# Context's modelling for participative simulation

**Romain Bénard, Cyril Bossard, Pierre De Loor**
CERV Centre Européen de Réalité Virtuelle
25, rue Claude Chappe
BP 38 F-29280 Plouzané (France)
email :{benard,bossard,deloor}@enib.fr

### Abstract

This paper reviews the interest of using context for participative simulation in virtual environment for training. Our aim is to simulate some cognitive mechanisms in order to obtain credible agent's decision-making. Another interesting aspect is the explanation needed when the learner makes a mistake. We argue, in this article, that context is a good concept to give better explanations. We describe a case-based reasoning architecture using a high level description of context. The situation's context is divided in social, environmental, historical and personal contexts. We introduced a context representation to use with a case-based reasoning system. At last we show an example of an agent decision-making.

## Introduction

This article presents a context modelling to make up a Virtual Environment for Training (VET). This VET will be used to simulate dynamic situations. For the learner, the aim is to recognize and to manage this type of situations.

VET uses Intelligent Tutoring System (ITS) (Rickel & Johnson 1998). Those tutors implement pedagogical strategies. Those one allow to have a pedagogical support which consists of interventions to guide the learner in his task. There are various ways to help him, for example by asking about his mistake or by showing him the significant information that he has missed. This approach has been used in various VET like (Querrec *et al.* 2004)

Our work is focused on a complex problem. We are interesting in dynamic and collaborative situations. The learner will not follow a well defined procedure, so his mistakes are not identifiable and not easy explainable. Moreover, he has to be immersed in a virtual environment and has to collaborate with autonomous agents to solve the problem. This is called participation. Participation is the integration of *the human in the loop* (Dautenhahn 1998; Schuler & Namioka 1993), which fully takes part in the resolution. It is necessary for the various actors of the system to understand each other in order to communicate.

Copyright © 2006, American Association for Artificial Intelligence (www.aaai.org). All rights reserved.

This article deals with a contextual approach of this problem. We put forward advantages of context modelling for decision-making of autonomous agents and explanations. One can find a lot of definition of context. We decide to keep the definition given by P. Brézillon and J-CH Pomerol (Pomerol & Brézillon 2001): *A context is a collection of significant conditions and surrounding influences that make a situation unique and comprehensible.*

A contextual approach will allow a better explanation (Brezillon & Pomerol 1999) of mistakes done by the learner. We have also based our work on the studies of R. M.Turner (Turner 1993) which considers that the context-sensitivity is fundamental to create an *intelligent* behaviour. (Mendes de Araujo & Brézillon 2005) underlines that the context allows to better take into account interactions between the human and the machine. We argue that it can be a really good way to share knowledges between human and agent in order to put in place the substitution concept described later.

This article is structured as follows, the part 2 explains what we mean by dynamic and collaborative situation and describes the agents architecture. The part 3 presents our approach of context modelling. This part begins with a definition of context, continues with our formalism and ends with advantages of our definition. The part 4 deals with the actions selection. At last, we show an example of the decision-making of our agent applied to a soccer simulation.

## Collaborative and dynamic situation

Dynamic and collaborative situations can be found in various domains of teamwork with time pressure (rescue, security) (Cellier & Hoc 2001; Rognin, Salembier, & Zouinar 1998) or in collective sports (Argilaga & Jonsson 2003).

- This implies various protagonists that interact in a common environment and have to solve a problem. The environment state and the protagonists one form the situation. A collaboration between protagonists is needed in order to solve the problem.
- Situation data can be interpreted according to the protagonists point of view. Those agents are able to adopt

epistemic point of view on the situation according to their roles.

- Situation interpretation allows a decision making that depends on protagonists objectives. The decision making is materialized by an action or interaction. An action modifies the environment.
- The last point implies that the situation is dynamical. Elements that are kept to take a decision change during the resolution. This evolution is function of the protagonists behaviour, but it is almost linked to environment. This one changes quickly, so the decision has to be taken under time pressure. It is not possible to have complex negotiation mechanisms. This does not exclude all type of communications. But, this one is simply brief and often non verbal.

Behavioural autonomy of agents, linked with their interactions and the environment role makes those situations harder and more uncertain (Woods 1988; Amalberti 1996; Cellier & Hoc 2001). Learning, understanding or simulating their recognition is a hard task. Creating a pedagogical aid implies to be confronted to those three tasks. To do that, we introduce an architecture based on the notion of context.

