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AIEDAM thematic collection: a perspective on data-enabled design – design meet data science

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Guest Editors' Notes

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This special issue shows a thematic collection of papers representing far-reaching collaborations between data sciences and design research that led to the emerging field of data-enabled design. This emerging field is promising since the prevalent adoption of Artificial Intelligence (AI) will allow designers to get continuous and systematic insights into and an understanding of the system they design for. This is because AI-based systems generate data that could (continuously) be incorporated into the design process.

However, incorporating the data from AI-based systems requires changes in the design process as well as in the mindset of design researchers and data scientists. This is because there is a misalignment between thick and small data from traditional user-centered design methods and big and thin from data sciences (Bornakke and Due, 2018).

In this special issue, we aim to bring these two worlds together, which represents a journey that started almost a decade ago from two different perspectives.

From a technology perspective, Bourgeois *et al.* leveraged the Internet of Things to understand householders' behavior better (2014a, 2014b). It led to an iterative prototyping process for developing home energy solutions. It quickly became evident that the abundance of sensor data only provides the "what". The participatory analysis of these data with householders completed the picture, revealing critical information that iteratively shaped the proposed solutions. However, the design involved in this analysis remained limited. Close collaboration with design researchers and practitioners would have facilitated the data shaping and storytelling, important steps to extract valuable insights throughout the interactions with householders. In this process, the combination of technical and design perspectives is essential to effectively and responsibly engage people whose behavior is captured in the data and shape data into forms that trigger reflection.

From a design perspective, Kleinsmann *et al.* showed that data-enabled design could support the design process by adding community-level data to the design process (see, e.g., Jung *et al.*, 2022). Through their "Quantified Heart" study, they explored how self-monitoring of blood pressure and other data points (e.g., health-related experiences) of a group of lead users from the Quantified Self community could be a source of new insights and ideas for new health ecosystems (Pannunzio *et al.*, 2020). They found that this new type of user data could support designers in finding the ecosystem boundaries, defining the system and propositions, and getting insights into possible (technical) challenges for users. Although Kleinsmann and her colleagues incorporated new types of data that were generated from the design process into the design process, the way they analyzed and discussed the data with participants is still closely related to traditional user-centered design methods such as co-reflection (Tomico *et al.*, 2009).

Design and data science have become a flourishing meeting point today. Van Kollenburg and Bogers explored how sensor data, combined with contextualized insights from interviews, can be used as a design material for remote design interventions and translated their findings into a framework for data-enabled design (2019; Bogers *et al.*, 2016). Giaccardi *et al.* explored how the perspective of things can introduce new ways for humans and non-humans to collaborate and generate design insights (2016; Chang *et al.*, 2017). King *et al.*, coming from a data-driven design perspective (originally evolving around big and thin data), argue for data-aware design. Describing a mindset for designers to validate design decisions by looking beyond "clicks" and "conversion rates" opens for a combination with thick data (2017). Gorkovenko *et al.* sketch and explore possibilities for future design practices (2020) and ethnographic processes around sensor data, observations, and probing questions (2019). These highlights show eagerness from the design field to leverage data science, although remaining in the scientific discourse.

Design researchers and data scientists actively joined forces at the Faculty of Industrial Design Engineering of the Delft University of Technology. An example we like to mention here is the Master thesis project of Hosana Morales (2020). Morales did a project in pediatric cardiology in close collaboration with cardiologists for the Sofia Children's Hospital in Rotterdam, The Netherlands. Children with congenital heart disease luckily survive childhood

as a result of improved medical care. However, they often develop secondary cardiovascular problems due to their sedentary behaviors. This project aims to support children with congenital heart disease to do more physical activity through remote care. We also include the parents in the solution because one of the main reasons for the lack of physical activity is the parents' overprotective attitude. So, we aim to design a system for both the children and the caregivers. The first step of the design process was to develop a patient and parent journey. The input for this journey was community-level data that we derived from social platforms worldwide on which parents of children who suffer from early heart defects wrote their experiences. We developed a new method to analyze these stories using multiple machine learning techniques. In this way, AI technologies supported our design process and made it possible to use community-level data. The result was a patient journey that we generated with relatively little resources, through which we could quantify certain events which we could not have done without using AI technologies. Especially, these quantifications of symptoms and experiences formed a rich additional input for the design process. Clinicians, parents, and children recognized this automated patient journey. It formed the input for a co-creation session and a design phase that followed. This all led to the design of a concept called "Bo" that you can see in Figure 1. Bo consists of a chatbot for parents, a wearable for the kids, and a dashboard for clinicians.

