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Enhancing Cultural Heritage through the Integration of Digital Technologies, Arts and Story-telling

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Abstract:

Purpose - The paper presents the research done by the School of Fine Arts, University of Ioannina, Greece as well as the methodologies utilized, challenges faced, and key findings during the implementation of the Research Project "Centre for Research, Quality Analysis of Cultural Heritage Materials and Communication of Science" funded by the Operational Program NSRF 2014-2020. The School of Fine Arts aim was to explore, in a holistic way, how digital technologies and artistic practices can enhance the experience of Cultural Heritage in the Region of Epirus, Greece, with the use of story-telling techniques, while, at the same time, safeguarding and valorizing it, making it more accessible and engaging for larger audiences.

Design/methodology/approach - Through a comprehensive and innovative methodological approach, the research team divided the work into discrete but interconnected phases, to achieve the project's objectives. In the first phase, archival and field research was conducted for various cultural sites in Epirus. In the second phase, state-of-the-art digitization techniques and advanced imaging technologies were employed to capture and document the places of interest. Finally, through artistic co-creating processes and game engine technology, story-telling scenarios were developed in AR and VR environments. This methodology enabled openness and flexibility throughout the process, and challenges faced during the project's implementation were easily assessed.

Findings - The implementation of the chosen methodological approach and the findings underscore the impact that the integration of arts and digital technologies can have on Cultural Heritage preservation, representation, and promotion. The project's findings highlight how digital media can become tools for interpreting and valorizing CH, offer novel experiences in a more inclusive and engaging way, and bridge the gap between art and

technology, to preserve collective memory, enhance cultural identity, and deepen a sense of belonging.

Originality/value - The integration of digital technologies and artistic practices in Cultural Heritage can offer new possibilities for the representation and interpretation of the content, modifying the way in which CH is perceived and experienced. The potentials of the new media are often focused on recreating high-quality copies of cultural assets as physical entities, which may be important for their safeguarding but fails to employ them as agents for surveying and exploring complex relations, notions, and concepts linked to their context. This merely technical approach does not take into account that digital media can be intentionally utilized to affect the significance of the content and impact the information and its representation, thus constituting expressive, interpretative tools. Through the integration of artistic practices and digital technologies, new, engaging modes can emerge, where cultural assets, tangible and intangible, are not just passive exhibition or storage objects, but become active agents for the design and development of meaningful experiences.

Index Terms — cultural heritage, digital technologies, arts, story-telling, integration.

I. INTRODUCTION

The utilization of digital technologies and artistic practices has emerged as a transformative force in the fields of Cultural Heritage (CH) preservation, valorization, and promotion. The paper presents a comprehensive overview of the research performed by the School of Fine Arts, University of Ioannina during the implementation of the Project "Centre for Research, Quality Analysis of Cultural Heritage Materials and Communication of Science" (KEYPK) funded by the Operational Program NSRF 2014-2020. The main objective of this endeavor was to explore the novel potentials offered by integrating digital technologies and artistic practices to enrich the Cultural Heritage experience of the Region of Epirus, thereby fostering broader accessibility and heightened engagement among diverse audiences. Through this presentation, we hope to promote

an interdisciplinary dialogue with various agents regarding the evolving realms of digital technologies and artistic reinterpretation within Material and Immaterial CH.

A. Background

The proliferation and advances in digital technologies are altering how CH is documented, preserved, represented, and experienced. As a result, the reimaging of CH has become an imperative undertaking. Traditional approaches of preserving cultural assets as static entities, while essential for safeguarding, often fall short in conveying the richness of their historical, cultural, and contextual significance. Recognizing this evolving landscape, the School of Fine Arts at the University of Ioannina tried to reinvigorate the appreciation and exploration of Cultural Heritage in Epirus by integrating the fields of arts and digital technology. The Region of Epirus embodies a rich field of cultural assets that resonate with historical depth and significance, representing a shared heritage, a repository of collective memory, and a source of cultural identity.

The research project KEYPK sought to transcend the defined boundaries of preservation, holistically utilizing digital media as an expressive and interpretative tool. In doing so, it aimed to explore new dimensions of engagement, where CH assets, both tangible and intangible, would evolve from passive exhibits to dynamic agents in creating meaningful experiences. This approach is propelled by the desire to preserve the past and infuse it with relevance, making it more accessible, relatable, and captivating to contemporary and future generations, enabling a dynamic reimagining of Cultural Heritage.

By employing artistic practices, digital media, and narrative techniques, the project endeavors to create immersive, interactive, and engaging experiences that bridge the gap between the past and the present, ensuring CH remains a vibrant and dynamic part of our cultural landscape. The project's outcomes contribute to the discourse surrounding the harmonious coalescence of digital innovation and artistic interpretation in the context of CH, with the potential to reshape the way we perceive and engage with our shared past.

B. Purpose and Significance

The purpose of this research project was to explore the potential of the dynamic synergy between digital technologies and artistic practices within the field of CH. This interdisciplinary endeavor sought to offer alternative perspectives on how Cultural Heritage is experienced and represented, specifically in the Region of Epirus. Employing artistic practices, storytelling techniques, and cutting-edge technologies the project aimed not only to enhance the accessibility and engagement of a broader audience but also to ensure the preservation and valorization of the cultural legacy.

The significance of this undertaking lies in its potential to reshape the way we engage with CH. The application of digital media in the context of preserving and representing CH has primarily revolved around the digital replication of

cultural assets, ensuring their safeguarding, albeit in a static and passive form. However, this technical approach often neglects the transformative potential of digital media as a dynamic, interpretative tool. It overlooks the capacity of digital technologies to infuse CH with new significance, transcending the realm of mere representation to become active agents for the exploration of intricate relationships, notions, and contextual concepts. By merging artistic practices with digital technologies, this project introduces innovative, immersive modalities in which CH, whether tangible or intangible, assumes an active role in the creation of profound and meaningful experiences, redefining the way we perceive and engage with our cultural landscape.

