Digital Innovations in Architecture, Engineering and Construction

Andrea Giordano
Michele Russo
Roberta Spallone *Editors*

Representation Across Boundaries

New Links with AI, AI-GEN, and XR Tools for Cultural Heritage and Innovative Design

Springer

Digital Innovations in Architecture, Engineering and Construction

The Architecture, Engineering and Construction (AEC) industry is experiencing an unprecedented transformation from conventional labor-intensive activities to automation using innovative digital technologies and processes. This new paradigm also requires systemic changes focused on social, economic and sustainability aspects. Within the scope of Industry 4.0, digital technologies are a key factor in interconnecting information between the physical built environment and the digital virtual ecosystem. The most advanced virtual ecosystems allow to simulate the built to enable a real-time data-driven decision-making. This Book Series promotes and expedites the dissemination of recent research, advances, and applications in the field of digital innovations in the AEC industry. Topics of interest include but are not limited to:

– Industrialization: digital fabrication, modularization, cobotics, lean.
– Material innovations: bio-inspired, nano and recycled materials.
– Reality capture: computer vision, photogrammetry, laser scanning, drones.
– Extended reality: augmented, virtual and mixed reality.
– Sustainability and circular building economy.
– Interoperability: building/city information modeling.
– Interactive and adaptive architecture.
– Computational design: data-driven, generative and performance-based design.
– Simulation and analysis: digital twins, virtual cities.
– Data analytics: artificial intelligence, machine/deep learning.
– Health and safety: mobile and wearable devices, QR codes, RFID.
– Big data: GIS, IoT, sensors, cloud computing.
– Smart transactions, cybersecurity, gamification, blockchain.
– Quality and project management, business models, legal prospective.
– Risk and disaster management.

Andrea Giordano · Michele Russo ·
Roberta Spallone
Editors

Representation Across Boundaries

New Links with AI, AI-GEN, and XR Tools for Cultural Heritage and Innovative Design

Springer

Editors
Andrea Giordano
Department of Civil, Environmental
and Architectural Engineering
Università di Padova
Padua, Italy

Michele Russo
Department of History, Drawing
and Architectural Restoration
Sapienza Università di Roma
Rome, Italy

Roberta Spallone
Department of Architecture and Design
Politecnico di Torino
Turin, Italy

ISSN 2731-7269 ISSN 2731-7277 (electronic)
Digital Innovations in Architecture, Engineering and Construction
ISBN 978-3-032-04710-6 ISBN 978-3-032-04711-3 (eBook)
https://doi.org/10.1007/978-3-032-04711-3

This Springer imprint is published by the registered company Springer Nature Switzerland AG
The registered company address is: Gewerbestrasse 11, 6330 Cham, Switzerland

Preface

The volume we are about to press responds to the need to present readers with the most up-to-date panorama concerning the international research of scholars in the disciplines of Representation, which faces the innovative themes of Artificial Intelligence and Extended Reality. The book title, *Representation Across Boundaries: New Links with AI, AI-GEN, and XR Tools for Cultural Heritage and Innovative Design*, intends to highlight the transdisciplinary approach with which the selected authors have approached cutting-edge research, both at the theoretical and applied levels.

The very rapid technological evolution in the investigated fields, imposes, on the one hand, a rigorous control of processes and tools possible only through solid theoretical foundations, and on the other hand, a careful and adequate application of the same processes, methods, and tools to use cases in the fields of cultural heritage and innovative design.

The volume was created under REAACH, REpresentation Advances And CHallenges association, https://www.reaach.eu/.

REAACH association aims to build a new knowledge network based on two pillars: people and research. The idea that inspires the association is that through the relations developed between people and research from different disciplines, it is possible to build new bridges that foster the development of accessible and free knowledge.

The book, organized into thematic sections, collects 57 chapters written by 164 authors. The submissions were selected following a double-blind Peer Review carried out by at least two reviewers selected from international experts.

The contributions are organized according to eight topics: AI&XR and Historical Sources, AI&XR and Museum Heritage, AI&XR and Heritage Routes, AI&XR and Education, AI&XR and Classification/3D Analysis, AI&XR and Shape Representation, AI&XR and Building Information Modeling, AI&XR and Building Monitoring.

Our thanks go to Ornella Zerlenga, president of the Unione Italiana Disegno (UID), for her generous support to REAACH Association, Francesca Fatta, former-president of the Unione Italiana Disegno (UID), for her advice during our work, to

Alessandro Luigini, president of the IMG Network, for sharing ideas and insights, and to the scientific committee, consisting of Violette Abergel (MAP UMR 3495 CNRS/MC, Marseille), Salvatore Barba (University of Salerno), Marco Giorgio Bevilacqua (University of Pisa), Stefano Brusaporci (University of L'Aquila), Valeria Cera (University of Naples Federico II), Pilar Chías (University of Alcalá), Francesca Fatta (Mediterranea University of Reggio Calabria), Alessandro Luigini (Free University of Bozen-Bolzano), Dominik Lengyel (BTU University of Technology Cottbus-Senftenberg), Alessandro Luigini (Free University of Bozen-Bolzano), Federica Maietti (University of Ferrara), Barbara Ester Adele Piga (Politecnico di Milano), Pablo Rodriguez Navarro (University Politècnica de València), Cettina Santagati (University of Catania), Alberto Sdegno (University of Udine), Victoria Szabo (Duke University), for their proactive proposals, hard work, and continuous support. Special thanks go to Martina Casciola (Sapienza Università di Roma) and Martina Rinascimento (Politecnico di Torino) for carefully editing this volume.

