Survey with 3D laser scanner as a tool for knowledge: analysis of case studies

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Abstract

Today the survey with 3D laser scanner is the most reliable and effective data acquisition system for the architectural survey; it aims to the recovery, preservation and valorization of built heritage not only as it allows to document precisely the complexity of geometries of space, but also as it is suitable to obtain - in support of the analytical assessments - a three-dimensional model explorable and full of informations. In fact, very often the historical and archaeological-architectural reconstruction of a building allows to complete the knowledge of the historical, social and cultural development of the communities in which it was built.
Moreover, this representation system allows to realize a cognitive analysis of built heritage, very important for the characterization of its state of pathological decay, in order to be able to define a suitable recovery intervention. The survey with 3D laser scanner allows, then to photograph the site quickly and to analyzed it subsequently, or remotely, allowing also the possibility to perform analytical modeling.
Although the conditions of urgency have made almost irreplaceable the use of 3D laser scanning technology, it is possible to generalize that in archaeological-architectural reconstruction the automatic data acquisition system constitutes a real revolution, since it is capable to associate with the metric data accurately deduced from the 3D model, information on materials acquired through the digital photomosaic combined with the vector model.

1. Introduction

The survey with 3D laser scanner (now widespread in various scientific fields) is a source of experimentation and research in the university circle, as it can see in the meetings and scientific communications that involve professors and researchers from different scientific disciplines. Before this acquisition technique of three-dimensional data become available to everyone (with more reasonable purchase and maintenance costs), it is important to define an appropriate guidelines for the actual suitability for different application fields and to define a suitable operative methodology.
In research carried in recent years by a group of the University of Basilicata (coordinated by Prof. A. Conte), the 3D laser scanner has made an important contribution (also irreplaceable, too) for some unique carried out experiences. In particular, the experiments carried out made it possible to evaluate the potential and appropriateness of this detection technique in the different case studies, sometimes very different and belonging to disciplines also not similar.
Along with a group at the University of Salerno, who has been involved in research and experimentation on these issues, it was carried out many types of detection, ranging from the architectural to the diagnostic survey for the recovering, from the structural monitoring to archaeological survey of underground environments.
This research aims to present – briefly – some of these experiences in a very summary form, to stimulate the reflections on the state and the adequacy of the survey 3D laser scanner in the various possible types of applications with different objectives.

2. Research experimentations and applications

Below they are presented some case studies related to detections with 3D Laser Scanner, chosen to understand how advanced technology for the survey can expand in multidisciplinary themes and different purposes.

The detail survey: the portal of "Santa Maria Novella" in Firenze

This survey example (Fig. 1) was carried out in a wide research on Leon Battista Alberti and, therefore, on how Renaissance perspective has been able to influence the architecture of the time. The instrumental detection input to the Florentine church was necessary to give an answer to the question concerning the constructive anomalies of pairs of pilasters in the main entrance of the church. Already it was possible to note that the inner pilasters - on both sides of the entrance of the church - were more flattened, as to highlight a perspective effect and depth. Therefore, they was quantized these anomalies to assume the likely point of vanishing vertical offsets generated by the lower and upper pairs of pilasters.
In this case, it can validate the suitability for use of the 3D laser scanner system for the survey detail where the precision of the data, linked to a strict geometry of the architecture, it is not easily accessible by conventional detection systems. The accuracy of the acquired data has allowed, in fact, to support studies and research in the field of architectural history for the reading and interpretation of rules and constructive geometric criteria of the past.