The project's significance extends beyond the preservation of cultural assets; it encompasses the preservation of collective memory, the enrichment of cultural identity, and the cultivation of a profound sense of belonging. This research fosters a new paradigm for CH preservation and interpretation, promising to stimulate broader discourse and inspire further exploration of the transformative potential inherent in the integration of digital technologies and artistic expression.

C. Aims of the Project

The overarching aim of the KEYPK project is to rethink CH for the digital age through the prism of creative practices. The specific aims of the project are the following:

a) Exploration of CH Holistic Enhancement: The project seeks to explore how a holistic approach, merging digital technologies and arts, can profoundly enhance the perception and engagement with CH in Epirus.

b) Innovative Storytelling Techniques: With an emphasis on narrative methodologies, the project aspires to foster storytelling approaches designed to invigorate CH narratives. The overarching objective is to enhance the accessibility, engagement, and relevance of these narratives across diverse audiences.

c) Preservation and Valorization: By its creative objectives, the project aims to ensure the preservation and valorization of CH, emphasizing its intrinsic value and significance.

d) Dynamic Interpretation: By integrating artistic practices with digital technologies, the project endeavors to move beyond the conventional, technical approach to CH and enable dynamic interpretation, imbuing the content with new meaning and relevance.

e) Cultural Assets as Active Agents: A central aim is to transform cultural assets, whether tangible or intangible, from passive exhibition objects into active agents that play a pivotal role in designing and developing profound and engaging cultural experiences.

f) Inspire Future Research: The project seeks to inspire future interdisciplinary research. Through its innovative approach to enriching CH, the KEYPK project holds implications for other CH sites and regions, encouraging them to embrace technology, art, and participatory methodologies in revitalizing their CH and cultural experiences.

These aims constitute the project's roadmap towards

redefining the CH landscape in Epirus and establishing a novel approach to preservation, interpretation, and engagement within the broader CH context.

II. THEORETICAL BACKGROUND

Digital technologies are altering established practices and paradigms, which succumb to the dynamic transformation of our rapidly evolving world [1]. This new condition presents significant questions and challenges for Cultural Heritage, constituting the need to reevaluate its role paramount, as conventional approaches of preservation, interpretation, and representation become outdated [2], [3]. This necessitates a novel perspective, one that leverages digital innovations and artistic practices to foster dynamic, inclusive, and engaging experiences for broader audiences [4], [5], [6].

The preservation and documentation of CH have undergone an important evolution in recent years, due to the advances of digitization methods and techniques [7], [8]. However, the potentials of these methodologies are often focused on the high-quality replication of cultural assets as physical entities, which may be important for their safeguarding but fails to employ them as active agents for the examination and exploration of intricate relationships, ideas, and concepts associated with their contextual framework [9], [10]. The significance of these intangible aspects of CH including memory, identity, and sense of belonging, shifts the perspective towards a more holistic understanding of Cultural Heritage, one that recognizes its capacity to evoke emotions, shape identities, and foster connections between past and present [11], [12], [13].

Additionally, this merely technical orientation does not take into account that digital media can affect the significance of the content and impact the information and its representation, thus constituting an expressive, interpretative tool, capable of creating aesthetic value [14], [15]. Consequently, the integration of artistic practices and digital media in the context of Cultural Heritage can enhance contextual understanding as artistic representation can convey the historical, cultural, and contextual significance of CH in ways that raw data cannot, and prevent default or generic representations [16]. Artistic interpretations can add layers of context that help audiences appreciate the historical and cultural context of cultural assets. Furthermore, artistic and aesthetic value infuse CH digitization with elements that resonate emotionally with the audience, making it more accessible, engaging, and inclusive [17], [18].

Through the integration of artistic practices and digital technologies, new, engaging modes can emerge, where cultural assets, tangible and intangible, are not just the passive exhibition objects of the past directly confronted by the dominant subject [19], [20] but become active agents for the design and development of meaningful experiences, engaging, immersive, and more inclusive [21], [22], [23]. This convergence of art and technology represents a critical juncture in the evolution of Cultural Heritage engagement.

In this context, the KEYPK project proposes a new approach to the safeguarding, valorization, and promotion of Cultural Heritage utilizing digital technologies, artistic practices, and storytelling techniques. The multidisciplinary conceptual framework of the project has been informed and influenced by a concise review of key studies and research on art, cultural heritage, and digital technologies, providing a solid foundation for its approach.

A. Cultural Heritage and Digital Studies

The advancement of Digital Studies has changed the way that Cultural Heritage is approached, preserved, and disseminated [24], [25], [26]. Research demonstrates the potential for bringing more people into contact with Cultural Heritage events by using digital technology to promote inclusivity and interaction [27], [28], [29], [30], [31], [32]. Building upon the fundamental ideas of Digital Studies, the KEYPK uses digital media to investigate and interpret Cultural Heritage in novel ways, allowing a deeper understanding of the history, and cultural identity of the Region through interactive interfaces, semantic mapping and analysis, and data visualization. The integration of the arts into the interdisciplinary field of Digital Studies, which now encompasses various disciplines beyond its original focus, represents an organic progression, enhancing out-of-the-box thinking for researchers and technologists, thereby stimulating innovation and creativity. This interdisciplinary methodology not only introduces novel experiential avenues for users but also establishes innovative mechanisms for linking historical contexts with contemporary experiences, thereby enhancing users' cognitive and emotional connections to Cultural Heritage. Widespread encouragement is extended to diverse audiences to actively engage in and contribute to the preservation, valorization, and promotion of both tangible and intangible cultural assets through the seamless integration of digital technologies with Cultural Heritage.

