DALICA: Intelligent Agents for User Profile Deduction

Stefania Costantini, Leonardo Mostarda, Arianna Tocchio and Panagiota Tsintza
Department of Computer Science,
University of L'Aquila, Italy
Email: stefcost,mostarda,tocchio,panagiota.tsintza@di.univaq.it

Abstract— **In this paper we are going to discuss the potential contributions that agent technology can bring into an Ambient Intelligence scenario, related to the fruition of cultural assets. The users are located in an area which is known to the agents: in the application, the users are the visitors of Villa Adriana, an archaeological site in Tivoli, near Rome (Italy). Agents are aware of user moves by means of Galileo satellite signal, i.e., the proposed application is based on a blend of different technologies. The agents, developed in the DALI logic programming language, pro-actively learn and/or enhance users profiles and are thus capable to competently assist the users during their visit, to elicit habits and preferences and to propose cultural assets to the users according to the learned profile.**

I. INTRODUCTION

The paradigm of Ambient Intelligence implies the objective of building a friendly environment where all of us will be surrounded by "intelligent" electronic devices, and this ambient should be sensitive and responsive to our needs. A multitude of sensors and actuators are already embedded in very-small or very large information and communication technologies, and a challenging task nowadays is to identify which advantages can be gained from these technology systems. Tourism for instance is a context where old and new aspects can be melted for reaching interesting results. In fact, tourism is a growing industry and it needs to evolve according to the tourists changing features. In the past, tourists were satisfied with standardized package tours. Today, with the popularization of traveling, tourists are expecting new tour experiences that are different and authentic [10]. Several interesting works have proposed a new manner of enjoying cultural places, as technology may support more dynamic and personalized methods to conceive the fruition of cultural assets. Park et al. in [8] propose a system named "Immersive tour post". It uses audio and video technology to provide improved tour experiences at cultural tour sites. This system reproduces the vision and sounds of the historical event that occurred at the particular space. Mobile applications in a mobile-environment have been experimented by Pilato et al. in [9]. Visitors are assisted in their route within the "Parco Archeologico della Valle dei Templi" (archaeological area with ancient Greek temples) in Agrigento (Sicily, Italy) by an user-friendly virtual-guide system called MAGA, adaptable to the users needs of mobility. MAGA exploits speech recognition technologies and location detection, thus allowing a natural interaction with the user. Several other proposals can be found in the literature, exploring the integration between human-computer interaction and information presentation. The system Minerva, proposed by Amigoni et al. in [1] organizes virtual museums, starting from the collections of objects and the environments in which they must be displayed, while the DramaTour methodology presented by Damiano et al. in [6] explores a visit scenario in an historical location of Turin. Visitors are assisted by a virtual spider that monitors their behavior and reactively proposes the history of the palace in detail with a lot of funny anecdotes about the people. The systems presented above have a common characteristic: they try to improve the traditional methods to inform the visitor by means of new catchy techniques for making the human-machine interface more friendly and intuitive. But, is it possible to go beyond, towards capturing the visitors desires and expectations? A particular mechanism for capturing the visitor interest for one or more cultural assets has been presented by Bhusate at al. in [2]. Each visitor receives a PDA associated to non-invasive sensors that measure "affective" context data such as the user's skin conductance and temperature. Preferences can be also catched by asking questions directly to the user before starting the visit. This method has been adopted in the system KORE [3] where parameters such as age, cultural level, preferences in arts, preferred historical period, etc., are taken into account for "tuning" the pieces of information provided, by throwing away those useless for the user (either too difficult or too easy to understand) and delivering only data which match the user profile. The architecture of KORE is based on a distributed system composed of some servers, installed in the various areas of museums, which host specialized agents. The KORE system practically demonstrates that intelligent agents can have a relevant role in capturing the user profile by observing the visitor behavior. In this paper, we present the architecture of the MAS DALICA applied to the Villa Adriana scenario for capturing the visitors interests and enhancing their profiles. Similarly to what happens in the KORE system, each DALICA intelligent agent starts its activity with the cashing of data such as the visitors' age, preferences, cultural level and so on. Then, it captures additional data about the visitor's movements and choices, elaborates them and updates the user profile. The visitor's movements are traced by means of the Galileo satellite. The learned profile allows DALICA to offer information on the cultural assets adapted to the visitor, and to proactively propose to see those assets closer on the one hand to the visitor's physical position and on the other hand to the visitor's preferences. The related items of information are provided in an appropriate customized form. As acknowledged in Section V, the DALICA system has been developed within the CUSPIS European project. In Section II we present the scenario where DALICA has been put at work and the features of the system. Section III is dedicated to the methods through which the intelligent agents are capable to capture the visitors' interest and the monitoring capabilities of the agents. Finally, we conclude in Section IV.

