When predictive modelling meet participatory simulation: a feedback on potential and issues of a combined approach

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1 Introduction

In the domain of agent-based simulation two main uses of simulation as a decision support system are classically identified and differentiated. The first, let's call it the *"classical" simulation*, involves the decision maker as a user of a model, which is viewed as an oracle that enables him to test the implications of different management scenarios. In the second viewpoint, *participatory modelling and simulation* involves several users, the simulation taking the place of an artefact needed for the interactions among users to take place, the overall experimentation having broadly three different possible purposes, i.e. either educational, the aim of the simulation is then to make participants learn about important aspect of the modelled system; or either experimental, the researcher aims at eliciting, through their participation to a simulation game, the strategy and decision rules of the participants; or finally operational, i.e. the simulation is an artefact that aims at helping participants to coordinate their strategy towards a collective management, for instance of natural resources. Notice that this latter case is in fact quite close to the "classical" use of simulation, a community of participants using the simulation as an oracle to test different collective management scenarios.

Participatory simulations require plausible models for making it as immersive as possible (Colella 2000, Guyot and Honiden 2006); yet predictive models built for decision-making are precisely designed for being realistic. Reciprocally, building a decision-support model requires the description of plausible behaviour for agents, while participatory simulation precisely offers the actors to play their own role with as much realism as possible. In this paper, we propose to change what looks like an interdependence dilemma to a complementary approach that uses the strength of each approach to fulfil the needs of the other: we propose to use a participative process to gather information on behaviours and decision rules of the local actors, and reciprocally to use the more realistic model built that way to improve the decision-support model.

Several problematic are inherent to the coupling of these two approaches. First, agents on the classical model should be made "un-pluggable" for them to be replaced by humans. This implies the design of the relevant user interfaces to enable players to act as agents. Secondly, human players are much less numerous than the artificial ones; as a consequence, their actions may have so few impact of the simulation that they would not benefit from the role-playing game. Experimentations are mandatory to assess the potential of such an approach; for instance, the re-usability of players' behaviour is unsure. One could also fear biases in such a coupling, such as having players that would play against the computer rather than with it.

In this article, we first describe an experiment based on a simulation model developed on the NetLogo platform in a water management case study and the use of this model in a participatory setting. We will then detail the solutions we found to solve the various problems inherent to such a coupling, and point out the various pitfalls and pratfalls of such a coupling, along with the potential benefits for both participatory simulation and classical modelling.

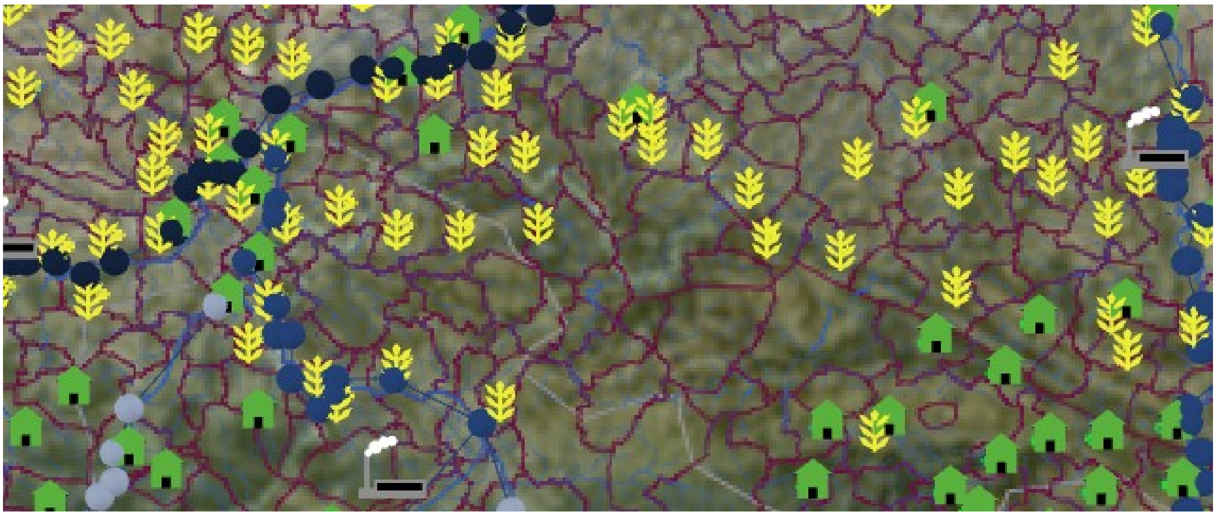

FIG. 1 – Screenshot of the GIS viewpoint of the model built for water management in scarcity period.

