ALTA SCUOLA POLITECNICA

POLITECNICO DI MILANO I POLITECNICO DI TORINO

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ASP XII Cycle Project Book

Neworkplaces

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Project description

The main objective of the project is the design of a space able to meet the requirements stated by UniCredit Business Integrated Solution, which proposed this exercise. In particular, the final outcome should have been a place outside the traditional offices where their employees can work remotely. The solution developed must be environmentally sustainable, for example this is possible by reducing the travel time to go to work and encouraging the use of public transports. The project needs also to have a solid financial structure that enables the bank to recover the initial investment and make it self-sustainable. The initial analysis focuses on the available literature about workspace and new trends around the

world, so the research team has been able to develop a draft of the project that, subsequently, has been proposed to the employees which potentially could have been affected by the project. The space described is a mix of already existing places: a café and a co-working area where the general users and UniCredit employees are separated because of privacy issue. After a positive feedback, the following phase was the definition of possible locations. The aim is to create a network around the city, so it has been taken into account where employees live, the main public transports and exploitable areas for a co-working space. The whole phase has been supported with a strict definition of the possible stakeholders. The team proposed a partnership with a public institution (Municipality of Milan) in order to find pre-existing buildings, other than new ones, that satisfy the criteria of accessibility, size, conservation state and cost in the selected area of the city. Analysing the possible architectural solutions, the result has been a definition of building typologies with the subsequent design of how space are organized and connected.
The project has a strong technological basis which is a strength that makes it extremely innovative. In fact, as reported in the business plan, there are different revenue streams: the co-working area, with the fees paid by the user; from the café, thanks to the products sold and to the companies paying for their advertising shown on the technological devices. In conclusion, the result of this project is a new model of workplace that meets the stated requirements of the client, and the trends in the field.

Tasks and skills
The five members of the team have worked in sub-groups taking advantage of their complementary backgrounds.

Ingrid Angelica Noe Colonia and Federica Mazzola have both a deep knowledge of architecture and design that allowed them to collaborate on the analysis of the urban context, define the criteria for the selection of the spaces, study the relationships between the spaces and represent the developed workplace model through graphical tools and 3D visualisation.

Barbara Francesca Cicconetti and Marco Vitale worked on the analysis of the urban context and the definition of possible locations derived from the application of the main regional economic theories. Additionally, Marco worked on the relationship between the space and the technology looking for innovative economic revenue streams.

Giorgio Ranza worked on the analysis of the users' needs (e.g. collection of the requirements and surveys) and the economic assessment of the project (e.g. market analysis, business plan, estimation of the financial impact).

The great effort of each team member as well as the excellent support from both academic and external tutors contributed greatly to the outcome of the project.

Abstract

Technology allows people employed in certain jobs to work everywhere, as long as they have a laptop, a phone and internet connection. However, this does not mean that offices are no longer needed, especially in environments where creativity and problem-solving are

daily activities. Human interaction is often the key to address such issues and come up with innovative solutions. This is one of the reasons why physical spaces still play an important role, although they present some challenges such as:

- Current locations force employees to long and expensive daily commutes;
- Need for sustainable space, from an environmental and economic point of view (current office space is mainly a cost-centre);
- Obsolete spaces often do not encourage smart working;
- Maximum potential for innovation is not fully exploited due to low interaction and socialisation among employees and third parties;
- Need for more flexible spaces;
- Lack of transparency and permeability of the space towards its surroundings (i.e. openness to the public).

The early requirement analysis has been performed on the basis of the information provided by UniCredit Business Integrated Solution. This was the starting point for the design of a draft solution to the exercise. Afterwards, thanks to surveys, it has been possible to fine tune the collection of requirements and have an early feedback on the draft. In this way, it has been possible to base the approach on flexibility rather than on vested limits: a mock up model to be validated by the users and gradually adjusted based on the suggestions.

Subproject description

Understanding the problem

In the recent years, the working dynamics in the world of knowledge workers have been irreversibly altered by the more and more pervasive use of the new mobile and digital technologies. In particular, there has been a gradual migration towards working frameworks with a high level of interaction that replaces the “one person - one desk” paradigm with an approach to the workplace as a community in which connections and interdependencies arise spontaneously, exceeding the standard hierarchical functional relationships.
Today it is possible to figure out organised working contributions in an increasingly autonomous and physically-separated way from the company’s headquarters, with significant advantages in terms of energy savings, environmental sustainability and human work-life balance. According to this approach, the company is able to optimise the use of spaces, while the employee can acquire a greater autonomy in managing her/his own work and time.
As a consequence, there is the need for a new vision of workplaces that are more and more characterised by the issues that they are intended to solve. In particular the working areas will be increasingly permeable and open to the city making blurred the boundary between public and private dimensions until to dissolve it.

Exploring the opportunities

The trends observed on the state of art in the new organization of work and workforce, implementation of the newest technologies in the day to day operations arises the need to adjust the workplace from an architectural, organizational and technological point of view.

For instance, in NYC was clear that the interest in coworking spaces is growing constantly, at a global level and especially in big cities with highly inflated rents. The innovation cases lay mainly on the space optimization and the different uses of the same space giving a series of connection between café and workplaces.

Spacious, NY coworking

However, these considerations have to match the specific complex set of requirements set by the bank. An additional element of complexity is provided by the fact that in this historical phase in Italy, even the biggest companies tend to watch their expenses more than they used in the past. This phase is associated with the sharp increase of competition, with the consequent shrinking of aggregate profits in the banking industry. This element generated the need for a fully economically sustainable solution, which is not always an easy target to reach as it may seem.
This is the reason why the solution proposed, the BankCoffice (i.e. Bank, coffee and office), may look like an unconventional answer one would give to the call specifications, but it was the result of a long journey and many revisions and modifications.

Generating a solution

The office environment should be seen as a place that makes working more enjoyable, productive and reachable for everyone, a place where relations can happen, where you can work and be delighted with a nice and calm atmosphere of the space. This must be achieved considering the main goals of saving on real estate expense, environmental sustainability and the possibility to add value to the city through a urban regeneration factor.

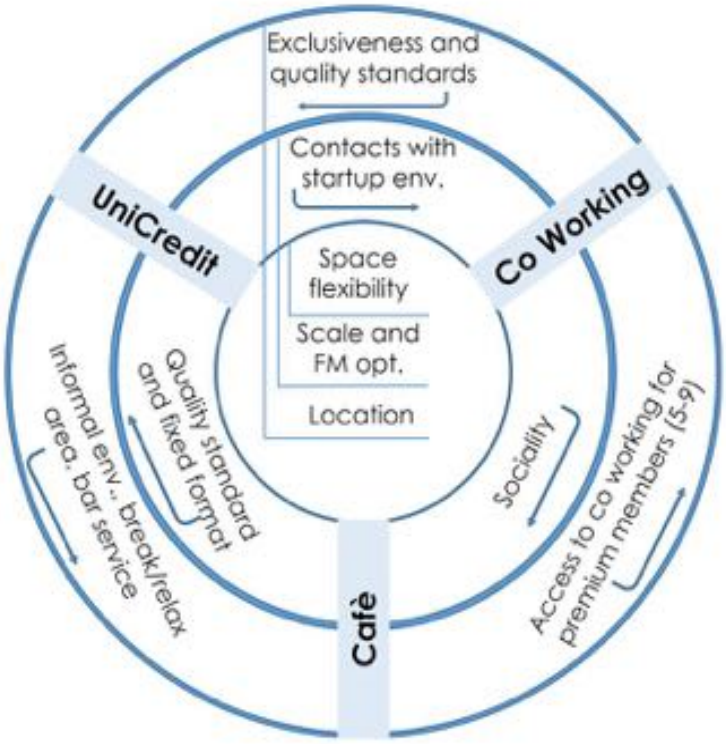
The concept aims to create a new hybrid space that merges the bank office space for Unicredit with a co-working environment and a café open to the public. One of the main goals is to make a workplace more enjoyable and reachable for bank employees, students, free-lancers etc., and can obtain an important value for the external users.

The solution proposed, the BankCoffice (i.e. Bank, coffee and office), may look like an unconventional answer one would give to the call specifications, but it was the result of a long journey and many revisions and modifications.
The solution is a space composed by three main elements:

- The cafè, which represents the public permeable space and a double revenue stream, both from the bar and the stay of the guests;
- The professional coworking, which acts as an additional
- revenue stream and exploits the design knowledge and professional environment connected to the bank;
- The coworking devoted to the activities carried out by the bank employees, designed following the specifications.

This concept provides several benefits for its stakeholders:

- Unicredit employees will have a greater satisfaction at work. They will be able to work close to home, saving time and money, and work in an informal atmosphere surrounded by an innovative environment;
- The bank will benefit from operative and strategic advantages. This concept will allow to increase employees' satisfaction, support the bank's image and brand as long being sustainable from an economic, social and environmental point of view;
- Local communities will have a new space where to work or study without paying any fee.



Tags

- Coworking
- Flexible workspaces
- Freeconomics

FIAMME

Finishing processes for additive manufactured metal components

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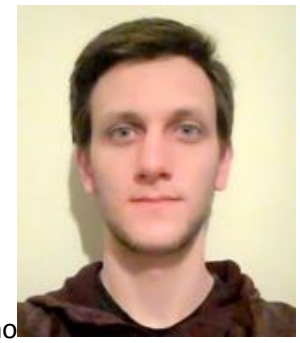

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 Matteo Loss, Aerospace Engineering, Politecnico di Torino

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Project description

Additive Manufacturing (AM) is a disruptive technology that has the potential to replace many conventional manufacturing processes. The adoption of AM as fabrication technique has a positive impact on the parts and assembly design, because the absence of geometric constraints allows designers focusing their efforts on part functionality. Despite its clear benefits, AM remains affected by technological issues. A characteristic of metal additive manufactured components fabricated from powder bed is the texture of the surface, originated by melting and solidification of the powder material. This mechanism leads to an average Roughness (Ra) typically higher than 20 microns, depending on the material properties and process parameters.

The main objective of the project is the study and development of a surface finishing methodology for improving the surface quality of components fabricated by additive manufacturing. Conventional and unconventional finishing processes can be applied to additive manufactured parts, but each process has a well-defined application range. For instance, processes developed for finishing internal channels are difficult to be applied to external geometries and vice versa. In the case of additive manufactured parts, due to the freedom of design and the complexity of shapes that can be realized, there is a need for the integration of existing processes to combine their specific advantages and the development of new finishing processes. These processes should be able to finish complex geometries, both external and internal, such as deep cavities and intricate through holes.

Starting from an extensive literature research on conventional and unconventional methods for surface finishing, on the basis of the characteristics of the metal alloy for AM selected as case study, a set of potential removal mechanisms and most promising media will be identified. Several copies of specimens of selected material will be produced. These samples will be outsourced to external finishing services or

finished by equipment available in internal laboratories. Then, surfaces will be analysed by means of optical microscopy, SEM, and a surface profilometer.

From the inspection results it will be possible to evaluate the efficacy of each process and identify capabilities, limitations and possible improvements. Subsequently a reference part will be designed whose geometry will be representative of free-form shapes that can be fabricated by additive manufacturing. After assessing the feasibility of the reference part by the available EOSINT machine at IIT and adopted material, some copies of the artefact will be produced. These parts will be outsourced to the same finishing services or finished by equipment available in internal laboratories, for comparison purposes.

This analysis will allow to select one or more mechanisms, or a combination of them and related media for implementation of an innovative finishing process.

Team description by skill:

Enrico Degregori: studied AM principles and issue, took care of the feasibility of the final component and carried out the preliminary roughness measurements in Turin.

Eleonora Francica: dealt with the design of the first three samples and the final one (3D and CAD). She took care of the graphics and of the photo report of the experiments.

Marco Franzoso: coordinated the Turin team and exploited his Material Engineering skills in critically analyzing the problem and the solutions that were found in literature.

Matteo Loss: helped select the final AM component to produce and studied the technical features of the device to reach the desired functionality.

Pietro Magni [Communication coordinator]: coordinated the team and took care of the communications with the tutors. He also supported the design and experimental phases.

Jaspreet Singh: Performed the electropolishing and chemical polishing experiments and managed all the operations regarding sample cutting and laser profilometry.

Roberta Togati: supported the design of the final testing sample thanks to her deep knowledge of the AM process and explored its possible application as FP-OHP.

Gaia Tosti: as a designer, she followed the development of the samples and the final components in all stages. She took care of presentations, photo shooting and video making.

Abstract

The FIAMME project consisted in developing a surface finishing process that could be effective on additively manufactured (AM) components with complex geometries. AM parts can reach average roughness (R_a) values up to 100 μm, which strongly affects the possible application of the component. The team focused on the surface finishing of internal mini-channels of an oscillating heat pipe (OHP) produced through powder bed fusion techniques. The optimal roughness of the internal channels of the component was investigated thanks to data found in literature and a target value was identified. A final testing sample was designed to test the developed surface finishing procedure on more complex parts with AM-friendly features.

After an analysis of the most promising unconventional surface finishing techniques, Electrochemical finishing, Chemical finishing and Fluidized Bed machining were chosen based upon their applicability and availability. An extensive experimental study was carried out to assess their effectiveness and define their most important process parameters. Simple screening samples with different internal channel diameters,

produced using EOS's EOSINT M270 DUAL Mode machine (provided by Fondazione Istituto Italiano di Tecnologia) were used in this phase.

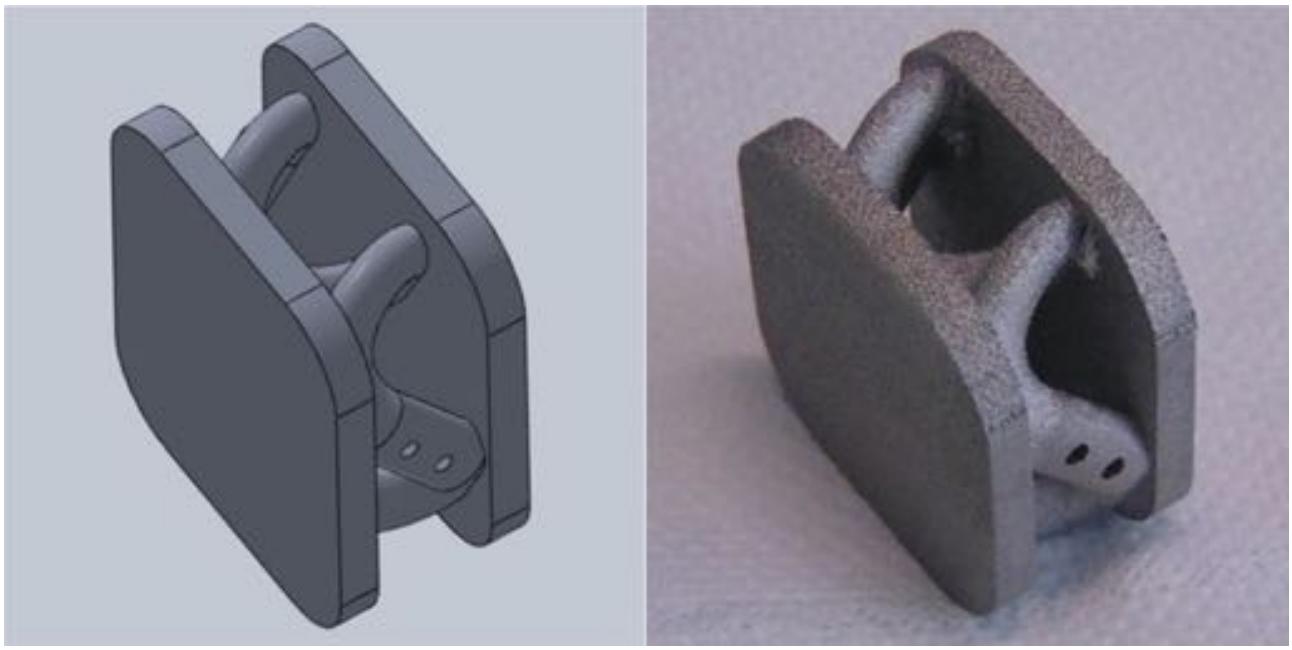
At the end of the screening process, a procedure consisting of Chemical finishing followed by Electrochemical polishing was developed and proved to be effective in reaching the target roughness value on the screening samples. The same procedure was applied on the more complex final testing sample using a peristaltic pump. However, the surface roughness value could not be measured because of a fine metallic powder that adhered to the internal channels and the result was deemed non-acceptable. Nonetheless, the procedure that was developed has significant value and needs to be further studied. It is thus believed that a simple tuning of the process parameters would allow to reach the target roughness even on more complex shapes.

UNDERSTANDING THE PROBLEM

Additive manufacturing is an exciting new production technique that allows to overcome some of the geometrical constraints typical of traditional forming processes. However, AM and, more specifically, powder bed fusion (PBF) techniques have intrinsic limits that affect the freedom of design and the properties of the final component. One of the most significant drawbacks of AM is the poor surface finishing of the parts produced, which could be incompatible with the requirements of the final application. An extensive post processing of the component may be necessary, but the complex geometry of AM components may prevent the use of conventional surface finishing techniques.

The work started with the selection of a component to analyze and improve. A previous study on a Ti-6Al-4V oscillating heat pipe (OHP) manufactured through PBF techniques was taken as a reference [1] and the effect of roughness on the functioning of this device was investigated. An OHP is a heat transfer device that effectively utilizes evaporation and condensation to transfer heat over a long distance and needs to have small internal channels to work properly. For small hydraulic passages, roughness features on the wall play a significant role in heat transfer and pressure drop characteristics of the flow. A target average roughness value of 4.59 μm was identified to balance the increase in the heat capacity (positive) and in the pressure drop (negative) of the device.

According to the team, a process of redesign of the reference OHP needed to be carried out. Even though the reference device was built taking advantage of the miniaturization that AM can provide, a traditional geometry was kept and no innovative geometrical features were implemented. What is more, the design did not consider the most significant AM geometrical constraints and problems during the manufacturing stage could be faced. For these reasons, a final testing sample (not a working prototype) was designed to illustrate how the device could be made more AM-friendly and to assess the effectiveness of the developed surface finishing procedure on typical AM channel geometries. This was a long and arduous process, during which the restrictions dictated by AM [2] and the key geometrical features of the reference component (long duct, reduced cross section) had to be carefully taken into consideration. The final testing sample consisted of two plates surrounding a spiral duct with an elliptical cross-section and two holes on the top and bottom planes to facilitate the powder removal and the surface finishing.



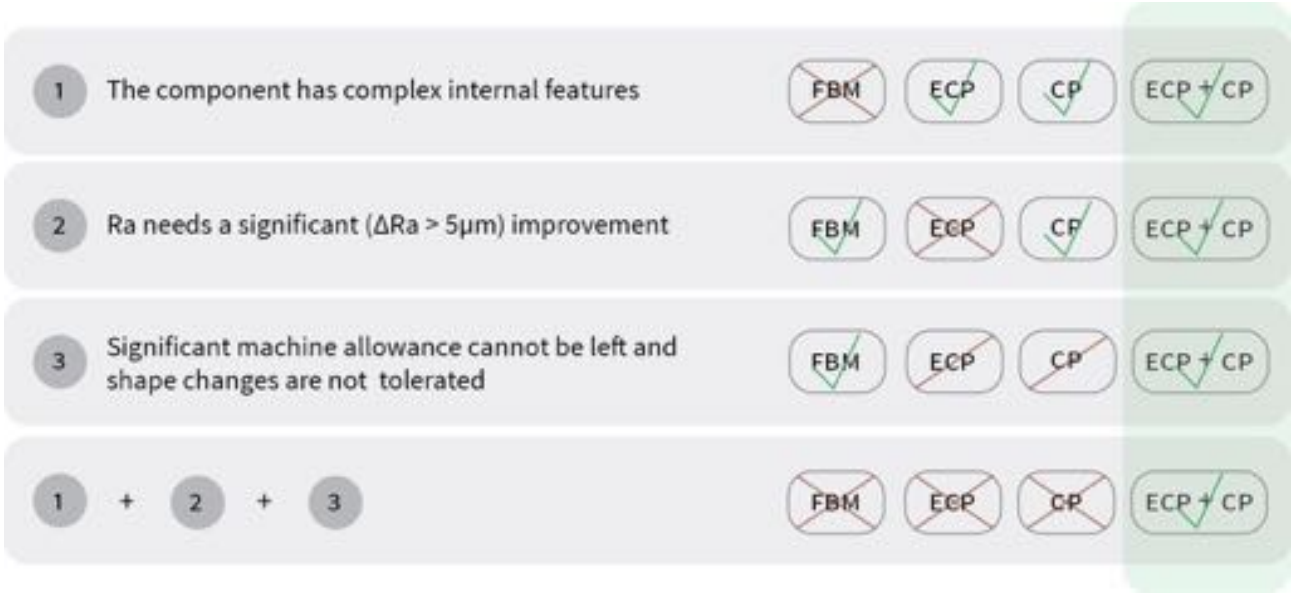
EXPLORING THE OPPORTUNITIES

Polishing small internal passages is a very challenging task, in particular for AM parts where the initial average roughness is high. Even though many unconventional surface finishing techniques have been developed and proved to be effective in polishing internal channels, there is a lack of proven solutions for AM parts [3]. A literature research was carried out to define the state of the art and multiple surface finishing processes have been analyzed, including abrasive flow finishing, fluidized bed machining, magnetic abrasive finishing, electrochemical polishing, chemical polishing and laser polishing.

An extensive experimental work was carried out on Electrochemical finishing (ECP), Chemical finishing (CP) and Fluidized Bed machining (FBM). In this phase, screening samples with different internal channel diameters (2, 5 and 10 mm) were produced in Ti-6Al-4V using EOS's EOSINT M270 DUAL Mode machine, provided by Fondazione Istituto Italiano di Tecnologia. The three surface finishing techniques were accurately tested to assess their effectiveness and determine their optimal process parameters.

This preliminary analysis highlighted that Electrochemical polishing produces highly reflective surfaces without a sufficient improvement of the initial average roughness. Higher ΔR_a were reached using Chemical polishing but the etching rates became gradually unacceptably low as R_a diminished. Fluidized Bed

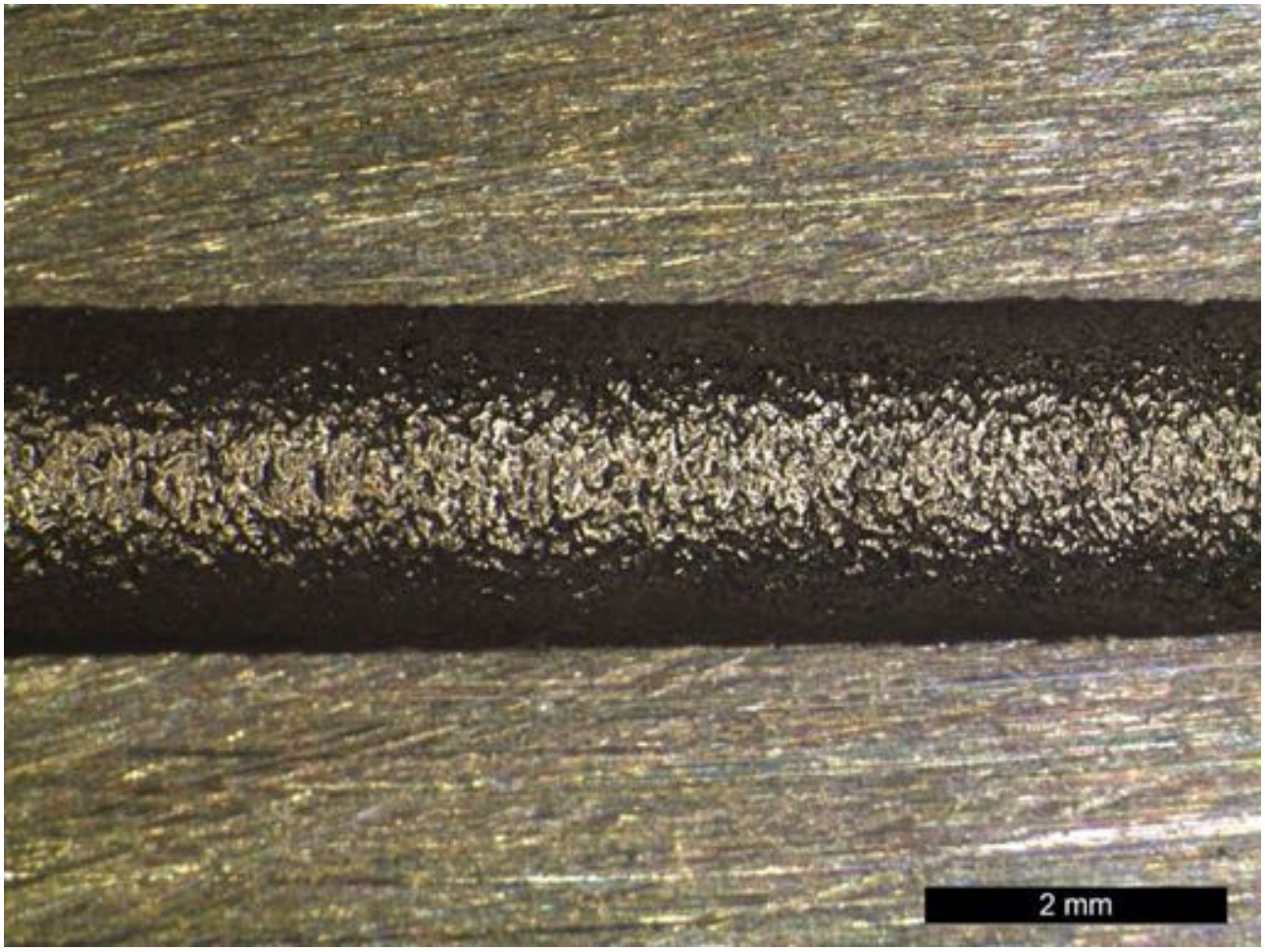
machining determined significant improvement of R_a on the external surface of the screening component but the internal channels were not adequately machined.



GENERATING A SOLUTION

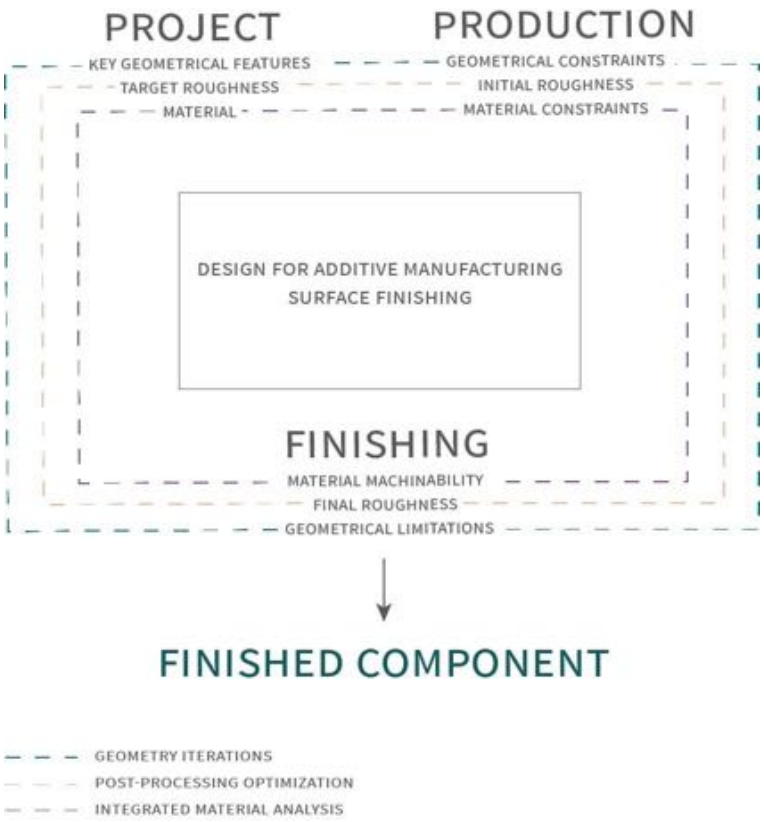
At the end of the screening process a surface finishing procedure combining a Chemical finishing treatment and an Electrochemical polishing was developed. Following an ultrasound cleaning that removed the debris deposited on the component, a chemical polishing was carried out to smooth the rough surface finishing determined by AM and quickly achieve high ΔR_a. After that, an electrochemical polishing was applied to further reduce the roughness of the component, since it proved more effective at lower starting R_a.

This treatment was preliminarily tested on the screening samples and allowed to reach the target roughness value. A smooth and reflective surface was obtained in the internal channels of the screening samples and the final roughness value could be controlled as a function of the process parameters of the two surface finishing techniques that were coupled. This procedure did not require any complex apparatus and the process parameters could be easily tuned to obtain different values of the final surface roughness.



This procedure was then extended to the final testing sample with the more complex channel geometry. Given the longer ducts of this component, a peristaltic pump had to be used to have the etching Chemical finishing solution and the Electrochemical polishing electrolyte solution flow into the channels and remove the metal alloy debris. However, the combined treatment determined the formation of a fine powder strongly adhered to the surface of the internal channels. This deposit did not allow to measure the surface parameters of the sample, but the morphology observed was deemed non-acceptable. Nonetheless, it is believed that an appropriate tuning of the process parameters (including that of the peristaltic pump) could extend the efficacy of this treatment even to more complex ducts.

The added value of the project lies in the study and implementation of a method for surface finishing of parts produced through AM with complex shape features. This procedure is the result of the combination of different surface finishing techniques whose operating parameters have been fine-tuned to achieve the target roughness. While the performance of the procedure is – of course – impacted by the geometry of the part, it is extremely flexible and can be applied to a vast range of shapes and sizes by varying the operating parameters. The working method that was followed could be easily extended to the surface finishing of other AM components and unconventional geometries in general. It is clear from the research carried out that the design, production and finishing of the part influence one another and a multidisciplinary approach should be followed to reach optimum results.



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[2] Kranz, J., D. Herzog, and C. Emmelmann, Design guidelines for laser additive manufacturing of lightweight structures in TiAl6V4*, Journal of Laser Applications*, 27:S1, S14001, 2015.
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TAGS

Additive; Manufacturing; Finishing; Polishing

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Architectural Design, Politecnico di Milano
Ludovico Pincini
Communication Design, Politecnico di Milano

Tasks and skills

Fabio Giulietto: Master of Science Chemical Engineering and Sustainable Processes. Scenarios definition, data analysis of the questionnaire outcome, business idea development of the hotspot, technical experiments planning. Team controller: activities scheduling. Communication coordinator: presentation of the recurring outcomes to Barilla Group.
Sara Bazzano (Industrial Production and Innovation Technology Engineer): team financial controller, scenarios analysis and rollout of the restaurant scenario with data analysis of the questionnaire outcome and business model development, use cases creation in the hotspot scenario
Fabrizio Carvelli: Master of Science management engineering student of Politecnico di Torino. Main tasks included the data analysis of the outcome of the questionnaire outcome,

definition of the hypothesis and development of the model used for determining the price of the 3D printer in both the scenarios analysed, definition of the use cases for the hotspot scenario.
Dustin Dopsa: Master of Science biomedical engineering student of Politecnico di Milano, Bachelor of Engineering in biomedical engineering at Ryerson University in Toronto, Canada. Main tasks included the pasta cooking experiment, business models and strategies, cooking techniques and additional writing.
Marco Marni (Energy engineer): scenarios analysis, design of the questionnaire directed to Michelin Guide restaurants chefs and results analysis, pasta cooking experiment, investigation of the actors involved in the supermarket hotspot scenario
Martina Merlo Master of Science in Architectural Design student at Politecnico di Milano, Bachelor of Arts in Architecture and Visual Studies at the University of Pennsylvania in Philadelphia. Main tasks included testing subject for pasta cooking experiment, architectural design of the supermarket hotspot and packaging design, hotspot renderings, additional help with the use cases of the hotspot scenario, and additional writing for the final report.
Ludovico Pincini (Communication designer): scenarios analysis, printer requirements matrix and typologies, pasta cooking experiment, supermarket hotspot and packaging design, renderings of hotspot and past boxes, graphic design of final report and presentation

Keywords

3D printing, pasta, food innovation, business strategy

Abstract

3D food printing integrates the technology and techniques of 3D printing and additive manufacturing, together with gastronomy. Alongside Dutch research institution TNO (The Netherlands Organization for Applied Scientific Research), the Italian pasta goliath, Barilla S.p.A., has developed a prototype 3D printer dedicated to the food market. Although the possibilities for this type of novel device are quite vast, the two preferred and selected scenarios focused on for this project were an in-store hotspot and restaurant with in-house 3D food printer. A set of pasta experiments, questionnaires and interviews of Michelin-starred restaurants, hotspot design and business model were devised for the report and assignment.

Understanding the problem

3D food printing has the combined ability to control taste, nutritional input, corresponding shape and design. The use of 3D printing as a new approach to cuisine has the ability to revolutionize food production and food business, but effective plans and scenarios for using 3D printing in the food industry have not yet been fully developed. The goal of the FoodMade4U project was to further understand where and how this technology could be applied, to make it applicable for a large, multinational pasta company. Upon launch of the project, there were no concrete requirements provided due to the multiple directions possible for the technology, and the company involved in the project (Barilla S.p.A.) had not decided on a specified direction, either. However, Barilla shared their interests and current endeavours to forge a path for pasta and biscuits in the 3D food printing marketplace. Accordingly, the possibilities and objectives were extensive; understanding the appropriate goals was difficult. It was our task to develop a focus in aspects of their ventures that we found interesting and produce valuable results and feedback. It was essential to understand and consider the user, this was done with an analysis of the potential users of the 3D printer, and the imaginable products. Thus defining use scenarios, where different food items are printed, their use contexts, and particular users. It was also necessary to obtain an understanding of the strategies for accessing markets for the technology, in order to assess future markets. To do so, understanding the most important stakeholders of the project, was essential. Of the use scenarios ultimately selected for the project, the most important stakeholders were Barilla, TNO, the grocery retailer, chefs and restaurants, and the end

user. Combining all stakeholders and their respective expectations for each scenario, it was possible to create a list of needs and requirements for the resulting hotspot and restaurant proposals, encompassing a comprehensive understanding of the project.

Exploring the opportunities

The first step after having identified the stakeholders was to perform a brainstorming, with the objective of finding the possible scenarios in which the 3D food printer could have potentially been employed.

The 3D pasta printer could be placed in a *restaurant* (Scenario 1), serving as aid to the chef and having the objective of automating the production of fresh pasta, allowing the chef to dedicate himself to other duties. The 3D printer could also be of help to a *catering* (Scenario 2) service, giving the possibility to produce fresh pasta anywhere the service operates, without having to pre-cook the pasta and warm it up once arrived at destination, guaranteeing a higher product quality. Another use case could be the production of food in *luxury retails* (Scenario 3), where it would not only be possible to produce 3D printed pasta, but also any other kind of food, i.e. chocolate, vegetables, and so on, allowing the personalization of the shapes and improving the value creation of food. It could also be possible to find the 3D printer in an attractive position, such as a supermarket or a mall, under the shape of a *hotspot* (Scenario 4), where customers could buy pasta or order it online and then pick it up while grocery shopping. Thinking of a more customer-oriented approach, a *family* (Scenario 5) could use a smaller and adapted 3D food printer at home, having the possibility to cook fresh pasta in an automated way and with a specific pasta design, for example to make it more appealing for kids. Another purpose could be to install bigger sizes of 3D food printers in *canteens* (Scenario 6), i.e. hospitals, prisons, schools and allow the personalization of nutritional values within the dishes. The same principle can be extended to *small crews* scenarios (Scenario 7), such as astronauts on a space shuttle and crew in a cargo ship, or *bigger crews* (Scenario 8), such as soldiers in a military base. Finally, the concept of 3D pasta printer could potentially also be used in the *industry* (Scenario 9) by creating plants of fresh pasta production with additive manufacturing productions.

Of course, all the scenarios listed above would require specific characteristics, in terms of size of the printer, production capacity, design, configuration, allowing for example the incorporation of a cooking unit, or the development of a multiple nozzle.

From the analysis of all these scenarios, we came to the conclusion that the restaurant scenario and the hotspot scenario were the ones worth developing with particular attention in order to find the most appropriate solution to our problem.

