GAMING AND AGENTS DESIGN: THE PAC (PLAYER, AGENTS, CAST) TECHNIQUE

Carlos Domingo[1,2]; Isaura Correa[2]; Marta Sananes[1]; Rafael Tineo[1]; Giorgio Tonella[2,3]
[1]Institute of Statistics and Applied Computing (IEAC), Economics Faculty, ULA
[2]Simulation and Modelling Center (CESIMO), Engineering Faculty, ULA
Universidad de los Andes (ULA), Mérida, Venezuela
[3]University of Lugano, Lugano, Switzerland
carlosd@ula.ve; sananes@ula.ve
Work made with finantial support of FONACIT and University of los Andes Venezuela

ABSTRACT
The idea of using computer aided games (gaming) to design agents in social models is presented. Many characteristics of the games to adapt them to this end are described, particularly the record of the justification of actor decisions. Some possible methods to use game collected data for agent design are considered. A discussion is included about the problems and advantages of a flexible model, which combines three ways to introduce in the model the decisions of the actors: by human beings (Players), by algorithms (Agents) and by simple assignations of values (Cast), the PAC (Players, Agents, Cast) technique. Finally a game for a national economic system is described and preliminary results are reported.

KEYWORDS
Gaming simulation, agent modeling, economic system model, Venezuela

1. Gaming and agent simulation

Computer aided games (gaming in Emshoff and Sisson [1] terminology) have been used by decades as educational tools for training in management and for generation of creative scenarios [2]. Participation in well designed and well conducted games is a stimulating experience for the players which in a short time learn many things about a complex system. On the other hand, gaming is of limited usefulness for the designers and directors of the game, because it is not suited for making controlled simulation experiments and decision making.

The designers of gaming models, relieved of the hard task of designing behavioral equations, do not learn too much about the more interesting and determinant part of the system: the behavior of actors. The human actors (players) behave in different ways in different games; in addition they may change the view of the situation even in the same game and commit unexpected errors. Though their final objectives may be known, their intentions remain scarcely accessible to the game designer or director.

The social computer models in which the actors are represented by algorithms (agents) are very useful for three reasons:

- The need to program actors put the designers in an effort to define their properties, objectives and actions and the relationships among them. The designers gain a lot of organized knowledge about the simulated system.
- The wholly computerized model can be run in different conditions in perfectly controllable experiments for which powerful statistical techniques are available.
- Experiments are cheap and quick.

But it is very difficult to introduce creative reactions in the agents, which occur naturally in gaming players. Agent rarely emerges perfectly armored to act as Athena from the brain of the designer. The imagination of the designer is usually outwitted by the ingenuity, or even by the irrational behavior of the real actors.

Thus, as gaming and agent simulation usefulness are complementary, the idea of a combination of both approaches comes into mind. But in order to apply this approach to social models, it is necessary to add some new methodological tools to the classical gaming approach.

2. Recording players' information

The new gaming approach requires that:

- Each Player represents an actor of the social system and that
- Each player is instructed about the actor nature, its goals and usual behaviour that she or he represents.

In addition, in each period players have to be informed about the values of certain variables (those corresponding to the information accessible to the real actor). The values of these variables for several past periods have to be also given. In most of the cases, the values of these **information variables** are numeric, which is suited for an economic model, but in some cases may be logical or ordinal values. Besides, the players have to receive a list of variables and they must determine for the new period the values of these variables (the **decision variables**). For certain variables the values must be obtained in a bargaining mode with other actors (for example, workers and entrepreneurs may decide in a meeting the level of salaries).

Furthermore, each player is required to justify the taken decisions used in the determination of the values of each decision variable. In the case of collective decisions, each decision maker reports his view. The report must be done in an informal piece of text or in a prescribed format according to the type of analysis intended for that data.

Once all the players have taken their decisions and written the explanations, the corresponding files are sent to the supervisor who introduces the values of the decision variables into the model. This computes the values at the end of the period of all the other variables that will be used as values at the beginning of the next period. These new values (perhaps with several past values of some variables) are sent to the actors for the playing of the next period of the game, so that the play can continue. After a prescribed number of periods the game is finished.

The supervisor may decide which variables to include in the set of information variables given to the actor. This possibility opens an interesting line of research about the influence of information.

3 Analysis of the results and agent design.

The analysis of the data may be done in many ways. If the results are expressed as a free text, a maximum of expressivity, the process generate interesting qualitative and quantitative ideas that may be useful to design the algorithm for the agent.

