Smart Garden (SMAG): A System of Outdoor Furniture Equipped with Artificial Intelligence

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Abstract. The "fourth industrial revolution" refers above all to production methods (Industry 4.0), the transformations of the digital technological components consequently also spill over into the world of product design. These transformations pose important challenges and calls for a partial revision of the design methods and operational processes. The article present a research project recently carried out in our laboratory that involved the use of advanced technology both for the operation of product and for the realization of the prototype. As within the Industry 4.0 paradigm, rapid prototyping and additive manufacturing technologies allowed us to introduce effective iterative product validation cycles for design.

Keywords: Industry 4.0 · Smart Garden · Technology · Prototypes · Additive manufacturing

1 Introduction

Technology has always been one of the engines of human history (Khanna 2013) [1], from tools invented in the Stone Age, to agricultural crops from the Neolithic period, it evolved with the exploitation of steam energy during the industrial revolution and with the invention of the Internet in the information age. According to many authors, all the global trends of the 21st century - the transition to multipolarity, the contraction of space, economic convergence and new forms of collaboration - have their roots in digital technology. Although the "fourth industrial revolution" refers above all to production methods (Industry 4.0), the transformations of the digital technological components consequently also spill over into the world of product design.

If once the technologies were physical projections of the human mind (the tool invented in the Stone Age) today they have become intangible and able to contract the relationship between space and time (Di Lucchio, Giambattista 2017) [2] distorting social, political and economic structures. According to the spouses Khanna (2013)

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Geotechnology will be the dominant paradigm of the hybrid age, technological innovations will determine both geoeconomic and geopolitical control.

The processes described so far, so crucial in reference to the panorama of social structures and relationships between people and groups, have obviously not failed to produce effects on the system of production and distribution of goods, also influencing the mix of instruments through which the company and other production facilities operate. Indeed, the phenomena of evolution of the entire industrial system have resulted, towards models characterized by greater efficiency, such as those evoked by the Industry 4.0 paradigm or by the concept of the fourth industrial revolution.

In production, and now hopefully also in the project, the almost universal availability of digital technologies and network connection has led to a new process model, in which the production phase is always followed, in a very short time and in a circular way, by tests verification able to produce rearrangement and reorganization effects, for product optimization and more.

These transformations pose important challenges in the design field.

This article will present a research project recently carried out in our laboratory that involves the use of advanced technology both for the operation and for the realization of part of the prototype. The SMAG (SMart GArden) project is aimed at creating a product-service system equipped with an advanced technological and social set-up capable of controlling vital parameters of the public or private garden using the Internet of Things. Thanks to the development of a multi-sensor system and a cloud platform for managing the collected data, it will be possible to intervene on factors such as: health of the garden and the people who frequent it, air quality, irrigation, lighting, air and noise pollution and more generally on the overall sustainability of the system.

In particular, collections of outdoor furniture (seats and vases) with intelligence have been developed. The goal of the project was the creation of a system of intelligent objects capable of relating to the various actors who interact with the system: on the one hand with the maintenance technician for aspects concerning health and maintenance of greenery; on the other with people, from an emotional/experiential point of view, with particular reference to the concepts of wellness and health.

In the project presented, Additive Manufacturing was used for the construction of the casing which houses the technological components of the system. In a sense, we can say that a technology of the fourth industrial revolution has been used to support the same technology that this revolution is developing.

2 The Project

The SMAG (SMart GArden) project, still under development, is aimed at creating a product-service system equipped with an advanced technological and social set-up capable of controlling vital parameters of the public or private garden using the Internet of Things. Thanks to the development of a multi-sensor system and a cloud platform for managing the collected data, it will be possible to intervene on factors such as: health of the garden and of the people who frequent it, air quality, irrigation, lighting, atmospheric and sound pollution and more generally on the overall sustainability of the system.

Digital technology has recently invaded green issues and the IoT is considered by some authors to be a valid tool for the maintenance of parks and gardens (Thamaraimanalan et al. 2018) [3].

