A Serious Game and Artificial Agents to support Intercultural Participatory Management of Protected Areas for Biodiversity Conservation and Social Inclusion

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***Abstract*—This paper addresses our experience in the design of a serious game, aimed at computer-based support for intercultural participatory management of protected areas, in order to promote biodiversity conservation and social inclusion. Its objective is to help various stakeholders (e.g., environmentalist, tourism operator, traditional community...) to collectively understand conflict dynamics and explore negotiation strategies for the management of protected areas. Therefore, this helps at mutual understanding and negotiation between different cultures, contexts and practices (traditional community, technical manager, environmentalist...) about the strategic issue of combining biodiversity conservation and social inclusion. After introducing the objectives of our serious game, named SimParc, we will describe its design, its current architecture. We will also discuss the introduction of various types of agents within the system: a decision making agent playing the role of the park manager; artificial players to replace some of the human players in the game; assistant agents to assist human players; and expert agents that can provide human players with technical information about the viability of their proposal (e.g., about the survival of an endangered species), or to analyse relations (e.g., dominance or equity) among players proposals. This last type of agent aims at introducing a technical viewpoint and culture in this intercultural participatory process. Some of these agents have already been implemented and tested and some others are in progress.**

***Keywords*-serious games, role playing game, artificial agents, decision making, negotiation, intercultural, participatory, protected areas, management, biodiversity conservation, social inclusion**

I. Introduction

The context of this work is an ongoing research project concerned with exploring computer support for intercultural participatory management of protected areas (for biodiversity conservation and social inclusion). Therefore, we designed a serious game, as our objective is educational and epistemic. Serious Games [1] are getting increased attention as a novel and effective approach for training and exploring possibilities, in context but without high costs or risks. Indeed, games are a good substitute for direct experience from real world or real infrastructures because they can generate learning experiences in a relatively fast and safe manner [2].

In our project and related game, humans play some roles, representing stakeholders (e.g., environmentalist, tourism operator. . .), with different cultures, contexts and practices, and discuss, negotiate and take decisions about environment management decisions. The park manager acts as an arbitrator in the game, making a final decision about the types of conservation for each landscape unit and he also explains its decision to all players. Using an artificial manager in place of a human manager allows reproductible experiments with controllable levels of participation and of manager profile (see Section V-A). Its objective is to make decision based on its own analysis of the situation and on the proposals by the players. The agent is also able to explain its decision based on its chain of argumentation. Other types of agents are introduced in the game: artificial players to replace some of the human players; assistant agents to assist them; and expert agents to provide them with technical information about the viability of their proposal.

II. The SimParc Project

A. Project Motivation

A significant challenge involved in biodiversity management is the management of protected areas (e.g., national parks), which usually undergo various pressures on resources, use and access, which results in many conflicts. This makes the issue of conflict resolution a key issue for the participatory management of protected areas. Methodologies intending to facilitate this process are being addressed via bottom-up approaches that emphasize the role of local actors. Examples of social actors involved in these conflicts are: park managers, local communities at the border area, tourism operators, public agencies and NGOs. Examples of inherent conflicts connected with biodiversity protection in the area are: irregular occupation, inadequate tourism exploration, water pollution, environmental degradation and illegal use of natural resources. These conflicts occur because of different cultures, contexts and practices.

Our SimParc project aim is to help various stakeholders at collectively understand conflicts in parks management and negotiate strategies for handling them. The origin of the name SimParc stands in French for “Simulation Participative de Parcs”. It is based on the observation of several case studies in Brazil. However, we chose not to reproduce exactly a real case, in order to leave the door open for broader game possibilities.

B. Approach

Our initial inspiration is the companion modeling (ComMod) approach about participatory methods to support negotiation and decision-making for participatory management of renewable resources [3]. They pioneer method, called MAS/RPG, consists in coupling multi-agent simulation (MAS) of the environment resources and role-playing games (RPG) by the stakeholders [3]. The RPG acts like a “social laboratory”, because players of the game can try many possibilities, without real consequences. Recent offsprings from ComMod, like [4], and [5], proposed further integration of role-playing into simulation, distributed support for role-playing and the insertion of artificial agents, as players or as assistants.

III. The SimParc Role-Playing Game

A. Game Objectives

Current SimParc game has an epistemic objective: to help each participant discover and understand the various factors, conflicts and the importance of dialogue for a more effective management of parks. Note that this game is not (or at least not yet) aimed at decision support (i.e., we do not expect the resulting decisions to be directly applied to a specific park).

