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DIGITAL CURATOR
TRAINING TOOL BOX

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Enriching Heritage through Digital Curation

Practice and Training Handbook

EDITORS Ramona Quattrini || Carlos Smaniotto Costa || Catarina Patrício

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CHAPTER 6

Essays

Digital Transformation and Architectural Heritage

How to Support the Triple Helix of Knowledge, Conservation, and Dissemination?

Ramona Quattrini, Chiara Mariotti

DIGITAL TRANSFORMATION FROM THE PERSPECTIVE OF CULTURAL HERITAGE: A BRIEF OVERVIEW

For several years, we have been facing epochal transitions, in particular the green and digital ones, which have significant impacts on our society, environment, economy, and culture. At the cultural level, and specifically in relation to cultural heritage, the European research programmes are primarily asking for the design and development of value-oriented and sustainable strategies to accompany these transitions (European Commission, 2022; Muench et al., 2022). The strategic agenda for cultural heritage and its transition reflects a dual tension. On the one hand, there is the willingness to take advantage of heritage as a dynamic resource with an adaptive capacity to respond to change. On the other hand, there is

the concern to maximise the physical permanence of heritage as a unique and non-renewable resource through knowledge-building, the conservation of material and memorial stratifications, and the dissemination and sharing of cultural content.

Several international policy documents have addressed the digital transition and emphasized the need to create synergies between heritage conservation and digitisation, which has been significantly boosted due to the Covid pandemic (European Heritage Alliance, 2020). To ensure brevity and clarity in this essay, it is useful to refer to the ICOMOS dossier on *Quality Principles* that outlines seven key pillars for all stakeholders involved in EU-funded projects and process on heritage conservation and management. Two of these are “knowledge-based actions”

and “good governance” (Dimitrova et al., 2020), which can be greatly supported by digital technologies, both in terms of data storage systems and process structuring. The European Union’s commitment in building competencies and tools to embrace the digital transition and encourage qualified innovation in the field of cultural heritage has been confirmed in some of the most relevant Italian programmes, including the National Strategy for Intelligent Specialisation (SNSI), the National Research Plan (PNR), the National Recovery and Resilience Plan (PNRR) and, above all, the National Plan for the Digitisation of Cultural Heritage (PND), issued by the Central Institute for the Digitisation of Cultural Heritage - Digital Library of the Ministry of Culture. In this context, it is worth mentioning the *Guidelines for the Quality of Architectural Restoration Projects* recently drawn up by the Italian Society for Architectural Restoration, which emphasises the use of digital methodologies to enhance and manage architectural heritage (SIRA, 2023). This position paper picks up again on the theme of quality, which has been brought strongly to our collective attention by the *European Year of Cultural Heritage* in 2018, whose framework for action was based on five pillars for an inclusive, sustainable, resilient, innovative and stronger co-operated Europe that relies heavily on the contribution of digital means (European Commission, 2019).

In addition, the strength of these new practices lies in sharing knowledge and responsibilities for heritage protection and preservation with the community. This allows for co-designing processes that promote conscious re-appropriation of heritage as an identity and socio-economic resource, as established by the Faro Convention (Council of Europe, 2005). In this perspective, the research and innovation calls of the Horizon 2020 programmes emphasised the impact of the digital transition on society. This was particularly highlighted in the work plan of “Societal Challenge 6: Europe in a changing world - Inclusive, innovative, and reflective societies”. The issue was then addressed in the Horizon Europe programmes, specifically in the work programme of “Cluster 2: Culture, Creativity and Inclusive Society”. In line with this proactive approach, Europeana PRO launched several initiatives aimed at supporting the cultural heritage sector in its digital transformation, developing expertise, tools and strategies to embrace digital change and foster partnerships that promote innovation (Europeana, 2022). The *Porto Santo Charter* has also recently returned to the social impact of digital transformation; it values cultural democracy as a primary objective of any cultural initiative for which digital transition can be an enabling factor. The Charter highlights the significance of diversity in accessing, producing, and sharing cultural content, and all opportunities for digital transforma-

tion are seen as facilitators of “cultural citizenship and digital territories”. The document also encourages digital literacy programmes and actions to overcome exclusion and ensure access to digital content of culture, heritage and the arts. This provides equal opportunities for people to participate, create, and enjoy online cultural experiences (Porto Santo Conference, 2021).

