN PHASE OF AN AIRCRAFT

Aircraft vehicle systems enable an aircraft to fly safely throughout a mission. Generating feasible vehicle system architectures at the aircraft concept design phase is complex. Aspects from various complex systems theories are used to provide different insights into this complexity. To address this complexity, a framework based on industrial reality that can used recursively is presented. The framework employs various design theories to harness the complexity of vehicle system design at the concept design phase of an aircraft.

https://doi.org/10.1017/pds.2022.187

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REQUIREMENTS TRADE-OFF CONSIDERATIONS IN DESIGN EVOLUTION

This paper presents approaches to compare criteria and help designers make decisions based on trade-offs between criteria. The impetus for the paper is to identify possible directions to improve/innovate a product and propose a value shell model displaying various criteria or their combination to represent the effort needed to improve the criteria. The focus is on automotive market and approaches in industry and government are differentiated. Since the effort (manpower, cost and time) needed to improve a product is not public knowledge, the paper leaves the evaluation of the approach to users.

https://doi.org/10.1017/pds.2022.40

Toller, Carl Nils Konrad; Johansson, Christian; Bertoni, Marco
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ISSUES IN CAPTURING AND UTILIZING NON-FUNCTIONAL REQUIREMENTS ALONG THE ROAD TO SERVITIZATION

The design process aims to maximize the value in the end solution. For traditional manufacturing firms pursuing a servitization strategy, non-functional requirements become more important compared to before. Therefore, this paper investigates issues in capturing and utilizing non-functional requirements for value creation in a servitizing firm. A single case study was conducted, which resulted in six issues across the design process. It was evident from the research that the firm requires new support to enable a better inclusion of non-functional requirements in the design process.

https://doi.org/10.1017/pds.2022.64

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University of Stuttgart, Germany

INQUIRY AND ANALYSIS OF CHALLENGES IN THE DEVELOPMENT OF SMART PRODUCT-SERVICE SYSTEMS

In a smart product-service system (smart PSS), non-tangible services are bundled with tangible products as well as options for information and communication technologies. Enterprises offer smart PSS in order to provide added value for customers and deal with increasing competitive pressure. However, the development of these complex systems also presents enterprises, especially SMEs, with challenges. In order to identify the challenges in the development of smart PSS and requests for corresponding support, a multi-method study was conducted with eighteen participants from German SMEs.

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Mallalieu, Adam; Hajali, Tina; Isaksson, Ola; Panarotto, Massimo
Chalmers University of Technology, Sweden

THE ROLE OF DIGITAL INFRASTRUCTURE FOR THE INDUSTRIALISATION OF DESIGN FOR ADDITIVE MANUFACTURING

The use of Additive Manufacturing (AM) can bring opportunities for industry, but several challenges need to be addressed, specifically the digital infrastructure comprising the AM value chain. A combination of a systematic literature review and an industrial use case study concludes that there is low consideration of the digital infrastructure in Design for Additive Manufacturing (DfAM) methods and tools which has a negative impact on the industrialisation of AM. It is therefore recommended that further studies are to be made on how to manage the digital infrastructure in DfAM processes.

https://doi.org/10.1017/pds.2022.142

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A FRAMEWORK TO COLLECT AND REUSE ENGINEERING KNOWLEDGE IN THE CONTEXT OF DESIGN FOR ADDITIVE MANUFACTURING

Design for AM (DfAM) requires the definition of Design Actions (DAs) to optimize AM manufacturing processes. However, AM understanding is still very blurred. Often designers are challenged by selecting the right design parameters. A method to list and collect DfAM DAs is currently missing. The paper aims at providing a framework to collect DfAM DAs according to a developed ontology to create databases (DBs). DBs were tested with two real case studies and geometric features to improve identified. Future developments aim at widening the database to provide all-around support for AM processes.

https://doi.org/10.1017/pds.2022.139

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ETH Zurich, Switzerland

COMPUTATIONAL DESIGN OF AN ADDITIVELY MANUFACTURED ORIGAMI-BASED HAND ORTHOSIS

This work investigates the application of origami as the underlying principle to realize a novel 3D printed hand orthosis design. Due to the special property of some origami to become rigid when forming a closed surface, the orthosis can be printed flat to alleviate the most of the post-processing, and at the same time provide rigid support for the immobilized limb in the folded state. The contributions are the origami-based hand orthosis design and corresponding computational design method, as well as lessons learned regarding the application of origami for the hand orthosis design.

