Technology and Architectural Heritage: Dynamic Connections

Maria Luisa Germanà

Abstract

Technological aspects strongly characterise the built environment in both material and immaterial dimensions. The architectural heritage (the built environment that has acquired cultural meanings, without prejudice regarding the age and the scale of observation) offers a peculiar point of view for dealing with this issue. This paper outlines the dynamic connections between technology, the whole idea of architectural heritage and the approaches to intervention. A focus is placed on four main theoretical aspects, the effects of which are also significant on the practical field: the distance from contemporaneity; the concept of Time; reliable conservation; sustainability. The technological evolution that has had such an effect on the architectural heritage is briefly outlined, starting from the First Industrial Revolution and concluding with digitalisation, which is now imposing a profound rethinking regarding both technology and heritage. From such considerations, it might be possible to derive a paradigm, to be discussed and shared, aimed at piloting the conservation of the architectural heritage in the forthcoming years.

Keywords

Architectural heritage • Technology • Concept of Time • Reliable conservation • Sustainable conservation • Digital technologies and heritage

1 The Connections Between Technology and *Architectural Heritage*

The expression *architectural heritage*, codified in Europe to indicate the built environment *of conspicuous historical, archaeological, artistic, scientific, social or technical interest* (CoE 1985), albeit deeply rooted in the origins of Western culture, has by now attained a global value (Jokilehto 1986, 2007) and concerns a wide range of examples without reference to the age and scale of observation. The need for conservation is closely linked to the architectural heritage, as evidenced by the word *heritage* itself, which indicates something to be preserved for posterity. The meaning of conservation has evolved in both its quantitative and qualitative aspects; in fact, conservation has extended its field of application, initially covering single historical buildings and gradually incorporating the surroundings of these buildings, urban and rural settlements, and historical centres and landscapes. Immaterial features of conservation have also emerged more recently; for instance, the integration of conservation with urban and regional planning (ICOMOS 1975) and the value of the cultural heritage for society (CoE 2005) now represent firmly established concepts. Lastly, conservation is currently seen as one side of the same coin, as enhancement of the architectural heritage; these are no longer seen as rivals, but as sharing a concurrent goal.

Over the last 20 years, research experiences in the Department of Architecture of the University of Palermo have provided the opportunity to apply a technological approach to the conservation of the architectural heritage and archaeological sites, demonstrating the need for concepts such as *process*, *system*, *reliability* in this particular field of application (Germanà 2014a). These experiences form the basis of subsequent considerations regarding the relationships between technological evolution and progressive change in both the practice and theory of conservation of the architectural heritage. The whole idea of the architectural heritage has had strong connections with technological

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culture ever since its origins. In the last three centuries, these connections have grown and have reflected the radical transformations in the technological processes that have taken place in this period. The paper proposes a critical summary of the changes occurring thus far, aiming to rethink the basis of these dynamic connections, to enhance their potentialities and to confront any eventual hazards.

2 The Distance from Contemporaneity

The concept of *monumentum* has existed since ancient times to indicate an object or a building, not necessarily old, devoted to perpetuating a memory. During the period between the late eighteenth and early nineteenth centuries, many artistic and philosophical trends, following the cultural revolution of the Enlightenment, broadened the meaning of this concept, contributing to the formation of the current idea of *Heritage*: the significance of *a marker of the past* was added to the role of witness to something memorable, thanks to the *qualities of commemoration, visibility and durability* (Meyers 2012, p. 8) (Fig. 1).

While acknowledging several contributory factors to the origin of the concept of *Heritage*, in the case of architectural heritage the main interpretation should be pinpointed in technological evolution, marked in this period by the landmark of the *First Industrial Revolution*. The profound transformation of manufacturing processes and the consequent availability of new materials (or those featuring higher technical performance) have led to discontinuity in traditional building techniques. Other effects aside, this discontinuity has formed the basis for contemporary architecture, influencing relationships with the built environment, which became obsolete within a few generations. In this framework, there has gradually emerged a cultural distancing from existing buildings (evident both in the technological aspects of the productive process and in the dimensional and aesthetical features of the new buildings) (Fig. 2).

A study of Italian architectural culture between the two world wars, mainly based on a direct reading of specialised journals published in Italy (Germanà 2005b, par. 1.3.1), highlighted the fact that the progressive and quite arduous enhancement of modernist architecture in this country has produced a clear evolution in design approaches to existing buildings. Before the spread of modernism, a mimetic approach connoted interventions on existing constructions; the aim, to guarantee total morphological coherence, was feasible, thanks to technical continuity. There appeared a tendency, around 1930, towards superimposing the new architectural style on existing buildings, but this did not necessarily have any connection with the introduction of new materials or techniques; the prevailing justification in this case was intolerance towards the old features and a search for aesthetical appropriateness to the contemporary. During the following decade, functional and structural inadequacy began to justify many transformation processes on existing buildings. The main aims were, on the one hand, to acquire indoor space where a new lifestyle might be comfortably

Fig. 1 Telamon of the Zeus temple in Agrigento. Photograph by G. Pitrone, 1926, Ente Parco Archeologico Agrigento

Fig. 2 Traditional buildings seen from the roof of BIGyard, built in 2010 in Berlin (Zanderroth Architect; www.zanderroth.de)

accommodated and, on the other, to guarantee safety, which traditional structures gave the impression of never having had (piloting a pernicious trend that would later cause so much damage in interventions on ancient buildings).

While the so-called *Second Industrial Revolution* was reinforcing and increasing the effects of the transformations in the previously triggered productive processes, the distance of contemporary architecture from pre-industrial buildings was increasing. At the same time and similarly, in that historic scenario, the architectural heritage was being dissipated, entering into an ever more delimited dimension, a niche, within which only a selected few could be absorbed. The separation of the architectural heritage from the ordinary sphere is seen very clearly in two principal aspects, becoming a constant for the entire twentieth century: the belief that only cultured people are capable of understanding the architectural heritage and the hyper-specialisation of the technical and architectural competences required to design or administer it.