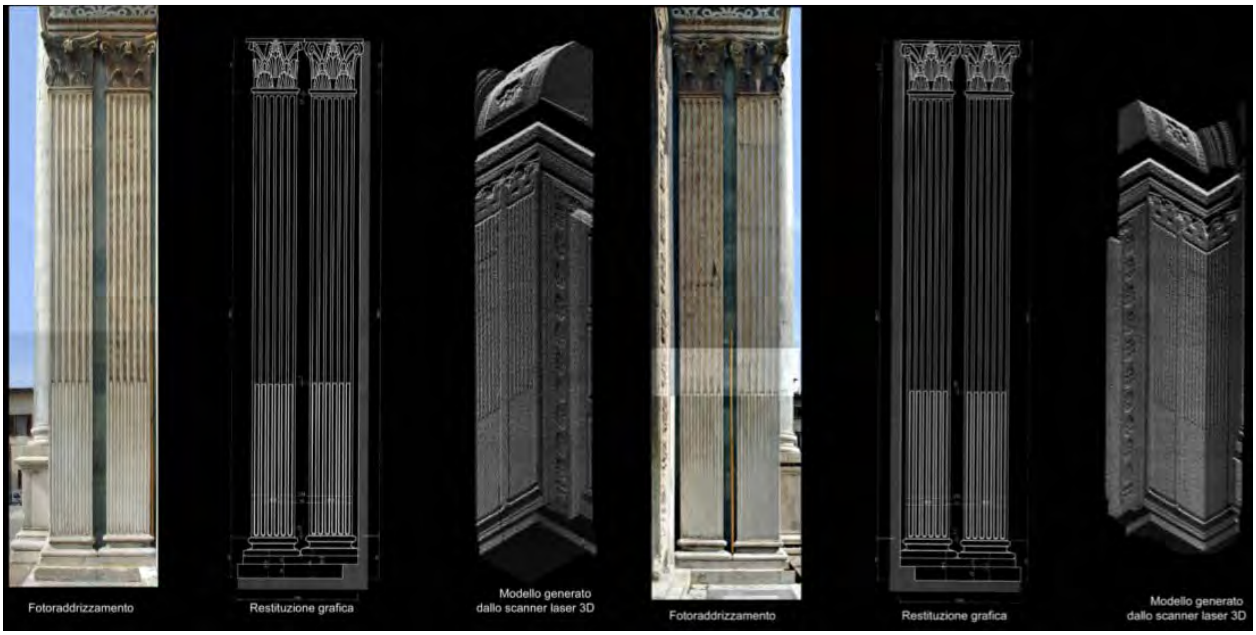

Fig. 1: Survey detail of pilasters at entrance of the church of "Santa Maria Novella" in Firenze

The architectural survey to define recovery interventions: the vaults of "Palazzo Dragone" in Matera

This documented survey (Fig. 2) is a part of a widest research carried out by professors and students of the International phD course in *"Architecture and Urban Phenomenology"* of the Department of European and the Mediterranean Cultures in Matera; it focus on the topics related to the architectural survey for recovering. The use of 3D laser scanner has been particularly useful for the study of the geometry of the vaults that characterize the "Palazzo Dragone" in Matera and, more generally, to document the damage and pathologies in progress on a building structure. The survey with 3D laser scanner, in fact, in addition to having returned

(with rigorous precision) the geometries of the architectural system, it allowed the evaluation of mechanisms related to degenerative instability going on, that were subsequently evaluated on an overall analysis of the building.
The survey with 3D laser scanner is today the most reliable and effective data acquisition system for the detection architectural aimed at recovering, not only because it allows to document with extreme precision the complexity of the geometry of the spaces, but also in order to have to support the analytical assessments, a three-dimensional model explorable and more complete information.

