Prospecting the future with AI

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***Abstract* — If we were able to foresee the future, we could be prepared to reduce the impact of bad situations as well as getting the most of profiting periods. Our world is a dynamic system that evolves as time goes by. The number of variables that can influence in future situations outnumbers our capacity of prediction at a first glance. This article will show an alternative way to foresee potential future scenarios based on human experts' opinion, what can be considered as a knowledge modeling tool.**

***Keywords* — MAS, Prevention, Prospective, Scenarios.**

I. Introduction

THIS article presents a solution to model human expert's opinion with the aim of generating future and possible scenarios. Although the problem of foreseeing the future is common to any area, an urgent solution is required to those with have critical social repercussions. Fields like national security, demography or economy are examples of areas in which Prospective techniques are applicable.

The goal of our current research is to obtain an applicable technology which enables us to be aware of possible critical scenarios before they actually materialize, allowing us to analyse them and come up with appropriate risk mitigation strategies. The project includes the application of a specific methodology [5] to foresee possible future scenarios of crisis based on the opinion of human experts and the development of multi-agent systems (MAS) [13] to automate the creation of such scenarios. Getting results in this field will enable the achievement of a new technology, and also a suitable methodology for the development of automated environments for the prevention of scenarios of crisis.

II. Foreseeing the future

Before facing a future scenario, the first and fundamental phase is to foresee it. It is better to be prepared for future scenarios rather than suffer their consequences. After figuring out the possible future scenario of crisis, the second phase consists of analyzing all elements or factors which should be modified in order to avoid the scenario to materialize.

The scenarios of crisis are mainly created inside a social environment. A social environment evolves as a dynamic system, with phases of stability, instability, or even worse, of a chaotic nature. The creation of future scenarios based on stable dynamic systems uses classical techniques like Prediction or Projection in which tendencies of historical data are applied. However, inside the field of security it is hard to meet a stable dynamic system which generates scenarios based on predictable guidelines. The collapse of transports, the economic crisis, natural disasters and terrorist attacks are just a few of many examples of scenarios of crisis which are difficult to estimate with techniques based upon Prediction and Projection. Normally, the scenarios of crisis are born due to an accumulation of events that would otherwise be ineffective in isolation; however when occurring together they create an unsustainable and critical scenario.

From a conceptual point of view, our research is going to be developed under Prospective proceedings (instead of Prediction and Projection). The final aim is to develop a technology which is able to identify and alert on the generation of possible social scenarios of risk or crisis.

III. Prospective techniques

Nowadays, the current use of Prospective is more related to the field of social sciences. Prospective tries to create an image of the future, reducing the consideration of the past, but never actually forgetting it. The prospective methods which correspond to an imaginative and intuitive exploration of the future, lie on structural premises based on the past but open constantly to changes [8]. Consequently, the opinion of groups of experts is used for the creation of future scenarios.

The classical prospective method would consist of [3]:

-Submission of a questionnaire to the expert group to grade the probability of each event.

-Achievement of the common criterion of the group by using the Delphi method.

-Use of the cross impact technique to modify the conditional probability of each event.

-Elaboration of the cross impact technique to obtain the most probable scenarios

-Strategic interpretation of the most probable scenarios.

Initially, a group of analysts select the area of study and identify a list of possible events related to a future scenario.

After listing the events linked to a scenario, a human expert group has to research the influence that each event has on the others. This enables a more thorough study in terms of probabilities. The Delphi method [6] is used to bring the group to a common conclusion. Since the events probabilities are not isolated, the Bayes theorem has to be applied to obtain conditional probabilities. After that, the analysts group has to produce a set of scenarios with their consequent probabilities. Of course, it is assumed that the probability of all possible scenarios is equal to 100%. Those scenarios with higher probability will be chosen for a detailed sensitive analysis. We can follow a similar process in analysing different contexts, like those related to banking, commerce, military operations, industry, disruptive technologies, etc.

After the application of the method we obtain a matrix with future scenarios graded by their probabilities.

The following figure shows an example of a matrix with ten possible scenarios. In the first column the events that can be involved in the scenario are listed. In the bottom line the probability for such scenarios to happen is given.

Ev	Sc1	Sc2	Sc3	Sc4	Sc5	Sc6	Sc7	Sc8	Sc9	Sc10
1										
2										
3										
4										
5										
6										
7										
8										
Prob	6.77	3.22	2.87	2.79	2.78	2.55	2.21	2.20	2.13	1.44

Cells in grey: the event doesn't exit

Figure 1. Example of a matrix with probable scenarios

IV. A MAS-ORIENTED ARCHITECTURE APPROACH

In this section, we illustrate our Multi-Agent System approach within this class of domains. The objective consists of the construction of a model that faces the problem from a different perspective from the classical statistical prospective methods exposed in the previous section. We use possibilities graded by linguistic tags instead of probabilities, we take a different track towards the problem compared to classical methods.