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Hilbig, Karl; Nowka, Maximilian; Redeker, Julian; Watschke, Hagen; Friesen, Vincent; Duden, Anna; Vietor, Thomas
Technische Universität Braunschweig, Germany

DATA-DRIVEN DESIGN SUPPORT FOR ADDITIVELY MANUFACTURED HEATING ELEMENTS

Additive Manufacturing (AM) enables innovative product designs. One promising research field is AM of integrated electrically structures, e.g. heating panels using Joule effect. A mayor challenge in designing heating panels using AM is the dependency of its resultant resistivity from material, process and geometry parameters. The goal-oriented design of heating panels with individual surface temperatures the interactions between these parameters need to be understand. Therefore, a data-driven design approach is developed that facilitates a design of heating panels with specific properties.

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DENSITY-BASED TOPOLOGY OPTIMIZATION FOR A DEFINED EXTERNAL STATE OF STRESS IN INDIVIDUALIZED ENDOPROSTHESIS

Endoprosthesis are exposed to the risk of aseptic loosening. The design of the prosthesis shaft to achieve physiological force application is therefore of great importance. Additive manufacturing offers the potential to fabricate highly variable topologies, but challenges the designer with a large number of design variables. In this work, a method is developed to determine an optimized density topology that approximates a given mechanical stress state in the bone after implantation. For this purpose, a topology optimization of the density distribution of the implant is performed.

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Chen, Youzhi
Politecnico di Milano, Italy

ADVANTAGES OF 3D PRINTING FOR CIRCULAR ECONOMY AND ITS INFLUENCE ON DESIGNERS

Based on the theoretical research of 3D printing and circular economy, combined with case studies, this paper analyzes the advantages of 3D printing in realizing circular economy and its influence on designers from the perspectives of "reduce", "reuse", "recycle" and distributed manufacturing. As a technological innovation, 3D printing not only promoted the transformation from linear economy to circular economy, but also had a certain impact on the role and skills of traditional designers.

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DESIGN OF AN INTRINSICALLY MOTIVATING AR EXPERIENCE FOR ENVIRONMENTAL AWARENESS

Augmented Reality seems a promising tool to provide engaging and effective educational experiences, thanks to its potentiality in stimulating intrinsic motivation, that could influence the learning process and the attitude of the users towards behaviours. This paper presents the Resized Plastic Augmented Reality learning experience, designed on the basis of Dunleavy's framework to provide a systemic overview of the microplastics issue to allow users to understand its mechanisms, educate them about their role in the system and help them to connect this information to their everyday actions.

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Nilsson, Susanne[1]; Shibwabo Kasamani, Bernard[2]; Hede Mortensen, Julia[1]; Stevanovic, Dunja[3]; Wanyang, Michelle[2]; Norell Bergendahl, Margareta[1]; Papalambros, Panos Y.[4]
1: KTH Royal Institute of Technology, Sweden; 2: Strathmore University, Kenya; 3: Botho University, Botswana; 4: University of Michigan, United States of America

CHALLENGES AND OPPORTUNITIES FOR ENABLING MUTUAL LEARNING AND COLLABORATION IN DESIGN AND INNOVATION FOR SUSTAINABLE DEVELOPMENT IN AFRICA AND BEYOND

Global collaboration and mutual learning in design are put forth as means to address the UN SDGs. This paper draws upon experiences in the Design Society's AFRICA-DESIGN initiative to build a network of design academics and practitioners based in Africa with a focus on design for sustainable development. We identify education and social sustainability as particular opportunities and challenges, highlighting the critical element of mutual learning in the collaboration process.

https://doi.org/10.1017/pds.2022.109

Andersen, Maria Haugaard; Hansen, Henriette Wallentin; Laursen, Linda Nhu
Aalborg University, Denmark

DESIGNING LONG-LASTING INTERIOR PRODUCTS: EMOTIONAL ATTACHMENT, PRODUCT POSITIONING AND UNIQUENESS

When prolonging the physical lifetime of products, it is important to also consider the value lifetime, the time before customers discards the products because it no longer has any perceived value. In this paper we study design and marketing strategies known to be particularly relevant to enhance the value perception of consumers, hence lifetimes of products. To do so, we first review literature to build a framework, we then use to conduct case studies at five Danish product design brands. This let us to insights on design and marketing strategies relevant to enhance product lifetimes.

https://doi.org/10.1017/pds.2022.98

Vignoli, Matteo[1,2]; Roversi, Sara[2]; Jatwani, Chhavi[2]; Tiriduzzi, Margherita[2]; Finocckì, Costanza[1]
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EVOLVING THE "HOW MIGHT WE?" TOOL TO INCLUDE PLANETARY BOUNDARIES

