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Digital Toolkit for the Representation, Survey, Preservation and Enhancement of 20th Century Buildings in Brazil and India †

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Abstract: The contribution deals with the elaboration of a digital methodology to be applied on 20th century buildings in Brazil and India as toolkit for their conservation and enhancement. The research has gone through a careful planning and guided process able to integrate all information related to the geometry with details concerning materials, phases of realization, technical characteristics, and environmental. The undertaken research path has shown that the application of technologies used through appropriate methodologies can be an effective approach for the preservation and enhancement of 20th century architectures in "global south countries" and for the transmission of this heritage to future generations all over the world.

Keywords: 20th century culture; modern architecture; cultural heritage; Brazil & India

1. Introduction

This research explores the current state of art of 20th century buildings both in Brazil and India and possible future challenges related to the preservation of design processes and buildings using digital technologies. The reasons why the research was based in these countries are basically two: on the one hand the level of innovation and architectural development of modernism principle achieved was astonishingly high; on the other hand due to both urban and natural pressure the modern architectures in Brazil and India are facing a continuous and very fast deterioration (Figure1). Furthermore the choice is also connected to the possible use of case studies in this countries as benchmark for application of a proper methodology to other regions both in Asia and South America, in different "Global South Countries".

The elaboration of digital methodology to be applied on modernism period architectures built in Brazil and India has gone through a careful planning and guided process able to integrate all information related to the geometry with details concerning materials, phases of realization, technical characteristics, and environmental factors such as landscape or climate issues. The digital tools applied on these architectures have been created taking advantage of the collected documentation. Pictures of original constructions were also utilized in order to study the materials framework [1]. The continuous dialogue among Brazilian, Italian and Indian researchers highlighted the great importance of preserving not only the buildings but also the architectural drawings and design approaches from the which they were born, a legacy that is nowadays in danger and unfortunately in some cases it has been already lost [2].

The preservation and valorization are at the present actively linked: researchers are nowadays able to laser scanning a building, produce increasingly sophisticated computer models to aid their research in cultural heritage, and quick disseminate it across the world. Young people are also very often attracted by technologies, which is crucial point in country such as the so called global south

countries (former developing countries), where students are not always keen to study conservation disciplines at university, [3,4]. Thus the applied methodology concerned data capture, virtual modelling for management study or for public display, non-invasive technologies and other techniques. This approach assisted researchers and professionals in heritage preservation field by identified topics of the research project that were evaluated and studied in order to create the bases for a structured research path. In parallel the case study assessment led to the identification several suitable buildings (both in Brazil and India). The chosen topics were then applied to the most suitable case studies in order to reach a methodological proposal.

The undertaken research path has shown that the survey of the project, the 3D modelling and advanced architectural survey techniques, can not only increase the knowledge about this heritage [5,6], but also be valuable tools for its transmission to next generations. For the future of the Brazilian and Indian modernist architectural heritage it will be very important the collaboration between research institutes and universities. The creation of a network of researchers that could act as a solid foundation for future research in the area and for the application of proven methodologies will be a key point for future international strategies in this sector.

Eventually this research has shown that project such as the collaboration with the USP University in São Paulo and the project in collaboration with CEPT University in Ahmedabad can be very useful in order to share skills and experiences that could lead to the use of this methodologies by experts and local researchers in an independent way as the future of 20th century architecture both in Brazil and India will be in the hands of local policy makers, researchers and professionals [7].

Figure 1. Modern buildings in decay, demolished, heavily modified, rebuilt or not properly maintained both in Brazil and India.

2. The Methodology

The research has explored by deep study modern architectures in Brazil and India and 2D/3D technologies for heritage conservation, highlighting the current state of art, opportunities, threats, processes and possible future challenges. The research themes were mainly two: the 20th century architecture framework in both the countries and documentation processes and technologies available nowadays. The whole process was based on the evaluation of digital archives and database use for heritage enhancement, 3D modelling for documentation and non-invasive technologies

(Figure 2). In selection process the main topics of the research project were evaluated and studied in order to create the bases for a structured research path; in parallel the case study assessment identified suitable buildings as possible case studies [8].

After that the chosen topic were then applied to the most suitable case studies in order to reach a design proposals guidelines based on local context and environmental issues. The cutting-edge building materials and structural systems that define the modern movement were often untested and have not always performed well over time. Heritage professionals do not always have enough scientific data on the nature and behavior of these materials and systems to develop the necessary protocols for conservation treatment. This research could actually help towards the creation of local conservation management plans that could guide long-term maintenance and conservation policies and the testing and analysis of modern materials.