Finally, our heartfelt thanks go to the authors who responded to the call by presenting high-quality papers and cutting-edge research. We hope their chapters will stimulate interest, exchange ideas, and provide inspiration for innovative research.

Padua, Italy
Rome, Italy
Turin, Italy
June 2025

Andrea Giordano
Michele Russo
Roberta Spallone

Contents

AI&XR and Shape Representation

AI&XR and Building Information Modeling

Artificial Creativity. Design Evolution in the Age of AI

Giorgio Buratti

Abstract The advent of artificial intelligence (AI), in combination with the ubiquity of digital sensors, computer networks, and automation that has characterised the last decade, is transforming the socio-economic environment and defining a probable new industrial era. This evolution also inevitably involves the Design world by redefining the designer's role, the object of design, and the user relationships. Many of today's artefacts, be they an iPhone application, a car, or a building, are increasingly connected to the designer who conceived them, thanks to a continuous flow of data detailing many aspects of the user experience. This same information can be used to train AI neural networks capable of autonomously generating specific solutions without human intermediation. An artificial intelligence engine can thus anticipate users' needs and behaviours, proposing solutions that are improved and customised according to the particular use that distinguishes each customer. This paradigm shift has important implications for the role of the designer. Through the analysis of pioneering case studies, this paper analyses the possible developments, delving into the repercussions for design theory and practice concerning the theoretical framework used today to interpret the discipline of Design.

Keywords AI development · AI uses · Deep learning · Design thinking · Design method

1 Introduction

The Design process involves creating and marketing new artefacts or services, usually produced in large series. This process is characterised by consequential design cycles to generate meaningful solutions, followed by the production and selling phases. Since designing different solutions for each user is technically and economically unsustainable, products and services are intended for 'segments' of the population,

G. Buratti (✉)
Dipartimento di Design, Politecnico di Milano, Milan, Italy
e-mail: giorgio.buratti@polimi.it

A. Giordano et al. (eds.), *Representation Across Boundaries*, Digital Innovations in Architecture, Engineering and Construction,
https://doi.org/10.1007/978-3-032-04711-3_41

with more or less limited customisation possibilities depending on the marketing sector. This organisational architecture entails significant effort and investment in redesigning artefacts or services, so innovation is postponed until its marginal value justifies its design cost.

Today's information technologies have revolutionised this scenario, promoting a design path continuously informed by data from real-time interactions between artefacts and users or from the ecosystem in which the artefact is located. The flow and mode of data use become fundamental and distinguishable in categories, ranging from static and linear use to more dynamic and interactive levels, where the variability of the parameters is a valuable element for exploring new design hypotheses.

Data's 'dimensional' aspect is equally significant and closely related to the use mode. Cultural and scientific evolution has been built for centuries by searching and processing 'small' data. Until the end of the millennium, libraries were still the place for satisfying study information needs, professional updating, or leisure. If the desired knowledge was unavailable, one had to go to a new library or wait for a book or magazine to be delivered. In the absence of direct access to the repositories of that particular information or direct experimentation, there was no other option but to give up the data sought.

Information technology has made the process of creating, collecting and transmitting information so cheap, and the data set so large that it requires new methodological tools capable of managing dynamics that inevitably influence the design dimension. From data that is stable over time, we have moved on to information that transforms with the infrastructural network with which it is associated, to data that autonomously produces other data [1], projecting the world into the age of Big Data. This era is characterised by massive, complex, high-speed data that is difficult for human capabilities to handle but ideal for the way AIs operate. In this scenario, it becomes fundamental for the designer to collect, interpret and normalise data to inform the set of programs and algorithms that replace certain cognitive aspects of man, which are now insufficient to manage the required information.

2 Design Ontology

To verify whether and to what extent AI tools can influence the design process, it is necessary to frame two levels of analysis [2]: Design's principles and Design's method.

The principles refer to the fundamental categories underlying the act of design, including the sociological, historiographical and speculative aspects that constitute the ontology of design and allow its existence as a discipline (improvement of people's lives, attention to the environment, social inclusion).

Design methods encompass the phenomenology of design in a specific context. They are linked to the methodological processes (design phases, tools used, methods of description and representation) that lead to the design objective (the solutions created, whether physical, digital or conceptual objects).