This work aims to study the evolution of the "Human and planet balance tool" as part of Prosperity Thinking. Prosperity Thinking is a sustainable design methodology that takes into account human and planet means. Through a literature review on sustainable design, we noticed that there is a lack of methods that take into account the problem definition stage. We developed a "Human and planet balance tool" which helps framing sustainable design challenges. Results show that designers, innovators, and changemakers have an interest in a methodology to analyze and address systemic challenges.

https://doi.org/10.1017/pds.2022.118

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APPLICATION OF EXPERT SYSTEMS FOR PERSONALIZING FINANCIAL DECISIONS

Due to the complexity of financial products, consumers with low financial literacy are left behind. However, few practical studies investigated the impact of digital advisory systems to improve customer experience. Configuration systems, as the most popular expert systems, have never been applied as a financial tool. In this study, we explore the application of configuration systems to educate consumers in achieving their financial goals. The results highlight multiple benefits from using the configurator, including greater financial literacy and improved individual financial decision-making.

https://doi.org/10.1017/pds.2022.82

Kent, Lee; Gopsill, James; Giunta, Lorenzo; Goudswaard, Mark; Snider, Chris; Hicks, Ben
University of Bristol, United Kingdom

PROTOTYPING THROUGH THE LENS OF NETWORK ANALYSIS AND VISUALISATION

Prototyping is a well-established and valued design process activity. However, capturing prototypes and the tacit knowledge that led to and was gained from their creation is a challenge. Beyond that, questions remain on how best to utilise that captured data. This paper looks at how one can exploit and generate insights from data that has been captured, specifically looking at graph databases, the network analysis techniques they permit and the differing fidelities of visualisation and interactivity that they enable.

https://doi.org/10.1017/pds.2022.76

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DATA NETWORKING FOR INDUSTRIAL DATA ANALYSIS BASED ON A DATA BACKBONE SYSTEM

Industrial Data Analytics needs access to huge amounts of data, which is scattered across different IT systems. As part of an integrated reference kit for Industrial Data Analytics, there is a need for a data backend system that provides access to data. This system needs to have solutions for the extraction of data, the management of data and an analysis pipeline for those data. This paper presents an approach for this data backend system.

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THE VALUE OF INFORMATION IN CLUSTERING DENSE MATRICES: WHEN AND HOW TO MAKE USE OF INFORMATION

Characterising a socio-technical system by its underlying structure is often achieved by cluster analyses and bears potentials for engineering design management. Yet, highly connected systems lack clarity when systematically searching for structures. At two stages in a clustering procedure (pre-processing and post-processing) modelled and external information were used to reduce ambiguity and uncertainty of clustering results. A holistic decision making on 1) which information, 2) when, and 3) how to use is discussed and considered inevitable to reliably cluster highly connected systems.

https://doi.org/10.1017/pds.2022.72

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FROM A MONOLITHIC PLM LANDSCAPE TO A FEDERATED DOMAIN AND DATA MESH

Product Lifecycle Management (PLM) is one of the most business-critical IT backbones of manufacturing companies. It often consists of numerous, rigidly interwoven monolithic applications and is seen as synonymous with costly maintenance, lack of extensibility, and poor scalability. This paper proposes an approach for transforming a monolithic PLM landscape into a federated Domain and Data Mesh. This enhances semantic interoperability and enables data-driven use cases by treating data as first-class citizens. User-centric PLM domains moreover help to increase productivity in the workplace.

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PROJECT-BASED LEARNING IN DISASTER RESPONSE: DESIGNING SOLUTIONS WITH SOCIOTECHNICAL COMPLEXITY

Design education increasingly blends technology learning with sociotechnical challenges, but little is understood about how students simultaneously engage with both of these elements. In this preliminary study, we describe the results of two offerings of a design course focusing on disaster response at a major public research institution. We present a preliminary analysis of 52 students' course reflections suggesting that sociotechnical challenges uniquely contextualize technology during project-based learning, presenting promising opportunities for future design education and research study.

https://doi.org/10.1017/pds.2022.240

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EDUCATIONAL PROBE FOR DEVELOPING ONLINE EDUCATION: A CASE OF ONLINE PROBLEM-BASED LEARNING IN DESIGN EDUCATION IN INDIA

The COVID-19 pandemic brought challenges and opportunities for higher education and one of the important areas was online education. Especially in design field, Online Problem-Based Learning has emerged as a promising method. This paper explores the potential of online-PBL and how it can be developed through a prototype approach. An action research in Indian HEI shows insights regarding the potentiality of online-PBL and application of a prototype approach to educational development activities. A concept of "educational probes" was proposed as a method to design educational program.