Even if the importance of protecting significant historic buildings from decay and destruction seems to be nowadays undeniable in some cases there is a different approach towards many important post-war buildings [9]. This study wanted to examine also philosophical and practical issues linked to the conservation of Brazilian and Indian modern buildings and also the problems faced by building practitioners in dealing with architectures constructed in a wider range of styles and materials than at any other time.

If time has slowly switched off the power of the transformer dreams of modernist architects, their buildings are a legacy of extraordinary value that should be protected and enhanced as it is a collection of real lessons of architecture. Analyzing the works of greatest architects of the period, it is possible to browse an important slice of history of architecture, passing by the national identity search for specific local features, an architecture that is eclectic, hybridized, which addresses the theme of living, of dwelling, with a completely new and varied language of a different symbolism from that of the past, redesigned with poetry and sharpness.

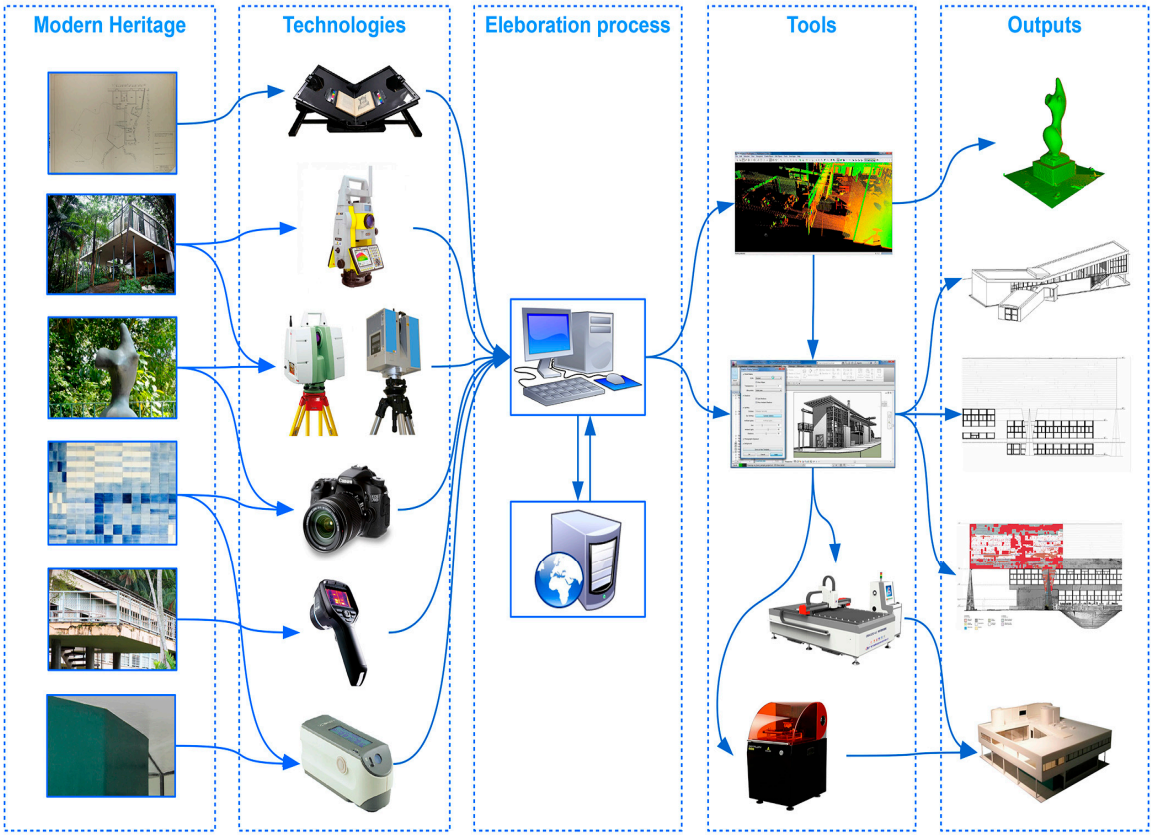

Figure 2. The technologies applied to the research theme (elaboration by the author).

3. The Main Research Topics

The contributions provided by the ICT in Cultural Heritage sector range from the acquisition and analysis of data, the creation of the digital archives as far as cataloguing, and digital dissemination.

Since 1970 several collections have been "digitized" taking advantage of the usual photographic campaigns extended to digital format and similarly, later during late '90s it was operated for three-dimensional objects, such as statues, in order to constitute a reference copy of the sculptures exposed to environmental degradation. In the 1990s the diffusion of digital tools has opened new opportunities for enabling people to select the information contents desired and for recreating immersive and stimulating experiences related to cultural heritage complex.

