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A user-driven platform for biodiversity conservation and promotion

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***Abstract*— The biodiversity-oriented platform, with a focus on promoting biodiversity and ecological importance, uses cutting-edge technologies such as augmented reality (AR) and web semantics to provide immersive and educational experiences for both on-site visitors and remote users accessing the content via the website and its mobile app. By integrating multimedia content and utilizing open source technology, the platform enables users to explore diverse ecosystems, interact with endangered species and engage with the ecology of Greece, promoting active participation and content contribution. Stakeholders benefit from the collection of meaningful metrics and feedback, which facilitates effective conservation efforts and raises awareness of the paramount importance of biodiversity and environmental conservation.**

Keywords—Biodiversity; Web Semantics; Augmented Reality; Multimedia technologies; Web Applications;

I. Introduction

The development and use of a platform for the conservation and promotion of biodiversity is missing from the Greek digital world. An effort is being made to implement it through the cooperation of stakeholders for the development of conscious actions on biodiversity issues and the promotion of conscious ecotourism. In particular, the project's platform system under development aspires to become a reference point and aims to promote and protect the natural landscape of the Greek nature through sustainable development and the participation of the population of the Ionian Islands. In this context, the project includes actions for the promotion, information, and dissemination of information and knowledge, as well as raising awareness on biodiversity issues.

This study focuses initially on the development of an innovative and model digital platform that will contain information on a substantial portion of the Ionian Islands' ecosystems in selected locations of Corfu, Kefalonia, Ithaca, Lefkada, and Zakynthos. The suggested system delivers a variety of relevant information and statistics in an organized, easily available, but also clear and user-friendly style that can be used by a broader range of stakeholders who are not immediately and directly active in environmental protection. The developed system is open and fully scalable, based on cutting-edge technology, and has the significant benefit of not relying on expensive equipment, but rather on the correct use of organized information and available skill set.

Using a flexible, open-standard framework, users can create interactive Augmented Reality apps for environmental education in big cities. This provides compelling experiences for both on-site and distant users, while stakeholders obtain vital input. The system is built with modular components that allow for independent updates and scalability. It makes use of contemporary technologies to ensure practicality and accessibility. Given the prevalence of internet access and mobile devices, privacy precautions are prioritized, and addressed.

This research is organized to begin with the associated cutting-edge, current work based on the most recent literature. The system's design and architecture are then described, along with a description of the platform's goals, specifications, and basic components. Finally, the system's implementation challenges will be discussed at the final chapter.

II. State of the Art

Over the last few years, a number of infrastructures have been developed to provide data and information from various sources related to the implementation and monitoring of EU biodiversity policies. They also contain additional tools such as the Biodiversity Data Centre [1], which focuses on information relevant to the implementation of the EU Habitats [2] and Birds [3] Directives, interactive maps (web-GIS), Natura 2000 Network Viewer [4] and the Target Cross-linking tool [5] which provides information on the links between national biodiversity-related targets at national, European and global level.

To begin with, Leo et al [6] presented GeoIKP (Geospatial Information Knowledge Platform), which is a user-driven web-platform created as part of the EU-H2020 project OPERANDUM. Nature-based Solutions (NBS) are promoted by GeoIKP for catastrophe risk management and climate adaption. GeoIKP empowers varied stakeholders by smoothly integrating science, policy, and practice, providing customizable interfaces for distinct user profiles ranging from policy bodies to citizens. This interactive portal combines scientific knowledge with webGIS tools, analytical algorithms, and a large NBS data store. Its customizable interface, which

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allows for real-time visualization and layering of geo-referenced facts, is a noteworthy feature. GeoIKP encourages cooperation and knowledge-sharing by permitting contributions to the data repository and NBS catalogue, as well as accelerating community-driven NBS adoption. In summary, GeoIKP pioneers a user-centric strategy, bringing stakeholders together and sparking NBS implementation against hydro-meteorological threats.