https://doi.org/10.1017/pds.2022.231

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ADAPTIVE E-LEARNING FOR THE ENGINEERING DESIGN EDUCATION AT RUHR-UNIVERSITY BOCHUM

Most lectures in the field of engineering are held in a traditional teacher-centred and frontal lecture format. This means that all students receive the identical information at the same pace without taking their individual skills, knowledges and competences into account. A didactic concept, that fosters an individual learning experience and digitally provides personalised learning materials for each student is Adaptive E-Learning. Within this paper the development of an Adaptive E-Leaning Environment in the course Engineering Design at Ruhr-University Bochum is presented.

https://doi.org/10.1017/pds.2022.234

Thakker, Urvi; Shrivastav, Shamit
Atlas Skilltech University, ISDI School of Design and Innovation, India

OVERCOMING PEDAGOGICAL CHALLENGES IN PRODUCT DESIGN EDUCATION DURING THE PANDEMIC

The education sector got severely impacted by the Covid-19 pandemic. In the beginning, remote learning posed challenges to teachers and students. However, many new pedagogical experiments demonstrated the potential to continue even in the post-Covid world. This study explains the pedagogical change in product design education from a traditional studio-based model to a virtual environment, without compromising the learning outcomes. The paper also describes the learning experiences of the students and measures the effectiveness of virtual education through qualitative and quantitative studies.

https://doi.org/10.1017/pds.2022.242

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CREATING A MULTIDISCIPLINARY COLLABORATION SERVICE-LEARNING EXPERIENCE IN DESIGN EDUCATION

The design process in most organizations is often collaborative and interdisciplinary in nature. Yet most institutions of higher learning do not offer students the opportunity to work in multidisciplinary teams. This study follows an experiential service-learning project over 3 years to explore the role of multidisciplinary project teams on design education outcomes. Findings suggest that the quality of designs improved over time and students consider experiential learning in multidisciplinary teams to be a valuable component in their education, increasing their job readiness upon graduation.

https://doi.org/10.1017/pds.2022.232

Wolf, Alexander; Fackler, Konrad; Reulbach, Magnus; Wartzack, Sandro; Miehling, Jörg
Friedrich-Alexander-Universität Erlangen-Nürnberg, Germany

COMPUTER AIDED ERGONOMICS: EVALUATION STUDY OF A INTERACTION MODEL FOR DIGITAL HUMAN MODELS

In user-centred design, digital human models hold the potential for proactive evaluations of ergonomics or discomfort in terms of a computer aided ergonomics tool. Therefore, models predicting human interaction behaviour, are necessary. In this contribution we present such a model as well as its initial evaluation. The evaluation is performed by applying the interaction model to a specific use case, conducting a comparison with an empirical subject study. The evaluation shows that similar and realistic human behaviour was predicted, which was consistent in terms of whole-body strain.

https://doi.org/10.1017/pds.2022.68

Session D426
Virtual Room 6
CET 14:45
CET 16:00

Urquhart, Lewis[1]; Wodehouse, Andrew[1]; Loudon, Brian[2]
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SYNTHESISING COMPUTATIONAL DESIGN METHODS FOR A HUMAN-CENTRED DESIGN FRAMEWORK

This paper presents models that identify two "cultures" of computational design practice. By reviewing the established culture of computational optimization efforts and contrasting it with the emerging work integrating human-factors into these optimizations, this paper argues that there are sets of key assumptions, outputs and tools that can be synthesized for a generalizable understanding of computational design. Furthermore, this synthesis facilitates the identification of key tools suited to computational design efforts seeking to integrate the complex data associated with human-factors.

https://doi.org/10.1017/pds.2022.65

Johnston, Sondre Haukås; Berg, Martin Francis; Eikevåg, Sindre Wold; Ege, Daniel Nygård; Kohtala, Sampsa; Steinert, Martin
Norwegian University of Science and Technology, Norway

PURE VISION-BASED MOTION TRACKING FOR DATA-DRIVEN DESIGN – A SIMPLE, FLEXIBLE, AND COST-EFFECTIVE APPROACH FOR CAPTURING STATIC AND DYNAMIC INTERACTIONS

This paper presents an exploratory case study where video-based pose estimation is used to analyse human motion to support data-driven design. It provides two example use cases related to design. Results are compared to ground truth measurements showing high correlation for the estimated pose, with an RMSE of 65.5 mm. The paper exemplifies how design projects can benefit from a simple, flexible, and cost-effective approach to capture human-object interactions. This also entails the possibility of implementing interaction and body capturing in the earliest stages of design, at minimal effort.

