

Smart Tourist Information Points by Combining Agents, Semantics and AI Techniques

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Abstract. The tourism sector in the province of Teruel (Aragon, Spain) is increasing rapidly. Although the number of domestic and foreign tourists is continuously growing, there are some tourist attractions spread over a wide geographical area, which are only visited by a few people at specific times of the year. Additionally, having human tourist guides everywhere and speaking different languages is unfeasible. An integrated solution based on smart and interactive Embodied Conversational Agents (ECAs) tourist guides combined with ontologies would overcome this problem.

This paper presents a smart tourist information points approach which gathers tourism information about Teruel, structured according to a novel lightweight ontology built on OWL (Ontology Web Language), known as TITERIA (Touristic Information of TERuel for Intelligent Agents). Our proposal, which combines TITERIA with the Maxine platform, is capable of responding appropriately to the users thanks to its Artificial Intelligence Modeling Language (AIML) database and the AI techniques added to Maxine. Preliminary results indicate that our prototype is able to inform users about interesting topics, as well as to propose other related information, allowing them to acquire a complete information about any issue. Furthermore, users can directly talk with an artificial actor making communication much more natural and closer.

Keywords: Virtual Human, Tourism, Embodied Conversational Agent, Ontology.

1. Introduction

The Province of Teruel is located in northeastern Spain, within the region of Aragon. It covers an area of 15.000 km^2 with a poor density of population (approximately 10 inhabitants per km^2). Teruel, surrounded by mountains, is well-located respect to the cities of Valencia, Madrid, Saragossa, and Barcelona. The County council³ is the institution that looks after the interests of the 236 municipalities that constitute the local governments of Teruel.

The economy of the province is mainly based on agricultural products, tourism, energy production, mines, and social services. In particular, it has rich cultural heritage,

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tourist resources, production of quality food, and 35% of its area is included in the Natura 2000 network [33]. The province of Teruel treasures a rich landscape, wildlife, and environmental resources that represent one of its main tourist attractions. Many of the tourist resources offered in the province are ideal for family enjoyment; therefore, Teruel has become a perfect destination for traveling with children.

Since 2001, the County council has an office that promotes the participation in European programmes that help to achieve the welcoming of the population in our territory, generate economic activity and employment, as well as make it possible to incorporate the rapid development of technology to the tourism industry to give this sector greater visibility [20]. These efforts are bearing fruit since the number of domestic and foreign tourists is continuously growing every year.

According to this line of action, the European Programmes Office of the County council decided to collaborate with the University of Zaragoza (Spain) to integrate and validate an advanced technology in a prototype, in order to promote the tourism sector. Specifically, this project aims at addressing the territorial governance of rural areas towards sustainability through an innovative integrated Planning Model. This smart tourist information point prototype is part of the MedStrategy project, a European project funded by the MED Programme [26]. In this way, we consider interesting to combine agents and ontologies to improve this kind of information systems, since tourist information, which is usually shown on websites (generally in text format), results in less interesting reading and it is rarely updated [19].

In Artificial Intelligence (AI), agents are a persistent, goal-oriented computer programs that react to its environment and run without continuous direct supervision to perform some function for an end-user or another computer program [34]. Some, but not all, agents have Graphical User Interface (GUI). Combining AI with a GUI, virtual agents are increasingly used to help people to perform tasks such as locating information or placing orders and making reservations. However, virtual agents are usually scripted to respond to a wide variety of questions and remarks. Therefore, a user can frequently become frustrated by the scripted responses. That is the reason why we propose to work with Embodied Conversational Agents (ECAs), they are human-like virtual characters that can provide direct and interactive communication with humans [9]. They are capable of real-time perception, cognition, and action, which allow them to participate in dynamic social environments.

As for ontologies, they are used to describe or to categorize objects. In particular, different communities are employing them for different purposes, and with different modalities. Regarding ontologies applied to the tourism sector, they are supposed to improve search and interoperability inside the vast amount of information available online, helping the categorization within the existing disorder [36]. In addition, there are several kinds of ontologies, according to the degree of formality, complexity of the graph structure, and the expressivity of the language used to describe them. In this paper, we are interested in the problem of classifying information in order to provide semantics to ECAs to give structure to unstructured natural language communication [12]. Specifically, we propose TITERIA, a lightweight ontology (LWO) created to help tourists to get the information about tourist attractions in Teruel. According to this, users can directly interact with ECAs, in natural language, to ask about tourist attractions and culture in the province. Hence, it allows tourists to feel like they were talking to a human tour guide.

The aim of our research work is to deploy smart tourist information points (in a real environment) with travel information knowledge using agent-based systems, semantic technologies, and Artificial Intelligence (AI) techniques. Hence, tourists can interact with the information points not only in natural language but also using a user-friendly interface.

The paper is organized as follows: Section 2 presents previous and relevant works related to our proposal. Section 3 details our novel proposal, a smart tourist information point which integrates an ECA, a LWO, and AI informed search methods. In particular, it explains the architecture of our proposal, and how the agent is able to communicate with the user. Section 4 presents the laboratory testbed used to evaluate the smart virtual tourist information point. Finally, section 5 concludes this paper.

2. Related Work

In this section, we review some of the most relevant works that addressed the use of agent-based travel systems and semantic technologies to support the needs of travelers applied to the tourism sector.

Regarding agent-based travel support systems, some works illustrate how different agents-based infrastructures are used to deliver personalized travel information services to the user. In this category, we find some works such as the one proposed by Balachandran and Enkhsaikhan [4], that suggested that multi-agent systems are indeed an interesting and valuable tool to solve a travel booking problem, and the work presented by Kera and Graham [22], that proposed the Living Avatar Network and conducted a series of design experiments and tests to discover new ways for motivating people to take a heritage walk which can engage both domestic and foreign tourists into experiencing Singapore, as well as its ethnic and cultural diversity.

