Designing with the use of data for a better understanding of people and operating contexts in sociotechnical systems

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# PREFACE

Welcome to the 13th biennial Norddesign Conference 'Design in the era of digitalization'! Following previous editions in Helsinki (1996), Stockholm (1998), Copenhagen (2000), Trondheim (2002), Tampere (2004), Reykjavik (2006), Tallinn (2008), Gothenburg (2010), Aalborg (2012), Helsinki (2014) and Trondheim (2016) it is our pleasure to welcome you back to Sweden and invite you to Linköping. The Norddesign conference series aims to serve as a Nordic complement to the large European and American Design Society conferences within the fields of Engineering and Product Design, but also welcomes participants from other countries. A Nordic Scientific Advisory committee, consisting of representatives from the main universities of technology in the Nordic region, guards over the quality and the continuity of the conference series. The Norddesign 2018 conference is hosted and organized by the Division of Machine Design at Linköping University, in co-operation with the Product Development Academy in Sweden and the Design Society.

# CONFERENCE PROGRAM

The theme of the 2018 conference is 'design in the era of digitalization', which covers a wide range of topics, ranging from the use of big data in the early phases of the design process, to the use of virtual reality in product development, and from the use of physical computing in design, to design automation. The proceedings will be published as open access by the Design Society on their website www.designsociety.org. During the conference, the papers are available via OneDrive. Use this shortlink **https://goo.gl/mmJPSL** or the QR code at the bottom of this page.

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**NordDesign 2018**
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**Linköping, Sweden**

# Designing with the use of data for a better understanding of people and operating contexts in sociotechnical systems

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## Abstract

The complex systems defined as 'sociotechnical systems' are made of software, hardware and people, somehow linked to the policy and a large number of stakeholders. They show complex dependencies and functional-based constraints. Over the last decades, the need to cope with the complexity took different forms, evolving in research activities and new disciplines. Systemic Design (SD) is an approach to manage the complexity that draws its origins into the General System Theories, cybernetics and generative science of the twentieth century, up to the recent attention towards systems thinking. Cyber-physical systems (CPSs), on the other hand, draws its origins from software and mechanical engineering, merging theory of cybernetics, mechatronics, design and process science. In CPS computing and communication are tightly coupled with the monitoring and control of entities in the physical world (Cheng and Atlee, 2008). The idea behind CPS is similar to the idea of the Internet of Things (IoT), with which it shares the same architecture. IoT is growing importance also in the design field. As design research by definition is intended to produce knowledge, this knowledge can be acquired by merging different methods, e.g. qualitative and quantitative. The data collected and made available from IoT technologies quantifies aspects that were not measurable before, providing content for other research activities such as ethnographic research and participatory activities. The designer could query some physical object and obtain useful data for the design. In this paper, we seek to address the design process in the era of the IoT, exploring the use of data in the early design stages as a means to investigate the application domain and stakeholders' interaction with products.

***Keywords: systemic design, IoT, data-driven approach, design methods, requirements***

# 1 Introduction

Nowadays, society is experiencing a significant number of changes such as increasing competitiveness and the expansion of technological resources (de Arruda Torresa, 2017). These changes are also experienced in design research. Simona Morini in her opening speech at FRID 2017 tried to answer the two questions: 'how does design research change?' and 'why does it change?' She identified among the causes, (i) the introduction of new technologies and communication tools, (ii) a change of scale from local to global, (iii) a change in methods and in the idea of 'knowledge' itself (i.e. Artificial intelligence, robotics but also IoT). Among the other factors that are fuelling this fire, more demanding and informed consumers, as well as the rise of sustainability concerns in an unstable environment, with financial crises of traditional economies (de Arruda Torresa, 2017). Bauman (2000) describes this change in values as a move from 'solid modernity' to 'liquid modernity'. Increased complexity adds more and more factors and makes it difficult to simplify in a complex world, leading to fluid and unclear situations. In this complex scenario designers, however, can use methods to simplify a certain node of the complex system network. In this paper we see how the evolution of the role of designer consists in the art of not knowing too early and dealing with open-ended questions (Sanders and Stappers, 2008), accepting that we will not be able to answer all questions at once. We see the 'potential' of new technologies and the data they make available to be used in the design process, overcoming our computational brain limits. Throughout this paper, we tried to answer the question:

> *''Which guidance can Systemic Design approach combined with Human Centred Design (HCD) methods and smart enabling technologies provide designers?"*

We believe that framing the problem, understanding stakeholders involved, contexts and relationship generated is more relevant than identifying a unique design solution to that problem. Systemic Design combined with HCD methods and IoT quantitative data could provide the theoretical framework to address the sociotechnical complexity.