Also, Popović et al. [7] present "Biologer," a user-driven open platform for gathering and maintaining biodiversity data. This platform allows a varied community of researchers, naturalists, and citizens to share critical observations about species and ecosystems. The authors highlight Biologer's user-friendly design, which fosters wider engagement and data input in real time. Notably, its connection with regional and global biodiversity databases improves data quality and compatibility, highlighting its value as a collaborative biodiversity research and conservation tool. The study, in essence, emphasizes Biologer's position as a user-driven platform defining the future of biodiversity data gathering and ecological understanding.

On top of that, Pimentel's [8] paper digs into the promising field of augmented reality (AR)-based wildlife interactions for conservation reasons. The research looks on the feasibility and usefulness of using AR technology to assist wildlife conservation activities. Pimentel investigates how augmented reality (AR) may provide consumers with novel and engaging experiences, thereby increasing awareness, involvement, and support for conservation activities. The paper sheds light on a cutting-edge technique that holds tremendous potential in the continuing global efforts to save and preserve species by examining the practicality and impact of AR-based interactions with wildlife. The study adds to our understanding of the junction of technology and conservation by providing a glimpse into the future possibilities of AR-driven tactics for increasing public understanding and participation in animal protection.

Furthermore, Dunn's et al [9] research looks into the impact of augmented reality (AR) mobile gaming on pro-conservation behaviors. The study looks at how immersive gaming experiences, such as the "Wildeverse" AR game, can potentially inspire beneficial conservation actions. The study digs into the possibility of AR gaming to establish a stronger connection between users and wildlife conservation initiatives by examining the influence of the game on participants' behaviors and attitudes. The findings provide insight on the transformative impact of gamification and augmented reality technologies in inspiring real-world conservation acts, emphasizing the importance of novel approaches to engaging individuals in environmental stewardship. This study provides unique insights into the convergence of technology, gaming, and conservation, providing an innovative approach to promote meaningful contributions to environmental protection.

Consequently, recent advancements in EU biodiversity policies have resulted in critical infrastructures for data exchange. The Biodiversity Data Centre and Natura 2000 Network Viewer are two notable systems. GeoIKP stands out as a user-centered web-platform that promotes Nature-based Solutions (NBS) for risk management and climate adaption. GeoIKP combines science, policy, and practice through customized interfaces, enabling real-time visualization and collaboration. Similarly, "Biologer" encourages the contribution of biodiversity data by bridging researchers, naturalists, and citizens. Pimentel investigates the possibilities of augmented reality (AR) for conservation through immersive experiences. Similarly, Dunn et al. study the impact of AR mobile games on pro-conservation behaviors, emphasizing the importance of gamification. These findings highlight the power of user-generated platforms and technology in transforming conservation paradigms.

III. System Design and Architecture

A. Objectives

The primary goal of the suggested framework is to establish a web-based platform / service dedicated to advocating and safeguarding biodiversity and ecological significance. This will be accomplished by utilizing cutting-edge and established technologies, including multimedia databases, digital repositories, web applications, and innovative presentation methods like Augmented Reality (AR).

The main specific objectives are, to provide:

- A web-based, mobile-friendly, Augmented Reality (AR) enabled application (front-end), that allows both remote and on-site users to access multimedia information about the ecosystem of a specific area using AR techniques. The mobile application will also allow users to contribute multimedia content to the platform (e.g. on-field pictures/videos) along with classification, semantic and geospatial information. Useful, user-centered metrics, can be also performed by the mobile application. The information can be accessed either on-site (by geolocation or by scanning appropriately placed marking e.g. QR codes) or remotely through a web browser. The use of contemporary presentation techniques like Virtual Reality (VR) and AR, and devices like VR and AR headsets, can offer a realistic virtual experience of the location.
- a back-end infrastructure, integrating a multimedia content database and digital repository for the maintenance of the multimedia content along with related semantic and classification information. The Back-end infrastructure also integrates user profiling and personalization mechanisms that leverage machine learning techniques, along with a Content Management System/Administration Application, which will serve as a central hub for managing the entire system. The services and functionality of the back-end infrastructure will be made available to the front-end mobile application via an Application Programming Interface (API). This API can also be used by third-party applications and platforms to take advantage of the system's content and features.