As for semantic technologies to support the travelers' needs, Abraham and Dai [1] proposed an agent-based architecture with Jena for Semantic Web Resources (OWL and RDF) in the accommodation services domain of the Australian Tourism Industry. Tran and Tsuji [38] used semantic technologies and OWL for dynamic and flexible trip planning. Mouhim et al. [30] and Kuntarto and Gunawan [23] examined the importance of knowledge management and the semantic web in tourism with the validation of the Moroccan Tourism ontology and the Indonesian Tourism ontology, respectively; both ontologies were built with Protégé 2000. Bradesko et al. [8] proposed a platform for the integration, reasoning, and planning over the Personal Information Management (PIM) data from various sources.

More recently, Park et al. [32] proposed: (i) a task model of travelers perspective based on their needs and activities, (ii) a task ontology using the generic tasks, their activities, relations, and properties, and (iii) an intelligent tourist information system using the task ontology based on various tasks and activities of travelers. Mohamed and Abdul [25], Ruta et al. [35], and Joseph et al. [21], proposed different semantic web technologies which facilitate the development of more intelligent location-based services that would provide relevant information based on the user's context and social semantics. Agarwal et al. [2] presented an approach focused on dynamic packaging applications in e-tourism using semantic web technologies. Finally, Chen et al. [10] presented a multi-dimension semantics travel service search, showing that semantic technologies can offer a plethora of services applied to the tourism sector.

Other proposals show how agent-based systems, combined with semantic technologies, can also help tourists to better plan, understand, and specify their travel requirements. For example, the Virtual Agent Travel System (VTAS) [39] formulates a scalable, flexible, and intelligent MAIS (Multi-Agent Information System) architecture with agent clusters based on a case study of a large service-oriented travel agency. Benaissa et al. [7] developed an architecture based on Multi-Agent Systems (MAS) and Semantic Web Services (SWS) for assistance in collaborative decision-making in the context of Tourism Supply Chain.

We can also find proposals mixing not only agent-based systems with semantic technologies but also incorporating Artificial Intelligence (AI) techniques to improve travelers' needs. Gordon and Paprzycki [17] proposed an agent-based travel support system using the JADE agent environment, the JENA repository for semantics, and JESS for providing expert system capabilities to the system. Guo et al. [18] developed an intelligent query approach based on the Chinese Short Message Service (SMS) for restaurants recommendation using a fuzzy method to solve the problem of understanding uncertain expressions of human languages. Zhang et al. [40] showed how Semantic Web technologies can support information integration, making it easy to create semantic mashups (i.e., semantically integrated resources). In particular, they proposed a tourism system based on an intelligent ontology which allows the integration of heterogeneous online travel information. In addition, thanks to a Bayesian network-based technique, the system recommends tourist attractions to a user by taking into account the travel behavior of the users. Finally, Bagaria et al. [3] provided a comprehensive suite of tools to help travel agents identifying and capturing new-sell/cross-sell/up-sell opportunities from the continuous flow of data in the travel industry.

As shown, although several solutions that provide new services to the tourism industry have been proposed so far, none of them combines the use of agent-based travel systems with its own database of knowledge, as well as with semantic technologies (ontologies) to support traveler's needs, and, on the other hand, none of them have also built a lightweight tourism domain ontology based on user's perspectives to help them to better plan, understand, and specify their requirements against an interactive kiosk. In this work, we propose an intelligent tourist information service centered on traveler's needs. More specifically, we proposed an agent-based prototype developed under the Maxine platform which includes a novel lightweight ontology (TITERIA) which guarantees the semantic interoperability during the speech recognition process. The system, which looks like a human tour guide, has been enhanced with artificial intelligence techniques to improve the information retrieval process and user's expectations. The use of lightweight ontologies also allow automated document classification for the knowledge located in the AIML (Artificial Intelligence Modeling Language) database and with the AI techniques (i.e., informed search methods) we have incorporated to the prototype, we can achieve more interesting tourism topics, as well as proposing additional related information about any touristic issue in which the user is interested. Therefore, our proposal is definitively a very powerful tool which can be exploited towards the automation of data reasoning and knowledge management to simulate intelligence through the integration of different technologies based on agent systems, ontologies, and AI techniques.

3. Prototype Description

In this section, the architecture of our proposal is presented. Our prototype, a smart tourist information point integrates different technologies. First, we briefly introduce Maxine and describe how the Maxine's semantic knowledge is built. Additionally, we present the functionality of the proposed ECAs to serve as an interface with the rest of systems in charge of performing the tasks required by the user. Second, we present TITERIA, a novel lightweight ontology with the aim to provide new added-value services to the Teruel tourism industry. Finally, we propose the integration and validation of both, TITERIA and Maxine, through an intelligent tourist point prototype which combines them.

3.1. How to provide Maxine with semantic knowledge

Maxine [5] is a powerful multimodal animation engine for managing virtual environments and virtual actors. The system is capable of controlling virtual 3D characters for their use as new interfaces in a wide range of applications. The affective capabilities are one of the most outstanding features of Maxine. In fact, the system supports real-time multimodal interaction with the user through different channels (i.e., text, voice, mouse/keyboard, image, etc.), and it is able to analyze and process all this information in real-time, being able to recognize the users' emotional state, thus accordingly managing the virtual agents decisions. Maxine virtual characters are endowed with facial animation, lip synchronization, as well as with an emotional state, which can modify their answers, expressions, and behavior [6].

Figure 1 shows our proposed architecture. In particular, it is composed of four main modules: the perception module, the affective module, the deliberative/generative module, and the motor module. In this work, we propose Maxine to closely interact with TITERIA ontology for automating reasoning, by extending knowledge of AIML by using OWL [37]. We did not consider to use RDF nor RDF Scheme (RDF-S) since they do not provide semantics, or only in a limited fashion (in RDF-S). OWL endows our ontology with more expressiveness.