# 2 System Theories. From the General System Theory to Systemic Design approach

To introduce SD, we need to step back providing a brief overview of the so-called **System Theories**. Far from being exhaustive, it could help starting from the progress in other fields such as biology and then link up with the developments in design to deal with complexity. Back to the end of 1960s, Ludwig von Bertalanffy postulated the **General System Theory** (GST) stating that systems could be investigated through abstract, conceptual models or principles, valid for 'systems' in general, whatever is the nature of the component elements and the relations of forces between them (von Bertalanffy, 1968). This general framework allows to address the complexity of different phenomena and disciplines, from biological, behavioural and social sciences, up to architecture and design. He highlighted some system properties and structural similarities or isomorphism in different fields. While von Bertalanffy was working on his theory, other theories were developed from other fields. **Generative science**, for example, explores the natural world and its complex behaviours as a generative process, showing how finite parameters in the natural phenomena interact with each other to generate infinite behaviours. Other scientists attempted to develop self-managed machines, leading to an entirely new field of investigation that contributed to the systemic vision. **Cybernetics**, indeed, was invented to control communication in both animals and machines, attempting to find the common elements in the functioning of automatic machines and of the human nervous system (Dubberly and Pangaro, 2015). Cybernetics has its peak in 1970s then disappears, but leaves traces in many areas and applications, leaving open the "discourse about the nature of knowledge and cognition; about the representation and embodiment of knowledge and cognition in computers; and how we interact with computers and how we design for interaction" (Dubberly and Pangaro, 2015). Cybernetic theories were also applied to artificial systems, such as objects and their context of use, productive processes with their organisations and management (Barbero, 2012). The generative sciences were further unified by Norbert Wiener and the information theory of Claude E. Shannon and Warren Weaver in 1948 (Barbero, 2012). The **Systemic Design** Approach (Bistagnino, 2011) draws its origin into the General System Theory, Generative Science, some eco-management theories (Industrial Ecology and Industrial Symbiosis) and Cybernetics. With Cybernetics, SD shares a multidisciplinary approach and the conceptual model. However, Cybernetics deals with how systems organise themselves, while SD addresses how systems regulate themselves, evolve and learn (Dubberly and Pangaro, 2015). Over the last decades, the need to cope with the complexity took different forms, evolving in research activities and new disciplines. **Cyber-physical systems** (CPSs) is another example. It draws its origins from software and mechanical engineering, merging theory of cybernetics, mechatronics, design and process science. In CPS computing and communication are tightly coupled with the monitoring and control of entities in the physical world (Cheng and Atlee, 2008). Other disciplines deal with building system, such as **Cognitive System Engineering** (CSE), that introduced the difference between sociotechnical systems and human-machine systems, also introducing the concept of cognitive system, an adaptive system which functions using knowledge about itself and the environment in the planning and modification of actions (Hollnagel, 1983). It raises the attention on the discrepancy between the ideal operator and the real operator of a system. **Resilience Engineering**, CSE successor, focuses on building systems that are able to anticipate, recovery and grow through adaptation, introducing the topic of Artificial Intelligence. **Soft System Methodology** (SSM) developed by Checkland (Checkland and Scholes, 1999) at Lancaster University in the UK, was built on von Bertalanffy's GST and Churchman's **inquiring systems**. It uses the notion of system to enable debate amongst concerned parties, promoting the discussion and exploration of models created ad hoc to discuss the system. It allows to address people, processes and environment that contribute to a situation or an issue, providing a method for participatory design and multiple perspectives in decision making, complex problem analysis and socially-situated research (Gasson, 2015). It analyses connections, conflicts and discrepancies between disparate elements of a situation, to cope with "real-world" problem situation.

