Towards a Collection-Based Knowledge Representation: Application to Geo-political Risks and Crisis Management

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Abstract

The paper aims at presenting the use of a collection based knowledge representation to improve a geo-political risks and crisis management system. Initially, the system was built onto classic ontological knowledge representation for the use in a multi-agent system. Events occurring were classified using object matching with model events. After comparisons with type scenarios, the system could predict if a crisis can happen. A better understanding of crisis appeared and the system was completely working but, only if the main agent which has the task of questioning the user was replaced with a human because an ontological model is not well adapted for such work. This gives us motive to reconsider the role and the design of the system, stressing the need of a better knowledge management. A collection based knowledge representation seemed to be a good alternative to gather and organize critical information without losing time and information in a type matching process. It is one of the first times this concept of collection, well known in the artistic domain is used in an IT system. We will explain this particular knowledge representation through the successful example of the CHEOPS Project.

1. Introduction

1.1. Industrial context

When a company wants to offer a new tender for its clients in the geopolitical crisis management domain, it has to solve a dilemma. Firstly it has to build rapidly, a functional product in order to take a place on this well discussed market but on the long term this strategy isn't sufficient. An incremental design process is required in order to organize architecture, to bring out functional and ergonomic specifications, and to structure an ontological application such as a multi-agent cooperation model.Furthermore a reflection on what a crisis is and how to represent it helps to make the model more accurate.

1.2. The CHEOPS project

The CHEOPS Project is based on a fictive crisis simulation in which a middle-east country (MEC) has some defence agreements with the French government [1]. The French army has to defend MEC from any possible invasions from a foreign country but at the same time the French army must not take part in interior troubles resolution and so it is critical to determine if there are some threats against MEC; from where, who and what can be the consequences. In such an environment with lots of constraints from different type: geopolitical, economical, ethnical, etc… it is essential to act in the right manner in the right time. Before the CHEOPS project the knowledge necessary to manage such geo-political crisis was held by some specialists, working in the area for years and their expertise was lost in vain when they leave that particular area. The CHEOPS project is a complete system aimed to use new tools offered by information technology like artificial intelligence, knowledge representation, geographical information systems (GIS) and databases to gather this knowledge and use it to help militaries to better understand the situation and to anticipate the events.

1.3. The scenario

In order to test the system in real conditions and to better understand needs and constraints, a scenario has been created as following: MEC is involved in a civil war where the rebels opposing the official government, are helped by a threatening neighbour country (TNC).
On the first day troubles appeared in some barracks, near the north frontier without having the possibility to know the causes of these troubles.
On the second day street Fights have been signalled in MEC capital near the national assembly, the consequence is that governmental troops have been sent from the north area to the capital.

On the third day, the airport of the capital has been bombed but the enemy fighter planes have not been identified. Experts are analysing bomb impact pictures. Rebels have old Soviet planes which would not have permitted them to commit this bombing.

1.4. What is a crisis? How to manage it?

Before all it is essential to define what is a crisis. A crisis can be defined as a pool of events that, in a particular context will lead to some unwanted situation [2]. In addition, we can define the crisis concept showing differences between permanent and crisis states. In the crisis state, the situation analysis is made harder because human discernment is wasted by stress, importance of stakes and indeed cost. The crisis generates a temporal paradox because its analysis and linked tasks, like communication or justification of choices, need time incompatible with crisis resolution. One man can not manage a whole crisis by himself like in the Marc Aurèle time [3]. Only virtual or real human groups working together can face a dynamic and complex situation [4], and so it is a typical multi-participant activity. To meet this multi participant requirement and match it with an IT based system, a multi-agent cooperation model has been realized [5-6].
In such multi-agent system, the challenge is to make human and artificial agents working together at the knowledge level (cf. Newell [7]). In addition, agents have to share the same knowledge which is on the basis of the crisis management but the knowledge is a generic concept and can be represented in different ways. The way the knowledge is represented will play an important role because this representation has to be significant and efficient for all the agents of the system and so knowledge representation seemed to be the main challenge of the project.
This paper aims at studying two methods of risks and crisis management: a first one based onto an ontological knowledge representation where each event is paired with a type event to fit in well known data structures, the second one, more flexible and less reducing the meaning of events is a collection-based knowledge representation

2. An Object-based knowledge representation

2.1. Crisis management within an object-based knowledge representation

To manage a situation with an "object" approach, the system matches any new event with a type event which has been identified from past events and crisis analysis and entered into the system. The same matching operation is done with situations: the system identifies the situation from all the events which happened in a given time and match it with a type situation. In order to predict the future situation, the system make analysis from past set of events entered in the system as ontologies and determines which one has the most probability to happen.