https://doi.org/10.1017/pds.2022.50

Perez Luque, Estela; Brolin, Erik; Högberg, Dan; Lamb, Maurice
University of Skövde, Sweden

CHALLENGES FOR THE CONSIDERATION OF ERGONOMICS IN PRODUCT DEVELOPMENT IN THE SWEDISH AUTOMOTIVE INDUSTRY – AN INTERVIEW STUDY

This paper presents an interview study aiming to understand the state of the art of how ergonomics designers work in the vehicle development process within the Swedish automotive industry. Ten ergonomic designers from seven different companies participated in the interview study. Results report the ergonomics designers' objectives, workflow, tools, challenges, and ideal work performance tool. We identify four main gaps and research directions that can enhance the current challenges: human behavior predictions, simulation tool usability, ergonomics evaluations, and integration between systems.

https://doi.org/10.1017/pds.2022.219

Molz, Carla[1]; Yao, Zhejun[2]; Sänger, Johannes[3]; Gwosch, Thomas[3]; Weidner, Robert[2,4]; Matthiesen, Sven[3]; Wartzack, Sandro[1]; Miehling, Jörg[1]
1: Friedrich-Alexander-Universität Erlangen-Nürnberg, Germany; 2: Helmut Schmidt University, Germany; 3: Karlsruhe Institute of Technology, Germany; 4: University of Innsbruck, Austria

A MUSCULOSKELETAL HUMAN MODEL-BASED APPROACH FOR EVALUATING SUPPORT CONCEPTS OF EXOSKELETONS FOR SELECTED USE CASES

REVIEWERS FAVOURITE

This paper presents an approach for evaluating exoskeleton support concepts through biomechanical analyses on a musculoskeletal human model. By simplifying the support forces of an exoskeleton as external forces, different support concepts can be biomechanically evaluated for the respective use case without concrete design specifications of the exoskeleton. This enables an estimation of the resulting relief and strain on the human body in the early stages of exoskeleton development. To present the approach, the use case of working at and above head height with a power tool is chosen.

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DESIGN OF (SEMI-)AUTONOMOUS VEHICLES: PERCEPTIONS OF THE PEOPLE IN SWEDEN

The field of autonomous vehicles is gaining wide recognition in the industry, academia as well as social media. However, there is a lack of knowledge on expectations of people regarding this topic. To this end, this paper analyses extant research on perceptions of people in various countries about semi-autonomous and autonomous vehicles. Secondly, based on the findings of this analysis, we developed a questionnaire to gauge the perceptions of the people in Sweden regarding such vehicles. The findings have important implications for the design of AVs in Sweden, and possibly other countries.

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IMPACT OF AUTONOMOUS SOLUTIONS ON ELECTRIC EARTHMOVING DESIGN USING MACHINE LEARNING: CASE STUDY

The increased development in automated driving systems (ADS) has opened up significant opportunities to revolutionize mobility and to set the path for technologies, such as electrification. The proposed methodology is a simulation model backed by a multi-objective optimization algorithm. This research investigates the adoption of future technologies in earthmoving application and explores its implications on the design of future machine concepts in terms of equipment size. The shift from "elephant to ants" in the machine selection, resulted in improved feasibility.

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REVIEWERS FAVOURITE

EXPLOITING 3D VARIATIONAL AUTOENCODERS FOR INTERACTIVE VEHICLE DESIGN

In automotive digital development, 3D prototype creation is a team effort of designers and engineers, each contributing with ideas and technical evaluations through means of computer simulations. To support the team in the 3D design ideation and exploration task, we propose an interactive design system for assisted design explorations and faster performance estimations. We utilize the advantage of deep learning-based autoencoders to create a low-dimensional latent manifold of 3D designs, which is utilized within an interactive user interface to guide and strengthen the decision-making process.

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SUPPORTING THE TRANSITION TOWARDS ELECTROMOBILITY IN THE CONSTRUCTION AND MINING SECTOR: OPTIMIZATION FRAMEWORK AND DEMONSTRATION ON AN ELECTRICAL HAULER

The paper presents a framework for the integration of the system's design variables, state variables, control strategies, and contextual variables into a design optimization problem to assist early-stage design decisions. The framework is based on a global optimizer incorporating Dynamic Programming, and its applicability is demonstrated by the conceptual design of an electrical hauler. Pareto front of optimal design solutions, in terms of time and cost, together with optimal velocity profiles and battery state-of-charge is visualized for the given mining scenario.