Generating a solution

Our solutions have been developed following three main directions:

- The evaluation of an eventual integration with the existing 3D printer of a cooking device for the printed pasta
- The investigation of the possible implementation of the restaurants scenario
- The design of a supermarket hotspot equipped with a 3D pasta printer

As regards the cooking device, a set of experiments have been carried out in order to perform a comparison of the resulting pasta quality cooked with a steamer and with the traditional boiling. The requirement at the bottom of this evaluation was the production of cooked pasta that had to be edible and provided with a certain level of quality. The results of

the experiments have been such that they do not support the implementation of an integrated cooking device.

In the restaurants scenario analysis, starting from the defined target restaurant obtained from the questionnaire data, some economic evaluation have been performed to assess the drivers that could allow the actual implementation of this scenario. Where actual data from

the questionnaire, Barilla or other sources were missing, all the economic analysis have been based on plausible and conservative assumptions to obtain results which are as accurate as possible.

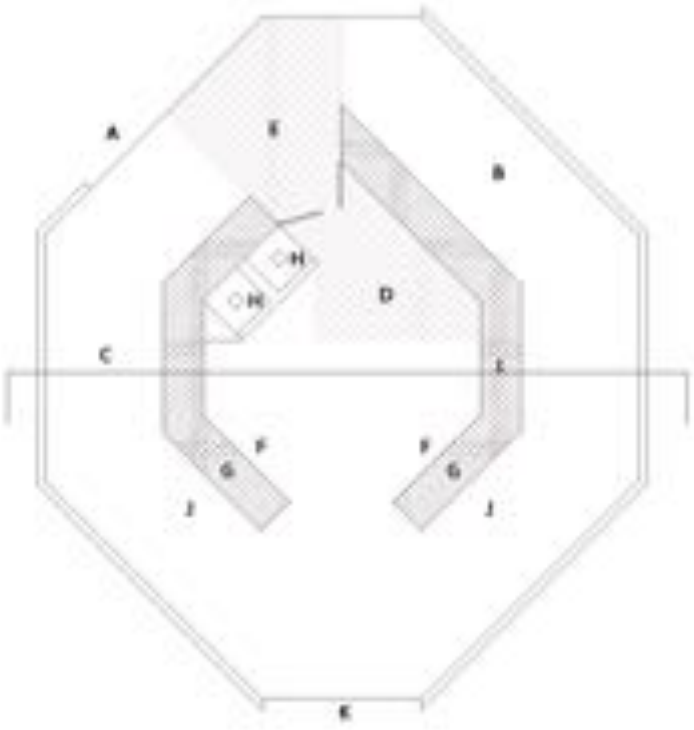
First of all, an estimation of the Net Present Value of an eventual restaurant investment in a 3D pasta printer have been carried out to determine the willingness to pay for this device.
After that, the competitive environment for this type of device has been investigated in order to assess a credible value for the price of the 3D pasta printer. Together with that the possibility of leasing the printers by Barilla to the restaurants has been examined as a promising option and a final monthly fee has been calculated.
Finally the volume of pasta 3D printed in the restaurants has also been taken into consideration to assess on the one hand the feasibility of the production of the necessary pasta in a plausible time within a restaurant and on the other hand the overall amount of refills production required to Barilla.

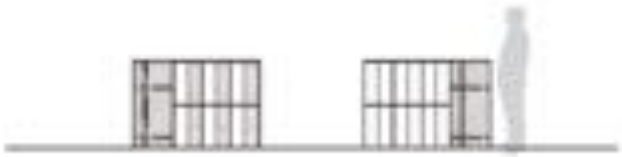
Concerning the supermarket hotspot design, we started with the definition of two types of customers, pre-order and on-demand, and the consequent design of their customer journeys. Then all the different actors involved in the hotspot operation and in the supply chain have been considered with the definition of all the duties and tasks. After that, a deeper look into the hotspot required functionalities has been effectuated and this has brought to the actual physical design of the hotspot.

Finally, we performed an analysis to understand the economic sustainability of the installation of the supermarket hotspots for Barilla. To do this, an evaluation of the volume of pasta sold by Barilla in hypermarkets where the hotspot may be installed and the calculation of the necessary price at which one kilogram of 3D printed pasta would need to be sold have been done.

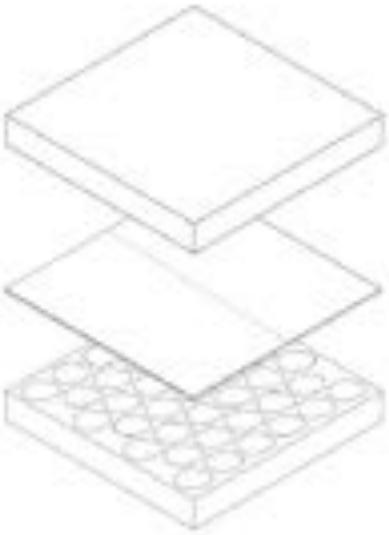

SMART
PASTA

Entrances	A
On-demand	B
Pre-Order	C
Restricted	D
Access to Storage	E
Shelving	F
Countertops	G
Printers	H
Cashier	I
Pickup	J
Exit	K

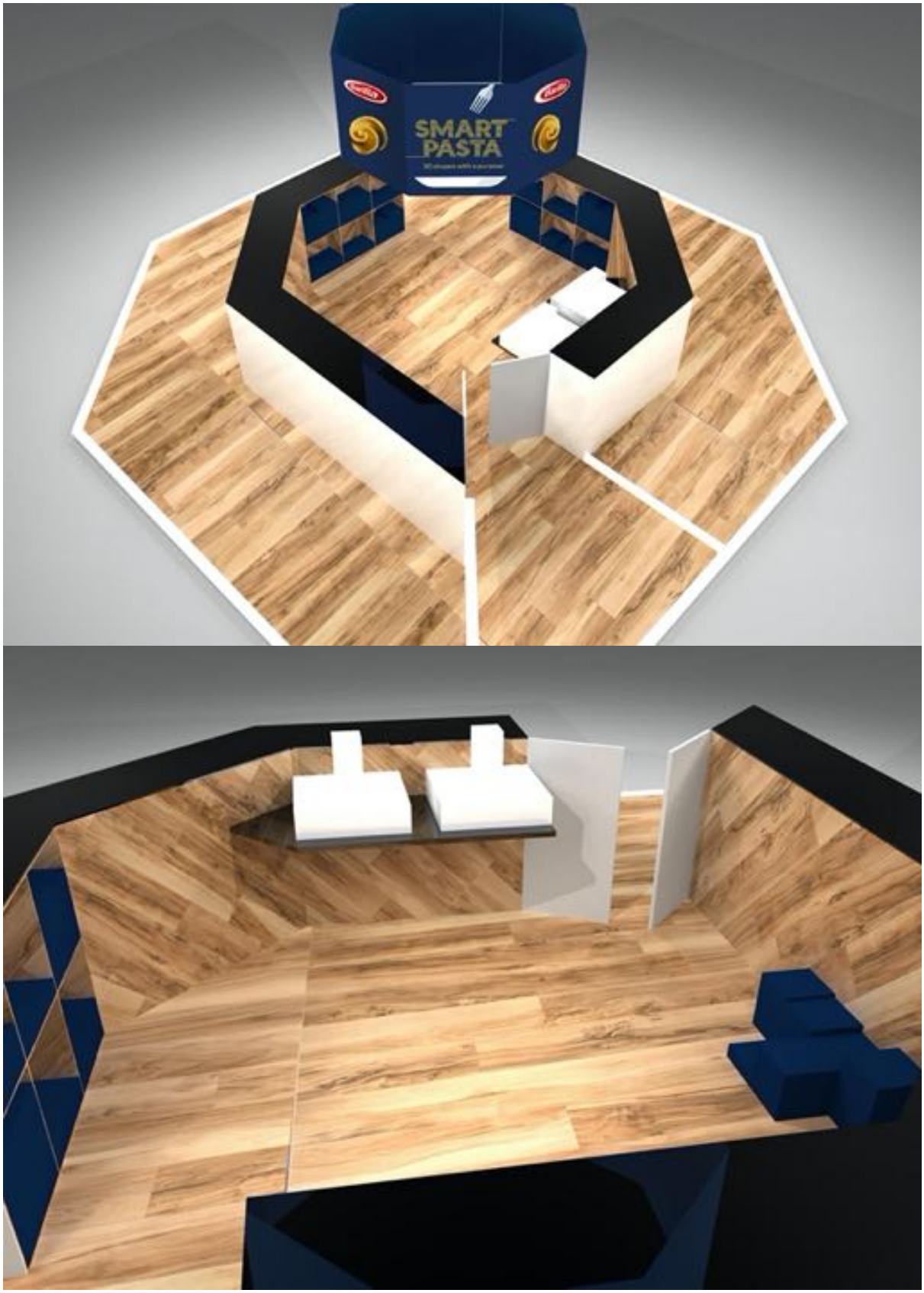




One layer packaging



Two or more layer packaging


SMART
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DREAM2
DRone tEchnology for wAter resources and hydrologic hazards Monitoring

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Tasks and Skills

Luke Addati – Developed the model for 2016 using photoscan by outputting the relevant files such as Digital Surface Models & Orthophotos. He worked on the data using QGIS to evaluate the data trend patterns on the glacier due to global warming. He also kept control of all the finances by organizing the budget, assisted the team with report writing the methods & conclusion section and attended both campaigns for data capture.

Pietro Lorenzetti – Pietro work on developing the model for 2016 by evaluating each individual photo and finding the relevant alignment points. He also assisted with data evaluation. He controlled and coordinated the report writing amongst the team members, writing an extensive amount himself, assisted with drone construction, attended the first campaign and coordinated the final presentation development.

Tommaso Francalanci – Investigated the state of the art drone technologies, organized a list of components, purchased and built the drone with the assistance of other team members. He attended both main campaigns and also assisted with smaller campaigns when more data was required. The Monographic points were tabulated by Tommaso for use within the model. He attended the SIFET conference in Sicily where he presented the DREAM project, where the project was chosen as the best at the conference.

Angelo Falleta – Worked on the hydrological analysis for evaluation of the Degree Day Factor between 2015-2016 and compared the results to the previous year's findings. The analysis was also compared to our results and traditional approaches to determine whether drone technology had viable results. He worked on the velocity map evaluation within the model development, assisted in the first campaign, wrote an extensive amount of the report theory & the hydrological analysis section.

Costanza Parisi – Supported the first campaign & worked on the monographic points for use within the model. She assisted in construction of the drone and report writing the section regarding the campaigns & the work that was performed in the area.

Project description

Nowadays, expected effects of climate change at local, regional and global scales endanger hydrologic budgets of Alpine regions. An example is the massive shrinkage of mountain glaciers, with the consequent problem of water resources reduction for civil population and ecosystems. Therefore, it is very important to monitor glaciers' evolution, in order to allow an estimation of glaciers' reduction and possible effects on the hydrologic cycle. This project aims at investigating new technologies and tools, especially Unmanned Aerial Vehicle (UAVs) for evaluating water resources at different scales. The eastern slopes of Monte Rosa and its glacier tongue (Belvedere glacier) has been used as test site. Research method analysis mainly followed three steps. Usually, glacier's thickness, area evolution, and glacial motion are monitored using time-consuming field activities, e.g. analysis based on point stratigraphy and mass balances or radar sounding, which do not allow to obtain a continuous-time, detailed and accurate information about surface and volume evolution at fine spatial resolutions. In the first step, we have used a fixed-wing UAV to acquire RGB images, in order to generate a dense DSM (Digital Surface Model). The acquisition was carried out with a field campaign in October 2016. Data have been elaborated with different photogrammetric software in order to investigate the ratio quality of the product/time consumption, with respect to hydrological purposes. The DSM obtained has been compared with the one realized in 2015 to estimate the volumes' variations, and the glacial motion in the period October 2015- October 2016. In the second step, we have designed, assembled and tested a quadcopter drone. In the third step, we have used the assembled drone in an ad-hoc field campaign realized in March 2017 together with commercial drones in order to check the validity and potentiality of the assembled drone. Finally, we have been compared the obtained results with the existent literature in alpine areas.

Abstract

As climate change continues to be of serious concern to the planet, countless hours of research are being invested to better understand this phenomena and to improve data acquisition. Due to the complexity of the problem, it is very difficult to understand what is going on with current technologies. Scientists are still trying to develop proper models but require additional data to assist in the development. The project continues to focus on the ambitious goal of investigating innovative technologies for data collection, while attempting to keep costs low and allow for good usability.

The first DREAM project successfully proved that it was possible to monitor and evaluate the glacier at Belvedere using Drone technology. The drone was fitted with a camera capable of taking high resolution images that could be utilized in photogrammetry to develop digital models for analysis. DREAM 2 further investigated this concept by continuing the same analysis and also developed a low cost drone for the Universities to use on the glacier. We successfully built and utilized our drone for the second campaign and were able to extract the data acquired to use for analysis. We utilized two sports action cameras, one with a regular filter and one with an Infra-red filter and were able to evaluate the differences in photo quality. In addition, we were able to use to the data obtained from the developed models to estimate glacier melting and compared it to actual data. As an extra evaluation compared to our predecessors, we were able to develop a velocity map, where we were able to compare various objects and evaluate their movement over the years. We can confirm that drones are a valid technology for investigating climate change at glacier locations, which are low cost, extremely versatile and with excellent usability.

Understanding the Problem

Significant development has occurred in drone technology, mainly due to the cost of components dropping significantly, allowing anyone to be able to build a drone themselves at a very good price. Due to its expansion into many fields such as agriculture, transportation, search and rescue and even hobby use shows that it has a broad use spectrum. The previous DREAM project proved the concept and set the foundation for DREAM2 to pick up the reins and to continue the great work being performed. We were tasked with continuing the work as per DREAM one with the extension of developing our own low cost drone for use on the glacier. The focus of the drone had to be on cost and usability, due to the budget constraints and the fact that the area where the drone would be deployed had harsh conditions.

UAV technology was investigated with the following key points;

- Investigating existing drone structures such as rotor or fixed wing topologies. Understand their benefits and drawbacks and select the right one for use on the glacier.
- Understand the conditions where the drone will work. Environmental conditions have adverse effects such as cold temperatures to batteries.
- Evaluate costs for each drone specification and find the lowest cost that meets our requirements.
- Review different sensor technologies and apply the best one onto the drone.

Like our predecessors, the test site was at the eastern slopes of Monte Rosa and its long glacier tongue (Belvedere Glacier). The valley lies at the base of the east side of Monte Rosa and stretches from its peak of 2200km to 1800km. The area is particularly interesting as the glacier is not retreating but is moving down the valley. The drone technology was required to gather data from the area to assist scientists in understanding and hopefully explaining its movements.

Exploring the Opportunities

By proving that a low cost drone can be used to evaluate an area such as the Belvedere Glacier, it has a huge impact for scientists and researchers who could investigate and implement the same technology in other environments. Opportunities could arise for the following areas;

Civil Protection – More morphological information can improve the understanding of critical phenomena and lower the risks for people being in an area during avalanches or landslides.

Valley Inhabitants – The glacier is one of the most important natural elements influencing the climate in the valley, its evolution may produce significant changes to the environment with direct consequences for the whole population, both from and individual and economic standpoint.

Regione Piemonte – Being responsible for the management of the territory, such an institution is interested in the matter of studying and knowing the dynamics of the Belvedere glacier. An increased knowledge of the area may result in an optimization of the plans for the development of local communities as well as an improved offer for tourism.

Agricultural Industries – Estimating the quantity of water they can rely on thanks to the snow is an actual need for them, especially in terms of forecast and water supply management. In addition, the planning and construction of agricultural infrastructures like dykes, dams or channels also rely on the knowledge of both accumulation and dispersion of the water resource.

Hydroelectric Companies – The glacier is a hydrological resource so that any increase in the knowledge of the belvedere area may actually interest such companies. Not only the Snow Water Equivalent (SWE) provides information about the size of the water resource, but also forecasting and information related to the timing of peak discharge can help hydropower plant operators maximizing the power production.

Drone and Sensor Manufacturers – New applications of drones for research purposes and area monitoring could lead to new developments in the drone industry. Furthermore, since this field if application is absolutely recent, where it's potential has yet to be fully discovered. There may be significant economic opportunities for using this cutting edge technology.

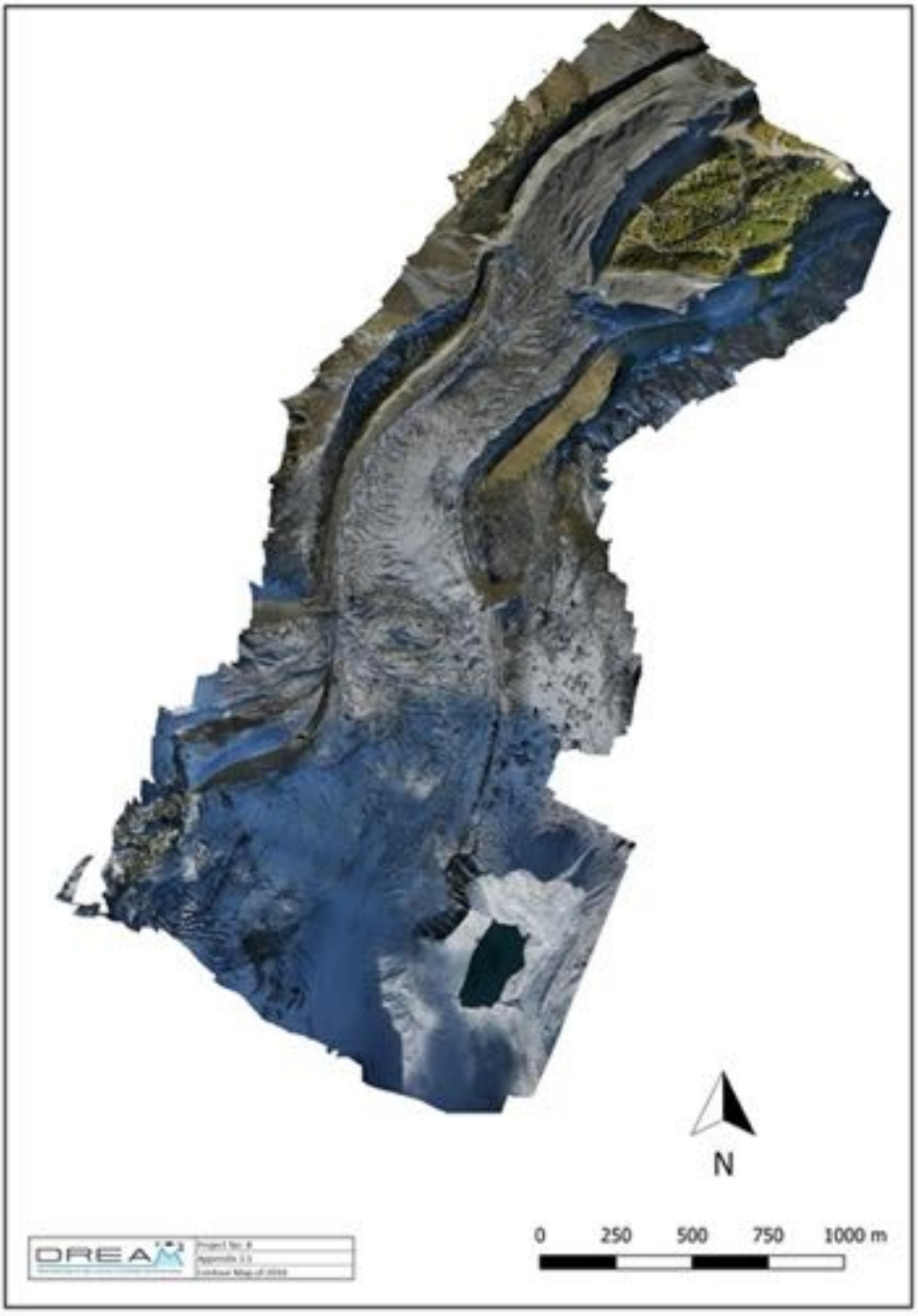
Generating a Solution

The project was separated into unique steps and phases which lasted for various time frames. We initially started with training sessions in Turin and Milan to understand the project and expectations better. The first campaign was performed in October 2016, where the team ventured to the glacier to gather data using an already built drone, the eBee SenseFly. As we were using indirect photogrammetry, Geo-Referenced markers were required to be positioned on the glacier, placed by us students and the professors which would be used in constructing the models from the drone images. The Geo-Referencing was performed using highly precise GPS equipment which provided us the exact positioning of the point on the glacier.

Once the data had been captured, we began post-processing of the data using photoscan and evaluating our models using QGIS. As an output, we obtained a Digital Surface Model (DSM) which would be used to obtain relevant information such as volume and contours, and also an orthophoto, which is a high resolution final image of all the images merged together. In parallel, the team also began investigating and developing the drone concept. Requirements for the drone were developed and agreed upon and finally the components were purchased. When the components arrived, the drone was constructed in Milan with necessary team members arriving to assist.

The drone choice was a rotary drone with 4 propellers to keep the cost low and sports action cameras were used to obtain the necessary image quality of the glacier. The drone was flown on the second campaign, where only a small section of the glacier was evaluated for the level of snow that had fallen. The flights proved extremely successful with only a few minor problems occurring which were resolved in the field. We were able to construct a fully functional drone which was low cost and highly capable of being used on the glacier.

The models from the first campaign were analysed and a difference in volume was found between the 2015 and 2016 models. The data was shown to be trending, where we could see similar patterns forming to where the volume was displacing. The models also allowed us to calculate the Degree Day Factor (DDF), a performance criteria used to determine the melting speed of the glacier. The results showed once again that the glacier is losing volume due to global warming, with the difference between 2015 and 2016 being the greatest loss in volume with respect to all other measurements so far. We also compared our data to traditional methods and found similar results in the melting speed.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Project Title:
AFCam - A Contactless System for the Detection of Atrial Fibrillation using Camera Recordings

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Luca Talenti [Team Controller, Communication Coordinator]
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Tags: Atrial Fibrillation, contactless diagnostic, machine learning, Policlinico di Milano

AFCam

Project Description

Atrial Fibrillation (AF) is the most common arrhythmia that affects about 2% of the population. The prevalence of AF increases with age, from 0.5% at 40–50 years, to 5–15% at 80 years. AF is associated with increased rates of death, stroke, heart failure and hospitalizations as well as degraded quality of life, reduced exercise capacity, and left ventricular dysfunction.
AF can be paroxysmal, meaning that AF events can occur episodically and self-terminate; in such cases the clinical diagnosis is performed by Holter recordings usually for 24h or 7 days. However, because of the time irregularity of this pathology, the monitoring period could be insufficient to detect AF. The main risks of undiagnosed AF events are associated to cardioembolic stroke and AF-related complications whose management would imply higher costs for health care system.
The project aim at the development of a contactless fully automated system for screening of AF patient in different environments. The system consists of a videoPPG system, i.e. camera that detects variations of light intensity reflected

by a region of subject's face, positioned at a variable distance. From video recordings, the blood volume pulse (BVP) of peripheral arteries is extracted and processed to detect AF.

The main advantages of the proposed solution are founded in its non-invasive, fully contactless technology which can be placed anywhere, in the absence of patient's compliance requirement and in the extensive usage of portable technologies (such as mobile phones) for diagnostic purposes. From these standpoints, the project targets the development of a product for the detection of AF events both from a technological and business perspective.

From a technical point of view, the tasks which have been required to the multidisciplinary team are:

- The development of signal processing techniques to enhance videoPPG signal and to quantify its properties
- The application of machine learning techniques to classify pathological (AF, other arrhythmia and healthy patient) and non-pathological status on the base of measured videoPPG signal
- The recruitment of AF patients at Istituto Policlinico Maggiore Ca' Granda (Milan) for the statistical testing and validation of the developed algorithm.

From a business and design perspective, the tasks team have been required to develop are:

- The definition of product requirement, characteristics and design;
- The definition of a mock business plan and prototype of the service.

The result of the team is then a complete technical flow, encompassing computer vision, signal processing and machine learning topics, which has led to the effective contactless detection of AF events. The technical product and its requirements are completed by a market study and the consequent creation of an innovative business model for the commercialization of the algorithm. The product is presented under the form of a prototype site.

Tasks and Skills

The composite structure of the project has led to the distinction of three main sectors which are consequently treated by different sub-teams.

Computer Vision

Alessia Botta: Literature analysis of the face detection and face tracking algorithms, requirement analysis and corresponding technical specifications for the computer vision system.

Gian Franco Piredda: Implementation of the face detection and face tracking algorithms in Matlab and C++ and quantitative benchmarking.

Nicolò Capobianco: Implementation of the face detection and face tracking algorithms in OpenCV and computational optimization.

Signal Processing

Claudia D'Ettorre: Literature analysis of pre-processing algorithms for BVP signal extraction from video recordings, implementation of BVP extraction algorithms in Matlab and quantitative evaluation.

Giacomo D'Alessandro: Literature analysis of features extracted from BVP signals, computation of the selected features in Matlab, quantitative benchmarking.

Andrea Mariani: Literature analysis of classification algorithms in biostatistics, implementation in Matlab and quantitative evaluation.

Business Modelling and Design

Anindya Fitriyanti: Ethnographic research, user experience and user design of the formulated service.

Luca Talenti: Market analysis, creation of a business model for the commercialization of the formulated service, business plan redaction.

Abstract

Atrial fibrillation (AF) is an arrhythmia due to irregular propagation of electric impulse in the atria. This disease is diffused in about the 2% of the population and negatively affects the life conditions of pathological patients, leading oftentimes to heart strokes and being expensive to treat for the healthcare system. It is proved that an early detection of the disease highly improves life expectancy and conditions while reducing the related costs. In this study, it is developed a contactless solution for the detection of atrial fibrillation from video recordings. The solution relies on the RGB imaging approach, which starting from a video recording of the patient's face can detect the Blood Volume Pressure (BVP) signal and consequently prove the presence of AF. For this purpose, five technological phases are distinguished: face detection, face tracking, pre-processing of the signal, feature selection and classification of the signal among AF, healthy and other arrhythmia. For each of the five phases, a literature review is developed for identifying the technological alternatives. The different alternatives undergo a process of quantitative benchmarking. The final solution for face detection and tracking is developed in C++ exploiting recently developed libraries of OpenCV. The following three phases, proper of signal processing and machine learning, target the maximization of correct diagnosis. The Zero-phase Component Analysis is found as the most effective in extracting the BVP signal. On the BVP signal, twenty-six features are computed. These features are finally classified by a K nearest neighbors classifier, evaluated as the most efficient in distinguishing between AF, healthy and other arrhythmia patients. The developed solution is embedded in a two-sided platform targeting the vast public and corporations, providing a business plan and the design of the service. The provided solution is consequently innovative for the method exploited as well as for the business model creation it is inserted in.

Understanding the Problem

Atrial fibrillation (AF) has, in the last decades, received increasing attention for the social and economic burdens it represents. Indeed, its diffusion in developed countries is doomed to rise in the next years because of the ageing population. Furthermore, the heavy treatments and continuous follow-up AF patients are subjected to enhance the necessity from institutions, but also individuals, to find innovative ways in dealing with the disease. In Italy, the real extent of this pathology, although presenting an increasing trend, has still to be uncovered both from a demographic and economic dimension.

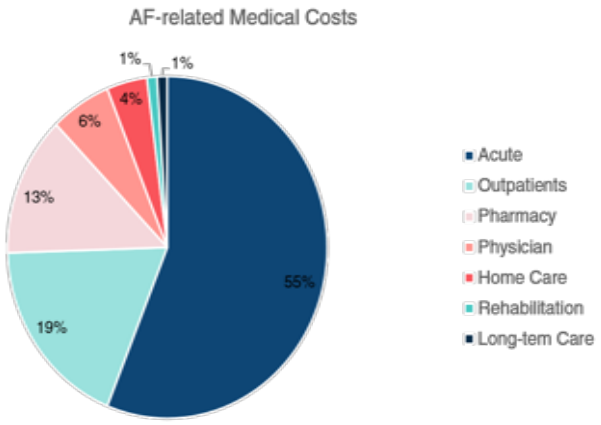

Figure 1 Breakdown of AF-related medical costs.

Several studies have proved how an early detection of the pathology combined with simple, accessible technologies can lead to a consistent lowering of this burden from a social and economic perspective. This is even more true considering that current diagnosis is based on electrocardiography, a process which requires the presence of technical staff to be performed and physicians to analyze the results.

The extent of actors concerned with AF is large, ranging from actual and potential patients to physicians, cardiologists and the healthcare system. Their needs have been studied from both primary, such as interviews and questionnaires, and secondary resources (articles, related webpages and forums). The requirement research pinpointed how a flexible, cheap, non-invasive and permeant diagnostic tool is needed for an optimal and simple measurement of the disease even in problematic settings or in sensitive patients.

Figure 2 Identikits of the main stakeholders.

For this reason, the objective of the study is is the design of an algorithm for an accurate contactless diagnosis and tracking of AF based on cutting-edge techniques and its embedding in an end-to-end viable service potentially releasable to the vast public.

Exploring the Opportunities

A contactless solution would allow the subject to behave normally without being aware of the investigation so as to obtain reliable measures without any emotional and psychological influence. Furthermore, no major contactless product or service is commercialized on the market. Indeed, other than the time-consuming and expensive ECG, just another major solution is proposed on the market: Kardia. This product, offered by AliveCor and recognized by the English healthcare system, can track an ECG from the fingertips of the user while providing diagnostics on the extracted signal. Nonetheless, such a solution can be considered as expensive for non-pathological patients who need sporadic measurements.

Given this setting, out of the contactless methodologies present in literature, the RGB imaging approach is chosen since proved to be implementable in portable devices, such as laptops and smartphones, consequently not requiring any additional product to be used. Such a technique relies on the extraction of the Blood Volume Pulse (BVP) from

face video recordings. This signal, even if less informative than the ECG, can detect the interbeat interval together with some other phase of the heart cycle.

Figure 3 Comparison of ECG and BVP signals.

This methodology is at early stage of development and its implementation is composed of five phases, related to five different technological choices:

- Face detection: face recognition and identification of the regions of interest (ROIs) in the target face;
- Face tracking: regions of interest tracking and extraction of RGB signals from the image;
- Pre-processing: extraction of the BVP signal from the RGB signals;
- Feature selection: selection of the features from the BVP signal;
- Classification: starting from the selected features, the algorithm should be able to discriminate among AF, healthy and another arrhythmia.

Each of the phases undergoes a literature review for understanding the latest advancements in the field and for creating a nurtured pool of options. The different sets are then analyzed and evaluated for arriving, in each of the phases separately, to an optimal choice, both from a technological point of view and from users' requirement perspective.

Generating a Solution

A deep evaluation of the face detection and tracking algorithms has been performed to overcome some present challenges in current heart monitoring techniques. As result, two different programming languages for algorithm implementation have been identified in Matlab and C++. These solutions differ substantially in some key parameters: computational speed, motion robustness, portability and ease of implementation. Both have been tested finding C++ more time-efficient and suitable for mobile devices. A further benefit of the second version is identified in the possibility of exploiting the potentiality of OpenCV library, an open source library for real-time computer vision. Several self-recorded videos that include different face movement and facial expression have been analysed for the algorithm validation.

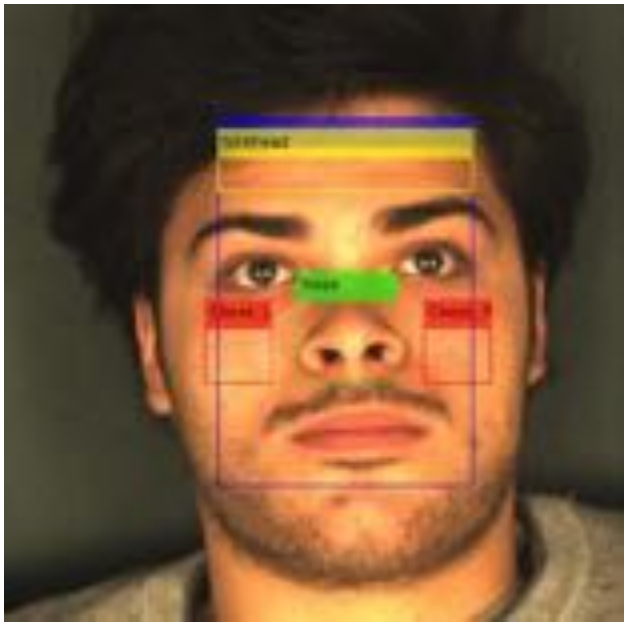

Figure 4 Identification of the regions of interest.

For the last three phases, signals have been recorded from 69 subjects recruited from hospitalized patients at Ospedale Maggiore Policlinico in Milan. Results obtained from different techniques have been compared to the standard ECG results. For the pre-processing phase, the method able to detect the most reliable BVP (defined as the most consistent with the corresponding ECG) from the video recording has been retained and it is recognized in the Zero-phase Component Analysis. Once the BVP is obtained, several features are extracted from it. These are found in literature and belong to four groups: time domain indexes, spectral analysis indexes, non-linear indexes and shape analysis features. Each of them has a defined range of values and properties for the identification and the distinction of patients in AF, healthy or other arrhythmias. Finally, from the selected features, the algorithm should perform a classification between healthy individuals, AF-patients and patients with other arrhythmias. The selection of the classification methods considers seven different methodologies (K nearest neighbours, neural networks, classification trees, support vector machine, fit discriminant analysis classifier, naive bayes classifier and classification ensembles) and evaluates them according to the accuracy, this is to say the rate of correctly classified individuals out of the whole sample. Out of the seven methods, K nearest neighbours displays the highest overall accuracy (higher than 80%). Furthermore, this method achieves the highest accuracy just considering three features.

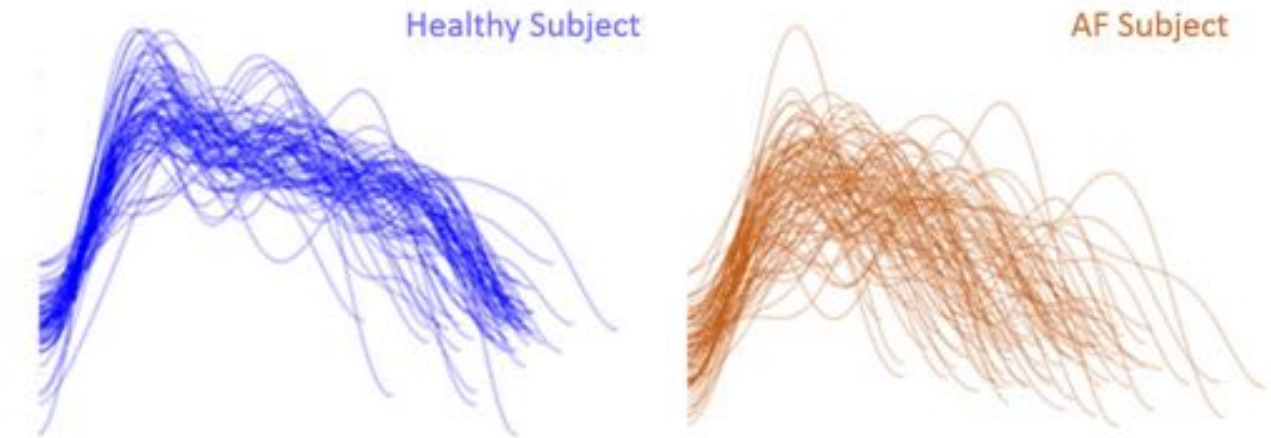

Figure 5. Difference in BVP between and AF patients and healthy individuals.

AFCam is then conceived as an internet and app-based two-sided platform addressed to consumers on one side and corporations on the other side. The two-sided platform provides individuals with the possibility to track their heart rate and BVP signal without need of contact, enabling the discovery of arrhythmias, especially AF, and the prevention of stress conditions. From the side of the corporations, a personalized and extendable contactless service is provided, giving the possibility to both employees and employers to track their own and their workers' conditions. Together with the conception of the business model, a business plan on three years (hypothetically 2017-2019) is redacted on a mock start-up considering also the strategy, the organization, financial projections and risk and key factors associated with the business. A user interface of the internet-based service is also formulated for illustrative purposes.

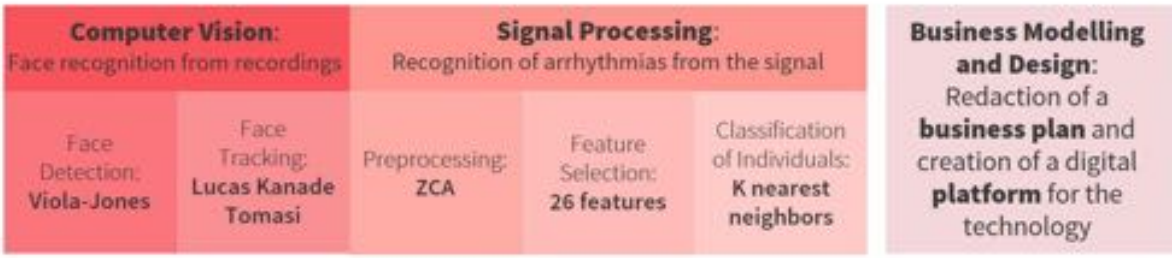

Figure 6. Technology and business decisions by phase.