2.1 Design Principles

The scientific debate on Design ontology has developed significantly in the international theoretical field, with an enormous wealth of contributions [3–5] and not a few ambiguities. Given the purpose of this paper, one will draw on the most recent developments of a specific current of studies related to the relationship with AI [6] that converges towards the definition of three fundamental principles:

- User-centricity

Design-led innovation stems from understanding problems from the user's point of view and making predictions about what might be meaningful for people's well-being rather than being driven by technological advances and/or what it enables.

- Abduction

The designer exploits a generative approach in the creation of solutions that are not based exclusively on deductive reasoning (what a phenomenon is like) and inductive reasoning (how a phenomenon is likely to be) but focuses on abductive logic, i.e., formulating hypotheses about what a given entity might be like. This speculative category often leads to the reformulation of problems and their defining premises, not containing a logical validity of its own but requiring empirical demonstration for validation [7].

- Iteration

The abductive process requires continuous adaptation and improvement obtainable through cycles of verification. In design, prototypes are a time for experimentation that allows ideas to be communicated, learning and progressing until a satisfactory solution is reached.

These principles can be implemented differently depending on the operational context in which the design is carried out. Over the decades, various models have been studied and evolved to frame different design phases by describing their parameters to optimise the path to the objectives.

2.2 Design Methods

The context in which most of the design practices we know today are conceived is based on managing heterogeneous data, distributed at different stages starting with the concept, passing through the intermediate stages of review and implementation, and ending with manufacture according to relationships typical of poietic disciplines. Each of these phases requires specific types of information, for example, to describe physical characteristics (weight and size), qualitative characteristics (motivations and perceptions), or functional and economic aspects. Market analyses, questionnaires and user trials, material tests, and the realisation of more or less functioning prototypes imply the collection of fundamental data for design purposes. This information will then be represented and shared to allow reasoning and actions leading to the final result to be retraced and confirmed. The systemic study of this heteroclite set stems from new management approaches developed in the mid-twentieth century in response to industrialisation and mass production. Over the decades, various models have been studied and evolved to frame the different design phases of the type of data used. A linear matrix usually unites these systems and develops sequentially, from identifying a problem to proposing a final solution [8].

Although there are differences depending on the cultural context and historical period, regardless of the complexity of the model, it is possible to recognise three shared phases: the Analytical Phase (planning and data collection, analysis), the Creative Phase (data comparison, synthesis, development) and the Executive Phase (design and communication) (Figs. 1, 2).

Such a structure, dating back to the 1950s and 1960s, remained unchanged until the millennium's end. This is not strange, considering that design was born in the 1800s in response to the changes in scale and perspective brought about by society's transition toward industrialisation, the serial reproduction of products and goods, and the expansion of modes of communication [9]. Life and work styles have been redefined in Europe and North America by transitioning from a predominantly agricultural to an industrial socio-economic system. In this context, dominant design paradigms will become entrenched in educational and professional practice in later years, eventually crystallising into norms, values, and assumptions that will survive over the years beyond real utility. Indeed, despite the obvious influence of the information technology revolution, the design methods used until the end of the millennium seem to be considered universal, timeless and applicable indifferently to any cultural or geographical context. While this inclusive view of design has undoubtedly opened up collaborative modes of design that have expanded its disciplinary boundaries, it has also given the illusion that "design thinking" is a set of tools that anyone can easily apply in any design context [10].

The contemporary era is marked by rapid technological innovations that increase the complexity of social transformation through new needs and scenarios. As design has progressively evolved in contexts other than the original ones, the focus has increasingly shifted from the outcome to the design process. Designing products, services or environments using information-based technologies, in a mutual and continuous exchange with products and customers, requires a different understanding of how to design [11] based on qualitative techniques such as ethnographic methods, cultural investigations and situated methods, capable of framing an overarching category of data. Thanks to increasingly sophisticated sensors, processing algorithms, and transmission systems, it was possible to create digital representations of processes, artefacts or environments capable of describing in real time their behaviour and relationships with users and the physical world [12].

This continuous flow of data makes it possible to recognise social patterns based on which predictive scenarios can be hypothesised, and in which services and infrastructures provide efficient responses to the needs of people and communities. Add to this mass of data the information from the systems that support social computing, i.e., the

