GAS PUBLISHERS
Journal of Arts Humanities and Social Sciences
(GASJAHSS)
OPEN ACCESS
Volume- 02 | Issue- 01 | 2024 Homepage: https://gaspublishers.com/gasjahss/ ISSN: 3048-5002

Wireless Sensing Solution for Monitoring the Microenvironment of Cultural Heritage Sites in Distant Locations: Case Study of a Byzantine Hermitage in Greece

Christiana Papitsi[1], Theodore Ganetsos[1*], Meropi Katsantoni[1], Christos Drosos[1], Eleni Symeonaki[1]

[1] Department of Industrial Design and Production Engineering, University of West Attica, Thivon 250 & P. Ralli, 12244 Egaleo, Greece

Abstract: This paper describes a method for automatically inspecting the parameters that affect the microenvironment of the Holy Cross hermitage, which is established into a distant small cave in Greece's Olympus region and holds astounding wall artwork dating back to the Byzantine period. The results show that the methodology adopted was effective in sustaining a long-term monitoring procedure and, as a result, gained insight into the hermitage's surrounding conditions in terms of its microenvironment. In such a case, it would be feasible to foresee any impending threats and hence arrange the necessary conservation measures.

Keywords: Cultural Heritage, Wireless Sensors, Monitoring, Microenvironment, Temperature, Humidity, Carbon Dioxide.

INTRODUCTION

Climate change, besides posing risks to infrastructure, ecosystems, and societal structures, is also intensifying the physical decay of cultural heritage sites, posing multiple considerations regarding their preservation [1]. Considering the actual and anticipated tendencies in key meteorological parameters, it is estimated that the detrimental and damaging impacts of climate change on cultural heritage sites will escalate [2]. As pointed out in the literature [3-5], deterioration and corrosion within cultural heritage sites, which particularly affect stone and brick structures, are exacerbated by fluctuations in atmospheric air temperature and humidity. In this regard, evaluating the effectiveness of microenvironment factors within these structures and analyzing the conditions necessary for artefact preservation constitute major issues [5]. Towards this objective, this study introduces a method based on wireless sensing [6] for continuously monitoring the parameters influencing the microenvironment [7] of a Byzantine Hermitage that is established in a small cave situated on the southwestern side of Mount Olympus in the Thessaly region of Greece.

Study Location

The Byzantine Hermitage, devoted to the Holy Cross, is situated in the Pythion region on the western slopes of Mount Olympus, approximately 650 meters above sea level, and originates from the 14th century. Its architecture extends into a small cave, conforming to the natural rock and vertical walls, as well as onto a narrow platform formed by the rock in front of it. Inside the Hermitage, there is a complex consisting of three chambers: the chapel within the cave, along with the narthex and the hermit's cell on the platform. These chambers were once covered by a single wooden roof, which has since been destroyed and remains unrestored to this day. Apart from the architecture of the Hermitage itself, the interior houses astounding wall artwork depicting saints, hierarchs, and scenes from the life of Jesus Christ. These frescoes date back to 1339

AD, during the reign of Byzantine Emperor Andronicus III Palaiologos and his wife Anna [8].

Methodology and Evaluation Results

Taking into account the architecture and unique characteristics of the Hermitage, a wireless sensor system was installed within its premises. This system comprises a network of battery-powered sensing nodes placed at the most critical and approachable spots. Its purpose is to facilitate the long-term monitoring and evaluation of microclimate variables, including temperature, relative humidity (RH), and carbon dioxide (CO_2) concentration. Data collection took place within the "Holy Cross" hermitage from December 2023, to February 2024. This duration allowed for observing the rate of changes in recorded parameters within the hermitage's interior for validation purposes. Temperature, relative humidity, and CO_2 concentration were recorded by the meters at one-minute intervals each day, resulting in a total of 85,236 values for each monitored parameter of interest. The range (minimum and maximum) and the monthly mean of the monitored values per parameter are illustrated in Figure 1a for temperature and relative humidity (RH) as well as in Figure 1b for carbon dioxide (CO_2) concentration.

