Data Driven Design: From Environment to the Human Body

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Abstract
Based on doctoral research developments, the paper presents an analysis of how the use of Artificial Intelligence technologies and Data Driven Design can be the key to activating sustainable design actions that have positive impacts on the human body and communities. First we will distinguish how technology can be beneficial, in two macro cases, whether placed within the design or in the product/service itself. This will be followed by an analysis of the types of spillovers based on spatial/temporal factors and types of implementation. Research still under development focuses on comparison of case studies and analysis of literature sources. A subsequent prototyping and testing phase is planned to test whether what is hypothesised in the current phase is tangible and to what extent the effects are controllable.

Keywords
Artificial intelligence
Design process
Well-being
Sustainability

Introduction

Artificial intelligence (AI) is considered, by experts and researchers (Google, 2021; Kahneman et al., 2021), to be a tool to automate a task, and useful in increasing a person's ability to perform that task alone, faster and more efficiently. For this reason, artificial intelligence can both help the end user with choices and actions and help simplify, automate, and augment the design process.
For the Ellen Macarthur Foundation (2022), designers working with AI can create products, components and materials suitable for the circular economy. AI can offer a more informed view of the most effective designs to create and test to make the best use of their time and skills.

Artificial intelligence can be used generally for:

- Inform and accelerate efforts to design out waste and pollution
- Increase the effectiveness of and optimise circular economy business models
- Streamline the infrastructure needed to keep products and materials in use
- and AI able to do it through the analysis of large amounts of well labelled data, such as material databases, consumer preference data, and sifting through countless designs and suggesting the ones which best circular design criteria.

If the goal is sustainability of products and services, technologies within the design process are useful if they are built to indicate constraints and parameters, to define design choices that will lead to achieving that purpose (Uçar et al., 2020). Sustainability is an issue of high complexity (Ghisellini et al., 2016), which is why it becomes increasingly necessary to take advantage of the technological features (Bressanelli et al., 2018) mentioned earlier.

Bringing together large amounts of data to provide both insights at an early stage conditions and rules during design development allows for more responsible design (Bihanic, 2016). It allows one to maintain an overall picture while having the ability to delve into the detail of an individual project component (Golinska et al., 2015).

In summary the use of artificial intelligence technology (Nazioni Unite, 2022; European Commission, 2022; European Commission, 2020), based on the collection and processing of data, allows the analysis of the entire life cycle of products (from the processes of conception and production, to those of the conclusion of the first lifetime and the start of new cycles) and for this reason it allows designers to control the management and usability of articulated systems of knowledge. As a consequence, the figure of the designer can act as a coordinator of a complex design process between stakeholders who have different technological knowledge and the use of tools that monitor the behaviours of the community in order to generate human-centred innovation processes that include both the level of techno-science and social innovation (Manzini & Vezzoli, 2002).

Methodology and stages of research

To assess the actual impact of artificial intelligence for the well-being of the individual and the community (Celaschi, 2017), the research is divided into stages subsequently described. Based on a multidisciplinary review of the existing literature, the work included an analysis of the relationship between implemented sustainable measures and the positive response of the community and in particular the psychological and physical well-being of the people involved. The purpose of the study is to establish an initial framework, to reason about what are the right implementation practices and how they are structured, to achieve sustainable outcomes while positively affecting people's health.

Therefore, this paper answers the questions: how could AI technologies support sustainable artefacts or project development? What factors influence the relationship between sustainable projects and effects on human well-being?

With the research questions in mind, the study identified two main roles of artificial intelligence, static and autonomous (Frank, 2021), and based on this identified several correlations between sustainability and well-being. These relationships are to be explored further in the following section: Case Studies and Preliminary Analysis.

The current research phase also involves active discussion with international research centers and leading companies. This is in order to be able to study design processes that operate with environmental respect, to understand how technologies (and the data that enable them to work) are structured and how designers relate to them. This will serve to better detail the research hypotheses and prototype an AI, with a reduced scope, to be integrated into some design processes. This will be done to test how this interaction occurs at all stages of the design process and what effects it has on both the ecosystem, the social environment, and individual users.