3 The Concept of Time Between Linear and Cyclical Vision

The massification of the industrial productive model (enhanced during the *Second Industrial Revolution*) has breached the traditional Western concept of Time, locating the Past in an extraneous dimension, almost always in an unequivocal contrast with the Present. The distance from the Past had been expressed centuries before, during the Renaissance, but the approach to historical remains was very different, because ancient architecture was felt to constitute the deep cultural roots of contemporary architecture and, for this reason, was experienced, within a sort of technical continuity, regardless of morphological and spatial evolutions. The clearest difference in this comparison can be seen in those vestiges of the Past that could not be reproduced after the nineteenth century, precisely as a result of the discontinuity in traditional technological processes. From this, there has arisen the need for ever more rigorous conservation of the material substance of the built heritage.

The role of the concept of Time in the approach to the architectural heritage and its conservation has been outlined in research into the artistic and technological contamination between Eastern and Western cultures (Germanà 2013, p. 113). The differences in the diverse concepts of Time in the built heritage have been demonstrated by comparing two edifices; both religious buildings built out of wood (Fig. 3).

One of the main reasons for interest in the Norwegian *stave churches* is the authenticity of the building material; most of the wooden elements are a part of the original construction dating back centuries. For the sake of preservation, ordinary church functions have been transferred to other, newer premises, while the old church buildings have been crystallised in the singular role of *monumentum*. In contrast, the Japanese Shinto shrines in Ise are rebuilt every

Fig. 3 On the left, Borgund Stave Church, Norway, built between 1180 and 1250 A.C. (Wikipedia Commons). On the right, the old and the new shrine of Ise, Japan, *immediately prior to the Sun goddess's progress of 2 October 2013* (http://www.japansociety.org.uk/)

20 years on an adjacent site. The building process features precise and ritual phases, beginning with the cultivation of the trees (their position during growth, and after cutting back, will reflect the orientation of the ensuing building element). The temporary nature of these buildings does not provide any excuse for their precariousness; due to its longevity, the Japanese cypress *hinoki* is used for the structure (Howells 1995, p. 10). The procedural preparation of the tools used to cut and to finish the wooden elements is very long and nothing is left to chance. The traditional *yariganna*, a spear used in ancient times to obtain smooth and waterproof wooden surfaces, was reproduced in a recent rebuilding intervention, to increase durability (Howells 1995, p. 11). Last but not least, especially in comparison with the present-day fall into disuse of the medieval Norwegian churches, the Shinto shrines cannot be regarded as vacant; the cyclical relocation, made possible by the ritualised vicennial rebuilding, assures the goddess's continuing presence.

The juxtaposition of authenticity and replica has spiced up a heated debate in the architectural conservation field (ICOMOS 1994; Weiler and Gutschow 2017); its meanings change more than a little in the light of the different concepts of Time. As a consequence of the linear concept of Time, every epoch lays down vestiges upon previous layers; this stratification gives substance to the heritage, in which cultural interests are recognised precisely because they are extraneous to the contemporary, as the beginnings of the culture of architectural conservation have shown (Riegl 1903, p. 52). The distance from contemporaneity makes sense only in accordance with linear Time: the Past does not belong to the current reality, which does not have the tools to reproduce it without falsification. The complete separation between Past and Present is in conflict with the circular concept of Time prevailing in Eastern culture, where material authenticity does not matter, because the cyclical repetition of the processes is enough to guarantee a satisfactory result. Cyclical Time renders the Past ongoing in a continuous Present, because attention is focused on the process and not on the product. This suggests a possibility for rethinking conservation; most interventions need technical continuity rather than innovative solutions, which inevitably end up as transformative and clash with the physiological nature of maintenance (Marconi 1984).

4 The *Imperative of Responsibility* and Reliable Conservation

Radical rethinking on technology guided the search for new paradigms during the last decades of the twentieth century. The evidence of the uncontrollable effects of most new technologies (Jonas 1979) encouraged the search for a different model of growth, more qualitative than quantitative. The spread of automated production as a consequence of the *Third Industrial Revolution* (Rifkin 2011) has veered towards even more quality-oriented, flexible and mass-customised, *lean production*. This further, profound technological evolution is also gradually changing the cultural and operational approach to the architectural heritage, highlighting reliability as one of the main criteria.

Fig. 4 Soluntum (Hellenistic archaeological site on the northern coast of Sicily, near Palermo). *Casa delle Ghirlande* in 1999 (on the left) and in 2015 (on the right). Photograph by M.L.G

The aim of reliability in the conservation processes has emerged as a reaction to the numerous critical conditions, which perpetuate emergencies in the architectural heritage field. There has been a focus on reliable conservation with regard to two different, but interrelated, dimensions: *material reliability*, referring to the permanence of the conservation results, and *immaterial reliability*, referring to the overall quality of the conservation processes (Germanà 2003). The first dimension helps us to tackle (and to avoid in any future interventions) the failure of certain technical and material solutions adopted in restoring the built heritage during the twentieth century (such as reinforced concrete or cement mortar) (Fig. 4).

The second dimension, highlighting the sequence of decisional, executive and management phases in the interventions, is aimed at rendering more practically pursuable conservation objective, outlining the need to assess the requisite skills, operational tools, costs and procedures. In any case, reliable conservation is closely linked to the *precautionary principle*, the need for which was derived from the ethical rethinking of technological culture in the last quarter of the twentieth century. In fact, it is based on a long-term view and on an awareness of the risks inherent in any operation and in any lack of intervention (Fig. 5).