## 2.1 Combining system theories with design

The correlation between design and system theories occurred to face the complexity of the design activities, which could no longer be performed intuitively, but require tools and methods. The more we add variables, the more we need a multidisciplinary approach that brings together different skills and expertise. To this regard, SD aims to keep the researcher expertise, providing a vision with which the researcher could come back to his/her home discipline with a different mindset (Dubberly and Pangaro, 2015). Many sociotechnical systems are currently in dire need to be considered and handled as systems, rather than attempting to convey the elements into a unique perspective (and solution).

*Strategic theories*

The design has progressively expanded from a technical and product-centric moving from product design to the design of integrated Product Service Systems (PSS) and large-scale evolving systems (sociotechnical systems). Some scholars in the first half of the 1990s (e.g. Ryan et al., 1992: p. 21) signalled the need for more systemic approaches targeting 'cultural change' in the society (Ceschin and Gaziulusoy, 2016). Design for production optimisation and the need for a systemic approach appeared as main topics from 1996–2000 (Pigosso, 2015). As Pigosso highlighted, today there is an increased focus on systems thinking for understanding relations and interactions among elements. Systems thinking is emerging as a promising approach to support the consideration of sustainability into product design and development —

> *A systems perspective has the potential to enable a better understanding of the effects of decisions taken during product development on the sustainability performance of products, and would enable the complex consideration of user behaviour* (Pigosso 2015).

Design researchers have also started to investigate how to design experiments to trigger and support sociotechnical changes and the importance of designing a multiplicity of interconnected experiments to generate changes in large and complex systems (Manzini and Rizzo, 2011).

*Systemic Design Approach*

The holistic approach that characterises SD makes it adaptable to several processes and sectors, from product design to service design. SD is considered a form of strategic design that goes beyond product innovation. Through the **holistic diagnosis** (Barbero, 2017) the designer provides scheme and visualisation, developing a common working table for the collaboration between different actors. SD addresses the 'product system' characterised by a social, political, economic and cultural context. Then it identifies actors (stakeholders) and relationships among them. Processes are schematised as flows of resources and information. From this point, expanding the boundaries of Systemic Design to sociotechnical systems has become imperative including into the analysis also human factors. Ceschin and Gaziulusoy (2016) suggested a combination of Systemic Design with other design approaches (e.g. Product-Service System Design or Design for Social Innovation). This work aims to suggest how SD, combined with HCD methods and the elaboration of IoT data, could successfully address product design in sociotechnical systems and the new challenges that derive from society.

## 3 An approach based on requirements and instrumented products

The holistic diagnosis carried out to analyses sociotechnical systems is schematised in Figure 1 and consists in:

- Identifying the main actors on which the project focuses
- Problem definition or problem framing, setting
- Application domain analysis (operating context)
- Identifying relationship among the different stakeholders of the system
- Studying their requirements and prioritise them
- Collecting data with instrumented products