SMAG, coordinated by the technological leader Nuvap and with the supervision of the DiD District, involves the two research bodies Department DIDA (UNIFI, design) and Department GESAAF (UNIFI, forest sciences) and two Tuscan companies in the stone sector: UP Group (marble) and Stone Furniture (travertine).

The project involves the creation of a hybrid Product/service system that will allow companies, including those of traditional manufacturing type (Stone Furniture and Up Group) and strongly focused on the product, to develop new paradigms that are attributable to the Smart Service Welt (World Intelligent Services) much more based on the relationship with the user, and above all it will allow to combine products with third party services on digital platforms, contributing to the creation of new digital infrastructures: intelligent spaces, (smart spaces) or environments where objects, equipment and intelligent, internet-enabled machines connect to each other.

The project, which has been running for about a year, is developing stone outdoor furniture systems equipped with the technological setups mentioned above.

In this year of work, the leader Nuvap has dealt with the development of technological components by defining a control unit capable of monitoring: temperature, humidity, PM10, PM 2.5, PM 1, CO, CH4, VOC, ATM pressure and brightness in addition to the remote control of sensors such as that of soil moisture; the company has also developed a cloud data platform and a series of self-adaptive algorithms for the correct functioning of the digital system.

Our Department has instead dealt with the development of the project concepts - outdoor furniture systems and objects of use - with particular reference to the meaning of the products, their functionality and their relationship with people through interaction through the App. The GESAAF Department investigated the issue of irrigation, contributing to the definition of the procedures to be used for the implementation and verification of the functioning of the components for the control and automation of the system.

The working group began the design phase with a Focus Group in September 2018 which involved around twenty figures including designers, sociologists, architects, urban planners, agronomists, nurserymen and professionals in the agricultural sector, in order to define: the scenario application, the parameters to be monitored and the reference market. At the end of the Focus Group, a summary document was drawn up which allowed the working group to start the operational phase.

As the DIDA Department, the topic was addressed within the Design for Sustainability course held by Prof. Giuseppe Lotti and Prof. Marco Fioravanti, at the Master's Degree Course in Design, where about 20 students dedicated themselves to the concept of the coordinated SMAG system by teachers Marco Marseglia and Jurji Filieri.

In the preliminary phase, desk and field analyzes were carried out on the theme of gardens and furnishings for green spaces both from a technological and a design-oriented point of view. Subsequently, students were provided with notions on stone working followed by visits to companies in order to better understand the project possibilities.

The concepts proposed by the students concerned the design of an outdoor furniture system both for the "Arredo di Pietra" company - public sector - and for the "UP GROUP" company - private sector -. The proposed projects also concerned the development of the interface for the management and control of the system.

3 Prototypes and Additive Manufacturing

After the work carried out with the students, our team worked on the executive development of the projects regarding stone objects and technological components. For the control board developed by the partner NUVAP, 3D models were created and then printed by means of the additive manufacturing.

The central issue throughout the design process was to coordinate the productions and contributions of each partner, bringing them together physically within a system of products which is the collection created.

On the one hand, it was necessary to create the material support to contain, protect and set up the technological (electronic) components within the products. It was necessary to guarantee not only practical functionality requirements, such as air permeability, waterproofing, power supply and ease of maintenance, also the possibility of integrating the system, through the addition of new sensors, indicators or actuators capable of configuring new application scenarios in an open-end model of the project.

On the other hand, the great complexity of a product, which largely consists of a service (the automated management of the garden through the detection and processing of its main vitality indicators), had to be traced back to the material perimeter of a series of objects (benches, fountains, vases, indicators, sports equipment and more) to be made of stone, through automated processing plants.

Both issues referred to a central problem of uncertainty (dimensional and application scenario) referring which it was necessary to use new operating methodologies, which could contemplate the need for multiple revisions, before definitive finalization of the final product. The design strategy was therefore to transfer some of the paradigms belonging to the Industry 4.0 model also to the project, configuring a process that we can define Design 4.0.

