Hypothesis of infographic digitization of the building stock: the innovative contribution of ICT tools.

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Abstract

For years now, the strategies of the Italian Government and public administrations are moving the interests of the clients towards politics apt to ensure the functional recovery and renewal of real estate infrastructures of which our country is extremely rich. The strong incentives regarding the energetic, environmental and structural requalification of the existing heritage in the construction industry ensure that the housing demand will be reduced recording a slow but constant decline in the construction of new homes and buildings in general. The asphyxia of the Italian real estate market is certainly due on the one hand to the economic crisis and on the other hand to the necessity to reduce the soil consumption for new buildings. However, if the new constructions are decreasing, the interventions on the built are recording a constant growth especially in recent years thanks to the economic and social policies aimed to an increment of the investments for the energetic, environmental and structural requalification of the existing heritage.
However it follows the need to prepare a management plan of the same building heritage able to guarantee the correctness of the implemented data and feedback of the same in order to define the possible planning guidelines for the future building projects.
In view of those considerations, in this contribution it is proposed a supporting methodology to adopt a new strategy suitable for improving the management of the building heritage and such as to realize the infographic digitization of the building through the implementation of appropriate information and Communication Technology tools (ICT), such as: the Building Information Modeling (BIM) and the Augmented Reality (AR): the result will allow to prepare a new design methodology of the building project - weather maintenance work but also a new construction - ensuring a growth in the productivity and an improving of the planning and executive efficiency of the work in question.

An overview on the Italian Building Heritage

In a reality like the Italian one in which the building heritage is overmuch compared to the housing demand and the current needs, the necessity to renovate the real estate infrastructures is greater than the need to build new homes and new construction in general. The Italian housing stock is so large and widespread, but at the same time ancient and under somewhat obsolescent, to require relevant interventions of building recovery and requalification.
These evaluations are also supported by some economic indicators about the construction market which, although providing a slight increase of the investments in new housing over the current year, confirm the 2016 will be the year of the ordinary and extraordinary maintenance with about two-thirds of the total building turnover, relegating at less than one-third the investments in the new buildings (Figure 1).
As Brandolini asserted (2004) at the turn of the. new millennium it seems inescapable the condition of having to work, in close relationship with the existing. Until about twenty years ago this could appear a principle or ideology choice, but today this is no longer a choice, but a necessary condition, of which you can not do without. Circumstances that pushed administrations and governments to promote recovery and

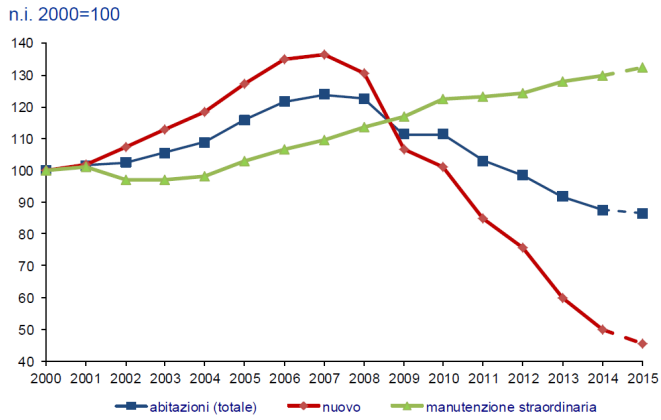

Figure 1 – Investments in the construction industry (ANCE).

restoration initiatives of the urban and territorial pattern, highlighting the need to reformulate the processes of intervention on the urban areas, encouraging the research for a structured path among governance, companies and local communities, with the emission and subsequent extension of rules – including important tax benefits – for building renovations and energy efficiency.
Unfortunately, the absence of this management and long-

term culture about the building work has discouraged the business operators minimizing the investments. In fact it is during the development of the planning strategy on the existing building heritage that the difficulties come to light and the flaws of an outdated regulatory system which is rooted in an impulsive way of building and that gives too little consideration to the managerial vision of the work in project become evident.

Therefore it would be more appropriate to shift the focus from the policies of the new to those of the existing, from the construction of new buildings to the conservation of those already in place, and thus to the redevelopment of disused settlements, with such implementation policies as to transform the organization of the renovation, maintenance or reclamation intervention in general, to management of the intervention good – and thus quality management – transforming a building project into a managerial action.