A connection can be observed between reliability and the above-mentioned concept of Time. In fact, the unity of Past, Present and Future, typical of the cyclical vision, is coherent with the quality-oriented productive processes and with the *kaizen*, a Japanese word introduced into the field of technology to indicate continuous improvement, to be achieved by small incremental advances towards greater efficiency and by a contribution from all the operators involved. The process-based view is also essential in the conservation of the architectural heritage; in a framework where knowledge, conservation and enhancement are concurrent objectives, a unified and systemic approach makes possible the organisation of the activities in sequences, in which necessary skills, operational tools, procedures and resources are clearly identified (Germanà 2014b). In addition, whereas, within the linear vision of Time, the Present is merely a sort of parenthetical phase (between the original time of the Past and the beneficiary time of the Future), the cyclical vision confers centrality to the Present, as the only moment in which attempts at conservation can achieve anything of consequence (Fig. 6).

5 Dual Sustainability of the Architectural Heritage[1]

Every productive process is currently always compared with the goal of sustainability, which includes many multifaceted and integrated aspects of quality with its three dimensions (social, economic and environmental). The progressive definition of this theme is consistent with the most recent developments in technological culture, as highlighted by two principal aspects: the growth of awareness of the limits of natural resources (Meadows et al. 1972) and the belief in the birth of *Anthropocene*, a new epoch triggered by the irreversible consequences of scientific and technological progress on our planet (Hamilton et al. 2015).

[1]The Author presented the contents of this paragraph as a part of the paper *The Dual Sustainability of Architectural Heritage: Environmental Aspects*, presented at the International Conference *Green Conservation of Cultural Heritage*, held in Palermo in November 2017.

Fig. 5 Gela (archaeological site on the south coast of Sicily). Evidence of the subsequent conservational interventions on the earthen urban walls of Capo Soprano. Photograph by M.L.G. 2015

Fig. 6 *Prudenza* (Prudence) by Cesare Ripa can be read as a metaphor for the cyclical vision of Time (C. Ripa, 1603, *Iconologia overo Descrittione di diverse Imagini cavate dall'antichità et di propria inventione*, p. 416, available at www.bivio.filosofia.it). In fact, the Prudence is represented as two-faced (one face towards the Past and one towards the Future). But a third face, in the mirror's reflection, seems to suggest an implicit centrality of the Present

Generally speaking, the role of the built environment in achieving sustainability is well known, especially regarding the reduction of energy consumption, both in the building phase and, even more so, in the utilisation phase; EU countries are sharing the ambitious goal of having all new buildings consuming *nearly zero-energy* by 2020 (EU 2010). The architectural heritage too is involved with sustainability, a globally shared necessity that has prompted further interest in the generally acknowledged areas of the traditional built environment (historical, archaeological, artistic, scientific, social or technical).

On the one hand, many examples of built heritage suggest a sort of precursory sustainability, because of some of their intrinsic technical features: the sensible use of materials, preferably available in situ; the natural tendency towards the recycling of entire buildings, constructive elements or materials; the application of passive solutions for the heating and cooling of spaces; the search for appropriateness in relationships with the surroundings, taking into account the main natural elements, such as the sun path, the prevailing winds and overall orientation. The architectural heritage might proudly proffer itself as an example of sustainable built environment, capable of providing useful indications for contemporary architecture (VERSUS 2014). Such features in traditional buildings are not casual. As research into Sicilian rural architecture has shown, precursory sustainability has also been recognisable in theoretical developments, ever since Vitruvio's *De Architectura* and right up to manuals dealing with the rural architecture of the nineteenth century (Germanà 2005a).

On the other hand, interventions in the architectural heritage also need to bear sustainability in mind. Referring to the sociocultural and economical dimensions of sustainability, many examples of best practices have shown that, if correctly oriented and promptly and effectively managed,

conservation processes play an important role in enhancing local communities, with relevant economic benefits and enrichment of the cultural identity (see, for instance, the activities of the *International Centre for the Study of Herculaneum*, reported in www.herculaneumcentre.org). With reference to the environmental aspects of sustainability, on the subject of cleaning treatments, protection and conservation, the impact on the environment of the products used, as well as on the built heritage and on the safety of the operators, should be carefully considered. In addition, preliminary knowledge of the environmental context is an indispensable condition for sustainable interventions, in order to avoid misunderstanding the bioclimatic features of the surroundings and of the building itself.

A bioclimatic study of the Hellenistic archaeological site of Soluntum, on the northern coast of Sicily, near Palermo, has added to available knowledge, by underlining the wisdom of the original choice of the place. In fact, the ancient city is well oriented to guarantee maximum solar gain; the nearby mountains do not project shadows upon it, even on the darkest day of the year (Fig. 7). Analysis of the state of conservation of the architectural heritage is carried out thoroughly, especially when also taking into account the environmental aspects of the surroundings; for instance, it is well known that solar radiation influences biodeterioration phenomena and winds compound the erosion of stone building materials. However, conservation operations may also benefit from the bioclimatic approach; focusing on the *protective* structures of earthen walls in Soluntum, a low-cost solution has been suggested, incorporating natural ventilation so as to avoid harmful consequences from the greenhouse effect (Fig. 8).

The appropriate importance attached to dual sustainability (both to the architectural heritage itself and to the activities carried out on it, as regards knowledge, conservation and enhancement) might have many positive consequences, not only in reducing the environmental impact but also in contributing to the above-mentioned reliable conservation, especially with reference to the durability of the technical solutions chosen for conserving the architectural heritage.