In this thematic collection, we elaborate further on this far-reaching collaboration between design research and data science by bringing together a set of six papers across this meeting point, from design to data science. This attempt to consolidate this emerging field highlights recent developments and directions in a single venue. This is a collection to trigger our readers' thoughts. What is in there for designers and data scientists? What are the roles of data in design processes in which designers and data scientists work together? What are the touching points between the two fields? How to educate future designers to use data as new material and how to teach data scientists about the design process?

The boundary between a prototype and a product that is put in the real world is disappearing because software-based products are continuously prototyped, released, and redesigned based on user data enabled through the Internet. The growing place of Internet of Things' technologies brings opportunities for continuous changes and modification of the digital materiality to physical products. This disappearing boundary also removes the partition between the design and implementation process, leading to a continuous development and implementation cycle. Lee and colleagues highlight this never-ending design process that is enabled by these digital technologies. They present a model to support the integration of data in the design process by dealing effectively with the multiple paces and purposes that come with the digital and material artifacts.

Meyer and colleagues shed light on potentials and challenges, including the non-obvious value of data and frictions around data sharing. They also stress the limited value of product data for "completely new products". Besides these challenges, they show how data can be a powerful means to improve manufacturing processes and product planning for product improvement since data can provide deep insights into the product's actual use.

Noortman and colleagues further highlight the potential of data as participatory and co-design material. Their Data-Enabled Design (DED) methods reflect the iterative process and aim for new products focusing on data interaction. They further develop this method toward a scalable approach. Through this process, they iteratively shrink the emphasis on design research, the lower loop of the DED model, towards the upper loop, involving more automation and closer to self-sustaining. By doing this, they stress the need and opportunity for a continuous transition. Throughout this design process, data lose its primary role of metric and assessment to become an inspiration material. Darzentas and colleagues illustrate this inspiration potential by sharing experience on museum experience co-design. Through a