The game is based on a negotiation process that takes place within the park council. This council, of a consultative nature, includes representatives of various stakeholders (e.g., community, tourism operator, environmentalist, non governmental association, water public agency…). The actual game focuses on a discussion within the council about the “zoning” of the park, i.e. the decision about a desired level of conservation (and therefore, use) for every sub-area (also named “landscape unit”) of the park. We consider nine pre-defined potential levels (that we will consider as types) of conservation/use, from more restricted to more flexible use of natural resources, as defined by the (Brazilian) law. Examples are: Intangible, the most conservative use, Primitive and Recuperation.

The game considers a certain number of players’ roles, each one representing a certain stakeholder. Each player, as in any role-playing game, has to embody the designed/selected role with its respective postures and objectives. To facilitate the incorporation of the role by the player, SimParc offers a set of personas to represent him/her during the game (see Figure 1). Depending on its profile and the elements of concerns in each of the landscape units (e.g., tourism spot, people, endangered species…), each player will try to influence the decision about the type of conservation for each landscape unit. It is clear that conflicts of interest will quickly emerge, leading to various strategies of negotiation (e.g., coalition formation, trading mutual support for respective objectives, etc).

Figure 1. Some examples of personas offered in SimParc.

A special role in the game is the park manager. He is a participant of the game, but as an arbiter and decision maker, and not as a direct player. He observes the negotiation taking place among players and takes the final decision about the types of conservation for each landscape unit. (It is important to note that this follows the situation of a real national park in Brazil, where the park management council - composed of representatives of diverse stakeholders - is only of a consultative nature, thus leaving the final decisions to the manager.) Decision by the park manager is based on the legal framework, on the negotiation process among the players, and on his personal profile (e.g., more conservationist or more open to social concerns) [6]. He may also have to explain his decision, if the players so demand. We plan that the players and the park manager may be played by humans or by artificial agents.

B. Game Cycle

The game is structured along six steps, as illustrated in Figure 2. At the beginning (step 1), each participant is associated with a role. Then, an initial scenario is presented to each player, including the setting of the landscape units, the possible types of use and the general objective associated to his role. Then (step 2), each player decides a first proposal of types of use for each landscape unit, based on his/her understanding of the objective of his/her role and on the initial setting. Once all players have done so, each player's proposal is made public.

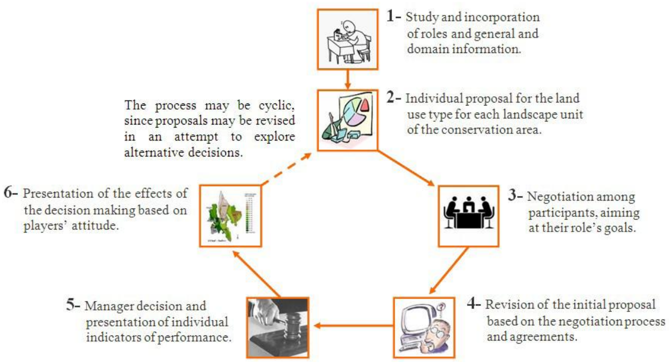

Figure 2. The six steps of the SimParc game.

In step 3, players start to interact and to negotiate on their proposals. This step is, in our opinion, the most important one, where players collectively build their knowledge by means of an argumentation process. In step 4, they revise their proposals and commit themselves to a final proposal for each landscape unit. In step 5, the park manager makes the final decision, considering the negotiation process, the final proposals and also his personal profile (e.g., more conservationist or more sensitive to social issues). Each player can then consult various indicators of his/her performance (e.g., closeness to his initial objective, degree of consensus, etc.). He can also ask for an explanation about the park manager decision rationales.

The last step (step 6) "closes" the epistemic cycle by considering the possible effects of the decision. In the current game, the players provide a simple feedback on the decision by indicating their level of acceptance of the decision.

A new negotiation cycle may then start, thus creating a kind of learning cycle. The main objectives are indeed for participants: to understand the various factors and perspectives involved and how they are interrelated; to negotiate; to try to reach a group consensus; and to understand cause-effect relations based on the decisions.

An ongoing sub-project plan is to introduce some assistance to players and to the park manager about evaluation of the quality of a decision, using viability theory [7], [8]. Note that a completely validated model is not indispensable as the park is fictive and the objective is credibility, not realism.

IV. The SimParc Game Support Architecture

A. Design and Implementation of the Architecture

Our current prototype benefited from our previous experiences (game sessions and prototype) and has been based on a detailed design process. Based on the system requirements, we adopted Web-based technologies (more precisely J2E and JSF) that support the distributed and interactive character of the game as well as an easy deployment.