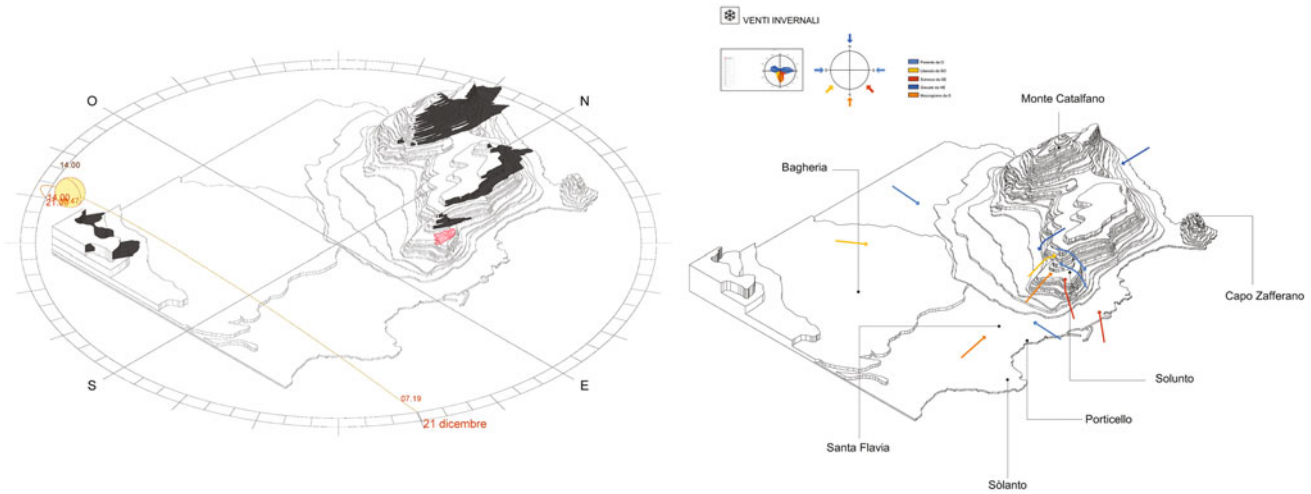

Fig. 7 Soluntum. On the left, general view at 2 p.m. at the winter solstice. On the right, part of the study of the prevailing winter winds (Germanà 2016a, p. 99)

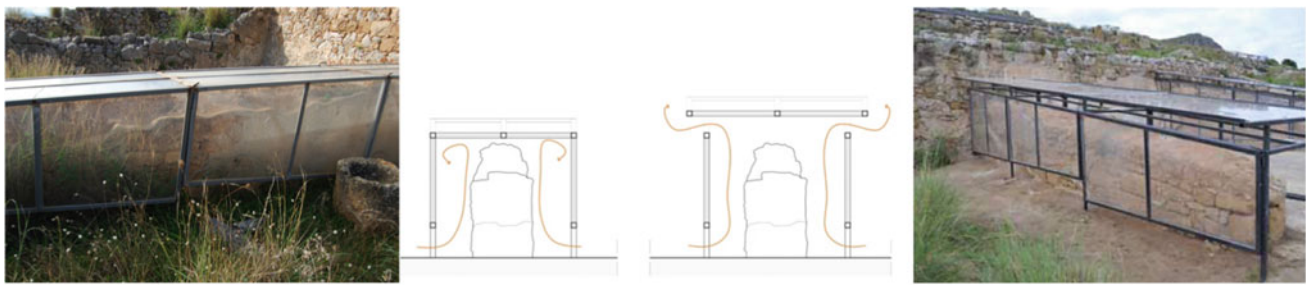

Fig. 8 Soluntum. A detail of the protective structures on the earthen walls. On the left, the situation in November 2014 (Photograph by M.L. G.). In the middle, the bioclimatic low-cost solution proposed. On the left, the situation in 2016 (Photograph by Bordonaro, Spatafora, in Cilia, E., and Not R. (eds.) (2016), *Conservare è Tramanadare. Tecniche innovative per pavimentazioni antiche e strutture in terra cruda: una sfida ben consolidata*, Centro Regionale Restauro Regione Siciliana, p. 62)

6 Digital Technology and Architectural Heritage: The Operational Transformations

The most recent and increasingly rapid technological evolutions are centred on digitalisation and include a variety of innovations, brought together by the so-called *Fourth Industrial Revolution*, which in some opinions can be read as the continuation of the *Third* one, in others as a new trend, made possible by the unprecedented advances of scientific knowledge, the practical applications of which are distinguished by *velocity, scope, and system* and announce *the transformation of entire systems of production, management, and governance* (Schwab 2015). Through conversion into digits, the technological processes seem to have achieved the maximum in dematerialisation. This phenomenon involves an increasing number of people: in fact since 30 June 2017 more than half of the world's population is an *Internet User* (www.internetworldstats.com). In addition, mobile devices have increased the opportunities for digital connection, liberating it from a specific place, characterised by what is a consequently specific material reality.

In a very few years, digital technology and the Internet have brought about several practical and operational transformations in the field of architectural heritage, the consequences of which are already evident and which will probably increase in the short term, thanks to a reduction in costs of devices and their ever-higher user-friendliness. In fact, many digital devices are currently being used in diverse activities carried out on the built heritage. These operational transformations form a composite framework that is continuously and rapidly evolving (Table 1).

Digital devices applied to knowledge processes are geared towards very specific operations, and their applications demand highly specialised expertise and extensive technical skills, even though the procedures are usually relatively quick and inexpensive. Regarding the dimensional surveys, devices such as digital cameras, laser distance measurers, laser scanners and drones have made precise and detailed dimensional results possible, also without any direct contact with the built objects to be captured. Thanks to digital surveys, an impressive amount of data can be collected, elaborated, stored and shared globally, rendering the dream of an entire global catalogue of the architectural heritage feasible. Regarding diagnostics, many digital devices or digital components belong to the toolkit of in situ, non-destructive analyses (such as thermographic cameras, ultrasonic devices and endoscopes) (Bianco 2017), and make it easier to understand the structural damage and transformations that have taken place over time, the traces of which are recognisable in the architectural palimpsest.