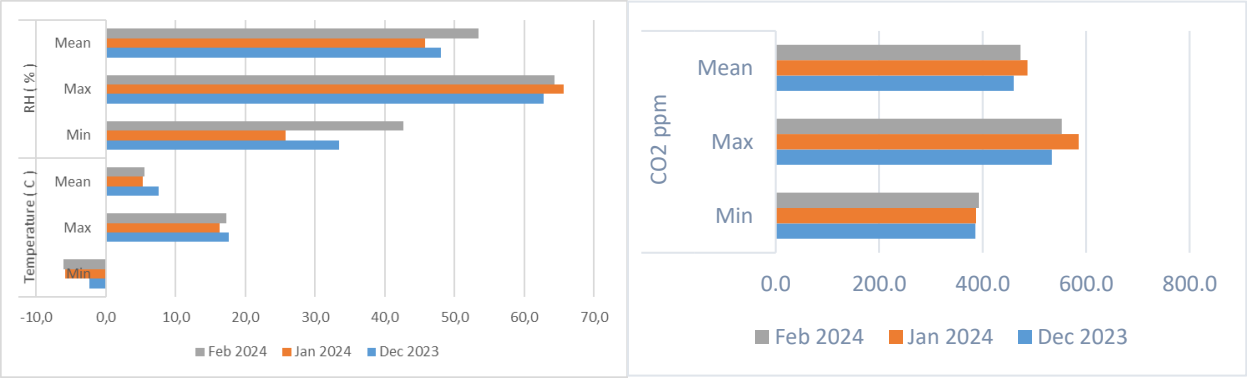

Figure 1. *Wireless data values: (a) temperature (°C) and relative humidity (RH%); (b) CO_2 concentration (ppm).*

CONCLUSION

The assessment of the system revealed that the adopted methodology proved highly effective for the long-term monitoring process and the evaluation of the microenvironmental facilitated the implementation of necessary maintenance actions. The forthcoming steps of this research focus on integrating the wireless sensor system into the Internet of Things (IoT) framework. This integration aims to facilitate the remote management of the Hermitage's microenvironment by enabling real-time monitoring and control of relevant parameters.

REFERENCES

1. Sesana, E. et al. (2021). Climate change impacts on cultural heritage: A literature review. *Wiley Interdisciplinary Reviews: Climate Change*, *12*(4), e710.
2. Cacciotti, R. et al. (2021). Climate change-induced disasters and cultural heritage: Optimizing management strategies in Central Europe. Climate Risk Management, 32, 100301.
3. Frodella, W. et al.(2021). Applying close range non-destructive techniques for the detection of conservation problems in rock-carved cultural heritage sites. Remote Sensing, 13(5), 1040.
4. Chen, X. et al. (2021). The organisms on rock cultural heritages: growth and weathering. Geoheritage, 13(3), 56.
5. Hong, J. et al. (2023). Differentiation Study of the Damage Characteristics of Rock Cultural Heritage Sites Due to the Sulfate Weathering Process. Applied Sciences, 13(23), 12831.

6. Jiang, W., et al. (2021, June). Application of Sensing Technology in the Protection of Architectural Heritage: A Review. In 2021 IEEE International Conference on Artificial Intelligence and Computer Applications (ICAICA) (pp. 654-658). IEEE.
7. Zahmatkesh, H., & Al-Turjman, F. (2020). A review on the use of wireless sensor networks in Cultural Heritage: Communication Technologies, requirements, and challenges. Trends in Cloud-based IoT, 21-35.
8. Gialouri, A.; Plastara, A.; Mitsatsikas, M. The Church of the Panaghia at Pythion in the Municipality of Elassona. Ministry of Culture and Sports. 7th Ephorate of Byzantine Antiquities, Larissa, Greece, 2014. pp. 7–8.