In this context, the possibility of quickly carrying out the validation phase in the integration of the parts made by the various partners (electronics and stone), has allowed the evaluation of a greater number of options and optimized the results with respect to the objectives set upstream, including for example widespread sustainability policies, through the minimization of energy and material consumption.

In the frame of the Digital Factory model it is expected that, to compensate for disturbances or deviations due to contingent, random or in any case not sufficiently foreseeable factors, the control and optimization action is applied iteratively and continuously over time, automatically recalculating the best re-compensation action, including design of the parties. This type of innovation, strategic in the SMAG project, was possible thanks to the construction of exemplary models of reality (models increasingly defined in digital architectures) in which it was possible to manipulate and modify the parts (primarily the plastic casing of electronics and subsequently the design of the stone parts designed to hold them) according to a comparative monitoring process with other case studies.

Moreover, each model returns a real or ideal representation of a scenario that is not completely known. This condition assumes particular evidence when the time frame extremes of the figurative context are moved forward to anticipate or hypothesize a future case. Every scholar and scientific researcher who deals with the processes and

methods useful for handling the future agrees that the future cannot be scientifically predicted. There are, in an equally concordant way, some characteristics, we could say conditioning, that concern the future and that interest designers, who in order to operate can only do so in presumption of a privileged future compared to others that can happen (Celaschi 2017) [4].

If the practice of the scenarios can therefore be taken as an effective practice for the definition of the set of dominant characteristics in a strategic vision for the design project, it is clear how this methodology becomes even more effective when the comparative phase is extended to a number of models infinitely large, for example thanks to the enabling technologies of Industry 4.0.

Once the cylindrical shape has been identified as the most effective and practical, also in function of the rationality of processing of the stone materials, the working group developed a first digital model of the control unit, preparing all those components and characteristics previously considered functional. The virtual model was therefore transformed into a maquette through Rapid Prototyping Process for functional verification, then modified through manual (on the prototype) and digital (on the virtual 3D model) intervention, always ensuring the continuous updating of the computerized model, intended for production.

Having defined the heart of the system, we moved on to developing the executive design of the series of objects, called to house the electronic platform: a system of seats, vases, street furniture and indicators with a geometric design for the public sector and a series of decorative objects and playful, still equipped with the same environmental control unit, but intended for the private garden. In this case, the three-dimensional models kept the mere digital configuration until they were shared with the business partners, who produced the individual objects through the direct interface with the processing plants for stone materials.

4 Conclusion

Two issues emerge from the project presented here; they appear central to any highly complex project activity. On the one hand the uncertainty and the interpretative difficulty of those functional and contextual discriminants, which guide the construction of product/service architectures enabled by communication technologies such as IoT (Ghajargar et al. 2018) [5].

On the other, the incontrovertible contingency of tracing all the projections related to usage scenarios, functionality and product/service integration within the perimeter (or rather the volume) of one or more forms, which must be dimensionally defined, technically feasible, significant for users and aesthetically pleasing.

When the project concerns new concept products, as in the case of SMAG, for which there is no possibility of comparative monitoring with other case studies, effective for each of the above validations, it becomes essential to identify process control tools (design), capable of manipulating that indeterminacy and, where possible, minimizing it (Baumer et al. 2014) [6]. In the case study, the working group operated in this way, primarily through the preliminary definition of application and use scenarios, so as to typologically and “geographically” circumscribe the product that was to be designed (Fig. 1).