Each agent of the MAS has been developed to carry out a specific function; all of them are based on Artificial Intelligence procedures [12] [14]. Taking into account the final objectives of the prospective technique (envisioning future scenarios and possibility of modification of those that can be critical); and on the other hand, the technological advantages of using a MAS-oriented architecture, we can summarise the knowledge extraction and knowledge exploitation as follows:

-Submission of a questionnaire to the expert group to grade the possibility of each event expressed with linguistic tags.

-Achievement of the common criterion of the group by using fuzzy logic procedures and generation of the set of most possible scenarios.

-Submission of a questionnaire to the expert group to grade the possible results of the most possible scenarios.

-Introduction of a real scenario and declaration of the general variables: intensity of migrations and level of social stability.

-In case of an undesired result, introduction of the desired variables and activation of the analyser Agent to look for the events that have to be influenced or modified.

From a methodological point of view to get to a solution with MAS, we have implemented a number of phases, as follows [5]:

A. Statement of the Problem

Our purpose is to construct a planning system based on MAS, with capacity to generate future scenarios by using prospective methods. Thus, this new approach helps us overcome the limitations and criticism pertinent to the classical Prospective technique [10].

B. Establishing the System Limits

An expert group will be in charge of defining the events that belong to a specific scenario. By applying fuzzy logic procedures, linguistic tags can be defined in order to identify each event's intensity. The system will yield a scenario as a result of such events.

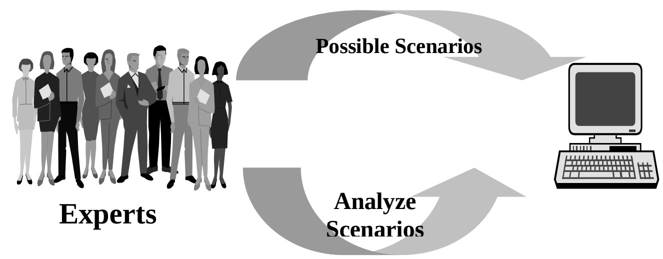

Figure 2. Knowledge extraction

C. Objectives Identification

The objectives that we are pursuing are summarised as follows:

-To provide a scenario as a result of the set of events and their intensities as given by the expert group.

-To perform a sensitive analysis in order to determine which events can have a major influence on the scenario and how to obtain an ideal scenario by changing as few events as possible.

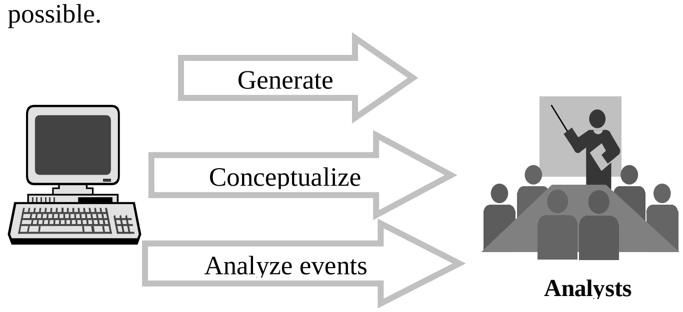

Figure 3. Knowledge exploitation

D. Data identification

The input of our planning system will be the set of events for a specific situation. These events will be graded for their relevance. The input will be provided by a group of strategic analysts.

The output of our planning system will be the global description of a scenario composed by several items and their corresponding relevancies. They will be defined by using linguistic tag variables [17].

Initially the output that matches a specific set of events will also be defined by the group of analysts.

The user could define an ideal scenario by modifying the relevance of the scenario items. The planning system will respond with a list of possible solutions by describing the events to be modified.

E. Rules Identification

We can identify two main processes in this MAS model:

-Matching events and their relevancies to scenarios defined by items and their intensities.

-Prospecting the range of possible events we can modify in order to obtain the ideal scenario.

F. Selection of Agents

We have used a neuro-fuzzy network [9] [17] aimed at reproducing human knowledge and experience in order to create a scenario by studying the influence among events. Thus, we talk about possibilities instead of probabilities and avoid using complex probabilistic techniques which are in most cases unclear for the human expert group.

We have implemented an intelligent search to make the sensitive analysis of variables (events) that can help us to arrive at an ideal scenario.

G. Model Building

We have built two agents in the MAS-oriented model: the Classifier agent and the Analyser agent. *The first one* will obtain the scenario after analysing the proposed events.