In the 2000s, the growing of cyber-museology trend has enabled online access to museum collections, allowing visitors to sense the exhibits with a completely new approach. In Europe, the use of technology in the field of Cultural Heritage has been pushed by national governments and the European Union. This has resulted in the creation of a common digital library (Europeana, released in 2008) that would gather all the collections of European libraries, archives and museums (Figure 3).

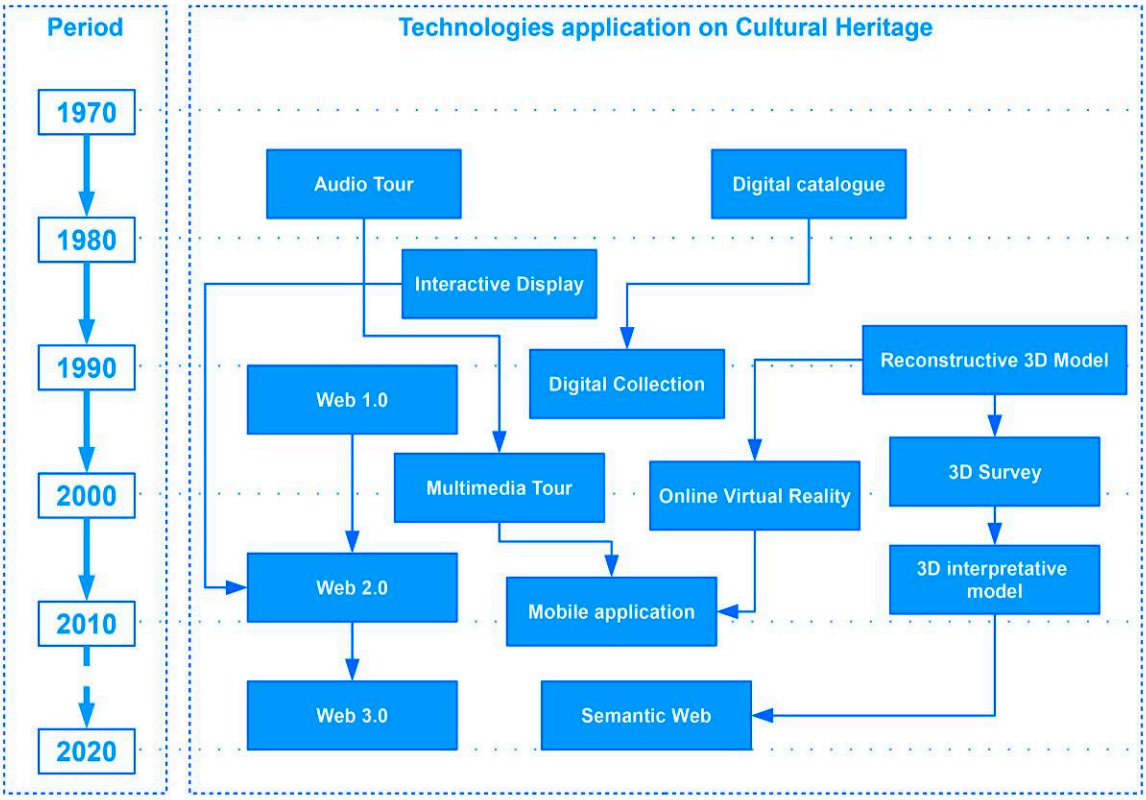

Figure 3. Technologies application on cultural heritage since 1970 (elaboration by the author).

Most recently, the focus of the discourse regarding the impacts of IT on CH has shifted from the mere digitization towards the creation of objects able to act as interactive analyses tools. In this scenario a development path emerges, leading to an ongoing convergence towards mobile platforms. This new platform is opening unprecedented opportunities for heritage institutions to provide customized interpretive facilities, thanks to a closer integration of different media and functions. Nowadays, researchers can access location-specific contents, tag the artworks, visualize suggestions for further research with other colleagues, or save resources for later analyses.

It is for this reasons the main topics explored by this research have been identified as follow:

- Creating accessible databases and digital archives;
- 3D models as possible preservation tool;
- non-contact and low cost predicting technologies.

3.1. Databases and Digital Archives

The cultural heritage can be represented using the most suitable technologies by for sure the real key to a revolution in this field is certainly the use of telematics networks for knowledge sharing. In fact, they provide access to a wider cultural heritage and thanks to search engines specially designed, you will have access to big data bases, not only with traditional searches but also for information such as images, templates, themes, etc.

The professionals, researchers and students can access information about the works, wherever it is stored, and compare them all similar works. In contrast to this potential, it is important to highlight today and even more in the near future, the abundance of data on the network generates pathological effects, including uncontrolled proliferation of references and lack of validity and reliability of the information transmitted [10].