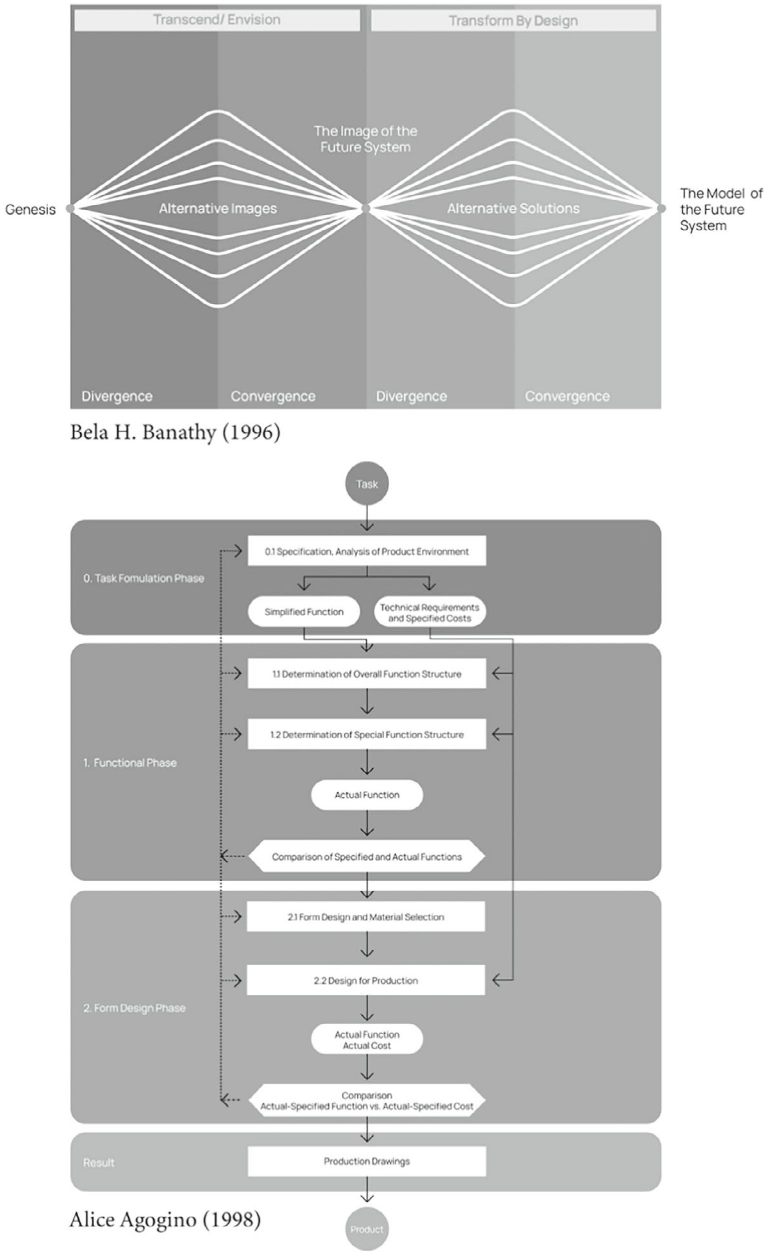
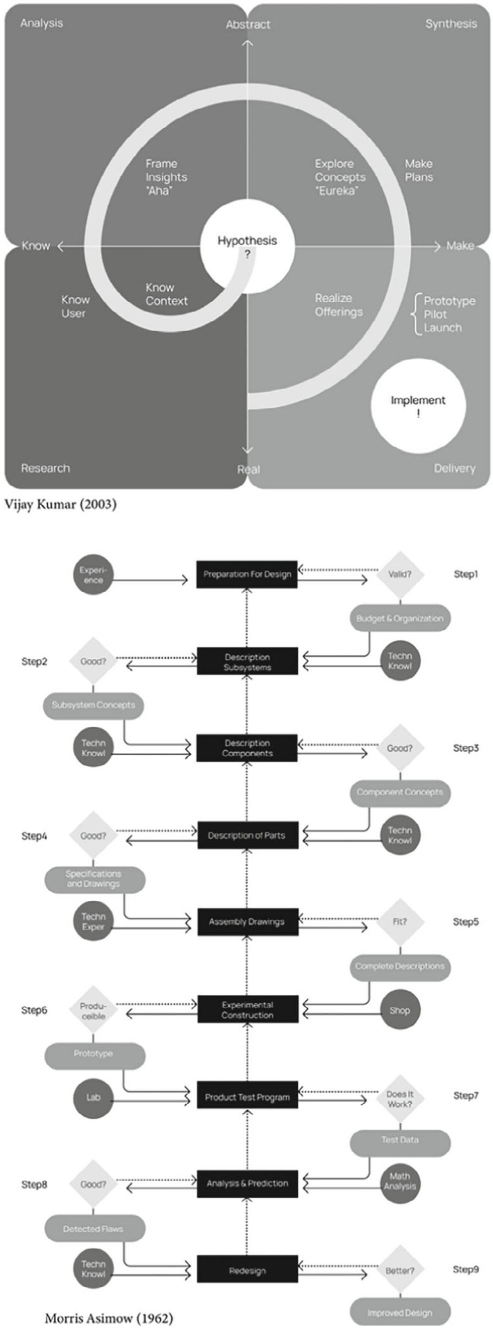


Fig. 1 Some examples of the method developed by design research over the years. (above) Béla H. Bánáthy Double Diamond divergence-convergence model proposed by the Hungarian-American linguist, later adapted to the design process by the British Design Council (Re-elaboration: H. Dubberly). (below) Alice Agogino model developed for NASA's Jet Propulsion Laboratory. (Re-elaboration: G. Buratti)