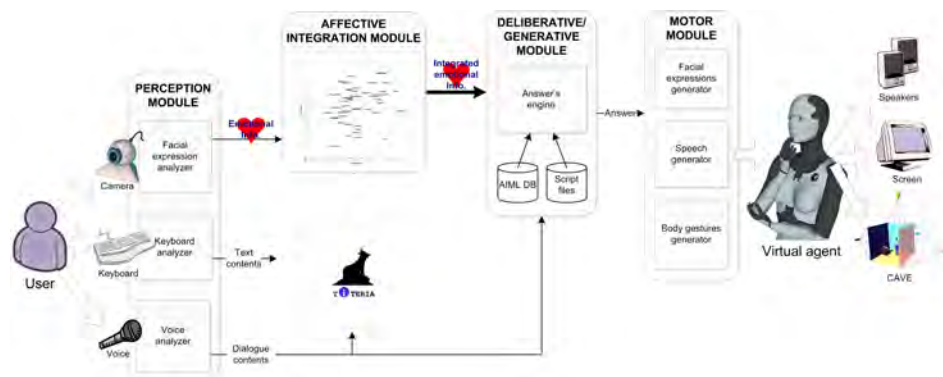


Fig. 1. Our proposed architecture

Maxine relies on storing its "brain" into AIML files, and search for the content to answer questions from users while speaking with them. Therefore, the answers search engine (Deliberative / Generative Module), processes the meaning of the input and assigns an answer to that question, searching in the AIML database, or generating it from an implemented script. These AIML files allow to store content and access it quickly, providing knowledge to the avatar. The power of AIML, and consequently of ECAs, can be depicted in two different ways:

- The AIML syntax allows easily extracting the semantic content of a question to quickly return the appropriate response.
- The use of tags to combine the answers increases the variety of them and the number of questions that can be answered.

AIML is a extension of XML (Extensible Markup Language). In particular, it is oriented to define structured knowledge, based on stimulus-response, and ready to be served, received, and processed on the Web. In particular, it was designed to be easily implemented, easy to learn, and to interoperate with XML. Listing 1.1 shows an example of an AIML file.

```

1 <topicname = GREETINGS>
2 <category> <!-- category 1-->
3 <pattern>Well</ pattern>
4 <that>HOW ARE YOU</ that>
5 <template>I 'm glad you are OK.</ template >
6 </category >
7 </topic >
8
9 <category > <!-- category 2-->
10 <pattern > _YOUR_NAME</ pattern >
11 <template >My_name is Maxine.</ template >
12 </category >

```

Listing 1.1. An example of an AIML file

As shown, *Category 1* is activated when the user says "Well," the topic of conversation is "GREETINGS" and the last phrase spoken by the avatar is "How are you". If any of these three conditions has a different value, this category will not be activated. *Category 2* will be triggered when the user asks questions like: "What is your name?" or "Tell me your name", but it will not be activated if the user only says "Your name" because "_" refers to one or more words.

Additionally, we have modified the AIML interpreter to be able to recognize the label `< script >`. Therefore, an AIML category can include command files or script calls. These commands are automatically executed when the category in which they are declared is activated, and their result will be returned as a part of the response to the user. Listing 1.2 shows an example:

```

1 < category >
2 < pattern >WHAT TIME IS IT< /pattern >
3 < template >× script >:TIME< /script >× /template >
4 < /category >

```

Listing 1.2. An example of an AIML file including a script call

According to this, when a user asks "WHAT TIME IS IT" this category is activated the commands included in the script *TIME* will be executed. Listing 1.3 presents an example of its code:

```

1 {TIME}
2 $wrk = $TIME,
3 $hour = @FIELD($wrk,1,":"),
4 $minute = @FIELD($wrk,2,":"),
5 $second = @FIELD($wrk,3,":"),
6 $oclock = $hour,
7 (am)[$hour <= 11] $ampm="am"? ,
8 (pm)[$hour >= 12] $ampm="pm" , $oclock=@INT($hour - 12)? ,
9 (12)[$oclock = 0] $oclock = 12? ,
10 $hour = @ZEROFILL($hour,2),
11 $minute = @ZEROFILL($minute,2),
12 $second = @ZEROFILL($second,2),
13 $oclock = @JUSTIFY($oclock,2),
14 nl,"It is_" $oclock,"_hours_" $minute ,
15 "_minutes_"_and_" $second,"_seconds_" $ampm,nl ,
16 remove $wrk

```

Listing 1.3. TIME script code

The answers search engine is the responsible for finding the most appropriate response to each input. More specifically, it seeks the pattern activated according to each input and executes the response associated with that pattern [34]. The root of the tree is a node that stores each of the different words starting at each AIML pattern. For each word, there is a branch tree that descends to the following nodes. For example, if the "brain" may contain 40,000 categories and about 2000 words at the first node. At the next level of child nodes each of the different following words is stored in those patterns. On the third level the words in third place are included, and so on. The number of leaf nodes is equal to the number of categories that exist in the database and each of these nodes contains the answer to that category.

To decide what pattern should be activated, the comparison follows a GraphMaster philosophy in which nodes are implemented as dictionaries. This data structure provides inserts and quick searches. This last issue is critical since the lower the response time is, the greater the sense of interactivity with the system. Once the knowledge of the avatar is written in AIML files and their syntax is correct, we need to store the contents of these files in a database that allows quick access to the patterns and responses. The AIML

interpreter examines these files to verify that the content complies with the syntax and format requirements. If the format is correct, the content is stored into three text files (i.e., index, patterns and templates) that make the function of a database. The index file contains the starting address of each set of patterns, stored in the patterns file.

Once the templates and patterns files have been created, the pattern file content is inserted into a search tree. Hence, the system has all the patterns and the location of their associated responses. This methodology allows modifying the contents of the database without having to recompile the code. Each time a change is made or new patterns are added, a simply sort through a script command will update the tree. According to this, we have implemented the AIMLPadLoq program, specially designed to create AIML files and generate the patterns accordingly, templates, and scripts files. More specifically, this program allows generating the AIML database, the script files, the grammar of pattern recognizer, as well as performing all tests including both getting answers and speech synthesis. Once the results are correctly defined, Maxine can use them. More specifically, it will build an identifier for each of the categories, to distinguish them from the others, and easily find any of them in the database. The AIML interpreter must construct these identifiers at load time and place them in a tree-like structure to be sought by the GraphMaster. A search identifier has three components, in the following order:

1. pattern: The pattern content of the category included.
2. that: The content of the *that* element that accompanies the pattern within the category.
3. topic: The *name* attribute of the parent topic element within the category.