The provided solution not only has undergone a scientific testing but it exploits cutting-edge methods both in computer vision, with optimized algorithm published in 2017, and in signal processing. In this latter field, the validity of the study has led to publication of a conference paper at CINC 2017. From a business side, new business models enabled by digital channels, such as two-sided platforms, are adopted, differentiating substantially the proposed service from the ones on the market.

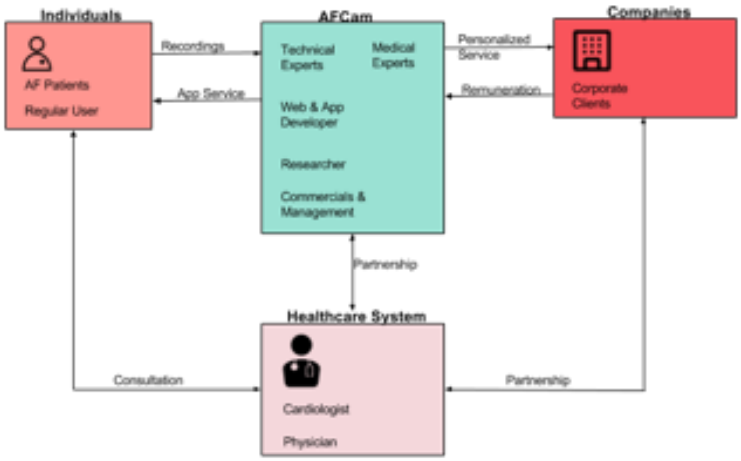

Figure 7. Scheme of the business model actors and functions.

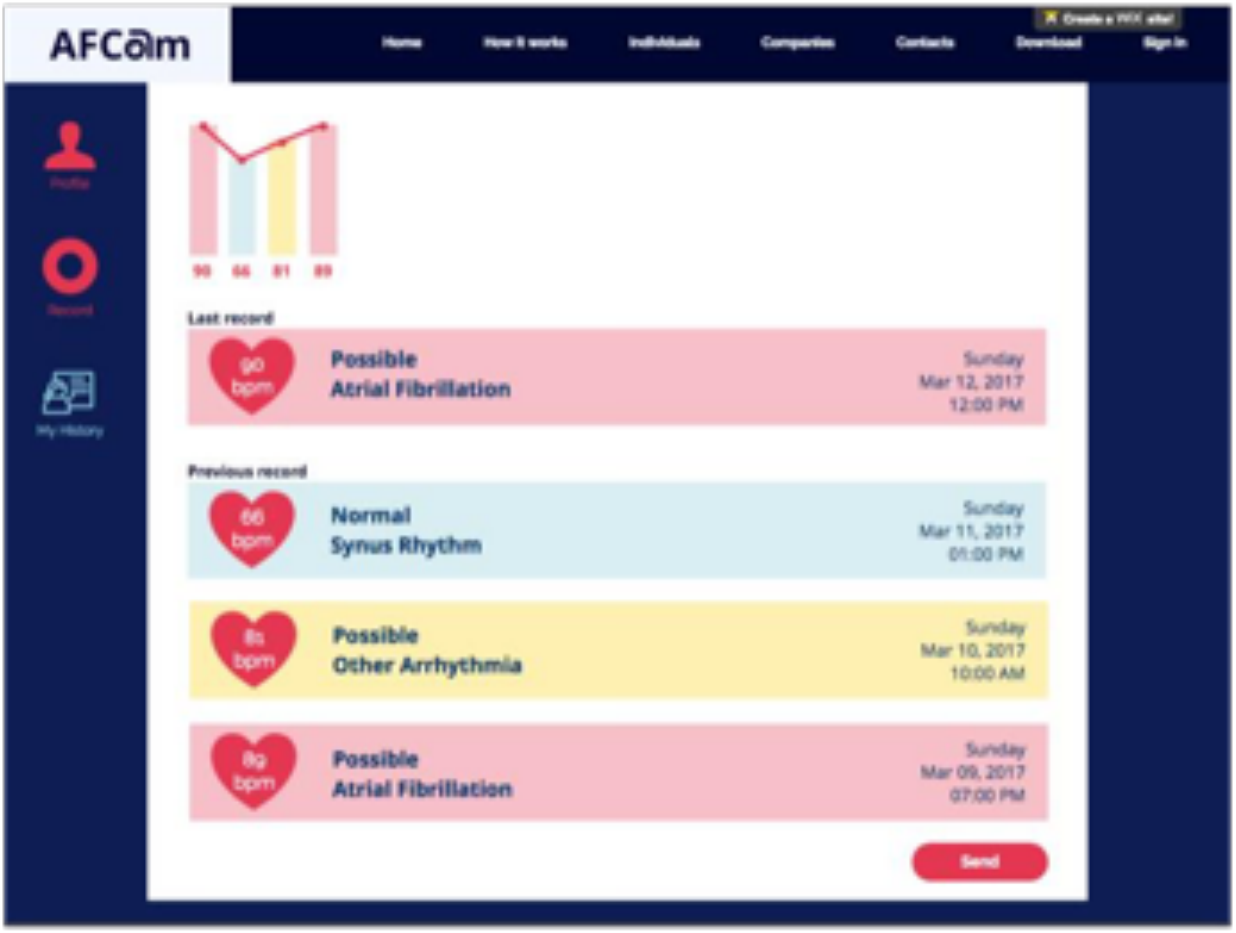

Figure 8 Design of the platform.

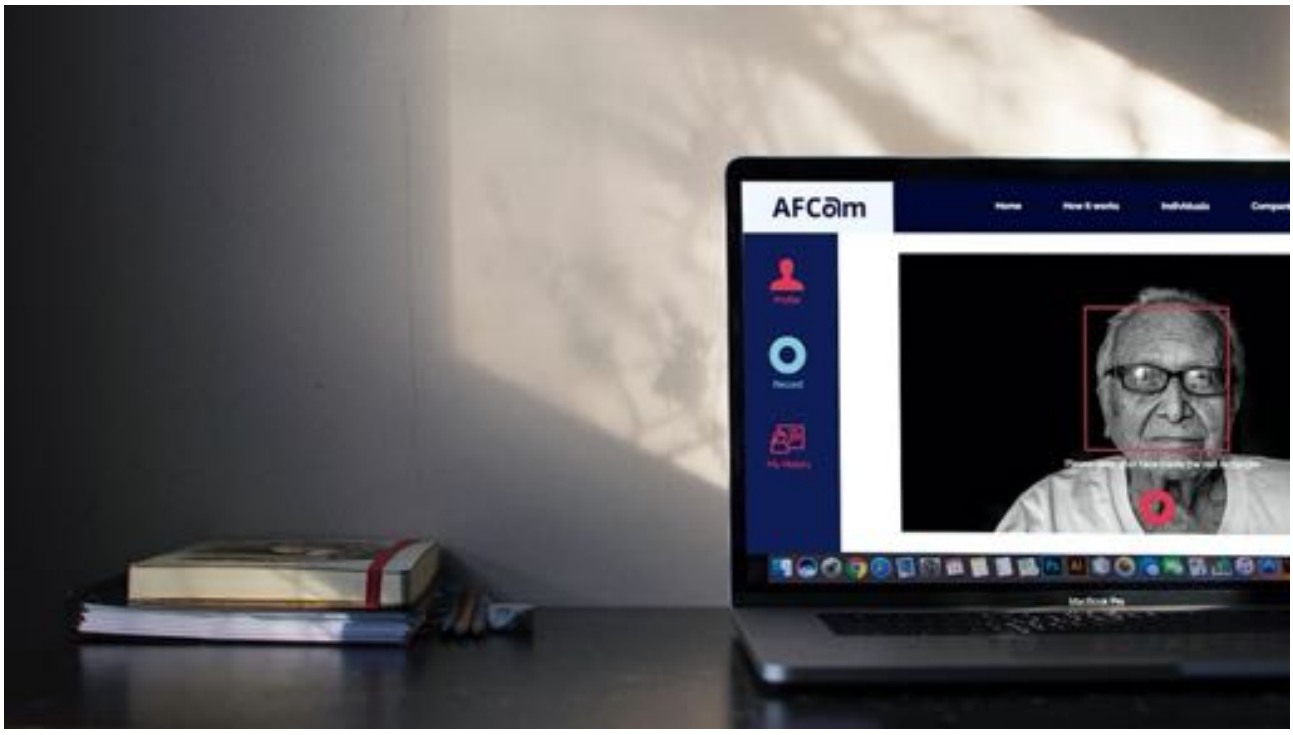

Figure 9 The AFCam platform design.

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Additional Material

AFCam Website – User Design: http://anindyafitriyanti.wixsite.com/afcam

Mock Business Plan: https://drive.google.com/open?id=0B-TJDwOWvawXdW9mNjBoRE12bTA

MODULA
Web Configurator for Automatic dispensing system

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Picture of the team

Description
The project addresses the development of a product configurator for Inkmaker s.r.l., an Italian SME, producing dispensing systems for inks and paints, acting on the B2B market. In an age of continuous technological breakthroughs, companies always need to ensure that the available technologies are employed in the best possible way. Moreover, the market in which the company is acting is characterized by some criticalities. In fact, customers simultaneously ask for: low price, short lead time, high product customization. To cope with these requirements, a two-steps approach is necessary: first, an improvement of the design and the assembly processes must be adopted, that will lead to the

modularization and standardization of the mechanical components of the machines, i.e. the final products. Second, the modularization will be used for realizing a product configurator. From this rough description, it is possible to grasp the intrinsic multi-disciplinary nature of the project. On the one hand, it is essential to understand the technical features of the products, so that the proposed modularization is effectively performed and supported by a solid and efficient IT solution; on the other hand, the economical results of this new paradigm must be taken into account, leading to an analysis of the impacts of the solution, ensuring that the configurator fits correctly inside the company's sales process.
This complex task has been performed with a scientific approach: identification of the main stakeholders and definition of their requirements; analysis of the state of the art; feasibility analysis; technical implementation.
Starting from these initial steps, three teams have been identified. A technical team worked on modularization of the machinery components, resulting in the definition of modules. Another technical searched for the optimal way to implement the product configurator.. In order to ensure that the definition of modules into final machines could be performed automatically, an optimization model has been introduced. Lastly, a business steam – mostly oriented on business and company economics – analyzed the business context, studied the impacts of the configurator and interviewed some customers of the company. The received feedback was then reported to the technical members, so that it was possible to improve the final implementation. Thus, these activities resulted in the final development of a functioning prototype of the product configurator.

Tasks and skills

Stefano Amato: *as a technical consultant, he analyzed the product features, designed the mechanical modules and worked on the parametric implementation of the modules.*

Alfredo Fantetti: *as a technical consultant, he analyzed the product features, designed the mechanical modules and worked on the parametric implementation of the modules.*

Sara Mottola: *as a business consultant, she worked on the requirements analysis, defined the process mapping and analyzed the internal impacts.*

Giovanni Prencipe [Team Controller]: *as the team coordinator and business consultant, he worked on the requirements analysis, studied the external impacts, edited the final report and managed the budget.*

Andrea Radaelli: *as a technical consultant, he investigated the state of the art of product configurators, designed the system architecture, and implemented the software.*

Arianna Rosa Brusin: *as a business consultant, she worked on the requirements analysis, defined the process mapping and analyzed the internal impacts.*

Alex Saja: *as a mathematical consultant, he worked on the state of the art, developed an optimization model and implemented it in an executable program.*

Keywords
Product configurator; Customization; Co-design; Modules standardization

Abstract

Nowadays, the increased competition on the global markets pushes companies to face the trade-off between volume and variety. Customers simultaneously ask for huge quantities and very specific product requirements. New strategies are required to keep high the competitiveness.

This challenging context has lead Inkmaker to establish some ambitious objectives and envision the project MODULA. Inkmaker s.r.l is an Italian SME realizing dispensing systems for inks and paints. Through MODULA, Inkmaker wants to achieve the following strategic objectives: realization of the machines co-design; modules standardization; reduction of lead time. They all converge in a design and manufacturing standardization. The adopted solution is an online product configurator.

To develop the solution, a scientific approach has been applied: identification of the main stakeholders and definition of their requirements; analysis of the state of the art; feasibility analysis; technical implementation;. Future steps are represented by the integration of the solution with the company ERP and the extension to all the portfolio.

Understanding the problem

Inkmaker's value proposition includes efficient and customized products, high reliability, great assistance service, and a cost based pricing scheme that has a relatively good profit margin.
However, in a context of fierce competition, to keep being profitable, it is necessary to: reduce costs; grant the maximum level of product customization. In fact, customers simultaneously ask for huge volumes and wide product variety. To keep high the competitiveness, the company would like to increase the internal efficiency - through a design and manufacturing standardization - and to improve the customer satisfaction.
To meet these ambitious objectives, the current project has been conceived: the implementation of a product configurator that will allow to realize the machine in co-design, with higher accuracy and design automation. Furthermore, the delivery lead time will be reduced.
The company realizes different type of products, that can be divided into two broad categories: small, relatively similar machines (called Croma) and large, more expensive, configurations. Since the first type of products could be better designed with a modular approach, they have been selected has pilot products for implementing the adopted solution.
After having outlined the context and the main stakeholders, the team identified a list of different requirements:

1. **Company** requirements, developed after a series of meetings with the company's employees, that can be classified into technical and business needs. The former ones refer to the products features, the latter involve the mapping of all the phases of the design and the selling processes. Moreover, the supply chain structure has been analyzed, resulting in the inexistence of a standardized process. This scenario often causes feasibility problems for the project of machines and time delays. The team recognized the needs of having the entire design process, from the first touch of the customer to the generation of the machine (Bill of Materials), of granting the right level of assistance to the customer and finally of granting customizability to the machines, responding to customers' needs.
2. **Customer** requirements, understood by means of a structured questionnaire, highlighting the desire of customers' of an online platform and the need of a short and efficient configuration process.
3. **IT** requirements, gathered from stakeholders interviews and analysis of the state of the art, which reflected the need of an online, easy-to-use and entirely automated solution.

Exploring the opportunities

To comprehend the effects of the adoption of a product configurator, a four step methodology has been adopted, with the original contribution of adapting popular literature models to small ETO companies.

1. Analysis of the as-is business model, based upon consideration of the classical business model canvas.
2. Analysis of the internal organization, that aligned the push for a configurator, with a modification of the manufacturing strategy.
3. Analysis of the supply chain, with a schematization of the supplier side, as the introduction of a configurator would involve.
4. Definition of the to-be state, where the desired scenario has been described.

This methodology has been applied within the paper “Deployment of product configurators: analysis of impacts inside and outside the user company”, presented at the 14th Conference on PLM, in Seville.

Discussion of the two papers at the 14th Conference on PLM, in Seville - Giovanni Prencipe and Alfredo Fantetti

The main internal changes - with respect to the user company - refer to the following processes: sales, design and manufacturing. Currently, the selling and the design process are conducted through the traditional human-based communication channel. Several interactions with customers are necessary, during the design process, due to misunderstanding of customers' requirements. This leads to high lead times. The introduction of a product configurator would automate both the selling and the design process, drastically reducing the lead time and increasing the accuracy: customers input the requirements and automatically obtain the machine BOM and the layout representation. Significant impacts involve also the manufacturing process. In fact, a standard modules inventory will be kept. After having received the order, Inkmaker simply has to assemble them, with a reduction of the manufacturing lead time. A total delivery lead time reduction of 58% will be achieved.

The external impacts involve: the supply chain, the market and the society. The impacts on the supply chain refer to a better integration and coordination with customers and suppliers. In fact, on the one side, customers directly configure the desired machines; on the other side, a better coordination with suppliers is necessary to manage the modules inventory. The presence of this stock will change the structure of the supply chain: it represents a downstream shift of the customer order decoupling point transforming the ETO configuration in an ATO one. Moreover, the implementation of the configurator would grant a higher competitiveness for Inkmaker who will be the first mover with respect to this new technology. Finally, the adoption of this solution can be seen as the first step to achieve the implementation of a Factory 4.0.

Product configurator: impacts evaluation

Generating a solution

Similarly, a structured plan has been employed in tackling the technical development of the configurator, resulting in a three-step procedure.

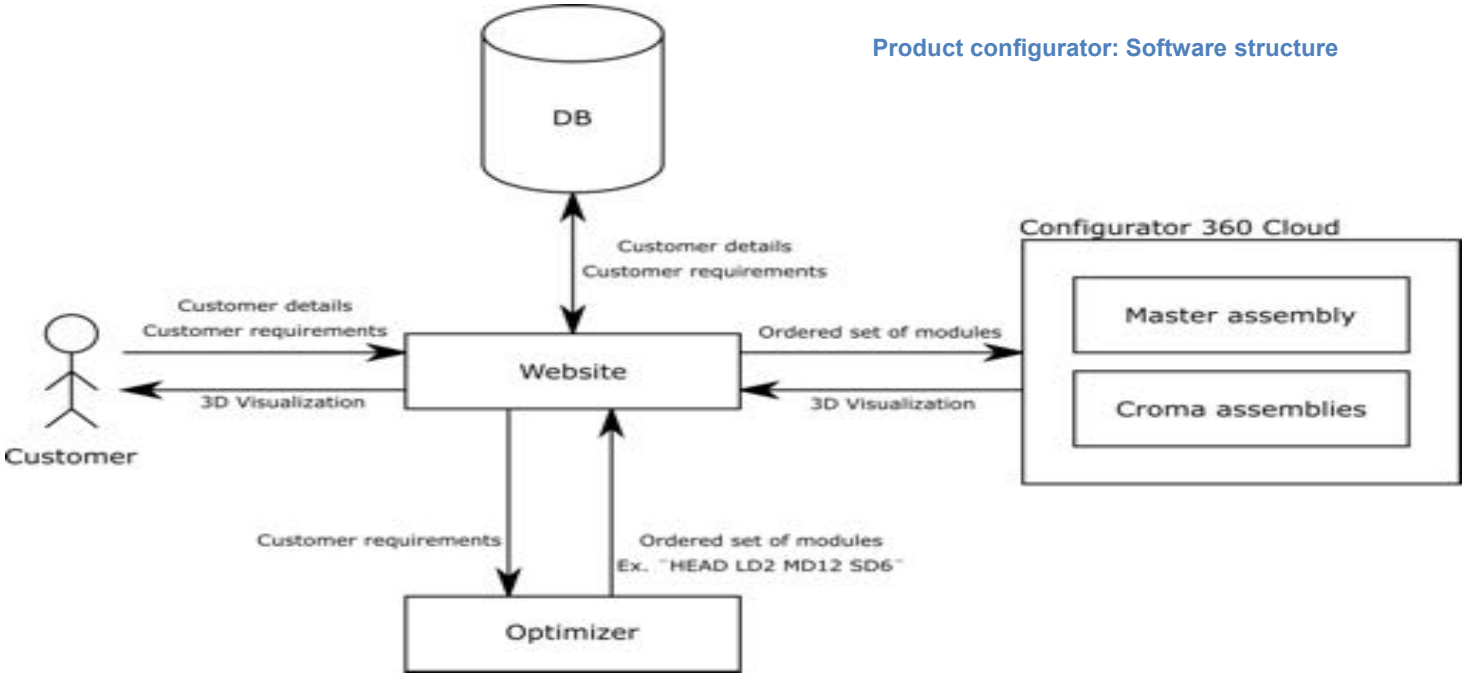
1. Technical standardization. This step consists in interviewing product experts and consulting company documentation to retrieve information about the knowledge and reasoning process underlying product development, leading to the definition of standard machine modules.
2. Knowledge representation. This step consists in the design of digital representations of the modules altogether with their bill of materials and engineering drawings, and of an optimization algorithm, able to compute the optimal allocation of the modules in the machines according to the customers' inputs.
3. Configurator implementation. The last step consists in implementing a software able to take in input the customer requirements, analyze them, and provide all the product information and specification necessary to validate the design and start the manufacturing phase.

This methodology has been described within the paper "Automatic configuration of modularized products", presented at the 14th Conference on PLM, in Seville.

The team started by analyzing past projects and realized that, among the different constraint types, topology played a major role. Each module consisted in a structural part, in electrical and hydraulic connections, and in a different number of slots for containers, that are of two different types (large or small). On the one hand, a low total number of modules was desired (to reduce variations), nevertheless it was necessary to define a sufficient set of modules. These opposing tendencies led to the definition of 15 modules, later applied on the past projects, with an 83 % of success. Not all projects could be solved with this approach, due to specific case limitations. These projects should be realized through the traditional design process.

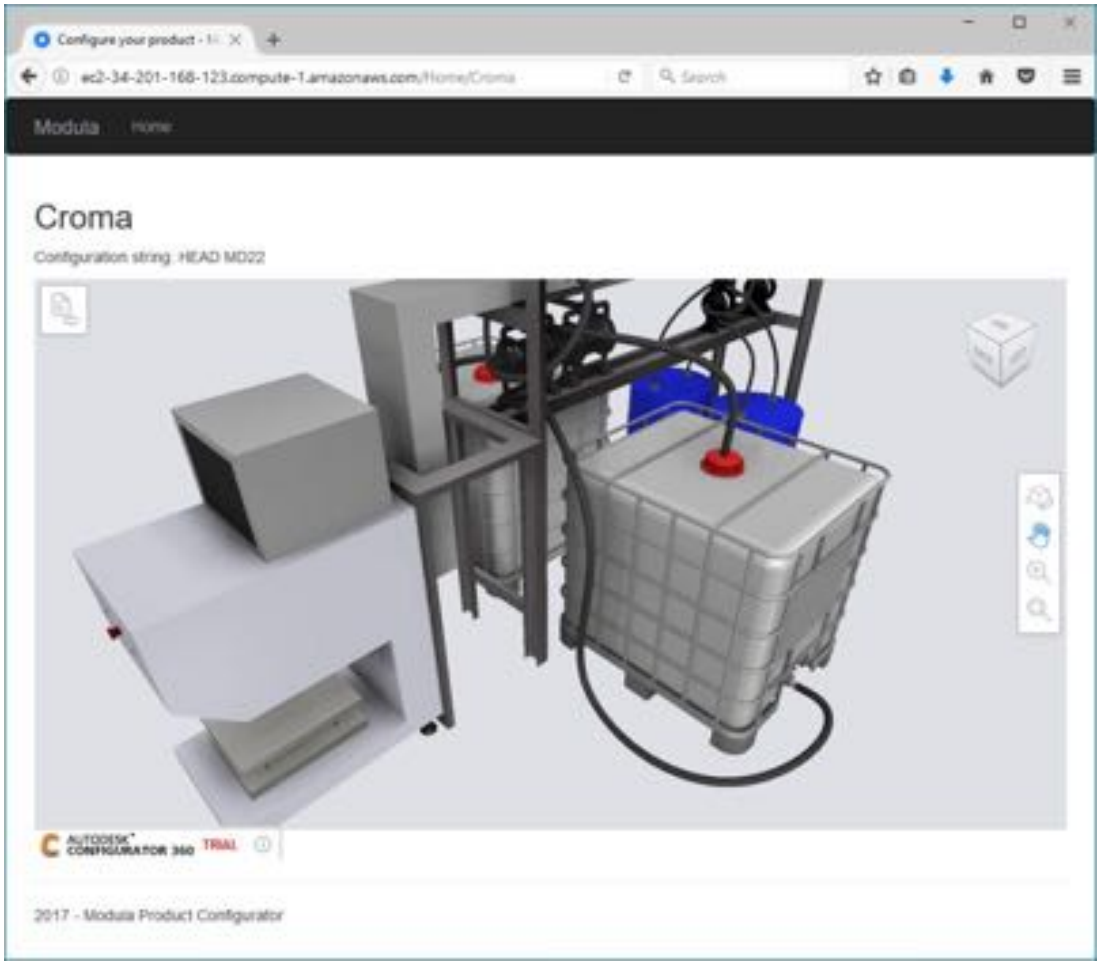
Success rate of test on past project

The modules identified have been digitally designed using a professional CAD software for mechanical design: Autodesk Inventor. The designs contain all information needed to build a module: the bill of materials, their dimensions, and how they are assembled together. Finally, it was possible to develop a prototype product configurator.



Product configurator: Software structure

The prototype is composed of four software components: Autodesk Configurator 360, the Optimizer, a database, and a website. Configurator 360 is a cloud service exposing the functionalities of managing the CAD files of the modules, generating the assemblies, the 3D visualizations, and the engineering drawings. The Optimizer is a custom program for solving the mathematical optimization problem of translating the customer requirements into the optimal set of modules minimizing the spatial needed. The database stores the information about the customer, their requirements, and their orders, collected during the configuration process. The website provides an interface accessible to any device with a web browser which can be used to configure a custom ink dispenser.



Prototype: screenshot of a machine configuration

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***Inkmaker* s.r.l.,** http://www.*Inkmaker*.com/.

WaLi Water for Life

Exploring Urban Landscapes for Water Harvesting with New Technologies

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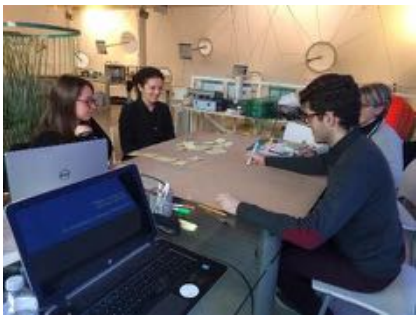




PROJECT DESCRIPTION

Water resources are the core of any sustainable development, but they have been highly affected by unsustainable development and lack of appropriate government policies, and that brought the constantly increasing demand for fresh water. If the balance between demand and availability of a limited resource will not be restored, the world will have to cope with a dangerous global shortage of water.

The aim of WaLi project is to propose an alternative solution to the increasing problems of water scarcity, through fog harvesting technologies, therefore taking inspiration from nature, and demonstrate that this solution could be applied at the urban scale for different purposes.

The main goal of the project is to create an alternative, innovative solution to conventional fog harvesting devices. The project investigates a wide range of relevant cases of Fog Water Harvesting, in order to establish parameters to identify urban and regional contexts where to define design strategies. It defines the framework of social and economic feasibility of fog harvesting technology integration into urban context, and the study of the most promising textile materials. The result includes the development of novel concepts of integration of fog water harvesting elements into and collective spaces, the definition of scenarios on the expected effects of the project in terms of regeneration, activation of places, raising awareness and possible consequences.

If in developing contexts the availability of water profoundly changed social relations, in the developed one it is expected to rather create a “green” conscience in the wider public and start a network of sustainable approaches to resource extraction and replenishment.

Also noteworthy is the landscape and cultural impact of such devices. The design idea developed is also meant to become relevant in specific contexts, thanks to multiple functions, offering locals designed and customized urban furniture, a place to have leisure time and creating a landmark, one that can rather become distinctive, promoting its image worldwide as a sustainability model.

TASKS AND SKILLS

Lucas Bandeira Calixto - state of the art research (fog water harvesting, case studies), problem detailing (location selection, stakeholders), design solution(location)

Runze Li - state of the art research (fog collector components), problem detailing (location selection), design solution (elements of the design, business model canvas, framework of social and economic feasibility)

Federico Lorenzon - state of the art research (fog collectors morphology), problem detailing (stakeholders), graphics

Sara Miladinovic - state of the art research (fog water harvesting, case studies), problem detailing (scenario identification), design solution

Gloria Morichi - field of research, state of the art research (fog collectors morphology), problem detailing (scenario identification), design solution

ABSTRACT

Water is critical for the sustainable development of our society, regarding social, economic and environmental progress. However, water resources are limited, especially the fresh water. And, the global water demand is anticipated to increase by 55% by 2050, because of population growth, urbanization, food and energy security policies and climate change. Moreover, different regions in the world face with various water problems and degree of severity and are already in need of some efficient alternatives.

One of the most promising solutions is fog water collection and in order to understand its functioning, different fog forming processes are studied, as well as efficiency, determining factors for its success and the typical and most common design and construction of the devices.

Further on, five fields of study (agriculture, urban design, building components, domestic use and outdoor activities), where fog harvesting techniques could be applied, have been considered. We also took into consideration different parameters, such as economic benefits, possibility of mass production, life cycle, market attractiveness and sustainability, for each scenario both in European countries and non-European ones. After a SWOT analysis, urban design field was chosen and a pilot project location was proposed among eight places from four continents.

Then, in the design phase, a modular hexagonal structure is considered. It is multifunctional and can be combined into complex structure, customizable according to different functions and users, being able to meet requirements of different contexts. While detailing design specifications, a business model was elaborated, to show the relationship among activities, partners, customers and revenues and a promotion strategy was presented to increase the customer segment, attract investors and increase water issues knowledge. In the end, socio-economic feasibility and sustainability of the project are also analyzed.

In conclusion, the implementation of fog harvesting technology into urban design devices is a new idea that, even if the requirements for its application differ in relation to the context, have high chance of improvement and large possibility of generating a positive impact on urban water resource management. Since in European context, water scarcity is not perceived as a problem yet, a possible perspective of lack of citizen's interest in the project pushed the design towards a solution mostly aimed at attracting people with an interactive and multifunctional proposal.

UNDERSTANDING THE PROBLEM

The term 'water scarcity' can be defined as a lack of water quantity. Climate change is a central external driver that affects both water and demands for all uses directly. In this context, fog has the potential to provide an alternative source of freshwater in many dry regions. Fog can be defined as thick cloud of tiny water vapor condensed into small water droplets suspended in the atmosphere at or near the earth's surface. The small water droplets present in the fog precipitate when they come in contact with objects.

Fog collection is essentially any activity that collects water condensed out of atmospheric water vapor. Numerous plants and animals use textural as well as chemical features on their surfaces to harvest this precious resource.

The amount of water that can be collected by a fog collector is directly related to the fog liquid water content (LWC) and the wind speed. The LWC values typically encountered in fog collection projects range from 0.1 to 0.7g/m^3, with 0.2g/m^3 being a representative value. Practical wind speeds for projects range from 2 to 12m/s. A typical wind speed is 6m/s. In addition, the number of hours per day with fog can vary from 0 to 24. A typical value would be 6 h/day. The combination of these typical values would produce about 5 L of water from a square meter of mesh per day.

Regarding the device, full-scale fog collectors could be a simple, flat, rectangular nets of nylon supported by a post at either end and arranged perpendicular to the direction of the prevailing wind. Alternatively, the collectors may be more complex structures, made up of a series of such collection panels joined together. Physically, a plastic mesh is stretched facing the prevailing wind direction and thus part of the fog droplets are intercepted as the air passes through the mesh. Minute fog droplets coalesce and form larger water droplets on the mesh fabric and trickle down into an attached gutter. The collected water can then flow to a sedimentation tank through gravity, and ultimately to a domestic water supply and/or irrigation system.

EXPLORING THE OPPORTUNITIES

According to the previous research, few fields in which fog harvesting technique can be successfully implemented were evaluated: agriculture, urban design, private/domestic use, building components and outdoor activities.

For the evaluation of all the possible scenarios, we took into consideration different variables, such as economic impact for production, social benefits, improve in sustainability, market attractiveness, and after the results were weighted, urban design and outdoor activities scenario emerged as the most promising ones.

After SWOT analysis, urban design (figure 1) emerged as the best field for fog harvesting technology implementation. The major factor that led to this choice was the goal of the present work, which aimed to reach the widest public possible and, above all, have the highest positive impact on environment and improve people's attitude towards water management practice.

Fog harvesting technique implemented into urban design project is a solution that can achieve positive results both in terms of fog water collection itself and of raising attractiveness of the technique for companies, and raising awareness for citizens.

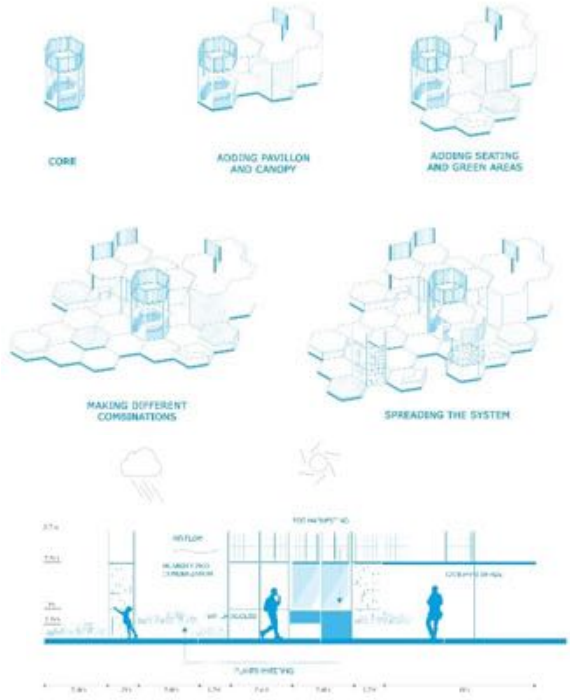
Regarding the project location, a study on climatic, social and economic condition in different cities was made. Tenerife scored the highest grade among the location considered. In Tenerife, fresh water is less abundant than in mainland Spain, as the island relies mostly on cloud water. The usage of fog harvesting devices could contribute not only to the local agriculture, but also to reduce the stress on hydric resources currently exploited, especially during high tourism seasons.

Among the other locations considered, Lima and Milan emerged as possible adequate options. Lima's hilly periphery makes it especially difficult for the construction of piping water distribution infrastructure, and so fog water harvesting is a promising way of supplying the city with its fresh water needs. Any fog water harvesting projects would not be big enough to supply the whole metropolitan area with fresh water. However, smaller scale projects placed in specific areas of the city could show some improvements

Milan represents a typical European metropolitan area, that is not currently jeopardized by water scarcity. It is moving towards a sustainable city model, therefore any innovative strategy of water management is a step closer to this goal. It would attract people and investments into the city, as well as raise awareness on water scarcity issue.

GENERATING A SOLUTION

The design process mostly consisted of literature review and analysis of existing fog harvesting techniques. New design alternatives should not be based on complicated shapes because the strength of the fog collection technique lays on the simplicity and adaptability of the system. Starting from a hexagonal footprint (inspired by the honeycomb structure), and extruding it to vary in its height, we came up with three - dimensional modules that seem the most efficient way to response climatically to fog water capture aspects.



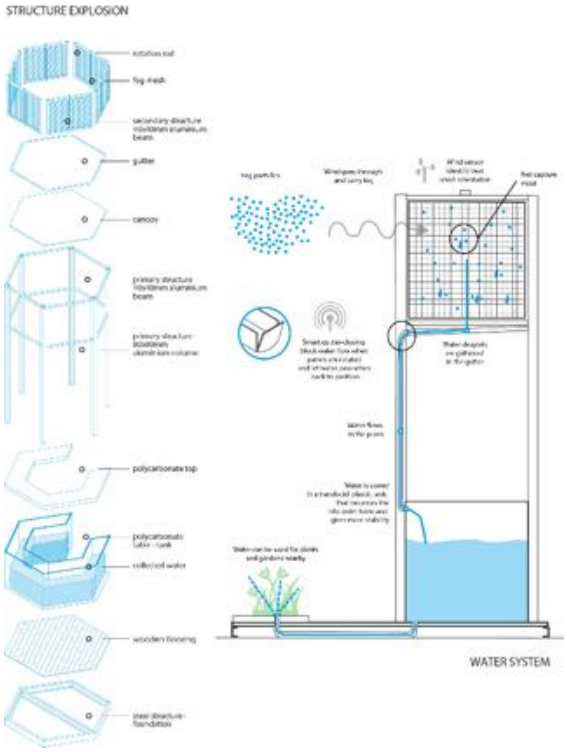
Various configurations may be arranged. An element always present in each configuration is the core, that represents the main fog collector. With every single hexagon module, we wanted to include different functions, so they correspond to individual users.

The design is easily customizable and it is suitable to a wide range of given conditions.

As for the functioning, the fog cloud passes through the net, which captures small water particles and creates water droplets. The water falls to the gutter and to the pipes, being collected in the plastic table/ tank and then stored to be used in different ways. Sensors are placed in the top of FHD to choose the best orientation for the mesh while a smart system with water level sensors decides the timing to put the panel back to the original position.