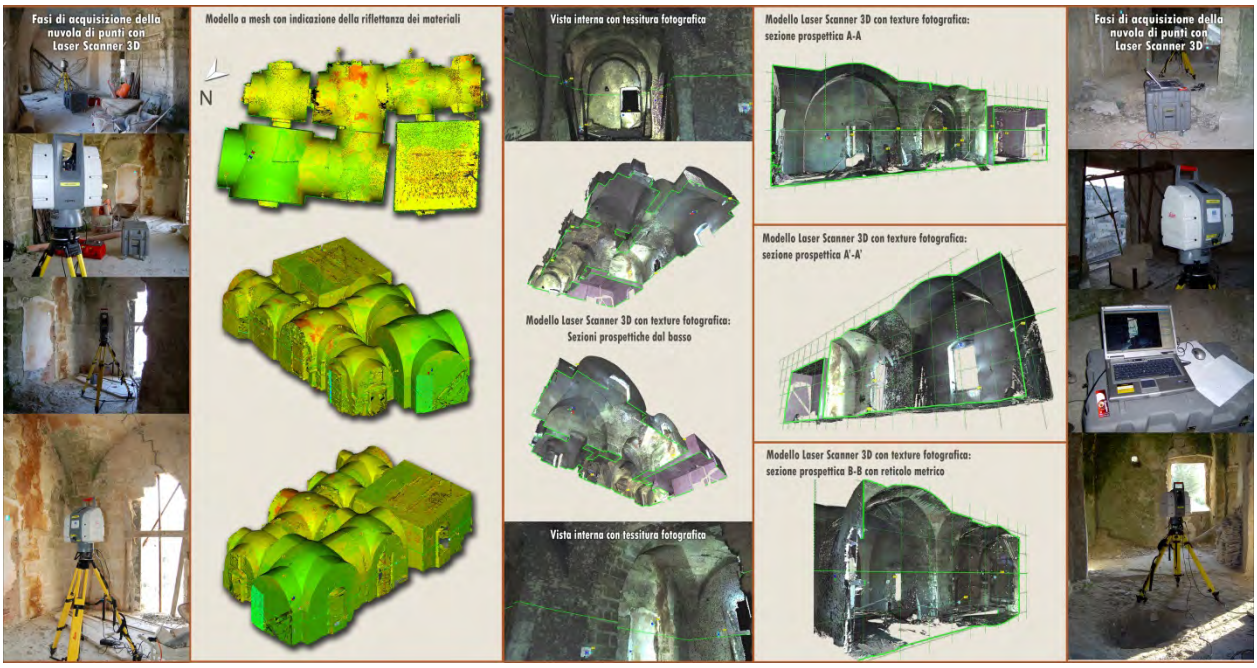

Fig. 2: Architectural survey of "Palazzo Dragone" in Matera

The hypogeum survey: the "Palombaro Grande" in Matera

This research (Fig. 3) is, perhaps, the most emblematic regarding the irreplaceable nature of the detection technique with 3D laser scanner in the study of some particular areas. The underground spaces, such as the Sassi di Matera, are characterized by an irregular geometry, not always characterized to standardized forms and easily schematized. Therefore, with traditional detection systems, the discretization of the survey feature points becomes too demanding and do not allow, however, a graphic rendering entirely faithful to reality.
The "Palombaro Grande", an old cistern of the ancient city of Matera, is a huge size underground that grows below "Piazza Vittorio Veneto", in the city center. The survey with 3D laser scanner in addition to returning a careful geometrical survey of this hypogeum, it allows to place the survey referring to the surrounding environment. In this way it is possible to understand of spatial relationship (plano-altitude) between the square and the underground space. The 3D laser scanner survey of "Palombaro Grande" has provided also important informations about the presence of water in the hypogeum spaces, clearly inferred from the different coloration of parts of the 3D model generated (whose color changes from blue, green, yellow and red). The above sequence is index of increasing "reflectance" of the surfaces: it is greater as much water as is present of the underground space and structures. Therefore, the water concentration goes from a maximum in the red areas to a minimum in the blue areas. This information concerning the presence of water in the old cistern have also made it possible to make evaluations on the hydraulic behavior of water conveyance systems within the "Palombaro Grande". For sites like this use of the detection system with 3D laser scanner it is absolutely indispensable and now irreplaceable.