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FUNCTION INTEGRATION THROUGH DESIGN FOR HYBRID INTEGRATING ADDITIVE MANUFACTURING TECHNOLOGIES

Additive manufacturing (AM) technologies enable the design of new products due to their potentials. The potential of function integration can be extended through a combination of AM with a component integrating technology forming a hybrid integrating additive manufacturing technology (hiAM). With a created development method optimization areas within a product are identified on a functional level using characteristics, structural configurations and integrated functional areas. These are derived analysing examples in literature. The method is applied to a mechanical arm and hand prosthesis.

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COST SENSITIVITY ANALYSIS FOR LASER POWDER BED FUSION

Laser Powder Bed Fusion is the most widespread additive manufacturing process for metals. In literature, there are several analytical models for estimating the manufacturing cost. However, few papers present sensitivity analyses for evaluating the most relevant product and process parameters on the production cost. This paper presents a cost model elaborated from previous studies used in a sensitivity analysis. The most relevant process parameters observed in the sensitivity analysis are the 3D printer load factor, layer thickness, raw material price and laser speed.

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KNOWLEDGE-BASED ASSISTANCE SYSTEM FOR PART PREPARATION IN ADDITIVE REPAIR BY LASER POWDER BED FUSION

For the economic use of repair in the spare parts business, additive repair by Laser Powder Bed Fusion (LPBF) is a promising technology. As material can only be applied to a flat surface in LPBF, prior machining is required. The selection of the section plane requires expert knowledge, though. To provide that knowledge and recommend a suitable section plane, an expert system can be used. In this paper, a concept for such an expert system is presented and its functionality is evaluated by an example.

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RETHINKING SYSTEM BOUNDARIES FOR BETTER UTILISATION OF ADDITIVE MANUFACTURING POTENTIALS – A CASE STUDY

The potentials of additive manufacturing for objectives such as lightweight construction are not yet fully exploited. In this paper, the possibilities of integrative function and system modelling for this challenge will be discussed. In a design study, a triathlon trailer is designed considering the constraints of AM. A suitable system boundary is to be detected using the one-part device method. The findings of the study will help to understand in which form methods such as functional modelling can be applied or adapted for the application of additive manufacturing.

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ADDITIVE MANUFACTURING CONFORMITY – A PRACTICAL VIEW

With the dissemination of additive manufacturing (AM), numerous methods have emerged to support the design process. One possibility is to improve functional solutions through AM-conformal design. Literature-based criteria for the assessment of AM-conformity already exist. Within our study, we address the gap in criteria between a theoretical perspective and a practitioner's perspective. To this end, we first explain the application of the criteria through a use case and conduct an evaluation in an industrial environment adding practitioner's criteria to enable the assessment of AM-conformity.

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SYSTEMS DESIGN USING SOLUTION-COMPENSATION SPACES WITH BUILT-IN TOLERANCE APPLIED TO POWERTRAIN INTEGRATION

Complexity in systems design can be reduced by computing permissible ranges for some crucial design variables that need to be defined in an early design phase. These ranges are calculated such that there is sufficient tolerance for the remaining design variables in later design phases, while still achieving the overall system design goals. A new algorithm for this approach is presented and applied to the design of a vehicle powertrain mount system. The results show large permissible ranges for mount positions while maintaining sufficient tolerance for mount stiffnesses.

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A MODELLING METHOD FOR DESCRIBING AND FACILITATING THE REUSE OF SYSML MODELS DURING DESIGN PROCESS

MBSE and SysML are increasingly finding their applications in industry as well as in academia. The reuse of the information described in SysML models depends, among others, on the modelling methods, management of dependencies between elements and on the needed remodelling effort. In this paper, a modelling method is presented that address the reuse of SysML models and descriptions as well as reuse of model variants in SysML. A case example is presented to explain the modelling methods and the gained experience is summarised in the form of general recommendations for further use.

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MODELING OF AN INTERFACE BETWEEN SYSTEM MODELS AND FEM MODELS FOR THE SUPPORT OF MODEL-BASED DEVELOPMENT IN MODULAR LIGHTWEIGHT DESIGN FOR AIRCRAFT CABINS

The modular lightweight design attempts to reconcile the partially conflicting goals between modularization and lightweight design in order to establish a harmonized modular hybrid design. This requires a close exchange of the resulting development data between the two areas. In this contribution a concept for an interface for the data exchange between system models and FEM models is presented and successfully implemented in the Cameo Systems Modeler and applied to examples from the aircraft cabin. With the interface the homogenization step of modular lightweight design can be performed.