## Architecture for training in collaborative and dynamic situations

The architecture of our virtual environment is shown on the figure 1. We use context and CBR system to create this architecture, this have been called Context based reasoning (CxBR) and have introduced in (Gonzalez & Ahlers 1998). A similar modelling for a personal assistant can be found in (Kofod-Petersen & Mikalsen 2005). Each agent has a behavioural cycle, that begins with perception filter depending on the agent role. This perception is compared to the old one that are stored in a case base. A context associated with a corresponding action is called a case. The most similar case is extracted and allow to define the behaviour for this type of situation. The behaviour consists in doing or not an action. Moreover we argue that using context and CBR will allow a better explanation of the reasoning according to a situation. Learner mistakes will be catch in an easier manner thanks to CxBR.

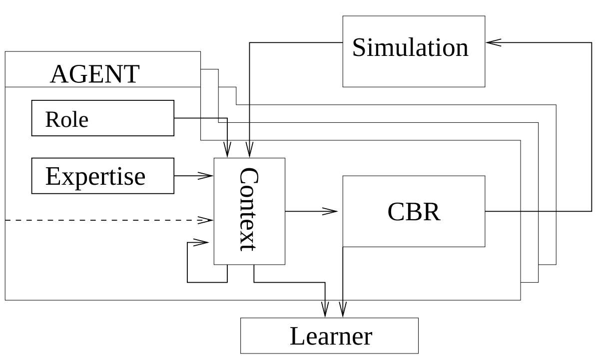



Figure 1: Agent architecture

In the framework of the development of a virtual environment for training, we have identified four advantages of using context.

1. As we have already said, we are interesting in the learner participation in the simulation, we need to have some credible action selection for the other agents in the simulation. Like (Brézillon 1999), we think that the context integration is a way to refine this decision-making. We are using context for the agent reasoning. Like (Kofod-Petersen & Mikalsen 2005), we argue that case-based reasoning (Aamodt & Plaza 1994) is a good solution for reasoning about context. This CBR system will take in entry the context and it will return the most appropriate solution according to old solved cases of the base. To do that, we have chosen a context representation allowing to evaluate its distance to *typical context* that are given by expert and stored in the case base.

2. Building the case base is a hard task, the crucial point is the definition of the significant information to describe a case. Situation must be described by all information needed to make it unique and comprehensible. A credible behavioural rules based system is hard to make, we argue that context and case-based reasoning allow to describe case in an easier manner. The context allows field expert to describe a situation with keyword of the domain. The last point is that new cases will appear in the simulation. Field expert opinion can be asked to solve the problem. The case can be presented with contextual form and so it only contains keyword of the domain.

3. Pedagogical support: Various learning strategies have been described by psychologists. For example, it can be interesting to show the mistake consequences or to underline significant elements of the situation. It can be interesting in order to help the learner to ask him why he has done like this. We argue like (Brezillon & Pomerol 1999), that context can be a good way to explain. The context will help the learner by showing the significant elements or a tutor can view the situation context and can directly help the learner.

4. The last point, we need in a participative simulation, is the *substitution*. This concept consists in allowing the learner, during an exercise, to take control of another protagonist. In the framework of the collective decision-making we consider, as (Mendes de Araujo & Brézillon 2005) proposes, that the context allows to better take into account interactions between human and machine. We argue that it can enhance knowledge sharing between an agent and the learner. The learner should be aware of the situation with the point of view of the role that he wants to play. He has to know the past experience of the agent. We argue that human and agent must share a common language to be able to easily play another role in the simulation. The context can be a good way to share knowledge.

## Context modelling for dynamic and collaborative situation

We present the central part of our approach in this section, we first detail our distinction between different contexts, and then we introduce their representation.

### Context delineation

Before introducing our context representation we propose a delineation of contexts. The sum of those contexts will form the global context of the agent. We decide to follow the psychologist's point of view as it is underlined in (Kokinov 1997) and we divide the global context in two parts. The *external* one refers to the physical and social environment, the second one refers to the internal state of the agent, such as skills, physiological, strategical...