The set of data, paper documents, drawings, photos, is a source, which, if not properly structured, and cleaned up to remove redundant information, it could appear to be out of control both in terms of accessibility and verification of the information accuracy. Nowadays understanding architecture project and being able to reproduce them with digital technologies will also improve the conservation of design process (Figure 4).

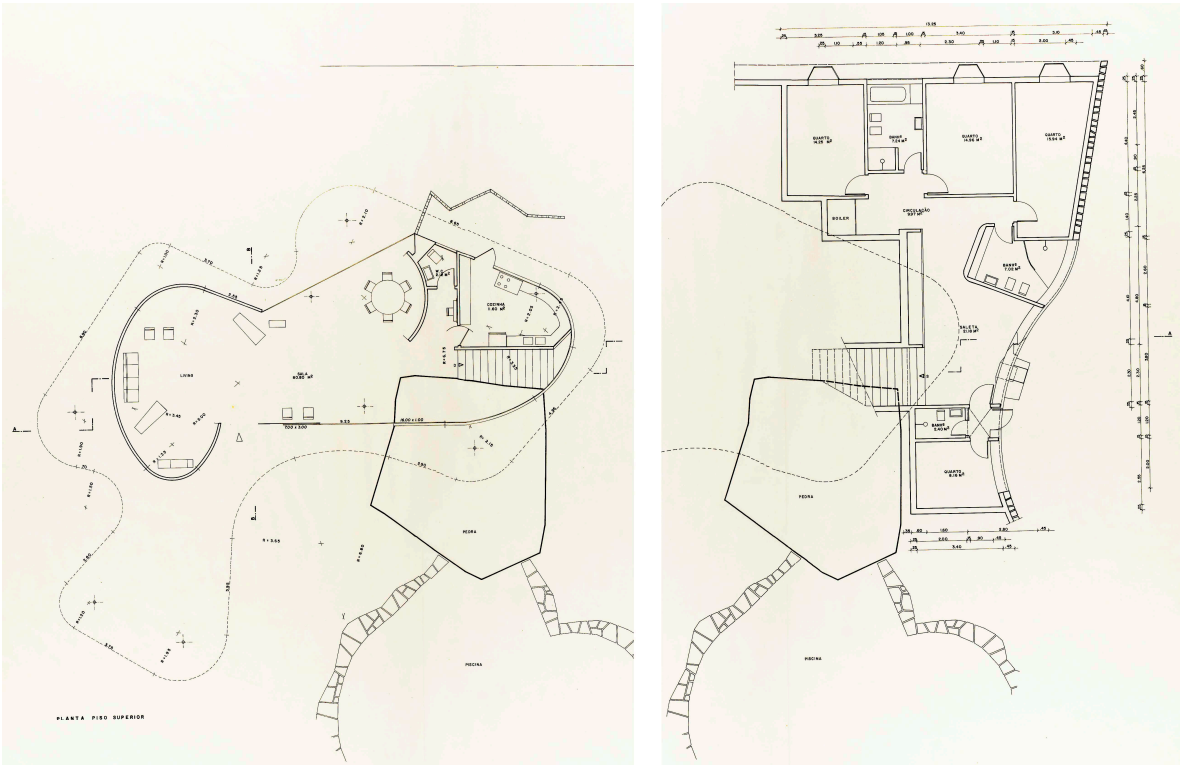

Figure 4. Digitalization of original drawings by Oscar Niemeyer for the project "Casa das Canoas" by Oscar Niemeyer Foundation, Rio de Janeiro, Brazil. (Photo credit: Oscar Niemeyer Foundation).

Actually, the preservation of the architectural projects by the masters is becoming nowadays a crucial point. Very often cultural foundations that manage the archives of the great architects of the 20th century are not always able to ensure an effective conservation because of lack of funds. The information system, consisting of sketches, drawings, images, maps needs thus to be understood and represented with all the features it brings, a set of elements linked by hierarchical relations in a sort of conceptualization of reality.

Youth researchers can play a key role in this process, as stressed by A.M. Ronchi about digital literacy "there is a need to channel the creative energies of young people by promoting digital literacy in the field on new ICT-enable or empowered creativity and expression. There is also a need to create a proactive environment that enhances the overall quality of eContent products. Digital and social divides must be bridged in order to provide access and added value to citizens. Digital

technologies and ICT tools provide an incredible opportunity to encourage growth and prosperity. Digital content and services empowered by broadband communications, both wired and wireless, could have a significant impact on society. One of the first steps in this direction is to promote human networking and the exchange of experiences and skills amongst different groups and communities", [11].

3.2. Three-Dimensional Models

Past experiences have shown how the 3D integrated methodology is able to reveal new aspects of buildings and analyze spaces and surfaces by means of innovative methods that have allowed to track research paths completely unexplored and unpublished. The 3D environment allows to work with intelligent objects able to relate to each other, requiring a high level of specialization from the user, with a designer approach [12]. The final output of this research highlighted a strong synergy between building management and valorization approaches through the workflow.