2.2. The multi-agent cooperation model

There are six main agents. The Military Attache (MA) collects information and sends argued reports on the situation (it is a human agent), the event database manager (EDM) classify each event, the map database manager (MDM) use a GIS to manage different maps, provides zoom and can put in relief thematic layers , the messenger (MSG) transmits messages (it is a human agent), the news report analyst (NRA) translates text news reports into the database format, the tactical simulator (TSIM) makes calculations and simulations in order to estimate current strength or necessary time to move units, and the arguer (ARGU) lets the user from tactical hypothesis to search corresponding events in the database and on the opposite, to analyse a pool of events in order to find strategic hypothesis.
Based on most of the activities on cooperation between human agents, we used the Maieutic approach [8-9] where the cooperation can be modelled with high level dialogues between agents. Agents try to cooperate; they share a working memory where a history of their dialogues is recorded. In order to illustrate this model, we will use an artificial problem resolution dialogue between local crisis management computer agents.

2.3. Details of a crisis management situation

The Table 1 presents an extract from the virtual dialog between agents. In this dialog we can see that the MA begins with an hypothesis: "interior troubles" because there are some hidden reasons that make him to prefer the hypothesis which does not need an intervention in order to avoid compromising. The arguer ARGU disagrees with MA hypothesis because he finds information that discredit MA event's classification. The MA is lead to test the ARGU hypothesis and ask him if he can show that rebels are implied in last events. ARGU does it and asks the tactical simulator (TSIM) to make a simulation of forces present in the north border area; the tactical simulator finds that the force ratio is highly in favour of the threatening neighbour country (TNC), ARGU reports to MA the situation.

Table 1. Extract from a dialog between agents in the problem resolution process.

1	MA: Did you receive the description of the events in the capital? It seems like the protestations are organized by some students from the opposition. This confirms that events in the barracks near the north border are probably just the consequence of a problem linked with the soldiers' salaries and so it is interior troubles…	**Build-Event Classify-Event Test-Type-Event Select-Hypothesis**
2	ARGU: I disagree, the cause of events in barracks is unknown because the M'Boutoul ethnic group implicated are with the rebels.	**Classify-Event**
3	MA: Can you show the possible role of rebels in recent events?	**Test-Type-Event**
4	ARGU: Yes! I can demonstrate it. (Demonstration following)	**Classify-Event Test-Type-Event**
5	MA: What are the consequences?	**Generate-Strategic-Hypothesis**
6	ARGU to TSIM: Can you make an estimation of forces present in the North area by taking the last events into consideration ?	**Generate-Strategic-Hypothesis**
7	TSIM to ARGU : Considering the rebel forces and TNC regiments the force ratio is unfavourable for MEC	**Generate-Strategic-Hypothesis**
8	ARGU to MA: If TNC rebels are implied, this means that an attack in the north area may happen at any time. The Chadian defensive potential is low in this area	**Generate-Strategic-Hypothesis**
12	MSG intervention : I just received the news that we were waiting for : It is possible that fighter planes which have bombed the Capital Airport were from the Marchetti SF-260 type	**Build-Event**
13	MA to ARGU : You may be right	**Select-Strategic-Candidate-Hypothesis**
14	ARGU: Why this change of opinion ?	**Select-Strategic-Candidate-Hypothesis**
15	MA: Because the airport bombing has probably been committed by Libyans who have this type of fighter planes, which can mean that a huge invasion may be in preparation	**Build-Event Classify-Event Test Event Select-Strategic-Candidate-Hypothesis**

The messenger (MSG) brings the confirmation that fighter planes which bombed the capital are a type of planes hold by TNC and so MA is lead to change his mind and to admit that passed events were not caused by some interior troubles but are evidence of an invasion in preparation.

