# A Situation-Aware Recommender System for Physical and Virtual Cultural Experiences

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***Abstract*—Following a period of inactivity, tourism, particularly in the cultural domain, has seen a significant resurgence, underscoring the importance of guiding visitors in their exploration of artistic and cultural landmarks. This renewed momentum has brought to light both longstanding challenges and emerging needs, calling for the integration of advanced digital tools to enrich the cultural visit. In this context, technologies such as the Internet of Things (IoT) and systems capable of Context and Situation Awareness enable real-time collection and analysis of environmental information, allowing for the flexible adaptation of tour itineraries based on current conditions. This work introduces a recommendation system that leverages semantic methods and probabilistic graph models to design hybrid itineraries, blending physical and virtual experiences, tailored to individual visitor profiles and contextual data [1]. The system delivers engaging multimedia content, promoting interaction and accessibility even in physically constrained heritage sites. The proposed solution was assessed through two evaluation phases: the first focused on the precision of the system's recommendations, while the second involved real-world testing through the design and deployment of cultural itineraries within the Archaeological Park of Pompeii, yielding promising and encouraging outcomes.**

***Index Terms*—Context-Awareness, Cultural Tourism, Recommender System, Situation Awareness**

## I. Introduction

Following the COVID-19 pandemic, cultural tourism has seen renewed interest, with a growing demand for personalized and meaningful experiences. This shift has revealed the limitations of traditional tourism, such as overcrowding and limited accessibility, and accelerated the adoption of digital technologies to enhance cultural engagement [2].

Technologies like the Internet of Things (IoT), combined with Context-Aware and Situation-Aware computing, enable systems to collect real-time environmental and user data [3]. This enables adaptive cultural experiences tailored to crowd levels, user location, and contextual factors. The use of the 5W+1H model and ontologies further supports the interpretation of context and the modeling of domain knowledge. To move beyond simple context perception, a predictive layer is necessary to personalize suggestions dynamically.

In this study, we present a Recommender System based on a Multilevel Graph architecture, integrating semantic, contextual, and probabilistic models [4]. The system delivers hybrid paths, combining physical and virtual visits, enhanced by multimedia content and digital storytelling, including immersive 360○. The main contributions of this study are:

- A Situation-Aware recommendation strategy for personalized and reliable suggestions;
- Integration of multimodal storytelling to support hybrid cultural routes;
- Use of virtual tours to increase engagement, flexibility, and accessibility. enriching the overall experience.

## II. The Proposed Approach

In the post-COVID era, cultural heritage experiences have undergone significant transformation. While long-standing issues remain, new forms of engagement, both physical and digital, have created the need for adaptive systems capable of responding to user preferences and environmental conditions. These systems must address challenges such as limited accessibility in historical sites and overcrowding at Points of Interest (POIs), while also enhancing the visitor experience through hybrid solutions. Among the most promising tools are 360○ photo-based tours, which offer detailed virtual access and can be combined with Digital Storytelling to increase user engagement [5]. Multimodal strategies further enable the delivery of dynamic multimedia content, allowing the narrative to adapt to the specific cultural setting.

The proposed approach integrates Situation Awareness with Recommender Systems to personalize cultural experiences through a two-phase process. An initial offline phase is used for training, followed by an online phase that enables real-time predictions cultural paths (Figure 1).

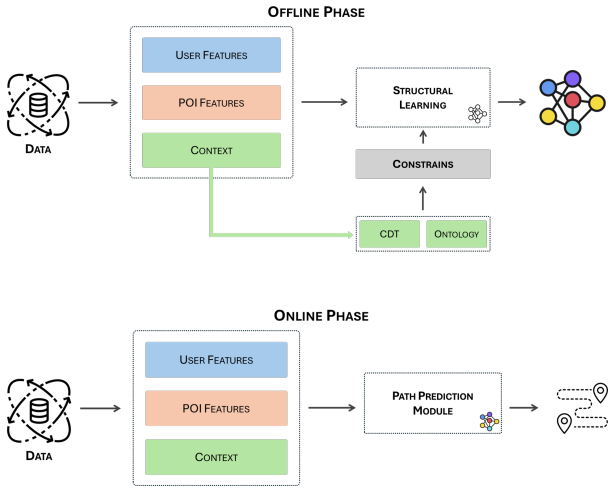


Fig. 1. Offline and online phase for elaborating personalized paths.

The system employs the Context Dimension Tree (CDT) for context management and uses ontologies to interpret data collected via IoT devices. These components support a predictive layer powered by a Bayesian Network, whose structure is learned through algorithms guided by contextual and domain constraints.

At the core of the architecture is the Multilevel Graph (MuG) Approach, which integrates semantic, contextual, and probabilistic reasoning [6]. The result is a recommendation framework capable of offering real-virtual hybrid paths, enriched by immersive media and storytelling techniques, tailored to each user's context and preferences.

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