The elements of the design used in the project are:

- The foundation - temporary structure, integrated with the upper structure.
- Lightweight structure - aluminum (square hollow sections 80mm×80mm for columns and 40mm×40mm for beams).
- Mesh - 3D polyester textile FogHa-TiN mesh, highly efficient and wind resistant.
- Sensor - an anemometer to measure wind speed and a vane to measure wind direction. This enables the mechanical system, to turn the net to face optimal direction to collect water efficiently.
- Distribution system - PVC pipes with a diameter of 60mm, that convey the water into water tank.
- Storage system - a water tank, integrated as a part of the core. Besides, it could also perform as an additional foundation, improving the stability of the structure.
- Smart screen - a database and interactive platform.



A promotion strategy is a fundamental way of getting closer to the public, in order to increase awareness about the water issues, as well as to draw attention of the possible future development and investment. Education can be a key to success. For this reason, our solution has an educational emphasis not only in the initial stage but maintains it throughout the entire project. A design made of nature-based principles can shift the way in thinking towards a more competitive, resource efficient and greener economy.

From a future perspective, this solution avoids consuming environmental resources and it could cut maintenance costs for green areas and water resources, offering a new alternative to improve water management. By

introducing this new topic of urban fog harvesting, the educational goal will possibly result in a positive economical outcome, so that this water management technique will become a common and widespread tool.

As architects and planners our task will be re-engineering cities, developing systems, networks and technologies to reduce water scarcity. Urban Fog Harvesting is one those systems (flexible, adaptable, responsive, scalable, and non-linear), which works as interface with the environment, trying to address or mitigate it operating at the scale of an area within the city.

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TAGS

#Sustainability #WaterManagement #EnviromentalDesign #FogHarvesting

MINT

MEMRISTIVE NEUROMORPHICS FOR SMART INTERNET OF THINGS

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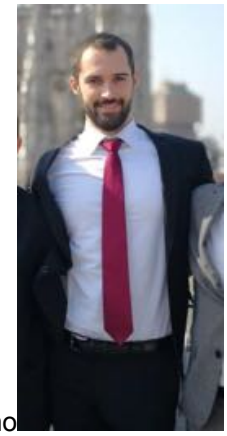

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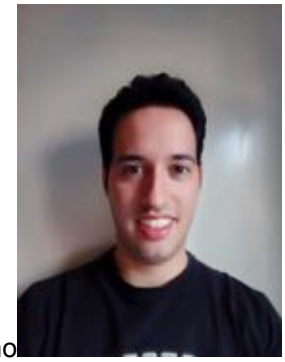 **Luca Nanni,** Computer Science and Engineering, Politecnico di Milano

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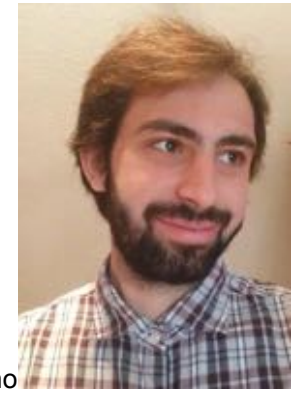 **Antonio Picano,** Engineering Physics, Politecnico di Milano

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Project description

At present the analysis of massive amounts of data is generally performed in the cloud by remotely accessing large computing resources. Cloud computing is however plagued by security limitations, lack of flexibility and excessive costs. In addition, conventional digital hardware has inherent difficulties in processing unstructured and multimedia data (video, audio, etc.), which instead are straightforwardly recognized and elaborated by the human brain. Power consumption is also a huge concern for data processing, especially for Internet of Things (IoT) applications which rely on energy scavenging for distributed sensing. These problems may be addressed by embedded intelligence, such as low-power neuromorphic circuits, aimed at real-time screening and pre-processing of data before they are transmitted to the cloud. In the last years, one of the main innovations in the field of electronic circuits consisted in the discovery of the memristor. This device is able to store information through a variable resistance, which can be modulated by specific input voltages. The variability of the resistance state which allow this component to assume values in a continuum range is of great potential with respect to current transistor based digital memories simply characterized by only two resistance state. Due to this peculiarity, the memristors have the potential to increase considerably the circuit density and are great candidates to replace the transistor in the for the future of digital memories. Furthermore, the large range of possible resistance states makes the memristor a very plastic device. Thanks to this plasticity property it can be used for building pattern classifiers.

The MINT project aims at evaluate and compare the usage of the memristor technology with respect to more classical electronic devices in the context of pattern recognition problems. In particular, a specific case study has been analyzed: the detection and classification of Arrhythmia patterns from ECG data. The arrhythmia case has been selected since it is a widespread disease indeed about 14 million of people in USA, a prevalence of 5% are affected by it. Part of the project focused on the understanding of the current trends of the IoT health market and of the possible product concepts applicable to this kind of health problem. The team developed a business model specific for the selected case study and gathered data from the different stakeholders. A final assessment selected the best product concept on the basis of the user requirements and the feasibility study previously conducted on the memristive technology, which was conducted as follows.
First of all a model of a memristor-based pattern classifier has been developed. This model has been tested on the MIT-BIH dataset of labeled arrhythmia patterns. Its performances has been compared to the one obtained by using a different device, BrainCard, which is a pattern recognition board for IoT applications developed by General Vision. The result of the comparison led to the design of a device targeting the arrhythmia classification problem.

Tasks and skills

In order to tackle the complexity of the project we decided to split the work between different subgroups.

The ***Laboratory and experiments group*** focused on the practical and experimental study of the memristive technology and other embedded solutions. The members of this group were **Luca Nanni** and **Gianluca Papa**.

The ***Business and market analysis group*** analyzed the IoT market and the selected application market in order to understand the main actors, their needs and extract the main requirements. The members of this group were **Paolo Ludovico Razzoli** and **Flavio Giobergia**.

Finally, the ***Theory and simulation group*** focused initially on the theoretical study of the memristor and on the machine learning and pattern recognition problems and later it designed a set of simulations in order to experiment the recognition capabilities of the memristive technology using a mathematical model. The members of this group were **Diletta Milana** and **Antonio Picano**.

Follows a more detailed description of the team members:

- **Flavio Giobergia** Computer Engineer specializing in data science. After getting an initial understanding of the memristive technology, Flavio tried to bridge the gap between the technical and the business sides of the project. Along with Paolo, he took care of the market analysis, concept definition and business model ideation.
- **Diletta Milana** Computer Scientist and Engineer specializing in Artificial Intelligence and Machine Learning, currently focusing on Deep Learning. Diletta analyzed the state of the art for arrhythmia detection and implemented the software simulations of the memristive network
- **Luca Nanni**: computer scientist and engineer with a specialization in artificial intelligence and machine learning. He worked at the implementation of the arrhythmia detection algorithm on the Braincard and at the laboratory analysis of the memristor.
- **Gianluca Papa** automation and control engineer specialized in modelling and control theory. He worked in the laboratory for the characterization of the memristive device and analyzed the current used algorithm for the arrhythmia detection.
- **Antonio Picano:** physics engineer specialized in condensed matter physics. He worked in the laboratory for the characterization of the memristive device together with Luca and Gianluca, and on simulations together with Diletta.
- **Paolo Ludovico Razzoli:** management engineer specialized in international economics. He worked on the business model side of the proposed application together with Flavio after a comprehensive research on IoT trends in healthcare.

Abstract

This project focus on the evaluation of the memristive technology applied to a specific pattern recognition problem. In particular, we selected as pattern recognition problem the arrhythmia detection and we compared the memristive technology performance with the currently used one based on classical technology.

The memristor is a newly discovered electronic component that can be used for building complex neuromorphic chips for pattern recognition and anomaly detection. Memristor-based neural networks are low power when compared to other kinds of hardware networks. On top of that, they allow for on-the-spot processing of data, without relying on cloud computing. This makes them a perfect tool to be used inside embedded systems and in particular in the context of the Internet of Things. While this

technology is unlikely to replace – at least in the near future – clusters of computers dedicated to the recognition task, the limited power consumption of this hardware-only technology makes it an appetible candidate when the context imposes constraints on this regard. The identified solution to the arrhythmia detection problem makes use of this peculiar feature of the memristors.

The project has been aimed at analyzing the feasibility of the application of this technology for neuromorphic purposes, highlighting strengths and weaknesses of such an approach when compared to other existing technologies.

Understanding the problem

The *memristor* is the fourth fundamental circuit element, after the *resistor,* the *capacitor* and the *inductor.* Its peculiarity is that it has a resistance that depends upon an internal state and, in particular, on how much electric charge has flowed in what direction through it in the past: the device remembers its history. When the power supply is turned off, the memristor remembers its most recent resistance until it is switched on again. Because of this, it is suitable for the emulation of synapses: this is why it finds its natural application in *neuromorphic computing* (as well as in *non-volatile memory* applications). Additionally, memristors are characterized by a low power consumption: this is ideal for cases where devices collect large amounts of data and need to process them, as is the case with the Internet of Things.

The ever-growing data generated by IoT devices needs to be processed in order to extract meaningful value: doing so locally significantly cuts delays, power consumption and data transferred. This is of particular importance in the wearable sector, where devices are required to have a long battery life and cannot be always connected.

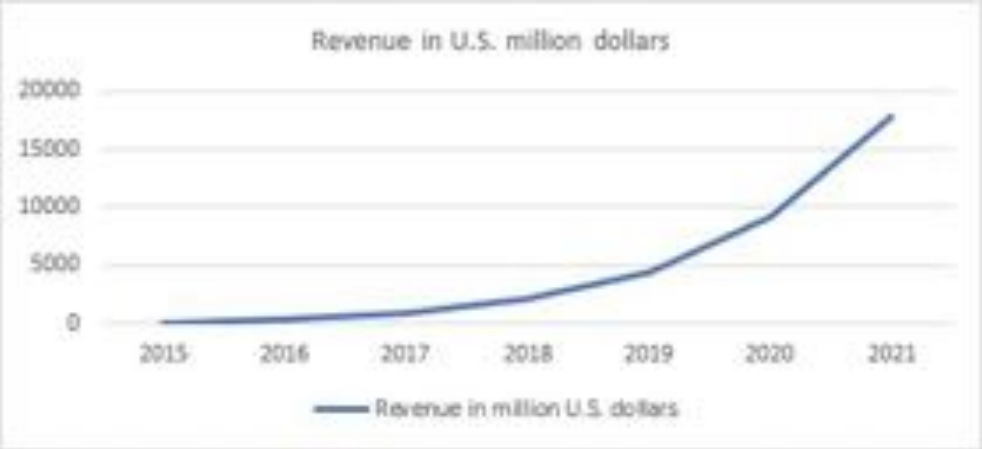

Figure 1 *Expected revenue of the wearable market in the next years*

The wearable market has experienced a huge growth in recent years, and is expected to do so exponentially in the years to come. One of the most important applications of this technology can be found in the health sector: vital parameters can now be tracked 24/7 with small, non-invasive devices. While today's technology already provides satisfactory results, the final consumers are unhappy with some of the problems imposed by the technological limits – first and foremost the short battery life available. Despite that, the state of the art is being redefined by new, more advanced technologies such as the memristive one. This, as explained, will allow for smaller, more performant devices.

Exploring the opportunities

After conducting the research on memristor technology and the market of health devices in the context of IoT technology we have deeply explored the universe of health monitoring devices. This enabled us to understand what is currently available and the state of the art of detection technologies in the field of arrhythmia and what will be their future development. The result of our analysis pointed out that, the future generation of healthcare wearable devices will be characterized by very general devices able to capture and autonomously elaborate significant wide range of data without the need of any human input. This trends towards the autonomous functioning will be mainly based on the newest developed neural network based arrhythmia detection algorithm. This new approach leverages the autonomous extraction of relevant features from the data and it has been proven to be significantly more accurate than the hand-crafted feature extraction methods. What is required for this algorithm to work is a specific hardware architecture.

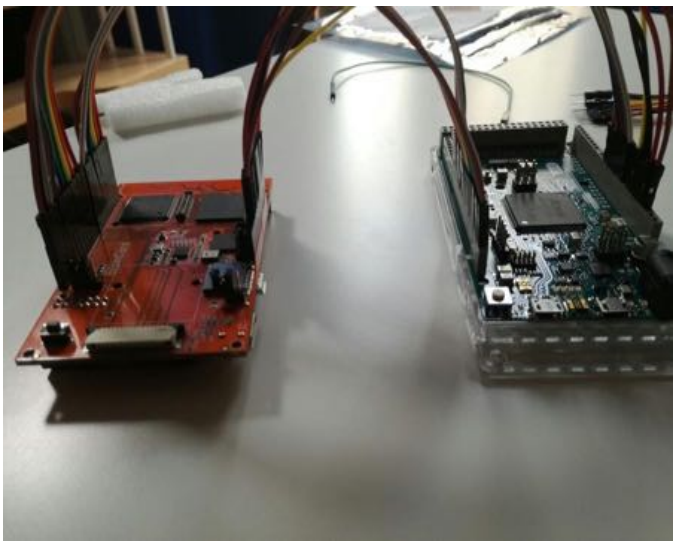

Figure 2 *Setup of the BrainCard experiments using an Arduino board as controller*

In order to identify the best architecture, we have compared two different technologies; the memristor based and the best option available on the market. For what concerns the memristor, we have defined a model that allowed us to exploit its strengths and weaknesses in terms of performance, size and consumption. For what concerns the C-MOS based architecture, we have not only realized and analyzed a software model but also work with a real physical device. To do that we got in touch with the General Vision a Californian company specialized in neuromorphic devices. This provided us with its most advanced pattern recognition chip called BrainCard.

The main components of the Braincard are the FPGA and the CM1K chip. The CM1K is a fully parallel silicon neural network composed by 1024 neurons which can store and process information simultaneously. The neurons can be trained either in real time or offline by providing them with learning examples without the need of any programming code. Indeed, it is enough to provide the Neuromem chip with a high quality labelled training data and it will do the rest.

Generating a solution

The first step for testing these two technologies consisted in the definition of a common training set. This was retrieved from the MIT-BIH Arrhythmia Database. The MIT dataset is composed by ECG signals. Each ECG signal has been labelled by cardiologists depending on the kind of arrhythmia it showed.

As far as the Braincard is concerned, we needed to establish a communication channel. This, has been accomplished thanks to Arduino, controlled using a specific Python library. Once established, the communication has been used to pass the preprocessed data directly to the embedded system which, after training, was able to extract the features useful for the arrhythmia detection.

The memristive technology has only been tested via simulation. Specifically, we implemented a simple memristive-based neural network (NN), a MultiLayer Perceptron (MLP) using Tensorflow. The behavior of the single memristor inside the NN model was designed to be as close to the one observed and reported during the laboratory experiment as possible.

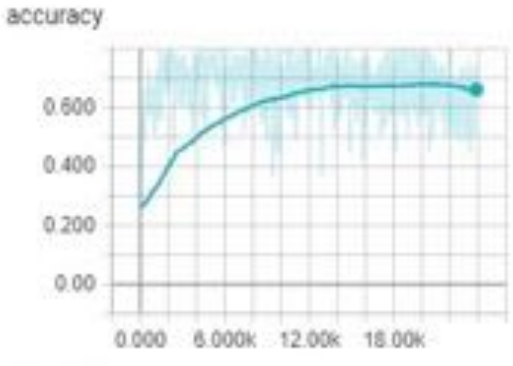

Figure 3 *Accuracy as a function of the training iterations for the memristive network simulation using TensorFlow*

After the training and testing phases the performance of the two devices have been compared. The results showed that the Braincard performs better when compared to the memristive-based model, which showed promising nonetheless.

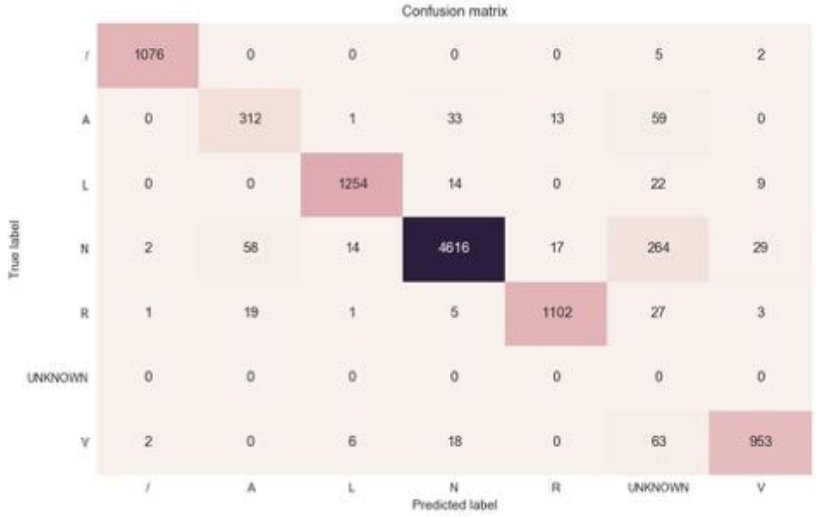

Figure 4 *Confusion matrix of the arrhythmia classification problem using BrainCard*

Furthermore, the two systems have been compared both in terms of power consumption and size. For the Braincard, these two pieces of information have been retrieved from the available datasheet. As for the memristive chip, the values have been obtained by considering both the size of the neural network and the average resistance values measured during the testing. The results showed that the memristive chip size is 100 times smaller than the Braincard, while the power consumption is reduced by a factor of ten. Overall, the reduced size of the chip and the overall power consumption resulting from the testing simulation balance the comparison with Braincard.

Given this superiority of the memristor when compared to other CMOS-based technologies, and given the promising results on the arrhythmia dataset, the next logical step is that of building a concept for a suitable device. In particular, the low power consumption and the chance of locally processing the data were found to be particularly suitable for a wearable device, and further design-centered considerations lead to the definition of a bracelet as the ideal product. Leveraging the information collected from potential customers, different features and characteristics have been further refined.

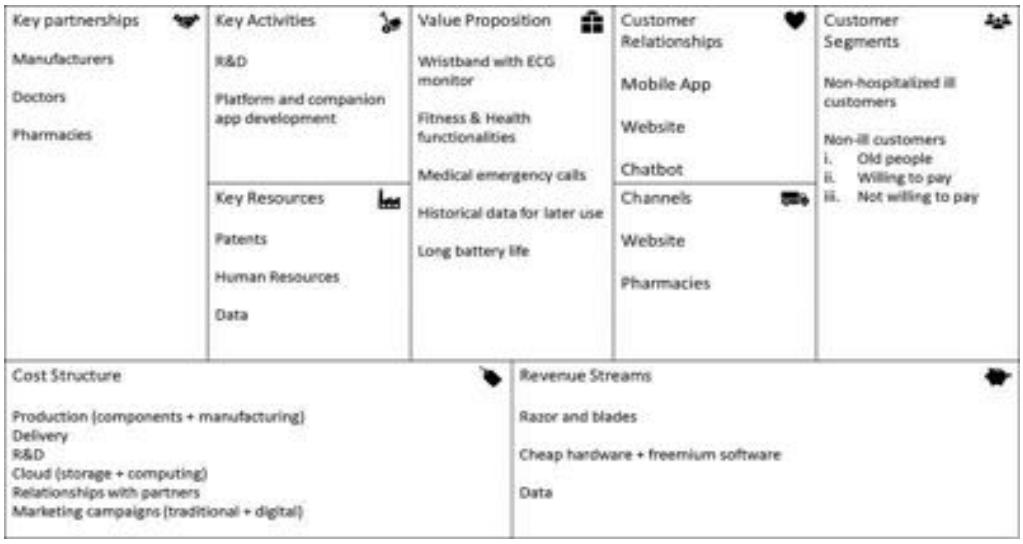

Figure 5 *Business model generated after the requirement analysis of the arrhythmia detection case study*

The business model for this product has then been laid out, with the bracelet as the core product. Considering that, based on the data collected and differently from what was previously thought, most potential customers embrace the idea of a cloud-aided service, additional Internet-enabled functionalities have been taken into account as a side, optional offering. While the basic arrhythmia detection feature of the bracelet has been thought as being able to work completely offline, the entirety of the collected data can be optionally stored and processed, thus offering an added value (e.g. evolution of the condition through time, or historical health information for future check-ups) for those customers interested.

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TAGS

Memristive technology,
Department of Electronic Information and Bioengineering,
General Vision,
CNR

MAP-Marginal Asset Project
Decisional Method for Adaptive Reuse of Disused Powerplants

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PROJECT DESCRIPTION

Figura 1. Team members during on site visit

Marginal Assets Project (MAP) has the aim to propose practices and recommendations for converting disused thermoelectric power plants maintaining their industrial heritage. In order to do so, the team committed to the project has been structured by choosing students owning different backgrounds and skills, thus allowing to cover all the fundamental aspects required to achieve satisfying results. However, throughout the whole duration of the project, each team member not only has provided contributions related to his/her academic background, but has also shown interest in enriching his/her personal skills by constructively interacting with the other team members in each step. Here follows the detailed description of MAP team members:

- Francesca Villa (Politecnico di Milano – Architectural Design): team controller of the group. She has successfully organized the group's activities and maintained contacts between the team and the academic tutors. She has contributed to all aspects of the project, from the phase of the analysis of both sites and then moving to designing the alternatives and evaluating them through ANP methodology.
- Sergei Bukreev (Politecnico di Torino – Petroleum Engineering): he has given his contribution through the whole project, especially helping in the understanding of all the plants' components which should have been subjected to adaptive reuse.
- Betsabea Bussi (Politecnico di Torino – Architettura Costruzione e Città): she has been present in all phases of the project, exploiting her knowledge in the stage of the analysis and design of the alternatives, as well as during application of ANP methodology.
- Daniel Cadoni (Politecnico di Milano – Management Engineering): he has taken part to the project particularly giving his contribution in the definition of the stakeholders and the definition of the economic aspects related to the proposals.
- Patrizia Dessì (Politecnico di Torino – Planning for the Global Urban Agenda): she has taken part in all phases of the project, by giving her contribution in both the analysis, ANP methodology and design of the alternatives by also producing their renderings.
- Paolo Palmieri (Politecnico di Milano – Environmental and Land Planning Engineering): he has given continuous contribution in all stages of the project. In particular, his skills have been necessary to provide environmental assessments and feasibility studies for the designed alternatives.
- Luca Teofani (Politecnico di Milano – Architecture): he has been present in all phases of the project, especially in the analysis of the world case studies, as well as in the definition of the reuse alternatives.

Overall, MAP team has worked as a tight-knit group, providing interesting reuse alternatives for both Bari and Campomarino sites. Indeed, the effectiveness of the work has been confirmed by the final rank of the alternatives proposed as final outcome of the project, since the top-ranked functional mix has resulted to be exactly the alternative proposed by the team.

ABSTRACT

The main issue addressed by MAP team is related to the adaptive reuse of thermoelectric power plants owned by ENEL, fallen into disuse due to their low level of efficiency compared to the alternatives available in the

current electricity production scenario. As project outcome, a complete set of recommendations and best practices has been provided, as well as proposals of adaptive reuse which have been carefully evaluated. In order to develop the work, the team has started with a collection of information, strengthen by an on-site workshop taken place at the two plants object of study (Bari and Campomarino). Subsequently, the analysis and organization of the data acquired has allowed to evidence strengths and weaknesses of both sites. Moreover, the individuation of the main stakeholders who could be involved in a potential project, has enabled to produce the first ideas of adaptive reuse. Indeed, the successive phase of the work has been focused on the elaboration and development of the proposals, evidencing a wider range of reuse opportunities (translated into functional mixes) in the urban context of Bari with respect to the rural area of Campomarino. As a consequence, it has been decided to compare and evaluate the alternatives only for the Apulian capital city. This task has been accomplished through the utilization of a multi-criteria decision analysis (Analytic Network Process), which has required to structure a decision problem as a dynamic model connecting the goal, the decision criteria and the alternatives. After imposing constraints and performing a first evaluation of the alternatives, the final step has involved mathematical algorithms used to weight the decision criteria and finally rank the alternatives (this final task has been performed by Prof. Salvatore Greco and Dott. Salvatore Corrente). The outcome of such procedure has highlighted a top ranked alternative, which resulted to be the functional mix proposed by the MAP team.

UNDERSTANDING THE PROBLEM

The aim of MAP project is to propose innovative and sustainable solutions to perform an adaptive reuse of thermoelectric power plants, fallen into disuse due to scarce efficiency both in economic and environmental terms. The work has been carried out in the context of "Futur-e Project", through which ENEL wishes to redevelop 23 power plants in Italy by maintaining their industrial heritage, and also strengthening the Company's relation with local communities. In fact, such initiative has been based on the "shared value approach", which consists in a close analysis of the context and direct involvement of local population.

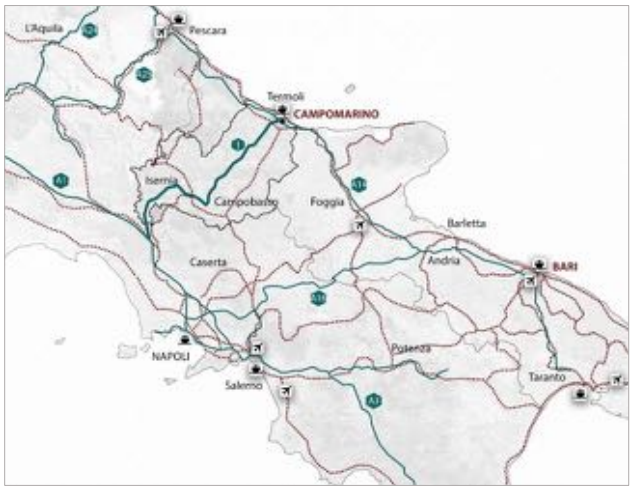

Figura 2 Powerplants localization

The first project phase has consisted of a survey of such industrial sites, subsequently resulting in the choice of Bari and Campomarino as case studies. These two plants have been selected to have the opportunity to analyse and compare two extremely different contexts: indeed, Bari power plant is characterized by a large size and is located in an industrial neighbourhood of the Apulia capital city, while Campomarino is smaller and situated in a rural area, far from any built-up area.

Figura 3 Bari Wet Cooling Towers

Subsequently an in-depth analysis and interpretation of the two sites have been carried out, focusing on the study of their characteristics (both structural and environmental), localization, accessibility and overall context. Moreover, a complete socio-economic analysis has allowed to have a full picture of the areas' potentialities. In order to perform an efficient work, a design workshop on both sites (performed during two days) has been conducted with the contribution of the external tutor ENEL, and it has been coupled with an inspection of the surroundings. During this phase, the attention has been focused also on the collection and classification of worldwide comparables, so as to start producing ideas applicable to the plants object of study.

Figura 4 Campomarino water tanks

EXPLORING THE OPPORTUNITIES

The second phase has exploited all the data obtained and organized in the previous step, by producing a SWOT analysis and a flowchart summarizing all the relevant information regarding the two sites, as well as regrouping the main stakeholders involved in a potential redevelopment project. Regarding Bari, it has been possible to recognize a favourable position of the plant in terms of accessibility and connections to the city centre, even though the immediate surroundings (being an industrial neighbourhood) appeared deteriorated and lacking of urban standards. The buildings of the project area were kept in discrete conditions, except for the northern part belonging to the gas tanks: indeed, this area has been highlighted as the main question mark of the site, due to absence of historical documentation (the plant area used to belong to a refinery before its opening in the mid '50s), unclear management of coal storage in the first years of activity and absence of environmental surveys. Overall, considering that Bari is a growing International reality (especially thanks to the International airport), with a great academic reputation and good touristic fluxes, the potentialities of the dismissed plant have been considered as quite high, since its renewal could include also a relaunch of the entire neighbourhood.

On the other hand, Campomarino has presented a completely different scenario. The disused plant has a relatively recent history (its operation started in the mid '80s), all machineries and buildings have been kept in satisfying conditions and environmental surveys have ensured the absence of any form of compromising pollution. However, the site suffers of a precarious accessibility and complete absence of any relevant neighbourhood, with rural landscape dominating all the surroundings. Consequently, local trends have been studied in order to provide a solution, trying to go beyond the most trivial solution coming from an agricultural reuse.

Figura 5 Bari and Campomarino flowcharts

GENERATING A SOLUTION

As a result of the third phase, three solutions have been implemented for Bari plant, while two for Campomarino.

In the case of Bari, three different multifunctional centres have been proposed:

- (A)mare Sea Centre-education and culture: a functional mix with education and local culture as main pillars. The figure of the sea, which is the main attraction of the city, is exalted in all the designed activities of the plant;
- (A)mare Sea Centre-production and sale: a functional mix with production and sales as main pillars. This solution still keeps the sea as the main subject, but it is more oriented to maintaining the industrial identity of the area;
- Bari Instant Centre: a more simple functional mix, characterized by the availability of huge free spaces for a more immediate restart of the activities.

Figura 6 (A)mare Sea Center, education and culture

Figura 7 (A)mare Sea Center, production and sale

For what concerns Campomarino, the two proposed alternatives are:

- E-Commerce Warehouse: analysis of local trends has shown an encouraging trend for the e-commerce retail, so this solution tries to exploit all the buildings and spaces available in the plant. This proposal is more market-oriented and does not exploit the agricultural potential of the area;
- Food Storage and Market, Consortium Headquarter: this solution aims to bring together the food consumers and producers. It exploits the agricultural potential of the area and performs a more consistent diversification of building functions.

Figura 8 Bari Instant Center

After evaluating the potential impacts on the local economies and communities, a deeper study has been conducted in order to evaluate the alternatives proposed for Bari thermoelectric plant. It has been decided to focus on Bari since it has been recognized as the only site between the two which was actually capable of offering a functional mix. Moreover, the more appealing context has made more interesting the utilization of the following methodology implemented in this last step of the project.

The Analytic Network Process (ANP) is a multi-criteria decision analysis, which structures a decision problem as a network connecting the goal, the decision criteria and the alternatives. Pairwise comparisons are then used to weight the components of the structure and finally rank the alternatives. In the case of this project, the structuring of the problem and the criteria has been performed by defining a dynamic model. Such model has been defined thanks to the help of ENEL's spokesperson and the academic tutors, after a preliminary analysis in which the main components constituting the problem have been highlighted.

Figura 6 Campomarino Food Market and Storage

The alternatives object of this study have been produced by dividing the site into six areas and then generating all the possible functional mixes, considering that each area could serve as free space, artisanal/commercial, services, housing or industrial. After imposing constraints and performing a first evaluation of the alternatives, only 19 of them reached the final stage, consisting in application of mathematical algorithms which have permitted to weight the decision criteria and finally rank the alternatives. This final fundamental step has been completed thanks to the precious help of Prof. Salvatore Greco and Dott. Salvatore Corrente from Catania University.

Figura 10 Campomarino E-Commerce warehouse

Figura 7 Methodology development Step by Step

As a conclusion and satisfying outcome, the top-ranked alternative has resulted to be really similar to the first (A)mare Sea Centre (centred on education and local culture) proposed by the team as adaptive reuse solution, thus reinforcing the quality and accuracy of the studies carried out in the area, which have led to the definition of such alternative.

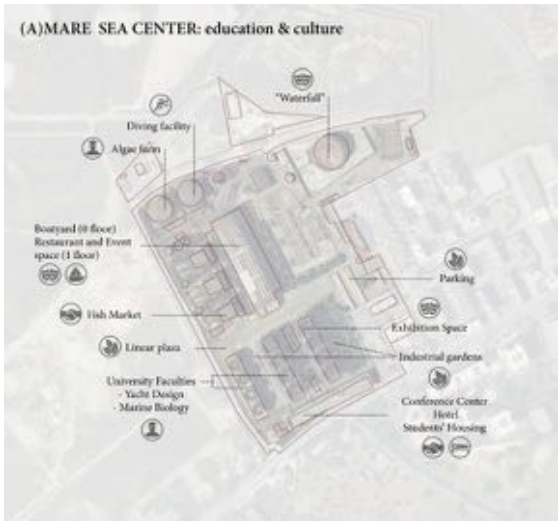

Figura 8 Top Ranked alternative

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MInD_PROJECT POSTER

INTRODUCTION

- **Project Title:**

MInD_Milan Innovation District
From industrial local areas towards innovation districts: implementing, attracting and developing a new territorial structure for new economy and production in Milan region
Team 4

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Prof. Ray Bromley
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Emanuele Moro, **Communication Leader**
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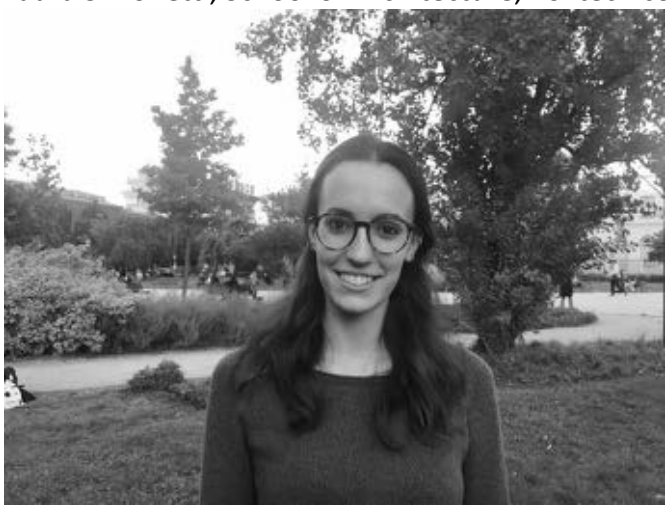
Laura Simonetti, School of Architecture, Politecnico di Milano



Enrico V. Sciannameo, School of Architecture, Politecnico di Milano

Diletta Trinari , **Team Controller**
School of Architectural Design, Politecnico di Milano

PROJECT DESCRIPTION BY THE PRINCIPAL ACADEMIC TUTOR

Figure 1 - Adda Valley

Students enrolled in this academic year at the Alta Scuola Politecnica are currently working on a special project called MIND (From industrial local areas towards innovation districts: implementing, attracting and developing a new territorial structure for new economy and production in Milan region). The project will make students work on the particular structure of the local industrial areas on the territory of the Adda valley in the eastern section of Milan region, proposing a way to change their rigid territorial structure into a more flexible combination of clusters in form of hot spots able to attract the contemporary industrial and manufacturing economy, aiming at creating innovation districts. Students should propose an innovative territorial model, understanding how innovation districts are able to change the territorial and economic organization, to catch the productive attitude of the region and to transform the rigidity of the existing districts, proposing a model able to create new supply chain, new smarter information, less impact on the environment reducing travels, new uses and new relations with the existing urban areas, and new visibility fostering the excellence of the economy and the excellence of the territories.

Students will propose a new territorial and management model for a regional territory able to consider it as a hot spot, combining a smart territorial management model (including distribution of activities, connection with infrastructures, proximity to services, efficient management of waste, goods, sources, connection among local institutions and between different levels' authorities) with a strong, contemporary model of sharing information

(about the attractiveness of the organized territory), finding financial sources (with a new role for co-op banks), opening to international markets through shared logistic platform and feeding employees clusters involving professional education schools. The result should be a strategic integrated plan able to reinvent a production system basing it on vocation, innovation, urbanity and where proximity and connections are everything.

Students should foster their ability in reading a territorial geography, understanding how manufacturing work according to the uses and the vocation a territory should show, learning how institutional territorial management work and above all understanding the degree of connection between industries, local communities, regional and national transport networks, environment and international markets.

Team description by skill: role of each member in the team

The MInD group is composed of six students all coming from the same Master Degree Programme in Architecture. Much of the work has been developed in workgroup sessions and has always been equal and chosen through personal research interests more than specific competences. Together the group went on a fieldtrip to Stockholm and visited the project site.

Through the process of developing the project, work was divided among members of the group. After individual analysis, all members would discuss results and find the relevant conclusions together. Specific tasks also shifted between members to allow for different perspectives and opinions to emerge.

ABSTRACT

MInD is a proposal for the development of a new territorial and management model. Set in the regional territory around Cassano d'Adda, the project builds on the current state of industrial production and its traditional unevolved settlements, organised in rigid and separated clusters, by proposing a new model based on a network of hotspots enhancing innovation through both material and immaterial production.

The brief of the project is derived from a main acknowledgement regarding the way the territory has been developing along with the growth of the industrial settlements in recent years. We are witnessing the shift from an old, traditional way of conceiving the territory to a smarter new one – from seeing the territory as the ensemble of cities and of the reciprocal relations among them, to an innovative way of understanding it as a whole region.

This process is driven by the concept of innovation as an engine to facilitate the transformation of the territory. The circumstances in which innovation has a key-role in the spatial definition of a region are readable in different contexts (as further explained by a

selection of case studies) and therefore give the present work the role of a model—something applicable, replicable and measurable in several, different contexts.