A management vision of the work would amplify the quality of the work itself simplifying the planning and the execution of any work that must be implemented on the existing building heritage, and also allowing the achievement of the optimum design. This would mean a long-term vision of the building contract/commission, which, at this point, would not be more limited to the alternation of three consequential operative moments such as the project, its start up and its enjoyment, but to a broader, global, all round vision that includes the whole life cycle of the property being studied, including inevitably the same stages of planning and testing, but not just this.

These in fact represent just a part of the long life that characterizes a property. Certainly it is not easy to invalidate a culture like the building one already consolidated, the transformation would be momentous, but the considerable advantages and the researches in this sense demonstrate it.

And yet talking about a management presentation of the work, we do not want to mean nothing but the custody of the data over time, the preservation of a technical memory of the all executive projects that allowed the realization of the architectural event, and that also contains the basic data indispensable for the programming of the future interventions to be implemented in an effective and economically advantageous manner/way.

CAD and Information Management

A first fundamental step in the evolution and improvement of the management of information is represented by the need to gather data in other formats which are currently presented in a CAD environment or in a paper format.

The relocation of data in CAD digital format into other more efficient ones represents the starting point for building heritage management. Almost thirty years ago – the first line in CAD was drawn in 1982 for building representation – the Computer–Aided Drafting software represented the point of arrival for building design. Yet, it was able to produce a mere two–dimensional or three-dimensional representation of a building or of an engineering project, which, nonetheless, presents an undeniable technical value.

It is true that both the standard requirements as well as an increase in communication standards have improved the diffusion of infographics (three–dimensional models, rendering and immersive videos) which are able to engage and attract the users directly.

Nowadays, however, it is not enough to communicate the “shapes”, the “materials” and the “colors” of an engineering work – this is still an enormously important factor – but also, and especially, the “information” enclosed within the work itself , meaning with them aspects related for example to the costs, to the stages of work, to the technical characteristics of the used materials, to the annual and multiannual management plans that these elements require.

Inevitably, the change in needs modifies the methodological approach used for planning, which becomes smart and planned management of the work planned: the working efforts are concentrated mainly during the first phase of the selection of design strategies, methods for achieving goals and in the choice of the technical and performance characteristics of the materials used.

The implementation of this innovative technology makes the design phase essential to the construction phase of an engineering work. In fact, it can allow for an accurate building inspection by improving the overall quality and, at the same time, providing an accurate virtual reproduction of the building. The basic idea is “design as you build”, this axiom can allow one to anticipate the difficulties that usually occur during the construction phase and during the preliminary planning phase. The advantages are considerable since they reduce misunderstanding of planning, delays and confusion between the different phases and design disciplines, which could otherwise mean changes to the plan with a consequent increase in errors, costs and inefficiency.

ICT tools for the management of the building process

In the construction industry, the need to share information is the basis for any planning condition, so the construction industry is employing more and more tools and technology that can improve the usability and speed of sharing.

Unfortunately, the absence of a true unified approach, and more precisely, the lack of education on real estate manage-

ment, highlights the complexity in the execution of operations, which, in our digital era, should require a simple click and not, as it so often happens, endless waiting due to bureaucratic matters which are often fruitless.

At the heart of these considerations, the need – and the proposal – arises to substantially modify the system so that it allows one to record the individual planned events related to the realization of an engineering work, for a more elaborate system capable of simultaneously recording all the design and construction events that occur successively during the building process. Therefore, this system must be able to collect all the necessary information for proper building management.

The benefits are evident and are proven by the major respect for the work itself, but especially, by a sharp reduction in research and survey costs.

The idea comes out through the existing buildings and through the enormous difficulties that are found during maintenance or recovery work. Therefore, the proposed methodology is an opportunity to define valid modus operandi for intervention on existing buildings and as a methodological approach for interventions on new buildings.

It begins through the enormous potential seen in the Information and Communication Technology (ICT) tools considered a set of technologies that allows one to create and communicate information through digital means. Their impact on modern society is deep since they drastically change the way one understands the market and they allow for the progress of globalization which, in some ways, is shared.