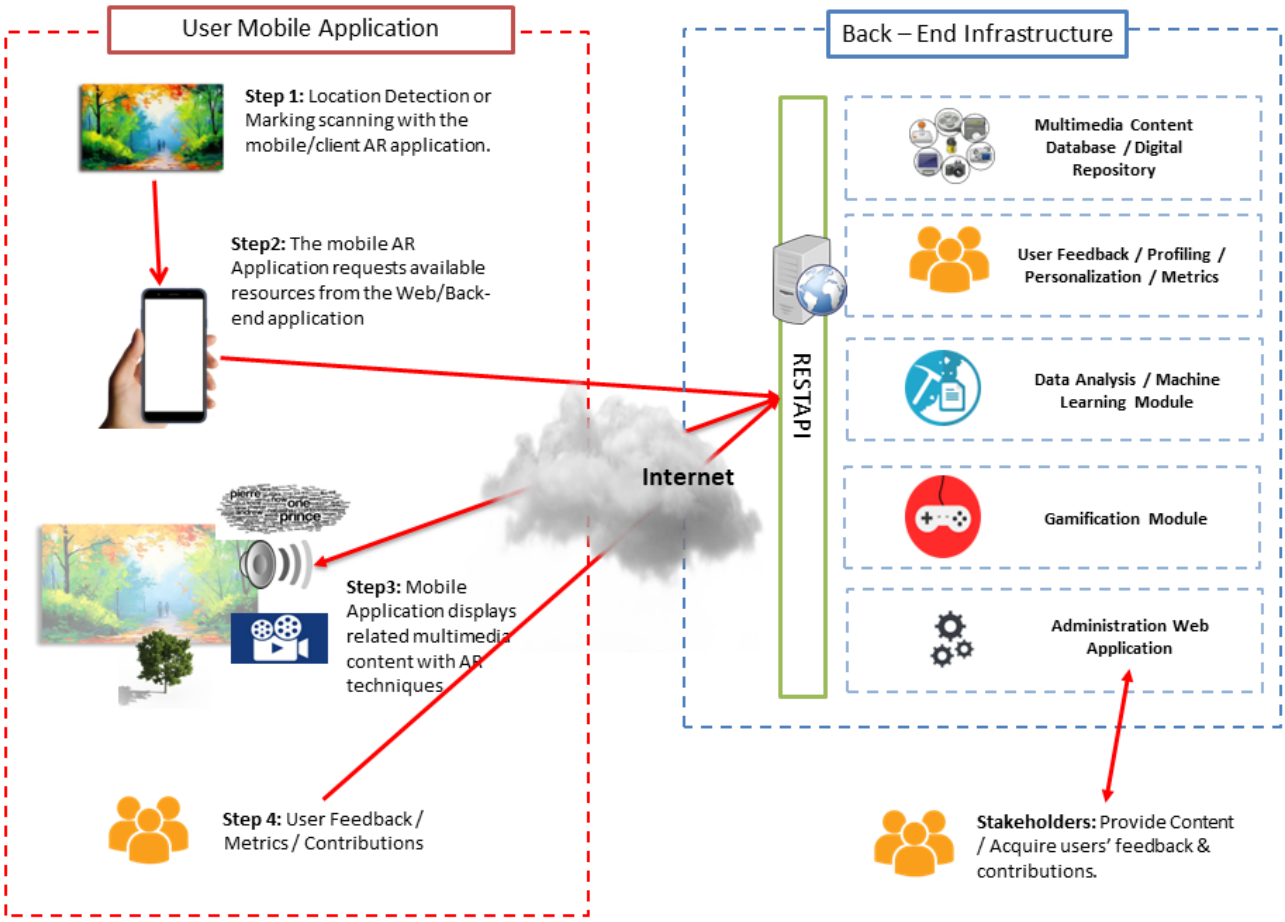

Fig. 1: System architecture and components.