Fig. 2 Examples of design method: Vijay Kumar teaches at the Illinois Institute of Technology's Institute of Design, his research includes a focus on understanding innovation; the Morris Asimow model introduced by Tomas Maldonado and Gui Bonsiepe to the design and architecture community, in their seminal article "Science and Design".
(Re-elaboration: G. Buratti)



social interaction that creates content, more or less consciously, from social media, e-commerce, wiki pages, blogs, and online gaming. If computer science provides the theory and technologies to process this information, Design offers methods to develop criteria for empirical data collection. Over the years, designers have contributed significantly to creating quantitative and qualitative data, supporting increasingly user-centred design practices [13]. However, while data collection methods have grown to support the design process, the study of the relationship between data and the design act itself has not grown proportionally.

3 Design, Data and AI

It is possible to differentiate the influence of data flow not only in representing and understanding the physical mode, but also in controlling, modifying and designing it in the following approaches: design ‘from’ data, design ‘with’ data and design ‘for’ data [14].

3.1 Design ‘from’ Data

Design ‘from’ data groups those design systems in which the designer identifies, selects and reworks information from direct measurement of known elements. In this approach, data is a premise of design. We have already written about the many methods designers use to derive data from social, technical and environmental contexts. The variety of techniques that fall into this category is not limited to the examples given but extends to all processes in which data is collected before being analysed and used to inform design decisions.

Design ‘from’ data is typical of those systems in which products and services are designed for ‘segments’ of the population, with more or less limited customisation possibilities depending on the product sector. This is because the design process, which starts with collecting data and ends with producing and marketing products and services, involves significant investments and serial productions that recover these costs. Innovation through the realisation of new products is postponed until the marginal value justifies the cost of re-design, as in the case of Apple screens (Fig. 3).

3.2 Design ‘with’ Data

Design ‘with’ data is characterised by a process still determined by the designer but supported by the flow of data from intermediate levels of process and product verification and review. The role of data, in this case, lies between the premises and the implementation phases of the project.

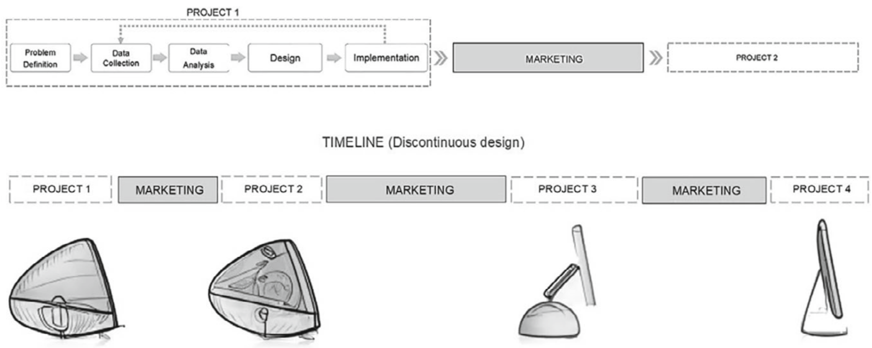


Fig. 3 The evolution of Apple's screens is an example of "design from data": market introduction is postponed until the marginal value of a new product exceeds the cost of its design. At this point, a new design cycle began, with a significant time separation between two initiatives in which research and development are frozen, leading to rapid product obsolescence. New ideas and improvements can only be studied for future solutions, released serially, episodically and for target customers. (Editing: G. Buratti)

The set of all networked devices, not only computers, but also household appliances, cars, environments and any artefact that connects to update services and/or the distribution of information and data, allow designers to maintain a continuous link with what is designed. Information flows bidirectionally, seamlessly even after commercialisation, remaining available to the designer and redefining the relationship between the designer and the design object [15].

The designer's role is now necessarily more dynamic, mediating his professionalism within a complex network of social and environmental connections created by usage feedback and user behaviour. Already, current marketing models for IoT devices or apps involve the customer buying a device that supports particular functions, but simultaneously transmitting such data to the manufacturer, who may sell it to third parties or use it for their development strategies. Data is no longer a resource to be examined a priori but a means by which designers can describe a phenomenon in real-time, understand its problems, decide which solutions to adopt and verify their effect in a new method whose effectiveness is unprecedented. A striking example is that of Tesla, which has adapted its car design to the new context by replacing physical interaction and control elements (buttons and levers) with digital touch-screen interfaces (Fig. 4). In addition, the cockpit and body are abundantly equipped with sensors to collect data related to environmental rather than internal conditions, in continuous transmission with the parent company. Interestingly, some of these sensors are not used to provide direct value to customers but are installed to anticipate future post-market-enabled services [16].