Considered a possible solution for controlling the interdisciplinary inefficiencies that regularly occur, the Building Information Modeling (BIM) is currently well-established in the world of design and property management at the international level. In fact, it is able to handle a large flow of information related both to the activities directly associated with the design (architectural, structural, engineering, etc.), but also to the enormous flow of information related to the management. Of utmost importance is the conservation of assets and, thus, the building heritage in general.

ICT does not waste information and it records it in a timely manner ensuring a real continuity between the phases of the building life–cycle: the design is automatically recorded and the "data", memory and informational knowledge used is stored.

The model is divided into parts from which it is possible to build a virtual document database, connecting the concept of interoperability throughout the design phases to the synchronization of three–dimensional visualization which facilitates the exchange of visual information, maintaining reliability. Therefore, the building, being in three dimensions, also acquires the features of a computerized, digital model, endowed with information of a technical, economic, and performance–related nature, whether they are physical–environmental (with implementations of the thermal characteristics of the elements that make up the shells), structural (with the calculation of the load bearing elements and related scaffolding), or numerical (with the extrapolation of materials list and related quantities).

The BIM–based design allows for everything, permitting the creation of an informational model of the entire building which proves that graphical representation is a valid communication tool. However, the documentation extrapolated from the use of imaging is an indispensable tool for the project.

Even though the potential of BIM in managing new interventions is well–known, there is still much to be done in regards to research into the modality of preservation and use of data over time.

BIM was created to produce new things. It has all the traits needed to consolidate a database as well as the possibility of gathering information that plays a key role in the building–related process.

Even though data storage is quite immediate in the database design (Figure 2), due to the adoption of a design methodology which places the BIM at the fulcrum of operations, visualization turns out to be more complicated; for instance, the execution of interventions located in the structure or even for research of essential information on site.

Unlike BIM, which is a big container of data, *Augmented Reality* (AR) could constitute a valuable tool for their use directly on site. AR is an instrument included among ICT tools, which is achieving more and more use in various industrial sectors. There are essentially two types of uses regarding interactivity with the scene and advanced visualizations. It has several applications, including the medical field, the fields of industry and maintenance, the IT field and even in the advertising, entertainment and military sectors.The term was coined at Boeing in 1990 by the researchers Tom Caudell and David Mizell. The two scientists, while working on a prototype capable of replacing the flight instruments, developed a device worn on the pilots' face used to rapidly view the route and all the information related to takeoffs and landings. The reality observed from this perspective was named augmented reality, because another type of information was added to the real world. Then, in 1992, the same term was by used by Ronald Azuma defining it as "[...] Augmented Reality (AR) is a variation of Virtual Environments (VE), or Virtual Reality as it is more commonly called. VE technologies completely immerse a user inside a synthetic environment. While immersed, the user cannot see the real world around him. In contrast, AR allows the user to see the real world, with virtual objects superimposed upon or composited with the real world. Therefore, AR supplements reality, rather than completely replacing it. Ideally, it would appear to the user

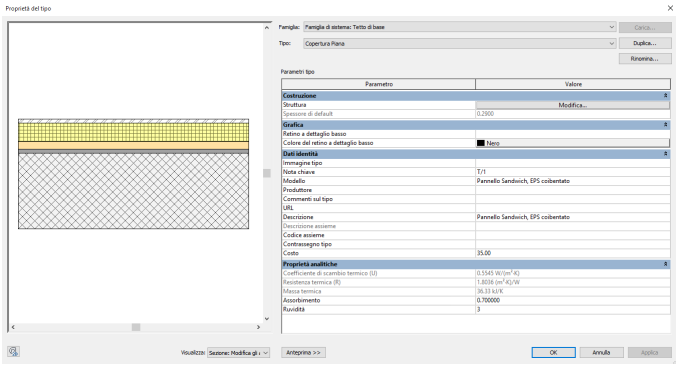

Figure 2 – Example of input data BIM.

that the virtual and real objects coexisted in the same space, similar to the effects achieved in the film "Who Framed Roger Rabbit?" (1997, 355).

Figure 3 – Augmented Reality (Wikitude APP).