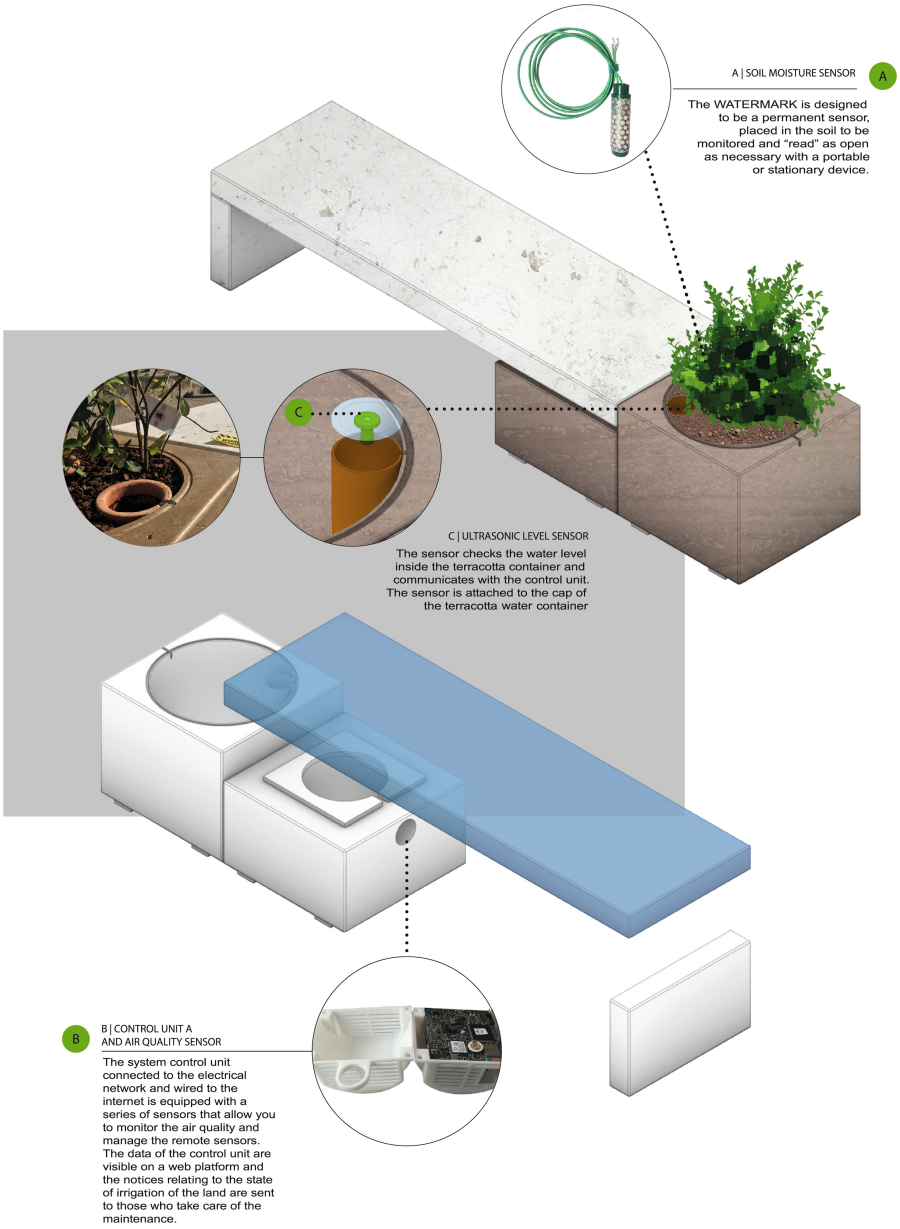

Fig. 1. Detail of the control unit and the container made in additive manufacturing

Secondly, technological, dimensional and material constraints have been isolated; these have made it possible to trace the extension of the "problematic field", within which the products have been designed, developed and finally created.

It was a matter of applying an approximate-iterative operating model, in which all the main characteristics of the product are derived from the incremental revision of a theoretical model, which in the case of design has been useful to realize through the production of prototypes through Additive Manufacturing.

Within the multidisciplinary working group, design has demonstrated an essential quality of coordination and supervision to lead the project to the end, confirming a strategic position also within the contemporary panorama of increasing diffusion of ICT. Designers and students supported NUVAP's electronic engineers and ultimately the companies that dealt with the creation of the products (UP GROUP and Stone Furniture), integrating soft formal qualities with mere functional essentiality and above all also directing contributions from technological and manufacturing partners in a creative direction.

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