When the category is not included in a *topic* element, or a *that* element does not exist, the AIML interpreter would implicitly add the '_' value to this component. To compose the identifier a string is required, in which markers [that] and [topic] are used as separation between the three components. For example, considering the following topics and categories (see Listing 1.4), the identifier will be represented as $C_{-}[that]B_{-}[topic]-A$.

```

1 < topicname = A>
2 < category >
3 < pattern >C _ < /pattern >
4 < that >B _ < /that >
5 < template > ... < /template >
6 < /category >
7 < /topic >

```

Listing 1.4. An example of an AIML file including *pattern*, *that*, and *topic* components

According to this, the old files can be replaced by the new ones in Maxine, without stopping the system or recompile the application. Using AIMLPadLoq the voice interface performance developed in this project can be tested to correct errors and make improvements without using Maxine. Finally, note that this system can serve as an interface with other systems in charge of performing actions requested by the user. This communication is possible because the information, ready to be processed by another system, can be easily included into the AIML code. Listing 1.5 shows an example of a script file that

connects to the WWW to know the temperature in Teruel and how it is included into a category:

```

1 {theweather}
2 url "http://espanol.weather.com/weather/local/SPXX0086",
3 $tag = "VALIGN=""TOP"">&nbsp;",
4 $at = @FIND($URLdata1,$tag) + @LEN($tag),
5 [$at <= 20] %err=1?, [$at > 20] %err=0?,
6 $ans = @SUBSTR($URLdata1,$at,200),
7 $to = @FIND($ans,"&deg;C") - 1,
8 %temp = @SUBSTR($ans,1,$to),
9 $tag = "CLASS=""obsText""> ,
10 $at_=@FIND($ans,$tag)_+@LEN($tag),
11 $ans1_=@SUBSTR($ans,$at,200),
12 $to_=@FIND($ans1,"< BR >")_--1,
13 %cond_=@SUBSTR($ans1,1,$to_),
14 [%err_=_0] %temp_"of temperature. The day is "%cond?,
15 [%err_=_1]"Connection error. Try again later"?

```

Listing 1.5. An example of a script to know the weather

A category including this script could appear as:

```

< category >
< pattern >WHAT IS THE WEATHER LIKE< /pattern >
< template >< script >:theweather< /script >< /template >
< /category >

```

In order to structure the data required to provide ECAs with intelligence, and with the ability of contrasting the keywords extracted from the natural language conversation, we propose to integrate TITERIA, a novel lightweight ontology, and the Greedy Best-First Search (GBFS), an informed search method that we have integrated into Maxine.

3.2. TITERIA: Tourist Information of TERuel for Intelligent Agents

TITERIA, our lightweight ontology, has been created to be used by an Embodied Conversational Agent (ECA) and focused on helping tourists to get the information about tourist attractions in Teruel, in contrast with previous initiatives such as: (i) the Harmonise Ontology [28], (ii) the Mondeca Tourism Ontology [29], (iii) the Destination Context Ontology (DCO) [11], or (iv) the Qall-me Ontology [31].

We have proposed a new LWO, instead of reusing any of the existing full-fledged ones, because similarly to other works [14,15,16,27], we consider that LWOs are suitable to automate important tasks when dealing with agent-based systems. Examples are semantic matching [14], encoding classifications [15], and automatic indexing [16] in multilingual environments. On the other hand, our LWO proposal (TITERIA) is aimed to create a data model to:

- Provide a shared terminology for accessing data, that human and software agents can understand and use
- Implement the semantics of the data model in a machine-accessible way
- Support Information Retrieval (IR) process
- Define the meaning of each term of the model in an unambiguous manner

Lightweight ontologies are those with a tree structure where each node is associated to a natural language label, they are primarily used for describing, classifying, and accessing (large) collections of documents or, more generally, data items and in practice, these ontologies often encode a hierarchy of classes which can be (automatically or semi-automatically) derived from web directories, thesauri and taxonomies [13]. They have a well-defined structure, and hence, they are easier to be created and shared among users. Additionally, they also provide more organized input to semantics-based applications, such as semantic search and navigation. Lightweight ontologies are enough for many kinds of applications, especially in the area of information retrieval where typed relationships between concepts are not really needed. Since lightweight ontologies can be constructed automatically from text documents, they can also play an important role in the first steps of building more detailed knowledge models.

To develop our ontology, we have built a model focused on traveler's needs, and taken into account the different Teruel tourism-related areas, their attributes and relationships. Specifically, we grouped the information into six areas: (i) Party, which contains information about the traditional or religious parties; (ii) Heritage, which collects data related to the monuments; (iii) Nature, which contains information related to flora, fauna, and mycology; (iv) Gastronomy, which collects information about the typical meals; (v) History, which collects data related to distinguished people, important periods, legends, etc.; and (vi) Cultural Center, which contains information related to museums, natural parks, or other places that can be visited. Furthermore, we consider that there are some relationships between the different areas, for instance, in a traditional party there may be a typical meal, or a cultural center can be focused on an historical event. Figure 2 shows the different components of the TITERIA ontology. More specifically, it is a directed graph whose nodes represent concepts. The links between the nodes indicates associations (or untyped relationships) between the corresponding concepts, and associations express semantic nearness.

Concerning to the Party dataset, the fields used are those indicated in Table 1. The data items of the Party dataset are: (i) the party name (used as an identifier), (ii) the date when a party takes place, (iii) the location of the party, (iv) a brief description, and (v) a complete description of the events that make up the religious and/or traditional party. Furthermore, as shown in Figure 2, we consider Party can be divided into two different subcategories: Religious and Traditional, providing another possible search criteria. Both subcategories have the same fields. We consider Party dataset has two relationships, one with Gastronomy (since in a Party there may be a typical meal), and the other one with History (because the party can exist due to a historical event).