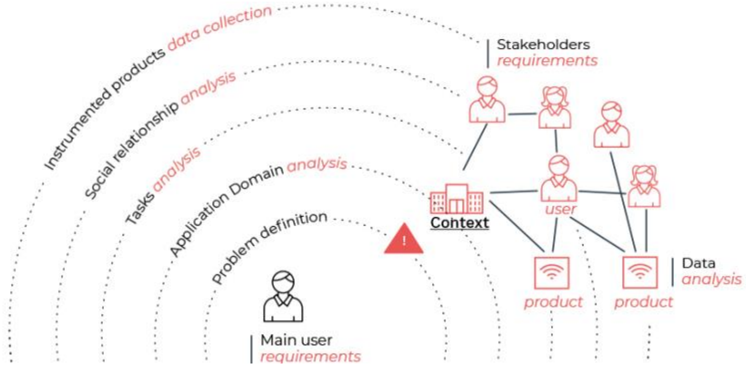


**Figure 1. Scheme of the Holistic Diagnosis**

### 3.1 The importance of problem definition

Despite the apparent focus on the solution, one of the most important competencies of design researchers is undertaking 'problem framing or 'problem setting' (Westerlund and Wetter-Edman, 2017). According to Sanders and Stappers (2008) a pre-design phase (or front end) is growing emphasis, involving the 'understanding of users and contexts of use, exploration and selection of technological opportunities such as new materials and information technologies' (Sanders and Stappers 2008). During this phase, the actual problem is explored and iterated, reformulated many times before being satisfactory, since design failures are often caused by addressing the wrong problems. Therefore, designers need to thoroughly analyse and frame the problem, before starting the actual development of a product or service. They need to obtain insights into technological possibilities, business opportunities, the political and legal system, as well as potential users and other stakeholders (Mink, 2016). As Rittel and Webber (1973) stated referring to wicked problems "part of the art of dealing with wicked problems is the art of **not knowing too early**…". Since there is no stable, valid problem definition the issue to be dealt with, it needs to be explored and critically investigated throughout the whole process (Westerlund and Wetter-Edman, 2017). For this reason, greater flexibility throughout the whole design process is required. The front end is often referred to as "fuzzy" because of the ambiguity and chaotic nature that characterise it. In the fuzzy front end, it is often not known whether the deliverable of the design process will be a product, a service, an interface, a building, etc. (Sanders and Stappers 2008). Designer should accept that requirements could be 'fuzzy' and 'not defined' at the beginning of the design process, accepting the idea of 'not knowing too early', exploring **open-ended questions** (Sanders and Stappers, 2008), exploring alternative propositions throughout the whole design process (Westerlund and Wetter-Edman, 2017). In this way, the knowledge about the problem and the design outcome increases and they co-evolve. (Mink, 2016). Westerlund and Wetter-Edman (2017) support this view and emphasise that we should "shift from a view of objective knowledge to multiple, located, partial perspectives that find their objective character through ongoing processes of debate". The fuzzy front end is then followed by the traditional design process resulting in ideas for product, service, interface, etc. (Sanders and Stappers 2008). After the initial problem-setting, there will be a co-evolution of the 'problem understanding' and the 'design proposal'. They should be seen as two intertwined activities that co-constitute each other (Westerlund and Wetter-Edman, 2017). Designers continually reframed the problem, constantly questioning the underlying assumptions during the design process (Zimmerman et al., 2007).

### 3.2 Application domain

Analysing the application domain consists in defining for which context the project is designed, where it is intended to work, for which environment and with which characteristics. It includes which stakeholders are involved and how they interact with that environment, what they take, what they leave, what they change and for what purpose, which stakeholders indirectly influence that application domain and how. The application domain or operating context, indeed, can be described and observed by humans, but also sensed by objects.

### 3.3 Stakeholders

When we talk about sociotechnical systems we deal also with human factors and we implicitly consider that they derive from 'different stakeholders'. For this reason, every project has its own stakeholder network. However, when starting from scratch, how can we define this network? Fred Brooks indicates complexity as a continuous change in contexts, constraints, functionality, which requires multidisciplinary teams (Berente et al., 2009), with considerable coverage of skills and expertise. Complexity goes hand in hand with the segmentation of knowledge to tackle a specific node of the system. Defining both the design team and the network of stakeholders is a project-specific operation, and it strictly depends on the product or service to develop. When we talk about design team we mean a multidisciplinary team able to cover all the perspectives needed to succeed with the project. Setting the dialogue combining expertise creatively and effectively is a difficult task and implies compromising goals and principles for a common goal (Norman and Stappers, 2016).

### 3.4 Requirements

Accurate studies on requirements emerged within the Requirement Engineering (RE) a branch of Software Engineering (Lyytinen et al., 2009) that investigates what engineers need to make to meet a specific need (Zimmerman et al. 2007). However, these studies were conducted in parallel in other fields, including design. The requirement setting is one of the peculiar task for the designer, together with problem definition and the analysis of the context of use. These operations set the values of the system designed.

*Evolving requirements*

From many perspectives, it emerges we cannot collect and validate all requirements in advance of building the system. Requirements will continue to change as time goes on and design decision will be made in response to new knowledge and understanding of requirements (Lyytinen et al., 2008). De Risi clarified that:

> *Requirements change over time, caused by (i) technology evolution, which enables new developments, (ii) context and socio-cultural evolution, [..]* (Germak and De Giorgi, 2008).