Unlike Virtual Reality (VR), which replaces the vision of the real world with the creation of an artificial one, augmented reality enriches the perception of the world by adding interactive objects which, in some cases, could be created through virtual reality. Therefore, it could be defined as un extension of virtual reality because in augmented reality the user continues to perceive the real environment. However, it could be overlapped and integrated with some digital images or with some data produced ad hoc which enriches the reality with useful information in order to resolve complicated situations. Therefore, it is known as a combination between the digital and the real world through which users continue interacting with objects in first person.

Interdisciplinarity for the management of building heritage

The concept of BIM–based interoperability is described as "[...] ability to manage and communicate electronic product and project data between collaborating firms and within individual companies, design, construction, maintenance, and business process systems" (Gallaher et al, 2004) and also applicable to disciplines that, at first glance, have very little in common, namely Augmented Reality. In this case, interoperability means interdisciplinarity and even the ability to exchange data between software and several applications in the area of several disciplines without losing information or generating useless redundancies. The benefits are obvious, proving themselves in the increase of productivity involving mapping and data use as well as the implementation of operational processes in order to increase the efficiency of planning and execution of engineering projects. Therefore, the idea of creating a point of contact between two tools developed in the time for need between their unknowns like BIM and Augmented Reality. The circle connecting the two ICT tools is completed in an application for tablet or smartphone developed ad hoc to keep apparently different tools in direct communication with one another.

InsidAR is the application for smartphones and tablets planned and implemented to "augment" the perception of reality in a building environment: that is to be able to produce from the information through three–dimensional models and technical documentation that allows the user to be immersed in the augmented reality and content. Taking advantage of the communicative capacity of Augmented Reality, the APP allows one to view technical information used during the design process in a BIM environment on the mobile device's video. It is the most suitable and innovative tool for performing infographic digitalization of the building, moving management and maintenance toward new horizons, definitively relegating the large amount of daily–produced, technical, printed documentation to a marginal role.

The development of the Augmented Reality application has seen the modern use of two applications, the interpretation of images taken from the mobile device's camera and the reconstruction of the image. To this end, Software Development Kit (SDK), meaning the packet of tools for software development, has been used for image recognition. In order to implement applications of any kind of SDK requiring environment of development software known in IT as Integrated Development Environment, or also Integrated Design Environment or Integrated Debugging Environment (IDE), meaning software in the stage of planning that helps the programmers with the development of the code coming from a program: for example, pointing out the code synthesis errors directly during the process of writing plus an entire set of support tools and functionality during the development phase as well as debugging. The connection between the SDK and IDE applications is realized through an alternative software that also works through the development platform and consists of connecting the database generated from the SDK, processing it in IDE systems and then visualizing it on the screen of your own smartphone or tablet (Figure 4).