The issue of digital literacy is crucial because digital technologies have become indispensable in all areas of life, including work, education, socialising, and access to services ranging from health to culture. Dependence on digital technology has also exposed its weaknesses, such as the digital divide that still affects many countries. The persistent digital presence has thus led the European Union to establish a *Digital Compass* to monitor the progress of the digital transition, close gaps in strategic capabilities, and implement specific targets by 2030 in view of a “human-centred, sustainable and more prosperous digital future” (European Commission, 2021). The four cardinal points of the European Digital Compass – skills, infrastructure, business, government – align with a community policy that opens up new perspectives and challenges for culture and cultural heritage, supported by the recognized contributions this sector can offer to transition and development processes. Empowering individuals to acquire

skills forms the cornerstone of numerous programs and projects designed to engage and cater specifically to various actors, including experts and non-experts, who participate in the processes of knowledge acquisition, conservation, and dissemination of cultural heritage.

HERITAGE DIGITAL TRANSITION PUT INTO PRACTICE

These theoretical and methodological approaches, which are widely accepted and supported, unfolded a challenging field of research and experimentation for cultural heritage. Technology is increasingly becoming a crucial component in complementing traditional processes, providing necessary and directed technological support for the objective of heritage conservation and enhancement. In line with these assumptions, the text provides an analysis of two research projects conducted by the interdisciplinary laboratory on digital cultural heritage DISTORI at Università Politecnica delle Marche (Italy), aiming to give an overview of their complexity and potential for exploration.

“The need to find a new use, to define a conservation project to govern the phenomena of degradation in the short term, to enable tools for its conscious and sustainable management in our critical present made it a key pilot to verify how technology and digital transition could facilitate these objectives in a sustainable, inclusive and innovative perspective.”

The first case concerns Villa Leonardi, a historic house located in the hinterland of the Marche region, in Treia, province of Macerata (Italy). Built at the end of the 19th century on the remains of a pre-existing farmhouse, Villa Leonardi is now surrounded by a 7,000 square metres garden that includes two out-buildings and a row of holm oaks leading to the Potenza River, which were declared historical-artistic interest in 2006, by the Italian Legislative Decree 42/2004. The house has been unoccupied for decades, which has resulted in a lack of use and periodic maintenance, negatively impacting its condition. The need to find a new use, to define a conservation project to govern the phenomena of degradation in the short term, to enable tools for its conscious and sustainable management in our critical present made it a key pilot to verify how technology and digital transition could facilitate these objectives in a sustainable, inclusive and innovative perspective. In the initial stage, the research developed a workflow based on non-parametric automatic 3D modeling and Industry Foundation Classes (IFC) authoring to combine geometry and semantic information (Angeloni et al., 2023). The proposed workflow consists of five steps: the 3D survey campaign and raw data processing, the semantic annotation of images according to different information layers, the annotation transfer from images to the point cloud representing the studied architecture, the obtained Point Cloud

Information Model (PCIM), automatic segmentation and 3D mesh wrapping, and finally the IFC generation for the Heritage Building Information Modelling (HBIM) representation. The final output is a 3D model of the building, automatically processed from digital survey data, and semantically enriched thanks to the material consistency and decay analysis obtained and annotated using spherical panoramas. The effectiveness of this approach was proven in the conservation project for the façades of the house: enriched data on materials and decay supported an action plan of restoration works, which was then recorded in the HBIM, thus permitting time and cost control. Another test explores the potential of open-source software tools for semi-automatic point-cloud segmentation in enriching heritage knowledge and contributing to the inspection of its state of conservation, with the aim of consciously integrating traditional and innovative methods (Nespeca et al., 2024). This ensures a 3D geometric view of reality and enables the identification of criticalities that may not be visible to the naked eye through colorimetric attributes. The investigation focused on the east and south elevations of the building, which were suitable for two distinct trials: a semi-automatic procedure for analyzing the quality of mortar joints in exposed masonry, and a semi-automatic procedure for mapping alterations and decay in plastered masonry. To validate the results, man-