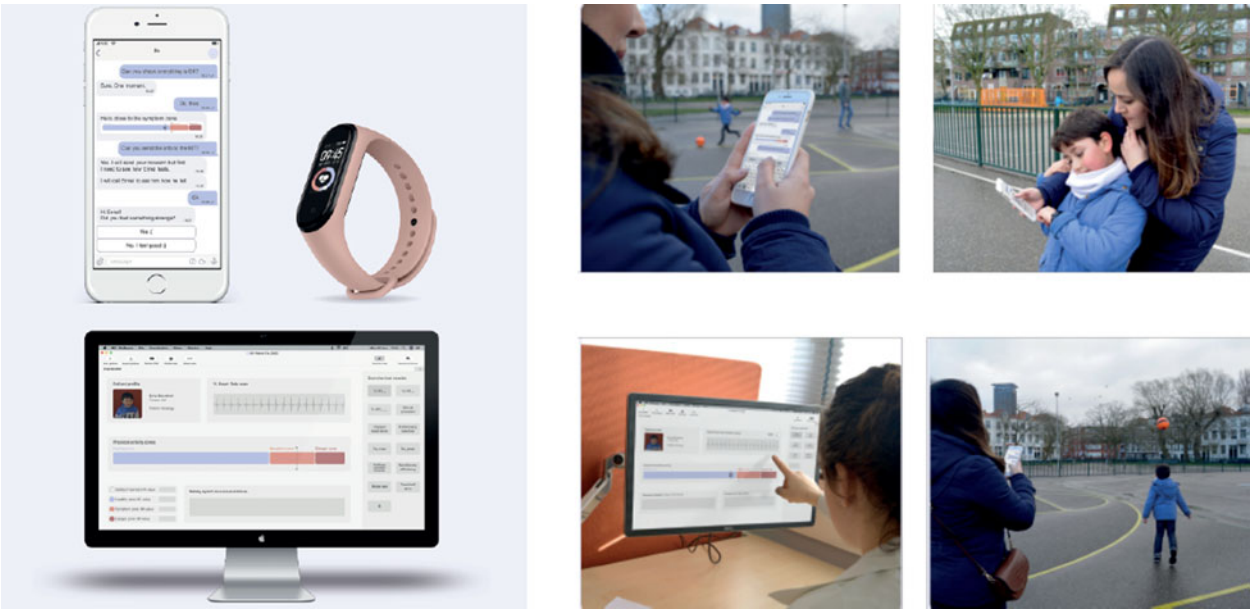

Fig. 1. A smart product service system to support parents and children with a congenital heart disease to be more physically active in a safe manner called "Bo" (Morales, 2020).

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generator of Kitchen layout, Pejic and colleague branches to generative design to support designers with functional and inspirational inputs.

Finally, Machine Learning is today's natural habitat for data, and the role of designers is still being shaped further. Sun and colleagues demonstrate that designing these algorithms is a fundamentally iterative and data-driven process. The inML kit aims at supporting designers in playing a critical role in the design of these algorithms through prototyping and literacy.

We do not doubt that this small thematic collection merely scratches the surface of designing with data and the data-enabled design processes that come with it. This is a modest contribution to an emerging yet scattered field. One that empowers design with appropriate data tools and methods. One that transforms designers with new roles and responsibilities.

More specifically, we identify four major action points to realize the potential of data and AI as design material.

Cross-pollination of methods – It is essential to dissect the methods of the respective fields to identify potential strengths without colonizing design them. Concrete examples are data donation, crowdsourcing, or citizen science, each offering opportunities for human-centered design such as scalability or collaboration. Yet, these methods aim at insights which are often misaligned with the human-centered approach. What are the tools to mediate designerly interactions with data? How can designers engage participants in active collaboration to develop the insights they need through these scalable data collection methods?

Transdisciplinary collaborations throughout the product lifetime – The development of a transdisciplinary community with a common language of data-enabled design methods is essential to facilitate the use of data and AI throughout the design process. It enables to educate designers and data scientists with the appropriate literacy and collaboration mindset. How do designers inject their data collection points to generate the insights and evidence they need for the subsequent design iterations? How to integrate these technologies into the creative phases of the design process?

Empower designers and data scientists to take responsibility – While collaborating, designers must remain independent in their ability to iteratively prototype and test their design solutions. What are the appropriate tools to empower designers to experience, shape, and design with data and AI? How to nurture a responsible use of these technologies to foresee risks, minimize biases, and deal with personal, intimate behavioral data?

Shape human-agent relations. AI technologies have transformed the nature of technological artifacts from being passive and reactive to active, life-like, forever learning, and adapting. The way these new technologies shape societal transitions is strongly influenced by the relationships and partnerships between humans and artificial agents. We see data-enabled design methods as powerful means to shape these new relations in an iterative and human-centered manner.

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Jacky Bourgeois is an Assistant Professor and Director of the Data-Centric Design Lab with the Department of Sustainable Design Engineering (SDE) of the Faculty of Industrial Design Engineering (IDE) of the Delft University of Technology. With a background in computer science, Jacky investigated the design of ubiquitous technologies to support domestic energy practices of "energy farmers", that is, households that generate their own energy from solar panels. He combined exploratory interviews, participatory data analysis, and in-home interventions to get a deep understanding of this context. He investigated case studies focusing on Energy Demand-Shifting in the context of domestic solar electricity generation around the laundry and the electric mobility routines. His objective was to understand the connection between consumption and local generation and design support for emerging energy practices. This process led him to appreciate data generated from the Internet and the Internet of Things as key resources in the design of end-user products and services. However, designers often lack the necessary data literacy to use this resource effectively and ethically as part of their design process. Jacky dedicates his research and teaching effort to addressing this challenge.

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