A capillary focus will include an analysis of how user participation in content and information generation serves the implementation of intangible platforms related to products and services (Li & Voege, 2017). This will be followed by an examination of that process in order to elaborate new user-artefact interactions and ascertain what parameters can generate solutions that converge toward broader social and environmental sustainability.

Artificial intelligence and Data Driven Design

Two macro-cases of AI use can be distinguished, one static and one autonomous (Frank, 2021). In the first case, the technology is used conventionally, and the magnitude of environmental benefits is determined by the design, production, and distribution of products pre-purchase, and therefore no longer editable. Autonomous environmental benefits result from autonomous post-purchase interactions between an AI-enhanced product and its environment, which include learning and decision-making. Product services that use artificial intelligence and are connected to the Internet (IoT) have a continuous interconnection between product, user and database, which involves constant deployment, and can be investigated as information-experiential hybridization to quantify and qualify the impacts these artefacts have on human behaviour (Zannoni, 2018).

Having AI and machine learning (ML) technologies embedded in the product/service allows for greater and continuous control by the design team. For that matter assiduous implementation of the user experience that improves the quality of the artefact and actual and perceived well-being.

The well-being effect that results from these implementations can be achieved with relative ease and speed, as the design and results of these design choices can be implemented and measured in a very short time frame (Bressanelli et al., 2018). Where autonomous technology is used, the design process is cyclical and tight. If, on the other hand, AI technology is only integrated into the design process for the purpose of developing sustainable products/services, the positive impacts on the community and individuals may vary in timing as the effects may not be as closely related temporally. As a result, some benefits of sustainable artefacts are not immediate. Therefore, this temporal factor was analysed, which is useful in understanding the relationship between technology, sustainability, and well-being.

Case studies and preliminary analysis

From the literature reviewed sustainable projects and implementations have positive effects on the well-being of individuals and the community, but how are these factors correlated? Therefore it is important to point out that most sustainability indicators ignore well-being and vice versa. An example of the former is the *World Bank's Genuine Savings* (GS) Index, while the *United Nations Development Programme's Human Development Index* (UNDP and HDI) is characteristic of the latter (Neumayer, 2007). So, if it is quite evident that there is a correlation between sustainability and well-being when does the latter manifest itself as a function of the former?

From a preliminary study, positive spillovers can be schematised according to the timing of impact, namely the time it takes to have a real effect on people's health. Of all the case studies examined, it was decided to show four illustrative examples, with different combinations in terms of AI use and timing, to be able to argue the considerations that emerged from the analysis. The table below shows the four case studies.

The case studies were retrieved from the webpage *Artificial Intelligence And The Circular Economy* (archive.ellenmacarthurfoundation.org), and from the sites mentioned in the footnotes. The table [tab I] relates whether and how the technology is used, what type of implementation it is, the timeframe it takes for the positive effect on people's health to manifest itself, and whether this effect is only reflected in the users or is it an extended community well-being.

CASE STUDY	TECHNO -LOGIES	STATIC	AUTONOM -OUS	IMPLE -MENTATION	IMPROVE -MENT OVER TIME	EFFECT	TIMING	TYPE OF EFFECT
Philips CityTouch[1]	IoT, RFID, data analytics		x	Energy saving, light distribution	Continuous	Direct to user	Short-term	Security, psycho -logical well-being
ZenRo -botics[2]	Robotics, artificial intelligence		x	Recycling	Continuous	Extended to com -munity	Long-term	Physical health, well-being
ACCMET[3]	Artificial intelligence	x		Rapid and systematic development, non-toxic metals	Does not change	Direct to user	Short-term	Physical health
MOTIVO[4]	Artificial in -telligence, data analytics	x		Chip design process	Does not change	Extended to com -munity	Long-term	Well-being

Tab. I
The table shows research and business projects that have been developed with AI or are being imple- mented thanks to AI. The projects were retrieved from the ellenmacarthur- foundation.org
1 www.lighting.philips. com
2 www.terex.com/zenro- botics
3 cordis.europa.eu/ project/id/263206
4 motivo.ai

The first case study concerns *Philips' CityTouch* model providing intelligent street lighting services. It extends the usage phase of streetlights and increases efficiency in public energy consumption. It provides an IoT (Internet of Things) platform for lighting management to which individual lampposts are connected via an RFID (Radio Frequency Identification) network. The sustainable impact occurs because the model allows the light intensity to be changed remotely according to daylight and street conditions. In addition, bulbs have to be replaced according to actual burning hours (Morlet et al., 2016). The improved visibility conditions increase the safety of drivers and those living near roads where these lighting systems are installed. Given these parameters, there is an immediate feel-good effect that is prolonged over time because it is always technologically up to date.