In the set of data related to Heritage, the fields used are those indicated in Table 2.

In this table all the data items of the Heritage dataset are described, i.e., the name of the item used as an identifier, the date and location it was built, the time interval during the heritage item can be visited (Visiting Hours), a short and complete description about it most important features and its story, and legend surrounding it. Moreover, we consider

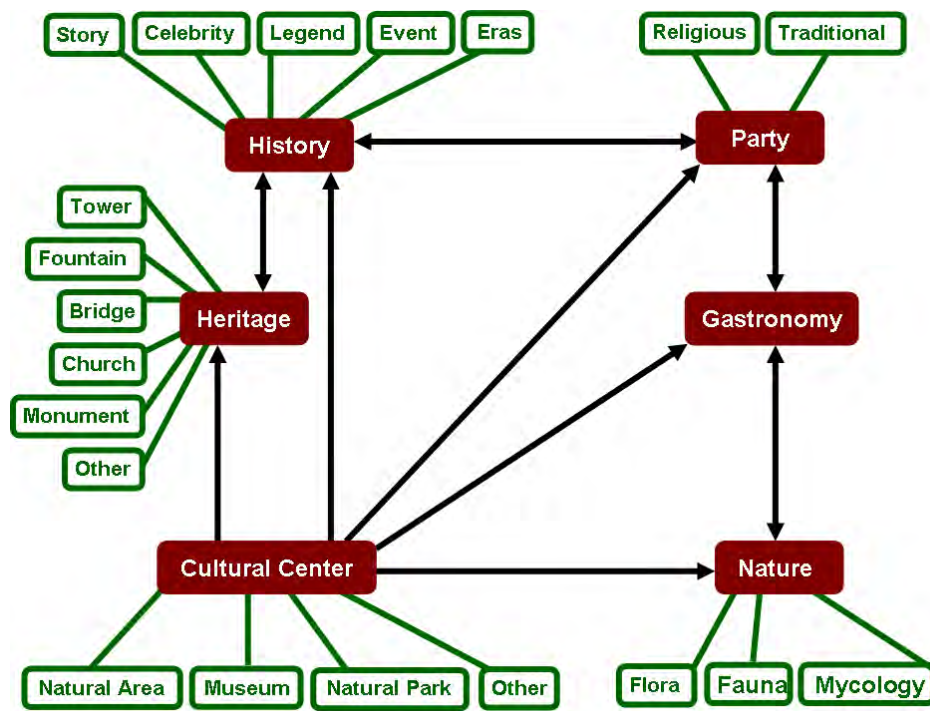


Fig. 2. TITERIA lightweight ontology structure

Table 1. Party dataset

Field	Description
Name	The party name (used as an identifier)
Date	Days when the party occurs
Place	Location of the party
Short_Description	Party summary description
Description	Party complete description

Table 2. Heritage dataset

Field	Description
Name	Item name (used as an identifier)
Date	Item construction date
Location	Location of the heritage item
Visiting_Hours	Time during the heritage item can be visited
Short_Description	Item summary description
Description	Item complete description
Story	Item related story

Heritage can be divided into six different subcategories (see Figure 2): (i) Tower, (ii) Fountain, (iii) Bridge, (iv) Church, (v) Monument, and (vi) Other. With this division, the system can make more refined searches. All mentioned subcategories have the same fields. We consider Heritage dataset has one relationship with History since a Heritage item was built because of a historical event or dated in an era.

With respect to Nature, the fields used are those indicated in Table 3. In particular, it includes: (i) the nature name (used as an identifier), (ii) the species and (iii) places you can find them and (iv) a brief, and (v) a complete description of the flora, fauna, and mycology each Nature item contains. As shown in Figure 2, we divided Nature into three different subcategories: (i) Flora, (ii) Fauna, and (iii) Mycology, in order to simplify queries. We emphasize the importance of mycology since in Teruel a great variety of mushrooms can be found. We consider Nature dataset has one relationship with Gastronomy because a Nature item may be used as an ingredient in a typical meal.

Table 3. Nature dataset

Field	Description
Name	Nature item name (used as an identifier)
Species	Nature item species
Places	Location where it is possible to find the nature item
Short_Description	Item summary description
Description	Item complete description

In the set of data related to Gastronomy, the fields used are those indicated in Table 4. This dataset only contains the typical meal name (used as an identifier) and the ingredients used to cook it. We consider that the Gastronomy dataset has two relationships, one with Nature (because a typical meal may have an ingredient considered a Nature resource), and the other one with Party (because, for instance, a typical meal maybe exists due to a Party) (see Figure 2).

Table 4. Gastronomy dataset

Field	Description
Name	Typical meal name (used as an identifier)
Ingredients	Ingredients used to cook the meal

Concerning to the History dataset, the fields used are those indicated in Table 5, i.e., information related to a historical event or celebrity name (used as an identifier), the date when it took place, and a short and complete description of the historical event or celebrity who are associated with it. Moreover, as shown in Figure 2, we consider History can be divided into five different subcategories: (i) Story, (ii) Celebrity, (iii) Legend, (iv) Event, and (v) Eras. With this division, the system can make more refined searches. All mentioned subcategories have the same fields. We consider History dataset has two relationships (see Figure 2). On the one hand, History has a relationship with Heritage, since a Heritage item may be related to a historic occurrence or with an important person. And on the other hand, it has a relationship with Party, because a party may exist due to a historical event or celebrity.

Table 5. History dataset

Field	Description
Name	The historical event or celebrity name (used as an identifier)
Date	Date when the historical event occurs or date when the celebrity lived
Short_Description	Historical event or celebrity summary description
Description	Historical event or celebrity complete description

With respect to Cultural Center, the fields used are those indicated in Table 6. As they can be located in a natural area, in a museum, in a natural park, inside a tower, it is very important to storage the name (used as an identifier), the location, the timetable during you can make the visit and a short and complete description of what you can find inside it.