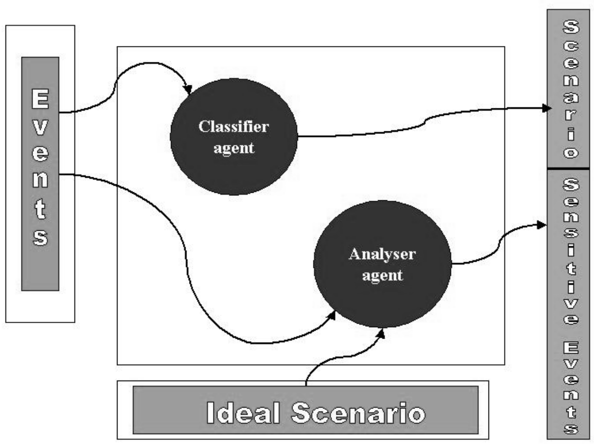

Figure 4. Strategic Planning Model

The process would be as follows:

The group of strategic analysts proposes different sets of events to the expert group. Each produced scenario will represent a global state as a result of the influence of the events. This state will be defined by the expert group.

The knowledge extracted from the expert group will be used to train the Classifier Agent. Once the Classifier Agent has been trained, it can be used to generate new scenarios by presenting it with a set of events never used in the training phase. Thus, the knowledge of the expert group has been transferred to the Classifier Agent.

It has been necessary to develop the classifier agent by means of fuzzy logic, since most of the times we express data in terms of adjectives. It is very common to define the relevance of the events or objectives in terms of linguistic tags. In this environment, Fuzzy Logic [15] provides a set of powerful tools.

The *second agent* is useful in determining which events can be influenced by us in order to arrive to the desired scenario.

It is possible that the scenario doesn't match our expectations. In this case, the Analyser Agent is responsible for looking for the events which are to be influenced in order to get closer to an ideal scenario.

We have used intelligent search as an Artificial Intelligence procedure to construct the Analyser Agent.

In Figure 4, we can observe the inputs to the model, the Agents we have designed to build the model, and the results we can obtain after its use. The model can be used for two purposes: to obtain a scenario as a result of the events, or to present an ideal scenario and look for the events that we have to influence in order to obtain such scenario.

In summary, the Classifier Agent receives the events and yields a scenario, while the Analyser Agent receives an ideal scenario and the original set of events and provides the list of events to be modified in order to obtain the ideal scenario.

V. A CASE STUDY FOR SOCIAL STABILITY

As a result of the application of the MAS-oriented model, we have developed a software prototype to validate the model in a real prospective problem. The prototype can be used to accomplish three different objectives: to produce the most possible scenarios, to foresee the result of a specific scenario, and finally to analyse which events should be modified to get an ideal scenario.

As an example, we are going to solve a strategic planning problem that deals with the future migratory movement in central Europe. The events and scenarios are fictitious. We want to know the possible influence of a set of events to create a political and social scenario.

The events are:

1-Higher restriction to obtain the nationality in the EC
2-Eastern Europe countries are accepted in the EC
3-Racial riots happen in European Cities
4-Worldwide financial crisis
5-Negative birth rate in Europe
6-Strong epidemic in Africa
7-European measures to support African economies
8-Economic instability in Russia

With the use of the software prototype we can get the following:

-Set of the most possible scenarios.

-Consequences of the most possible scenarios regarding two general variables: intensity of migrations and level of social stability.

-Introduction of an ideal scenario.

-Events that should be influenced or modified to obtain the ideal scenario.

A group of strategic analysts have created a set of ten questionnaires to be studied by the expert group, who have to qualify them with adjectives like 'Very possible, Possible, Not possible'.

Ev	Sc1	Sc2	Sc3	Sc4	Sc5	Sc6	Sc7	Sc8	Sc9	Sc10
1										
2										
3										
4										
5										
6										
7										
8										
VP,P,NP										

Cells in grey: the event doesn't exit

Figure 5. Possible events questionnaire

The answers from the expert group are treated with fuzzy logic procedures. The extracted knowledge is fed into the Classifier Agents. The software prototype is ready to be used. It yields the list of the most possible scenarios. The prototype found a total of 49 highly possible scenarios that can be displayed or printed. The group of strategic analysts has to decide whether to choose all of them or whether to choose only the most relevant. The group decides that the scenario in which all events are present has to be analysed in depth (Sc1). The analysts submit a new questionnaire to the expert group with ten possible scenarios. They will grade the possible results in terms of intensity of migrations and level of social stability.