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THE USE OF FUNCTION MODELLING METHODS IN INDUSTRY: INSIGHTS FROM A LARGE SCALE STUDY WITH AN AUTOMOTIVE OEM

This paper presents an evaluation study for the System State Flow Diagram function modeling framework based on a large-scale study with an automotive OEM. Technical reports are used to evaluate the usage of the framework within the organization. The paper also introduces a list of the type of problems that engineers are interested in in practical function modelling. The findings suggest that there is a widespread uptake of the framework across the organization and it supports the usage of relevant key engineering tools within the context of a broader model-based Failure Mode Analysis methodology.

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A SYSTEMS THINKING APPROACH TO DATA-DRIVEN PRODUCT DEVELOPMENT

The amount of information in our society and its opportunities have given rise to Big Data research. The systems supplier industry needs suitable tools and methods to ensure the harvest and utilization of Big Data in their product development. This paper used Systems Thinking to analyze the current state in the industry and suggested leverage points for further research direction. The findings suggest that the research project should emphasize the industry cases, the collaboration between the companies and academia, develop a Big Data systems architecture, and maintain a socio-technical view.

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KNOWLEDGE ANNOTATION WITHIN RESEARCH DATA MANAGEMENT SYSTEM FOR OXYGEN-FREE PRODUCTION TECHNOLOGIES

The comprehensive implementation of digital technologies in product manufacturing leads to changes in engineering processes and requires new approaches to data management. An important role belongs to the processes of organizing the collection, storage and reuse of research data obtained and used in the process of product, system or technology development, taking into account the FAIR data principles. This article describes a Research Data Management System for the organization of documentation and measurement requests in the research and development of new oxygen-free production technologies.

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PATENT DATA FOR ENGINEERING DESIGN: A REVIEW

Patent data have been utilized for engineering design research for long because it contains massive amount of design information. Recent advances in artificial intelligence and data science present unprecedented opportunities to mine, analyse and make sense of patent data to develop design theory and methodology. Herein, we survey the patent-for-design literature by their contributions to design theories, methods, tools, and strategies, as well as different forms of patent data and various methods. Our review sheds light on promising future research directions for the field.

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PATENT-KG: PATENT KNOWLEDGE GRAPH EXTRACTION FOR ENGINEERING DESIGN

This paper builds a patent-based knowledge graph, patent-KG, to represent the knowledge facts in patents for engineering design. The arising patent-KG approach proposes a new unsupervised mechanism to extract knowledge facts in a patent, by searching the attention graph in language models. The extracted entities are compared with other benchmarks in the criteria of recall rate. The result reaches the highest 0.8 recall rate in the standard list of mechanical engineering related technical terms, which means the highest coverage of engineering words.

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INFORMATION RETRIEVAL AND SURVEY DESIGN FOR TWO-STAGE CUSTOMER PREFERENCE MODELING

Customer survey data is critical to supporting customer preference modeling in engineering design. We present a framework of information retrieval and survey design to ensure the collection of quality customer survey data for analyzing customers' preferences in their consideration-then-choice decision-making and the related social impact. The utility of our approach is demonstrated through the survey design for customers in the vacuum cleaner market. Based on the data, we performed descriptive analysis and network-based modeling to understand customers' preferences in consideration and choice.

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PLANNING THE ANALYSIS OF USE PHASE DATA IN PRODUCT PLANNING

The ongoing digitalization of products offers product managers new potentials to plan future product generations based on data from the use phase instead of assumptions. However, product managers often face difficulties in identifying promising opportunities for analyzing use phase data. In this paper, we propose a method for planning the analysis of use phase data in product planning. It leads product managers from the identification of promising investigation needs to the derivation of specific use cases. The application of the method is shown using the example of a manufacturing company.

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TESTING IN ENGINEERING DESIGN: WHAT ARE WE TEACHING

Although testing is critical in industries, the general approaches of testing in engineering design are under-represented in academia. This research investigates the current state of testing based on design textbooks. The findings suggest there is no clear definition of testing. Testing appears in different design stages with adjacent concepts such as prototyping, experimentation, verification, and validation. The processes of testing and its role within engineering design are ambiguous. Recommendations to design educators are provided, and the limitations of the study are discussed.

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IMPROVED APPROACH TO IMPLEMENTING DESIGN EDUCATION FOR ADDITIVE MANUFACTURING USING A RC MODEL RACE CAR

The integration of additive manufacturing processes into the teaching of students is an important prerequisite for the further dissemination of this new technology. In this context, the DfAM is of particular importance. For this reason, this paper presents an approach in which a connection is made between methodical product development and practical implementation by AM. Using a model racing car as an example, students independently develop significant improvements of particular assemblies. A final evaluation shows that the students have significantly improved their skills and competencies.