Since the agent-based system supported by the Maxine platform did not incorporate semantics, we have now proposed TITERIA that fits perfectly to the existing constraints (in terms of communications, technology, and budget) of existing infrastructure. Regarding the knowledge representation language used, we selected the Ontology Web Language

Table 6. Cultural Center dataset

Field	Description
Name	Cultural center name (used as an identifier)
Location	Place where the cultural center is located
Visiting_Hours	Opening hours
Short_Description	Cultural center summary description
Description	Cultural center complete description

(OWL) to create the XML-based messages, since it is a flexible and expressive language, which provides a basic syntax to endow ontologies with more expressiveness. We discarded other possibilities such as RDF or RDF-S since they did not provide enough semantic capabilities required to the implementation of our system. By using OWL, we can add semantics to the schema. More specifically:

- To infer implicit facts, e.g., that 'Diego and Isabel' is the same concept as 'The Lovers of Teruel'.
- To state that the 'Bodas de Isabel de Segura', described in TITERIA, are the same concept as the one described in the 'Gran Enciclopedia Aragonesa'⁴, as well as the one presented in the 'Bodas de Isabel' official website⁵.
- Finally, it eases AI informed search methods (e.g., the Greedy Best-First Search (GBFS)) used by our agent-based system.

Thanks to the use of OWL, our proposal becomes more flexible, allowing the choice of which AIML items would take part in the transformations, adapting the knowledge to the domain, as well as enriching communication with users.

Our contribution involves not only the use of a Lightweight Ontology (LWO), but also we have made the integration and interoperability of Maxine and TITERIA, as well as have designed a feasible system, incorporating AI informed search methods to improve Maxine.

Listing 1.6 shows an example of a TITERIA structured information message. Note that the keywords obtained from the speech software recognition process carried out about the conversation maintained in natural language, between the ECA and the user, can be matched with the set of terms proposed from the ontology vocabulary. The objective is to take advantage of all functionalities, such as inference and reasoning tasks, already available in the system.

3.3. Intelligent Tourist Information Point

The development of the tourism sector in the Teruel province is increasing rapidly. The enormous efforts made to improve the road infrastructure in recent years have propelled that more and more people come to, or pass through, Teruel. Although the tourist information requirements are higher, making the deployment of multilingual tourist offices and

⁴ <http://www.encyclopedia-aragonesa.com/>

⁵ <http://www.bodasdeisabel.com/>

tour guides is not feasible due to the wide dispersion of tourist attractions. So, it is very difficult and expensive to provide human tourist guides in all the places of interest that tourists can visit. However, the use of intelligent tourist information points can solve this problem.

```

1 <?xml version="1.0"?>
2 <rdf:RDF xmlns="http://www.owl-ontologies.com/TITERIA.owl#" ...>
3   <owl:Class rdf:ID="Flora">
4     <rdfs:subClassOf>
5       <owl:Class rdf:ID="Nature"/>
6       <owl:ObjectProperty rdf:ID="Name">
7         <Name>
8           Pinus pinaster
9         </Name>
10        <Species>
11          Tree of the family of Pinaceae
12        </Species>
13        <Places>
14          Albarracin , Gea of Albarracin , Bezas , Rubiales , Dornaque , Tormon , and
15          Jabaloyas
16        </Places>
17        <Short_Description>
18          Pinus pinaster is a medium-size tree majority located in the
19          province of Teruel.
20        </Short_Description>
21        <Description>
22          Pinus pinaster is a medium-size tree , reaching 20-35 m tall and with a
23          trunk diameter of up to 1.2 m, exceptionally 1.8 m. The bark is
24          orange-red , thick and deeply fissured at the base of the trunk , somewhat
25          thinner in the upper crown. The leaves ('needles') are in pairs , very
26          stout (2 mm broad). The cones are conic , 10-20 cm long and 4-6 cm
27          broad at the base when closed. The seeds are 8-10 mm long , with a
28          20-25 mm wing, and are wind-dispersed .
29        </Description>
30        ...
31        ...
32        ...
33      </rdfs:subClassOf>
34    </owl:Class rdf:ID="Flora">
35 </rdf:RDF>

```

Listing 1.6. A fragment of TITERIA OWL-based information message

According to this, we propose the use of the advanced technologies provided by the Maxine engine along with lightweight ontologies in order to provide an interactive information service with an attractive and intelligent interface.

Figure 3 shows the architecture of our prototype. Firstly, our ECA is connected with a server that contains information about the Teruel province, structured according to TITERIA. This connection has been implemented through LUA scripts [24]. Secondly, to select the correct LUA script, the ECA consults its local AIML database which built-in the keywords extracted from the conversation maintained in natural language between the ECA and the user that has to be contrasted with the TITERIA ontology. Finally, when this internal and transparent testing to the user, the ECA is able to deliver all the information applied.

To select the correct script, the ECA consults its AIML (Artificial Intelligence Metadata Language) database, which contains all its local knowledge. Maxine looks for information at TITERIA server, which contains structured data, using its intelligence located