Ev	Sc1	Sc2	Sc3	Sc4	Sc5	Sc6	Sc7	Sc8	Sc9	Sc10
1	H	M	L	H	H	H	M	M	L	L
2	H	H	H	L	M	M	H	M	H	H
3	H	H	M	H	M	M	M	H	L	H
4	H	H	H	H	M	M	L	H	L	H
5	H	B	H	L	H	M	M	M	H	L
6	H	H	L	H	M	L	M	H	M	L
7	H	H	H	H	H	M	H	M	M	H
8	H	H	H	H	M	L	L	H	L	H
Migration										
S. Stabili										

H=High; M=Medium; L=Low

Figure 6. Possible scenario questionnaire

The answer of the expert group is treated with fuzzy logic procedures, and again the extracted knowledge is forwarded to the Classifier Agents. Once the events that belong to the scenario are defined, the group of strategic analysts presents one situation which is the most possible or perhaps the one which will result in the worst case scenario. Inputs are introduced in the prototype.

Eventos	Influencia
Higher restriction to obtain the nationality in the EC	Medium
Eastern Europe countries are accepted in EC	High
Racial riots happen in European Cities	High
Worldwide financial crisis	High
Negative birth rate in Europe	Low
Strong epidemic in Africa	High
European measures to support African economies	High
Economic instability in Russia	High

Figure 7. Possible events

The classifier agent will produce a global scenario definition in terms of intensity of migrations and level of social stability.

Escenas	Intensidad
INTENSITY OF MIGRATIONS	Medium
LEVEL OF SOCIAL STABILITY	Low

Figure 8. Expected scenario

The group of strategic analysts decides that it is dangerous to permit the creation of a social environment with a low level of social stability, so they introduce an ideal scenario with the intention of knowing the events that should be modified.

Escenas	Intensidad
INTENSITY OF MIGRATIONS	Medium
LEVEL OF SOCIAL STABILITY	Medium

Figure 9. Ideal scenario

The prototype has generated a great number of solutions in a short period of time. The solutions are sorted and listed according to the number of events to be modified.

	Descripción del evento a modificar.	Grado de Influencia.
Solución..1...		
	Strong epidemic in Africa	Low
Solución..2...		
	Higher restriction to obtain the nationality in the EC	Low
	Negative birth rate in Europe	High
Solución..3...		
	Higher restriction to obtain the nationality in the EC	Low
	Negative birth rate in Europe	Medium
Solución..4...		
	Higher restriction to obtain the nationality in the EC	High
	Strong epidemic in Africa	Low

Figure 10. Events to modify

In summary, given a specific set of events that are considered as most possible, we have obtained a scenario in which social stability is low. To get a medium level of social stability we should act according to one of the solutions generated by the prototype (e.g. to reduce the possibility of 'a strong epidemic in Africa').

VI. Related Works

The problem that we address consists of the construction of agent-based models to solve a specific operational problem such as foreseeing future undesired social scenarios. We tackle this problem with a methodological approach, with the aim of preventing undesired future scenarios form happening. Consequently, the two main fields that are related to this paper are: MAS-oriented architectures and Prospective planning methods

The concept of agent generation is not new and has been addressed in many publications such as in [11], [16] and [7]. Agents have to be constructed under a specific objective. There are many papers related to methodologies in this field; however, most of them are targeted at obtaining efficient communication among agents as in [1], [2] and [4]. This paper tackles the specific construction of MAS-oriented models to solve strategic planning problems in the field of security. Prospective is a well-known technique based on statistical methods, as described in [8] and [3]. In this work a new solution is given on the basis of a MAS-oriented architecture. The model is built by using a methodological approach [5].

VII. FUTURE WORKS

In order to validate the architecture and new approach showed in this article, in 2010 we are going to develop some prospective studies together with the Spanish Institute of Strategic Studies. The initial scenarios on which we are going to work are:

- The strategic and political future of Afghanistan
- The future of the North Atlantic Treaty Organization
- Policy and Security in the European Union

The results in these areas will be published at the end of 2010. We are also planning to present a large scale European Project under the FP7 to validate the concept of MAS-oriented architectures for prospecting in field of security.

VIII. CONCLUSION

In this article we have presented the idea of Prospective as a useful tool to envisage future and possible scenarios of crisis or risk. We have illustrated the use of Prospective in domains where decisions with long-term impacts need to be taken. One of the most important advantages that this work can offer is the possibility of foreseeing future scenarios with computer aided control. This characteristic implies the automatic reorganization in real time if the scenario changes or new biased events show up unexpectedly as time goes by. Furthermore, by comparing our work with classical methods, we found the following advantages:

- A natural use of linguistic tags instead of probability to define the possibility or intensity of events.
- The achievement of a common criterion of the expert group without using the Delphi method.
- The use of the concept of scenario implications expressed with global variables.
- A Sensitivity analysis of the events that should be modified in order to obtain an ideal scenario.

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