B. *System Requirements*

The primary system requirements are:

- The content and functionality provided by the front-end application to on-site and remote users, should be accessible via a modern web browser, either on one of the widely used smart/mobile devices, such as smartphones and tablets, or on a typical personal computer (e.g. desktop or laptop).
- Modular design: The entire system should adhere to a modular design, where each module contributes to the total functionality and is seamlessly incorporated into the end-user interface, ensuring a transparent interaction for the end-user.
- The system should be capable of handling various contemporary multimedia content formats such as streaming videos, 360º panoramic videos and images, and animated 3D objects to enrich the user's experience.
- User profiling functionality: Maintenance of end-user data and personal profiles to enable the delivery of customized, personalized information tailored to the user's preferences.
- Notifications: The mobile application should proactively notify and inform users about nearby ecological sites and areas of high biodiversity that align with their individual preferences. This will not only increase awareness but also serve as a valuable educational tool.
- User Feedback/Contribution: The system should enable users to share feedback, contribute content, and assess the provided information, in addition to tracking useful metrics on users' behavior, especially during their on-site visits. This valuable data, when processed through data mining and machine learning techniques, can offer significant insights to stakeholders, including relevant governmental and non-governmental organizations. As such, the system acquires a robust crowdsourcing aspect that aids in the study, promotion, and preservation of biodiversity.

C. *System Architecture and Components*

The complete system architecture is depicted in Figure 1, alongside a typical usage scenario. This scenario involves an on-site user utilizing the mobile Augmented Reality (AR) application to access ecological/biodiversity multimedia content. The content is either triggered automatically by geolocation or by scanning markers installed on-site. This

content, enhanced by Augmented Reality techniques, amplifies the real-world experience. Users are encouraged to provide their feedback, such as photos of observed species accompanied by classification information. In the meantime, metrics on user behavior are collected for subsequent analysis using data mining and machine learning techniques.

Table 1 provides a concise overview of the functionality of each module. The location of each module, whether it's on the front-end/client side or back-end/server side, is also detailed.

TABLE 1: SYSTEM MODULES

Module	Description	Module Location
User Feedback, Profiling. Personalization and Metrics	This module undertakes the management of individual user profiles, drawing on both the information users provide and their behavioral patterns while interacting with the platform, such as favored locations, reviews, platform contributions, and conducted searches. It also automatically generates metrics related to user activities, such as the amount of time spent on a specific area, focus on particular specimens, and points of interest that garner significant user attention. Lastly, the module provides the functionality through which end users can contribute content to the system and provide feedback on the received information and their overall platform experience.	**Front-End (Mobile Application) and Back-End (Server).** The functionality of this module spans both the client and server side. Metrics generation and user contributions will be carried out via the mobile application, and the resulting data will be sent to the server for additional analysis. All data associated with users will be stored centrally on the server side. The server will also facilitate tasks such as profile management and user authentication, among others
Digital Repository with Multimedia Content	A Digital Repository system, structured around a relational database, houses multimedia content - this includes text, audio, video, images, 360º photos and videos, 3D models, virtual walkthroughs, etc - pertinent to areas of biodiversity interest and thematic journeys (for instance, local wildlife, endangered species). Additionally, the digital repository will incorporate the semantics for the collection of biodiversity related data. The Augmented Reality (A-R) mobile application will frequently inquire the multimedia database for corresponding information, either based on the visitor's location or the scanning of distinct markings. This information will then be displayed via the presentation module.	**Server Side (Database Server, Web Server).** The digital repository will be centrally located on the server side. Additionally, the module will incorporate an administrative web interface, enabling stakeholders to manage and refresh the content as required.
Presentation	Incorporated within the mobile application, this module will deliver the digital repository's content to users. This can be achieved either through Augmented Reality (AR) techniques, overlaying digital information onto the real-world environment, or via a Virtual Walkthrough, accessible through a web browser or Virtual Reality (VR) headset. These methods offer an immersive and media-rich virtual visiting experience.	**Client Side (AR Mobile Application).** The multimedia content is displayed on the user's device, which could be a smartphone, tablet, web browser, or VR headset. To ensure the widest possible reach, support should be provided for the most common platforms, including various operating systems, web browsers, and specialized equipment like VR headsets.
Data Analysis / Machine Learning Module	This module consists of a set of processes designed to data-mine and analyze visitor contributions, feedback, profiles, and metrics. The goal is to provide meaningful insights for stakeholders and to enrich the user experience, such as by offering the most relevant content or suggesting places of interest. The integration of machine learning techniques will further augment user profiling. It will also enable automated suggestions and the classification of users' contributions. For instance, a photo of a plant or animal submitted by a user could be automatically recognized and classified by the system. This classification would be based on information from the digital repository and the location where the photo was captured. Finally, the data analysis and machine learning	**Back-End (Application Server).** This module is located on the server side of the system, where it analyzes the collected data. It also includes a web interface designed to present the extracted information to stakeholders in a manner that is both intuitive and meaningful.

