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VASARI Project: a Recommendation System for Cultural Heritage

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***Abstract*—Promoting cultural tourism and encouraging people to visit the most beautiful works of art and monuments are fundamental activities to foster the outstanding Italian cultural heritage. Indeed, introducing the user to works of art and monuments that are less known, albeit no less important, represents one of the most stimulating challenges in the field of *Cultural Heritage Promotion*. An intelligent virtual assistant, capable of aggregating data from heterogeneous sources, can exploit semantic technologies to identify the relationships between seemingly diverse resources, and propose to the user suggestions that meet his interests while also adapting to the context, so as to guide him even in the event of unforeseen or sudden changes to the originally planned route.**

***Index Terms*—recommendation systems, artificial intelligence, virtual museums**

I. Introduction

The Italian cultural heritage is one of the richest and most varied in the world. Despite this, it still plays a limited role in the Italian economy, compared to its enormous potential, and is not properly valued and capitalized on. According to a recent report published by the Italian National Institute of Statistics [1], less than half of the museums are part of networks that share technological and financial resources, for the organization of cultural initiatives and the promotion of tourist itineraries. Often, small realities are excluded from all this, even though they constitute a distinguishing trait of Italy, and are excluded from itineraries suggested to tourists.

The research laboratory of Artificial Intelligence and Distributed Systems of the University of Palermo is sensitive to these issues and actively contributes by carrying out activities and projects that exploit Artificial Intelligence for the enhancement of cultural, artistic and historical heritage.

In particular, the University of Palermo is partner through the CINI of the VASARI project (*VAlorizzazione Smart del patrimonio ARtistico delle citta Italiane*), which aims to create new ways to experience works of art and promote them, by emphasizing smaller territorial realities. This is intended to overcome the current information segmentation, as well as to create new mechanisms to combine and integrate existing cultural services.

A cornerstone of the VASARI project is that the digital scenario of the Italian museum ecosystem is highly dispersed and non-homogeneous, due to the lack of coordination among the main cultural institutions in recent years. To make matters worse, the leading cultural institutions in Italy have often followed an individual process of digital innovation, instead of converging towards the use of strategies that include all the different realities that revolve around cultural heritage. To address these issues, the VASARI project proposes to integrate the physical spaces of museums and historical sites into the digital space of cultural content and services, which will be interconnected in a multi-site logic.

A whole range of other issues are more closely related to the tourism domain, and concern the intrinsic complexity of the operations that must be carried out by the user to plan an entire tourist-cultural route and make all the necessary choices, by using a multitude of websites, apps and related services.

The lack of interoperability that hinders these systems to meet the individual needs of each user is often caused by the problem known as *data heterogeneity*.

In this regard, many researchers have emphasized the need to structure information to make it easier for computers to understand data and to improve interoperability between different systems. For example, intelligent search engines can adopt a semantic approach, examining documents by considering the concepts they contain, instead of relying exclusively on keyword analysis.

A possible solution is to leverage semantic technologies to interconnect resources, such as works of art, museums, monuments, and related services in order to aggregate information and infer new knowledge from many heterogeneous sources. To do this, data must first be converted into a machine-processable format, which can be used directly by intelligent software agents to refine the services offered to users while helping them plan entire multi-site itineraries.

II. Recommendation System

Recommendation systems are particularly useful in the field of cultural heritage. In fact, such systems provide valuable help in finding accurate information and in planning thematic itineraries to visit, by adapting to the needs and interests of individual users or groups of users. The suggestions proposed are based on the context, the characteristics of the works of art being visited and the surrounding area, as well as the profile of the user. The latter is built by observing and analyzing the user's past choices, behaviour and preferences.

The quality of the suggestions provided by these systems, however, is closely related to the precision with which the works of art and the preferences of the users are described [2]. It is therefore necessary to provide metadata and semantic information that can formally describe the relationships between the works of art and the areas of museum exhibits. To this end, it is useful to adopt ontologies that associate different models based on the semantic relationships established between them, overcoming the inevitable heterogeneity of terminology adopted by different organizations [3].

By exploiting the expressive power of ontologies [4], it is possible to create software agents capable of processing these relationships in an automatic way, inferring new knowledge from that already known, while supporting users' preferences, thus proposing valuable and personalized suggestions.

The recommendation system will be able to guide users both during the planning phase of the visit and on site, offering suggestions that vary according to the context and adapt to the situation, so as to manage unexpected events or sudden changes in travel plans. We chose to adopt a hybrid approach when designing the recommendation system, taking into account the characteristics of works of art, museums and sites of interest (*content-based filtering*) [5], the preferences and profiles of individual users (*user-based filtering*) [6], and feedbacks from users with similar profiles (*collaborative filtering*) [7].

The system takes into account not only explicit feedback from users, but also implicit information, inferred from their behaviour. The profiling tools we use take into account previous tours and the analysis of preferences and interests of similar users, with the purpose of providing increasingly personalized suggestions.

The process of generating suggestions follow three main steps: *data retrieval*, *ranking* and *semantic enrichment*. The relevance of each resource may be assessed according to preferences expressed by the user (e.g., a specific artistic movement), selecting only those that respect certain constraints, such as the distance from the user's current position and the opening hours of the museums that host them. Potential suggestions will then be sorted according to the feedback, implicit and explicit, available, also considering the preferences expressed by users deemded similar. Then, results can be appropriately combined using *data fusion* techniques.

A *semantic enrichment* [8] phase lets the recommendation system analyze the list of suggestions to identify other works of art that do not fully meet all parameters set by users, but are semantically linked to the chosen ones. Such results can enrich the visit allowing users to discover lesser known works of art and artistic movements, which are nevertheless relevant and tailored to their preferences.

The system will also plan complete tours, including visits to different museums, planning the itinerary according to desired search criterias (e.g., historical period or artistic style), or according to spatial, time and budget constraints.

Another very interesting problem regards the precision with which it is possible to locate a user inside museums, especially when it is not possible to use a GPS receiver as the person is inside a building. Indeed, in order for the recommendation system to provide dynamic suggestions that can guide and assist the user even in the event of sudden schedule changes, it is essential to locate him precisely within the museum structure.

However, traditional bluetooth beacon-based solutions for user localization are not very precise. Thus, they are not sufficient when different works of art are placed too close to one another. The distance of a receiver (e.g., a smartphone) from the transmitter (bluetooth beacon) is calculated on the basis of the RSSI (Received Signal Strength Indicator) or other similar values, i.e., on the basis of the strength of the radio signal received. This kind of measurement, however, is very susceptible to environmental interference of various kinds, and the distances detected are often unreliable. The inaccuracy problems that affect these technologies are obviously amplified by the particular application context and the usual proximity of different works of art, given that the associated beacons may interfere with each other.

We think, therefore, that a more effective solution would be to develop a different system, in which information yielded by the localization system is merged with that coming from IoT [9] sensors, in order to determine the exact position of the user in relation to the work of art he is observing.

Moreover, the generality of the recommender system will allow to adopt the same framework to provide suggestions in a variety of application scenarios, such as smart campus [10]–[12] and other smart environments.

As future work, we plan to investigate the use of reputation management mechanisms [13], [14] in order to detect and discard feedbacks provided by untrusted users that are interested in creating a system malfunction.

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