The Minerva Multiagent System for Museum Organization

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ABSTRACT
The application of artificial intelligence (AI) tools to cultural heritage is acquiring an increasing importance, promoting new technological solutions for museums and art exhibitions. We present a system, called Minerva, able to automatically organize virtual museums, given the set of works of art and the environments in which they must be displayed, and to support the user in the visit and fruition of these museums. Minerva has been experimentally implemented in two different versions: the first one arranges archeological finds for allocation in historical buildings; the second one arranges design objects for allocation in imaginary virtual environments.

Keywords

1. INTRODUCTION
The application of artificial intelligence (AI) tools to cultural heritage is acquiring an increasing importance, promoting new technological solutions for museums and art exhibitions. We present a system, called Minerva, able to automatically organize virtual museums, given the set of works of art and the environments in which they must be displayed, and to support the user in the visit and fruition of these museums. By organization we mean two distinct processes: the preparation (the arrangement of works of art in conceptually relevant ordered groups) and the allocation (the placement of these works of art within a given geometrical space preserving their arrangement). Minerva has been experimentally implemented in two different versions: the first one arranges archeological finds for allocation in historical buildings; the second one arranges design objects for allocation in imaginary virtual environments.

Minerva constitutes an example of how traditional and recent AI techniques can be successfully applied not only to the fruition of works of art, but also to their organization and management. Minerva blends together the classical inferential techniques of AI and the recent paradigm and technology of multiagent systems, that is very influential in current AI research. It is thus composed of agents (and components) that have been designed to be modular and independent in their activation, in such a way that the structure of the system can dynamically change according to its activities. In designing Minerva we have emphasized flexibility and generality: the system can manage different kinds of works of art and different environments, as demonstrated by the two versions of the system. Both have the same architecture (illustrated in Section 3), but different interfaces and contents.

This paper is organized as follow. The next section describes some typical scenarios of employment of Minerva to show its relevance. Section 3 presents the description of the technical implementations of the system. Finally, Section 4 concludes the paper.

2. SCENARIOS OF USE
The main purpose of Minerva is the automatic organization of museums, given the works of art and the environments in which they must be displayed. The task of organizing a museum is usually thought as a typical human-exclusive activity based on aesthetic and personal criteria producing, as final result, a global coherent setting that allows an effective visit of the museum. However, the organization follows some criteria; some of these criteria can be considered for an automatic organization. First of all, there are the physical criteria: for instance, some works of art cannot be inserted in some rooms, some rooms can be scarcely lighted, and some other rooms can be too hot or too cold to keep works of art in them. In addition, the artistic criteria are taken into account: they play a central role in the final result, since they concern, for example, how to give emphasis to particularly important works of art or how to build connections among different works of art.

Minerva users can be roughly grouped in four different typologies, each one corresponding to a different pattern of behavior. The museum expert and the museum organizer users adopt Minerva for simulating potential organizations (controlled by the users themselves) of the works of art in some environments with the aim of studying and evaluating them. The artistic expert users use Minerva by making requests on the works of art to be displayed, but do not interfere in the organization of the museums. The inexperienced users make virtual visits of already organized museums. The technical users modify the system, for instance to update the database of the collections of works of art and that of the environments.

In order to describe the functioning of the system, let us consider the archeological version by referring to a museum organizer user who has the complete control over the activities of the system. In this case the user can tune the various parameters and criteria driving the processes of preparation and allocation of the selected works of art in the selected environment (Figure 1). The parameters of the preparation process determine the order in which the works of art are displayed (according to their shape, production technique, type, age, culture, material, and place of origin) and the conceptual criterion (historical or artistic) by which the works of art are classified in consistent and coherent
groups. The parameters of the allocation process control all the aspects of the placement of the works of art in the environment, including the maximum and minimum occupation of the rooms and of the shrines, the order (clockwise or anticlockwise) in which the works of art are placed in the rooms, and the algorithm by which the taxonomic tree produced by the preparator agent is visited. When the preparation and the allocation activities have been performed, the user can visit the automatically organized museum in a VRML virtual reality setting, as shown in Figure 2. All the works of art are virtually reproduced according to their three-dimensional models obtained from the real objects or from their representations (e.g., pictures). In the virtual museum, the user can follow a list of viewpoints and access the detailed information (including a better VRML model and a number of textual descriptions at various levels of detail) associated to the works of art by clicking on the works of art themselves. The information can also be accessed by a rudimentary natural language interface.

The second version of Minerva is devoted to the organization of a museum in which a collection of design objects that have been awarded with the Compasso d'Oro (the most prestigious Italian design award) are displayed in a totally imaginary virtual environment. This environment is shaped as a spiral whose dimension depends on the number of design objects resulting from the process of organization. The user performs the same operations as in the previous case. Specifically, the user tunes some parameters that constrain the automatic selection of the design objects to be inserted in the museum and the preparation and allocation processes (Figure 3). In this case, the parameters are the following: the year of awarding; the object degree of innovation in shape, function, material, manufacturing process, structure, and communication; the area of use (house, work, communication, entertainment, and movement). The prepared and allocated museum is displayed (with SHOCKWAVE technology) to the user (Figure 4). As in the previous case, the user can navigate in the automatically organized museum and can request more information about the displayed design objects.

Figure 2. The VRML virtual visit of an automatically organized archeological museum.

Figure 3. The parameters and criteria for the organization of a design museum.