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EMERGING MATERIAL RESEARCH TRENDS: FOSTERING CRITICAL MATERIAL RESEARCH IN DESIGN STUDENTS

Sustainable production transition requires new paradigms and strategies, as well as alternative materials. Recently, an increasing number of innovative materials were developed. Such novelties greatly affected the design practice, widening the materic possibilities for designed products. However, traditional material classification does not apply well for these new materials trend. In this paper, the authors cooperated with design students to identify an iterative tracing activity of the new material trends for design, finalised to embed in the same work new tendencies that may rise in future.

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THE GAP IN DESIGN CREATIVITY EDUCATION BETWEEN CHINA AND DEVELOPED COUNTRIES

Extant research indicates that Chinese higher education has overlooked creativity. However, based on indirect clues, we infer that the degree of emphasis on creativity and related courses in Chinese higher education has changed. Therefore, we conducted a survey using a questionnaire to compare the creativity-related courses and adopted creativity methods in higher education between China and developed countries. The results indicate that participation rates and assessments of creativity-related courses, adopted creativity methods, and evaluations differ between China and developed countries.

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A WRITING TYPOLOGY FOR DESIGNERS

While design is often thought of as a visual field defined by renderings, models, and sketches, the use of writing can be just as pertinent and necessary. This paper presents seven writing types used by students uncovered during an ethnographic study of three interdisciplinary design studios. By reflecting on a compilation of writing practices, this study presents the modes in which we communicate design textually while reconsidering the possibility for new ones that incorporate interdisciplinary values and verbiage.

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THE CONTRIBUTION OF DESIGN DISCIPLINE IN BUSINESS DECISIONS THROUGH DESIGN-ORIENTED PRODUCTION DIVERSIFICATION: A CASE STUDY IN ITALIAN FURNITURE SECTOR

Firm diversification is a growth strategy that allows firms to launch new products in untapped markets to increase revenue. It is the identified approach where industrial designers can contribute to exploring new tactical assets. The paper analyses the design-oriented diversification of a furniture company in Italy, where Design played a crucial role in positioning new demands. The tool applied to display the current and the feasible product portfolio is the Product Space. The company has leveraged its know-how on bent glass to produce iconic objects, winning prestigious design awards.

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THE INTERGENERATIONAL CO-DESIGN OF GLASGOW COP26 SOUVENIRS

There has been an increasing interest in intergenerational activities where young people and older adults work together in the exchange of knowledge, new ideas, methodologies and ways of thinking. With the leading international climate change conference in Glasgow in Nov. 2021, this paper presents an intergenerational co-design COP26 project where co-design pairs designed and made Glasgow COP26 souvenirs, exhibited and sold them in a COP26 'pop-up' shop. The project delivered important learning and teaching including project launch, studio sessions, external design reviews, and prototyping.

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EXPLORATORY ANALYSIS OF ADAPTIVELY MORPHING HANDLE FORMS FOR LOAD TRANSFER USE CASES

Through optimal design of the human machine interfaces, especially the hand-handle contact surface, high usability of hand-operated products can be achieved. The complexity of the user specific hand anthropometry has to be considered in the design of load transfer handles. Use case optimized, personalized, and adaptively morphing handles aim at fulfilling this requirement. To identify design parameters for adaptive handles an experimental design for systematic analysis of user and use case requirements is proposed and evaluated showing the potential of adaptive handles.

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EXPERIMENTING IN INDUSTRIAL PRODUCT DESIGN. THE CASE: "ART, DESIGN AND BUSINESS PROJECT FOR NEW YOUNG TALENTS - YOUNG CULTURE AS A MOTOR FOR A NEW BUSINESS ECONOMY IN TUSCANY"

The design of mass-produced products is a design process aimed at the masses, which describes approaches and phenomena in strong transformation. The production techniques, the semantic value of the products, the concept of mass production and the similarities between these factors explain new production and design balances following the latest technological and cultural transformations within contemporary society and the market. The paper discusses and investigates the theme of industrial design aimed at the masses, reporting relevant case studies and experimental tests.

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A USER-CENTRED DESIGN SUPPORT FRAMEWORK TO DEVELOP AESTHETICALLY PLEASING AND SUSTAINABLE OVER-THE-COUNTER PHARMACEUTICAL PACKAGING

Stakeholders consider aesthetics and sustainability as important aspects of over-the-counter pharmaceutical (OTCP) packaging, and studies show that their interests should be represented more. To address this, a framework which supports designers to develop aesthetically pleasing sustainable OTCP packaging was generated, keeping at its core the stakeholders. The requirements were identified, leading to the architecture development and implementation in a prototype tool. Results provide a degree of evidence that the framework contributes to a user-centred design approach for OTCP packaging.

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