II. The DALICA ontology

DALICA system plays a relevant role because spies the users during their visit, captures their habits and elaborates a profile for a customized assets fruition. Villa Adriana turns out to be the greatest villa never belonged to a roman emperor, testimony of the extraordinary level of ability caught up from the roman architecture. With a perimeter of 3 Km, it combines the best elements of the architectural heritage of Egypt, Greece and Rome in the form of an 'ideal city' [11]. For a visitor, Villa Adriana is a unique wonderful place. For DALICA, Villa Adriana is a set of Points of Interest (POI's). For "POI" we intend either a specific cultural asset or a public places like restaurants located nearby. The structure of a single POI contains the following fields:

- *Identifier*: a string identifying uniquely the POI;
- *Latitude*: the latitude of the POI defined through the Galileo satellite.
- *Longitude*: the longitude of the POI defined in the same way as the Latitude.
- *Radius*: the radius of the circle that contains the POI area.
- *Keywords*: a list of the POI characteristics like, for example, 'mosaic' if the POI contains a mosaic, or 'water' if in the POI there is a fountain or a water basin. Considering that each POI can have one or more keywords, we combined each one with a number indicating its weight in the POI description. The weights are chosen according to the relative importance (expressed as a percent value) of the POI characteristics. Clearly, this information has been provided by experts.
- *Time for visit*: is an average of the time that we suppose an user will employ for visiting the specific POI.

Keywords are important because they allow to establish the possible similarities between POIs and, consequently, to discover if the visitor is interested in a particular feature which is common to them. The POIs descriptions have been collected into an appropriate ontology (developed by the group of Artificial Intelligence and Natural Language Processing at the Dept. for Computer Science, Systems and Management of the University of Rome Tor Vergata, in the context of the CUSPIS project).

III. Constructing the User Profile

The main goal of the DALICA system is that of supporting users during their visits. For this reason, when an user starts the visit, a DALICA agent is created for spying and assisting him. Agents are destined to create and upgrade the user profile according to which is proposed the information about Villa Adriana but through which steps are they able to reach the goal? The profile are created starting from an embryonal status defined by the user before starting the visit. In fact, each visitor, at the beginning of the visit, has to book the route on an Internet site where she/he can express some preferences and choices about the service fruition. The initial profile contains some data related to the visitor's name, surname, age, job and some related to the visit that she/he intends to perform (day of the visit, starting and ending time, preferences,...). Preferences express the POI characteristics that the DALICA system should take in consideration for proposing the POIs to the users. For example, if the user declares to be interested in 'mosaic' and 'plants', the system should select for him those POIs in Villa Adriana having the above keywords with a high weight value. When the visitor starts her/his route, an intelligent agent, called User Profile One, is generated. At the staring phase, it elaborates the data coming from the user-profile stored on Internet and determines an initial fruition profile. Then, it re-elaborates the fruition profile according to new data derived from the user behavior. New enhanced fruition profile will possibly substitute the former one while the visitor proceeds in the route. At this point, it is necessary to explain through which strategies is possible to capture the visitors interests in a scenario such as Villa Adriana, where the cultural assets are arranged in an area of 300 hectares.