This dialog is a part of a bigger one between all the agents managing all the events of the scenario.
A very interesting fact is that all this dialog between agents can fit into an inference's structure which is a well know graph in the social sciences domain [10-14] and can be easily be explored by IT tools.

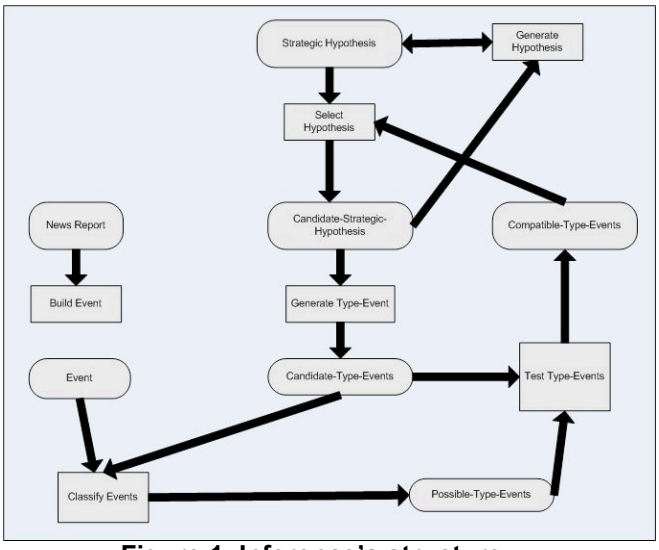

Figure 1. Inference's structure.

2.4. Conclusion

The system is a success because it fulfilled its role: The human user is in permanent contradiction with an arguer agent who always tries to present other parts of the situation. The goal is to make the user sure of is decision and making him passing out non factual opinions based on hidden reasons. This is only possible if the arguer is replaced by a human. We could not manage with classical ontologies to make a virtual agent capable of questioning a human in his language (Cf. Turing's test [15-16]) because it is a task which has to be realized at the knowledge level by an agent with high abstraction capabilities to figure out that a hypothesis is not reliable without testing all the possibilities. In addition, a computer, which use, logical relations to make hypothesis is limited in its hypothesis making process because all the situations are not logical. Given that this agent cannot be replaced by an artificial agent, the system has to be re-think.

2.5. How to re-think the crisis management system?

A good way to re-think the system is to think in terms of knowledge representation. Let us analyze the knowledge representation of the CHEOPS project. An event was paired with a type event, but the events are highly dependent of their context: For example a trouble in a barrack near the border will not have the same consequences as troubles in barracks in the middle of the country. In addition the same troubles will not have the same consequences if they happen in a crisis suspicion situation or in peace situation. Within these examples we can see that an event is spatio and temporal dependent and matching it with a type event will lose an important part

of information. An Object based knowledge representation cannot well represent this spatio-temporal dependence clearly and so we studied a concept well known in the artistic domain: the collection.

3. A Collection-based knowledge representation

3.1. Collections versus classes

For Piaget [17] the main difference between collections and classes is that a collection exists only because of the union of its elements in space whereas elements of a class can be separated in space without changing class properties. For example: cats have in common certain properties whereas other properties are common with other animals but in this definition of a class there is no property or relation linked with space [18]: cats can be dispersed in space randomly or in groups, it will not modify the class properties. On the opposite, a collection like a collection of paintings is a whole: a painting cannot be removed from the collection without modifying the collection itself. We can also distinguish figural collections and non-figural collection. A figural collection is a figure itself, not mandatory linked with relations between its elements. In this project we will just focus on these figural collections which are the only ones which can represent spatio-temporal dependence needed in the crisis management. Many researches have been going on the concept of collection itself [17-24] and on their possible implementation in computer science to give an alternative to object-based data representation [25-27]. This work takes part to the exploration of this new field of research using collection as a knowledge representation.

3.2. Why a collection?

As we have seen before that, a crisis is a whole dependent of time and space and so a crisis can be seen as a figural collection of events. The difference with the object based model is that there is no a priori event analysis because there is no type event matching: the system manages a collection of event of different types with spatio-temporal dependencies.