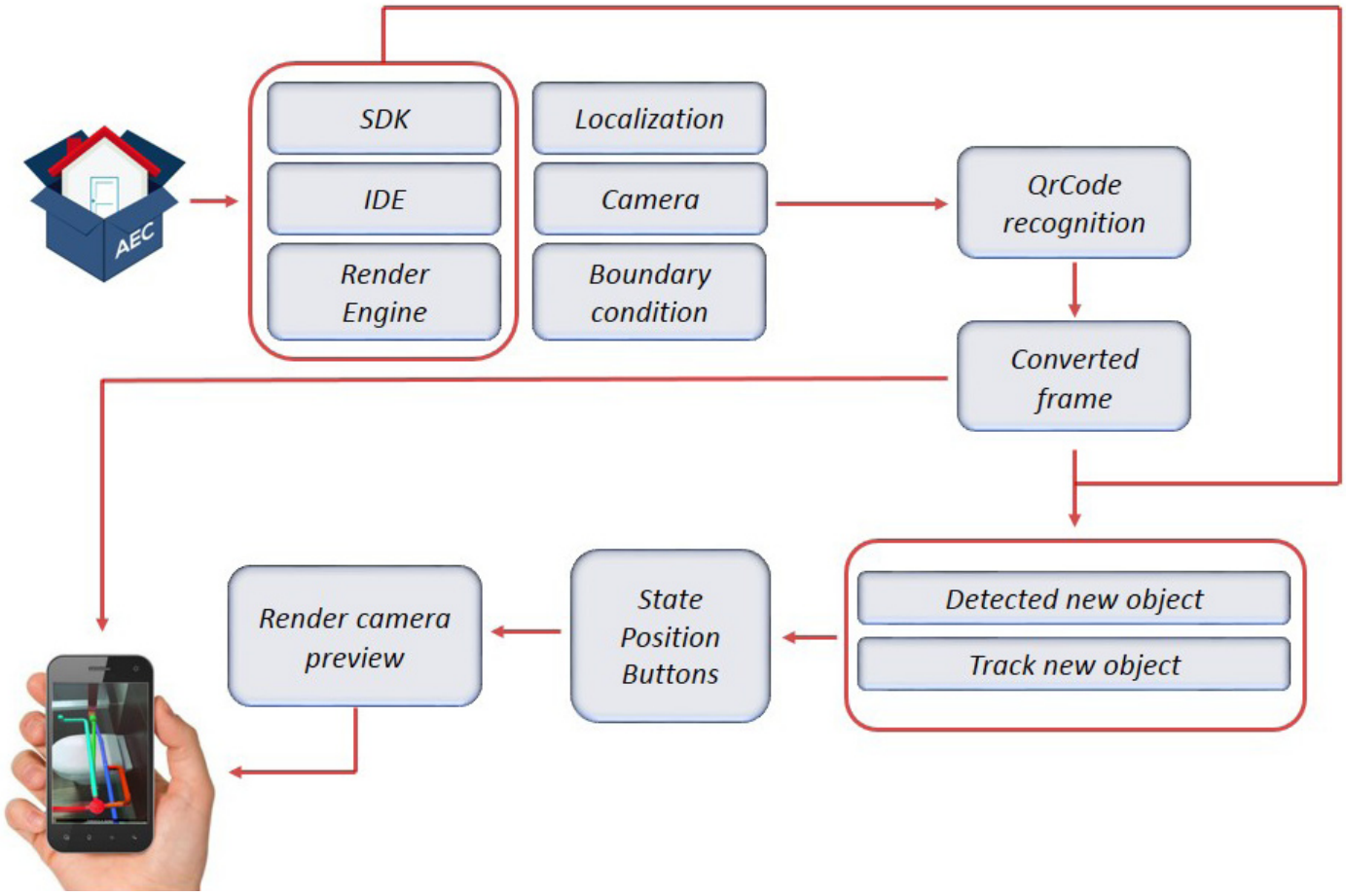

Figure 4 – Scheme of the InsidAR software architecture.

The identification of the scene to be linked to the setting and then the visualization via video on the mobile device is done using a Quick Response Code (QrCode): when it comes to images that the software is able to identify and control, the accuracy depends on the number and on the peculiarity of said images, for example, high contrast, the lack of repetitive themes, the abundance of details. So, once the APP is started, when the mobile device's camera focuses on the QrCode, it superimposes the infographic model onto the – document, or parts of three–dimensional models – previously linked to the BIM database. Once the target is recognized, the APP will follow the image throughout the camera's entire visual field. The icon chosen for the APP – an opened box out of which a stylized house appears (Figure 5) – is meant to highlight the concept of "container of information" for AEC (Architecture, Engineering and Construction): all the input data in the design phase (architectural, engineering, construction and others) are contained inside it, a simple tap on the mobile device's screen is enough to create a unique QrCode – conveniently located at the point of interest and linked to the digital database – the AEC container is opened and the experience of navigating the scene linked to the target in Augmented Reality begins.

The BIM is the box, Augmented Reality is the means of communication between the virtual world and the real one, and the App is the tool for viewing the contents of the box on the device's screen and virtually "saving" it inside. Through the InsidAR application, a representative environment is created that actually allows one to view objects or three–dimensional elements that would otherwise be invisible right on the mobile device's screen. Specifically, the APP is able to superimpose, first of all in virtual reality and than onto reality (Figure 6), the three–dimensional reconstruction of an apartment's drainage system as it is designed during the BIM planning phase: even if it is completely hidden, given that the entire floor area and the interior walls are included in the design and therefore not always visible, InsidAR easily allows one to examine their position and therefore, in case of maintenance or inspection, intervene where necessary, without wasting or losing time.
The user is free to move around the image being viewed, the mobile device can be inclined, and the object can be moved. The advantage of Augmented Reality for such devices is tied to the fact that there is total freedom of movement allowing visualization of the scene in reality and virtual reality from every angle.