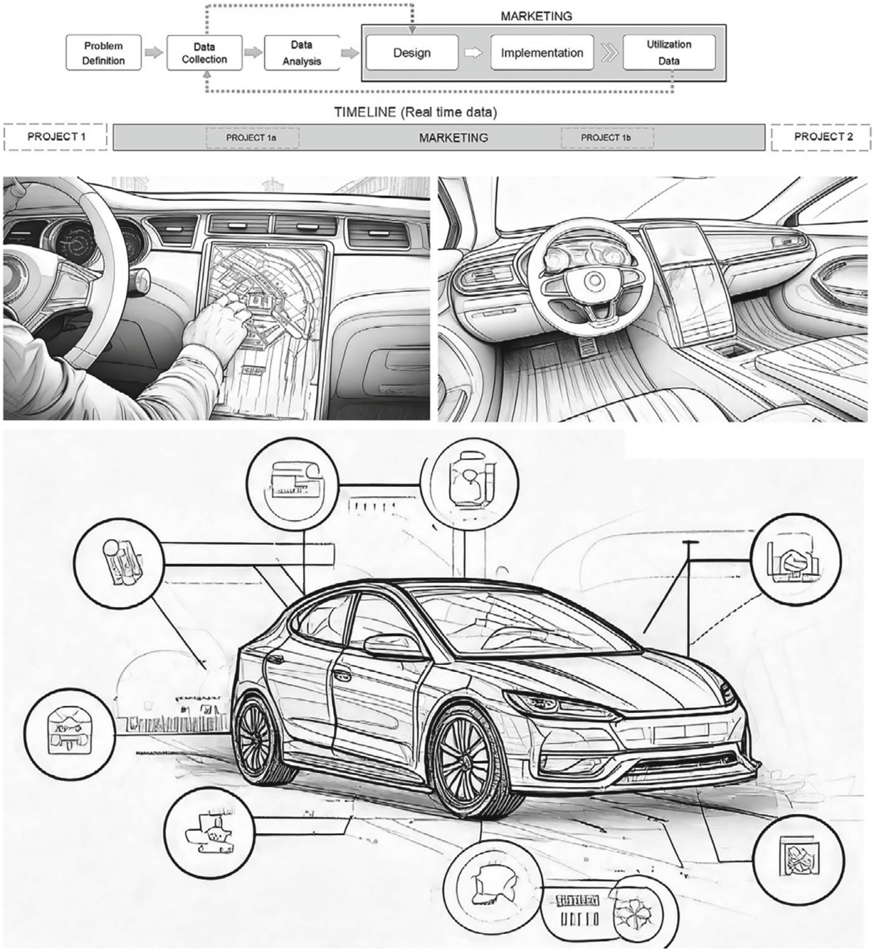


Fig. 4 In Tesla's cars, the redundancy of the sensors and the use of touch screens allow a continuous data flow between the car and the designers who designed it. This allows the continuous updating of the systems and introducing new, customised features over time (Editing: G. Buratti)

3.3 Design 'for' Data

Design 'for' data occurs when a designed system autonomously produces information through intensive data analysis from the interaction between people, computers, artefacts, and environments. This pioneering mode is closely linked to adopting AI tools. Problem-solving, hitherto the prerogative of designers, is being automated in learning algorithms that address complex questions through simple rules, iterating exponentially without volume or speed limits [17]. Think of an entertainment content streaming platform such as Netflix (Fig. 5): constraints and parameters are specified by human designers at an early stage of the process, but the organisation, graphic language and especially the class of products (comedies, documentaries, TV shows, fantasy, westerns, etc.) to be shown on the screen are decided by the AI.