3.3. Crisis management within a collection -based knowledge representation

Within the new knowledge representation the system can play a new role: it can be seen as a creativity helper. We renounced to build an arguer making hypothesis at the knowledge level. We decided to build a system which suggest embryos of hypothesis in displaying events and information in different ways, helping user's creativity.

We can take a typical example of figural collection: a painting museum as an analogy to imagine what could be the new crisis management system.

In a museum the main agent is the curator; his role is to manage the collection. The subject of the collection has been previously defined (e.g.: impressionist paintings) and he has to buy new paintings to keep the collection up to date, to arrange and rearrange spatially the collection in the way it is displayed to the public (with the help of other agents who put the paintings in place), he can also conduct research on archives of the collection (with archivist agents) and rearrange the collection between the displayed collection and the collection's archives or reserves (with reservist agents). As we have seen before, a collection is a whole and the collection's archives or reserves of the collection have the same importance as the displayed part. The following table shows possible analogies between museum's curator and collection's curator in a geo-political risk and crisis management system.

Table 2. Analogies between curator's role in a museum and in a geo-political crisis management system.

	Museum	Geo-political crisis management
1	Manage the collection of Paintings	Manage the collection of Events
2	Buy or sell paintings to keep collection up to date	Integrate new events in the collection
3	Arrange and rearrange spatially the collection for public (humans)	Arrange and rearrange spatially events in the system interface for public (human and artificial agents)
4	Conduct research on archives (with archivists) to find new information on paintings	Conduct research on archives(with archivists) to find new links between events and situations or new information
5	rearrange the collection between the displayed collection and the collection's archives or reserves to refresh the collection	rearrange the collection between the displayed collection and the collection's archives or reserves to bring creativity by showing new embryos of hypothesis

Every museum has a displayed part of the collection and a part of the collection in the reserves. The coherence of the collection is guaranteed by the collector or the curator.
The way the collection is displayed is crucial because it is more than paintings put together. Each painting has its meaning for the collection just displayed with others. When displayed in a certain way the paintings tell a story and bring some feelings; displayed in another way they will also tell another story and bring other feelings. It will be the same for the geo-political crisis: displayed in a certain way events will tell a certain story and bring hypothesis of what will happen. The user interacts with the collection to arrange and re-arrange it accordingly.

3.4. The new mutli-agent cooperation model

The new multi agent cooperation model is composed of eight main agents:
The 2 main agents running in foreground are the MA (human) and the Curator (CUR).For the crisis management system the arguer can be seen as the curator: he displays relevant events in the right place and the right time with the help of the spatial display agent (SPDIS). The time event displayer (CHRON) shows in another widget animations of events in a given time

We also have some agents running in background: The archivist (ARCHV) conducts researches on the past crisis archives, the reservist (RSRV) manages the reserves of the collection (the part of the collection which is not displayed), an image analyzer (IMAN) and the tactical simulator (TSIM) which is almost the same like the one design in the past using graph handling calculations and forecast of forces, time to move units using classical graphs handling methods.

3.5. Details of a crisis management situation

To test our system we can take the same military attaché who prefers to consider the "interior troubles "hypothesis in order to avoid compromising and we can see how the agents solves the problem : In this dialog all the interactions between MA and CUR are done graphically via the user interface.
On the first day when some rebellions in barracks near the border appear, the curator CUR opens a new collection named "troubles near border". This event is displayed spatially (display_event(event,location,time)) near the border of the threatening neighbour country (TNC). With this the Military Attache MA is invited to consider that TNC maybe implied in that event. But MA does not consider this event significant enough to make simulations or hypothesis

On the second day when protestations in the capital appear, CUR puts this event in a temporary collection because it doesn't know if these two events are linked. The event is displayed and the supposed link between the two events is suggested to MA by a special widget.. MA point out the word "student protestation" and show it to CUR that this event is not linked with borders troubles. CUR asks MA if he can investigate between possible links. MA agrees and CUR asks archivist ARCHV and reservist RSRV agents to investigate links between this two events.