Figure 5 – InsidAR icon.

Conclusions

In conclusion, the demand to deal with the existing building heritage is strong, especially in Italy. This is a demand tied to the need to retrofit the existing real estate with respect to technology, functionality and energy while recognizing that it is unprofitable to abandon the building heritage on the one hand, but that there is limited potential for growth of urban centers on the other hand. Undoubtedly, the recovery and urban redevelopment may mean a time of growth for all the stakeholders involved in the construction sector. The interventions on existing building heritage, however, highlight the limits of traditional methods of "doing construction" in Italy. Indeed, these methods should be more dynamic; placing the management phase on the same level as the design and construction phases.

The aim of this paper is to propose a methodology that allows both the planning of interventions (either of a new construction or of a renovated one) and the management of work done. Therefore, the modeling is also stored as data. Furthermore, the enormous potential of representation and analysis typical of Augmented Reality linked to BIM–based design allows one to implement the methodology for both existing buildings and new ones. The interoperability and the design of the BIM document database, added to the visualizing capacity of Augmented Reality, makes InsidAR a valid and innovative tool for the management of real estate. The relationship between the two ICT tools is represented by the App which carries out the digitalization of the building and its parts.

We are immersed in a virtual world where the perception of things is augmented, the scene responds to the actions of the user who modifies it until placing it back inside the box: every single event is recorded into the database and then placed inside the "box", opened and queryable. So it becomes a real container of digital information.

Nowadays the extreme fragmentation of documentation that the Italian technicians have to deal with could be replaced by a more fruitful digital database loadable through a simple tap on a box. Since management implies coordination, it is definitely impossible to coordinate without knowing and then measuring how much is at the work site and there is no doubt that, to date, Information and Communication Technologies are providing considerable support to revolutionize the current building design and management system.

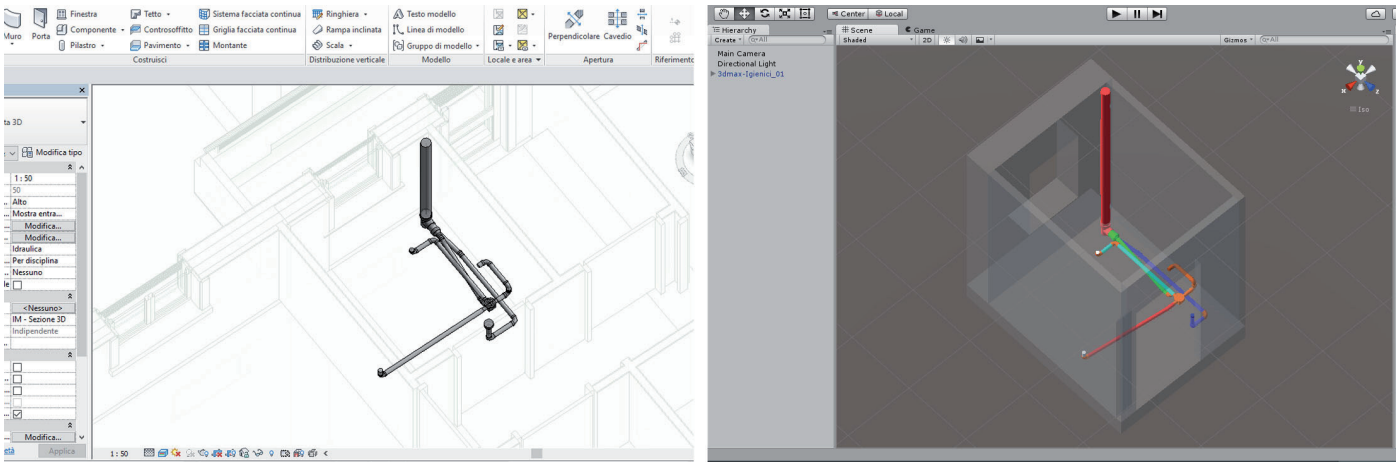

Figure 6 – From BIM to Virtual Realty.