ual and semi-automatic obtained maps were compared using both qualitative and quantitative assessments. Qualitative assessment involved overlay and visual analysis, while quantitative assessment involved transforming the segmented point cloud into a mesh and calculating the resulting surface area. Additionally, a HBIM model was built up in order to test a complete modelling workflow that from the integrated survey, co-ordinated with the constructive and material knowledge of the building, passing through the degradation analyses. Its main goal was the complete modelling of knowledge with adequate Levels of Detail and the preliminary check of some peculiar aspects of the conservation project, as a basis for future management plans. The critical interpretation of this case study revealed both advantages and disadvantages; overall, experimentation highlighted the added value that advanced digital process can bring to the issue of heritage preservation.

The second case study – the Palazzo Olivieri-Machirelli in Pesaro (Italy), currently in use as a music conservatory – is developed on a historical building resulting in a complex stratigraphy in terms of volume. However, significant capabilities need to be enhanced, even if it is still in use. The architectural complex, which includes the Auditorium Pedrotti, is linked to the legacy of the main historical figure of the town: the opera composer Gioachino Rossini.

For its prominent position, barycentric in respect to other urban public spaces, but also being underexploited as a venue for public performances, highlights opportunities for broader community engagement. Thus, a need for strategic innovation arises, leveraging a combination of physical and virtual space utilization to unlock its full potential. The main objectives of the technology-oriented research implemented in this case study stem directly from its characteristics: a physical and virtual experience was hypothesized to facilitate its role as a venue for performances and to highlight its connection with the Rossini personality. Therefore, the applications were intended to multiply opportunities for both material and immaterial reappropriation. Digital transformation was thus employed by embracing the paradigm of informed modelling to facilitate management and leveraging the potential of eXtended Reality (XR) to convey cultural content. The study, extensively presented also in Clini et al. (2023), explored the potential of digitizing architectural heritage through HBIM and XR. The research investigated HBIM applications in managing and narrating tangible and intangible aspects of cultural heritage. A comprehensive workflow was tested, beginning with integrated surveys to create high-quality numerical models adaptable for various purposes and Levels of Detail. A key advancement was achieved through the interoperability of HBIM with XR applications,

allowing for engaging presentations of the historical building and its evolution over time. User-friendly applications, including augmented reality (AR) and mixed reality (MR), were developed to make invisible concepts visible, such as depicting the building phases and recreating historical performances in the Auditorium Pedrotti. Overall, the study demonstrated HBIM efficacy in narrating the temporal dimension of architectural heritage and preserving intangible cultural memories.

CONCLUSION NOTES

Both the exemplifications presented here demonstrated the same backbone: a technological approach and the use of digital technologies to address the challenges of adaptive reuse and conservation of heritage considering its material and immaterial values. The digital technologies employed different tools to meet diverse needs, all while remaining aligned with the specific features and vitality of cultural heritage under consideration. The research is triggered by the digital transformation consequences and oriented to principles such as quality, scientific rigor, and usefulness for communities. Data capturing, data mining and algorithmic analysis, point clouds enrichment and HBIM, and XR are exploited to enlarge the data uses and to enhance heritage knowledge, conservation and dissemination, as a triple helix.

As in the history of humans, technological revolutions have always innovated the way we interact with the reality and especially with culture. For example, photography was the spring that triggered Andr  e Malraux's reflections on his *Mus  e Imaginaire*, a "Museum Without Walls" according to the most accepted English translation. There is a prevailing consensus that what was achievable in the 1990s with photographs can now be replicated digitally, particularly in the realm of three-dimensional replicas, especially when concerning architecture and spatial environments.