A. Deducing the Visitor's Interests

Intelligent agents in DALICA are reactive, pro-active and communicative. Their are capable to percept the data coming from the environment such as the satellite coordinates or the POIs chosen by the visitor and to react appropriately. While reactivity allows the agents to adopt a specific behavior in response to the external perception, pro-activity has a main role, because the reasoning process that leads to the interests deduction is based on the correlation of several data coming from the environment, from the ontology and from some basic inferential processes. Communication capabilities intervene whenever it is necessary to send data to the visitor's PDA: e.g., the explanations of what is being seen or the list of the deduced interests or the proposed other POIs to see or the warning that the visitor is entering in a restricted area. In the rest of this section we concentrate the attention on the methods used for deducing the user interests, while in next section we present the strategies for assisting her/him during the visit and for checking her/his behavior. We divide the agent deduction process into three phases: the first one represents a basic deduction level while the second and third ones elaborate the results by concatenating the previous deductions. We starts the explanation by illustrating the algorithms concerning the first phase:

Deducing the interests based on time: This algorithm is founded on the consideration that a visitor is interested in a POI if she/he observes it for a time interval "longer" than the average time of the visit for the specific cultural asset.

The meaning of "longer" can be modulated according to the current visitor's profile. So, if a visitor has booked a visit that lasts up to six hours the time interval for the observation will be longer than that of a visitor that booked a visit lasting for two hours.

How is it possible to determine which POI the visitor is looking at? The method is based on the Galileo Satellite. Each POI, as explained in the previous section, is identified by a circle (whose center is defined by a latitude and a longitude) and by a radius. If the visitor position (expressed in latitude and longitude and coming from the PDA) belongs to the circle related to a specific POI, we can suppose that she/he is visiting that POI. If two or more POIs are close enough to determine an intersection between their circles and the visitor is located in the intersection, then the algorithm, not being able to capture the real intention of the visitor, presumes that the visitor is interested in all those POIs. Each POI which is selected according to the visitor movements is identified by a list of keywords. The algorithm elaborates the keywords of all selected POIs and then extrapolates the most frequent ones. These keywords represent the hypothetical user interests that, once deduced, will have to be confirmed both by subsequent user behavior and by other deduction mechanisms.

Deducing the interests based on the visited POIs: This algorithm considers the POIs chosen by the user and its outcome improves when several POIs have already been visited. In fact, for each POI the algorithm extracts the keywords and the most frequent ones are asserted as "deduced interest".

Deducing the interests based on the chosen route: If a visitor decides to follow a predefined route chosen between those proposed by the system, the agent tries to capture the visitor's interests by studying the POIs included in the route. POIs keywords most relevant for describing the route will be selected for the next step of the deduction process.

Deducing the interests by similarity: This algorithm employs a similarity measure. In particular, the interests expressed by the visitor in the web site are matched with those in the ontology. Those in the ontology which look to be similar enough are selected as deduced interests.

Deducing the interests according to some questions: Another strategy for capturing the visitor's interests is centered on some occasional questions about the POIs located near the visitor. The agent observes the POIs around the PDA, chooses one of them and asks the visitor's opinion on it. A positive response such as ("Yes, I like the Odeon") will trigger the interests deduction process.

Deducing the interests according to cultural questions: The last strategy for deducing the visitor's interests takes into consideration the cultural level of the visitor. Some questions such as "Do you like the ancient art? Do you know what is a cavea?" are useful to determine the information level to submit to the visitor. Moreover, some parameters such as the visitor's job and age are involved in the process. The agent compares the data acquired via the questions and via the other parameters and elaborates them in order to determine the appropriate degree of the information. We have identified for now three degrees.

Basic: It is related to a basic information level where the user prefers a superficial information on the POIs combined with details on the ancient people's life. This level usually fits primary and secondary students and occasional visitors.

Medium: Provides more technical data on POIs and particular attention is reserved to their structure. This level fits people fond of art.

Specialized: Provides the visitor with a detailed information on POIs combined with information about the materials and techniques used to manage the cultural assets. This level is tailored to specialized students, technical people, researchers and so on.

The second deduction phase captures the results of the previous deduction algorithms and tries to compare them, with the aim of reaching a more precise user profile definition. In particular, those interests coming from the previous phase and confirmed by this second one are involved in a process that selects only the most frequent ones. In fact, each deduced interest is involved in a *interests updating process*. More precisely, each interest/keyword is associated to a weight (priority) N. For a specific deduced interest K, we have define a global evaluation function computed on the weights. In this manner, the system takes in account not only the interests more frequently deduced but also their 'relevance' in the deduction process. Then, these interests are sent to the visitor's PDA in order to be confirmed by her/him. Precisely, this second phase is based on the following algorithms:

Filtering the deduced interests according to the time: This filter combines the deduction of the interests based on the permanence near a certain POI and the moment when the deduction itself has been reached. In particular, this step has the objective of understanding whether a visitor remained in a specific area because interested in a POI or for some other reasons (e.g., she/he was sitting on a lawn eating a sandwich).