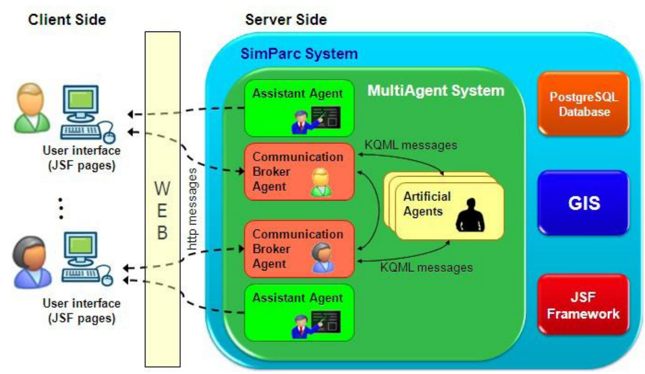

Figure 3. SimParc general architecture.

Figure 3 shows the general architecture and communication structure of SimParc current prototype. Distributed users (the players and the park manager) interact with the system mediated internally by communication broker agents (CBA). The function of a CBA is to abstract the fact that each role may be played by a human or by an artificial agent. A CBA also translates user messages in http format into multi-agent KQML format and vice versa. For each human player, there is also an assistant agent offering assistance during the game session (see more details in [8]). During the negotiation phase, players (human or artificial) negotiate among themselves to try to reach an agreement about the type of use for each landscape unit (sub-area) of the park.

A Geographical Information System (GIS) offers to users different layers of information (such as flora, fauna and land characteristics) about the park geographical area. All the information exchanged during negotiation phase, namely users' logs, game configurations, game results and general management information are recorded and read from a PostgreSql database.

B. Interface

The interface for negotiation is shown at Figure 4. It includes advanced support for negotiation (rhetorical markers and dialogue filtering/structuring mechanisms, see details in [9]), access to different kinds of information about other players, land, law and the help of a personal assistant.

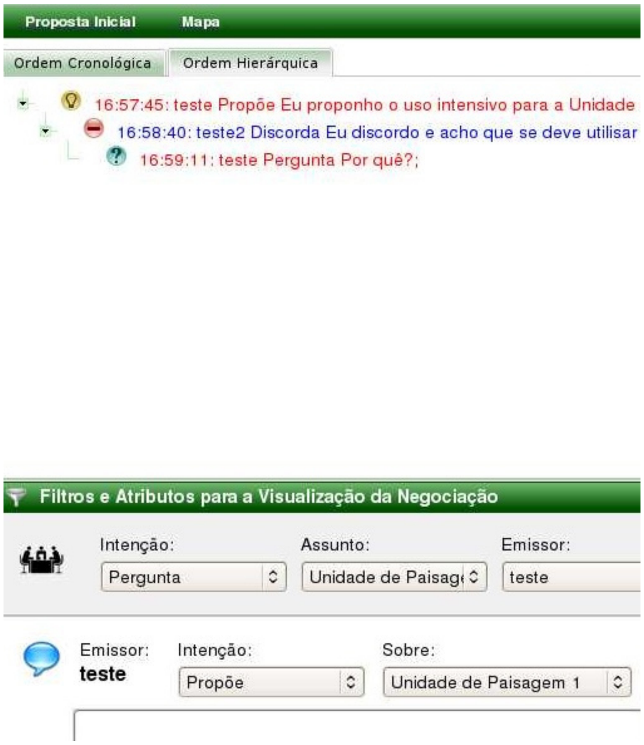

Figure 4. Current prototype's negotiation GUI.

The interface for players decision about the types of use at Figure 5. In this interface, the players can analyze the area based in its different layers (e.g., land, hydrography, vegetation. . .).

Figure 5. Current prototype's decision GUI.

C. Preliminary Evaluation

The current computer prototype has been tested through two game sessions by domain expert players in January 2009 and in January 2010 (see Figure 6). The 9 roles of the game and the park manager were played by humans. Among these 10 human players, 8 were experts in park management (researchers and professionals, one being a professional park manager in Brazil). The two remaining players were not knowledgeable in park management. One was experienced in games (serious games and video games) and the other one a complete beginner in all aspects.

Figure 6. SimParc current prototype game session.