The figure 2 illustrates the distinction between external and internal context and their refinement:

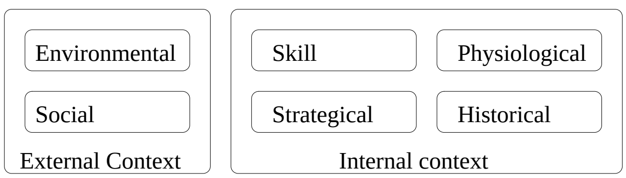



Figure 2: contexts division

The external context is made up of two more specific contexts that we detail:

- *Environmental context* : refers to the physical elements of the simulation. This can be an actor, an object, or everything that the agent can see or hear. It is used in the decision making process and to update others contexts. An example is given at the end of this paper.
- *Social context* : allows the agent to have a perception of the general mood of the group. This context strongly depends on the number of communications between actors, and especially on the type of conversations, such as for example number of refusals or number of requests for assistance...

The internal context is the sum of four distinctive contexts that are:

- *Skill context*: represents the agent skill in the domain of the simulation. This context is useful for the action selection when two or more actions seem to be good. The agent will choose the most appropriated one according to its skill context. It is used in decision making.
- *Physiological context*: reflects the psychological and physiological state of an agent. This agent can be disturbed, exhausted, inclined to collaboration or in peak form. It influences mainly the strategy of collaboration and partially the decision making. It depends on the historical context. This context is not currently implemented in our simulation.
- *Strategical context*: refers either to the strategy that the agent should execute, or to the future situation according to its point of view. It depends of the historical, social and environmental contexts. This context can be used to force the agent strategy by ordering him to follow a predefined plan. It is used in the action selection, but it is almost used to explain mistakes to the learner.
- *Historical context*: allows the agent to keep a trace of its past experience. The case base is a way to keep information but they are not ordered. This is the role of the historical context. In practise, it is a graph containing the old cases previously solved by the agent. It can be used, for example, when the coach wants to replay a situation

We can put forward three interesting points of our delineation of contexts. Those are:

- It simplifies the definition of the pertinent context to describe a situation. The expert can tell what context is important for this situation. This is important for building the case base in the simplest way.
- This delineation allows a better explanation to the learner when he makes a mistake. We can easily underline contexts that were relevant in this situation and so the learner can be concentrated on the interesting point of the explanation.
- The last point is our selection action method. The different contexts do not have the same role in the action selection. Some of them like environmental, social and physiological are important. As we have illustrated before, the skill context will be useful in the selection action, when two or more actions are chosen. Else it is used to specify action parameter (dexterity for an action).

### Representing context

Comprehension is not a deliberative and enumerative simple mechanism. It is often based on analogies and gatherings, what psychologists call *typical schemas*. This concept was reused by R. M.Turner (Turner 1998) as *contextual schemas* allowing the agents to reason with their representation of the context. We use schemas to represent contexts.

We describe here our contexts semantic, they have all the same general form. Every element of a context is represented by an attribute and each attribute can be divided in features. At least, an action is associated to this context. All contexts must have the same structure in order to be compared. We will now shortly describe this prototype:

- *attribute:* represents an object. This object can be a physical object or an abstract one that can represent a concept like the stress, a skill...
- *feature :* is a part of a more complex attribute and represents a particular point which is interesting for this attribute in this context. The example, at the end, will illustrate the usefulness of features.
- *action:* is the most appropriated action that should be executed in this context. Each context has, at least, one action except the skill one.

Attributes and features are made up of a name, a value, a weight and a type. The type of an attribute or a feature can be a value in the list:

- *fuzzy* allows to represent a concept by using notions to describe a feature of the concept. An example applied to the distance can be closer, close, far ...
- *string* represents a string value. This can be for example, the team of a player (blue or red).
- *compound :* an attribute can be complex so we have to divide it in features. It is illustrated in the last part.
- *exact* represents an exact value. For example, a distance can be 13.5 meters.

A case is divided in attributes. An attribute has been mentioned by a domain expert as significant for this situation. For example, in the environmental context, it can be a physical object. The expert gives a weight to every attribute of a case. This weight is given in function of the interest of the attribute for the case.

We have described our vision of the context for our agents, we will see how it is used in a case based reasoning system for actions selection.

## Action selection

As we have said before, we use case-based reasoning in association with context to simulate a credible decision-making for our agents.

We will briefly describe a CBR system but we will not explain in details our action selection. The similarity measurement, retrieving methods or learning algorithm are not developed here. We just want to give an overview of the CBR that we use with context retrieval to select agent's actions. A CBR system reuses old solved problems to solve a new one. The system is made up of a base containing solved cases, the new case we want to solve will be compared to the already solved one stored in the base.