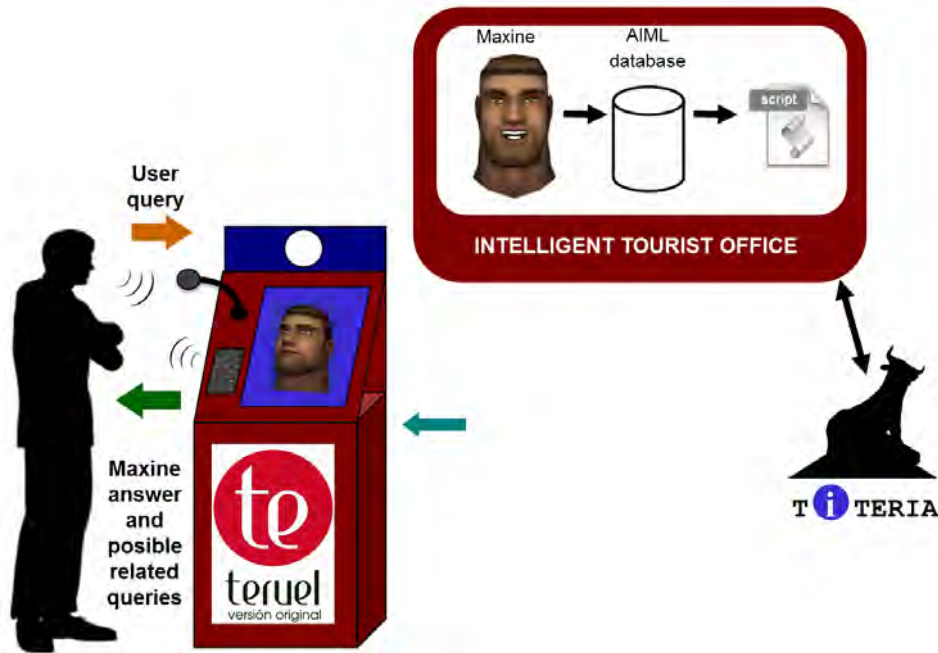


Fig. 3. Smart Tourist Information Points Architecture

at the AIML database. According to this scheme, when a user asks the ECA about something related to Teruel tourist information, the virtual agent uses its AIML database to search the correct LUA script. This script queries the TITERIA server, and then, obtains the information requested. After that, the Lua script decodes the information and returns it to the ECA, including other possible related issues. Finally, the ECA delivers all this information to the user.

Our system is able to inform users about tourism issues, as well as to suggest additional related information, allowing them to get more information. Tourists are able to directly talk with a humanoid interface, making communication much more natural and closer. Moreover, information is stored in many languages, solving the aforementioned multilingual problem.

In real environments, our proposal would work as shown in Figure 3. Maxine would be integrated, as an application software, into a typical interactive kiosk configured with (1) cabinet, (2) CPU, (3) display, (4) peripherals (speakers, keyboard, and a microphone) and (5) additional signage area consisting of a computer with Internet access. While TITERIA would be maintained on a separate server to avoid overloading the kiosk interactive software. This server and the Maxine interactive kiosk should be connected using the public Internet access interactive kiosks usually provide. A versatile, agile and adaptable solution is proposed.

Our ECA is connected to a web server that contains information about Teruel province structured according to TITERIA. This connection allows users to get real-time complete and additional information about any tourism issue of their interest. While typical inter-

active tourism kiosks select basic and limited information such as advertising, promotion, opening times, ordering, virtual applications, etc., our proposal provides further information.

As previously commented, TITERIA is maintained on the server side rather than in each kiosk to avoid overloading it. Although this specific approach can present several disadvantages (e.g., when many kiosks access to the server at the same time, or when connection problems appear), existing constraints such as budget and current infrastructure forced us to consider this architecture.

4. Laboratory Testbed

In order to test our proposal, we performed some simulations in the laboratory. In this section, we first detail the simulation environment, and finally, we present the results obtained.

4.1. Description

The first tests were conducted in an environment as close as possible to reality, that is, a PC laboratory acting as an interactive kiosk with outward speakers and microphone looking at the user (see Figure 4 (a)). In particular, we tried to simulate the real situation reflected in Figure 3; however, this configuration derives in some problems (background noise, micro-speaker overlap, distance change). Hence, the second tests were performed integrating the headphones and microphone in one peripheral device (see Figure 4 (b)).

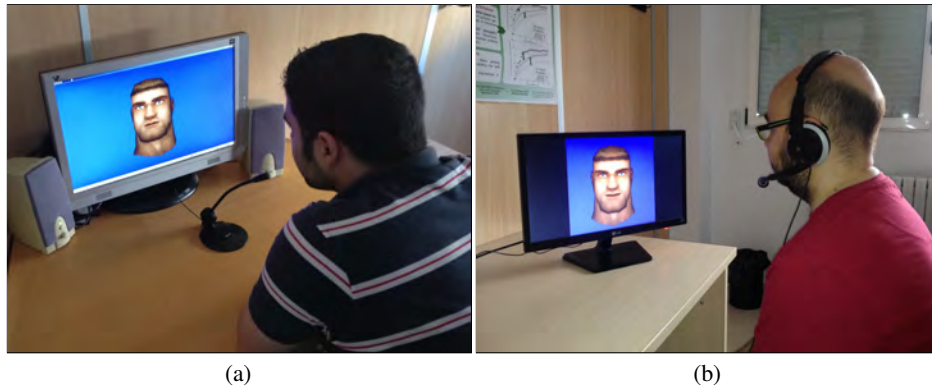


Fig. 4. Users testing the intelligent tourist information point prototype

In Table 7, the test features performed in the laboratory for each environment are presented. The first column lists the hardware components necessary to simulate an interactive kiosk, the second column corresponds to the environment used for the first tests (outward peripherals), and the last one describes the characteristics for the second tests

where the microphone and the speakers are integrated into a single peripheral. We would like to emphasize that the most important hardware device of the testbed is the microphone, since to correctly recognize speech, the following assumptions must be met: (i) it is necessary to get the message without affecting the ambient noise, (ii) only the microphone should capture what the user says and not what comes through the speakers and, (iii) regardless the microphone format (integrated or outward), it should be always at the same distance to the smart service of tourist information for laboratory tests being as reliable as possible.

Table 7. Environment Test Features

Component	Environment 1	Environment 2
Speakers/Headphones	Genius SP-G06	Plantronics GAMECOM 1
Microphone	NGS MS 102	
CPU	Intel Core 2 Duo E8400 3GHz	
RAM	Kingston DDR2 2GB	
Graphic Card	Nvidia Gforce 210	
Network Card	Intel 82566DM-2 Gigabit	
Text to Speech software	Loquendo TTS v7	
Speech Recognition software	Loquendo ASR v7.9	

Then, a user asked the laboratory prototype (interactive kiosk) some questions in natural language (see Listing 1.7).

First, the user asked about one specific topic, for example, the legend of the Lovers of Teruel. Our system answered with a short description about the topic. Then, it asked the user if he wanted to know more information about this topic. As the user answered affirmatively, it provided him the complete description and suggested him other related topics. After that, user selected one of them, specifically, related parties. The ECA provided him a short description of the party and asked him if he wanted to know more information. He answered no. Finally, it asked the user if we wanted information about other related topics, he answered no again, and the conversation finished. After describing the process, it will proceed to describe the problems encountered in testing.