Table 3. Extract of the problem resolution between MA and CUR.

1	CUR to MA:	Collect_Event() Display_Event()
2	CUR to MA	Collect_Event() Display_Event() Find_posiible_links() Display_possible_links()
3	MA to CUR	Point_possible_link_incoherence()
4	CUR to MA (auto –reply to last MA intervention)	Link_investigation_authorization()

On the third day there are some bombings on the capital airport: CUR collects this event and displays it. The possible link between the two operation zones: the capital and the border are still in evidence. MA will try to find if this event is linked with a possible foreign treat or interior troubles. MA knows that the type of plane used can lead to the responsible of the bombing and so he will show graphically using special widgets that information on the type of plane can confirm or not the link.

The background agents find that the M'Boutoul ethnic group implied in the troubles in the barracks near the border is engaged with the Threatening neighbour country TNC. The information is displayed in over the link between the two operation zones as a possible justification. MA can agree with this justification by clicking to this widget. He wants to have a confirmation: he asks CUR to estimate forces in presence around the border during the past 3 days. CUR mobilizes the tactical simulator TSIM to make the simulation for these 3 days and CHRON, the time event displayer, to show MA an animation showing the evolution of forces in presence in this zone during the past 3 days. It shows that in reaction of protestations in the capital, troops have been sending from the border to the capital and the present forces are unfavorable for MEC. It leads MA to agree with the link between the events in the border and in the capital. The hypothesis concluded by MA behind all these events is a possible invasion from TNC and so the collection is renamed in consequence.

The information on the type of plane used for bombing arrives: these planes are TNC planes and hence the hypothesis of a possible invasion from TNC is definitely confirmed.

3.6. Conclusion:

This artificial problem resolution is a success because even if the MA starts with the hypothesis "interior troubles " the system makes him change his mind by

displaying information in a way that brings him embryos of hypothesis and justification. This has been possible by using collection as the knowledge representation. An interesting point to stress is that all the dialogues between the agents are technically possible because they do not need to dialog in the knowledge level; the curator manage the collection of events and for him each event is of same importance.
In addition, this knowledge representation allows us to have a real dynamic knowledge representation because each event is handled as it happens in real time. The meaning of this event appears instantly when it is incorporated into the collection. In an object based knowledge gathering, meaning of the event is conjectured after it is matched with a type-event analysis which takes time that we do not have in a crisis situation.

4. Conclusion

Here we have designed a system that brings creativity because it does not reduces the meaning of the events in matching them with type-events. On the knowledge level, words mean much more for humans than for machines because an ontology (which is the way for a machine to represent links between words) can not be perfect and it is impossible to design an artificial agent capable of knowing all the mean of the human language. And so it appears very important to display events without interpreting it. The collection appears to perfect tool to do so.

In addition in the design of the CHEOPS system we successfully made two main knowledge representations working together. Some agents working with classical object based methods and the rest working with collection-based methods.

During the development of this system we found a new type of agent that could be useful: an inquirer.
As we have seen in the Piaget's definition of figural collections [17], a collection is a whole and so a lack in the collection will change the collection itself. We could use this particular property to design an agent capable of identifying lacks in his knowledge that makes the collection incoherent. If this agent manages to gather the information which lacks, the collection is kept coherent and the knowledge is increased but if it finds an information that cancel the coherence of he collection it can detect a possible failure in the knowledge and in the links between events. This agent could help to predict crisis and avoid it.

This work is still in progress and its development is linked with a philosophy workshop on the "inquiring process". We are hopping that it will lead to improvements in the concept that will allow us to implement it with IT tools.

This collection-based knowledge representation can be used in many domains where a object-type matching loses a part of the object. We can find many examples in different domains: In digital data management it can be more relevant to manage a whole collection of files than to match it with their type. For example, it is too limiting to match a song with a music style and it limits the choice of the listener [28-30]

A lot still has to be done but the matter is scientifically rich enough to let a great deal of researchers in multidisciplinary domains to bring their contribution. This subject is a challenge for us because beyond technological and scientific aspects invites us to think about our intelligence and the way we are representing the world.

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