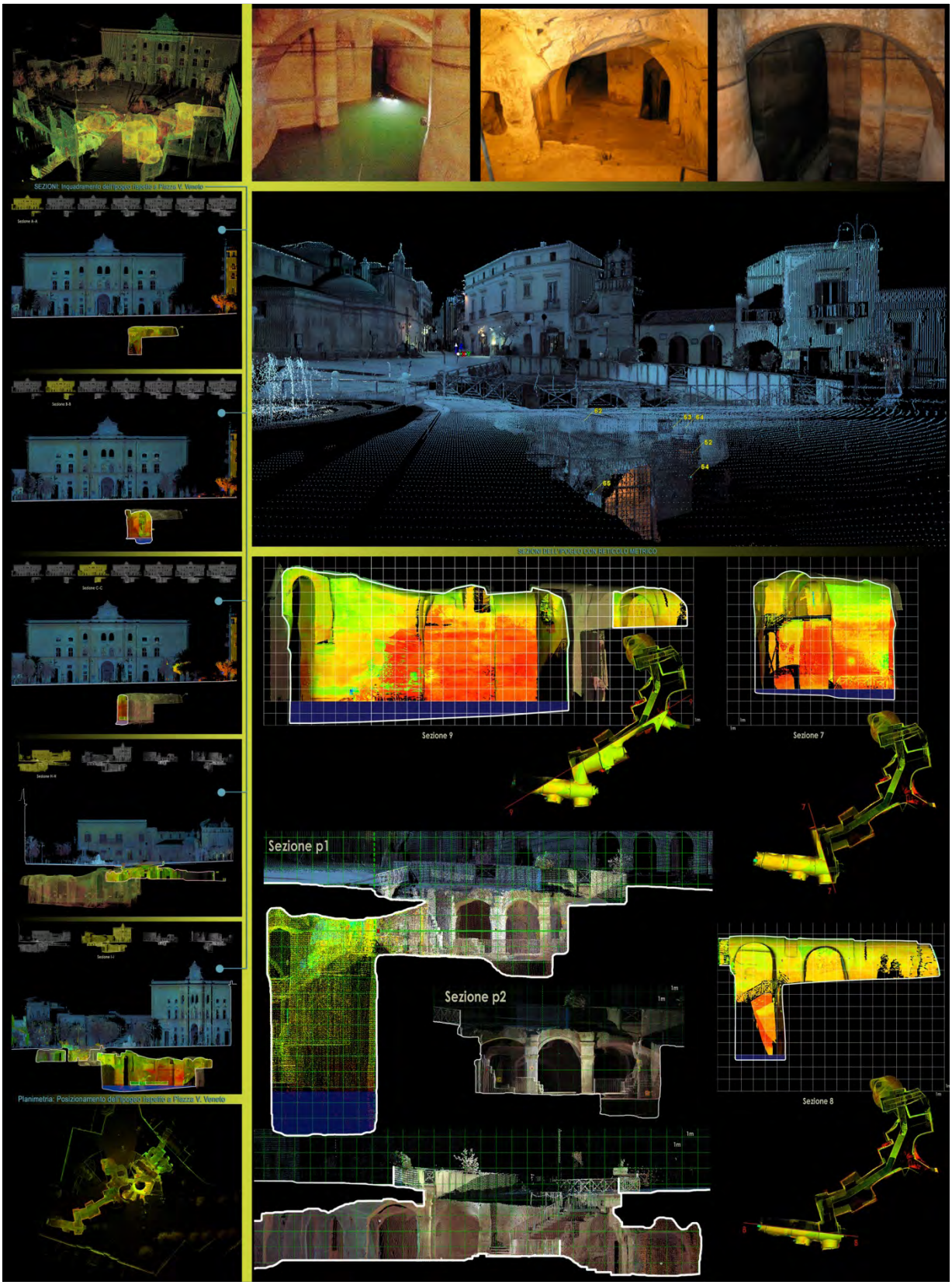

Fig. 3: Survey of hypogeum "Palombaro Grande" in Matera

The monumental survey: the "Tempietto di San Gerardo" in Potenza

This research experience (Fig. 4) was realized within an agreement with the Municipality of Potenza for the survey of some areas of the historic center of the city, subject to urban renewal. The building represents a

symbol for the city as depicting the patron saint of the city. The “Tempietto di San Gerardo” is, from some time, subject to degenerative diseases present on stone surfaces of the construction elements. Its recovery is part of a larger redevelopment project of the “Piazza del Sedile” in the historical city center.
The use of 3D laser scanner, although it can seem overwhelming to the detection of an object so small and geometrically regular, has proved extremely useful to characterize the building and to tackle questions related to the drawings according to orthographic projections able to fully represent the particular geometry and uniformity of monument.