Module	Description	Module Location
	procedures, can autogenerate semantics for the user-contributed material.	
Gamification Module	This module will prioritize educational aspects through gamification techniques, aiming to advocate for the importance of biodiversity preservation and heighten awareness around ecological matters. Using content from the digital repository and combining it with metrics and sensor data (such as geolocation) from the mobile application, the module will engage users in treasure hunt-like activities. For example, it might guide them through a series of locations to discover and collect information on local species.	**Front-End (Mobile Application) and Back-End (Server).** The functionality of this module spans both the client and server side. The mobile application will handle the metrics, provide the sensor-data and handle the presentation enriched with AR techniques. The server-side part will provide all the necessary material by the digital repository, upon request by the mobile application.

IV. Discussion

The current research details the blueprint and a suggested framework for the creation and roll-out of a web-based system to elevate and spread knowledge about local ecosystems and the crucial part biodiversity plays. By leveraging a versatile, module-based, open-standard framework rather than depending on proprietary and costly solutions, stakeholders can efficiently and economically set up educational, informational, and crowdsourcing apps, enriched with Augmented Reality technologies, on sites of considerable environmental and biodiversity value. Both on-site and remote explorers will benefit from a more engaging, augmented, and tailored experience, while stakeholders will receive important feedback, user-generated content, and metrics..

The system executes its functions via a series of modules, with some being back-end modules situated on the hosting web/application servers, and the remaining ones located on the front-end, which is the mobile application. Contemporary mobile and web technologies are utilized across the system, and the implementation can be based on open-source tools and platforms.

Segmenting the overall system functionality into modules enhances the system's upgradability, scalability, and maintainability. Each module can be independently updated and upgraded without impacting the rest of the system's functionality. For instance, the mobile AR application could be updated to support new media formats, or the backend feedback/user metrics analysis could be upgraded to incorporate more advanced analysis methodologies.

The selected strategy relies on contemporary yet sufficiently mature and established solutions and technologies, so no significant technical hurdles are anticipated during implementation. The ability to access the platform through all modern smart devices and computing hardware, combined with the ubiquitous presence of web and mobile applications in everyday life, ensures a substantial base of technologically adept users and the feasibility of the concept.

Privacy, especially in applications that track location, is a key consideration and needs to be accounted for during system design, execution, and usage. Anonymous data, whenever possible, should be preserved for subsequent analysis.

Finally, the need for internet connectivity to utilize certain parts of the system's functions (for example, the presentation module by on-site visitors) may incur charges from telecommunications service providers. Nevertheless, mobile internet connectivity is already commonplace with steadily declining costs, and alternative networking options that are free (such as metropolitan public access Wi-Fi) are increasingly prevalent..

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