B. Art and Technology Integration

Integration of art and technology has been investigated as a novel strategy for enhancing experiences with Cultural Heritage [33], [34]. Empirical studies have indicated that the amalgamation of art and digital media can augment historical narratives and elevate cultural awareness [35], [36], [37]. Additionally, audiences can establish more immersive, meaningful, and captivating connections with Cultural Heritage through this integration. By combining digital tools, the KEYPK project effectively blurs the lines between the real and virtual worlds by fusing art and technology. Because of this mutually beneficial relationship, Cultural Heritage can be more accessible and relatable to wider audiences.

III. METHODOLOGICAL APPROACH

The Methodology section of the study outlines the systematic framework employed to achieve the project's overarching aims. This section provides a detailed account of

the specific methodologies performed, the challenges and limitations faced, and the procedures applied throughout the project.

A. Project's Methodology Overview

Through a comprehensive and innovative methodological approach, the research work was divided into discrete but interconnected phases to achieve the project's objectives. In the first phase, the research team gathered a selection of cultural sites related to the water routes of Epirus, focusing on three traditional stone bridges, the Bridge of Spanos, the Bridge of Kyra, and the Bridge of Politsa. Stone bridges constitute an integral part of the region's architectural, cultural, and historical landscape and their comprehensive study is pivotal for the preservation of Epirus' CH, the promotion of regional identity, and the acquisition of valuable historical and cultural knowledge. When the sites were selected archival and field research was conducted. In the second phase, state-of-the-art digitization techniques and advanced imaging technologies were employed in order to capture and document the places of interest. In the third and last phase, through artistic co-creating processes and game engine technology, story-telling scenarios were developed in Augmented Reality (AR) environments.

B. Challenges

Throughout the implementation of the selected methodological approach, several limitations and challenges were encountered, and appropriate mitigation actions were taken that enabled the successful and timely delivery of the project's outcomes:

a) Site Selection Complexity: The selection of the three traditional stone bridges entailed careful deliberation due to the rich and diverse architectural, cultural, and historical context of the region. This process posed notable challenges concerning the representativeness of the chosen sites. To address the complexities associated with site selection, a comprehensive approach was adopted, involving a multidisciplinary team of experts. The team engaged in consultations and assessments with relevant stakeholders and CH institutions to ensure that the chosen bridges sufficiently represented the architectural and cultural diversity of Epirus.

b) Archival and Field Research Challenges: The subsequent phase, involving archival and field research, was marked by difficulties related to data accessibility and data acquisition. This included issues such as access to historical records, documentation, and the physical exploration of often remote cultural sites. These challenges introduced temporal and spatial constraints to the research process. To mitigate the challenges proactive measures were implemented. Collaboration with local historical and archival institutions was intensified to facilitate data accessibility. The spatial and temporal constraints were addressed through careful planning and the utilization of advanced research methodologies, including remote sensing and digital archival techniques.

c) Technological Complexities: The utilization of state-of-the-art digitization techniques, was indispensable for

capturing and documenting the selected sites, however technical issues related to equipment calibration, data processing, and the acquisition of high-quality imaging presented challenges that required a proactive approach to resolution. As a result, regular calibration checks and quality control procedures were integrated into the research process to ensure the acquisition of high-quality data.

d) Artistic Integration Challenges: The final phase, involving the artistic development of story-telling scenarios in AR environments, introduced challenges in artistic collaboration and technological alignment. Ensuring a seamless fusion of artistic creativity with technological precision demanded interdisciplinary coordination. For this reason, regular interdisciplinary workshops and feedback sessions were conducted to foster effective communication and synergy between creativity with technological precision.

Throughout the project's implementation, the iterative nature of the methodology facilitated adaptability but also necessitated ongoing assessment of emerging challenges and opportunities, thereby contributing to the project's overarching flexibility. This iterative approach enabled the team to refine the project's methodologies and outcomes in response to evolving circumstances.

C. Literature and Field Research

The conducting of literature and field research of the project was designed to establish a comprehensive understanding of the traditional stone bridges' context as well as their architectural morphology.

The first stage was a systematic review of relevant literature and archival research. Academic databases, historical archives, and CH repositories were extensively explored to gather a solid knowledge base. The search encompassed a range of academic disciplines, including architecture, history, and cultural studies, to ensure a holistic approach to the subject matter. Additionally, collaborations with local heritage institutions, such as the Service of Modern Monuments and Technical Works of Epirus, North Ionian, and West Macedonia, and the Ephorate of Antiquities of Ioannina, were cultivated to facilitate access to primary source materials. Archival research played an important role in unveiling historical narratives associated with the traditional stone bridges under investigation.

Field research was instrumental in augmenting the understanding of the selected stone bridges. The research team embarked on physical explorations of the cultural sites, employing advanced surveying and mapping technologies (**Fig.1**). This included 3D laser scanning and photogrammetry techniques, enabling precise documentation and imaging of the bridges.



Fig. 1. Field research in the bridge of Kyra (photo of the authors).

The research benefited significantly from the interdisciplinary collaboration involving architects, historians, and archaeologists. This collective expertise fostered a multifaceted approach to the analysis of the bridges, encompassing architectural design, historical context, and cultural significance. Finally, a data management system was established to catalog and store research findings. Digital repositories were employed to house the collected data, ensuring its accessibility and preservation for future reference and analysis.

D. Digitization and 3D Reconstruction

The digitization and 3D reconstruction phase of the research was undertaken employing advanced technological tools and a systematic approach to ensure a comprehensive and accurate representation of the selected traditional stone bridges.

The primary stage involved data acquisition, where state-of-the-art digitization techniques, such as high-resolution 3D laser scanning and photogrammetry, were utilized to capture detailed information about the stone bridges (Fig.2).