Fig. 4: Survey of the “Tempietto di San Gerardo” in Potenza

The urban survey: “Piazza Prefettura” in Potenza

Also this research (Fig. 5) was realized within an agreement with the Municipality of Potenza for the urban survey of the most important square of the city. The “Piazza Prefettura”, in particular, has been subject of a requalification intervention of public space, designed by an Italian architect Gae Aulenti. The City Council has carried out a detailed surveys of the space in order to have an important support for the project to verify, on a 3D digital model, the feasibility and suitability of the project on the defined area. This experience has allowed to validate the use of the 3D laser scanner for the reliefs of urban areas, both as regards the planimetric analysis of the spaces and to define, in a rapid and automatic way, and the relationship of proportion between the various parts of the spaces as well as the profiles of surrounding streets.

Fig. 5: Survey of "Piazza Prefettura" in Potenza

The archeological survey: the excavations in "via San Biagio" in Matera

The archeology is one of the research areas that has most benefited from the 3D laser scanner survey revolution. In fact, the archaeological sites, characterized by different work phases, need to monitor the excavations. The uncertainty about what will come out from the excavations, the ability to find more layers, the risk of not being able to provide for the extension of the buried heritage, constitute a state of "uncertainty" that is resolved gradually during construction. Therefore, the surveys in an archeological site are continuous if not intended to be cataloged and taken at laboratory. For this reason, it is necessary a continued presence of the detectors, that 3D laser scanner technology greatly accelerate to preserve the excavation story.

The presence in Matera of a School of Specialization in Archaeology at the University of Basilicata required a continuous and constant commitment to archaeological survey operations that, in recent years, have seen the use of lasers 3D scanner. A special case is the excavation in "via San Biagio" in Matera, in the historic center of the city. In fact, the Postgraduate School of Archaeology was involved by the Superintendence for Archaeological Heritage of Basilicata to resolve a situation of urgency due to the discovery of medieval burials in one of the most important squares of the city of Matera.

The emergency condition has required a very rapid survey work without sacrificing accuracy and retail. The purpose was to document the findings surfaced during the work on repaving, in front of the church of "San Giovanni Battista", as the excavations would be finished in short time. In this case the detection with 3D laser scanner (Fig. 6) allowed to "photograph" the site quickly and it can be analyzed retrospectively, ie even after the archaeological excavations had been covered. In fact, the 3D model derived from the survey was subsequently the subject of study and drafting of further graphic processing. Although the condition of urgency has made almost irreplaceable the use of 3D laser scanning technology, it is possible to generalize that in similar archaeological context automatic data acquisition system constitutes a real revolution, since it is capable to associate with the metric data accurately deduced from the 3D model, information on materials acquired through the digital photomosaic combined with the vector model.