Combining the deduced interests: The interests deduced by the previous algorithms based on time, on visited POIs, on the chosen route and according to some questions are crossed in order to obtain a more reliable user profile definition. The interests which are confirmed will be involved in the *interests updating process*.

Using similarity for confirming the deduced interests: Reliability of the interests deduced in the previous phase is checked according to the similarity degree with those inserted in the visitor's profile in the web site. If the similarity is greater than a prefixed threshold, the interest will be involved in the *interests updating process*.

The third phase delivers data related to the elicited interests to the visitor's PDA. When the visitor receives the interests list, she/he can confirm either all interests or a subset of them. The selected interests are managed by the agent for updating the user profile. Moreover, the agent communicates them to a central system that manages the information for the visitor in order to propose (through the agent) data and POIs closer to her/his desires and expectations.

B. Monitoring Visitor's Behavior

Intelligent agents in DALICA are also used for monitoring the users behavior with a fixed frequency. The situations where the reactive and proactive capabilities of the agents are put at work for this kid of monitoring are at least the following.

Checkinging the forbidden areas: In Villa Adriana there are areas where visitors cannot enter. These areas are defined in the ontology and an agent monitors from time to time the visitors' movements in order to guarantee that no one violates the rules.

Monitoring the visitors route: The agent has the ability to follow the visitor that has chosen a predefined route along her/his visit. For instance, the agent is able to make the itinerary shorter or longer (by either removing or adding POIs) according to the user pace, so that the user can complete the itinerary in time.

Creating a list of POIs: When the visitor has finished the visit, the agent collects all POIs that she/he has visited and puts them in a file with texts and images. This allows the visitor to keep a reminder of his visit to Villa Adriana.

C. The DALICA Architecture

The DALICA architecture involves a MAS and a central external system. This system on the one hand acts as a "router" between the MAS and the PDA's: in fact, the MAS is presently too heavy to be directly installed on the PDA's. Thus, the MAS resides on a more powerful machine and uses the central system to exchange data with the PDA's. It receives messages from/to the agents and delivers them from/to to the PDAs of the visitors. On the other hand, the central system collects and stores data about visitors and visits for future use. In the DALICA MAS, several intelligent agents cooperate in order to support the users during their visit. The three most important agents composing the MAS are the following.

Generator Agent: The role of this agent is to automatically generate the User Profile agents when a user starts a visit. The generation process happens when PDA sends a positioning message related to a new visitor.

User Profile Agent: Acts as described before in this section. They deduce the visitors interests and monitor their behaviors.

Output Agent: Manages communications between the DALICA MAS and an external central system.

DALICA agents have been implemented in the DALI language,[4] [5] [12], an Active Logic Programming language for executable specification of logical agents. DALI is a prolog-like logic programming language with a prolog-like declarative and procedural semantics [7].

IV. CONCLUSIONS

We conclude this paper by making some considerations about our work. It is not so easy to find an application where intelligent agents are put at work in a real scenario but it is even less frequent to find intelligent logical agents at work. In the light of these considerations, the DALICA MAS is a novelty. This also because DALICA exploits the signal of Galileo Satellites to deduce the Users Profiles. DALICA at work in the area of Villa Adriana practically demonstrated that logical agents can be applied successfully for capturing the visitors habits and preferences. Our system cannot be compared with platforms such as MAGA and DramaTour where the main goal is to offer information to the visitors via specialized interfaces. DALICA mainly deduces the visitors interests and leaves the job of presenting the information to an external component. KORE is the system closer to DALICA because it uses agents for managing the information through the study of the User Profile. KORE does not use the Galileo signal and its agents are not logical. Moreover, DALICA is more centered on the deduction profile process while KORE mainly filters the information according to the User Profile characteristics. As future developments, the system reasoning capabilities that are presently quite basic can be improved. Also, previous experience can be better exploited. Different agents managing different visitors might communicate so as to cooperate in improving their performance and enhancing the services they offer.

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