If the data are quantitative, the result would be a time series for each decided variable and for the variables that the player declares that were used in the decision. If the player uses different variables in the successive periods to calculate the values of the same variable (as it actually happens) one solution is to complete the set of the used variables by putting the actual value of the omitted variable. Then, a possible design of the agent is made by multiple regression of the decided values of the decision variables on the values of the used information variables . More interesting is the method used in data mining [3] to obtain a logical expression from a data table of qualitative data. To record that type of data the player has the option of expressing the reasons of the numerical decisions in an ordinal scale (used very high, high, normal, low, very low). These semi-quantitative values have been shown very convenient to the players. The model may translate some of these values to numerical ones. Other proposed method is to use bootstrap techniques that have been used with good results for inputs in simulation models [4]. Up to now only the first method was used.

4 Combining player agents and cast actors

Once some ideas are deduced from several games it is useful to program a first version of the model of agents. The project is actually at this stage. There are some advantages to have, in the same model, players and **algorithmic actors (agents)** [5].

In addition, sometimes it is not possible to get the number of players required for a simulation game. For example, in the model presented below, 14 actors are needed. In these cases, the game is run with a combination of human players and algorithmic agents. In particular, some users prefer to play individually with all the other actors algorithmic. It is possible to run the model with agents only to make controlled experiments.

To adjust the algorithmic model to historical data "historical actors" (the **"cast" actors**) were introduced. An actor is simulated as an "historical actor" by assigning the historical value to its decisions for the historical periods. Furthermore, it is also possible to assume values for future periods to generate scenarios or to change true historical value for experiments in "virtual history" of the system. For the importance of this type of research see for example [6].

The director of the game (Supervisor), in the actual implementation for a local network and with complete direct communication with the players, can decide for each actor if it will be a player, an algorithmic (agent) or a cast actor for a given period. This allows to continue the game if a player leaves the game without spoiling the others work. This situation will be a serious possibility of the Internet version of the game, now being developed.

The test of the correctness of the model is done by putting all the actors as cast actors with historical data. The other variables values, computed by the model, must approximate the historical data. The model presented below was adjusted in this way. In addition, to adjust the algorithm of a particular agent, the model is run with this actor as algorithmic and all the others agents as cast

agents; in addition, it tests how accurate are the computed results. In this way, the model may be tested adjusting agents one by one.

Sometimes the process of modelling the agents suggests useful changes in the game, especially in the set of information variables of each player.

The mix of different actor types (algorithmic, cast, etc.) poses a series of problems. For example, not all combinations of actors have a clear economic sense. When two or more actors have to consult each other it is wise to choose the same class for them. If all of them are players the decision is made by meetings and by direct talk; if all are agents, the computer model provides an agreement algorithm. If they are of different classes the criterion was to decide by a fixed priority descending order: players, agents and casts. The decisions of the others are neglected.

5 The model

The model used to test the above new approach of gaming and agents design, is a model of the economy of Venezuela [7] developed by the interdisciplinary group for the study of Venezuela (GIEV). The model has 212 variables and for 70 of them the values must be set by the actors. The other are computed by the basic model.

The model includes:

Actors, information, decisions and modalities
The are 14 actors: Exterior, OPEC, PDV (Venezuela state oil company), Government, Enterprises 1,2 and 3, corresponding to large firms, intermediate and small formal firms and informal enterprises, Workers 1,2 and 3 corresponding to each type of firm, Oil Workers, Government Workers and Central Bank.

The **Supervisor** or director is a special player (he may be a cast actor, but not an algorithmic one) that decides at the beginning of each period the values of some exogenous variables that cannot be calculated by the model or decided by the players. The price of the oil, from which the economy depends, is one of its decisions. The economic growth of Exterior is also a Supervisor decision.

The dependences of the variables explained here correspond to the algorithmic actors but are approximately valid for rational players.

Exterior: using information of the economic growth and strategic reserves to accumulate, he decides how many oil to buy from Venezuela; using the external and internal debt of the government, the **modality** of the Government (see below), the foreign currency reserves and the change of exchange rate, he computes the Country Risk index (a sort of risk to invest, similar to the Emergent Market Bond Index Plus or EMBI+ [8]).

OPEC: Using the band of oil prices (a maximum and a minimum defining an interval within which the production is not changed) and the actual price of oil, OPEC decides the cut of OPEC oil production, from which the model estimates the possible price increase.

PDV (Venezuela state oil company)**:** Using the income data, economic growth (external and internal), and oil reserves, PDV decides the production of oil and derivatives, the internal and external investment, salaries (jointly with the Oil Workers), loans, and, with the shareholder (the government), the oil fiscal income (royalties, dividends, taxes) always a conflictive variable in the real system.