Reymen and Romme (2009) added:

> *Requirements cannot be fixed at the beginning of the process and may (need to) change rapidly. In general, requirements will not lose their importance if they are able to adapt and respond as an open, evolving system. If requirements are fixed at the outset and cannot change, they will become obsolete and irrelevant to how the project or discourse evolves and matters to the people engaging in it* (Reymen and Romme, 2009 p.100)

*Negotiating requirements priorities with the stakeholders*

Multi-stakeholder's decision making, processes and solutions require collaboration and agreements of multiple actors. Moreover, during the process, every actor may change (idea, behaviour, status, way of doing things). As for the system itself, the result of bringing together different experts and skills results in an emerging, unpredictable collective behaviour that differs from those of individuals. For large scale systems, design can be considered an 'interdisciplinary negotiation'. How can multiple requirements from multiple stakeholders be accommodated into a system? We should rethink the role of requirements and design 'product systems' more fluidly, in particular when these systems permeate all aspects of our lives as well as our everyday activities. These systems entail requirements that are richer, more complex and more elusive than ever and designing to meet these requirements in our evolving sociotechnical environment poses a plethora of new challenges.

### 3.5 Collecting data with instrumented products

*The growing role of artefacts and prototypes*

The artefact through which the designer collect information becomes the means for thw **Research Through Design** (RTD) approach (Frayling, 1993; Findeli,1998). RTD is usually pursued in the form of application-oriented research (Zimmerman et al., 2007). As such, it is expected to produce useful – i.e. applicable – knowledge, in line with the growing significance of practice-oriented and application-related knowledge for science and society (Michel, R. 2008 p.16). Objects, indeed, are the means through which transfer knowledge between different domains to facilitate communication between designers and end-users (de Bont et al., 2013). A prototype helps to set the dialogue between the designer and the user, gaining useful insights into both requirements and 'situated knowledge' (or local knowledge) on how products are used. RTD generates knowledge by designing innovative artefacts, models, prototypes, products, concepts, etc., and evaluates them (validation process) by conducting various experiments (tests, perception experiments, etc.) to answer the research question. Evaluation differs from the simple testing of a prototype since the 'applicability of the knowledge gained' is not restricted to the product on which research is being conducted (Schneider, 2008). Prototyping is considered an activity for exploring, proposing and creating knowledge and is one of the tools used in participatory design (together with scenarios, virtual reality, etc.) which produces a reality that can be aesthetically experienced, providing a representation of a future situation, allowing stakeholders to collaborate and discuss design proposals. (Westerlund and Wetter-Edman, 2017). In evaluating the performance and effect of the artefact situated in the world, design researchers can both discover unanticipated effects and provide a template for bridging the general aspects of the theory to a specific problem space, context of use, and set of target users (Zimmerman et al., 2007). Prototyping should also support the previously mentioned problem-setting, creating knowledge about messy contexts (Westerlund and Wetter-Edman, 2017). Other approaches such as **Contextual Design** (CD) uses field data collection technique to capture detailed information about how users interact with the product in their normal (work) environment, applying these findings into a final product (Beyer and Holtzblatt, 1997). However, those data are quantitative, and authors do not refer to an automated acquisition of them, nor objects instrumented with sensing technologies. Nowadays, with advances in sensors and IoT technologies, these approaches can be reconsidered from a different perspective.

## 4 Addressing the fluidity of design

Requirements research seeks to articulate user needs (and then requirements) through methods like ethnographic analysis of user activity, bringing relevant functionality into future designs. A new challenge to design is that product systems could require a level of malleability, or fluidity in their designing. This concept was introduced by Berente and colleagues:

> *This could involve practices such as co-design with users or developing toolkits for user customization, but can also involve intelligent agents that learn from usage, dynamically evolving artifacts, or user generated artifacts* (Berente et al., 2009).

We use SD as a theoretical framework to combine practices such as **participatory design** and **data-driven approaches** that derive from instrumenting objects with sensors.

The fluidity of the design requirements for example accommodates the continuous evolution of the artefact after implementation (Hansen et al., 2009). Designers usually consider projects as 'complete' at some point. In the same way, before the introduction of WEEE waste regulation, manufacturers paid scant attention to their products, once the product has been sold and the warranty has been expired. Software updates are just an example of a product that evolves over time, changing and adapting to technological changes. In this scenario, the user may purchase or rent a basic product and then he/she could transform and shape it according to his/her needs with components and functions that can be integrated. What if the product would change its behaviour according to contextual factors, usage information and the habits of those who use it? In this scenario, the user purchases/rents a product, he/she start using it and after a while his/her expectations will be delivered, because the product evolves to meet user's requirements.