According to (Aamodt & Plaza 1994), reasoning by re-using past cases is a powerful and frequently applied way to solve problems for humans. We can take, for example a little mathematical problem: Somebody asks you to solve 11*11 you will find the good result, 121. What happens if we ask you to find 11*12? You will not try to calculate 12*11 but adapt the result of 11*11, by doing 11*11+11, and find 132. This simple example illustrates how we can use experience to solve new problems by reusing previous one.

This example and the figure 3 illustrate the principle of the CBR. The first step is the *elaboration* of the new case. In our approach, this step is the context retrieval. Since the agent knows the context, it will compare it to those that are stored in its case base. This step is called *Retrieve*. The comparison is done thanks to a function, a good overview of this type of function can be found in (Bogaerts & Leake 2004). After that, the case is adapted according to the current context in order to be more appropriated, this is called *Reuse*. If the case is not present in the case base, the expert or the agent itself will decide if the case should be stored in the case base, this is the *Retain* step. This step will enhance agent experience.

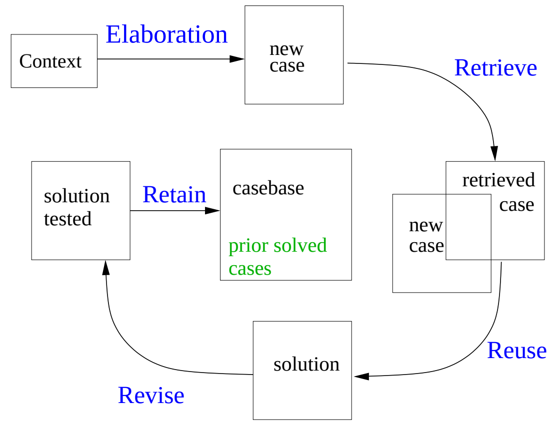
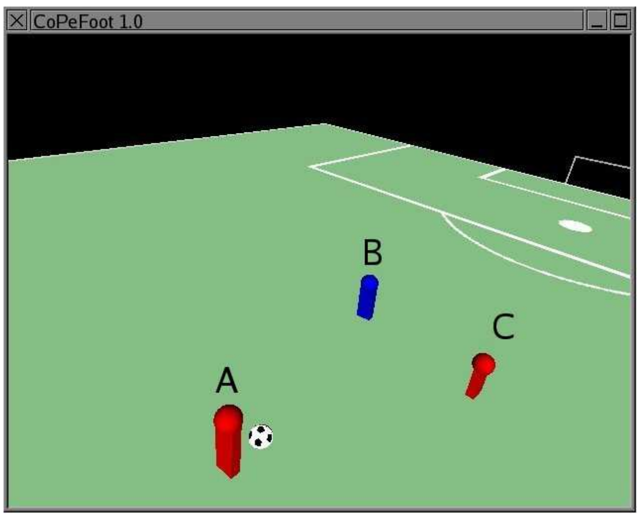



Figure 3: Our CBR cycle

## Application example

A simple example to illustrate our proposition is extracted from our simulation of a football match. We are currently working with psychologists to create a virtual environment for training, called *CoPeFoot* for Collective Perception in Football. The aim is to allow users to recognize collective situation in a football match. We are not interesting in the technical aspect of soccer, but in the strategical one. Learners have to recognize dynamic and collaborative situations and take the good decision. As we will see in the example, the aim is not to know how to pass, but when a pass is needed.

The example given here is a situation where a player *A* of the red team has the ball and is face to a player *B* of the blue team. He has to eliminate him. To do so, he should see the player *C* of his team behind *B* and passes it the ball. The figure illustrates the current situation.




We have chosen to use XML to represent our context. CBML Case-Based Markup Language

(Coyle, Hayes, & Cunningham 2002) is a good example of using XML to represent cases. This representation allows a simplest similarity measurement as it is underlined in (Coyle, Doyle, & Cunningham 2004).

We have simplified the current context, we just give here the environmental context of the player who has the ball. His context looks like:

```
<context type="environmental">
 <attribute name="Player" type="compound" weight="0.25"/>
  <feature name="distance" type="fuzzy" value="close"/>
  <feature name="side" type="string" value="left"/>
  <feature name="team" type="string" value="opponent"/>
 </attribute>
 <attribute name="Player" type="compound" weight="0.25"/>
  <feature name="distance" type="fuzzy" value="close"/>
  <feature name="side" type="string" value="right"/>
  <feature name="team" type="string" value="same"/>
 </attribute>
 <attribute name="Ball" type="compound" weight="0.25">
  <feature name="distance" type="fuzzy" value="closest"/>
  <feature name="side" type="string" value="face"/>
 </attribute>
</context>
```