Fig. 2. Digitization of the bridge of Politsa using laser scanning (photo of the authors).

This methodology was employed to obtain precise and comprehensive spatial data, facilitating the creation of detailed point clouds, and enabling the accurate documentation of the bridges' geometry and architectural features. Multiple scans were performed in each bridge, to create as complete a point cloud as possible in the subsequent processing. At the same time, in places where the 3D scanner couldn't be positioned due to the steep and rocky geomorphology of the terrain, the material was collected utilizing drone footage and the method of photogrammetry. Georeferencing was conducted to

position the acquired data within a geographic context. This process allowed for the spatial alignment of scanned datasets, ensuring that the point clouds accurately represented the physical locations of the stone bridges. Quality control measures were applied to guarantee the fidelity and accuracy of the registered datasets.

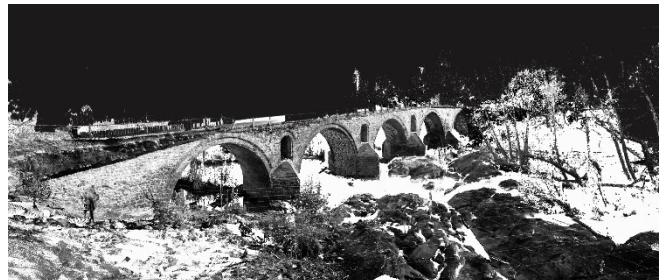


Fig. 3. Registered point cloud of the bridge of Spanos (image of the authors).

Subsequently, the results of the individual scans and photogrammetric data were registered into a single, processable, point cloud for each stone bridge (Fig.3). However, as the total amount of points reached at times even 360 million, containing a large amount of excess information, the usability and further processing of the files was constituted rather difficult. As a result, in the next stage, the point clouds were thoroughly cleaned of the extra data, to keep only the necessary material, creating a complete digitized dataset. The cleaned dataset was then imported into building information modeling (BIM) software to be used as a reference for performing measurements and test sections to the maximum level of detail. The extracted results from the processing in BIM were vectorized in a CAD application and the final architectural drawings were produced (Fig.4).

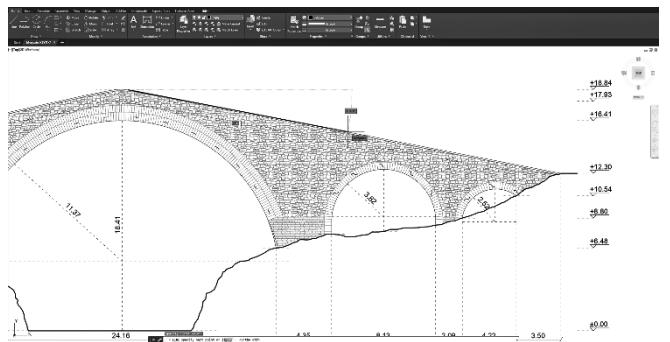


Fig. 4. Creation of architectural plans in CAD (image of the authors).

The last stage involves 3D modeling and reconstruction of the selected stone bridges. Utilizing specialized software, the acquired point clouds and the vectorized architectural drawings were processed to generate 3D models of the stone bridges (Fig.5). These models preserved the structural integrity and architectural details, providing a faithful representation of the physical structures. To enhance the visual fidelity of the 3D models, texture mapping was applied. High-resolution images captured during the field

research phase were seamlessly integrated into the 3D models. This step imbued the models with realistic surface details, such as color, texture, and material characteristics.

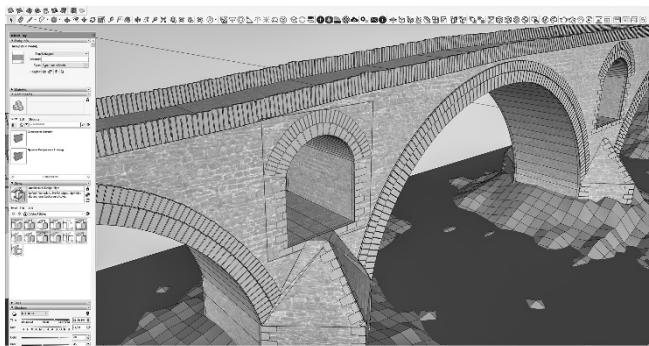


Fig. 5. 3D modeling of the bridge of Spanos (image of the authors).

Quality assurance processes were executed at each stage of the digitization and 3D reconstruction process. This entailed constant checks for data accuracy, alignment, and model completeness to ensure that the final 3D representations faithfully represented the stone bridges' physical attributes.

At the last stage of this methodological step, an interdisciplinary analysis, encompassing collaboration between engineers, architects, and CH experts was conducted. This collective expertise allowed for a holistic evaluation of the 3D models, ensuring that architectural and historical details were accurately captured and preserved.

E. Drafting of Story-telling Scenarios

Concurrently with the digitization and 3D reconstruction phase, the research team started the process of drafting story-telling scenarios for Augmented Reality (AR) environments. Utilizing the data acquired during the literature review and the archival research regarding the historical and cultural context, the team conducted a creative, interdisciplinary approach to provide engaging and immersive experiences, bridging technology and art.

The initiation of this phase involved the conceptualization and design of narrative structures for the story-telling scenarios. The drafting of the narratives was a collaborative effort between artists, and technology experts and played a major role in ensuring the successful outcome of the project. Artists, architects, graphic designers, 3D modelers, and software developers worked to create a seamless narrative experience that would constitute the experience meaningful and relevant to contemporary audiences. This involved iterative feedback and collaborative workshops to refine and optimize the storytelling scenarios.

