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SMART LIGHTING AND THE DIGITALIZATION OF ARTISTIC HERITAGE IN MUSEUM SPACES

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The study examines how smart lighting and digitalization reshape the perception of art in museums. LED technologies provide efficient illumination while protecting artworks, and intelligent systems with IoT sensors regulate light levels to prevent damage. At the same time, digital tools such as 3D scanning and AR/VR applications transform visitors from passive viewers into active participants in exploring museum collections. In the Republic of Moldova, initiatives like the "Museums of the Future" project at the National Museum of Ethnography and Natural History and the digitalization of artworks at the National Museum of Art of Moldova demonstrate the potential of these technologies to enhance visitor experience while preserving cultural heritage.

Key words: LED lighting, IoT, 3D digitization, AR/VR, conservation, cultural heritage, visitor experience, Republic of Moldova.

INTRODUCTION

Museums preserve cultural memory, yet they continuously evolve, adapting to technological developments and how visitors interact with art. LED technology and intelligent lighting systems play an important role, protecting objects while reducing energy consumption. At the same time, digitalization through 3D scanning and AR/VR applications offers visitors an interactive experience. Projects implemented in the Republic of Moldova illustrate how technology can revitalize museums while protecting heritage and making art more accessible. In essence, smart lighting and digitalization complement each other, transforming traditional museums into vibrant and interactive environments.

PURPOSE

The aim of this study is to investigate how modern lighting technologies and digitalization processes contribute to the conservation and promotion of artistic heritage in museums. The research focuses on understanding the effects of natural and artificial light on artworks, evaluating the advantages of LED technologies and intelligent lighting control systems. In parallel, the study explores the impact of digitalization on visitors' experience and public access to museum collections. In this way, the research proposes an integrated perspective on how technology can complement both the conservation and presentation of cultural heritage.

RESULTS AND DISCUSSION

Lighting plays a crucial role in the way artworks are perceived by the public. It is not only about visibility; light shapes the perception of forms, colors, and details.



For instance, a painting illuminated from the front may appear visually uniform but may lose the subtleties of its texture. In contrast, lateral lighting highlights surface relief and creates delicate shadow effects. In the case of sculptures, the direction of light becomes even more important because it accentuates volume and the dynamics of forms, making the visual experience significantly more complex. From this perspective, exhibition lighting becomes a tool of visual interpretation, almost like a dialogue between the object and the viewer.

Natural lighting provides a full spectrum of light, which contributes to accurate color rendering. For this reason, many contemporary museums incorporate large windows or skylights. However, natural light also involves certain risks: ultraviolet radiation and fluctuations in light intensity can damage artworks. Consequently, museums often use UV filters, specialized glazing, or automated shading systems. Artificial lighting, on the other hand, offers a much higher level of control. Modern systems frequently combine direct lighting – used to highlight specific objects or details – with indirect lighting that creates a balanced ambient environment.

LED technology has significantly transformed the way museums are illuminated. LEDs produce very low levels of ultraviolet and infrared radiation, thereby reducing the risk of degradation of sensitive materials. Furthermore, these systems allow the adjustment of color temperature and light intensity depending on the type of exhibited object. Textiles, for instance, require lower light levels, whereas metal or ceramic objects can be exposed to higher illumination levels. The integration of sensors and IoT technologies enables continuous monitoring: intelligent systems can automatically adjust lighting depending on visitor presence or ambient light levels. In practice, this approach protects artworks while reducing energy consumption, and the principles of smart lighting used in interior design can be successfully adapted to museum spaces to optimize both visual experience and heritage conservation [1, 2].

The digitalization of museum heritage complements these measures. 3D scanning, photogrammetry, and digital archiving allow detailed documentation of objects and the preservation of information while also providing broader public access to museum collections. Increasingly, museums use augmented or virtual reality applications to present exhibits, enabling visitors to access additional information, historical reconstructions, or interactive animations directly from their mobile devices. As a result, museum visits become far more engaging and interactive.

Alongside the development of intelligent lighting systems, museums in the Republic of Moldova have also begun adopting digital technologies for the conservation and promotion of artworks. A relevant example is the “Muzeele Viitorului” project implemented by Artcor in partnership with the Ministry of Culture of the Republic of Moldova and the Future Technologies Activity project funded by USAID and the Embassy of Sweden in Moldova. This initiative illustrates how advanced technologies can revitalize the museum experience.