However, enthusiasm for technology and digital can be dangerous and prone to meaningless drifts, especially since technology is by its very nature a form of religion (Valerio, 2023). Indeed, the author recommends that we should not abdicate our responsibilities by relying solely on algorithms, questioning that with the algorithm you do not have to be good or bad, it does everything for the person. Now that Artificial Intelligence (AI) has become a desk tool with the web services based on open AI, the renunciation of individual responsibility is even more worrying. Although most definitions state that AI should imitate the logic of the human mind, Mario Carpo (2018) affirms it is increasingly evident that computers can solve some hitherto impervious categories of problems precisely because they follow their own, quite distinctive logic. In spite of this,

emerging principles for the responsible use of AI always emphasise the need for human supervision, as in the law just passed by the European Parliament.

Considering similar risks and perspectives, this essay has described approaches aimed at fostering the digital transition and facilitating the responsible integration of traditional and innovative tools and methodologies for heritage conservation and enhancement. Digitisation can take on various

forms that enhance knowledge, data storage systems, diagnostic investigation methods, and cultural accessibility to architectural heritage. It also improves the verification of coherence between project premises and objectives. Both cases have demonstrated more positive than negative aspects. However, it is important to note that the updating of these processes must be critical and conscious. Similarly, actions on heritage should never be entirely automated.

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She is the author of around 70 scientific publications on these topics, many of them presented during national and international congresses. She is a full member of the Italian Society for Architectural Restoration (SIRA). She is member of the "DISTORI Heritage", the interdisciplinary research lab in Digital Cultural Heritage for UNIVPM. She has been working on international scientific projects; she is currently involved in the European Erasmus + "DCbox project" which deals with teaching practices for digital curation of cultural heritage as communication manager.

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Cristina Stefanelli works as a Project Manager at UNIMED - Mediterranean Universities Union, where she mainly focuses on digital education and inclusion. Since 1998 she has been involved in numerous European projects spanning Europe, Latin America, the Middle East, and North Africa, contributing to the advancement of cultures of innovation, policy

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Daniele A. De Luca was research fellow at DICEA, graduated in Architecture & Building Engineering at the Università Politecnica delle Marche in 2022. His research is focused on BIM and HBIM modelling, integrated with surveying methods.

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Isabel is a Master's degree student in Photography at Universidade Lusófona, Lisbon, Portugal. Her artistic works predominantly explore themes of vernacular archive, absence, and memory, often focusing on personal photographic archives, including both her own and those of others. These projects have resulted in several exhibitions, lectures, and limited-edition photobooks. Over the past decade, she has conducted investigative work, including living abroad, and actively engaging with local communities to deepen her understanding of other cultures. Having returned to Portugal in 2019, Isabel continues her exploration of memory, both personal and collective. She has participated in artistic residencies as both a participant and a producer. Additionally, Isabel is the Co-Founder and Creative Director of ANALOGICA - Analogue Photography Festival in Chamusca, Portugal, where she is dedicated to preserving analogue photography's timelessness while fostering innovation through traditional methods.

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Iva Vasic is a PhD student in the DHEKALOS lab at the Polytechnic University of Marche in Italy. She received her MS in architecture from the University of Nis, Faculty of Civil Engineering and Architecture in Serbia. She is the author of several articles related to the VR application on complex images from Computer Tomography and Magnetic Resonance Imaging, shape similarity analysis of complex three-dimensional models, and user behavior tracking in virtual museums. She received the Salento AVR 2021 Best Paper Award for her paper titled "A New Technique of the Virtual Reality Visualization of Complex Volume Images from the Computer Tomography and Magnetic Resonance Imaging". One of her research focuses is dedicated to investigating user behavior in virtual cultural heritage environments in order to enhance the user experience and provide digital curators with a valuable tool for evaluating and comparing the significance of the artworks. Her main research interests include 3D geometry analysis, 3D modeling and visualization, cultural heritage digitization, neural networks in 3D shape classification, user behavior analysis in virtual environments, and virtual reality.

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Massimo Gasparini, graduated (Laurea Triennale) in "Scienze dei Beni Culturali" from the Università degli Studi di Urbino "Carlo Bo" (Univrb. Urbino, Italy) (2009), he completed his training with the completion of the Master (Laurea Magistrale) in "Archeologia e Letterature Classiche del Mediterraneo" (2011) studied at the Univrb.