In the next stage, the research team created the digital assets, including 3D models, textures, audio, and visual elements. These assets were created to be integrated into the AR environments, providing users with an immersive experience. High-resolution imagery, audio recordings, and historical elements were utilized to enhance the narrative.

The development of the AR platforms, which are described in the next section, involved an iterative development process to ensure that the scenarios were

optimized for various devices and platforms, promoting accessibility and engagement for a broad audience. To achieve high-quality outcomes, pilot testing of the storytelling scenarios was conducted to gather user experience and feedback. The insights garnered from these tests played a crucial role in refining the scenarios, addressing user concerns, and enhancing the overall narrative experience.

F. Development of Augmented Reality Applications

The last phase of the methodological approach concerned the development of Augmented Reality (AR) applications (Fig.6). Technological innovation and artistic creativity were seamlessly integrated into three extended reality experiences to not only offer an additional means of representation of the project's results but also provide accessible, engaging, and immersive interactions with the selected cultural heritage sites.

The inception of the XR applications began with the conceptualization of the user experience. Aiming at an action-driven presentation of information and the narrative unfolding of events, while encompassed by the interactivity of augmented reality, meaning that the realization of said experiences had to be a multidisciplinary effort. Developers, user experience (UX), and narrative designers worked together to realize the requirements, constraints, and challenges and provide a cohesive enactment of the storytelling scenarios. Storyboards were created and when the narration layouts were complete, we were ready for the development of the experiences.

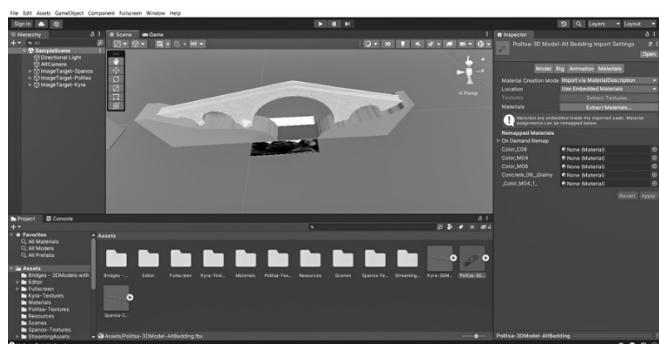


Fig. 6. Development of the AR experiences in game engine environment (image of the authors).

The 3D models, textures, and audio elements that were created in the previous phases were cataloged and organized in a library of assets constituting a pool of available resources for the creation of scenes. Prototypes of these scenes were drafted using game engine technologies (namely Unity). This way, the initial spatial planning of the experiences could be evaluated and reiterated to meet the criteria set by the creative team. These spaces and the various elements that constitute them were then geolocated and mapped using various software development kits (e.g., Vuforia SDK, MRTK for UWP). Specifically, Model Targets were created from the cataloged 3D models, and Area Targets were generated from the geo-referenced point clouds representing the bridges' locations. After this phase, the experiences started to assume form and the testing

phase could begin.

User testing and feedback sessions were conducted to evaluate the application's functionality and efficiency. The insights and suggestions gathered during these sessions were instrumental in refining the applications, addressing usability concerns, and enhancing overall engagement. Moreover, since inclusivity was a fundamental component of the project's objectives, the testing process which included a diverse set of subjects, helped pinpoint which parts of the experiences needed to change for them to warrant the desirable accessibility.

IV. RESULTS

The results of the KEYPK project provide a comprehensive overview of the experimental findings and outcomes derived from the innovative methodologies employed to reapproach and enhance the cultural experience of Epirus. The combination of the digitized cultural assets, the AR applications, and the artistic interpretation and storytelling narratives offer users personalized encounters with the Region's past, encouraging active engagement and participation. The interpretation of the project's findings underscores the significance of the KEYPK project in facilitating cultural engagement, preserving CH, fostering a dynamic relationship between past and present, and inspiring future research and interdisciplinary collaborations. The results of the project can be summarized as follows.

A. Research and Documentation

The research team carefully selected three traditional stone bridges, the Bridge of Spanos, the Bridge of Kyra, and the Bridge of Politsa, as focal points for the project. These bridges are integral to Epirus' architectural and cultural landscape. Comprehensive archival and field research was conducted, uncovering historical narratives associated with these bridges, enabling access to primary source materials, and contributing to the preservation of Epirus' CH. This part is very important for the safeguarding of the Region's CH as these structures, due to their age, use, and neglect, are in danger of ruination or collapse. Additionally, this research facilitated the exploration of the original forms of the bridges, for example, the Bridge of Kyra was destroyed in the 1850s, illuminating historical and architectural aspects that are lost or unknown. Specifically:

1) The bridge of Spanos



Fig. 7. The bridge of Spanos, current condition (photo of the authors).