The use of drawings in order to carry out analytical reviews of the archival heritage of 20th century architectures in India and Brazil can reveal design experiences that reflect the different territorial contexts from which they emerged and the cultural forces behind them. The so called "survey of the project" was the adopted methodology: by analyzing and redrawing the original documents using innovative graphic layouts the research can highlight the potentials of these built heritage. The aspects taken into account in this phase describe the complexity of the study and the need of well-structured data. The process led to a very good understanding of the designer's work by the interpretation of original drawings, scheme and pictures, that reveal the design process behind the construction. The deep knowledge of the buildings, carefully selected and analyzed with a precise methodology and representation techniques, had as outputs an exceptional variety of suggestions for further research paths and reinterpretations.

For instance the study of demolished modern buildings or the reconfiguration of different design hypothesis for the most important buildings of this period. The elaboration of digital models should thus operate through a careful planning and guided process in the field of BIM as for the case study of the Ramkrishna House in Ahmedabad the which gave to research team basic shared knowledge of the data harvested from the documentation analysis and helped to manage all information about the building (Figure 5). The house, designed by Charles Correa, has parallel walls which form the backbone of its plan, a structure divided into 4 main zones: living areas, guest rooms with private garden, service area and bedrooms on the upper floors. Built between the 1960 and 1962 the house explores the ideas related to dwelling issues in India in strong relation with climate challenges.

Figure 5. Ramkrishna House in Ahmedabad, India, by Charles Correa: original pictures (**left side**) and photo-realistic views (**right side**).

The BIM model of this architecture has been created taking advantage of the documentation research on Charles Correa drawings. The picture of the original construction were thus utilized in order to study the materials framework. Beside being a strong base for spatial research and study by this model was also possible to create a virtual reality (VR) model. Software as V-Ray use a proprietary stereoscopic rendering camera to generate a 3D environment with existing Revit cameras, lighting and materials. With this environment it was so possible to generate photo-realistic images of the Correa project to give to the public a sense of what the house look like by creating a VR "map" of a building inside and out (Figure 6).