Digital technology applied to surveys and analysis is certainly an important facilitator of knowledge, and, consequently, of the conservation of the architectural heritage. However, as these innovations are not miraculous, they cannot resolve certain critical conditions (Germanà 2014b) that remain in the process, both upstream and downstream. How to tackle the planning of the surveys and analysis (bearing in mind the status quo, the objectives of the intervention and the available financial and technical resources)? How to guarantee access to knowledge and how to deal with data obsolescence? This last problem is particularly urgent today; in addition to the usual need for updating information regarding the architectural heritage and

Table 1 Digital devices used in architectural heritage field: a partial summary

Examples of devices	Main applications	Critical aspects
Specific devices: – Laser scanner; – Digital cameras; – Thermographic cameras; – Ultrasonic devices; – Endoscopes	Knowledge processes: – Surveys; – Monitoring; – Diagnostics	Highly specialised expertise Extensive technical skills Activities planning Interoperability Data accessibility Data obsolescence
Generic devices: – 3D printer	Conservation processes: – Reproduction of missing parts	Activities planning Interoperability Customisation
Generic devices: – Personal computers; – Smartphones; – Tablet; – Displays; – Touch screen	Enhancement and divulgation processes: – Basis for virtual reconstruction and for sharing cultural experiences	Activities planning Interoperability Loss of the connection with the specific place Loss of identity Lack of accuracy of the contents

its contextual conditions, digital data very soon become unreadable due to the obsolescence of the format in question.

Many well-known examples regarding the cultural heritage demonstrate the increasing diffusion of other digital devices that are not actually characterised by a specific applicative field. Most of these devices, which are pervasive in many other aspects of daily life, have also changed the way of dealing with conservation and the fruition of architectural heritage.

With regard to interventions on the material elements in the built heritage, 3D printing has been adopted in reproducing missing parts of mouldings and other details, on the basis of 3D models obtained by laser scanner surveys (Fig. 9). Also in this case, digitalisation involves only the operational, and not the decision-making aspects of interventions. It is foreseeable that 3D printing will become more widespread in the field of heritage, not just for producing gadgets and reproductions but also for supporting both the off-site and the on-site productions of the building materials to be used in refurbishing, as is already happening in the building sector (Codarini et al. 2017). The customisation of design solutions and self-build practices may nowadays sound rather strange for architectural heritage, especially considering the public dimension of its meanings (Germanà 2016b). However, two aspects might reduce this strangeness in the foreseeable future: the diffusion of cultural meanings in *minor* assets, the private dimension of which could be relevant; the ever more active role of the *user*, who in this specific case may be a citizen, a visitor or a person working and living in historical buildings or cities. In the latter case, digital technology will certainly be a key factor.

Finally, the broader impact of digital technology on conservational activities may be individuated in the innovation of processes. In a very few years, BIM has pervaded the architectural, engineering and construction industry especially in the design and construction of new edifices. The representation has surmounted the three-dimensional space, containing information on materials, costs, performances and maintenance needs. The most revolutionary possibility that makes BIM a new paradigm (Takim et al. 2013) is the integration between the phases of design, construction and management, which contributes to solving the sectionalisation of the productive model that prevailed during the twentieth century; this has laid the basis for interoperability, the major consequence of which is overall efficiency. Cutting-edge research is also exploring the potentialities of BIM in the management of existing buildings (*Existing Building Information Modelling*) and of historical buildings *Heritage Building InformationModelling* (HBIM), focusing on the issue of what information is required in order to achieve (and improve) efficient management (Edwards 2017). Even if only niche applications are available as an example, it is foreseeable that the new paradigm of HBIM will soon be a key driver towards the aforementioned reliable conservation.

Last but not least, a wide range of recent examples show the potential of digital technology in the enhancement and propagation of architectural heritage. Digital media consent dynamic and credible representations, very easy to reproduce and share. In the case of incomplete built heritage (mostly, but not only, archaeological built heritage), 3D models offer the basis for virtual reconstructions (both of the buildings and of the ancient relationships with the surroundings), making the ruined vestiges more comprehensible. These representations are suitable for interactive use by every kind of visitor to a cultural place, via digital displays and touch screen tables. Again, via the Internet, one can undergo cultural experiences (heritage included), at any time and in any place, using digital devices such as personal computers, smartphones and tablets, with which one can access every kind of information and service. Finally, digitalisation has opened up previously inconceivable new forms of sharing and enhancing the cultural and architectural heritage: by accessing the Internet and, above all, the social media, local communities are discovering their own heritage, organising bottom-up initiatives centred on collective visits, in which digital devices are used to their utmost potential (see, for instance, the Sicilian experience of *Invasioni*

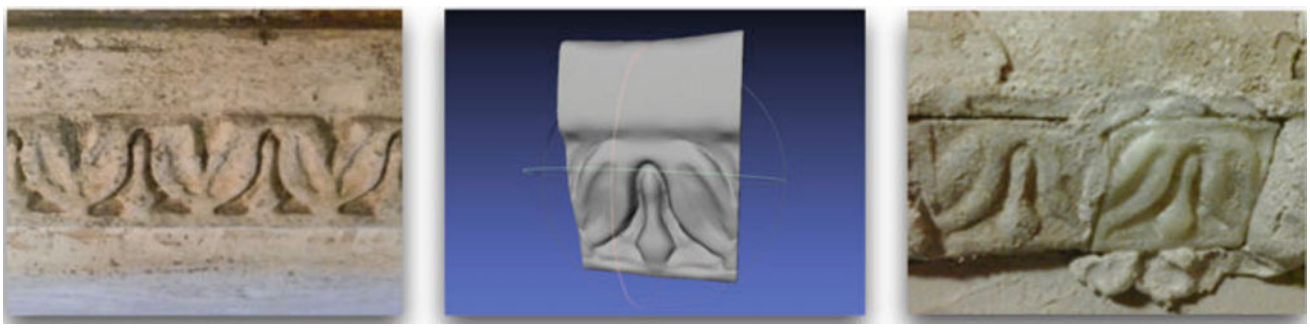

Fig. 9 Moulding in Palazzo Ducale (Mantova): integration of a missing part (laser scanner survey, 3D model and 3D printer) by HeritageLab (http://fablabparma.org/heritage-lab/)

Fig. 10 Digital invasion of Villa Emo by Andrea Palladio (Treviso) in 2016. A treasure hunt was carried out, using digital devices, to find in situ, architectural decorations and paintings (https://www.villaemo.org/single-post/2017/04/25/Le-Invasioni-Digitali-approdano-a-Villa-Emo)

Digitali (Digital Invasion) at http://www.invasionidigitali.it/; Fig. 10).