Overall, the game was well evaluated by the human players. We analyzed data on the game sessions (written questionnaires, recorded debriefing, etc.) and a detailed analysis is presented in [8]. An interesting finding after the sessions was also that all players learned and took benefit of the game. The experts explored and refined strategies for negotiation and management, whereas the beginner player took benefit of the game as a more general educational experience about environmental management. In other words, the game appeared to be tolerant to the actual level of expertise of players, an aspect which had not been planned ahead. We believe these preliminary results are very encouraging and we will soon conduct new game sessions with experts.

V. Artificial Agents

We are currently inserting different types of artificial agents into the prototype:

- a decision making agent playing the role of the park manager;
- artificial players to replace some of the human players in the game;
- assistant agents to assist human players;
- and expert agents that can provide human players with technical information about the viability of their proposal (e.g., about the survival of an endangered species), or to analyse relations (e.g., dominance or equity) among players proposals.

A. Park Manager Agent

As explained in Section III-B, the park manager acts as an arbitrator in the game, making a final decision for types of conservation for each landscape unit and explains its decision to all players. He may be played by a human or by an artificial agent. The game manager decides when creating and configuring a new game session about the park manager.

The artificial agents architecture is structured in two phases. The first decision step concerns agents individual decision-making process: the agent deliberates about the types of conservation for each landscape unit. Broadly speaking, the park manager agent builds its preference pre-order over allowed levels of conservation. An argumentation-based framework (see, e.g. [10]) has been implemented to support the decision making. The key idea is to use the argumentation system to select the desires the agent is going to pursue: natural park stakes and dynamics are considered in order to define objectives for which to aim. Hence, decision-making process applies to actions, i.e. levels of conservation, which best satisfy selected objectives. The second step consists in taking account of players preferences, with the possibility to adjust the profile of the park managers, from autocratic to democratic, and therefore the influence of players votes.

Details about architecture formal background and implementation are reported in [11]. The architecture has been implemented and tested offline and its outputs (decision and arguments) have been validated by our project domain experts. Next step is to organize a new series of game sessions, with an online test of the artificial park manager architecture. Some possible future work is also to use the traces of arguments produced for the decision as a basis for the explanation of the decision to players.

B. Artificial Players

Artificial players represent an ongoing research based on previous experience on virtual players in a computer-supported role-playing game, JogoMan-ViP [5]. The idea is to possibly replace some of the human players by artificial agents. The two main motivations are: (1) the possible absence of sufficient number of human players for a game session and (2) the need for testing in a systematic way specific configurations of players profiles. The artificial players will be developed along artificial park manager existing architecture (see previous Section V-A), with the addition of negotiation and interaction modules. We plan to use the argumentation capabilities to generate and control the negotiation process. In a next stage, we plan to use automated analysis of recorded traces of interaction between human players in order to infer models of artificial players. In some previous work [4], genetic programming had been used as a technique to infer interaction models, but we also plan to explore alternative induction and machine learning techniques, e.g., inductive logic programming.

C. Assistant Agents

The assistant agents are being designed to assist players through the game. It is important to emphasize that the user has total control over his assistant, enabling or disabling it at anytime. The basic initial function of these agents is to present and explain each step of the game. During the negotiation step, assistant agents may also propose to participants some helpful information, in order to improve their analysis concerning the negotiation. For instance, they may provide each player with an ordered list of the players taking into account criteria such as the compatibility or incompatibility of proposals of other players with the proposals of the assisted player. Since we decided to favor a bottom-up approach, we decided to avoid intrusive assistant agents through the game. We believe that intrusive assistant agents could interfere in the players cognitive processes. That is why our assistant agents cannot suggest players a decision. A first implementation has already been completed a A first prototype implementation of an assistant agent has already been implemented [8] and tested through small game sessions.

D. Expert Agents

We are also working on expert agents that can provide the human players with information about the efficiency of a given park management policy (considering conflicting stakes such as the survival of an endangered species and cultural tourism), or that can suggest modifications of a given policy in order to improve the resilience of the park (that is, its resistance to perturbation, regarding the issues at stake). Mathematical viability theory [7] allows to identify the policies that can retain or restore desirable properties of a dynamical system, as it has been shown for lake eutrophication [12]. It is far better to ask the players for desirable properties than for optimization objectives, which are generally not unique and unknown for environmental issues. With viability theory, players have to define desirable properties as constraints on the park state variables. We expect this method to be easy to implement in a participative game, since the constraints define in fact satisfactory areas. Discussion about areas should be easier than discussion about fixed objectives. The viability analysis will help to define the set of states in which the park should be kept in order to guarantee or restore the desirable properties, and the policies that allow to reach these states. The technical evaluations will be encapsulated into expert agents, technical assistants for the players. Expert agents will also provide the players with an analysis of the management policy and vote results from the decision theory viewpoint (dominance relations, fair compromise), in order to sustain the discussion.