2 Study about water management in period of scarcity.

2.1 Decision support simulation: the SIMPAGE project

One aim of the study was to set up a decision-support model to study water management in the Adour-Garonne basin, especially during the low water period. The basin is positioned in the south west of France. It corresponds roughly to a 1/5th of the French metropolitan territory. It includes 120.000 km of rivers and 634.000ha of irrigated fields. Water scarcity is frequent in this basin with an annual deficit in water estimated to 300 millions of m3. In period of scarcity, the needs of the various water users (farmers, industries, hydroelectric producers and potable water managers) become conflictual, the individual and collective objectives being eventually contradictory (Ostrom et al., 1994). In order to solve these conflicts, an institutional framework was set up in which the higher authority - the prefect - may punctually limit the water consumption of several actors or request dam managers to release water into the river.

As the model was intended to be used for decision-support, it was important that the interfaces could be well understood by the different users. When building this descriptive model, we choose to put much efforts on the spatial representation of the Adour-Garonne basin in the model. For this, we assumed that a cartographic GIS-like representation of the model's environment was likely to allow a consistent analysis of the simulation results by the end-users. The first step was thus to integrate in the model the shape and river network of the watershed and major geographic points (townships, water uptake points,...).

The second step was to add the agents in the environment. There are five kinds of agents, based on the different actors identified in the watershed (Saqalli et al. 2009): *farmers* watering their fields, *industries* using water in manufacturing process, *dam managers* handling the water flow for electricity production, *drinking water managers* pumping water for citizens needs, and the *water prefect* (single character and agent) regulating water consumption and representative of the authorities. Again, using GIS data enabled to position agents of the different kinds in the environment. Finally, the GIS data indicate rivers locations and we use them to draw the rivers in our environment and put water agent on the notable locations of the water network (uphill, downhill, junction, capture point) and then link the agents to rebuilt the network and generate water movement in the environment.

Finally, in addition to the attributes, sensors and abilities, we added functions to the agents giving them several behaviours based on the consumat approach (Janssen and Jagger 2001). In brief, agents are able to choose to uptake water or not according to the resource level and their production need. This model was studied by experts in water management, acknowledging it is model realistic enough to run different scenarios and produce consistent results for analysis of the various water needs and impacts of actors decisions on the water management system.

2.2 A Role-playing game experiment to better understand actors' strategies

Implementing a role-playing game (RPG) on the basis of an already existing agent-based model requires two main tasks. First , to transpose the automatic actions done by agents of the model into a set of options and rules for a person to play a role. Second, to create an immersive situation for participants to act according to their role and the study. In this experiment we choose to develop a RPG mixing human-controlled and computer-controlled agents (also called Hybrid Agent-Based Simulation Model (Becu et al., forthcoming 2010), with the possibility to switch from one control-mode to another during the course of a simulation.

The way to immerse participants into a RPG highly depends on the context and issue studied. So to immerse participants and make them aware of water management issues at this scale, we started the RPG session with a slide-show displaying pictures of the different water uses and resource conditions (e.g. rivers in low water period). Then, in order to transpose agents' automatic actions into rules and decision options for participants we used synthetic role sheets. The role sheets provide information about the goals of the player (e.g. retain water for the hydroelectric producer role), the means to fulfil his objectives (e.g. water sources for the farmer role), as well as figures and tables summarizing technical aspects related to a role (e.g. theoretical filling curve of hydroelectric dams).

Then, participants were seated at separated desks where they received their role sheets and discovered their individual objectives. They are free to elaborate a strategy that would either try to match both individual and collective objectives or to follow a more individualistic path. During the eight turns of the game, the players have two way to gain information about their individual decisions: public announcements about the evolution of hydrological conditions in the basin or through the GIS-like spatial interface.