Visitors of the National Museum of Ethnography and Natural History can explore the mural paintings “Hora Moldovenească” and “Nunta” through the Artive



application and the “Găsește Dinoteriul” application, which use augmented reality to create an interactive experience (fig. 1a, b, c). AR and VR projections, together with intelligent sensors, enable an engaging presentation while simultaneously protecting artworks from prolonged light exposure and other potential risks of deterioration [3].

At the National Museum of Art of Moldova, ten representative artworks have been digitized through high-resolution 3D scanning. This method allows accurate documentation of artistic details and facilitates the valorization of cultural heritage through interactive exhibitions and digital platforms accessible to the public, creating a new form of interaction with museum collections (fig. 2a, b).



Fig. 1. NMENH. a - Digitization of the “Nunta” Hall; b - application “Găsește Dinoteriul”. Photo from the personal archive of Matcan-Lisenco Inga.

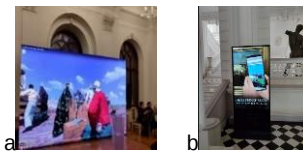


Fig. 2a, b. Digitization of artworks, NMAM. Photo from the personal archive of Matcan-Lisenco Inga.

Thus, digitalization becomes a natural complement to smart lighting. While LED and IoT technologies optimize the protection of artworks and reduce energy consumption, digitalization enables the interactive exploration of cultural heritage and preserves information for future generations [4]. In combination, these technologies contribute to the development of sustainable models for managing and presenting artistic heritage, transforming traditional museums into dynamic platforms for education and research.

The digitalization of these artworks allows the presentation of pictorial details and the historical contextualization of the works, contributing to the development of cultural education and improving public access to artistic heritage. In this regard, digitalization initiatives implemented in museums in the Republic of Moldova demonstrate that the integration of digital technologies can support both heritage conservation and the modernization of the museum experience. Three-dimensional documentation, digital archiving, and the use of augmented reality offer new perspectives for research, education, and cultural interpretation, while also ensuring the transmission of artistic values to future generations

CONCLUSIONS

Smart lighting and digitalization emerge as essential strategies in the advancement of contemporary museums. Their combined implementation supports both the protection of artworks and the creation of engaging visitor experiences. By employing LED technology and intelligent lighting control systems, museums can optimize energy consumption while minimizing the risk of damage to delicate objects. Simultaneously, digital tools expand public access to cultural heritage and



enable interactive approaches to art interpretation. Integration of these technologies complements rather than replaces traditional museum functions. Preservation remains a central role, but museums increasingly serve as platforms for research, education, and cultural engagement. Looking ahead, the development of sustainable models for lighting and digitalization has the potential to enhance heritage conservation and reinforce the societal role of museums.

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МАЦКАН-ЛІСЕНКО І. РОЗУМНЕ ОСВІТЛЕННЯ ТА ЦИФРОВАННЯ ХУДОЖНЬОЇ СПАДЩИНИ В МУЗЕЙНИХ ПРОСТОРИ

Дослідження розглядає, як розумне освітлення та цифровізація змінюють сприйняття мистецтва в музеях. LED-технології забезпечують ефективне освітлення, одночасно захищаючи твори мистецтва, а інтелектуальні системи з IoT-сенсорами регулюють рівень освітлення, щоб запобігти пошкодженню. Водночас цифрові інструменти, такі як 3D-сканування та застосунки AR/VR, перетворюють відвідувачів із пасивних глядачів на активних учасників дослідження музейних колекцій. У Республіці Молдова такі ініціативи, як проєкт «Музеї майбутнього» в Національному музеї етнографії та природної історії та цифровізація творів мистецтва в Національному художньому музеї Молдови, демонструють потенціал цих технологій для покращення музейного досвіду відвідувачів, водночас зберігаючи культурну спадщину

Ключові слова: музейне освітлення, світлодіоди, Інтернет речей, 3D-оцифрування, AR/VR, консервація, культурна спадщина, враження відвідувачів, Республіка Молдова.

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