7 Digital Technology and Architectural Heritage: Evolution of the Process

The consequences for architectural heritage of most recent technological evolutions are better outlined within the framework of their general impact on the ordinary built environment. The building sector, after having initially encountered resistance to change, especially in comparison with other productive fields, has now been overrun by digitisation, which is definitely modifying, on every scale, the way in which we design, transform, manage and use the built environment. For the sake of brevity, only three general aspects, related to the architectural heritage, will be specified as examples: the morphological consequences, the smartness and Internet of Things (IoT) and the search for sensitiveness.

New figurative trends in buildings and in objects, driven by *Computer Architectural Aided Design*, have been the first and most evident consequence for the architectural field in the short term (Riccobono and Pellitteri 2017). The consequent morphological transformation has deepened the aforementioned (par. 2) scar that had cut through pre-industrial architecture after the *First Industrial Revolution*.

Subsequently, *smartness* denoted the built environment (*smart city; smart building*) to indicate a sort of assembly kit of innovations, made possible by the latest technological developments and aimed at improving environmental sustainability. The idea of smart technology has now reached a more mature phase, in which the need for integration between the *users' sphere* and the *experts' sphere*, invoked decades ago by Pacey (1983), has shifted the focus to the human factor. In the case of smart solutions, there is an escalation in the consequences on the effective energy use of individual behaviour (Janda 2011); cultural habits and economic conditions increase in the case of smart solutions, due to the greater incidence of technological appropriacy, also with regard to the generational gap (the *digital natives* approach current technology more easily) and social and economic inequality (*digital divide*). Research on the historical centre of Agrigento has shown the potentialities of smartness as applied to the architectural heritage (Vattano 2013): the hypothesis of a smart reconfiguration of the historical centre creates a link between the material reality and the virtual image; this is drawn from daily experience in a dynamic form, with new kinds of utilisation emerging, thanks to digital technology that enables personalised exploration, in which experiential feedback, shared through the social media, becomes a driving factor (Vattano 2016).

Further theoretical developments on the application of digital technology on the cultural heritage have suggested the idea of *Phygital Heritage*, to observe the seamless blending of physical and digital qualities, especially in heritage communication (Nofal et al. 2017), and the concept of *Internet of Cultural Heritage*, as a specification of the *Internet of Things* (Piccialli 2016); this should negotiate the gap between online and offline experiences, enhancing the physical encounter through digital contents (Petrelli et al. 2016).

A *sensitive* built environment (Ratti and Claudel 2016) represents one of the more interesting possibilities provided by digital technology; some applications (aimed at reducing energy wastage, facilitating an automatic survey of users' needs) have developed a personalised heating, cooling and lighting system which follows occupants as they move around the building, like an individually tailored environmental bubble (Fig. 11). The vision of a *sensitive* built environment includes the issue of emotional and psychological reactions, which can be deduced from facial recognition technology using artificial intelligence; the Venchi edible chocolate pavilion is conceived to be more than a recreational example and it opens up a new frontier, where the indeterminate edge between concern and enthusiasm is very disorienting (Fig. 12). A part of the NEPTIS project, funded in 2015 under PON FESR Sicily 2007–13 Program (co-funded by the European Community) and devoted to information and communication technologies (ICT) in the field of the cultural heritage, is focusing on the integration between the knowledge process and conservation and enhancement processes, based on 3D laser scanner surveys and the 3D model of a residential unit in Heraclea Minoa, a Hellenistic archaeological site on the southern coast of Sicily. A hypothesis has been sketched, moving towards the theory of a *sensitive heritage*, in which the experience of the visitor, documented by sensors and/or by an app from the mobile digital devices, contributes to maintenance and to management of the site.

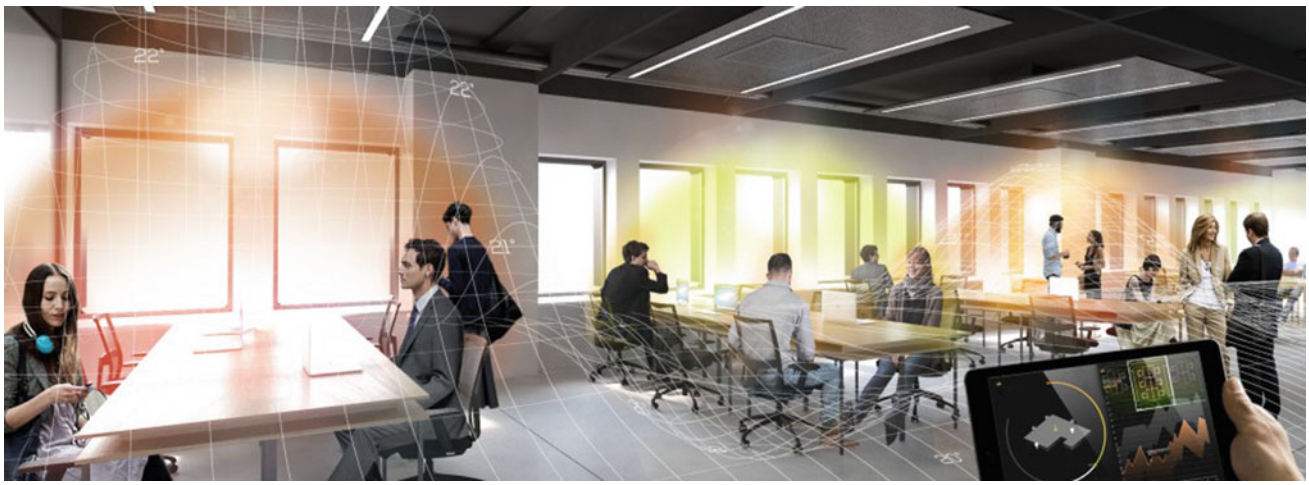

Fig. 11 Agnelli Foundation headquarter, housed in a historical building in Torino; representation of the *environmental bubble* www.carloratti.com/project/fondazione-agnelli