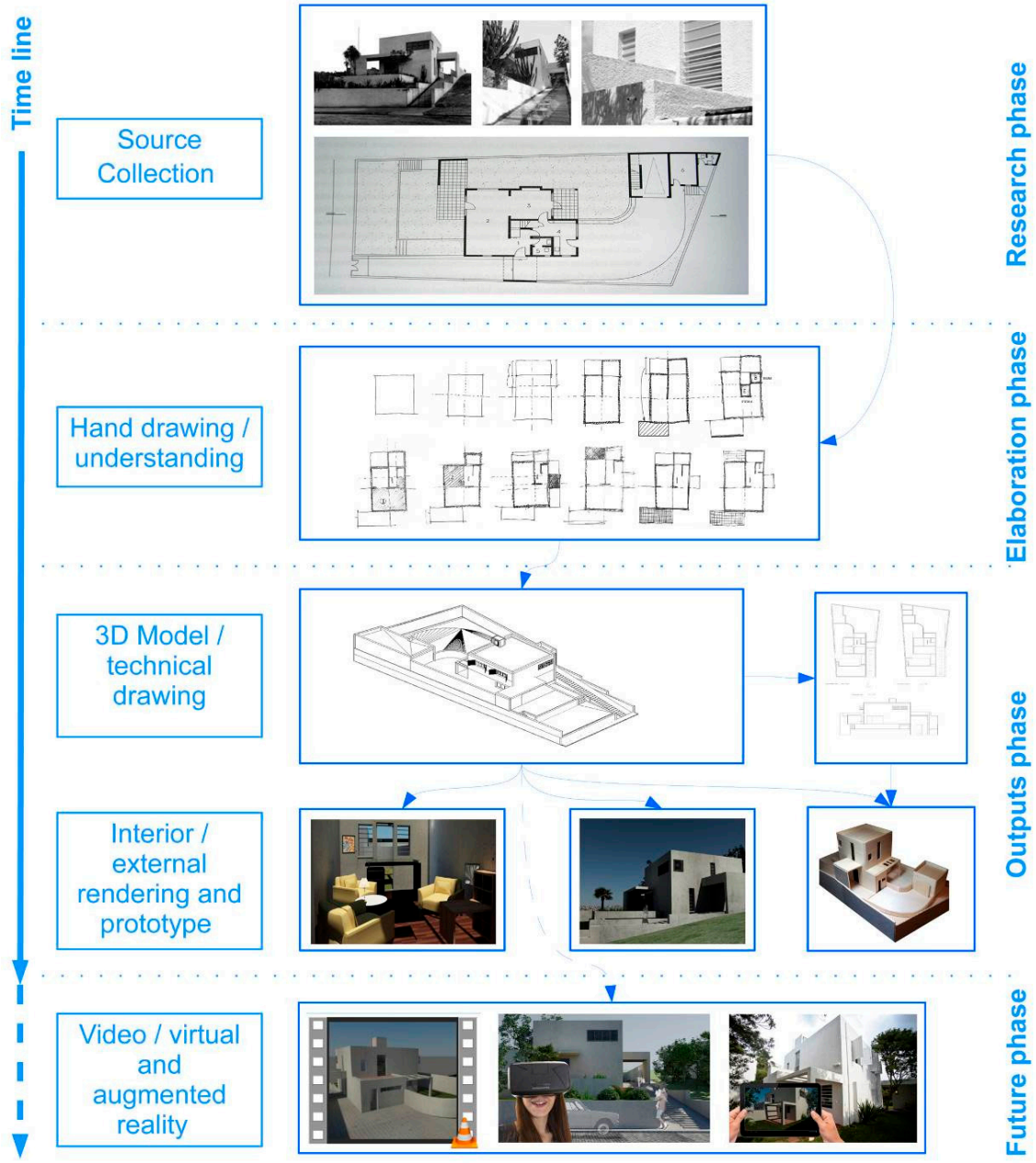

Figure 6. The methodology conceived on modern building in Brazil and India for the 3D database creation and related outputs (elaboration by the author).

3.3. Non-Contact and Low Cost Predicting Technologies

The FAU USP building, in Sao Paulo, Brazil, is a very good example of the importance of effective maintenance program on modern buildings [13]. The complex designed by Vilanova

Artigas was partially restored in its external concrete walls and roof' shells, during the intervention campaign that (due to difficulties in obtaining funds) effectively began in 2012, and it was recently finished in February, 2015. The building during its life had to face basically the lack of a maintenance culture, especially regarding reinforced concrete buildings (Figure 7). In fact, supporting the adoption of this material by Brazilian modernists was the belief that it was indestructible. The modern architects believed that reinforced concrete was capable of facing time and climate with little alteration, thus underestimated little problems that could be handled by daily maintenance developed into major damages to the building.

Figure 7. FAU USP building, one of the façades before restoration in 2014.

This has been especially damaging to buildings which are innovative both in its construction technique and its form, such as Vilanova Artigas Building. This attitude towards the building's maintenance has contributed to the deterioration of the concrete surfaces, a phenomenon that is known today and is accelerated by the worsening of the environmental conditions. The constant treatment and protection of the exposed reinforced concrete structure, especially its vast and intricate roof and the façades, thus is essential. The last intervention in 2015 left many doubts concerning the quality of the choices that have been taken: particularly the filling material that was injected to repair the crack of the concrete façades seems to be non-consistent with the old material. (Figure 8). This recent large scale intervention has great implications to the conservation plan that will be developed, hopefully, with the funds of this grant initiative. These interventions have, so far, been approached with little consideration to the building's historic fabric.

As a result, past interventions, although respectful to the original design intent, have not followed a historic conservation methodology, often causing sacrifice of original fabric and application of treatments that are not compatible with conservation of historic significance, as is the case of the most recent façade concrete patching campaign

The building is currently in a good conservation state and adequate to its use. It is important to remind that even with the aforementioned problems faced during its 46 years of existence Vilanova Artigas Building has never stopped being fully used, even if without ideal conditions.

Following the needs identified by the FUSP Foundation the DIAPReM centre, at the Architecture Department of University of Ferrara has been identifying the proper methodology for the metric and diagnostics analysis of the building.

Figure 8. FAU USP building, one of the external pillar before (**left**) and after (**right**) the heavy treatment in 2015.

First, in order to keep the total cost lower it has been decide to limit the 2D survey to the 4 elevations that define the perimeter of the building of the Faculty of Architecture of the University of São Paulo (FAU USP). The façades have been then evaluated in their conformation by scanning the outer surfaces and concrete structural elements that define the perimeter of the building.

The identification of the areas of survey has been closely connected to the possibility of access (with or without time restrictions), to the anthropic context and compatible with permission of private or public property and in safe condition.

During on-site activities the survey vegetation and other natural or man-made non-removable obstacles were integral part of the survey in some case allowing only a partial assessment of the hidden surfaces. The survey was an integration of technologies and skills: a topographic survey by total station (by Leica TPS instrument type 1202) has been initially carried out in order to capture coordinates of target, and the generation of a local system reference.