VI. Conclusion

In this paper, we have presented the architecture of an artificial decision maker agent for the SimParc project, a serious game about participatory management of protected areas. We have also summarized the various kinds of agents populating the game to help players and increase game possibilities. So far, various game sessions conducted with domain experts have been quite encouraging. It is important to emphasize that the game SimParc was developed based on the recovery of initiatives for the construction of methodologies which help to consolidate democratic spaces of decision in cases of protection of nature. In this sense, the game intends to be a tool capable of contributing to the intercultural dialogue on consolidation of commitments to conservation, particularly management of national parks and other protected areas. Considering that the game could be (and already has been) played by real managers, it is important to reflect how far the game, that is fun and educational, should be closer to reality and what are the necessary representations/abstractions to achieve the required goals. For example, how the process of negotiating social pacts and democratic management of protected areas can be promoted without losing the focus on respect to real problems and operational by the tax legislation and guidelines for management? Similarly, how to balance technical and scientific expertise in the social participation in the management of nature? Although more evaluation is needed, we believe the initial game session tests are encouraging for the future and we are welcoming any feedback and input from similar or related projects.

Besides the project specific objectives, we also plan to study the possible generality of our prototype for other types of intercultural conflicting scenarios.

More information about the SimParc project is available at:

`http://www-desir.lip6.fr/~briot/simparc/`

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References

[1] D. Michael and S. Chen, *Serious Games Games that Educate, Train and Inform*. Thomson Course Technology, 2006.

[2] J. Warmerdam, M. Knepflé, R. Bidarra, G. Bekebrede, and I. Mayer, "Sim-port: a multiplayer management game framework," in *9th International Conference on Computer Games (CGAMES06)*, Dublin, Ireland, 2006.

[3] O. Barreteau, "The joint use of role-playing games and models regarding negotiation processes: Characterization of associations," *Journal of Artificial Societies and Social Simulation*, vol. 6, no. 2, 2003.

[4] P. Guyot and S. Honiden, "Agent-based participatory simulations: Merging multi-agent systems and role-playing games," *Journal of Artificial Societies and Social Simulation*, vol. 9, no. 4, 2006.

[5] D. Adamatti, J. Sichman, and H. Coelho, "Virtual players: From manual to semi-autonomous RPG," in *AIS-CMS'07 International Modeling and Simulation Multiconference (IMSM'07)*, F. Barros, C. Frydman, N. Giambiasi, and B. Ziegler, Eds. Buenos Aires, Argentina: The Society for Modeling Simulation International (SCS), February 2007, pp. 159–164.

[6] M. Irving, *Áreas Protegidas e Inclusão Social: Construindo Novos Significados*. Rio de Janeiro: Aquarius, 2006.

[7] J.-P. Aubin, *Viability theory*. Modern Birkhäuser Classics, 1992.

[8] E. Vasconcelos, G. Melo, J.-P. Briot, V. S. Patto, A. Sordoni, M. Irving, I. Alvarez, and C. Lucena, "A serious game for exploring and training in participatory management of national parks for biodiversity conservation: Design and experience," in *VIII Brazilian Symposium on Games and Digital Entertainment (SBGAMES'09)*, Rio de Janeiro, Brazil, October 2009.

[9] E. Vasconcelos, J.-P. Briot, M. Irving, S. Barbosa, and V. Furtado, "A user interface to support dialogue and negotiation in participatory simulations," in *Multi-Agent-Based Simulation IX*, ser. LNAI, N. David and J. S. Sichman, Eds. Springer, 2009, no. 5269, pp. 127–140.

[10] P. M. Dung, "On the acceptability of arguments and its fundamental role in nonmonotonic reasoning, logic programming and n-person games," *Artificial Intelligence*, vol. 77, no. 2, pp. 321–357, 1995.

[11] A. Sordoni, J.-P. Briot, I. Alvarez, E. Vasconcelos, M. de Azevedo Irving, and G. Melo, "Design of a participatory decision making agent architecture based on argumentation and influence function – Application to a serious game about biodiversity conservation," *RAIRO – An International Journal on Operations Research*, vol. 44, no. 4, pp. 269–284, Oct.–Dec. 2010, special Issue on COGIS'09.

[12] S. Martin, "The cost of restoration as a way of defining resilience: a viability approach applied to a model of lake eutrophication," *Conservation Ecology*, vol. 9, no. 2, 2004, article 8.