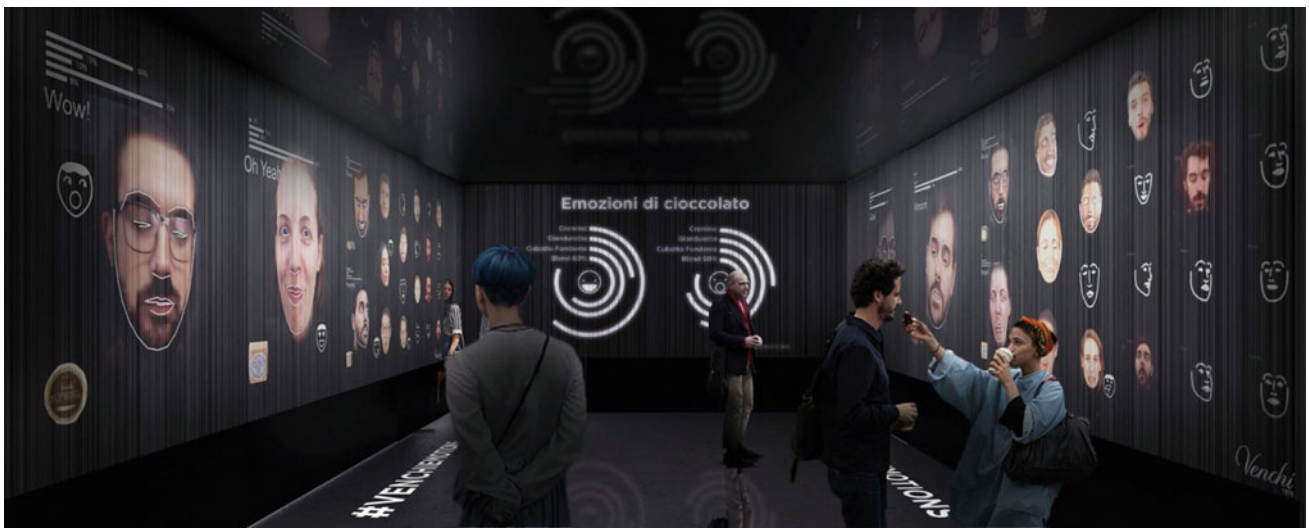

Fig. 12 Interior of the Venchi pavilion in Bologna *FICO Eataly World* (inaugurated in November 2017), where the recorded emotions of visitors, after tasting chocolate, are exhibited (Ashar, R. (2017), *Edible Architecture—an experience beyond*, October 2017; available at http://globalhop.indiaartndesign.com/2017/10)

The APER Project (Domestic Punic, Hellenistic and Roman Architecture: conservation and enhancement), funded by the European Union as part of the *Italie–Tunisie 2007–2013* cross-border cooperation programme and concluded in 2014, has paved the way to this latest research. In the framework of the search for the connection between knowledge, conservation and enhancement, in order to resolve certain operational aspects (and, not least of all, to tackle a lack of funds), the APER Project has proposed: a strategy founded on a technological approach, as the basis

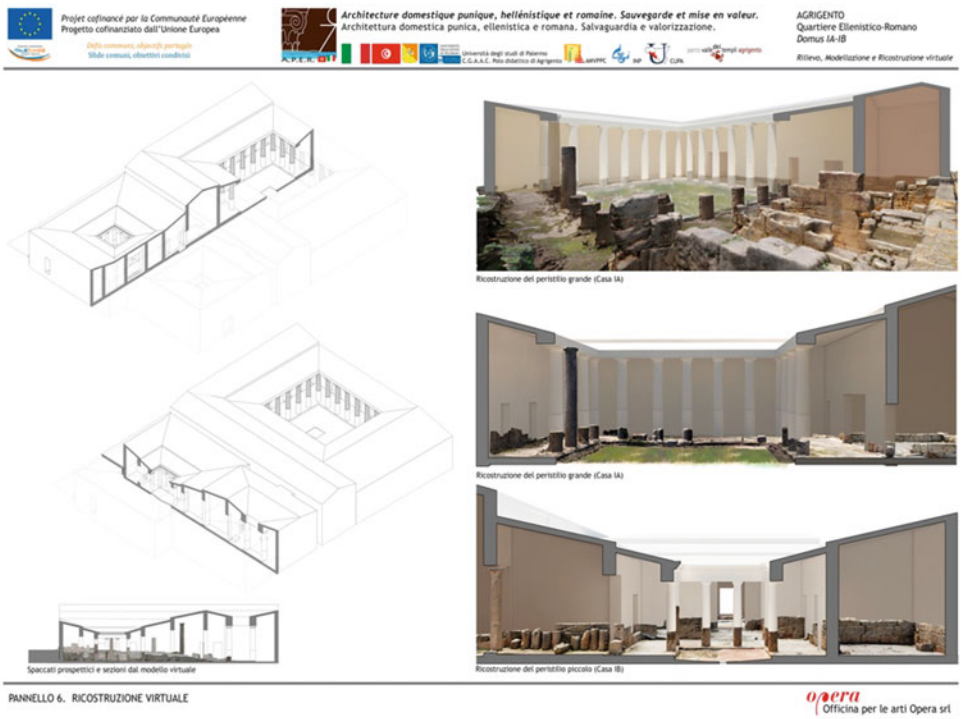

Fig. 13 Some of the results of the APER Project. On the top, survey and virtual reconstruction of the Domus I A and B of the Hellenistic-Roman quarter of Agrigentum; on the bottom, browsing tips for augmented knowledge (Ferjaoui and Germanà 2014)

for a multidisciplinary effort; a process-based view, considered as the main tool of overall efficiency, hinging on systemic knowledge in which the visitor can play an active role (Fig. 13) (Ferjaoui and Germanà 2014).