The bridge of Spanos connects Epirus with Macedonia and is built on the Venetikos River, shortly after its confluence with the tributary of the Stavropotamos River (Fig.7). It is the largest surviving stone bridge in Macedonia. The choice of the specific point for its construction was because, in contrast to the relatively soft, clay soil of the surrounding hills, the bottom of the river is rocky and uneven so it is considered suitable for laying the foundations. In addition, the great width of the river, at this particular point, makes its flow less rapid [38]. The total length of the bridge is approximately 85m and its width is 3.50m. It has five arches of similar size and shape. It is built with hewn stone and reinforced with iron on the sides of the arches. It has four relief holes, while all the middle piers have wedge-shaped projections at the base, to channel the water under the arches. It should be noted that the original form of the bridge has been altered after its repair with reinforced concrete so that it can also be used by vehicles. The construction of the bridge is dated in 1846, according to an engraved inscription on the north-eastern face of the pier of the great arch. The sponsor of the bridge was Mustafa Aga from Argyrokastro, the so-called "Spanos", which means someone with little or no facial hair. Right next to the bridge, Mustafa built an inn, where the caravans going to Thessaloniki or Ioannina and the herdsmen of the plain spent the night on their way to the pastures of Pindos [39]. The income from the inn was used for the maintenance of the bridge. According to the physician and historian Ioannis Lambidis (1839-1891), the cost of building the bridge amounted to 50,000 grossi, while the hostel received 400 grossi annually [40]. Mustafa Pasha himself was buried in the same area, and his tomb was preserved until 1980 when it was destroyed by gravediggers [38]. Of interest is the testimony of the French doctor, traveler, and consul in Ioannina, François Pouqueville (1770-1838), who crossed the area in the spring of 1806 and who, at a distance of about 2-3 km from the point of the bridge of Spanos mentions the existence of five stone arches, remains of a large bridge, which had been erected in the 14th century by the Ottoman conqueror Bayezid Yildirim (1354-1403) [41]. Contrary to Pouqueville, the English Captain William Leake (1777-1860), who was in the area in 1805, mentions the existence of a bridge [42]. In 1995 the bridge was classified as a historic and preserved monument (Government Gazette 632B/1995).

2) The Bridge of Kyra



Fig. 8. The bridge of Kyra, current condition (photo of the authors).

The Bridge of Kyra was located east of Ioannina, where Arachthos River joins its tributaries Zagorios and

Metsovitikos (Fig.8). During the 19th century, the bridge was a particularly important passage, as it connected Epirus with Macedonia and Thessaly. François Pouqueville (1770–1838), mentions this road axis as the busiest road in Lower Albania, a fact which is proven by the large number of inns that were in the area [41]. Pouqueville, in his "Voyage de la Gréce", mentions the bridge of the "Kyra" (meaning "Lady"), describing a stone bridge with four arches, situated right in the gap formed between the mountains of Mitsikeli and Chuka Rosa (Red Mountain) and forming the western side of Pindos [41]. According to him, the bridge was built by Suleiman Pasha's wife. The latter ruled the Vilayet of Ioannina from 1780 to 1786 [40], [43], [44], when he was beheaded by a sultanic order. During this time, according to Pouqueville, the bridge was erected and took on the nickname "Kyra", in honor of the pasha's wife. We derive the same information from Panagiotis Aravantinos, who in his work "Chronographia of Epirus", mentions the wife of Suleiman and sister of Kalos Pasha, Ayse, as the sponsor of the bridge and the adjacent inn [45]. From the above, it can be concluded that the bridge of "Kyra" was built in the period from 1780 to 1786, the time of Ayse's first term as pasha's wife. The financing for the construction of the bridge was obtained through heavy taxation and the imposition of compulsory labor on the citizens. References to the bridge of "Kyra" continue in the works of three English travelers, who found themselves in Epirus at the beginning of the 19th century. Captain William Leake (1777-1860), who visited the area in August 1805, describes it as a bridge of three arches, disregarding the auxiliary arches [46]. The doctor Sir Henry Holland (1788-1873) refers to the bridge describing it as "well built" [47], and the diplomat William Turner (1792-1867) as "very beautiful" [48][49].

In the first half of the 19th century, the bridge began to show clear signs of deterioration, resulting in its collapse. The English bishop Christopher Wordsworth (1807-1885), who traveled through Greece in 1832-1833, mentions that he visited the bridge of "Kyra", which, however, he attributes to Ali Pasha [50]. Continuing, he points out that the bridges on the road to Thessaly are either demolished or have decks covered with grass, while the inns are deserted. As for the date of the destruction of the bridge, the Greek-Turkish newspaper "Yanya-Ioannina" mentions the year 1858 [51]. The destruction of the bridge was also mentioned by the military engineer Ifikratis Kokkidis (1833-1922), in 1880 [52]. Given the importance of the passage, it was deemed imperative to immediately restore the broken communication. In the following years, a series of attempts were made to restore the connection, which, however, did not succeed. A remnant of these unsuccessful attempts is a part of the pier with the beginning of an arch, which is located on the left bank of the river. The first recorded attempt to rebuild the bridge dates to 1864, when the English consul in Ioannina reported the start of construction work, in a location adjacent to the original one. The consul mentions the existence of the remains of three older bridges, which had been washed away by the waters of the

river [53]. The next recorded attempt dates to 1871, when a tender was held for the construction of a new bridge. The project, undertaken by the master craftsman Ziogas Frontzos, was not completed for unknown reasons [39].



Fig. 9. The bridge of Kyra painted by Louis Dupré (Public Domain, source: National Historical Museum, www.nhmuseum.gr)

Given the collapse of most of the bridge, its original form can be deducted from drawings by foreign travelers. The French painter Louis Dupré (1789-1837), drew the bridge of the "Kyra" during his trip to the area on March 28, 1819. He then used it in the background of his work entitled "Un Grec de Janina", which was included in his book "Voyage à Athènes et à Constantinople, ou Collection de Portraits, de Vues et de Costumes grecs et ottomans, peints sur les lieux, d'après nature lithographiés et colorés... accompagné d'un texte" and published six years later (Fig. 9) [54]. The English writer and landscape painter Edward Lear (1812-1888) crossed the area on May 14, 1849, during his journey from Ioannina to Thessaly. In his diary, he describes the moments of midday rest at the inn of "Kyra", where he had the opportunity to draw it [55]. The sketch shows the inn, the bridge, and other buildings, probably mills and watermills, which were usually erected near the inns (Fig.10).