He obtained the title of Doctor in "Architettura Classica e Studi Vitruviani. Analisi, rappresentazione, comunicazione, tutela" (2015) by the School of Engineering of the Università Politecnica delle Marche (Univpm, Ancona, Italy).

His postdoctoral training has been enriched thanks to obtaining a postdoctoral stay abroad (2015-2016) from the Univpm, developed in the Department of Art History, Archeology and Music of the University of

Córdoba (UCO) with the theme "Sviluppo di filiera produttiva speditiva e low-cost per l'acquisizione di documentazione grafica tridimensionale, basata su structure de motion, di complessi archeologici e architettonici".

He has participated, always with executive responsibility, in R+D+i projects at different levels, including international, among which he stands out as a member of the scientific team of the Missione Archeologica Italiana in Libya (Cyrene) of the Università degli Studi di Urbino "Carlo Bo" (Italy).

He also belongs to the PAI-HUM 882 Group Ancient Cities of Andalusia: from archaeological research to social profitability.

Additionally, Massimo has been director of several archaeological activities authorized by the Ministry of Culture and Historical Heritage of the Junta de Andalucía.

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Olesya Ivanova, an expert in Marketing and Communication, currently holds the position of Marketing Manager at Sinergia Consulenza S.r.l. in Pesaro, Italy, since 2021. Armed with a Master's Degree in Marketing and Communication from the University of Urbino Carlo Bo, her educational background is geared towards both the continuous updating of knowledge and the acquisition of operational skills for formulating and managing competitive and marketing strategies for companies.

In her role at Sinergia Consulenza, Ivanova manages marketing and communication activities, from identifying target groups and ensuring communication objectives are aligned with these groups, to drafting editorial plans that guide communication strategies. She is skilled in organizing and managing corporate events with team building objectives, enhancing the company's marketing and communication efforts in collaboration with Sinergia teams, and updating communication kits with branding elements such as websites, brochures, email signatures, and presentations.

Ivanova also manages the marketing and communication activities for startups within the Tonetto e Londei® Business Group.

Olesya Ivanova has experience in the creation and technical management of Learning Management Systems (LMS), such as Moodle, for developing training courses.

Her digital competencies: content creation as a video maker and editor, editorial planning, graphic design skills, marketing strategies including email marketing, LMS, creation of marketing funnels, SEO and SEM strategies, and management of platforms with WordPress, data analysis and visualization, as well as social media management.

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Olivera Nikolic, architect, PhD candidate in architecture and assistant at the Faculty of Civil Engineering and Architecture, University of Nis, Department of Visual Communications. She is a permanent associate of many museums in Serbia and has designed and implemented permanent and occasional museum exhibitions. Knowledge of BIM is applied in the protection of architectural heritage. She is the winner of the prestigious award of the Aleksandar Radovic Foundation, awarded for overall work and merits in the protection of cultural and architectural heritage.

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Full Professor ICAR 17 (drawing) in the dep. DICEA of the Faculty of Engineering of the University of Ancona. He graduated in the same University in 1991 with a thesis on the Digital survey and the analysis of Gaudi's Sagrada Familia with 110 and praise. In 1997 has achieved the title PhD in "Drawing and survey of architecture" in the Faculty of Architecture of the University of Florence, with a thesis entitled: "The Basilica of Vitruvio in Fano, from the archaeological ruins until the reconstruction and creation of a three-dimensional digital model". He won in 1999 the competition for researcher at the University of Ancona. In 2002 he obtained the diploma to the European Masters in History of Architecture at the University of Rome III with a study entitled "The drawings of the Basilica of Fano in "De Architectura" of Vitruvius, drawn up under the guide scientific of Professor Pierre Gros. From 2000 he teaches survey and history of architecture at the Faculty of Engineering of Ancona. Its interests concern analysis and historical architecture representation with digital technologies aimed at the communication of the architecture. On these topics is author of many publications and he participated in many national and international conventions.