Government is the more complex actor. He knows all the oil variables, reserves, exchange rates, and fundamental macroeconomic variables. He decides income of government workers (jointly with them), investment, social transfers to workers, expenditures in services, internal prices of hydrocarbons, loans given and taken, and different types of taxes.

Entrepreneurs of different types: based on the Risk Country Index, the past economic and profit growth and oil prices, they decide the production for the next period. From these values the model estimates the number of workers and the demand of foreign currency. In addition, it computes the investment, and it adjusts the decided product (and government expenditures) to the currency reserves. This shows a particular characteristic of the Venezuelan economy: government expenditures and private production adapt themselves to use the foreign currency reserves. It is the only case in which the decision of a player is modified. The model computes imports of intermediate goods and services, the salaries, capital consumption and growth, and finally the profits. From an approximate estimation of the number of entrepreneurs of each class, a mean profit per capita was considered and from this the savings and exports of savings.

Workers: The main decisions of workers are the consumption fraction of their income. The income is computed by the model considering salaries, social transfers and taxes. For high income workers (PDV, government and large enterprises) a fraction of exported savings is considered.

Central Bank of Venezuela (BCV): it determines the rate of exchange and interest rates based in reserves and demand.

For all these computations many coefficients (parameters) are needed. For example, the fraction of the government income invested or the fraction the income of a type of workers that is consumed. They were estimated with the

data of five years (without the use, for the time being, of an econometric adjustment). For the **algorithmic actors** many coefficients are also computed.

Modalities

To make interesting experiments, actors may have different modalities. For example, in the case of **Government**, four modalities are considered: Rentist Capitalist (help and protection of national capitalism using the oil rent), Rentist Social (use of the oil rent mainly to social welfare), Liberal (use of oil rent to government services and infra-structure, with low taxes and openness to imports and capitals), Developing Oriented (fostering selected national capital and strategies of non oil exports to reduce oil dependence). "Rentist" and related words are used by venezuelan economists to qualify oil rent distributor governments and rent seeker economic actors.

The coefficients for the first one were computed from the actual system until 2002, after this the Rentist Social was assumed. The data are still incomplete for this modality. The data of the last two modalities were guessed from socioeconomic consideration. Modalities for some other actors are for example: **PDV**: Autonomous and Government Controlled. **Entrepreneurs**: Rentist and Developer. **Workers**: Consumist and Saving Oriented

The Supervisor defines, for each period, the modalities of the algorithmic actors.

General schema of the model.

The basic model (without behavior equations) computes the values of variables and parameters in the following order:

i. The parameters of the algorithmic actors that have to decide jointly (bargaining).
ii. Total selling of oil (buying of the exterior less OPEC cuts) plus internal selling.
iii. Income of PDV and its division in investment expenditures, salaries and transfers to government.
iv. Income of the government from: PDV, profit of state enterprises, taxes, interest and amortizations from loans.
v. Government expenditures in salaries, investments, transfers, subsidies, goods and services. Payments of interests and amortizations.
vi. Government deficit or surplus and external and internal debt.
vii. Private investment, capital consumption, expenditures and private workers employment.
viii. Profits of entrepreneurs.
ix. Total income and, using the consumption fraction, the savings and the export of savings.
x. Consumption, saving and exported savings of entrepreneurs
xi. Expenditures, income and reserves of foreign currency.
xii. Finally the model estimates the GDP, an index of inequality, employment and other macroeconomic variables.

6 Some experiments and results.

Many experiments of the game were made with different people: students, researchers, etc. The early games revealed errors and omissions and were important to develop a stable basic model.

In addition, experiments were very useful to develop the algorithm for the actors and the reading of the records suggested many reforms. In particular, it was noted that the meetings of players for bargaining went beyond the prescribed limits given in the instructions to the players and produced unexpected but interesting arrangements.

The main practical difficulty was to put together the adequate number of actors for several hours (each period of the game needs 20 to 40 minutes). For this reason, the new version of the model, in the final step of development, is based in Internet. New opportunities and problems appear in that development, among them the facility to run a model for several days using participants from different locations, background and professions. Many institutions were interested in this new version.

As an example we consider the following outputs in which we represent the per capita GDP, a global result of the basic model with actor inputs for the following cases (see figure below):

1. All the actors of the cast type, i.e. the decisions of the actors were directly assigned and aproximately were the historical ones. The results computed by the basic model agree fairly well with the historical data for the period 1998-2004. This shows the exactitude of the basic model, that is essentially an accounting model that has not behavior equations for the actors.