3. TECHNICAL IMPLEMENTATION

Minerva is implemented as a multiagent system [8] composed of autonomous computational entities, called agents [6]: some of them exploit the inferential techniques of AI in order to carry on the organization and management of the works of art. Museum organizations are the result of the cooperation activity of the agents of Minerva. A preliminary description of the archeological version of the system can be found in [1], while a more detailed technical description of Minerva can be found in [2].

The main distinction among the entities composing Minerva is between agents and components. The agents provide fundamental “intelligent” and autonomous functions, whereas the components provide peripheral “service” functions. For instance, the user interface is managed by a component that exploits the functions
of the agents to provide a performance to the user. A static representation of the architecture of Minerva is shown in Figure 5, in which only the main communication flows are shown, even if all the agents and the components can communicate together in an internal message format. The agents and the components are coded in JAVA; in addition we employ the JADE framework [4] as middleware and the JESS framework [3] to perform inferential activities. In the following the components and the agents of Minerva are described.

The supervisor component "recruits" and activates the agents and the components that are needed to carry out a given activity. For example, during the organization of a museum, the preparator and allocator agents are the only active agents, while during the visit of an already organized museum the only active agents are the navigator and the commentator.

The user interface component generates the pages displayed to the user via a HTML browser and manages the interaction with him or her according to what discussed in the previous section. In particular, the user interface component translates the geometrical description of the allocation of a collection in an environment, which is produced in the Minerva internal format, to the format displayed to the user (VRML [7] or SHOCKWAVE [5]). The user interface component reads (from the works of art database) the three-dimensional models of the works of art and inserts them in the three-dimensional model of the environment (read from the environments database) according to the geometrical result of the allocation process. Then, the VRML or SHOCKWAVE model is displayed to the user who can navigate inside it.

The natural language processing component translates the requests of the users from (a subset of) Italian to the Minerva internal message format. The DB management component translates the queries between the internal message format and SQL. The databases of Minerva are the works of art database and the environments database.

Let us consider now the agents that constitute the kernel of Minerva. Given a collection of works of art and an environment (selected by the user), two agents operate to find, respectively, a preparation and an allocation. The first agent, called preparator agent, automatically determines, on the basis of the criteria selected by the user, the conceptual arrangement in which the works of art of the collection will be displayed: first it classifies the works of art in groups and then it orders these groups. More precisely, the preparator agent uses the JESS engine to apply inferential techniques for classifying the works of art of the selected collection into groups, each one composed of homogeneous objects. In doing that the preparator agent exploits the expertise inserted in its knowledge base about museum criteria concerning the possible ways in which the pieces of a collection can be classified and grouped. This expertise has been acquired from human experts in museum organizations. The criteria, expressed as rules in JESS, the preparator agent adopts to create groups of homogeneous objects are based on both cultural (such as age, type, place of origin, and culture of origin) and physical (such as size, weight, shape, and material) features of the objects. At the end of the process the preparator agent stores the obtained groups of works of art in a taxonomic tree. The ordered groups produced by the preparator agent and the environment selected by the user constitute the input for the allocator agent.

The allocator agent automatically finds, within a given environment, the best geometrical allocation for the works of art of the groups in the taxonomic tree, preserving the ordering on groups imposed by the preparator agent. Also the allocator agent exploits the knowledge inserted in its knowledge base about museum criteria concerning where to place the works of art in a given environment. These criteria, expressed as rules in JESS, consider, among others, the minimum and maximum occupation of the space in a room, the minimum and maximum occupation of the perimeter of a room, and the distances governing the collocation of the shrines according to the collocation of the doors, windows, and other shrines. The groups of works of art are allocated in the rooms in decreasing importance order (as established by the preparatory agent). In particular, the allocator...
agent tries to allocate each group in a different room; if it fails, the group is spread over more rooms or more groups are allocated in the same room. When the allocator agent cannot place the works of art in a room according to the selected criteria, it requests the preparator agent to find an alternative preparation. This primitive form of negotiation between the preparator and the allocator agents is an expression of the multiagent nature of Minerva.

The navigator agent and the commentator agent are still in a primitive stage of development and are employed in the visit of a museum that has already been organized by the preparator and allocator agents. The navigator agent tailors specific paths in a organized museum (in this sense, it acts as a rough personalization system), on the basis of the requests from the users. The commentator agent is activated when the user, while visiting a museum, requests more information about a work of art. In this case, given a work of art, the type and the detail level of the information the user requested, the commentator agent dynamically builds a description of the object including physical, historical, and artistic information (retrieved from the works of art database). The description is composed of written text and of three-dimensional models of the works of art.

4. CONCLUSIONS
In this paper we have illustrated, by discussing Minerva and its two implemented versions, how traditional and recent AI techniques can be successfully applied to cultural heritage and, in particular, to the organization, management, and fruition of works of art. Future work will be devoted to improve some technical aspects of Minerva: in particular, the communication and the negotiation aspects of agents interaction and the retrieval of information concerning the works of art from the Web. Furthermore, we aim to apply the same kernel of Minerva to the organization of other museums, but also to build systems devoted to the management of domotic devices in houses and the structuring of electronic courses. These extensions are based on the idea that in both cases we deal with the organization of objects, both real (domotic devices) and virtual (learning objects), in environments, both real (houses) and virtual (electronic courses).

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This paper is dedicated to the memory of Marco Somalvico who first started the Minerva Project in 1995.

6. REFERENCES