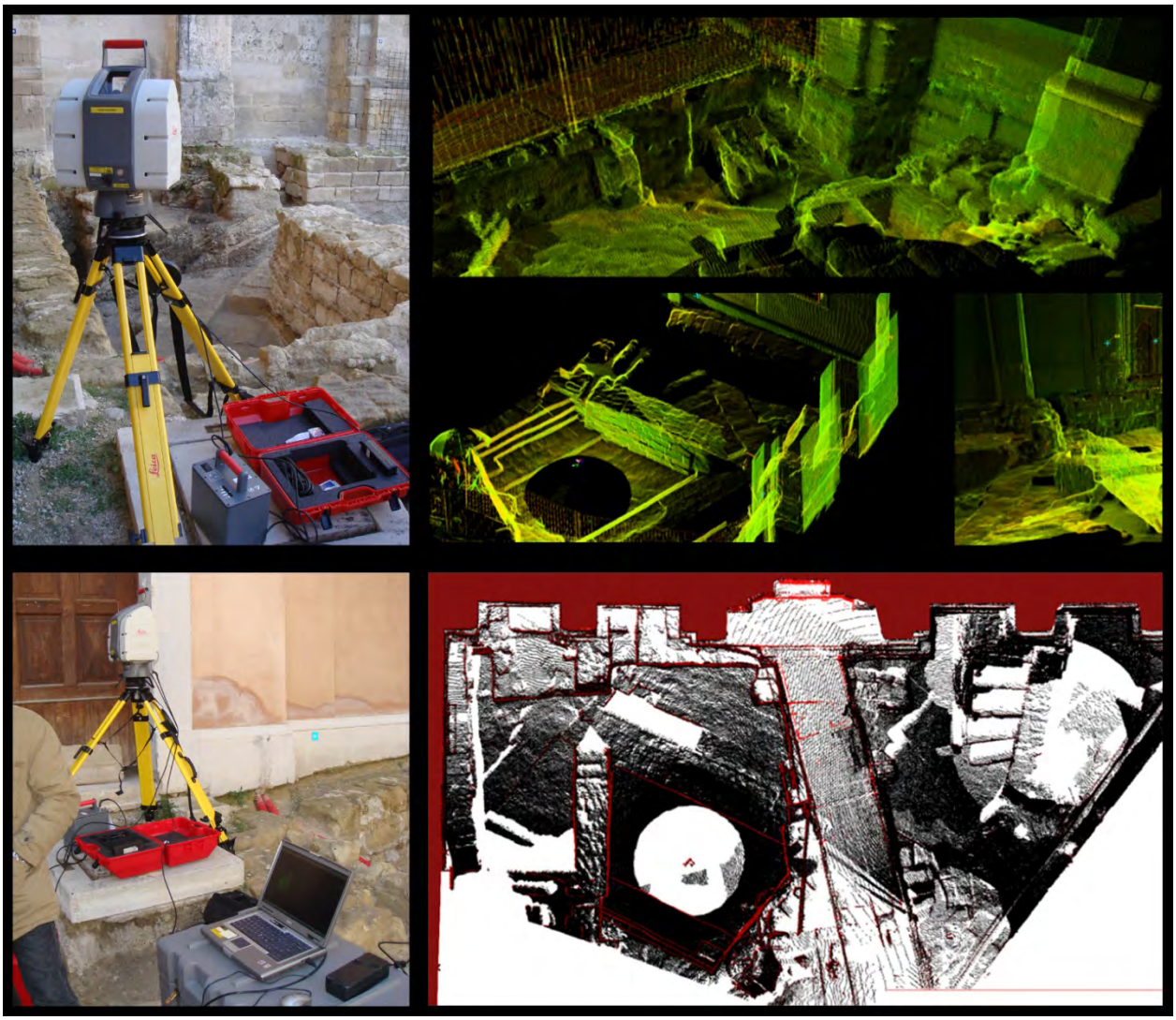

Fig. 6: Survey of archeological excavavation in "via San Biagio" in Matera

Conclusions

This research shows that the detection with 3D laser scanner represents an indispensable tool for the construction activities of the architecture and recovery of the built heritage. In fact, the knowledge of the archaeological sites, the material and technological characterization of a building system, the definition of strongly articulated architectural spaces, the analysis and the diagnostics in the architectural and urban field, they become the only way to define a recovery process that is suitable with the past but, at the same time, open to the reasons of technical innovations. All science in engineering support is based on simplifications of geometric and mathematical models that are synonymous with careful consideration and reasoned decisions. In short, the research highlights that is necessary to take up the technology in all its forms to define the criteria and methods of operation that ensure quality in analytic processes, supported by extreme automation and technological facilities.

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