Fig. 10 The bridge of Kyra depicted by Edward Lear (Public Domain, source: Archive of Stone Bridges, arhiogefirionipiroton.blogspot.com)

3) The Bridge of Politsa

The Bridge of Politsa was built to serve the villages of Ambelochori, Raftanaioi, Agnanta, Pramanta, and Ktistades and to connect them with Ioannina (Fig.11). It consists of four unequal arches. The central arch, through which the Arachthos river passes, has a span of 23.50 m and a height of 13.70 m. During the 19th century, the bridge was part of a busy route, and had an inn, catering to travelers and ranchers. The construction of the bridge was made with local stone, by masons originally from Ambelochori [56]. The date of its construction has not been determined.



Fig. 11. The bridge of Politsa, current condition (photo of the authors).

It is, however, known that in 1874 repair work took place on the bridge, which cost 17.000 grossi, and was sponsored by Ioannis Loulis [40], [57]. In its original form, the bridge had a single arch, which was founded on rocky ground. In 1932, due to a series of accidents that had occurred, it was decided to repair it again. Nikos Mantzos (1891-1967) from the village of Raftanaioi was chosen as the master craftsman, who added three additional arches to the bridge. The arches, whose aim was to absorb the Arachthos River flood, relieve the construction, and constitute it a safe passage, gave the bridge its current form. In 1984 the bridge was classified as a work of art (Government Gazette 814B/1984), given that, due to its form, materials, and construction method, it is a remarkable example of 19th-century Epirus architecture. In the 1980s, next to the stone bridge, a new reinforced concrete bridge was built, to serve vehicles.

B. Digital Documentation and 3D Representations

The digitization and 3D reconstruction of traditional stone bridges have resulted in highly detailed, accurate, and visually engaging 3D models (Fig.13,14,15). These models faithfully replicate the architectural and historical features of the bridges, providing invaluable resources for heritage preservation and research.

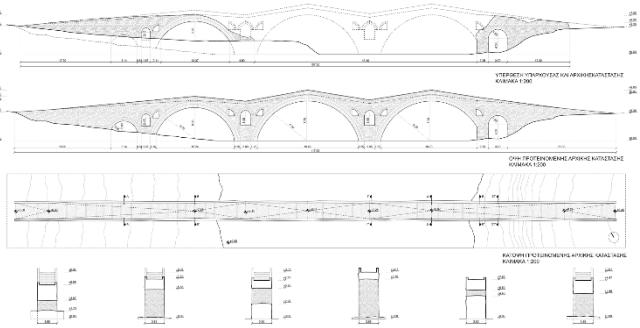


Fig. 12. Architectural plans of the current and the proposed original condition of the bridge of Kyra, produced by the digital documentation (image of the authors).

Of special importance is the digital reconstruction of the destroyed bridge of "Kyra" as it allows us to witness its original form for the first time. Utilizing the previous data from the archival and field research, the research team came up with a proposed original form of the Bridge, which satisfies the numerous research parameters, such as the travelers' reports, the pictorial references, the remaining parts of the building and the change in the flow of the Arachthos River, with the subsequent fillings. It was therefore a bridge with a total length of about 118 m with three large arches, the central and the right one almost identical with an arch span of 19.50 and 18.50 m respectively, while the left one was a little smaller at 15.50 m (which is still preserved). The river ran under the central arch. The deck followed the movement of the arched exteriors, and had an average width of 3.80m, with parapets on either side. There were also 6 relieving quatrefoils (one survives on the left bank), and 3 pointed arches, of Islamic style, in the middle ones. On the left bank, there was an auxiliary lower arch, which survives, to achieve a smooth end, while on the right bank, there is a rectangular one with semi-circular coping (Fig.12). All the arches were constructed with a double row of domes, arranged alternately light and dark.

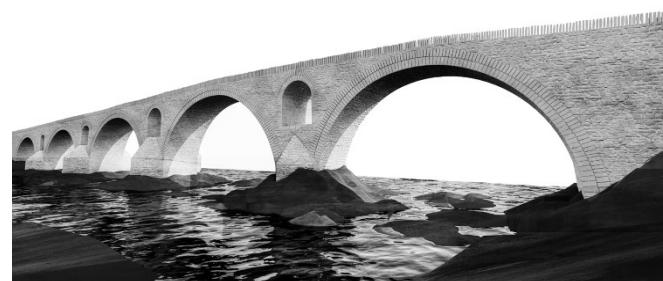


Fig. 13. 3D representation of the bridge of Spanos (image of the authors).

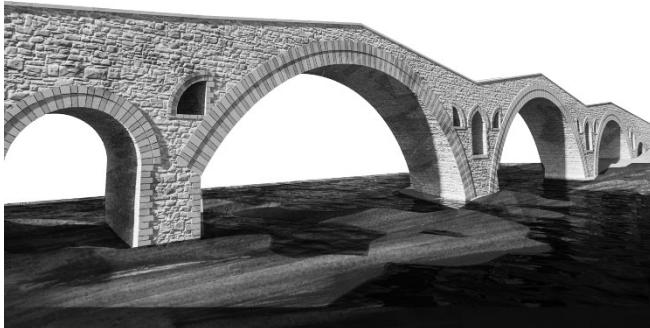


Fig. 14. 3D representation of the bridge of Kyra (image of the authors).



Fig. 15. 3D representation of the bridge of Politsa (image of the authors).

C. Augmented Reality Experiences

An important part of the project's motive has been the artistically curated yet engaging and informative presentation of its results. Augmented reality experiences can satisfy these demands by enabling the blending of aesthetic mediation in representation – as produced by the project's digitization and 3D reconstruction phase – with interactivity and play. Three AR experiences were created – one for each bridge studied – allowing users to learn about the research outcomes in a dynamic and captivating way.

For every bridge, a narration was crafted. A printed corpus of targets (i.e., images or sketches that can be used as triggers for the augmented content) was created and printed as a booklet. One target was created for each bridge and each narrative corresponds to a different target. The person, assuming the role of a 19th-century explorer of Epirus, scans the different triggers found in the corpus via a smartphone application.