These are two non-inclusive examples of exploring new scenarios and smart enabling technologies.

## 4.1 Participatory design

**Participatory design** is a qualitative research method that advocates the participation of potential users throughout the design process, giving citizens or workers a voice in design decisions that influence their lives (de Bront et al., 2013). Users can be actively involved at various stages of the design process, including analysis, design and evaluation activities. The use of special tools and techniques enables users to take an active role in designing and experiencing product concepts revealing covert or subconscious user needs. In this way, users can apply their practical knowledge, and complex use situations can become more concrete, being useful for unfamiliar or specialist target groups (de Bont et al. 2013). Starting from an abstracted knowledge of the problem, the design team could receive insights on users' tacit knowledge and practical knowledge (i.e. about how things are currently done and about use problems) and into the use of a product (situated knowledge). According to Sanders and Stappers (2008), the application of participatory design practices to very large scale problems will lead to significant consequences and long-term impacts. There is a very broad range of participatory design approaches where participants are welcomed into the heart of the design process rather than being the subject of insight gathering from designers as seen in conventional HCD (Cruickshank and Trivedi, 2017). These are typical bottom-up approaches, and the integration of people in the innovation process depends on their participation and collaboration, made possible through information technologies. The opening of the innovation process to society (de Arruda Torresa, 2017), the democratisation of design, brings benefits and involves some risks. The most recent democratisation took place with the advent of crowdfunding, in which people are invited to participate in the process of creating innovation (de Arruda Torresa, 2017).

*Expected impacts of involving the user*

We list some of the expected benefits of involving potential users in the design process elaborating the benefits expressed by Mink (2016) and de Bont et al. (2013):

1. **Understanding the user**, his/her tacit and practical knowledge that would otherwise not be available to designers, enabling participants to explain issues and opportunities for product concepts about their own practical knowledge and use situation. This, in turn, should lead to less frustration during decision making.
2. **Engaging with the user**. Involving users in product development, such as in crowdfunding campaigns, can create a positive bonding of (future) customers with a company or a brand.
3. **Improving products**, by improving the accessibility, applicability acceptance and adoption of the designed product or services.
4. **Satisfying the user**, providing more flexibility and robustness in product use.
5. **Decreasing time and cost**, reducing the number of design iterations and thereby the time and cost of development

The insights gained from consulting users should guide designers to go beyond their own assumptions, resulting in bottom-up solutions with more impact (Mink, 2016).

*The evolving role of designers in co-design*

We are witnessing a progressive change in the role of the designer, which can no longer aspire to a monopoly in the design activity (de Arruda Torresa, 2017).

In this scenario, designers oversee problem setting and problem definition (framing). They have the mental structure for dealing with incomplete information without getting stuck. By selection and training, most designers are good at visual thinking, conducting creative processes, finding missing information, and being able to make necessary decisions in the absence of complete information (Sanders and Stappers, 2008). According to Sanders and Stappers (2008):

> *In the near future, designers will find themselves involved not only in the design of stand-alone products but in the design of environments and systems for delivering healthcare, for example* (Sanders and Stappers, 2008)

However, when people become co-creators, designer-researchers' role is "to support participants, stimulating their creativity stimulating ideation, expression and visualisation" (de Arruda Torresa, 2017), supporting their ability to foresee future scenario and explicit unexpected needs. Sanders and Stappers (2008) present the idea of designer as a creative facilitator, mediating projective interactions to be established between people with different levels of knowledge, skills and creativity. By this way, designers must lead, manage, guide, support and assist participants in the task of creating and implementing solutions to their everyday problems. The authors highlight the importance of designer as a domain expert in project development, creating new tools to develop co-design process to support collective creativity (de Arruda Torresa, 2017).