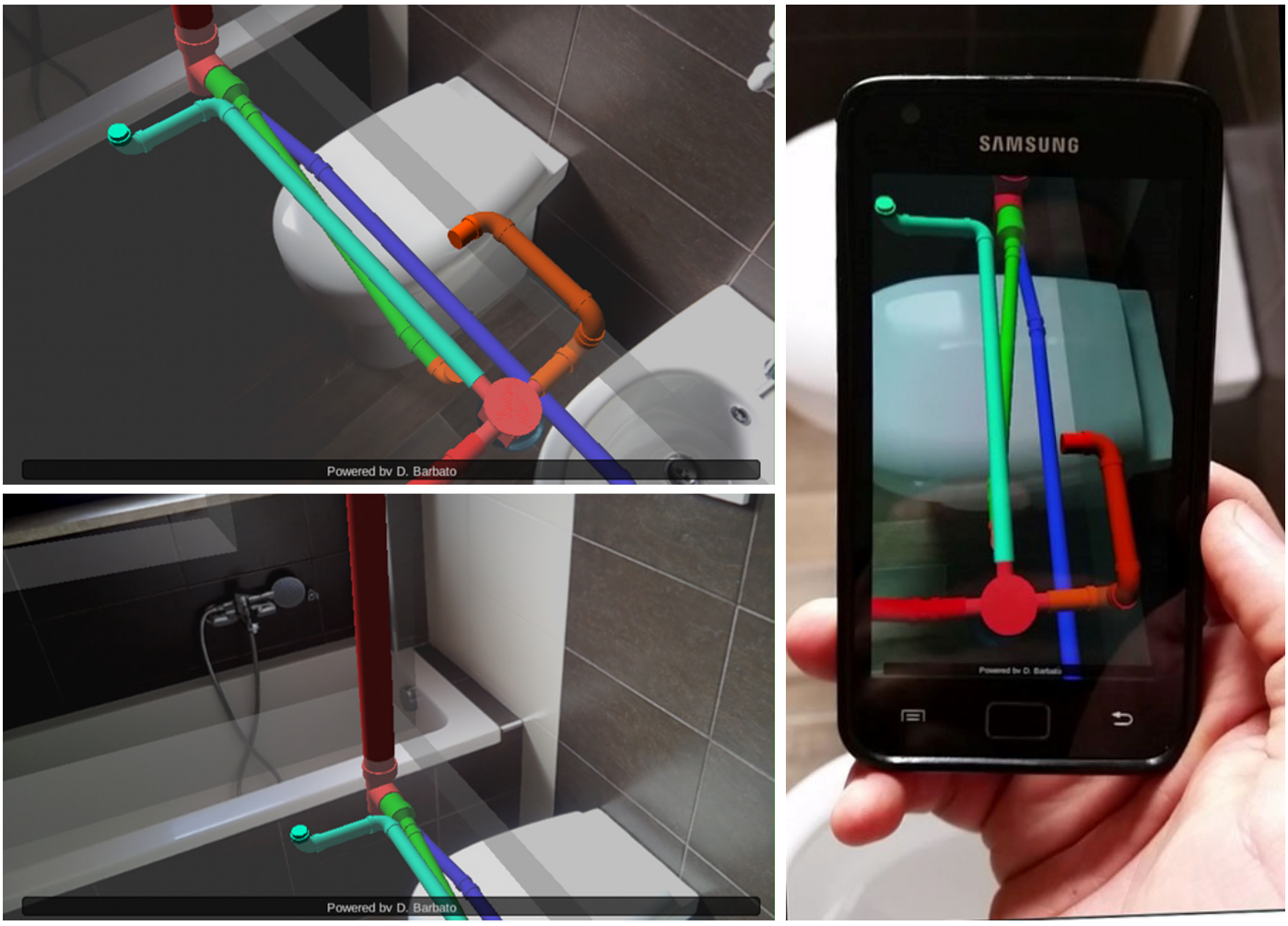

Figure 7 – Screenshot and picture of APP in work.

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