1) The Bridge of Spanos

The app detects the target and provides a brief introduction to the Bridge of Spanos, displaying a 3D model of the bridge over the Venetikos River as it is today. With a simple gesture, you can choose to “travel back in time” and watch the bridge transform from its current state to its 19th-century form. As you explore the 19th-century version of the bridge, an AR character of Mustafa Aga appears, sharing his story about why he sponsored the bridge's construction. He explains the bridge's significance and how it benefited travelers and herdsmen in the region. Mustafa Aga also provides insights into the inn's history and its connection to the bridge's maintenance. When you zoom in or tap on the

different construction features of the bridge, a modal window appears containing its name and information on its usage.

2) The Bridge of Kyra



Fig. 16. Demonstration of the AR experience (photo of the authors).

Puzzles, challenges, and riddles have been incorporated into the bridge of Kyra experience forming a gamified exploration of its past (Fig.16). After its initial collapse in 1858, the bridge has undergone various efforts of reconstruction. This setting forms the narrative that aims to involve users in these endeavors while at the same time introducing them to the bridge's history. During this narration, various figures related to the Bridge of Kyra – benefactors like Suleiman Pasha and Ayse and historians like François Pouqueville and Captain William Leake – appear revealing construction characteristics and morphological features. You are then prompted to aid the craftsman Ziogas Frontzos in the reconstruction (by dragging and dropping elements or answering questions).

3) The Bridge of Politsa

Given the architectural and historic significance of the Bridge of Politsa, the AR experience focuses on promoting and showcasing its qualities. After scanning the appropriate trigger from the booklet, you are presented with a detailed model of the bridge in its original form (the one with four arches). Through a gesture, you can “fast forward” in time to its current state (after the addition of three extra arches). Both models are meticulously crafted to encapsulate the bridges' morphological intricacies while also providing structural and architectural information. Users can traverse their length or choose specific features and learn more

about their significance via modal windows (pop-ups). A soundscape consisting of sounds from the roaring Arachthos River along with the bustle of the then-busy roads is prevalent.

In conclusion, the results of the project underscore the transformative potential of integrating digital technologies and artistic creativity in the preservation and promotion of CH. These outcomes not only provide resources for scholarly research but also engage and educate the broader public, contributing to a deeper appreciation of the CH in Epirus.

V. DISCUSSIONS

The application of the selected methodological approach and the resultant findings emphasize the profound influence of integrating arts and digital technologies on the preservation, representation, and promotion of CH. The project delves into the capacity of digital media to serve as tools for interpreting and enhancing CH, providing innovative experiences more inclusively and engagingly. Through a synergistic and dynamic blend of historical research, advanced digitization techniques, innovative AR applications, and artistic interpretation, the project aimed to rekindle the historical narrative of Epirus' cultural assets and shed light on their cultural significance. It successfully bridges the gap between art and technology to safeguard collective memory, enrich cultural identity, and foster a heightened sense of belonging. The discussion below highlights key insights and implications stemming from the project's execution:

a) Digital Technologies and CH Preservation: The project's success in applying advanced digitization techniques to traditional stone bridges has demonstrated the value of technology in CH preservation. The 3D models and architectural drawings generated provide a comprehensive and accurate record of these cultural assets. This not only ensures their structural integrity but also facilitates their long-term preservation. Moreover, the georeferencing of data allows for spatial accuracy, which is essential in safeguarding these sites.

b) Interpretation and Engagement: The project has not only preserved CH but also reinvigorated its interpretation and engagement. The creation of AR story-telling scenarios has provided a dynamic means of interacting with these historical sites. These scenarios bridge the gap between art and technology, enhancing the understanding of their cultural significance. Users can explore the bridges in an immersive and inclusive way, promoting a deeper connection with CH and its historical narrative.

c) Collective Memory and Cultural Identity: By merging artistic creativity with technology, the project contributes to the safeguarding of collective memory and the enrichment of cultural identity. The innovative experiences created through AR scenarios not only educate but also instill a profound sense of belonging among users. CH is no longer a static representation but an active agent in the preservation of cultural identity.

d) Future Implications: The success of this project has

broader implications for the field of CH preservation and interpretation. It encourages the exploration of innovative approaches that combine the richness of historical research with the power of digital technology and artistic expression. Furthermore, the project's flexible and iterative methodology serves as a model for future endeavors.

e) Limitations and Future Research: It's important to acknowledge the challenges faced during this project, particularly concerning site selection, archival and field research, and technological complexities. Future research can delve into refining methodologies to address these challenges more effectively. Additionally, the project's outcomes provide a strong foundation for further studies examining the impact of digital technologies on CH engagement.

In conclusion, the KEYPK project has laid a solid foundation for future research in the field of arts, digital technologies, and CH. These future research directions have the potential to offer new possibilities for the preservation and education of CH, fostering a deeper appreciation for its significance in contemporary society.

VI. CONCLUSION

The KEYPK project is reconsidering the potential of integrating arts and digital technologies in the preservation, representation, and promotion of CH in the Region of Epirus. In combining innovative approaches in historical research, advanced digitization techniques, AR applications, and artistic interpretation, the project has not only revitalized the appreciation of CH but also enriched the understanding of its cultural significance, modifying the way CH is perceived and experienced. By bridging the gap between art and technology, the project has succeeded in creating new, engaging modes for holistically interpreting and valorizing CH. It highlights the potential of digital media as expressive and interpretative tools, dynamic agents for exploring complex relationships, notions, and contextual concepts, capable of preserving collective memory, enhancing cultural identity, and deepening a sense of belonging. By merging artistic practices with digital technologies, new and engaging modalities emerge, where CH, both tangible and intangible, becomes an active and meaningful part of our cultural landscape.

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