## 4.2 Data-driven design approach

According to Zimmerman et al. (2007), a design researcher could able to analyse artefacts to discover patterns. RTD can be performed with prototypes or current products instrumented with sensors for a specific purpose. The material objects' perspective adds a perspective to the investigation of patterns, interaction, places, contexts. The potential of using 'thing ethnography' as a tool for designers is gaining appeal among researchers in the design field:

> *Things' perspective gives a different point of view about things' use and movements, understanding relationships among people, objects and use practices that would be difficult to elicit through traditional observations and interviews alone* (Giaccardi and Cila, 2016).

This approach is suitable for the study of daily home practices involving everyday objects, i.e. daily interactions with material objects and the natural environment (Cruickshank and Trivedi, 2017). We talk about an ecosystem of things intertwined with people in a specific operating environment. Objects do not see, but they could sense and could reveal insights about themselves and the relationship with the users. With the introduction of sensing and communicating features through ubiquitous technologies, in the next future there will be another horizontal arrangement that will include things-to-things or things-to-service perspectives, not just what machines can do for us.

> *In other words, while the (object) may be facilitating the task of the human, it is also performing its own task, which may be quite different to the task that the human is concerned with.* (Lindley et al., 2017).

Beyond data exchanges, updates, reconfigurations, download (tasks that are clear in our mind), other actions can derive by the ability of things networked to communicate and interact with one another. There is a branch of contemporary philosophy, known as 'Object Orientated Ontology', which deals with this topic promoting the absence of hierarchies among human and no-human actors (Lindley et al., 2017). Many authors refer to it to support a change in the way we design and we deal with interconnectedness and smartness.

## 5 The evolving role of design and the need for new tools

In 1980 User Centred Design (UCD) codified a way for designers to conceive of their relationships with people that will use their designs, structuring the role of the user (or 'human') that matters in design processes, whose understanding of needs, abilities and perspectives should improve the effectiveness of a design. (Cruickshank and Trivedi, 2017). Now we need an inclusive design approach to deal with the new smart objects able to sense and experience the world and collect information from environments and contexts (Cruickshank and Trivedi, 2017). How can we design for this complex system of people and things? Understanding how designers adapt their design practice to deal with the IoT is not enough. Design research probably needs new platforms for performing future design practice (Lindley et al., 2017), able to provide the fluidity needed to address both uncertainty, evolving requirements and things perspective. It can be noticed that many design researchers consider design tools and methods as insufficient to deal with the complexity of sociotechnical systems, evolving requirements and the new challenges of smart technologies. From a practice perspective, crowdfunding platforms can be considered as platforms of interaction between designer and early adopters. On the one hand, designers propose concepts through video, photo, storyboard etc, on the other hand, people provide feedback on the prototype during the whole crowdfunding process, thus impacting the design process (Vitali et al., 2017) and the development of future products. These digital platforms establish a two-way dialogue between users and designers, facilitating co-design initiatives, enabling user innovation (Vitali et al., 2017).

### 5.1 A platform of interaction 'designer-user'

Sociotechnical systems demand for new approaches and more flexible tools. Using a digital platform of interaction between design team and stakeholders seems to be a viable way to cope with this emerging need. Through the platform, the design team could accommodate the evolving requirements of stakeholders (also those connected to other services, policies), helping the designer to address different perspectives and requirements that derive from different actors, including the insights deriving from smart enabling technologies. In this way designer could keep the requirements at hand in every step of design, validating, testing allowing running changes, providing the fluidity needed in dealing with sociotechnical systems, as well as providing a platform on which to share concepts and models. The data that the objects sense could be accommodated in this type of platform helping the designer during the immersion phase (de Arruda Torresa, 2017), i.e. when designer (or more often, the design team) goes into the field and observe on site how people live, how they perform their daily activities, identifying their aspirations, behaviours, dreams, difficulties, frustrations and experiences. In this way, the investigation can rely on feeling, intuition and inspiration of the design team combined with measurable information. The use of a platform mitigates some of the problems generally attributed to participatory activities, such as time and resource-consumption, helping to manage roles and purposes.

**Conclusions**

The aim of this work is, therefore, to develop a designer-friendly approach to efficiently guide product designer when comprehensively exploring 'How can these approaches make designers understand people's needs and, in parallel, promote innovation in product design? The anthropocentric vision of design can evolve into a holistic one, in which multiple aspects are considered simultaneously.

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