4.2. Testing Problems

As we commented before, and can be observed in Figure 3, the user is speaking to the information point at a distance through a built-in microphone, the environment equivalent to our first stage. One of the problems we perceived in such configuration is not only the background noise that may appear but also, the data that microphone can capture coming out of the speakers, making the ASR recognizes words badly. That is why in the laboratory and until these issues were resolved, we decided to test our proposal with a micro and speakers integrated into a single peripheral device, at the style reflected in Figure 4, i.e., the environment equivalent to our second test stage.

Finally, as shown in Listing 1.7, our prototype is able to inform users about touristic topics, as well as to propose other related information thanks to the ontology incorporated

to Maxine, allowing users to get a complete information about any issue (e.g., the Lovers of Teruel). As shown, in line 4 you have the definition of the topic, but from line 8 onwards and thanks to the ontology, the user can easily access non-trivial information related to the Lovers of Teruel. In particular, users can directly talk with an artificial actor making the communication process much more natural and closer.

1	User:	Hello .
2	ECA:	Hello , good morning .
3	User:	Can you tell me something about Lovers of Teruel?
4	ECA:	Lovers of Teruel is a romance story that is alleged to have taken place in
5		1217 in the city of Teruel. Do you want to know more information about
6		this topic?
7	User:	Yes .
8	ECA:	In the city there were two important and wealthy families , Marcilla and
9		Segura. Juan Martinez (also known as Diego) was a Marcilla and Isabel a
10		Segura...
11		
12		...She proceeded to walk to the front of the church and place a kiss on
13		the man whom she had refused but in doing so Isabel died , falling
14		prostrate on the body of the man whom she loved .
15		Do you want to know related information about this topic?
16	User:	Yes .
17	ECA:	Related to this topic , you can ask me about heritage or parties .
18	User:	I want information about parties .
19	ECA:	Weddings of Isabel of Segura revives the story of the Lovers of Teruel .
20		This party takes place in the month of February in the city of Teruel .
21		Do you want to know more information about this topic?
22	User:	No .
23	ECA:	Do you want to know related information about this topic?
24	User:	No .
25	ECA:	Do you want any more information?
26	User:	No, thanks . Bye .
27	ECA:	Bye .

Listing 1.7. Example of conversation between a user and the ECA

We tested our system in two different languages, English and Spanish, obtaining good results in all cases.

5. Conclusions

The role and impact of technology in tourism and hospitality are complementary; symbolic and cultural meanings guide the process of constructing technologies and in reverse they delineate new cultural images and practices. New insights speak about socio-technical design, a view in which the new user of the ICT is the community, for example medical tourism will be a booming business. Tourism is one of the most effective money-moving mechanisms, redistributing wealth, and promoting local economies. It brings income into a community that would otherwise not be earned. Hence, tourism markets should develop new models to sell their destinations by improving tourists virtual experience, attracting potential clients by using technological innovations such as augmented reality, biometrics, brain-computer interfaces, artificially intelligent agents, and other technological breakthroughs will help tourists to complete more transactions in less time and gather more relevant information about their destinations in real-time.

Then, in this paper we present a smart tourist information point prototype which combines the use of the Maxine engine (a platform that allows the management of scenes and virtual characters, paying special attention to multimodal and emotional interaction with the user), and TITERIA (a lightweight ontology which aims at providing ECA's with tourist information).

Our contribution involves not only the use of this LWO but also being able to make the integration and interoperability of Maxine with TITERIA and the user, as well as to design a feasible system while considering the real and specific limitations of the environment. We additionally applied AI informed search methods the answer according to the tourists' needs.

Our proposal is helpful and interesting for domestic and foreign tourists, since they can get information of tourist attractions based on travelers' needs, in a more agile way, unlike either existing proposals that are usually built on system's perspective domain ontologies, or traditional approaches that usually present data in plain text, or by means of a website. Our approach fulfills the Teruel tourist office needs, thereby reducing the cost of the required infrastructure, and making it possible to deploy tourist guides in everywhere, especially in remote and rural points of interest. Specifically, our proposal is innovative since it provides an intelligent virtual multilingual tourist guide service thanks to TITERIA, and it is capable of interacting with the user in a multimodal way (text, voice, mouse/keyboard, image, etc.) through Maxine, making the communication much more natural and suited to any user, regardless of his/her gender, condition, and age, due to the variety of interfaces.

To verify that our proposal works correctly, we performed a testbed in our laboratory consisting of recovering as much information as possible of a tourist attraction in which a user or a traveler is interested. We corroborate some of the problems that exist in those systems such as the microphone and speakers orientation and the physical distance between the user and the interactive kiosk microphone. However, some interesting and cheap solutions can be taken to overcome them, e.g., integrating both peripherals (i.e., microphone and speakers) in a single device, or interacting with our prototype by using keywords or short phrases, as usually done with search engines like Google. Experimental results indicate that TITERIA is able to correctly inform tourists about interesting tourism topics and to propose other related information about any touristic issue.

In the future, our objective will be to make tests of this smart service with real users in real environments to assess their satisfaction degree, to detect real problems of real scenarios, and to identify possible further improvements. In addition, we plan to adapt our system to other platforms, since the architecture of our proposal allows easy portability across different devices (e.g., tablets, smartphones, etc.) thanks to its multimodal interaction and graphical user interface versatility.

Acknowledgments. This work was partially supported by the *Diputación Provincial de Teruel*, Spain, under Grant *Convenio de colaboración DPT-UZ Proyecto MedStrategy*, as well as the *Ministerio de Economía y Competitividad, Programa Estatal de Investigación, Desarrollo e Innovación Orientada a los Retos de la Sociedad, Proyectos I+D+I 2014*, Spain, under Grant TEC2014-52690-R.

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Received: April 4, 2015; Accepted: July 25, 2016.