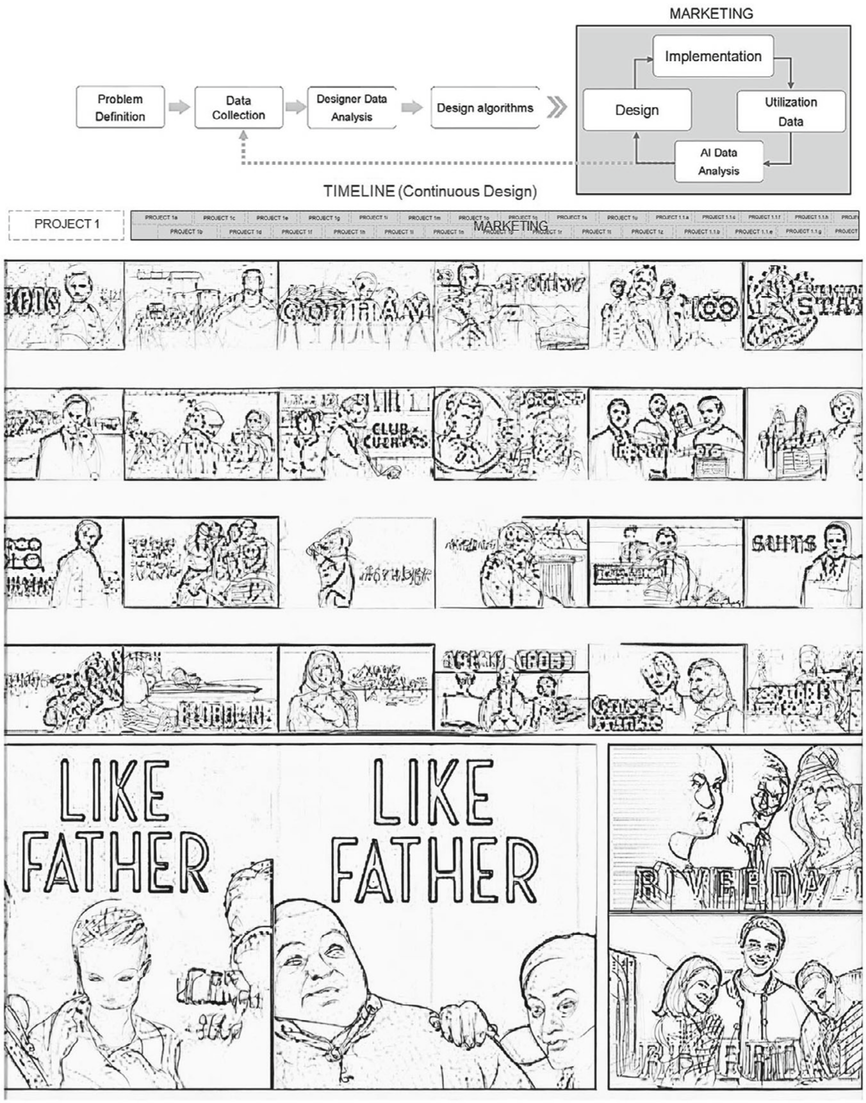


Fig. 5 Netflix's operating model focuses on managing data and parameters using Artificial Intelligence agents. The collected data trains the AI, which designs the interface elements in real-time and autonomously, personalising them according to the user's characteristics, such as ethnicity or tastes, changing the visual appearance accordingly. (Editing: G. Buratti)

The latter keeps track of the user's previous interactions with the platform and compares them with all the information available in dedicated databases (web browsing, credit card purchases, reviews on social media, etc.), working out the solution deemed most suitable for that specific user at that instant. The continuous collection of new data improves predictions of user needs and behaviour, enabling increasingly customised and efficient solutions. Design 'for' data therefore involves the implementation of autonomous design systems, capable of exploiting large amounts of information to develop specific solutions, evolving design 'with' data, as it does not need to continuously redesign or update the operating model.

4 Conclusions

The three classes identified reflect existing practices and methods and their likely evolution. Evolving the conventional use of design 'from' data, the categories design 'with' and design 'for' affect the design principles and methods differently.

Designing 'with' data, for example, does not distress design assumptions but significantly affects the design methods. The marketing of new products according to methods derived 'from' data is based, as explained above, on consequential cycles of design (search for a meaningful solution), realisation (production and marketing of these solutions), and use (customer). This structure implies a significant temporal separation between two consecutive design initiatives. Research and data collection stops during this period, while technological or socio-cultural evolution does not. In this mode, design solutions quickly become obsolete, as innovations can only be incorporated into new products produced serially, episodically and for market segments.

In design 'with' data, there is no solution of continuity between different moments, because the data collection provided by users and contexts is continuous and constantly modifies the value proposition of the marketed product or service [18]. Users become 'prosumers' [19], i.e., consumers who actively define products and services because they are, directly or indirectly, proposers of new solutions or design problems. Products are thus components of more complex systems where the physical object is a minority manifestation of a broader service. This process, called servitization [20], transforms everyday objects such as household boilers, thermostats, washing machines and the like into artefacts that generate valuable data to improve the products but, above all, change their associated value over time. New methods capable of managing continuous cycles of design and redesign are needed for this category: data management is a complex process where interpretation depends on many variables, and it is always necessary to consider the context for it to take on meaning. Design is evolving towards an increasingly active role in mediating data that influence the morphology and functions of artefacts according to the needs of individual users. Digital immateriality promotes this process, while for 'hardware' related fields there are objective difficulties, although the Tesla example seems to anticipate future methods.

Design ‘for’ data promotes the evolution of the designer figure and the design process even more radically. If, so far, computer tools have been used mainly to reduce costs and time needed to develop and produce artefacts and services, AI introduces digital automation at the concept stage with repercussions both in terms of results and method. Indeed, the problem-solving capabilities typical of these applications make it possible to delegate to algorithms the definition of detailed design choices, hitherto the exclusive prerogative of the designer.

The first radical change concerns the design outcome. Traditionally, designers design mass-marketed solutions (products, services, architecture). A team of specialists has previously conceived and detailed what the client uses.

Using AI, the solution is designed at the moment it is requested and used by the user. The designer’s job is no longer to devise products, services or architecture but to anticipate new contexts and then design problem-solving algorithms that will autonomously develop customised solutions according to the individual user’s wishes.