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Ramona Quattrini, architect & building engineer, PhD, associate professor of drawing and survey in the Dept. Construction, Civil Engineering and Architecture (DICEA), Università Politecnica delle Marche (Univpm). She serves also as Vice-Director of the Department.

Her research focuses on Digital Cultural Heritage (DCH), in particular on architectural and cultural heritage survey, 3D digital artifact capture and representation, semantic segmentation and HBIM for smart access to knowledge, web-based and mobile technologies (VR/AR) for CH story-telling, technologies for virtual and digital museums. She is member and co-founder of DISTORI Heritage, an interdisciplinary research group in Digital Cultural Heritage, in Univpm.

She published more than 100 works, including one book and 50 papers on scientific peer-reviewed journals. She has been selected in International Conferences as speaker and as participant, in addition she serves as Associate editor in the ACM Journal of Computing and Cultural Heritage.

She has been responsible in research projects based on competitive funding, dealing with digitization of cultural heritage and its exploitation for touristic purposes: IT-HR REMEMBER which implemented Virtual Museums regarding tangible and intangible heritage of 8 Adriatic ports, and Erasmus+ KA203 Rail to Land project, having in charge the 3D contents and narrative about landscape from the train. She served as scientific responsible of the Interreg AdriPromTour and of the Erasmus + project DCBox, which deals with teaching practices for digital curation of CH.

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Renato Angeloni, architect & building engineer, is a research fellow in the Dept. of Civil and Building Engineering, and Architecture at UNIVPM. He is also a contract professor of 3D modelling and representation at

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Photographer and visual artist, Ricardo Geraldés is a PhD student in Media and Communication at LUSOFONA-ECATI, granted with a FCT fellowship, and a researcher collaborator at CICANT. Holding a master degree in Communication Sciences (NOVA-FCSH), a post-graduation in Information Management and Curation (NOVA-FCSH), Ricardo Geraldés holds a degree in Communication Sciences (NOVA-FCSH). He is also graduated in Photography at Ar.Co, and at the School of Photography and Visual Arts Maumaus. His artistic practice and theoretical research assumes Earth and its materiality as the main object of thought.

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Romina Nespeca is a researcher (SSD ICAR/17-Drawing) and adjunct professor at DICEA, Department of Civil Engineering and Architecture, at the Polytechnic University of Marche (Italy). She works on international projects such as the INTERREG IT-HR “REMEMBER” (2019–2021) and ERASMUS+ “MUSEUM-NEXT” (2022–2024). Her research focuses on the digitization of Cultural Heritage, in the archaeological and architectural fields. She works on drawing and surveying, from acquisition to 3D modelling, up to the implementation in AR and VR systems. She is particularly specialised in the management of point clouds in integrated surveys. Author of 50 publications, including a monograph and scientific articles in national and international journals, she has participated in several conferences.

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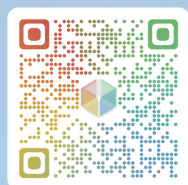
PhD, Associate Professor at the University of Nis, Faculty of Electronic Engineering since 2023, has 15 years of experience in teaching a significant number of different academic courses on all three study levels. He serves as the Head of the Laboratory for Control of Cyber-Physical Systems at the Faculty of Electronic Engineering at University of Nis. He is author and co-author of more than 90 scientific papers in refereed journals and at international/national conferences. He is a Vice-president of the Organisational board of SAUM scientific conference and Editor-in-chief of scientific journal *Facta Universitatis, Series: Automatic Control and Robotics*. He worked as a reviewer for many well-known international scientific journals with IMPACT factor (IEEE ASME Mechatronics, IEEE Signal Processing Letters, IEEE Trans. on Industrial Electronics, IEEE Trans. on Cybernetics, etc.). His current research interests include artificial intelligence, neural network, machine learning, big data, genetic algorithms, mechatronics, and control theory in general. As a coordinator and a team member, he participated in numerous domestic and international projects mainly financed by European funds (BEOPEN, IF4TM, NORBAS, ADRIA-HUB, IBigWorld, Waterline, FAAl, SPaSE, etc.).



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