Along with this just mentioned contexts, this project builds on a specific site: the region of the Metropolitan City of Milan, especially its eastern part, and specifically the town of Cassano d'Adda.

With this in mind, a model is proposed based on three different topics (players - attitude - activities), consisting of a toolbox of guidelines useful to test the ability of a site to host innovative transformations. Its application to the Cassano d'Adda regional context evaluates if the guidelines are applicable to a specific context and the extent to which the region is able to generate interactions among the three aforementioned elements. The outcomes of the application of the model show that the region is suitable for this kind of urban transformation.

As the region of Cassano d'Adda shows potential to become part of a new territorial structure we investigated and proposed solutions regarding the three topics of urbanism, energy and society applied to a specific site within the region able to act as a catalyst for future development.

Figure 2 - Site visit to the former linen factory, Cassano d'Adda

Figure 3 - An industrial heritage, Cassano d'Adda

Figure 4 – Adda River, Cassano d'Adda

SUBPROJECT DESCRIPTION

UNDERSTANDING THE PROBLEM

In order to understand the attitude of the place, a territorial analysis has been conducted at a regional scale. Traditionally, Lombardy Region can be defined as a polycentric metropolis with Milan as the main urban core and the smaller centres as its polarities. The results of the mapping about the activities and the vocation of the area show that the area is characterised by industries developed along the infrastructural lines. These industries are still separated, small and barely connected within the region, part of a rigid and fragmented system in which Cassano d'Adda occupies a central position. Paradoxically, these industries are better inserted in an international network where they are known for the excellence of their production. The geography of production, conducted in order to deeply understand the vocation of the city and the typologies of activities, reveals that the composition of production companies.

Figure 5 – Traditional way to interpret the territory: main urban cores and smaller centres as polarities

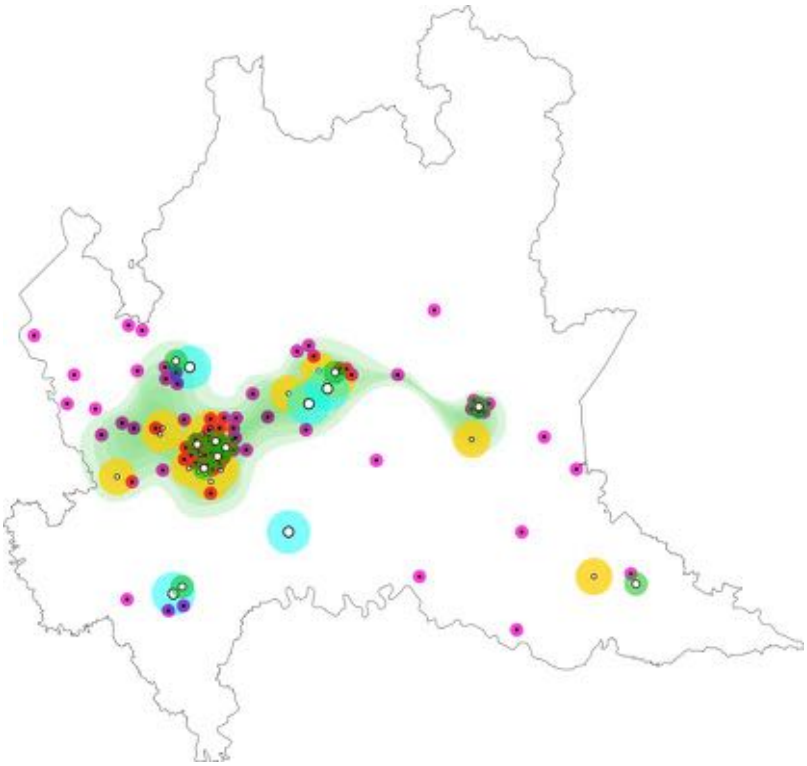


Figure 6 – How innovation shapes the regional territory of Lombardy

Figure 7 – Agricultural tradition and production vocation

Figure 8 – Industrial areas are still separated, small, and part of a rigid and fragmented system

This process has been crucial in order to develop a proper stakeholder analysis. In particular, a communication plan, consisting of four parts (exploring, setting, acting, valuing) has been developed. The first parts, that concerns the initial issues of the stakeholder analysis, are divided in listing the players potentially involved in the process and preparing a SWOT analysis (Strengths, Weaknesses, Opportunities, and Threats). Then, interlocutor's power of influence and attitude analysis have been applied in order to understand the target, the needs and influence of the different actors relevant to the project.

EXPLORING THE OPPORTUNITIES

The concept of innovation and the theory behind innovation district models were analysed. Thereafter a selection of successful innovation districts such as Boston Seaport District, Viikki District in Finland and Brainport in the Netherlands were studied in detail to explore the state of the art. Moreover, a field trip to Stockholm County Council and the Stockholm Royal Seaport has been organized. With the lessons learnt from these researches, three major fields were identified:

Urbanism: a vision in the short, medium and long term period along economic, physical and social dimensions, can become the key to shift the focus of the project from the cities scale to the regional scale creating new synergies outside the boundaries of the city.

Energy: it is important to consider sustainability as a driving force for its development. The use of high technology tools and materials and smart solutions concerning the energetic aspects should have a huge relevance to the project.

Society: it is clear the importance of building a network of relations and investments that involve the community and the interested stakeholders into the process. The network of relations should be enhanced by the special configuration of the site, gathering economic clusters, leading local and regional institutions and companies.

The MInD project takes the key lessons learnt from these models and will adapt it through an application in the Italian context.

Figure 9 – Visit to Stockholm County Council

Figure 10 – Stockholm Royal Seaport

GENERATING A SOLUTION

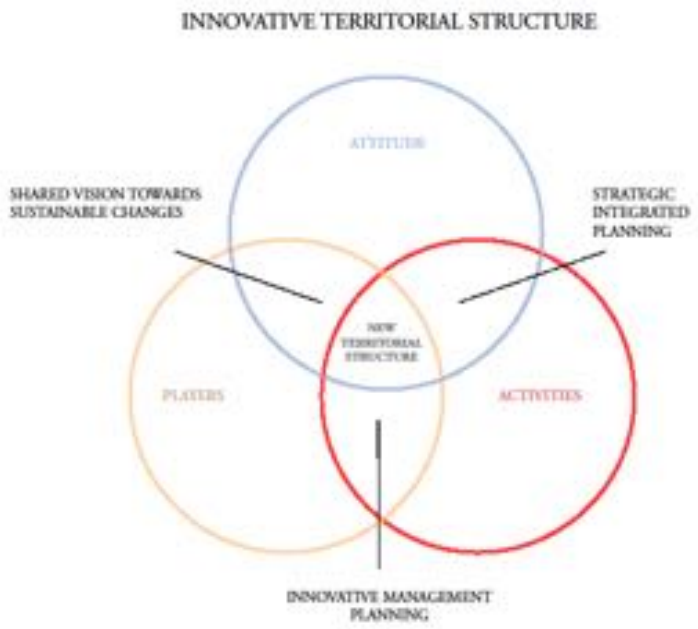


Figure 11 – Framework to test the potential for a new territorial structure

For the proposed model, we defined three main topics, attitude, players and activities, that formed the basis for the development of our model. Its structure is made of consequential steps. Firstly, we defined general guidelines, related to the three main topics, that we took from literature and the case studies previously described. After that, we applied these general guidelines to the specific territory. Then we analysed the application and placed them into the diagram: the position the applied guidelines have shows how many topics overlap in the specific case. The third step is measuring the degree of innovation and interaction: the more the applied guidelines tend towards the centre, the more the region is able to host a new territorial structure.

In the case of the Adda Valley, the results show a satisfactory outcome, because the tested area has a high potential to host innovation due to the presence of the necessary players, activities and the strong attitude of the region as well as the possibility for cooperation among them.

As it has been determined that the region has the capacity to host a new territorial structure, the development of an innovation district is proposed for the Linificio site that will act as a catalyst for collaboration and innovation within the region.

The site specific strategy follows the key perspectives of an innovation district model as developed from our research and case study analysis (energy, urbanism and society). We

therefore propose: innovation from the local construction industry and technology companies should be applied to the new urban development and the reuse of former industrial buildings of the site, acting as a testing ground for new sustainable, light, green and energy saving building techniques. In this way, the Linificio will act as a showcase of the innovative attitude and character of the region. A focus on innovative energy production must be promoted where the Adda River plays a central role. In this way, the area can attract key investments and promote a sustainable lifestyle through its status as a self-sufficient district in terms of clean energy production and the subsequent economic advantages. Lastly we believe that a leading company needs to be attracted to the site to use its influence to act as a catalyst for collaboration among smaller existing companies. This can be achieved by promoting the competitive advantage in energy production and innovation in the built environment found on the site.

As the initial steps have been completed through this project, we would like to apply this knowledge to bring actors together. We therefore propose an event to act as a platform to present our findings of the potential of the region to the stakeholders we identified. Once the relevant actors have been brought together, a vision needs to be created with input from all stakeholders to develop a shared strategy for future development and collaboration.

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TAGS

urban transformation, new territorial structure, regional development, innovation districts

BMSI – Bosch Mobility Scope Italy

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PROJECT DESCRIPTION by Marco Cantamessa

Technological innovation, matched to radical shifts in market trends, are leading t
the XX century “era of the car” to an emerging “era of mobility”. For a firm operating at the heart of the automotive value chain, such a transformation is potentially disruptive, since it does not only imply a shift in underlying technology, but also in its reference markets. Bosch inspired the BMSI (Bosch Mobility Scope Italy) project in order to gain insight on potential new markets and products where to direct the firm’s efforts. The project aimed at finding suitable intersections between the objective attractiveness of the market space and Bosch’s subjective potential

competitive advantage, taking into account its current and prospective portfolio of competencies and technologies. The BMSI project therefore had a dual objective, the former consisting in the identification and conceptualization at least one new and promising market-product dyad, the latter of proposing and experimenting a structured and replicable approach for conducting this type of investigation.

The student team worked on this relatively ill-structured and open-ended project brief by starting from a preliminary analysis supplied by the company, which contained a macro-segmentation of the "mobility market". This segmentation included traditional automotive OEMs, emerging automotive OEMs, Mobility sharing providers, Logistics providers, and Connectivity providers. The team performed a broad study of the trends occurring in each segment (via a PEST analysis) and assessed both their industry-level attractiveness (using Porter's five forces framework) and the fit with Bosch technologies and competencies, progressively weeding out alternatives that did not appear promising enough. Following a round of interviews with industry players, the team identified three somewhat promising areas, and conceived a range of innovative products and services per each such area, eventually selecting the most promising one.

The final part of the project consisted in a preliminary feasibility study of the selected alternative, i.e. a platform for last-mile logistics in rural areas, consisting in the use of a delivery van that moves across the territory and from which a fleet of rotary wing drones takes charge of the final "van-to-doorstep" leg of delivery. Monte Carlo simulations were carried out, in order to identify the most appropriate parameters for this system (e.g., number of drones, allocation of distance to be covered by the two modes, etc.) and to provide a preliminary list of technical requirements.

In the end, the dual objective mentioned above was achieved. First, the team conceptualized and made a preliminary simulation-based validation of the "van+drone" delivery concept, whose business case will be further examined by the firm. Second, the project can be seen as the prototypical instance of a process that Bosch – or other companies – may use when tackling strategic reorientation**.**

ABSTRACT

Profound and dramatic changes in the customer needs and requirements are shaping the mobility industry and new business models based on innovative products and service systems are arising in the market. Incumbents, e.g. Bosch, are looking for new opportunities to expand their customer base and product service portfolio.

The project aims at defining the positioning of Bosch in the Italian mobility industry in the next 5-10 years. The approach is based on successive screening and developing of business opportunities for Bosch.

The mobility market has been splitted into five main segments. Key insights from the literature, partecipation at international conferences and interviews to key actors of the Italian mobility industry, have been part of the analysis of the attractiveness of each segment.

Considering Bosch internal capabilities and resources, together with the company managers and project supervisors, five innovative concepts of mobility solutions have been developed in the Logistic and Mobility Sharing segment. Ultimately, after having assessed each concept the Drone

Delivery Service in the rural area has been selected. Bosch will develop, manufacture and install the drones in third party logistic truck. Additionally, Bosch will develop the software and its cloud for managing the system. The market analysis and the economic feasibility have highlighted the viability of this solution. A Monte Carlo simulation in three Italian rural areas shows the optimal configuration of the delivery operations.

The project shows that drones have the potential to disrupt the last mile deliveries in rural areas in the next few years and Bosch has much to gain from entering this market.

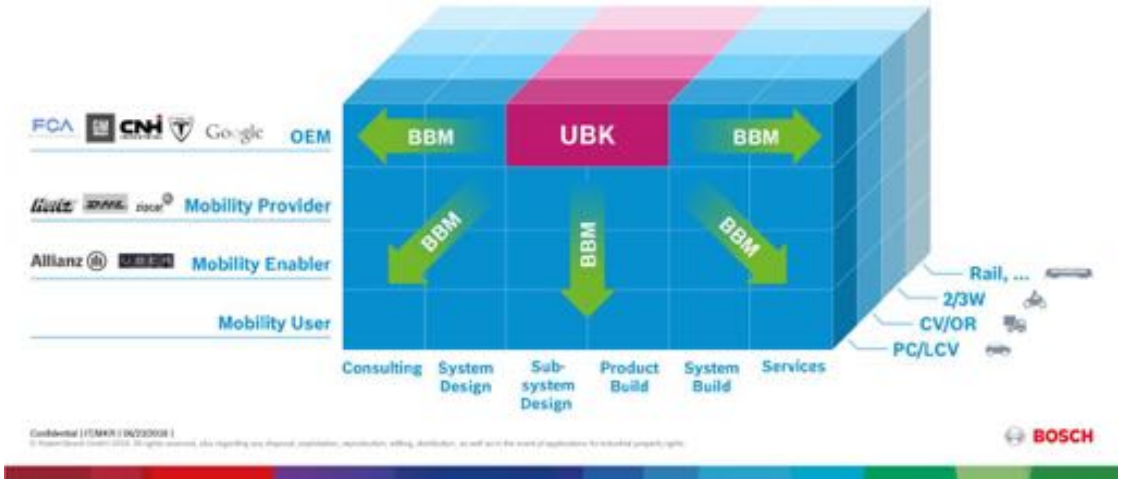
SUBPROJECT DESCRIPTION

Understanding the problem

During the last years the Automotive Industry has experienced a significant change from its original configuration of the last century. In fact, traditionally the market was almost completely constituted by OEM's and their supplier, whose main activity was to produce and supply all the required components to manufacture and assemble the final vehicle.

Nowadays, however, the Automotive Industry must be considered and analysed with a much wider view. It is in fact mutating toward a more complete and vast world, which is represented by the Mobility Industry. The direct consequence of this transformation is a significant increase of the number of players acting in the market, of the possible products and services to offer and of the means of transport that could be targeted.

As represented by the image below



the customers of this revised concept of Automotive Industry are not anymore constituted just by OEM, but there are also three other main segments. A first one is represented by Mobility Providers, which includes fleet operators, logistic companies and intermodal and public transports. A second one constitutes the Mobility Enablers, companies that provide products and services to improve the effectiveness or the efficiency of the mobility. As last, Mobility Users, actors that experience some mobility needs in general, from both the consumer and industrial perspective. Moreover, also the variety of products and services that a company could offer to the market has

significantly increased, ranging from consulting to system design, system manufacturing and complementary services.

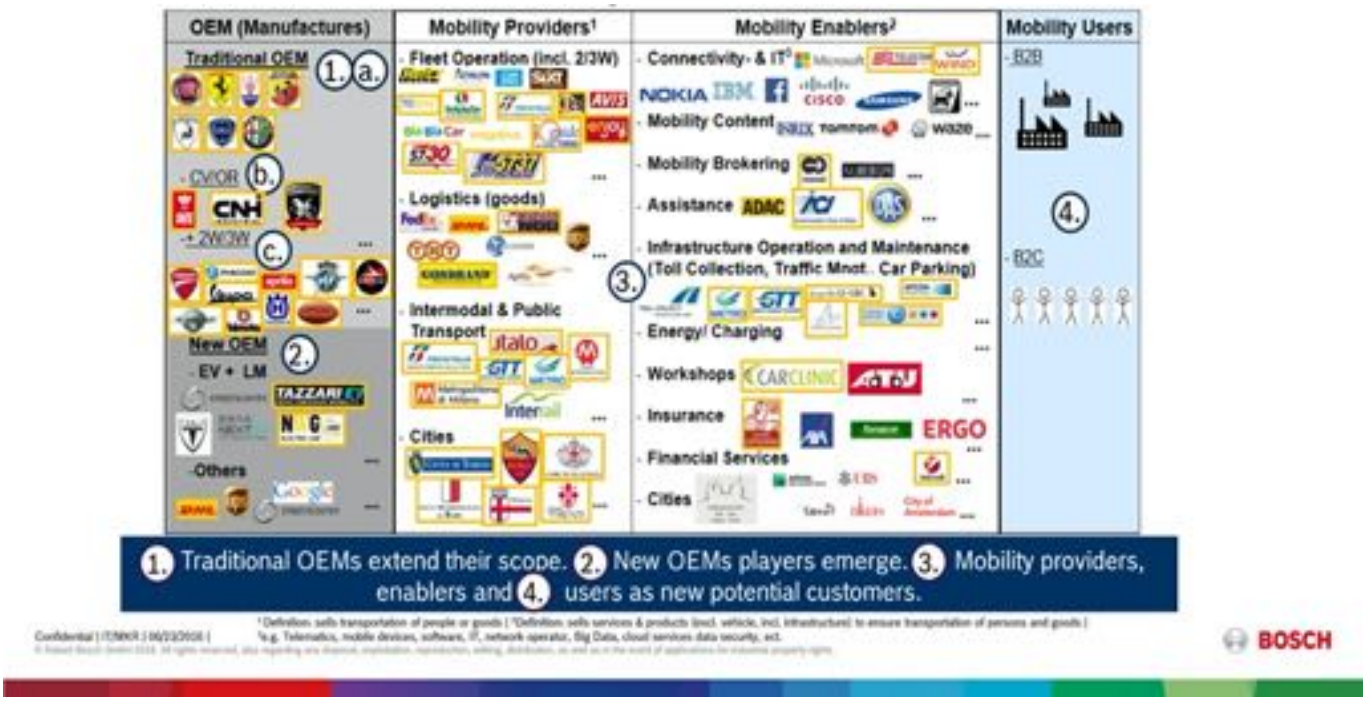
Given this complex and dynamic environment, the goal of the project is to define which could be the future positioning of Bosch in the Italian Mobility Market in a time horizon of 3-5 years. Traditionally Bosch has been always focusing just on OEMs, providing them components designed and manufactured internally. The idea is to enlarge in some way the customer base of the company towards the new segments of the Mobility Industry, adding then to the product portfolio some additional innovative and profitable products/services. It is clear that the general aim of the project is quite vast and includes a considerable number of possible alternatives, given the complexity and dynamicity of the context. The process adopted throughout the project is therefore designed to progressively divide and select possible interesting and promising directions, in order to achieve at the and a specific viable solution.

Exploring the opportunities

Given the complexity and the vastness of the project, the first step was related to the necessity of "cutting the elephant" in to comprehensive and measurable pieces. In order to do so, the team carried out a significant research phase with the aim of developing a clear and complete insight of the Italian Mobility Industry.

A PEST analysis was performed and all the main trends were depicted and interpreted, in order to qualitatively predict the possible evolution of the industry.

Successively, the market was divided in five main segments: Traditional OEMs, New OEMs, Mobility Sharing, Logistics and Connectivity.

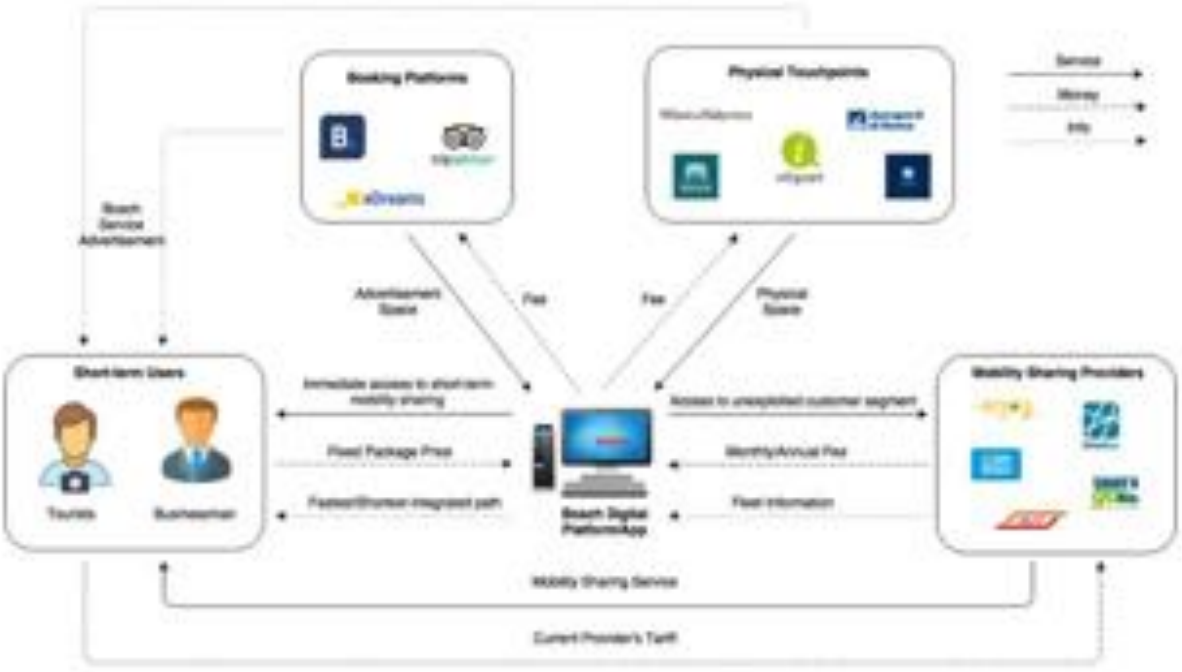


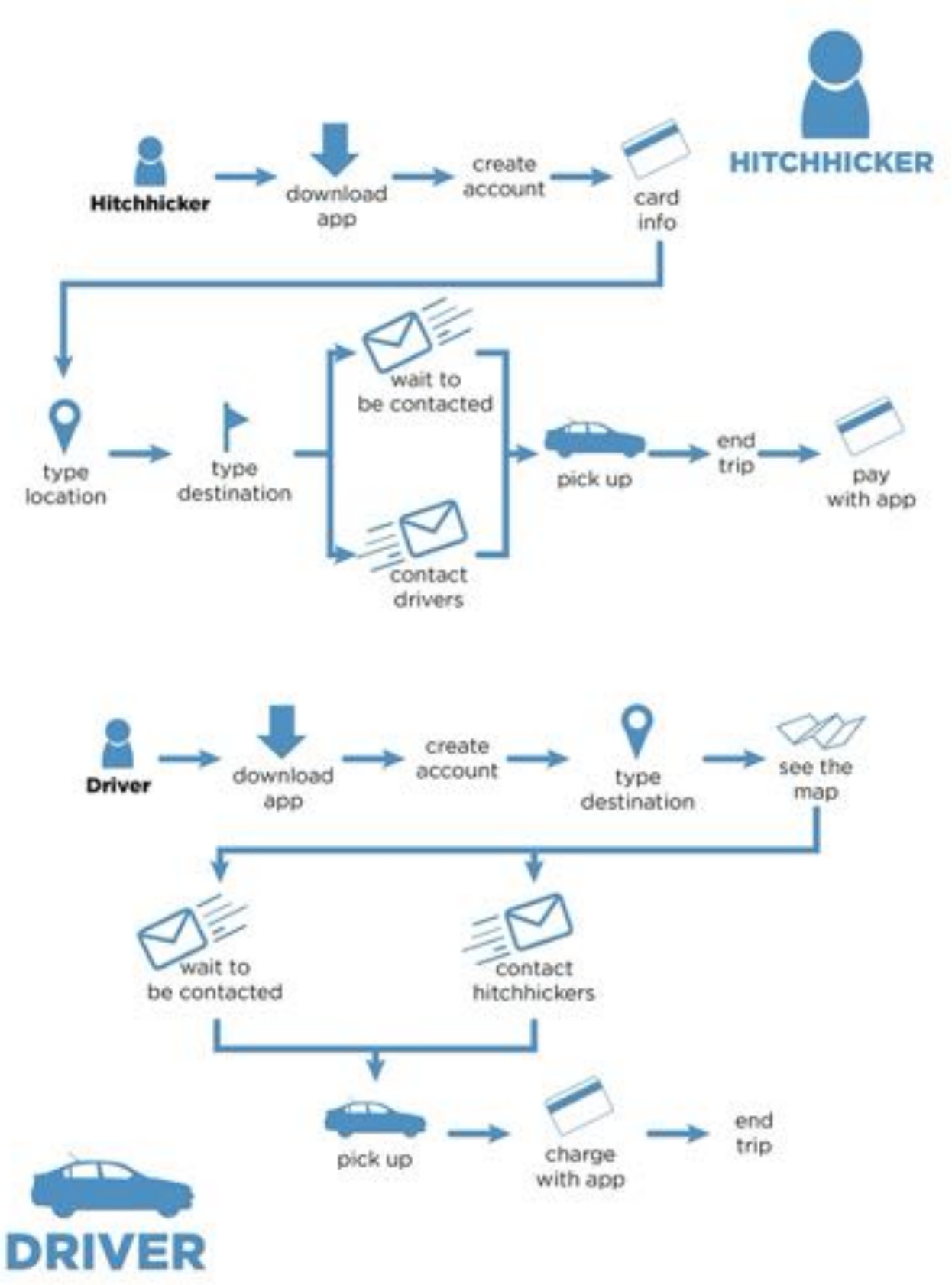
Once identified, the segments were deeply analysed in order to understand their needs and requirements, the specific rules of competition and the critical drivers of success, adopting the Porter's 5 Forces model, the supply chain analysis and the KSF analysis.

At the end of this research phase, the team had a complete view of the Italian Mobility industry and of its main segments. Thanks to this information, it was possible to target some specific customer groups, specifically Mobility Sharing and Logistics, considering both the potential profitability and the interest of Bosch in entering new segments.

The subsequent phase was aimed at going deeper with the understanding of the two segments selected, in order to identify some latent needs and spot new innovative business models and technologies. With this goal, the team took part to four conferences in Lisbon, Maastricht, Lainate and Aachen, and interviewed some companies in the field like FCA, Uber, ToBike and Up2Go (image below).

Putting together all the information from the research, the team was able to develop five concepts of new product/services. In particular, these possible solutions were Short-term Mobility Sharing, Real Time Carpooling, Big Data Navigator, Car Sharing in Small Towns and Delivery Drones:

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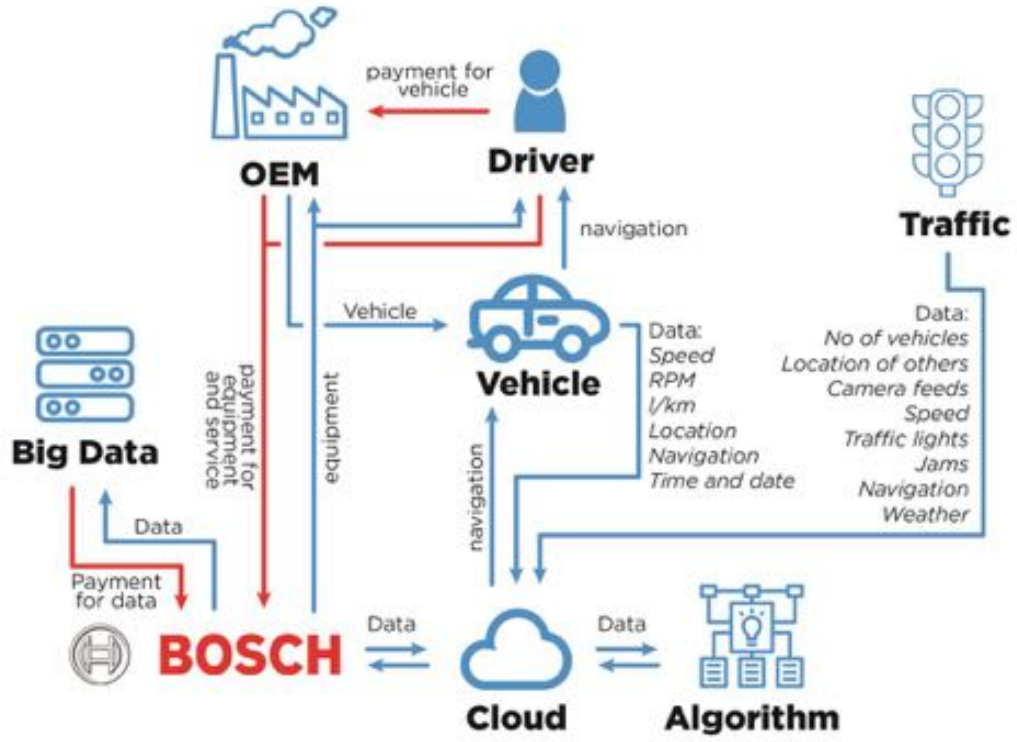


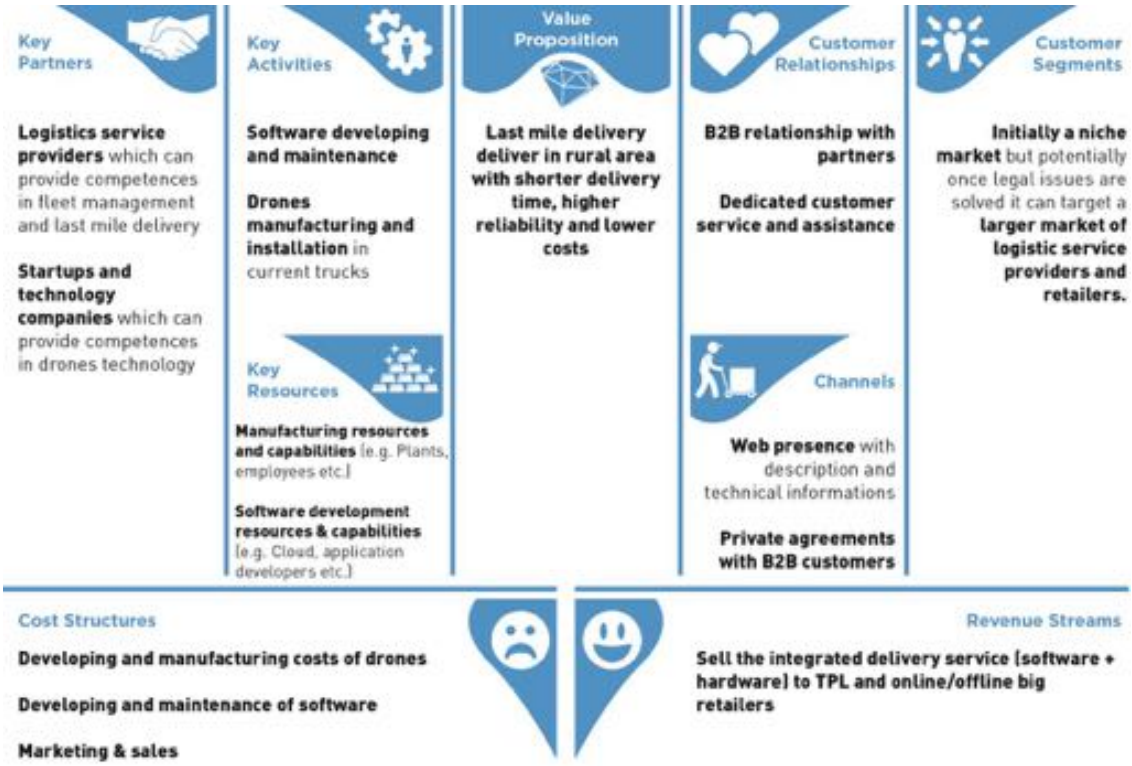
At the end, considering the potential market dimension and the fit with Bosch core competences, the team opted for the latter.

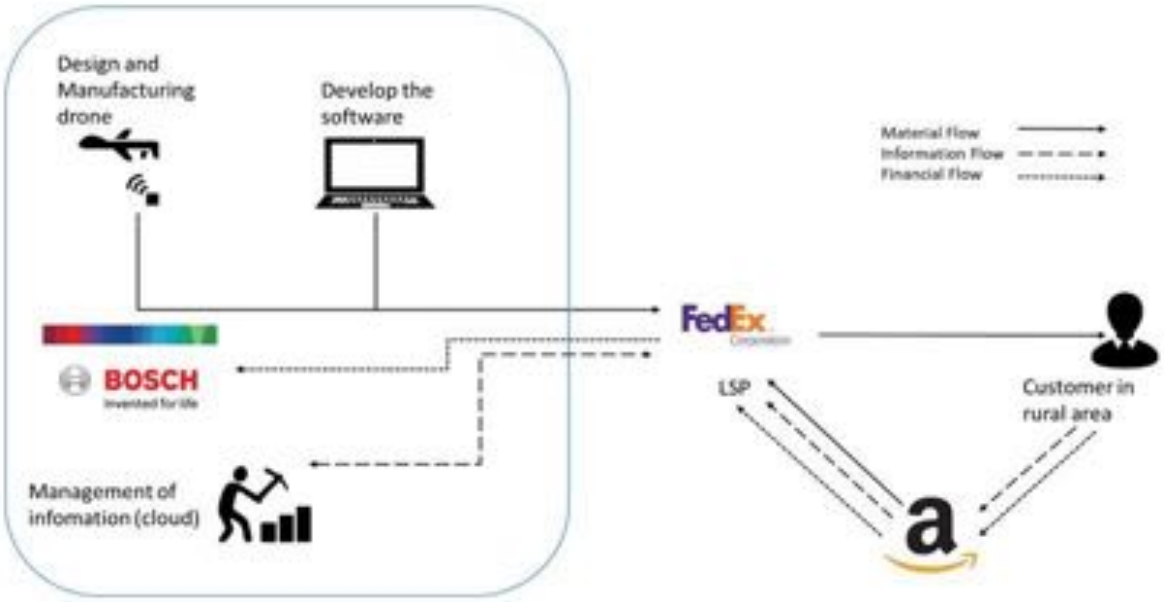
Generating the solution

Many applications of drones in different industries are already common today. However, the usage of drones in logistics are still at early stages. This vision will become reality within the next ten years. The speed at which different countries will adapt depends mainly on three factors: labour cost, regulation and public acceptance.

Size, growth, difficulties facing by incumbents, and new business models provides many reasons for studying the future development of the last mile delivery both in urban and rural area. The global parcel delivery market amounts to more than 70 billion €. The growth rate ranges around 10% in mature and up to 300% in developing markets. In the last mile delivery, which represents about 50% of the total parcel delivery cost, incumbents are facing difficulties due to the increasing labour cost. The competition among large e-commerce players has risen. Thus, consumers preferences are considered more and more important and last-mile delivery is a key differentiator in terms of price and time.

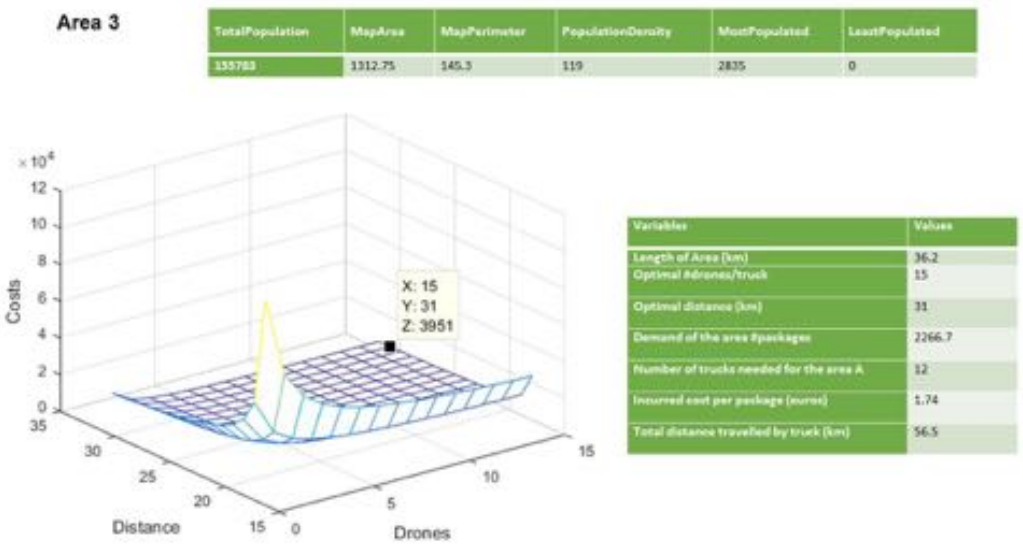
Bosch drone delivery service aims at providing a service which support TPL to deliver parcel in rural areas with shorter delivery time, higher reliability and lower costs. . Bosch will develop, manufacture and install the drones in TPL truck. Additionally, Bosch will develop the software and its cloud for managing the system. Daily operations will instead be managed by TPL.