The consequences for designers, researchers and, above all, teachers of design disciplines are meaningful. How do you design algorithms to create an AI capable of solving a specific design problem? How do you devise design tasks based on elementary rules that, once replicated several times, can autonomously provide highly complex solutions to users?

Currently, designers are not skilled in this way. Their mental schemata are trained to tackle and solve, more or less systematically, complex tasks, not to instruct a digital agent on how to solve the same problem autonomously.

In the new paradigm, is design practice still people-centred, through abductive processes that are subsequently tested experimentally and iteratively?

Ultimately, AI does not undermine the core principles of Design Thinking but enables its scale, scope and learning limitations. Solutions can be more user-centric by achieving extreme customisation through continuous updating via learning iterations that cover the entire product lifecycle. On the contrary, the practice of design will probably undergo a profound transformation: traditionally performed by designers, problem-solving tasks will be partly automated by learning agents operating without limits in volume and speed. AI tools have the potential to free designers from the burden of detailed development, allowing them to focus on understanding fundamental problems, designing solving algorithms, and pointing them in a meaningful direction. The designer’s role will then be to formulate the right questions to obtain the most appropriate answers to the set goal. The ethical component related to what is produced with these tools is often misled by the term ‘intelligence’ by which these tools are classified. An algorithm created to solve a problem cannot refuse to solve it. Otherwise, humans can avoid acting, for moral, cultural or intrinsic reasons [21]. In this perspective, design becomes a matter of choice: machines produce innumerable variants, while humans choose according to their visions and purposes. As design theory and practice have so far focused on solving problems aimed at value creation, the understanding of the relationship between design and generations of meaning is still limited and opens up broad and interesting areas for research.

References

1. Cox, G., Mc Lean, A.: Speaking Code: Coding as Aesthetic and Political Expression. MIT Press, Cambridge, MA (2012)
2. Orlikowski, W.J.: Cambridge Handbook of Strategy as Practice. Cambridge University Press, Cambridge (2012)
3. Margolin, V.: Design Discourse: History. Theory and Criticism. University of Chicago Press, Chicago (1989)
4. Margolin, V., Buchanan, R.: The Idea of Design. The MIT Press, Cambridge (1996)
5. Galle, P.: Philosophy of design: an editorial introduction. Des. Stud. **23**(3), 211–218 (2002)
6. Verganti, R., Vendraminelli, L., Iansiti, M.: Design in the age of artificial intelligence. Harvard Business School Working Paper, pp 20–091 (2020)
7. Fann, K.T.: Peirce's Theory of Abduction. Martinus Nijhoff, The Hague (1970)
8. Munari, B.: Da Cosa Nasce Cosa, Appunti per Una Metodologia Progettuale, 8th edn. Editori Laterza, Roma (2017)
9. Dilnot, C.: The matter of design. Design Philos. Pap. **13**(2), 115–123 (2016)
10. Zurlo, F.: Designerly way of organizing. The design of creative organization. Agathón Int. J. Architect. Art Des. **5**, 11–20 (2019)
11. Forlano, L.: Posthumanism and design. She Ji: J. Des. Econ. Innov. **3**(1), 16–29 (2017)
12. El Saddik, A.: Digital twins: the convergence of multimedia technologies. IEEE Multimedia **25**(2), 87–92 (2018)
13. Norman, D.: Why doing user observations first is wrong. Interactions **13**(4), 50 (2006)
14. Speed, C., Oberlander, J.: Designing from, with and by data: introducing the ablative framework. In: Lloyd, P., Bohemia, E. (eds.) Proceedings of DRS 2016 Design Research Society 50th Anniversary Conference, pp. 2991–3003. Brighton (2016)
15. Kozinets, R.V.: Netnography 2.0. Handbook of Qualitative Research Methods in Marketing (2006)
16. Electrek Website: https://electrek.co/2019/07/24/tesla-use-camera-inside-cars-personalize-in-car-experience/. Last accessed 05 May 2025
17. Buratti, G., Rossi, M.: Is a picture worth a thousand words? Comparative evaluation of generative AI for drawing and representation. In: Giordano, A., Russo, M., Spallone, R. (eds.) Advances in Representation. Digital Innovations in Architecture, Engineering and Construction. Springer, Heidelberg (2024)
18. Normann, R., Ramirez, R.: From value chain to value constellation: designing interactive strategy. Harv. Bus. Rev. **71**(4), 65–77 (1993)
19. Toffler, A.: The Third Wave. Bantam Book, New York (1980)
20. Vandermerwe, S., Rada, J.: Servitization of business: adding value by adding services. Eur. Manag. J. **6**(4), 314–324 (1988)
21. Csikszentmihalyi, M.: Motivation and creativity: toward a synthesis of structural and energistic approaches to cognition. Flow Found. Positive Psychol. 155–173 (2014)