ZenRobotics combines robots and artificial intelligence to recover recyclables from waste. The *ZenBrain* software, through the reprocessing of visual data provided by cameras and sensors, is able to increase the recovery rate and purity of secondary materials. The technology allows for a continuous improvement in performance, but the effects related to sustainability and well-being are not immediate and are difficult to perceive by the population (Ottman, 2017).

The EU-funded *ACCMET* project (Accelerated metallurgy - The accelerated discovery of alloy formulations using combinatorial principles) was launched to accelerate the process of alloy identification. Using advanced algorithms, all the information collected is stored in a virtual library in order to identify properties, composition, structure and processing parameters and predict the properties of new compositions.

The focus on environmentally friendly alloys at an early design stage, in combination with life cycle analysis, helps to conserve natural resources and assists the move towards low-carbon technologies. One consequence of designing with the principles of the circular economy in mind is that the designed alloys will be non-toxic, and thus have an immediate impact on the health of the population.

The company *Motivo,* from San Francisco, develops artificial intelligence and machine learning solutions for chip design analysis and optimisation. Thanks to its tools, semiconductor companies have been able to reduce the costs of design and test iterations. In two pilot projects, it was demonstrated that the tool can reduce semiconductor design processes from several years to a few weeks. This results in reduced costs, increased reliability and yield, improved quality and faster time to market. In this case, the improved utilisation of resources generates a welfare that can be demonstrated in the long term. While the economic well-being generated by *Motivo* can be manifested in the immediate term, the improvement in health develops as the waste of materials (silicon) decreases, and as they are used more correctly. For these reasons, the latter is complex to calculate.

In summary, the following close correlations can be deduced from these examples in the table above: The first is that the implications regarding improvement over time are due to how the technology is used, whether static or autonomous. The second concerns the time of impact with respect to who is affected by the effect, whether it concerns the user or is extended to the community. Thirdly, the type of implementation is then reflected in the type of positive effect.

Final considerations and future developments

As previously described, it can be inferred from the case studies that when technologies are integrated into the project there is a continuous improvement in well-being because there is an autonomous and continuous implementation. One observation needs to be made explicit, namely that the continuous increase can occur even when there is a use of AI in the design phase alone, but this increase is due to the extension of the project's area of deployment and the enlargement of the pool of users involved in the use of those artefacts. Not because of an increase in those artefacts already produced, but only because of the continuous improvement of the design that will bring improvements in future artefacts.

One piece of evidence that emerges from the table is that the closer the product/service is to the body (spatial proximity) of individual users, the more immediate and explicit the impact on wellbeing (temporal proximity). Regarding timing of the implementation of the beneficial effects is concerned, short timeframes are therefore expected for projects that directly involve users, while long timeframes are expected for projects that focus on environmental sustainability.

These factors and their correlations will be useful at a later stage as parameters for outlining how AI can be integrated into design and products. What is the possible impact of the technologies both ecologically and in terms of people's well-being? What is the most effective and fastest way for these impacts to occur? Given these preliminary considerations, a precise scope of investigation will be defined, i.e. a choice will be made as to which of the design phases to implement. This focus will make it possible to deepen the research and produce a prototype in a shorter time. This prototype will be realised in collaboration with the partner company of the PhD project and will be a machine learning system based on ISO standards and European guidelines (European Commission, 2020; 2022). Subsequently, there will be an autonomous implementation phase of the prototype, which will be used during the design of a previously chosen product/service. It will proceed in an iterative manner by testing and improving system bugs. After this phase, it is of interest to research how the specific solution found can be adapted to other aspects of the artefact, and to other design phases.

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