Under certain assumptions, the economic feasibility analysis shows the viability of the solution. It can be a relevant source of competitive advantage for any TPL, with a reduction of costs of approximately 4 €/parcel and greater potential revenues due to shorter lead time in comparison to their traditional service.

The team developed a mathematical model able to take as input some exogenous variables to describe the rural area under investigation and provide as output the optimal configuration of the drone delivery service, based on variables like number of drones per truck, maximum distance covered by each drone and total number of trucks needed. A Monte Carlo Simulation was then performed for three rural areas in Italy, highlighting the potential cost reduction of the proposed solution.



TAGS

Bosch, Italian Mobility, Logistics, Drones

The Active Pedal Project

Keywords: Smart mobility; Active Accelerator Pedal; Safety; Driving Simulator

The Active Pedal is an innovative accelerator pedal developed by Robert Bosch GmbH which applies haptic stimuli (vibration, counterforce or knocking) under certain situations; the commercial target of the pedal is the automotive market, aiming to reduce the fuel consumption and to improve the safety during driving.

The objective of this Alta Scuola Politecnica multidisciplinary project is to identify new possible pedal uses, mainly dealing with the connectivity, to prove the pedal effectiveness and to evaluate new business opportunities in the global mobility environment.

Team Members and Skills

Bombardi Giulia: Electronics Engineering Student specialised in ASIC design. Giulia mainly worked on state of the art and market analysis and installation of the Pedal in the I.Drive simulation laboratory. In particular, she developed from scratches the communications protocols needed to connect the pedal to the already existing systems. Giulia also helped in the organization and implementation of the testing activities.

Bonomi Mattia: Electronics Engineering Student specialized on analog design and silicon photonic integration. Mattia focused on the state of the art and patent analysis and on elaboration and interpretation of the big amount of data coming from the eye tracking systems. Mattia worked to provide useful insights on the benefits in terms of decrease of distraction in the driver coming from the use of the pedal.

Fontana Francesco: Project Team Leader, Automotive Engineering Student specialized in technology and innovation management. Francesco mainly worked on state of the art analysis and competitor landscape and market analysis. He then focused on the interpretation of the data regarding speed limits and driver reaction times and on the design and interpretation of the survey aimed at the evaluation of the pedal User Experience.

Lucarelli Daniele: Automation Engineering Student specialized in control of multiagent and networked control systems. Daniele initially focused on state of the art analysis and patent search and interpretation. Later on, he worked on the elaboration of new use cases and business opportunities and on the interpretation of data and results coming from the Eye Tracker.

Terzo Leandro Corrado: Team Financial Controller, Automotive Engineering Student specialised in hybrid powertrains. Leandro initially worked researching and understanding Bosch competitor's patents. Then, he focused on the elaboration of new business opportunities especially related to light and heavy commercial vehicles. Eventually, he focused on the elaboration of data coming from the simulation environment.

Tordini Pietro: Design and Engineering Student. Pietro worked on market and competitor analysis. Then, he focused on the installation of the pedal and on the construction of the simulation environment in the PoliMi I.Drive Laboratory, enabling the realization of the testing activities. He eventually contributed to the whole set-up of the laboratory and to the organization of the tests.

ABSTRACT

Safety, connectivity and user experience are increasingly assuming a central role in today transportation and mobility environment. From this point of view, the Robert Bosch active accelerator pedal, on which the entire work is based on, could represent a break-through for the entire accessories and optional market.

Indeed, the aim of this work is to explore and understand the market potential and the effectiveness of a new technology developed by Robert Bosch GmbH in the field of the smart mobility: the active accelerator pedal.

The work starts with a deep analysis of the current market situation, patent analysis and state of the art relative to the active accelerator pedal.

Then, new possible use cases and business opportunities have been investigated and presented to Bosch. Among the proposals, following Robert Bosch' business interests, an analysis on the benefits coming from the use of the pedal to improve vehicle's safety and reduce cognitive and visual distraction in the driver has been carried out. In particular, the benefits in the fields of reducing distraction in the driver, improving the human machine interface between cars' smart systems and drivers and consistently brushing up driver's response in emergency situations have been analyzed.

A simulation environment has been created ad hoc in the Polytechnic of Milan driving simulation laboratory (I.Drive Lab) and the gathered data regarding safety and user experience have been analyzed and presented. As it will be seen, the active accelerator pedal by Bosch strongly emerges as an effective tool to improve driver attention (up to 14% increased time of attention at the road of the driver) and to dramatically decrease the reaction time (more than 50% reduction).

Eventually, all those considerations are presented in a brief summary consisting of the assessed benefits coming from the use of the pedal and the suggestions to further proceed with the project and to confirm the results achieved.

Exploring the opportunities

The first task the Team worked on has been the identification of the state of the art and the understanding of the current market situation and competitor strategic positioning. In particular, an accurate patent search analysis and a deep web investigation have lead the team to gain awareness on the extreme competitiveness of the sector and on the global market situation related to the Active Accelerator Pedal. The results have been presented in October 2016 to Bosch Management in the Company’s Headquarter based in Stuttgart, generating an increasing interest in the project from the Company itself. Thanks to the aforementioned work, indeed, it has been possible to understand and highlight Bosch’s pedal unique features and strengths as well as possible weak points to be improved. During this preliminary phase, and having the market and patent research as input for the work, new possible uses and business opportunities have been presented in December to Bosch.

The presented new possible use cases, which are summarized below, tried to exploit in the best way Bosch pedal unique technical feature, considering the potential fertile markets segments:

- Charging Station Optimal Speed Advisory (CSOSA):
- Green Light Optimal Speed Advisory (GSOSA):

- Light and Heavy Commercial Vehicles safety and fuel consumption reduction;
- Cognitive distraction reduction;

Following Bosch' business interests and needs, the Team then focused on the implementation and study of the applications of the pedal in the field of cognitive distraction reduction in the driver.

Generating the Solution

In order to investigate the real benefits coming from the use of the pedal, the Team decided to perform a set of virtual driving simulation tests. From this perspective, a prototype of the pedal made available by Robert Bosch GmbH has been installed in the I.Drive simulation laboratory of the Polytechnic of Milan. In particular, to accomplish to this task, three parallel activities have been planned and carried out. The first activity regarded the study and implementation of the communication protocols between the pedal and the other simulation systems to ensure the correct control of the pedal. The second task concerned the physical preparation of the mechanical end electronical environments to host the active accelerator pedal and the third the designing and building of a simulation environment to host the simulation.

After several months of work, the simulation environment has been tested and marked as ready to host the tests. In order to gather a significant amount of data, twenty male students, aged from 21 to 26, have been recruited to take part to three simulation tests to assess and isolate in an objective way the benefits coming from the pedal use as alerting tool. Indeed, the participants were asked to drive in a highway scenario in three different conditions: without any assisting driving system, with an acoustic and visual signal on the dashboard and with the active accelerator pedal functioning. The alerting tools, when present and functioning, were meant to advise the driver both in case of emergency conditions and in case of infringement of the normal driving rules (i.e. safety distance or maximum speed limit not respected). The tests provided useful insights from two different perspectives: from one side thanks to the I.Drive infrastructure and technology was possible to gather eye tracking, bio metric and general data which have been later analyzed and interpreted. From the other side, the participants' answers to the two surveys presented before and after the tests gave extremely useful information on potential customer perception of the pedal, both from the user experience and from the market potential.

Conclusions

After the completion and elaboration of the data, the team was able to finally assess the benefits coming from the use of the pedal and to evaluate the customer user experience. The results achieved, from one side confirmed a consistent possible improvement in vehicles' safety and from the other side helped in understanding the user experience and market attractiveness of the pedal. Going into the details, from the data gathered during the simulations it was possible to assess a consistent reduction in the cognitive and visual distraction of the driver. It is interesting to point out that the distraction using the pedal was significantly less with respect to both the simulation using visual and acoustic alerting tools (7% reduction) and to the simulation in which no alerting tools were implemented (11% reduction). Out of one hour of driving in a highway scenario, this means the driver would look at the road up to six minutes more. This result is even magnified underlining that six minutes at a speed of 120 km/h means 12 kilometers more of attention. To further strengthen the

innovativeness and great potential of the pedal, it has been recorded an impressive reduction in the reaction times of the drivers during emergency situations, with reaction times cut up to 50%. Always assuming a cruise speed of 120 km/h, this would lead the driver to stop the car more than 33 meters in advance than usual in an emergency braking situation.

Starting from the aforementioned qualities and performances of the pedal the team has started to evaluate the market and business potential of the pedal, trying to understand the perceived value from the customers. However, the relative price estimate coming from the analysis of the surveys resulted to be lower than the final proposed price by the OEMs and car manufacturers. This important consideration should drive a discussion on possible strategies to either augment the perceived value of the pedal or to sensibly reduce the final price seen by the potential customers.

However, it is opinion of the team that the pedal could represent a real break-through in the vehicles' safety, helping in the achievement of the ambitious European targets on road safety.

NRGWaste
A safe small scale thermal treatment for unsorted solid waste with recovery of energy

Principal Academic Tutor
Debora Fino
DISAT, Politecnico Di Torino

Academic Tutor
Isabella Nova
DIE, Politecnico Di Milano

External Institution
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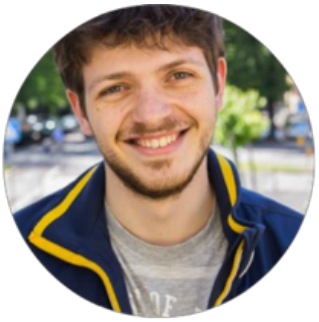

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PROJECT DESCRIPTION

NRGWaste is a micro scale, turnkey, self-contained system for the treatment of unrecoverable waste at the point of arising, based on high temperature plasma pyrolysis and on downsized waste pre-treatment technology (metal extraction, shredding, pelletisation). The core of the micro treatment prototype is based on the downsizing of the technology used in large waste to energy plants using components already largely used for industrial applications (i.e. TIG welding torches as a basis for a new way of generating plasma at low cost) coupled with a novel, self-adaptive control system to reach the highest levels of efficiency. The system includes a fully-automated control of the electric arc generating the plasma and a gas recirculation system to ensure safe generation of syngas (i.e. no furans and dioxins) ready to be exploited for energy generation.

The prototype was fully studied from the modelling side as well as from the experimental campaign performed at IRIS Srl facilities. Some improvements on the present technology arose from this project and were proposed to the company in order to fit different market applications ranging from stationary to non-stationary waste treatment as a result of the different skills present in the team, hereafter described, and to IRIS Srl company, always involved during the whole duration of the project.

Team Description

Energy Engineering

Cecilia Vicinanza

She was the team leader. She mainly worked on the energy engineering aspects of the project, performing the thermo-economic analysis together with her colleague Nicola. She also had a supervisory role, interacting with team members, tutors and stakeholders, taking care of the bureaucratic aspects of the ASP project.
Nicola Frascella
Together with Cecilia, he evaluated the interactions with energy world, from assessing the exergetic balance of the system to evaluating the market feasibility for the component.

Chemical Engineering
Manuel Innocenti
He worked on the system chemical modelling, focusing on the code assembly and the computational simulation. Moreover, he performed the sensitivity analysis for the same system through the computational model he had built.
Ahmed Mohamed Sadek Elgendy
He worked on the litter characterization and street sweeping waste, identifying the chemical reactions involved in the pyrolysis/gasification process and the related kinetic and thermodynamic calculations.
Eddy Christopher Batok Embanglian
He focused on the initial marine waste characterization, based on composition. Further, he separated the waste based on the various compositions for the rest of the experiment.

Electrical Engineering
Davide del Giudice
He focused on developing an improved version of the mechatronic control module in order to achieve a higher arc stability and thus a more efficient waste thermal treatment.

Mechanical Engineering
Donato Sportelli
He put his attention on developing a rotational system to achieve a better-treated waste processing by increasing its exposure to the plasma arc, improving the prototype efficiency.

ABSTRACT
NRGWaste is a prototype, owned and patented by IRIS Srl, that consists of a small scale system for the thermal treatment of unsorted solid waste using plasma technology, allowing energy recovery through thermal and electrical power generation with no harmful emissions. The system is constituted by a reactor, inside which there are two electrodes connected to a power generation unit. During operation, an electric arc is ignited to obtain plasma, capable of conducting electricity and characterised by a high temperature. The electric power generated in the arc is converted into thermal power, exploited for the treatment of the waste.
The main challenges that were faced were: the stabilisation of the arc, the evaluation of the syngas composition with respect to the waste composition, the introduction of a new

mechanical rotating system, the performing of thermo-economic analysis of the component.
In order to ensure a proper arc voltage, the MCM (mechatronic control module) continuously regulates the distance between the electrodes during operation. The team proposed different versions of the MCM code, which have been tested on the real prototype to assess which code could ensure the best performance of the MCM.
Laboratory experiments have been performed on the plasma generator model using three waste typologies: household, street sweeping and marine waste. A simulation model has been developed to describe the gasification process and a sensitivity analysis was performed to study the temperature impact.
A mechanical solution was developed to obtain a suitable rotational system able to mix up the waste inside the reactor and to expose it more uniformly to the heating source.
In order to verify the feasibility of the machine, an input-output thermo-economic analysis was performed for three different applications, which gave as a result the percent value of which the price of the NRGWaste component should decrease in order to make its sale profitable for the user.

UNDERSTANDING THE PROBLEM

Waste disposal is an issue which deeply permeates the modern society, from the largest point of view (cities, countries) to the smallest one (isolated mountain villages, ships). Particularly addressing this last area, the available solutions to deal with waste disposal are not so performing, and generally require high costs and lead to resources wastage. Therefore, the IRIS Srl Green Plasma project, which NRGWaste has prosecuted, specifically considered that application field and proposed a small prototype for those small, isolated entities, in order to heavily reduce the waste disposal problem and to treat waste on place, through the thermal plasma technology and the pyrolysis process. Consequently, the principal involved stakeholders have been the potential customers (big/small ships, isolated mountain villages) and IRIS Srl (NRGWaste external partner and owner of the prototype), both of them interested in the prototype economical and developing aspects. However, also research institutes and governmental authorities have been identified as concerned by the project outcomes, particularly considering its researching, innovative and environmental aspects.
All those stakeholders have then allowed to identify and define the different requirements and tasks, which affected all the expertise areas of each group member and leaded to carry on the project work. The different considered aspects started from the need to find a way to move the reactor, in order to ensure a temperature homogeneity and to let the entire waste amount being reached by the plasma, and then involved the necessity to provide a chemical model of the system, to set it on a software and to use the software to perform a sensitivity analysis, necessary to study the system behaviour. Moreover, experiments on the real prototype were required, in order not only to validate the chemical model, but also to test the different Arduino codes; in fact, improving and modifying the Arduino code represented another fulfilled activity, aimed to make the plasma arc stabler and therefore increase the overall process efficiency. Lastly, a thermo-economical analysis was proposed, in order to evaluate the prototype feasibility for those potential application areas.

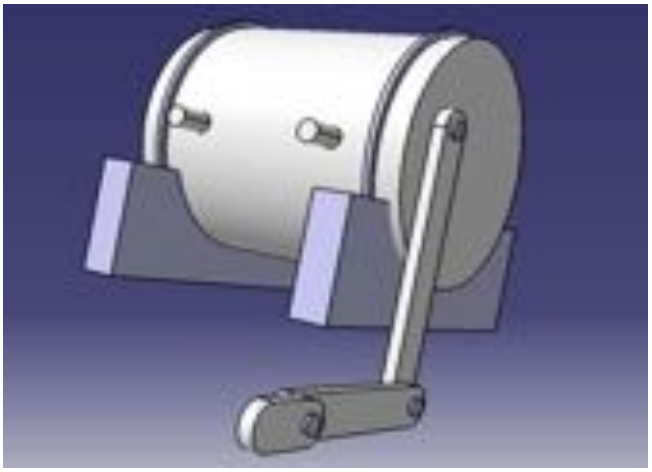
EXPLORING THE OPPORTUNITIES

The main concern with small-scale devices, is that of making a safe and clean environment also profitable, without the possibility of scaling up taking advantage of scale factors. On the other hand, once obtained an effective prototype and identified the potential stakeholders, the market share available is weakly limited, entering a sort of “Blue Ocean”.
To evaluate correctly the potential of such innovation, an input-output analysis was carried on from a thermo-economic point of view, in order to clearly understand the energy fluxes interesting the process, the value created in it and where the inefficiencies compromising the result came from. Indeed, any activity producing waste and disposing it in an expensive way would be interested in getting rid of such cost, obtaining synthesis gas in exchange. As the team understood in international conferences, syngas exploitation is gaining interest in the energy field, since it could lead to clean carbon fueled technologies; this trend is leading to an increasing number of bottoming machines, such as microturbines or internal combustion engines, able to use such fuel to cogenerate electricity and heat. However, since the flexibility of such devices depends mainly on the composition of the syngas and consequently of the waste, experiments were made in order to evaluate the chemical compounds most likely produced during the process. Further requirements came from the continuity of the process, mined by the extinction of the electric arc, and the maximization of the energy output, compromised on one side by a portion of waste not affected by the reaction, and on the other side by a portion of water cooling down the reactor and sent to a chiller. To overcome the former problem, the team had to understand the code regulating the electrodes responsible for the plasma stability, while to tackle the second problem two different paths were considered: regenerating the value of the hot water as thermal power, and making the whole system rotate.

GENERATING A SOLUTION

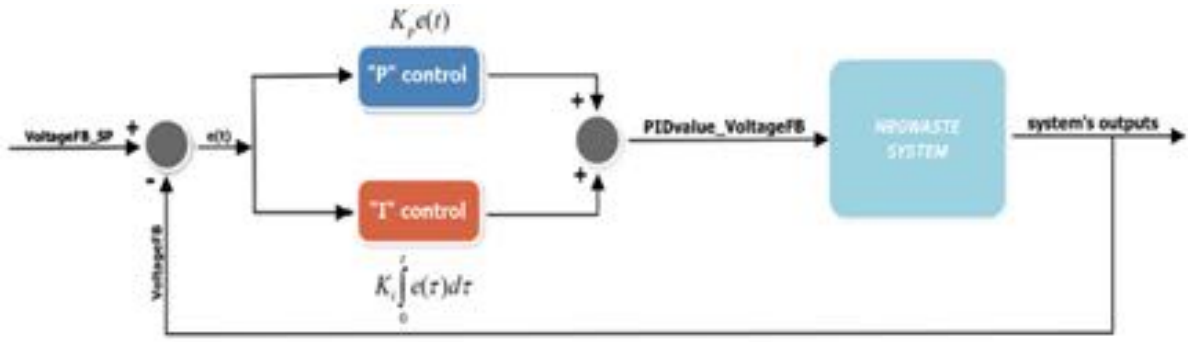
The solution proposed by the team is aimed at increasing the energy efficiency of the prototype, as well as its attractiveness from the potential customer viewpoint in the light of a commercial roll-out.

The team designed a rotational system for the reactor that could allow the waste inside it to be thermally treated in a uniform manner. The team analysed two solutions: a fluid dynamic model and a mechanical model. In the former solution, the water inlet coming from the heat recirculation module of the system is exploited to rotate the reactor. In the latter solution, instead, an electric motor connected to the reactor by means a four-linkage mechanism (constituted by a crank, a rod and a rocker) is used. After a comparative analysis of the two solutions, the team deems the mechanical model to be the best fit due to its much lower costs of implementation.



The mechanical model solution for the rotation of the system.

Another focus of the project was to develop an improved version of the script used in the mechatronic control module. In particular, the parameters of the PI filter used for the electrodes position control have been changed and tuned to ensure a better system operation. The new script, which has been tested and validated on the real prototype during the experimental campaign organised by IRIS Srl at its lab, proved to make the mechatronic control module less susceptible to the peaks and dips in arc voltage, enabling the system to maintain a constant arc voltage and temperatures inside the reactor, resulting in an overall more efficient waste thermal treatment.



Block scheme representation of the PI filter used for the electrodes position control in the MCM.

The previously mentioned experimental campaign also allowed to validate the chemical model used to describe the chemical reactions occurring inside the reactor during operation and to understand how the syngas composition changes based on the waste input characteristics and on specific process parameters. On one hand these findings can be a noteworthy contribution to the efforts of research centres and universities devoted to analyse the plasma pyrolysis process. On the other hand, such results provide a good starting point from which the potentialities of the NRGWaste system can be assessed not only for waste disposal, but also for cogeneration purposes.

In order to evaluate the attractiveness of the proposed solution in case of its commercial roll-out, a thermo-economic analysis has been performed by simulating the adoption of the prototype in different scenarios, such as isolated mountain villages, small boats for marine litter disposal and cruise ships. Despite its investment cost, it has been observed that the adoption of the prototype is particularly beneficial in touristic islands. In fact, the prototype would allow an easy disposal of waste around the shores and the syngas produced from the thermal treatment could be used later on for electricity production in an energy storage system connected to the island's main grid.

TAGS

Waste to energy, sustainability, micro cogeneration, plasma.

S[m]ART
Yummy it, reduce food wastage

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Terraneo Emanuela
MSc Architectural Design PoliMi

PROJECT DESCRIPTION

The ASP group developed their activity working in parallel with the S [m2] art research project, winner of the MIUR Smart Cities and Social Innovation tender (SCN_00325). In particular, starting from the same concept of S [m2] art, they had the task of designing some alternative proposals, even more innovative. The member group belongs to the architecture and design field, except for Atanasovska Martina - urban planner - and Delvino Michele - management engineer.

At the very beginning phase of their activity, the ASP Team members collaborated in a brainstorming activity, with the same role, but, of course, contributing on the basis of their specific study background. Also in the second phase, when they were divided into 3 groups of 2 students each and detailed 3 scenarios of "smart meter square", they had the same "role" of designer, with the exception of Delvino Michele, a management engineer who started a transversal activity, supporting the 3 groups in the service-design activity, on the basis of his specific skills.

After the discussion with the research and business partners (Telecom Italia and ThemaProgetti Group), one of the 3 scenarios were chosen as the most innovative and interesting for the further investigation in the field of smart urban furniture: the food storage, delivery and distribution, talking in account of all related social innovation issues.
In order to develop the concept in a more detailed project, the students took part in an international workshop in Food Design, hosted during the Italian Design Day by the East China Normal University February 27th to March 5th 2017. The workshop gave ASP team the opportunity to dialogue with the multidisciplinary student of the Master in Food, in a design workshop in Shanghai, based on the smart meter square concept.

Team description by skill:

Urban and architectural design

Atanasovska Martina: issues related to the urban scale integration of innovative street furniture; concept development, service design and policymaking.

Callegari Sandra: developed the user centered design and requirement / performances analysis; analysis of urban context, concept development, service design, app design.

Chan Ho Yin William: developed the user centered design and requirement / performances analysis; analysis of the state of art, concept development, user interaction.

Moreno Romero Juan Sebastian: developed the user centered design and requirement / performances analysis; analysis of current situation, analysis of urban context, concept development, service design.

Terraneo Emanuela: Team controller, developed the user centered design and requirement / performances analysis; analysis of current situation, concept development, app design.

Economic evaluation

Delvino Michele: Analysis of the market, analysis of cost and revenues.

ABSTRACT

The YummyIT service, comes as a concept from a thorough research on the current market in Italy and Milan, where it should be implemented, starting with the idea of transforming the existing telephone cabins that are owned by telecom company, into something which will have twofold benefits: the main one reduction of food wastage and second the reactivation of public spaces and creation of a unique user experience. These two objectives are as a result of two crucial problems that we are facing nowadays:

First, the irresponsible wastage of food, especially coming from big food chains as supermarkets as well as households. Moreover, the impact of this is not only to be look at the amount of food wasted but also at all of the resources being used in order to grow the raw products, harvest them, bring them to the desired destination to either sell them or prepare them further in order to get a final product. This whole process is nevertheless also affecting negatively the environment that we live in.
Second, the forgotten idea of what public space should be really used for. In an era of fast living and things happening in the blink of an eye, people usually just pass through places and do not tend to stop and look around them, which is transforming the cities in a completely different and maybe unhuman way.

Bearing in mind these two problems, the YummyIT services offers a solution through a social perspective of giving to the users a unique satisfaction of using it.
It works in a simple way where the S[M]2ART sqm of the telephone cabins is transformed into a point in a public space where people through obtaining one of the main activities for both survival and satisfaction, that is eating, get the chance to meet other people and create a specific identity about that place. Moreover, the main and only providers of food in this case are supermarket whereas the users could be various, students, workers, families etc. The services itself is designed in a way that would make both sides providers and users to benefit out of it, with the main aim of raising awareness of the problem of food wastage and at the same time reducing it.
This resulted in creation of YummyIT which tends to be a user friendly service and works towards generating a more eco-friendly living environment in the future.

SUBPROJECT DESCRIPTION

UNDERSTANDING THE PROBLEM

The aim of the "S[M2]ART" (Smart Square Meter) project is to create a scalable system of urban smart fornitures, throught a working network which takes in considerations the users needs. The primary objective of the service is to improve the welfare of the citizens thanks to new techonogical features. The project is not only a service but it becomes a new aggregative point where people can gather and interact reconstracting the relationship with other people and the sourranding environment. The project was selected by the MIUR competition "smart cities and communities and social innovation", involving Telecom Italia, Architectural department of design of Politecnico di Torino, GTP, Politecnico di Milano, Reply, Metalco, H&S, Astrel, Winext, Dimensione Solare e Neriwolff. Basically, starting from the telephone box located in Turin and in Milan- owned by TIM group- the idea is to come up with a service that can help people to be active inside the city: this means not only to pass throught public spaces but to stop, observe around and use the space. Milan,as a prototype site area, have been chosen. To design the service, itt is considered fundamental to make an users's analysis to understand their needs and requirements. is useful to trace the IDcard of the different users pointing out their specific traits and the role they played. Understand the specific users requirements is fondamental because through them we can measure the fulfilment of the needs, define what aims and functionalities the service should get and set up the boundaries to produce a solution. Needs and requirements are clustered on human basis- end user -, technical aspect, business basis and regulatory basis. To positively influence humans' quality life and their mental status, people need to feel in a homeenvironment, user-friendly, to be safe, to have all the information they need clearly and easily to understand. Thus, our solution should be adaptable to different type of users from different ages, country and culture and it should provide positive feelings. On the technical-functional basis, technology and innovation will foster the idea of generating and implementing,within the built context, smart points of gathering and sharing as well as social interaction.our solution should answer to the need of citizens and tourists of having customized and easily understandable information. Cost-and market based characteristics set what is necessary in order to make profit and to be compliant with the investors' business mission. As regulatory and policy is concerned, Local companies and big enterprise look for a service in order to increase their profits by reducing utily costs and time for designing or installing and managing/ maintain urban infrastracture. Instead, public administration has to guarantee an efficient government and the respect of law.

EXPLORING THE OPPORTUNITIES

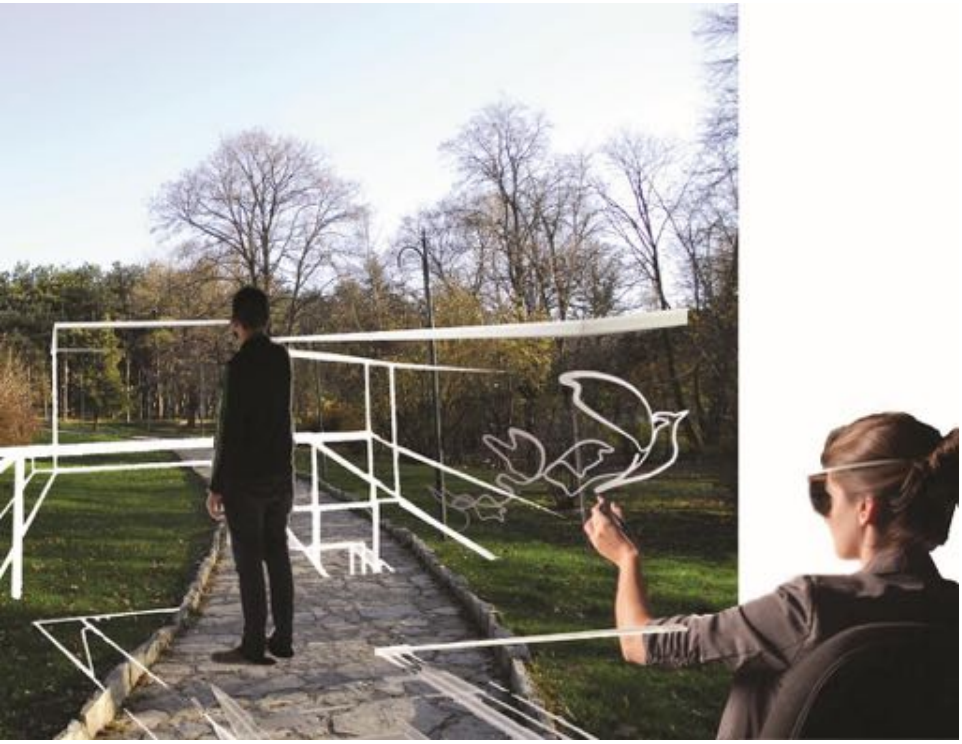
In the analysis of the state of the art, international precedents were examined according to the requirements of the project. Particularly, projects were selected based on their interactivity and user-friendliness in adapting new or existing technologies to solve future problems, where people are placed at the center of the design, such as home biogas, pay by weight food management, people's fridge, Bumpmar, Eco giardians.

Such human-centered design are important in relating to the social impact and usability of the proposal. The different solution generated were based on 4 main aspects:

1. placemaking, create vibrant public spaces and strengthen the connection between people and the places they share.
2. social interaction, bring people together in a place in order to socialize and create a sense of community.
3. technology and innovation, a 'smart' solution to activate the public.
4. networking, foster connectivity between the smart urban furniture.

A social approach to idea generation was developed to focus on urban problems common to both Milan and Turin. By ensuring that people are placed at the center of the project, public spaces can be activated to help with the social and environmental sustainability in cities. Key social problems were identified, which resulted in potential social opportunities, with food wastage, health and sport, connectivity and people's services selected for further refinement.

Different solutions were pointed out: an open air gym, where people with the same passion could interact; Smart food sharing, using the wasted food; Trip Planner, an implemented tourist guide; Visual Building, using augmented reality to recognize buildings and give a short explanation to users and last virtual sketching, a sketching virtual reality screen, where people can explicit their idea.

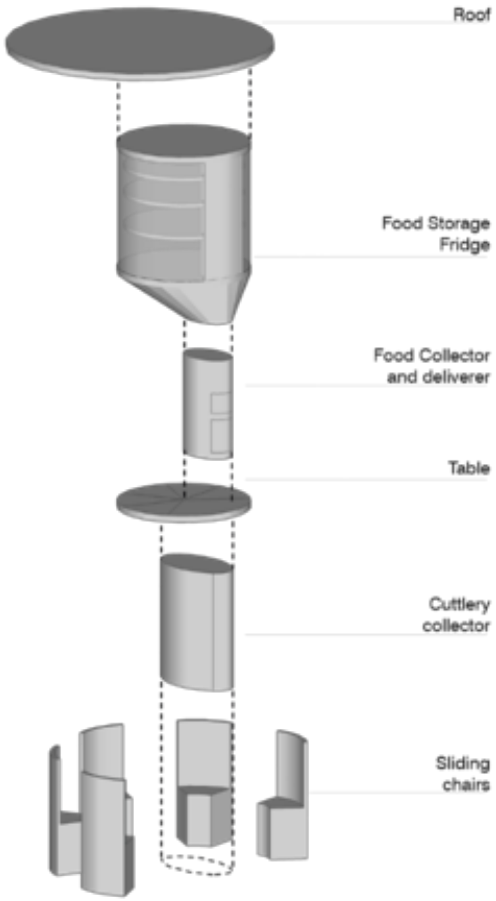


After a canvas analysis the most convenient solution pinpointed is the smart food sharing, being the wastage of food one of the most crucial problem of nowadays.

GENERATING A SOLUTION

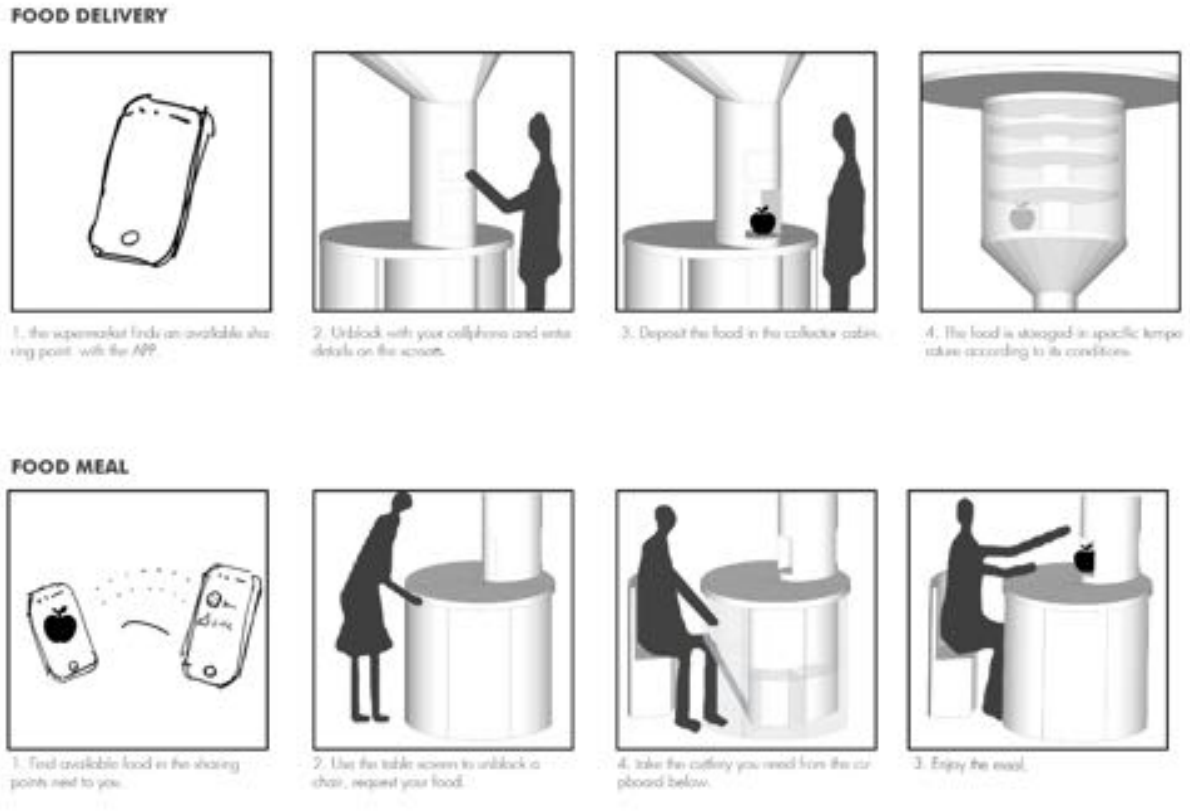
The S[m2]ART project team took part in a workshop in Shanghai organized within the Italian Design Day carried out by the Italian Consulate in Shanghai collaborating with East China Normal University and many other individuals concerned with the problem of food waster in the big cities and possible sustainable solutions. Consequently the aim of this workshop was exploring new possible ways of transforming a module with the usage of innovative technology for city problem-solving through the aspect of food wastage. The workshop highlighted the huge problem linked with food. According to the United Nations, one third of global edible food (3.9Gtonnes) is wasted in step between

production and consumption phase. The overall food waste value equates to roughly 1 trillion $ each year. In volume food wastage is is estimated at 1.6 Gtonnes of “primary product equivalents”.Food waste is not only an ethical and economic problem but also an environmental problem. 1.3 billion tonnes of food produced but not eaten is responsible for adding 3.3 billion tonnes of greenhouse gases (in CO2 equivalent) to the planet’s atmosphere. The Country “Food wastage” would be third nation for GHG emissions after China and USA.