After that a 3D Laser Scanner survey by time-of-flight equipment (by Leica type C10) has allowed the survey of the geometric detail of the surfaces and DEM (Digital Elevation Model).

In the meantime a photographic documentation (by Canon 650D) on the building has been implemented to describe the most important survey operations and areas that are most representative of the general state of conservation (Figure 9). These data have then been used for the analysis of macroscopic morphologies of degradation affecting the surfaces. This diagnostic analyses was crucial to support the comprehensive picture of the state of conservation given the amount of material instability identified during the first days on site. The integrated methodology led to a geometric model of spatial coordinates hierarchically-defined and with a single reference system.

After the on field activities, back in laboratory, the DEMs were created and used as basis for editing CAD drawing of the façades.

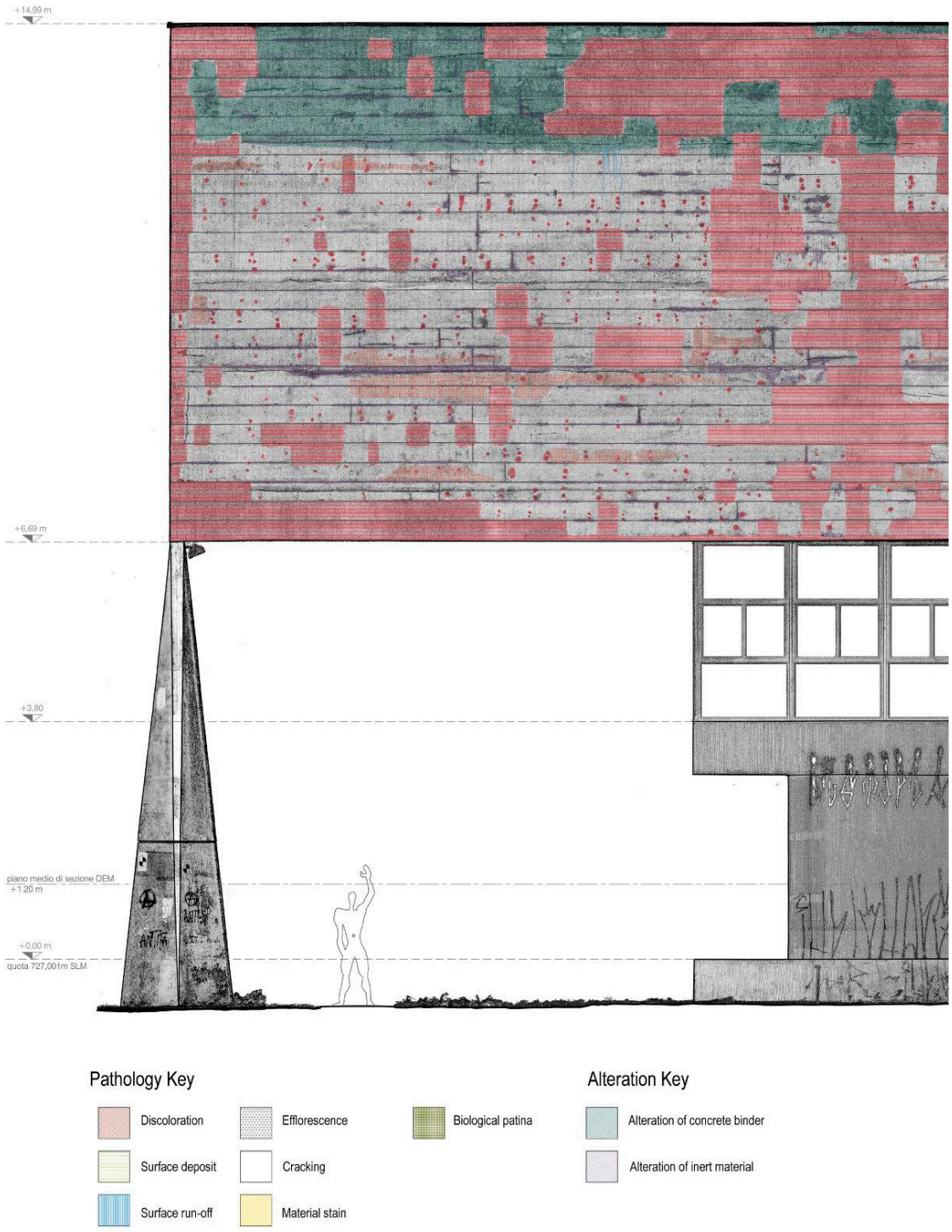

Figure 9. FAU USP building, surface analyses identifying main pathologies and materials alteration.