Finally, to capture participants strategies, four recording methods were used. First the automatic recording of all manipulations done on the custom interface (including the comments filled-in by the participants). Second, video recording when the *Prefect* player calls all participants for a meeting to discuss about collective water management. Next, by having a person in charge of observing participants' attitudes and interactions during the entire session. And last by conducting a collective debriefing at the end of the game session during which participants are asked to explain the reasons of the decisions they took. This material enables conducting an ex-post in-depth analysis for better understand participants' strategies.

2.3 A mixed agent-based simulation with human and virtual agents

In order to enable users to play the role of agents in this model, we make some adjustments to the original NetLogo model. We used the NetLogo networking functions to enable each player to connect to the simulation on his own computer. When a human player joins the game, he is able to choose the role he wants to play and then, he replaces an agent on the environment, acquiring its attributes, skills and capacities. The possible roles for a player are settled according to the different actors identified in the study (farmer, dam manager, … see above). Besides, to facilitate immersion and enhanced plausibility, the graphical user interface depends on the player role during the simulation.

Human player are by far less numerous than agents; for instance, the model counts hundreds of farmers, while only two or three humans played this role during the participatory simulation. The consequence is that artificial agents are required to play the role of the hundreds of other agents, which have a plausible artificial behaviour designed by a standalone model. However, the limited representation of humans among agents also limit the impact of players' actions on the system. In other words, like in reality, a single actor does not have the power to change the whole world. But this limited power may also become an issue if human players are outnumbered by artificial agents so they can't appreciate the effects of their choices and actions. It's what we name the "dissolution problem". It is a drawback from the participatory viewpoint because the player can't see his actions' consequences. Due to this, the players would not discover positive or negative impacts of their behaviours and the pedagogical purpose of the participatory simulation would not be satisfied. *We solved this problem by representing human players as leaders for a proportion of agents*. These agents are dedicated to mimic players' actions and the size of this set allows to interfere on the players' power.

3 Feedback & discussion

The problem of the *dissolution of players' action because of their weak number was solved by our proposal to give the player a role of leader* whom behaviour is mimic by several artificial agents. One unique player, in charge of drink water in the RPG, complained about the lack of impact of his actions on the system; in fact this impact is also very low in the studied watershed. This may suggest at the first look that involving human players for agents having few impact on the system is useless; however, such a complain during the debriefing reunion may be of help for other players to understand the weak impact of the other player, which could be of use if this role is involved in a conflict in the real system.

We reused for the graphical interface of players the very same captors and effectors that those of artificial agents. In this experiment, no player complained about a lack of information for reaching his goals, supporting the choices made during the modelling process. Note that *such a direct mapping would have failed in the model wouldn't have built for being descriptive*. The experiment also learned us that their *presentation may be of importance;* for instance, a player in the role of dam manager asked us to change the unit for displaying the amount of water available in the dam.
The pedagogical purpose of the participatory simulation was satisfied, as participants declared to have understood not only the difficulty of water management in the watershed, but also the necessity for each player to take others' needs into account. All the players were very implicated in the simulation, some of them being even impassioned during the RPG. The

conjunction of both a descriptive model that describes the socio-environmental system in a plausible way and a well managed participatory experiment probably explains this success, confirming the interest of such a coupled approach. Also, one risk identified with this coupled approach was players to try to challenge the computer like in video games. It could result in biases in simulation results. However, we didn't observed this phenomenon in this experience because of a careful introduction to the RPG.

The experiment also brought benefits to the model itself, notably as being a *solution to drive a careful and deep validation* of the plausibility of each component of the model. For instance, dam manager detected excessive values for the volume of water contained in their dam; even if that fact was next shown to have no impact on the simulation results, the participatory simulation detected this flaw that had passed previous validation steps, *suggesting that participatory simulation may be of use to enhance the validation of models.*

Given this experiment, c*oupling a descriptive decision-support system with a participatory simulation appears to provide benefits to both of them*. The plausibility of the model is checked during the RPG, while the participatory simulation becomes more immersive to the players. The solutions we propose to actually couple these approach appear to be relevant. This approach may constitute a way to parameter agents' behaviours on scenarios that cannot be tested in a real setting, in order to complete the spaces of models' parameters that cannot be defined using field observations. Without surprise, several questions remain open; among others, appropriate methods are still required to study the behaviours gathered during the participatory simulation.

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