Therefore the service is developed in a smart square meter, where the providers such as big chains supermarkets bring the overloaded food and the user can go to the service and through an app, order the food that suits him. The service is designed in a minimal way, the upper part a fridge with separated boxes to maintain the food following the Italian laws; under there is a table with sliding seats and a digital scree, so that also people who are not able to have a phone can choose the food from the service.

Numerous startup businesses focus on the transformation of food waste as part of the biological cycle and circular economy. From individual household systems to more industrial systems that allow food waste to generate composting or electricity through anaerobic digestion.



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TAGS

smart, innovation, foodwaste, placemaking

SMITh

Smart **M**etering with **I**nternet of **Th**ings

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Keywords: Internet of Things, intelligent agents, distributed optimization, energy management, demand response, user experience

Project description

SMITh (Smart Metering with Internet of Things) is a one year project launched in 2016 within the XII cycle of Alta Scuola Politecnica. The project has involved academic institutions (Politecnico di Milano and Politecnico di Torino) as well as two industry partners, Edison and Reti. The project goal was to develop a feasibility study of an IoT (Internet of Things) system for applications in the field of Demand Response (DR) and energy management.
The SMITh project received the contribution of a team of students, academics, and professionals coming from the fields of electrical and energy engineering, computer science, and service design. A comprehensive solution was developed addressing the technical specifications, the market integration, and the user experience domains.
The main goal of the SMITh project is to develop an ecosystem based on IoT which coordinates sensors and actuators to optimize the energy consumption of a typical household providing DR services in synergy with the energy utility. The specific objectives of the project were the following:

- Create a cloud system where all components are interconnected and can interact without leveraging a central logic controller
- Modularize power bills so that energy companies and users could agree on custom fees
- Automatically schedule consumptions to minimize electricity bills, also taking advantage of some services that loads can provide to the distribution grid.

In particular, the goals can be grouped in three main disciplinary areas:

1. IoT and system architecture
2. Energy services and market
3. Service design and User Interface (UI)

This project can be described as a technology push project, where the suitability of a new emerging technology in the IoT sector is tested to respond to a demand arising from the energy sector (need of active demand to provide system flexibility).

Tasks and skills

Davide Comuzzi: Davide is a service system designer and his main task was the user requirements analysis done through interviews and workshops. He also carried out the study on state-of-the-art trends in user experience connected to IoT and energy management.
Simone Prato: as Energy engineer, Simone contributions were: analysis of demand response potential and barriers to adoption in the energy market, definition of energy pricing mechanisms and modeling of agents in the algorithm. Description of simulation scenarios, simulation running and data analysis to evaluate the algorithms performance and potential.
Francesco Sala: Electrical engineer specialized in energy systems, Francesco worked at the analysis of demand response and pricing mechanisms. He also developed the

mathematical models of the battery and PV systems within the algorithm. As team controller, Francesco supervised the whole team activities and the project budget.

Andrea Semprebon: Computer Science engineer, Andrea took care of the following tasks: analysis of technological feasibility, definition of appliances' mathematical model, development of custom algorithm for distributed optimization, development of backend and web interface for data visualization.

Andrea Taverna: as service designer, Andrea worked at the development of the user interface and at the realization of a model prototype. He also contributed to the user requirements analysis and took care of the graphical design of the presentation video.

Abstract

The ongoing transformation of energy systems towards a decentralized production model requires a new centrality and active involvement of energy consumers (or prosumers) in electricity markets. The consumption behaviors should be adapted to market conditions providing savings to the customers and benefits to the energy system as a whole. Customer empowerment requires the adoption of innovative technologies, such as sensors, controllers, and communication systems on a vast scale and with high levels of reliability.
SMITh project provides a totally innovative solution in this field exploring the opportunities offered by IoT and decentralized multiagent optimization.

Understanding the problem

In the future, an ever increasing amount of electricity will be produced from Variable Renewable Energy Sources (VRES). This trend, supported by climate and environmental policies, is poised to deeply change the way power systems are operated towards a Smart Grid paradigm. In particular, an increasing need of flexibility is evident to cope with the variability of energy sources like sun and wind. If decreased flexibility is made available on the supply side, due to the dismissing of traditional generating plants, the demand side must be involved in providing flexibility. Demand Response (DR), i.e., the adjustment of consumption behaviors based on external signals such as energy prices, is seen as a fundamental resource of flexibility in future power systems. The challenge to exploit this opportunity arises from three different levels:

- Technology innovation is required in the house environment to create a smart home where energy consumption can be monitored and optimized thanks to sensors, intelligent controllers, and communication systems.
- Market and regulatory reforms are needed in order to allow such systems to be commercialized integrating DR services in the existing electricity market architecture.
- User experience (UX) requirements should be satisfied, preserving privacy and comfort, and allowing the user to interact with the system in an intuitive and flexible way with a clear perception of benefits.

Exploring the opportunities

The DR pilot projects which are currently underway usually exploit a centralized intelligence. A typical example is represented by the Address project, led by Enel, EDF, and Iberdrola, where a central unit, called "energy box" performs the whole optimization and then sends commands to each appliance. This dominant trend emerged from a wide state-of-the-art analysis and is mainly due to the fact that distributed intelligence is still not reliable enough and too complex (mainly due to the need of coordinating many agents).

However, a distributed solution offers the advantages of being more resilient to single failures and avoiding the need to share all the information about each device functioning (e.g., proprietary data on consumption cycles) enhancing also the user privacy.
The decision, in agreement with the industrial partners Reti and Edison, was to try to develop a feasible system based on intelligent agents and distributed optimization, which could compete with current more mature centralized solutions.
From an energy market perspective, several mechanisms could be considered, mainly belonging to explicit and implicit DR categories. In explicit DR, loads participate directly in the electricity market via aggregation, offering bids to change their consumption and receiving direct payments.
In implicit DR, consumption behavior is adjusted on the basis of a price or volume signal coming from the market (e.g., a dynamic price). In our analysis we chose to investigate implicit mechanisms and in particular to compare real-time prices (defined each 15minutes) with the current Time-of-Use (ToU) tariff system, which involves only a price differentiation between peak and off-peak periods.

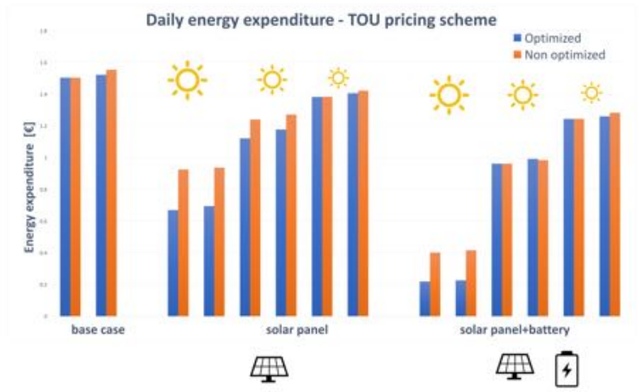
Generating a solution

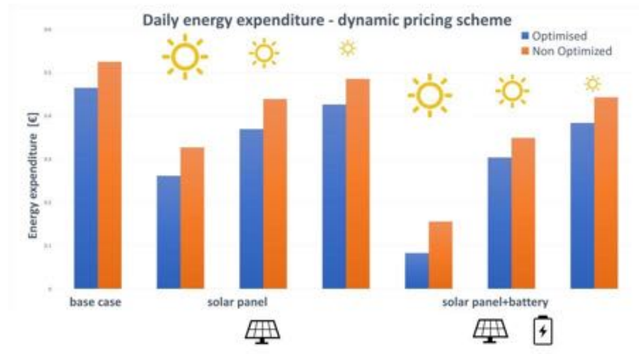
The solution developed is based on the concept of a distributed optimization system that is able to optimally schedule the consumption of several electrical appliances for the next 24 hours. The selected representative appliances were the dishwasher, the washing machine, and the boiler, since they belong to the class of thermal or shiftable loads, which offer the biggest potential in terms of DR services. Also a solar photovoltaic (PV) system and a battery were included to account for a future prosumer scenario. The input parameters of the system are the appliances cycles, the preferences set by the user (e.g., finish before or start after time *t*), the energy cost in each time step, weather forecast to calculate PV production, the initial configuration of the system (e.g., battery state of charge), and the user presence.

The output of the system is an optimized consumption schedule for each appliance which minimizes the electricity bill costs.
A complicate part was the development of the optimization algorithm. The corresponding mathematical problem belongs to the class of Distributed Constraint Optimization Problems (DCOP) since we do not have a central optimizer, but all the appliances act as intelligent agents that run the optimization in a coordinated way exchanging messages. Existing algorithms able to solve this type of problems were first considered. But we discovered that they are able to handle few agents and a limited number of time steps due to the exponential increase of messages exchanged.

Therefore, a new innovative algorithm was specifically developed for this project using a modified version of DPOP (Dynamic Programming Optimization Problem), able to perform much more efficiently and minimize the data exchanged. The algorithm was programmed in Python.

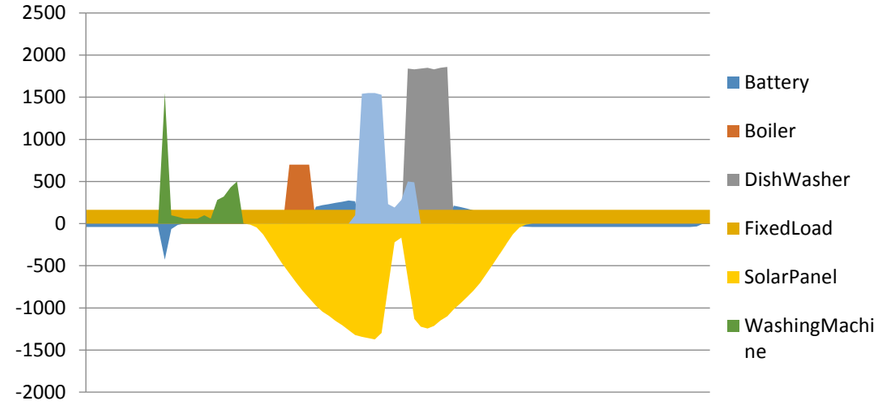
Once tested the proper functioning of the algorithm, realistic scenarios were developed to see the results deriving from its application to a real house. Appliances cycles were modeled using data coming from Edison Smart Home. Also real solar data and energy prices from the Italian energy market regulator (GME) were used.
Simulations considering several scenarios (presence or absence of PV system and battery, different solar radiation levels, different energy tariffs, etc.), with and without the use of SMITh system, were carried out. Simulations gave very positive results, with an average **saving on the energy bill** equal to **12% in case of ToU** tariffs and **19% in case of real-time prices**. Savings **on a single day** reached **up to 46%** depending on solar radiation levels and user preferences.





Savings emerged to be higher in case a more dynamic pricing scheme is in place, as it will be probably the case in the near future but today happens only in few countries (e.g., Norway).
Benefits are also higher in presence of PV system and battery since the optimization helps to shift the consumption towards periods of higher solar production avoiding withdrawing energy from the grid.

Additionally a prototype using Raspberry Pi microcontrollers was realized to test if the algorithm can effectively run in a distributed way. Communication was realized using Wi-Fi protocol, even though other protocols can be used (e.g., such as ZigBee). The test gave positive results validating the possibility to concretely deploy the system conceived. One obstacle to full commercialization still lies in the fact that the controller should be incorporated in the appliances by the manufacturer.



Finally, the interface of a web app was developed even though still not complete. The interface was designed taking into account requirements coming from the user experience domain such as the visualization and interaction needs of the user, the priority to clearly show the economic and environmental benefits obtained using the system and the lowest degree of intrusiveness possible.

The positive results obtained will be the basis for continued development of the system, hopefully in cooperation with the actual project partners and other interested parties. Attention will be focused on the following activities:

- Increase the number of appliances controlled including heating/cooling systems and electric vehicles.
- Improve the model accuracy of agents: e.g., battery model, use of stochastic solar production forecasts, etc.
- Consider more complex pricing schemes: e.g., *scambio sul posto* for solar PV production.
- Consider a possible interface mechanism with aggregator to offer ancillary services, like participation in explicit DR mechanisms.
- Implementation of a field prototype with real appliances at Edison Smart Home R&D Lab.
- Finalization of the graphical user interface.

BRIDGE

Bridging the gap between Industry and Academia

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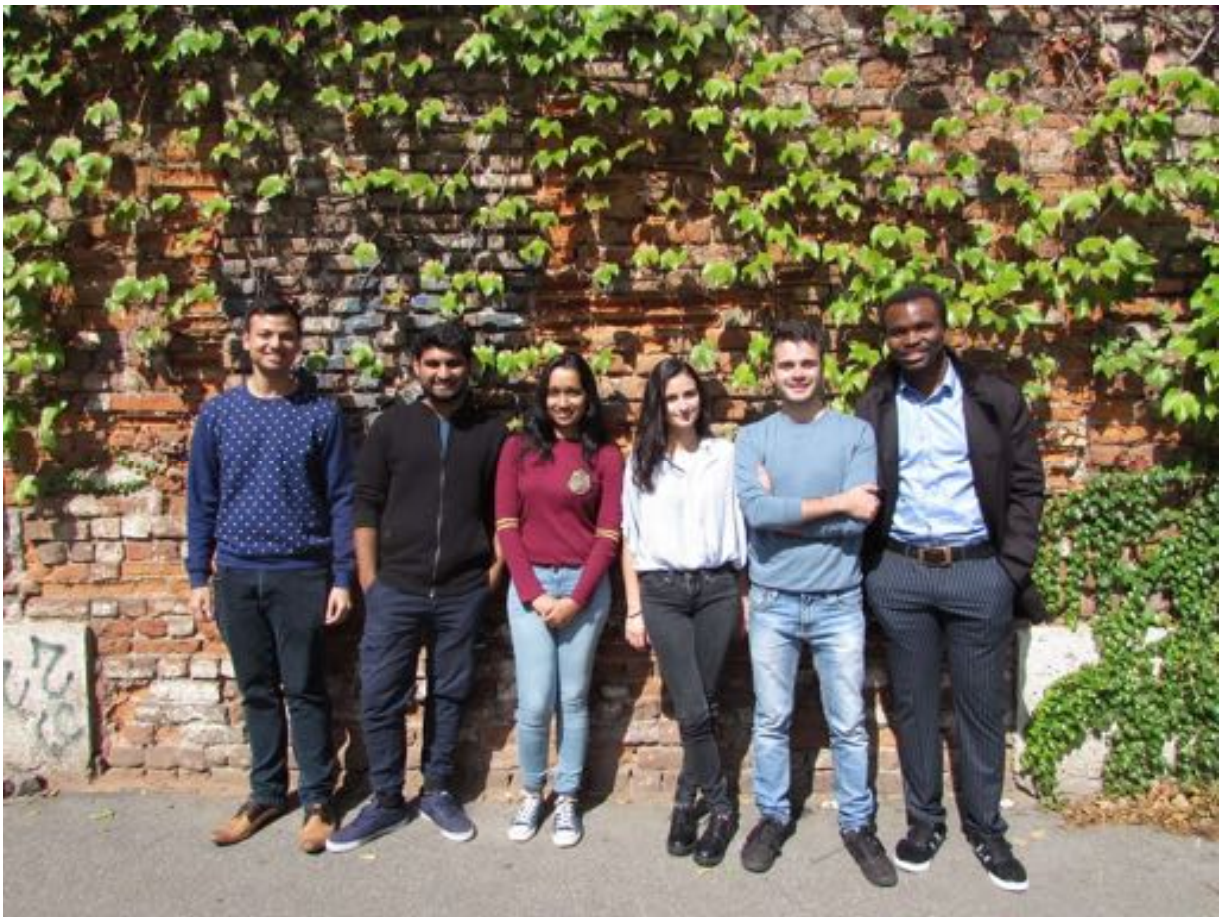


PROJECT DESCRIPTION

Over the years, the transition of graduates from the academia toward the procurement of the suitable career line of job in the industry of their choosing, which is in tune with their skills and talent had been an arising and interesting topic. But surely, there has been a gap between the academia and the industry in terms of perfectly matching each graduate to their new jobs, that people in these sectors mentioned, have been trying to describe and fulfil it completely; but it has never been enough. Companies had begun to see the need to adequately match each employee's skills and abilities to their relevant job. This is to encourage a smooth transition during the employee's course of working in the company and thus maximizing their potential to proffer solutions as deemed fit due to their prompt adaptability to the job specification being assigned to them. Overtime, lots of steps have been taken to crunch this gap as much as possible,

ranging from on-the-job training while in studies as related to undergraduate training-ship, curriculum adjustment and so on. But still yet, this effort has never been enough to see this imminent problem solved.
In an attempt to explore and solve this problem, the bridge project took a critical multi-criteria analysis at the above mentioned issues.
First, the initial step taken, was to perform a Stakeholder and needs analysis, necessary to deepen the investigation into the problem at hand, to identify all relevant needs and requirements.
Then in a study of state-of-the art, a preliminary screening is conducted in looking at the journey from education to employment while looking at it from two perspectives; the social-economic perspective and a broader theoretical perspective.
A systematic methodology was adopted on the development of possible solutions considering the needs and its respective requirement. This methodology was defined by listing these collective requirements and weighted based on their relevance. The solutions were analysed using the SWOT analysis, whereby the best fit solution was selected using numerical evaluation through weighting of requirements met. Second details about proof of concept prototype were noted, of which is divided into different phases, followed by the key performance indicator of the solutions measuring the feasibility of the solution.
The final phase of the report discussed about the feasibility of the solution with concern to the future. The main stakeholders were highlighted and all possible scenarios were developed about the future sustainability and scalability of the project. Moreover, layout was drawn for the future activities which needed to be done to make this project more effective and efficient for future iterations.
An important fact to point out, is that the selected solution" called "Bridge", added much value to the project by creating a connection for students and their prospective employers, as this model brings about a platform for interaction whereby each student can learn certain facts about their skills and build on their communication with interviewer and an overall boost in their confidence.

Task and Skills

The group was multidisciplinary and worked jointly towards the realization of the final idea and proof of concept. Starting from the three solution generation, interviews to stakeholders, realization of surveys and many other team-activities. Then the team split up and each member focused and worked on specific part of the project.

- **Martina Bonetti:** worked on the graphic part of the project and performed the user requirements studies.
- **Sneha Davis:** organized and facilitated the proof of concepts
- **Emecheta Kemjika Chukwunyere:** organized and facilitated the proof of concepts
- **Subhojit Mukherjee** organized and facilitated the proof of concepts

- **Awais Sadaqat:** worked on the solutions business logic and meetings with the stakeholders

- **Gianfranco Savino:** performed the state of the art studies and literature review.

ABSTRACT

Seeing the need to have more communication skill training done in the academic sector, gave birth to this project being recommended by IBM and further harnessed by the Alta Scuola Politecnica advisors. To explore the transition for this work, a multi-criteria analysis is performed. The first step is the Stakeholder analysis, necessary to deeply investigate the problem and to identify needs and requirements. In this section, five stakeholders were identified and a correlation between them was carried out to fully meet those needs with the right requirements. Then with the study of state-of-the-art for each technology, a preliminary screening is obtained.

A systematic methodology is adopted to select the most promising solution. This methodology needs a list of criteria, defined by clustering of requirements and weighted depending on their relevance. *Job satisfaction, increased employability and feasibility* were basic needs been highlighted for consideration to be met based on the solution deduced.
the criteria were defined and weighed, the selected solution was prototyped through a proof of concept event and then further analyzed in terms of business viability in the community. This study required the team to design three different business plan options:

- **Alumni -**making use of the ASP Alumni network as a resource to keep our service proposal running in the future.
- **Career service -**exploiting the already existing Career Service infrastructure to organize more events like the project proof of concept.
- **In-house outlook -**ASP board taking full charge for the service future, logistically and financially.

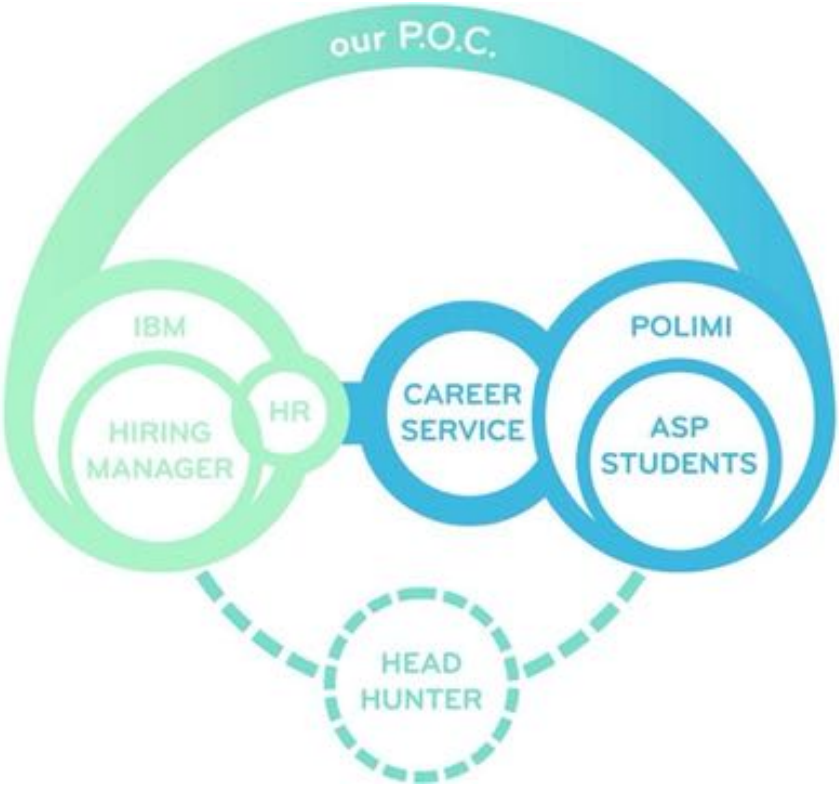
1. UNDERSTANDING THE PROBLEM

Our project investigates on the gap between the academia and the industry from a multidisciplinary perspective. In this context, to improve the knowledge of the problem, a fundamental step is the Problem Analysis, which consists of Stakeholders Analysis. Three very important Stakeholders were identified for the BRIDGE project: IBM, Career service and Politecnico di Milano (Career Service)

IBM : it provided the platform for the hiring managers and Human resources, who needed more solution to the rising need of having recent graduate groomed in certain soft skills such as communication, teamwork and adaptability to their job roles in the industry, being that fighting the retention rate in newly graduates hiring has been an issue at hand.

Career Service : Sustainable relationships with a number companies. Would love to create more understandable job ads, more events to promote job opportunities for the students in the campus, as well as more events to prepare students to job finding which would eventually all lead a more higher hiring rate amongst students of the institute

ASP Students : They were the ones who would require the need in developing soft skills, understanding the match between their study course and job titles thus knowing where to find job ads and having more contacts with the industry while still in university.



Schematic future State

The next step in the analysis is to individuate and make a list of the NEEDS and suitable requirements that the outcome of the project – the final product – must fulfil. The requirements are mainly of three types and can involve one or more stakeholders.

1. **Job satisfaction :** The solution should provide a common jargon for job ads, so that students know their future roles before applying. It will reduce the churn rate.
2. **Increased employability :** The solution should assess and accentuate the students' soft skills to become better prospective candidates during job seeking.

3. **Feasibility :**The solution should be viable for testing within the time-frame of the ASP project

2. Exploring the opportunities

The problem can be seen from two different perspectives: a socioeconomic perspective and a broader theoretical perspective. The Socio-Economic Perspective describe the problem from the market standpoint. Job market is intended as the platform where employers, education providers and youth deal with each other. A 2012 McKinsey report, *Education-to-Employment: Designing a System that Works*, highlights the following six facts:

1. **Employers, Academia, and youth live in parallel Universes.** They have different understanding and perspective of the same problem.

2. **The education-to-employment journey is full of obstacles**. The journey is a highway with three critical intersections: enrolling in education, building skills and finding a job. Each intersection hides significant challenges.

3. **The education-to-employment system fails for most employers and young people.**

4. **Innovative and effective programs around the world have important elements in common**.

Successful school programs around the world share two important features: (1) education providers and employers actively step into one another's worlds. Employers help to design curricula and offer their employers as faculty. Academia have students spend half their time on a job site, eventually receiving a job offer. (2) employers and academia work with their students early and intensely**.**

5. **Creating a successful education-to-employment system requires new incentives and structures.**

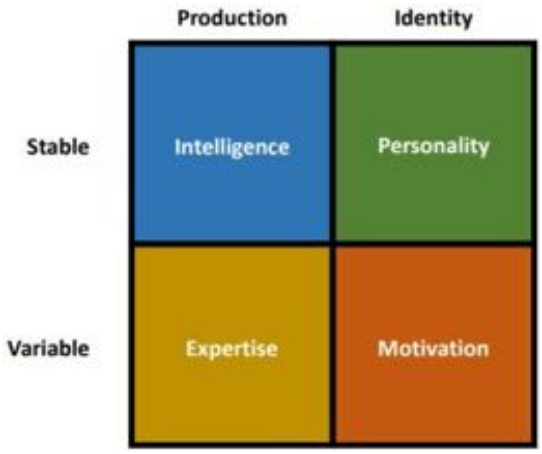
6. **Education-to-employment solutions need to scale up.** There are three challenges to achieving scale: (1) constraint on the resources of education providers, such as finding faculty and investing in expansion; (2) insufficient opportunities to provide youth with hands-on learning; (3) the hesitancy of employers to invest in training unless it involves specialized skills.

Education providers, employers and youth live in parallel universes. Each one sees a different perspective of the whole picture, making difficult their alignment to improve the education-to-employment system. For instance, education providers focus their efforts principally in developing technical skills in young graduates, while what companies are really looking for are soft skills. A theoretical perspective of the problem is given by the book "Il Cerchio e la Bilancia".

Here, the author talks about the functional description of the human brain, and also methods for testing and measurement.

The goal of the framework is to objectively compare candidates and to minimize evaluator bias. The brain is stimulated by the environment. It is then divided in four zones,that can be seen horizontally and vertically.

The horizontal view identifies two different zones: The production zone where the human brain concerns principally in primary needs, e.g. Find food, knowledge, and skills applied to work. In this zone, there is no generation gap: our brain is shaped by evolution, over thousands of years, not by technology. The Identity region implies Social interactions, Self-consciousness and the way we behave at work. The vertical view shows the difference between the stable area which is less likely to change over the years and the variable area.



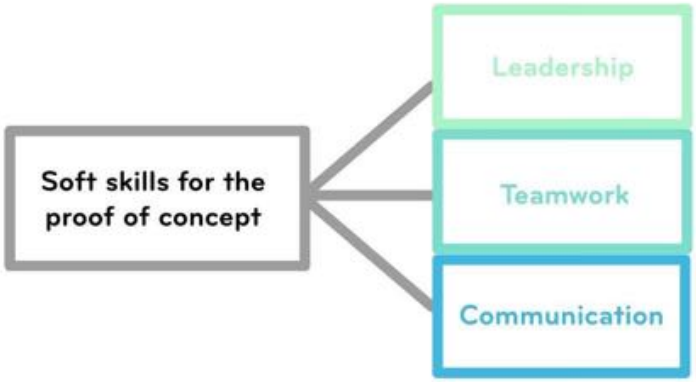
Assessment logic Model

3- Solution:

With the framing of the problem and a thorough understanding of the environment we established the guidelines for the selection of the most feasible and effective solution. The solution developed was able to justify and satisfy most of the requirements of the three main stakeholders.

Our service, Bridge, is changing the way ASP connects to companies by offering its students soft skills assessments run by professional hiring managers. Through the evaluation, Bridge teaches hiring managers from the industry how to spot the perfect candidate for their company. At the same time, it provides students with training for their upcoming first job interviews.

> Bridge is an objective structured assessment in which hiring managers from market leading companies will come and assess the students(ASP) on their **soft skills** *(such as Leadership , Communication Skill and team working).*



Soft skills for Proof of concept

The basic concept of the solution revolves around assessing the soft skills of the students which was identified as one of the major need for all the concerned stakeholders. It involves the managers of the company who will be trained by the external HR consultants on how to assess the soft skills, who then assess the soft skills of the students in specially designed exercises which highlight the competences of the student.

Elements of Innovation:

The concept in itself is unique in the way it combines the two main stakeholders. The solution provides a platform which allows the stakeholders (Industry, Academia and students) to interact in a completely different way so as to understand each other in a better way. Instead of using standard advertising methods and career service events to understand the requirements, an interactive platform leveraging on the soft skill assessment activity which brings to the surface the needs of all the stakeholders and giving an open networked approach to better fulfill the requirements.

The platform does more than just providing a multi stakeholder interactive environment, as it possesses attractions for all the stakeholders packed in a unique way. This solution in comparison to others possess the following **advantages**:

This solution, though requires the involvement of one extra stakeholder, is a flexible and scalable option. The solution set can be designed in its entirety from scratch, and later can also be molded according to the needs of the other stakeholders. Also, since soft skills evaluation and training is one of the key pillars of all the three solutions, it is best if we could actually employ the expertise of a person or a body, who is experienced in the same. Hence, it was decided that in the interest

of the task at hand, the solution which involves a third party needs deeper analysis so that it can be employed in future.

POC Implementation

POC Implementation

The **disadvantages** are of course the bureaucracy due to involvement of multiple stakeholders, both public and private, and this is delineated later.

In summary, this structure in itself inherits the following **benefits** for all the stakeholders:

Students:

- Identify personal strengths
- Get feedback from Industry managers on their soft skills
- Opportunity to network beyond study courses
- Experience an interview assessment before real interviews

ASP

- Improve the visibility of the ASP program and communicating the worth and value of the ASP students.
- An new interactive channel to interact with the Industry
- A possible channel to strengthen the network with the ASP Alumni

Hiring Managers:

- Meet Young Talent
- Get training on soft skills assessment from professional HR consultants
- Get feedback on the assessments performed

SWOT Analysis of solution bridge

Implementation and bureaucracy:

The concept though simple in its formulation, inherits many implementation and bureaucratic difficulties. One of the biggest problems which project presents is finding an agreement with all the academic partners involved in this initiative on management and implementation issues, since it involves the students from two different universities, the level of response and integration of resources from the career services of the two universities (Polimi and Polito) remained a major issue.

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Tags

Soft-skills, communication, teamwork, leadership

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Alessandro Bertagna [PoliMI – Mechanical Engineering]: Member of the Mechanics sub-team. Team in charge of the design, manufacture, test and optimization of the mechanics of the sensor

Juan Cols [PoliMI – Electronic Engineering]: As member of the Electronic sub-team oversaw the development and implementation of the DAQ and communication system. Creator of the Project Logo.

Luis Estrada [PoliTO – Mechatronic Engineering]: Team coordinator. Responsible of integrating the different sub-teams to meet the specified deadlines. Supported the sub-team's activities.

Silvia Milan [PoliTO – Production and Innovation Engineering]: Responsible of the product development, budget administration and contact with the external stakeholders for the project success.

Romeo Casesa [PoliTO – Aerospacial Engineering]: Member of the Mechanics sub-team. Team in charge of the design, manufacture, test and optimization of the mechanics of the sensor

Andrea Zanotti [PoliTO – Computer Science Engineering]: Responsible of the development of the UI, the data management and processing
Worked together with the Electronic sub-team.

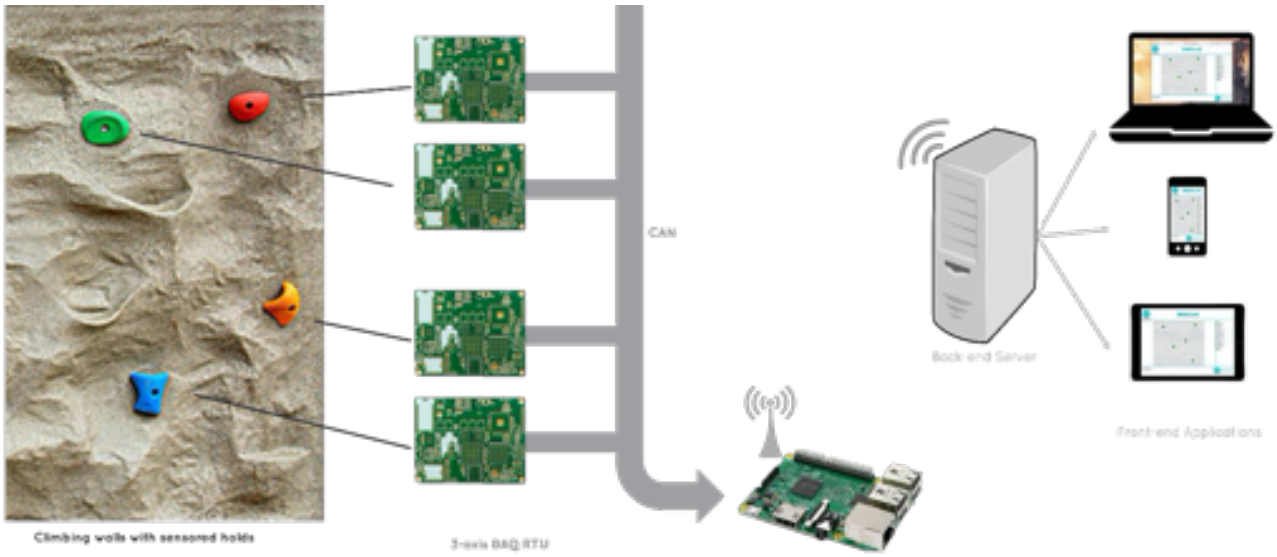
ABSTRACT

Climbing is a complex task, involving strength, balance and coordination. The performance of a climber is experience based and more insights in the mechanics of climbing could be gained by measuring the contact forces of the climber, for the centre of mass calculation in real time.

A multiaxial load cell was developed to measure the evolution of load in time and space. The sensor is clamped on the climbing wall and on the other side the hold is blocked. When the climber hangs on the hold the load signal is read and sent to a PC.

Sensor design allow to measure the force components applied to the climbing holds, regardless of the application point of the force on the hold. The contributions to the deformation due to bending moments and torsion on the sensor are neglectable. The sensor was designed considering a maximum applicable load of 200 kg without plastic deformation, which is consistent with the regulations. For the design phase, both analytical and FEM analysis were used for the geometry optimization. An experimental calibration and testing campaign was performed to validate the sensor design.

The strain signals generated in the Wheatstone Bridge are collected by a dedicated acquisition system.



The embedded system performs analogue-digital conversion and collects the raw data. Different kind of acquisition systems have been tested and performances have been compared with standard industrial equipment.

The force acting on the climbing hold is extracted and its components along the three axis X-Y-Z are computed. The processed data in then sent through a CAN bus to a WiFi-capable device. A Raspberry is thus used for the collection and analysis of the data coming from all the holds.

Once the data is ready in the device, a transmission and a processing is needed to present the information to the user. The devices, connected via their Wi-Fi interfaces to a local Access Point, using a standard HTTP POST request upload the data to a web server. On the server, the data are converted into a human-readable format and additional information are computed, such as the centre of mass. This information is then stored to a NON-SQL database which is accessed from a web application that keeps the data shown in the web page synchronized with the database.

UNDERSTANDING THE PROBLEM

From a general point of view, climbing is a mix of mental and physical workout involving strength, balance, and dynamic coordination of lower and upper body movements. As every other sport, the performance of a climber may improve with constant practice, with the right training sections and a good coach. The specific exercises may vary based on aim, outdoor climbing or competitions, and the category, such as bouldering, speed or lead.

General workout is usually performed in indoor facilities and focus mostly on strength, resistance, balance, coordination, and technical gesture. When talking about climbing movements it should be highlighted that the precise and correct execution of a climbing sequence is a task that even a very experienced climber can typically complete only after multiple rounds of trial and error. Since macroscopic changes in energy efficiency usually arise from posture changes as small as a single misplaced finger, the energy spent to complete a route is a good indicator of movements accuracy. Today trainings are carried primarily in two different methods.

About the technique, learning the perfect way to grab a hold and the correct weigh distribution requires an experienced coach and a lot of trials: "*Do it again. And again. And again. Till you succeed*".

On the other hand, as far as body strength is concerned, climbers execute specific exercises to strengthen each single muscle, until a sufficient power for completing a path is obtained. This could be an erroneous approach as it would be as an engineer attempts to increase the engine HP without being able to analyse how many of those HPs are used and how effectively.