4. Conclusions

All over this research path more than 250 buildings were catalogued and thanks to 3D modelling procedures and integrated surveys the overall knowledge on some of them was greatly improved. These data should now be used as a base for students and academics (not only in Brazil and India) for further analyses on buildings or more specific research on the modern architecture in Brazil and India even from afar. Great importance in this process of knowledge and toward a real scheduled maintenance program have had the 3D integrated surveys.

The case studies identified by the research make up a significant contribution on an issue of permanent validity, since the emergence of preservation of modern heritage has dramatically

highlighted the lack of knowledge/awareness and organized and finalized information about this architectural heritage in Brazil and India. Through the analyses of examples of high quality built heritage it is possible to investigate the dynamics of the construction and design processes highlighting technological elements that have led to a morphological evolution of case studies and offered an opportunity for a methodological comparison.

The cooperation with the scanners manufacturers in Brazil has shown how it could be possible to use expensive tools even in low budget projects. These tests were also useful in order to evaluate the impact of the research: beside the important outputs extracted from the three-dimensional database that allowed high technology analyses on the buildings, several awareness program (seminars and conferences) on stakeholders have been based on these surveys. This helped to improve the spreading out of new technologies in heritage field in both the countries and has led to the creation of a laboratory net able to autonomously develop local methodologies for the modern buildings preservation (Figure 10).

Last but not least some indication for the preservation of modern buildings by integrated methodology and continuous maintenance have been conceived in order to reduce the need of important restoration works. This has been the challenge of the recent past and it will be the one of the near future: how to use the right tools for the monitoring and the yearly maintenance of these buildings.

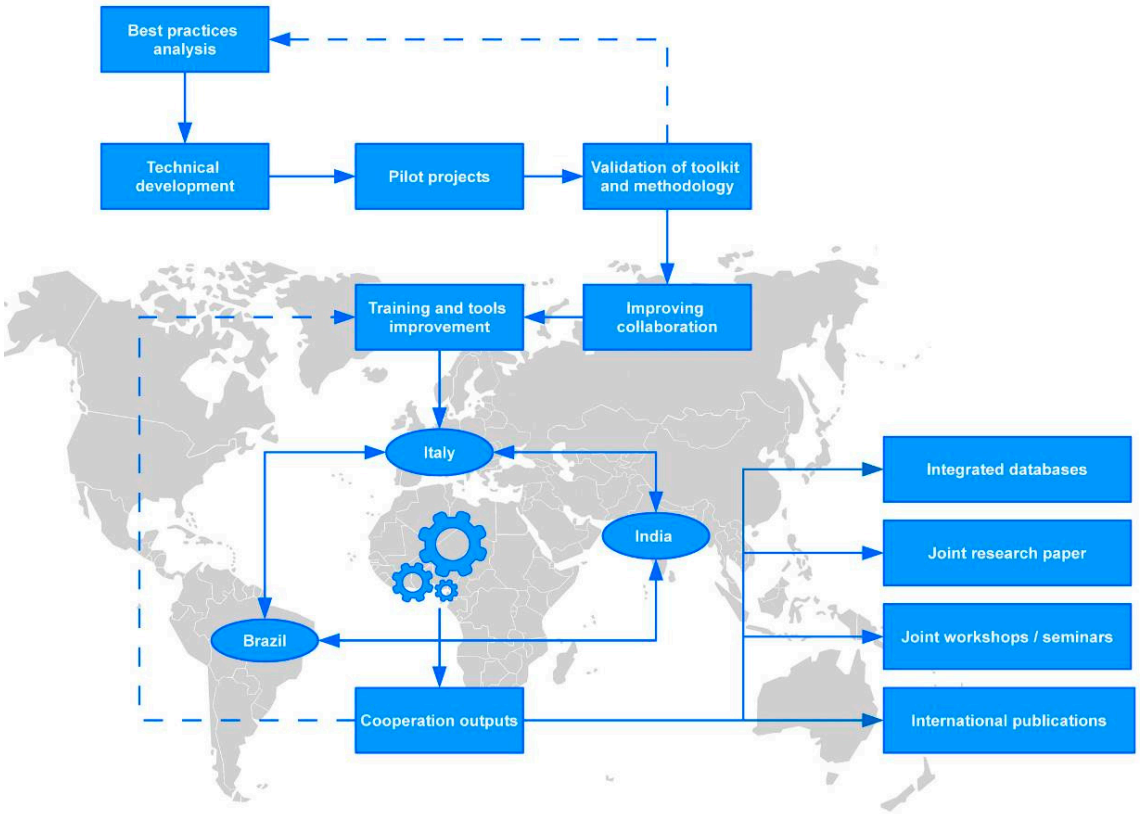

Figure 10. The cooperation net and related outputs developed along the research path.

Conflicts of Interest: The author declares no conflicts of interest.

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