8 Digital Technology and Architectural Heritage: Theoretical Developments

While these rapid operational and process transformations are going on, a slower and invisible evolution is taking place in architectural heritage as a consequence of the *Fourth Industrial Revolution*; other major changes, readable from a multiscale viewpoint, are gaining substance and becoming more widespread, but they will probably induce more incisive and visible transformations in the medium and long term. A series of disruptions has marked technological evolution over the last centuries, from the emergence of industrialisation to digitalisation. The *First Industrial Revolution* caused a disruption of traditional productive processes, paving the way for a distancing from the contemporary, from which the actual idea of cultural heritage has derived its roots. On the other hand, the *Fourth Industrial Revolution* is causing a theoretical evolution; in less than a generation, it has given rise to a disruption that has started to change not only the way of producing but also the way of thinking, because it is transforming the individual and collective perception of two fundamental concepts: Time and Space. In the light of these theoretical transformations and their ethical and social consequences, a profound parallel revolution is foreseeable in the meanings of the architectural heritage and its social role.

The reciprocal influences of technology and society, occurring ever since the earliest historical epochs (Singer 1954), have changed with the advent of digitalisation and they have lost their customary contact with human experiences. Since communication has been indicated as the main feature of the relationships on which society has based itself and evolved, it has been considered one of the key aspects in understanding the current trend: *(…) the new communication system radically transforms space and time, the fundamental dimensions of human life. Localities become disembodied from their cultural, historical, geographical meaning, and reintegrated into functional networks, or into image collages, inducing a space of flows that substitutes for the space of places. Time is erased in the new communication system when past, present, and future can be programmed to interact with each other in the same message. The space of flows and timeless time are the material foundations of a new culture that transcends and includes the diversity of historically transmitted systems of representation (…)* (Castells 2010, p. 406).

The substitution of the *space of places* by the *space of flows* has provoked a loss in the contiguity of social practice, with the specific material support that was previously indispensable (Castells 2010, p. 431); this might create a conflictual situation in the built heritage, the peculiarity of which embraces a relationship with a specific place. Digital technology has brought about a sort of eradication of the architectural heritage: the virtual visit often replaces the real one and, consequently, there emerges the risk of disregarding the actual conditions, having faith in indirect recommendations (no matter how reliable) from someone who might have come across—in a specific manner and time—certain architectural heritage. With the aim of combatting this trend, research into the enhancement of archaeological sites has indicated the solution of identifying and reinforcing the relationships between the architectural heritage, the contextual environmental and socio-economical conditions, by going beyond a site-centric vision (Ferjaoui and Germanà 2014).

Timeless time, time that is instantaneous or with multiple temporalities, has led to the loss of the continuity that, before the advent of digital technology, distinguished between visions of Time, both linear and cyclical. This sort of intermittent time, coherent with the binary logic of the computer, raises legitimate questions regarding the very idea of *Heritage*, and not only on foreseeable developments in future generations. As a consequence of this compressed and undifferentiated digital time, in which the sequence of events is dissolved in a *perpetual present*, will the memory still possess meanings, or rather, which *forms* will our memory possess (Yuan 2016, p. 127)? Furthermore, due to the fact that the *processes of human memory are adapting to the advent of new computing and communication technology*, a sort of *transactive memory* (in which collective and outgoing forms have taken the place of individual and ingoing ones) will spread, something very different from the memory we are used to (Sparrow et al. 2011).

As a synthesis of these theoretical transformations, it is enough to mention that digitalisation has produced profound changes in communication, which also apply to the architectural heritage, leading researchers to a crisis point when dealing with any representation: the advent of multimedia *is tantamount to ending the separation, and even the distinction, between audio–visual media and printed media, popular culture and learned culture, entertainment and information, education and persuasion. Every cultural expression, from the worst to the best, from the most elitist to the most popular, comes together in this digital universe that links up in a giant, non-historical hypertext, past, present, and future manifestations of the communicative mind* (Castells 2010, p. 403).

Fig. 14 A teenager, while dancing to the pop song *Happy* in the archaeological site of Utique (Tunisia), aiming to reproduce himself in a globally shared video: a valuable example of sense of belonging, which conservation of the architectural heritage needs (https://www.youtube.com/watch?v=s2hqBPKQvqM, accessed in April 2014)

9 Conclusion: Rethinking the Architectural Heritage

This article has tried to synthesise a very wide-ranging and complex issue: the evolution of the connections between technology and architectural heritage, from the *First Industrial Revolution* to digitisation. For reasons of conciseness, a focus has only been placed on a few points that may be significant to understanding the main phases of this evolution, on the future of which the scientific community should reflect.

Architectural heritage does not belong directly within the category of objects: firstly, it is a concept that has emerged from a general cultural environment in which its meaning has matured. Ignoring the essence of *concept* in architectural heritage, transforming it into a *preconception*, might be a mistake that prevents the dynamic vision necessary to understanding the profound theoretical and operational transformations of the current scenario. However, at the same time, ignoring the essence of the physical object in architectural heritage, in the excitement of the fascinating potentialities of digitalisation, may be an even worse mistake that threatens the permanence of these testimonies to past ages.

Considering the risk of extinguishing the basic connotations of architectural heritage, as a consequence of the obsolescence of its theoretical foundations in the wake of digitalisation, there is an urgent need to rethink its current and anticipated role. The dynamic connections between technology and architectural heritage may offer a key to interpretation, aimed at rethinking both of these themes. On the one hand, the field of architectural heritage might increase awareness of the processes of knowledge, conservation and enhancement, by applying a synergic and uniform, technological approach. Digitalisation's potential in achieving a virtuous, rather than virtual, reality could be addressed in removing architectural heritage from the rather haughty isolation of the niche to which it has been consigned over the last hundred years. On the other hand, within the framework of the *space of flows* and *timeless time*, architectural heritage might represent, for current and future generations, the cornerstone on which the difficult but invaluable coexistence of global dimension and local identity might be created (Fig. 14).

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