2. The result of a game with nine players (Exterior, OPEC-PDV, Government, Entrepreneurs I-II, PDV workers, Government workers, Workers I-II, Entrepreneurs III-Workers III, Supervisor-BCV). Note that some actors were agregated in the same player to simplify the game. This agregation assumes that the effeect of the information transfer between the actors represented for the same player is not significant. In particular Entrepreneurs III and Workers III are usually both considered as "marginals" Different games may produce very different results, many of them unrealistic, but even those gave useful information for the design of the algorithms of the agents. It was madenot attempt by the players to reproduce the historical data for 2000-2004.

3. An experiment made by algoritmic actors (except the Supervisor that was a player).

Modality of the government was changed from Rentist Capitalist to Rentist Social in 2003.

As it was said, these algorithms were designed after the analysis of many games, although up to now, the possible formal methods to extract agent algorithms from game data were not used.

7 Perspectives of the game-agents symbiosis

The **player-agent-cast (PAC)** approach introduced in this paper provides an integrate environment to developing, testing and using complex social models. The cast actors are useful to adjust the models and agents while the players, besides the pedagogical profit of gaming, can contribute, through reports of all kinds, to a rich and imaginative agent design. This allows the developing of the wholly algorithmic model that is suited to controlled experiments. Moreover, it is hoped that gaming is a good didactical introduction to understand the intricacies of the programming of agent models.

Acknowledgements

We would like to acknowledge the financial support to FONACIT-ULA (project 19097-003692) and the discussions and advices provided by the members of the research group in Venezuelan economy (GIEV): C. Domingo, M. Fargier, J. Mora, V. Ramírez , M. Ribas, A. Rojas and G. Tonella.

References:

[1] Emshoff J. and Sisson R. *Design and use of computer simulation models* (Mac Millan: London, 1970)

[2] Guetzkow H. *Simulation in international relations* (Prentice-Hall: Englewood Cliff N.J., 1963)

[3] Witten J.H. Frank E. *Data mining:practical machine learning tools and techniques with Java implantation* (Morgan Kaufmann: San Francisco CA, 1999)

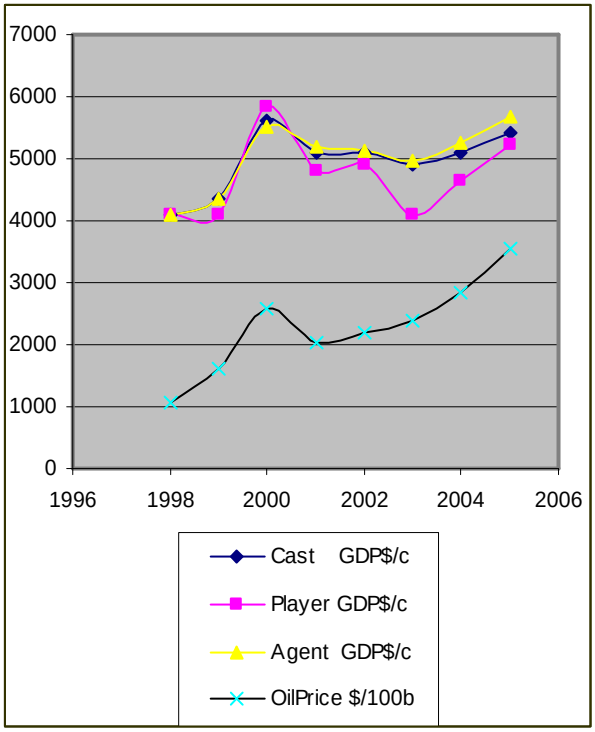
[4] Correa, I. Simulación de la emergencia pediátrica, hospital universitario de los Andes. (Tesis, Universidad Nacional Abierta, Mérida, Venezuela, Diciembre 1999)

[5] Correa I. Agentes para un modelo juego de la economía venezolana. (Tesis de Maestría, Universidad de los Andes, EISULA, Mérida, Venezuela, 2002)

[6] Ferguson N. (1997) *Virtual History: Alternatives and counterfactuals*. Picador 1997

[7] Domingo C. (2004*) Modelo de apertura petrolera. Segundo informe de avance*. ULA-FONACIT Proyecto 19097-003692. Mérida, Venezuela.

[8] Morgan, J.P. The EMBI Plus Index (http://www2.jpmorgan.com/MarketDataInd/EMBI/embi.html, last visit, January 2005)



Experiments with the economic model of Venezuela:

Player, Agent and Cast type of actors were considered. See the strong influence of the oil price on GDP. The effect is inmediate in the capitalist modality of Government in which the foreing currency has a direct effect on private production which is strongly dependent on importations. In the Social modality (after 2002) the effect is delayed, perhaps by the larger but slower direct social expenditure of the government.