A force sensor on each single hold, able to measure the forces along the three spatial components, normalized with respect to the climber weight, can be the technological bridge between sport technique and body power. Especially, knowledge of the four applied forces can be used for plotting the position of the body's centre of mass along the path for monitoring the correct distribution of loads. A climbing path with 10-12-14 smart holds can be used for analysing the efficiency and the correctness of movements. This synthesis can be carried out substantially in two different ways: comparing data between an amateur and a professional athlete, for highlighting the significant technical differences, or monitoring the improvements of a single climber, for showing which gesture or body coordination caused this improvement.

As a matter of fact, different climbers on a given path will usually show a different behaviour. When professional athletes are observed, they will give the impression that they are not struggling to complete the route. It can be expected that a more experienced climber will use less force, in relation to its body mass, with respect to a beginner, and his higher performance is not just due to a greater athletic capacity.

Apart from a comparison between athletes, it should be noted that also the same climber repeating a certain route several times will have an evolution in the applied force on the wall, even after just few hours of training. This fact is surely not due to a miraculously immediate strength improvement but rather to a better coordination and posture. Measuring the evolution of such performance it can be expected that the force on the axes decreases with the number of repetitions up to a certain asymptote such as charging a capacitor. In practice, this can be seen as the learning curve of the climber practicing that specific route.

These two analysis modes combined would lead to many other interesting analysis: comparing the learning curve of different climbers, knowing how experienced climbers execute the route and apply forces on climbing holds, would help trainers and trainees to develop specific training programs to get better results in a short time.
Despite of the many advantages listed above little has been done so far in this direction, mostly due to the cost of instrumenting a wall for the purpose, and as said before to a certain "suspicious adversity" towards technology among conservative climbers.

Nevertheless, the climbing industry has been experiencing an exponential growth in the last years, and this allows new technologies to enter this market, and break down existing barriers.

EXPLORING THE OPPORTUNITIES

Indoor climbing has been experiencing an enormous growth in the past ten years, and thanks to the inclusion of this sport in the 2020 Olympic Games, the number of practitioners is expected to

increase exponentially in the next future. This has led to a rising number of companies interested in developing technology-based solutions to approach this sport. Nevertheless, all of them are still in development or in early diffusion phases, and this is mainly due to a certain immaturity of the market, where just a niche market is investing in new technology solution.

Rock climbing has seen an interesting growth in the last years both for outdoor and indoor practitioners. Since the first climbing gym in the late '80s, the number of indoor facilities have grown and according to the Climbing Business Journal has reached a total of 414 commercial climbing gyms in the US at the end of 2016. Even if this year was characterized by a relatively low growth of 6.9% instead of the expected 16%, as anticipated in May at the annual CWA conference, climbing remains an appealing market for investors. In fact, 56% of new gyms were opened by first time by climbing operators which saw in this sector a profitable investment despite the huge initial cost: For example, Rockwerz, a rock wall construction company states that the initial investment is approximately equal to $400,000 for a 6,000 square-foot climbing wall, and $600,000 for a 12,000 square-foot one.

Based on the 2016 Outdoor participation record, the number of people in the US who participated in both indoor and outdoor climbing is 1.6% of the population, that is about 5 million people, of which 1.3 million are American guys under eighteen years old. These numbers have slightly decreased in the last two years but a new wave of interest in this sport could come from the 2020 Tokyo Olympic games in which sport climbing has been recently introduced. Such a huge international event could increase the pairs of eyes watching the discipline, enhance the interest in practising it, and thus create new possible investments.

Although the market is growing, the current widespread technology has arrived at its top performance and new alternatives are emerging. These innovative systems for climbing have not reached a dominant design yet. This means that new alternatives which include a sort of technology improvement have not reached a successful diffusion phase.

According to the Abernathy – Utterback model the development of a product consist of 3 stages: fluid, transition and specific stage. And it has been possible to place the climbing technology in the first stage.

The fluid stage has the characteristic of having firms competing on basis on its product features, and uncertainties remains in the market. So, new technologies are competing to be the next technology, but all of them are between the incubation or early diffusion phases. The project MACLoC enters to this market in the exact phase where big innovations are occurring.

GENERATING A SOLUTION

A triaxial force sensor and the related DAQ and processing systems are presented as an example of IoT application, applied to indoor climbing, allowing the user to access real time data coming from multiple sensors during performance.

From the state of the art, and after the first stages of the product development, the team identified an opportunity to patent the measurement strategy of the sensor. This includes, geometry of the sensor and strain gauges location. The patent procedure currently in process within the Intellectual Property office of PoliTo. For that reason, further details about the sensor were attached neither the patentable information nor the schemes.

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TAGS
Internet of Things, Force sensor, Indoor climbing, Embedded system

M^3

Metereosensitive User-Controllable Skin for Dynamic Façades

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Team Members




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Project description written by the Principal Academic tutor

One big question for architecture is why humans have to adapt to buildings and why cannot architecture adapt to humans. Even during the modern movement, exterior walls in architecture were designed to be static and rigid. Visual access between interior and exterior environments was open with the use of glass and steel, but artificial climate control still determined the impenetrable limits of those glass walls.
As times change, more recent public interest in sustainable design, energy conservation and zero-emission building design has infused the industry with renewed impetus to seek alternative solutions. The always most diffuse use of dynamic skins facades have brought incredible results for high performances buildings, increasing interior comfort and reducing energy consumption.

Skin is the mediator between the body and the environment, between the inside and the outside. It is the visual manifestation of a mass or volume, giving form to a grouping of organic cells. In architecture, the basic purpose of this skin or membrane is no different from that of animals or of humans. Not only specializing as a covering, the skin acts as a barrier that can selectively modulate the passage of physical, mechanical and chemical stimuli, such as heat, water, force, and other organisms in both directions.

Once merely an element to build shelter, materiality has now become instrumental in the design of building skins. The experimental attitude to materiality has architects considering the use of materials in new and unexpected ways, in unconventional situations and conditions. Many of these newly developed materials are capable of reacting flexibly to the external conditions physically or chemically in response to changes in the temperature, light, electric field or movement.

Despite the advantages of current dynamic façade experiments, there are still many limitations, such as the use of electricity or the lack of user control over the façade movement. The term Smart Materials has been used to define these materials that have changeable properties and are able to reversibly change their shape or colour. These materials are important to architectural skins in that they allow the building surface to be reactive to changes, both inside and out, automatically.

Project M^3 aims to create an innovative dynamic facade system that, by the use of shape memory morphing structure, it is able to change its geometric shape following sun and temperature cycles. Moreover, in addition to its autonomous actuation, the facade would be able to guarantee the user a manual and interactive control of the system.

Team description by skill:

Alain Boldini: He took an important role in the stakeholders' needs and requirements analysis. As an expert in continuum mechanics and material modelling, he focused on the multiphysics description of Nafion™ and on its finite element analysis, helped also by the expertise of Prof. Akbarzadeh from McGill University.

Marco Colangelo: He participated to the definition of the concept structure and mainly dealt with the study and implementation of shape memory alloy materials (NiTi alloys) for actuation purposes. Moreover, as an expert on integrated electronics, he designed, built and tested the electronic system needed for actuation and overall control.

Andrea Pilla: in his role of Communication Coordinator, managed the contacts between the whole group, the tutors and ASP administration. As Building Engineer, he dealt with the engineering of the concept and he performed daylight analyses and evaluated performance indicators. Moreover, he participated in the mechanical tests on Nafion™ and he performed the following data processing.

Matilde Tavanti: As Architect, she focused on the analysis of the start of art of kinetic and adaptive structures, she focused on the concept development. Moreover, she implemented the 3D model in Rhinoceros-

Grasshopper and contributed to the finalization of the project and the architectural synthesis of the work, by means of renders. She took care of graphical representations.

Abstract

In the context of high performance buildings, adaptive dynamic skin façades represent a promising and efficient strategy to ensure daylight and thermal comfort and to reduce energy consumption. M^3 project fits in this framework.

The aim of project is the creation of an innovative dynamic smart façade with solar shading system actuated by shape memory morphing structures. In the proposed system, sun sensitivity and autonomous actuation are merged with the vital feature of user controllability and interaction.

Inspired by nature, just as sunflowers move petals in response to light from the sun, the designed shading system dynamically adapts its wings to the incoming radiation, by adjusting their folding/unfolding configuration. The mechanism is possible thanks to the use of shape memory materials that possess the unique characteristic of memorizing shapes that can be recovered through the application of external stimuli. The external shape memory polymer layer allows a completely autonomous passive control of internal conditions and zero-energy actuation. Moreover, the integration of a shape memory alloy-actuated internal opaque layer grants the possible implementation of the resulting structure in real buildings, conciliating comfort, well-being and performances (adaptive comfort) and allowing personal control of living and working environments.

These modules are assembled together to create a skin to be inserted in the double façade cavity in order to attain at the same time the benefit of this technology, higher durability of the skin and protection from the wind.

The project tried to face the whole design process from the architectural concept to the mechanical design of substructure and testing of the actuation system, and from lighting numerical analysis to the creation of a real scale prototype.

Final visualization of the façade application, external view

Final visualization of the façade application, view from the interior space

UNDERSTANDING THE PROBLEM

Morphing metamaterials represent a huge new field of investigation for scientists and are becoming interesting for engineers for a potentially great number of purposes. Among all the different applications, the context of high energy-performance buildings has been chosen, focusing, in particular, on the control of daylight and environmental conditions, which is of primary importance.

Once fixed the framework, the main stakeholders have been identified, including the internal users, the building engineers and architects, the companies involved in the production, construction and maintenance and the investors.

From the point of view of the users, two important conflicting requirements have been recognized: the nearly-zero energy actuation of the shading device, which is essential for the environmental sustainability of the system, and the user controllability, which instead is fundamental for the practical implementation of the conceptual design, since the user has to be able to modify the behaviour of the façade according to his will.

While the former requirement would imply the use of a passive system that can adapt automatically to the external conditions, the latter instead would require an active system, which could be managed by the user, having energy consumption as an unwanted effect.

By an analysis of the state of the art of dynamic façades, it has become clear that these two conflicting requirements are not satisfied together in the existing dynamic façade's paradigms, which ensure just one of the two requirements. In this framework, the technological innovation brought by morphing metamaterials can be a vital push for the creation of new concepts.

Other requirements are considered for the design of the system. A captivating design is necessary from the architectural point of view, in order to attract investors and to have an appealing public image. The system should be as simple as possible, so that the production, installation and maintenance phases are easy; a great advantage in this sense, is brought by modular devices, which are widespread in the context of dynamic façades. Finally, the economic feasibility of the project is related to the life cycle cost of the system: investors could be willing to face a higher initial investment if it is compensated by energy savings during the life of the device.

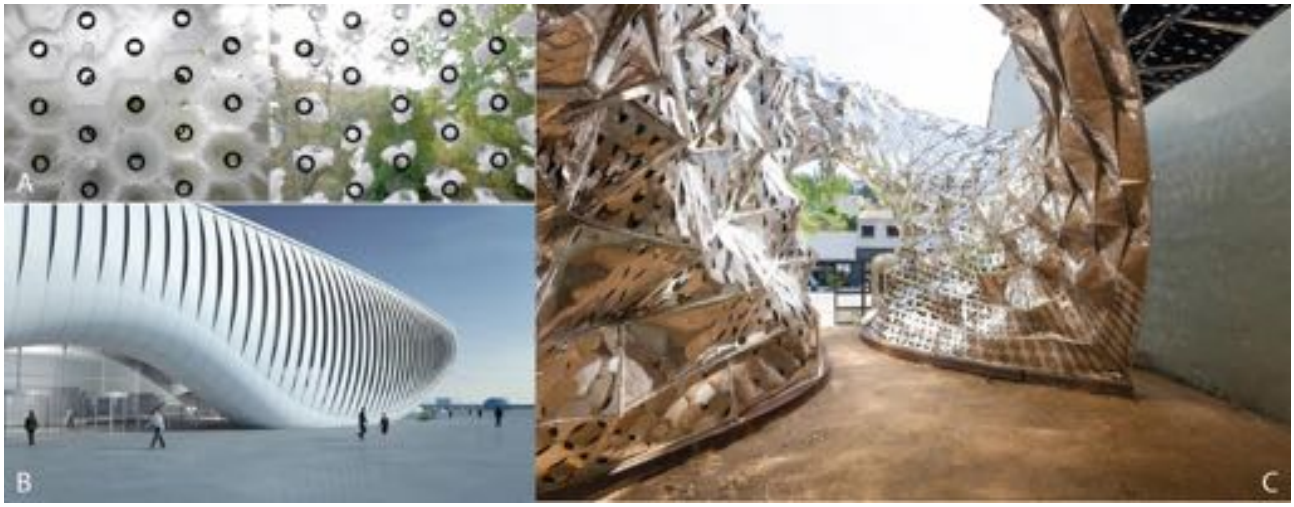
EXPLORING THE OPPORTUNITIES

The incompatibility of the two user requirements represents the most critical issue of the entire project: the necessity of having a system which incorporates passive and active characteristics at the same time has led to the study of the state of the art of dynamic facades to explore current solutions.

The zero-energy actuation is nowadays satisfied using self-regulated facades which exploit particular materials or structures responsive to air flow (Breathing Skin - Tobias Becker, Fig. 3A), sun irradiance (Bloom - Doris Kim Sung, Fig. 3C), moisture or temperature gradients. The zero-energy actuation capabilities are given by the fact that no user-provided energy is required as the actuations are powered by harvested environmental energy. Nevertheless, this huge advantage is nullified by the absence of user controllability which impedes the actual exploitation of such facades.

The user controllability is instead satisfied by the creation of mechanically complex structures user-actuated by providing energy to coupled electro-mechanical systems (One Ocean – Soma, Fig. 3B). Such solution even

if convenient from a usability point of view, requires a huge amount of energy and ends to be an aesthetic expensive unsustainable system from both construction and operation point of view.



Collage of analysed case studies

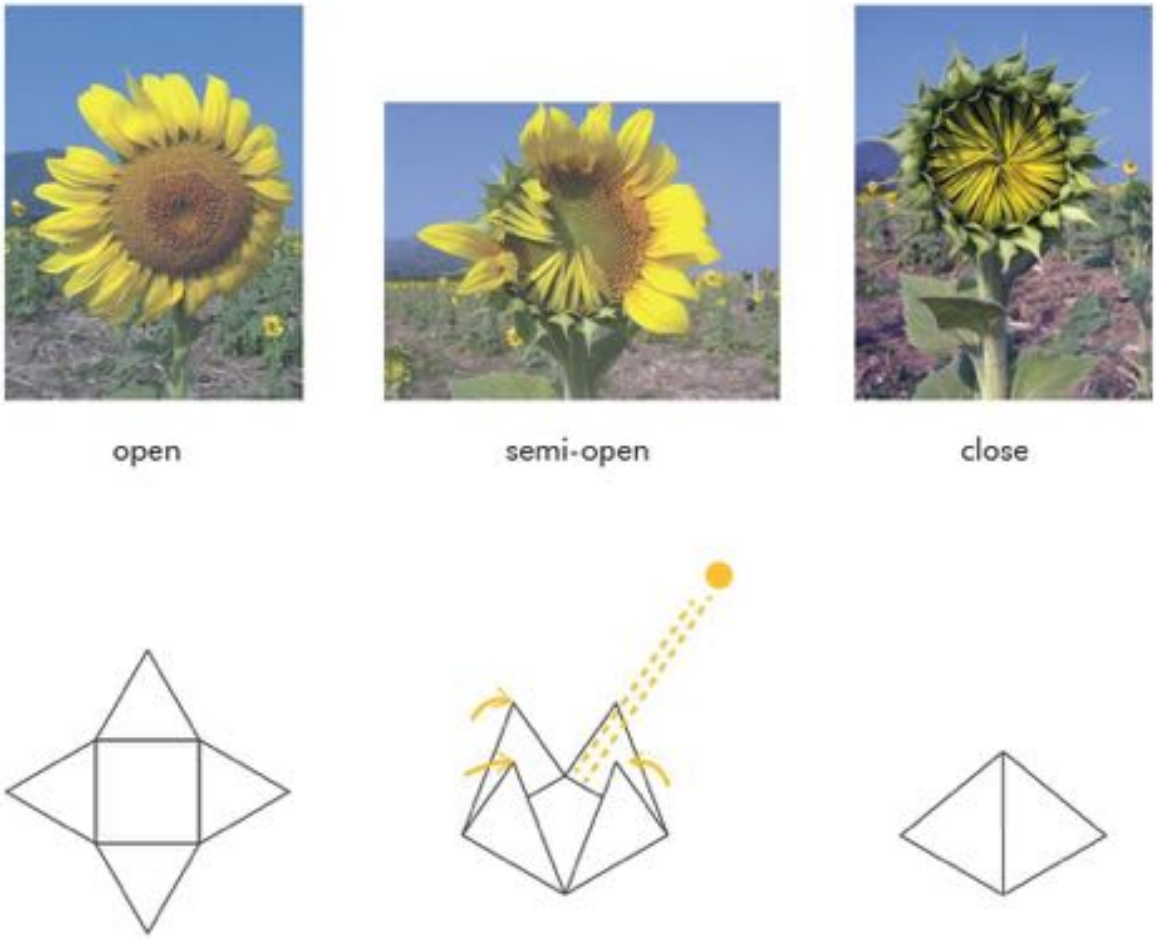
This conflict can be solved by the creation of a meta-material, intended in a broader sense, as an innovative structure combining properties naturally not available together. The concept is based on the use of advance materials having shape memory effect (SM). The advantages offered by SM materials, in this context, are the actuation possibilities which can allow the operation in passive and active mode at the same time, using different actuation sources, granting therefore zero-energy actuation and user controllability.

GENERATING A SOLUTION

After the analysis of the state of the art and the exploration of different opportunities, in the final stage of our project we proceeded with generating our own solutions to the aforementioned challenges.

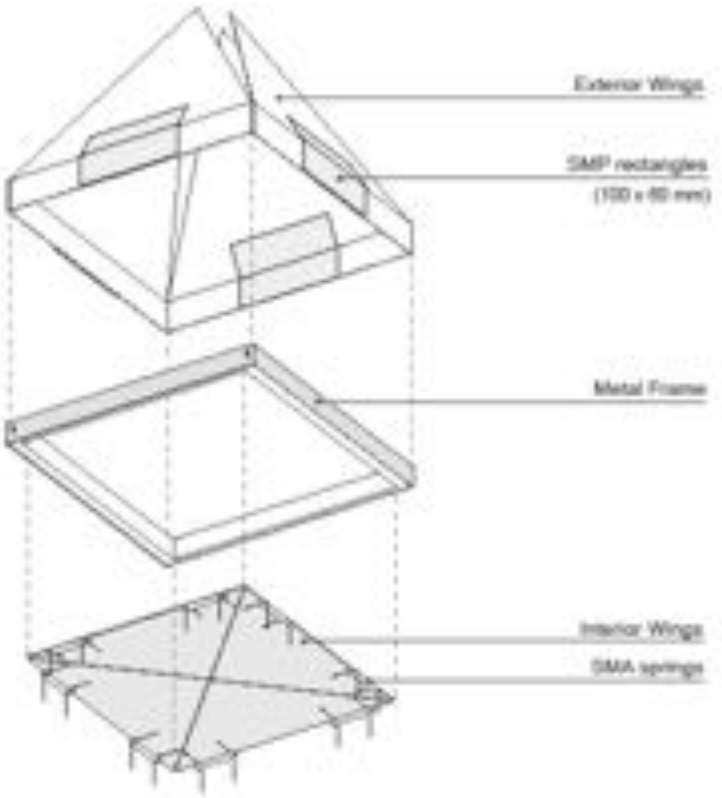
The idea to allow the building to be reactive to changes, both inside and outside, was the starting point. The proposed solution aims at mimicking nature's movements: just as sunflowers react to solar radiation adapting their shape to the surrounding environment, the same can occur within an architectural component.

Therefore, the proposed shading device derives from the geometrical schematization of a flower: a square basis module with four petals dynamically adapted to the incoming radiation.



Geometric schematization of the concept

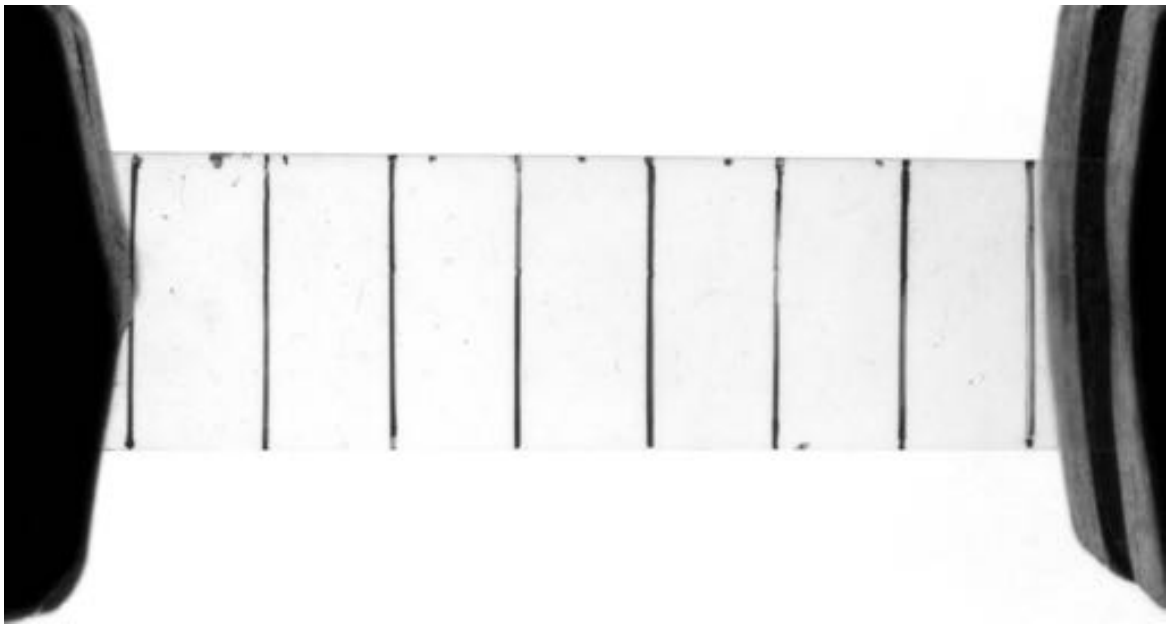
More in detail, the module is composed by two matched devices: the outer structure, actuated by a two ways shape-memory polymer (SMP), reacts to different surface temperatures, consequence of direct solar radiation, opening at low temperatures and closing at high ones, in an autonomous way; the inner structure, instead, is driven by shape-memory alloy (SMA) springs, which may be electrically controlled by the user in order to modify the effects produced by the external layer, without any interference with it when not actuated. The internal layer is programmed to potentially interact with the external layer antagonistically. However, in default position the internal layer does not actually interact with the external one.



Schematizing of the module parts

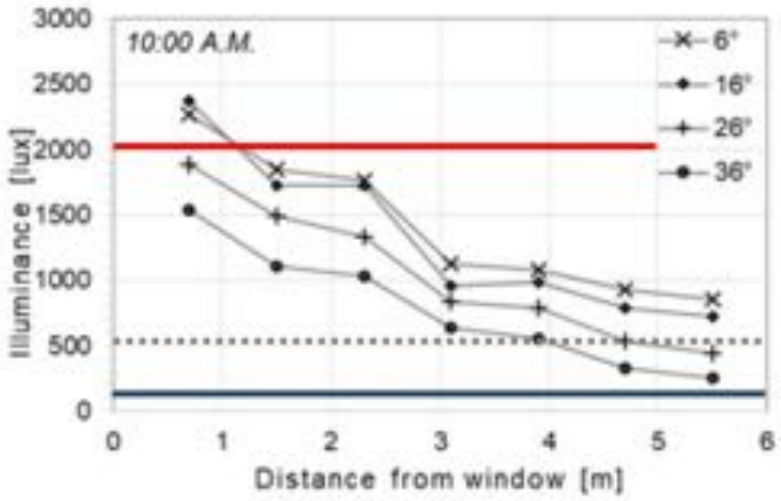
The SMP layer allows a completely autonomous passive control of the internal conditions and zero-energy actuation. The integration of the SMA-actuated module permits the possible implementation of the resulting structure in real buildings, conciliating comfort, well-being and performances, adaptive to a personalized control of living and working environments. The two layers are both fixed to a metal frame which guarantees structural resistance of the module and allows anchoring to the substructure. The modules are inserted in the gap of a double façade in order to combine the energetic benefits of this system, in particular during the winter period, with the shading during the summer period. The placement inside the gap thus protects the modular skin from the external environment and also from the wind.

The validation of our concept has experienced different stages: first, we implemented numerical simulations in Grasshopper; then, we tested commercial polymer, which, according to literature, should show two-way shape memory effects.



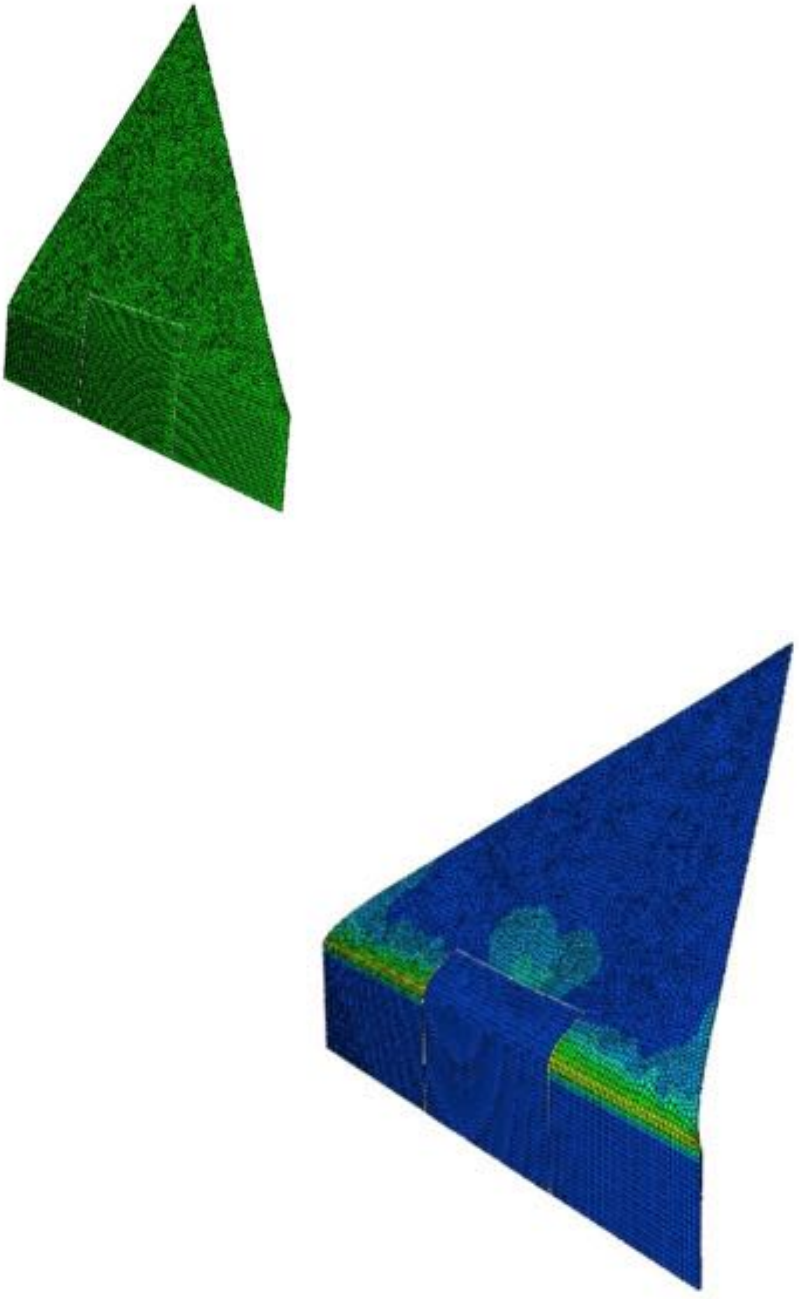
Politecnico di Milano, sample of Nafion^{TM} during tensile test in thermal chamber

Finally, we proceeded with the construction of a real scale prototype. More specifically, in Grasshopper we simulated the movement of the module during different hours of the day and we verified the daylight performances of the system.

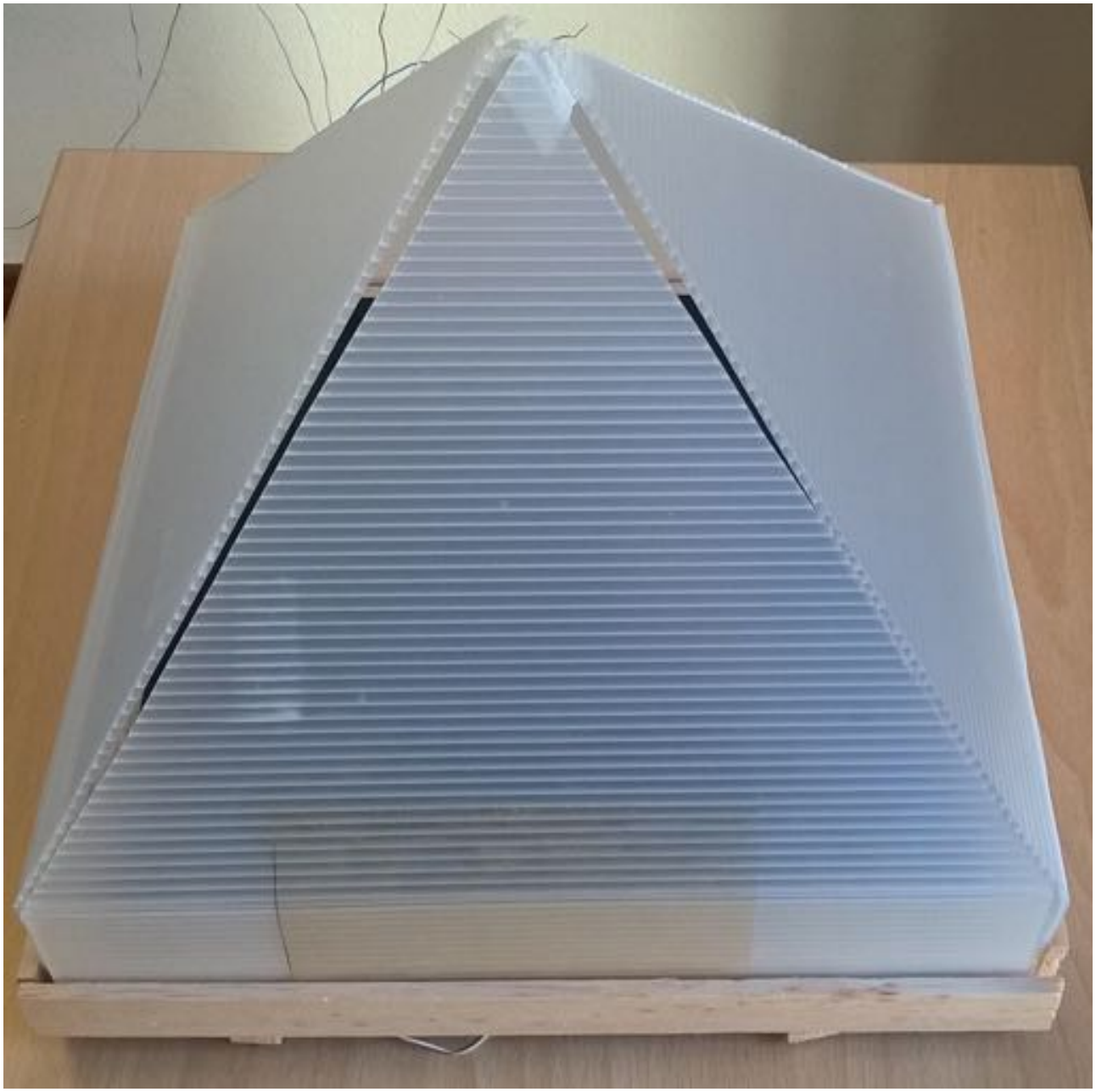


Average work plane illuminance along the depth of the room – 4th March 10:00 A.M.

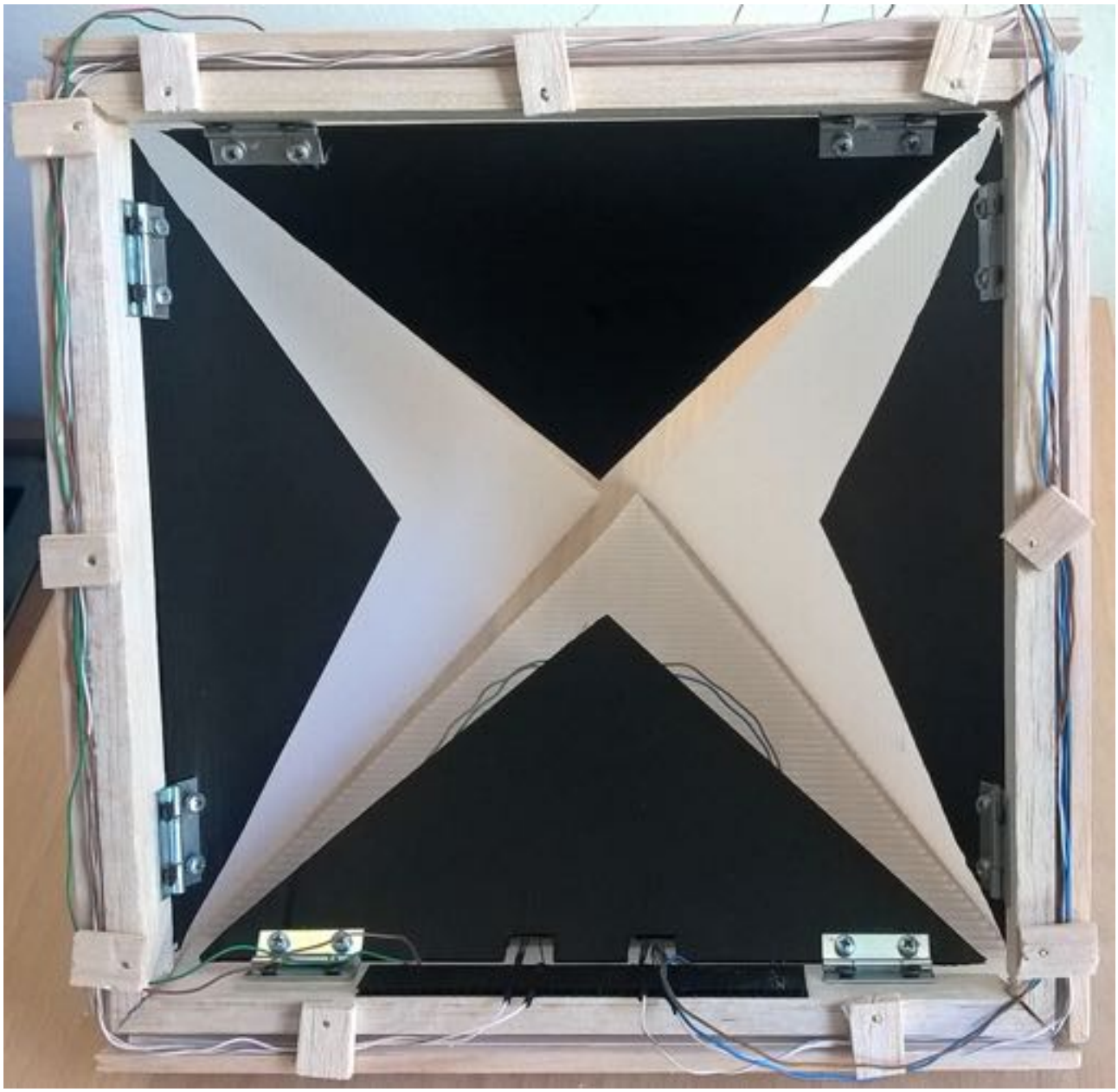
This latter stage was necessary in order to optimize the module shape and define the operating conditions of the system. Part of the project time was spent to verify the two-way reversible shape memory effects of commercial Nafion™ membrane and the implementation of a model, in the commercial finite element code Abaqus™, through the user subroutine UEL, to check the induced stresses.



Output of FEM analysis in Abaqus



Final physical mode - Top view of the external side



Final physical mode - View from below of the internal side

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TAGS

Sun Responsive architecture; Shape memory materials; Adaptive building skins; User controllability