The environmental context is made up of the ball, an opponent and a partner. In order to simplify, we just show two relevant contexts stored in its case base. The first one describes a context where the player has the ball and is face to an opponent.

```
<case number='5'>
<attribute name="Ballon" type="compound" weight="0.25">
<feature name="distance" type="fuzzy" weight="0.75"
 value="closest"/>
<feature name="side" type="string" weight="0.25" value="face"/>
</attribute>
 <attribute name="Player" type="compound" weight="0.25"/>
  <feature name="distance" type="fuzzy" value="close"/>
  <feature name="team" type="string" value="opponent"/>
 </attribute>
<action name="dribble" arg1="Ballon" arg2="Player"/>
</case>
```

The second one is similar to the first one and describes the same situation except that a partner of the player is present and can help him, this case looks like:

```
<case number='7'>
<attribute name="Ballon" type="compound" weight="0.25">
<feature name="distance" type="fuzzy" weight="0.75"
value="closest"/>
<feature name="side" type="string" weight="0.25" value="face"/>
</attribute>
 <attribute name="Player" type="compound" weight="0.25"/>
  <feature name="distance" type="fuzzy" value="close"/>
  <feature name="team" type="string" value="opponent"/>
 </attribute>
<attribute name="Player" type="compound" weight="0.25"/>
  <feature name="distance" type="fuzzy" value="close"/>
  <feature name="team" type="string" value="opponent"/>
 </attribute>
<action name="pass" arg1="Ballon" arg2="Player"/>
</case>
```

The similarity between the actual context and the context number five is 0.66 due to a penalty given because it lacks an attribute *Player*. The second similarity measurement is 1. This leads to the choice of the action associated with context number 7, that means the agent will pass the ball to a partner. The adaptation consists in identifying that the partner is the player B. This is done thanks to the current context.

This example highlights too the possibility of using context to easily interpret mistakes in the case of the agent have been an avatar. For example, here, if the learner did not see the second player of his team, we could have stopped the simulation to show him the information he has missed.

## Conclusion

We have introduced in this article our approach to create a virtual environment for training for DCS. After having developed the notion of dynamic and collaborative situation, we have described the way we use context and CBR to simulate the agent behaviour in this type of situations. At last, we have illustrated the action selection by an example extracted of our simulation.

We argue that using context is a good way to simulate credible actions selection for autonomous agents. We are sure that context is a good manner to create better explanations in a non procedural training. The association with CBR will enhance these two points we have developed.

The application example, CoPeFoot will allow us to validate the credibility of our agents. It will be used too to study knowledge transfer between virtual reality and real world. Some of contexts presented in our contexts delineation are not yet implemented. This concerns essentially contexts that are useful for explanation.

We are currently working on the definition of a shared context. This context will be an abstraction of each protagonist context. (Mendes de Araujo & Brézillon 2005) underlines that a group context allows a newcomer to more quickly take into account the current situation. It can be a good way to enhance the substitution concept. We argue that it can make a coherent point a view for the agents that share the same group context.

## References


[Aamodt & Plaza 1994] Aamodt, A., and Plaza, E. 1994. Case-based reasoning: Foundational issues, methodological variations, and system approaches. *AI Commun.* 7(1):39–59.

[Amalberti 1996] Amalberti, R. 1996. *La conduite de systèmes risques*. Presses Universitaires de France - PUF.

[Argilaga & Jonsson 2003] Argilaga, M., and Jonsson, G. 2003. Detection of real-time patterns in sports: Interactions in soccer. *International Journal of Computer Science in Sport* Volume 2/Edition 2(1):118–121.

[Bogaerts & Leake 2004] Bogaerts, S., and Leake, D. B. 2004. Facilitating cbr for incompletely-described cases: Distance metrics for partial problem descriptions. In *EC-CBR*, 62–76.

[Brezillon & Pomerol 1999] Brezillon, P., and Pomerol, J. 1999. Contextual knowledge sharing and cooperation in intelligent assistant systems.

[Brézillon 1999] Brézillon, P. 1999. Context in problem solving: a survey. *Knowl. Eng. Rev.* 14(1):47–80.

[Cellier & Hoc 2001] Cellier, J.-M., and Hoc, J.-M. 2001. La gestion d'environnements dynamiques. *Psychologie Francaise* 46:103–106.

[Coyle, Doyle, & Cunningham 2004] Coyle, L.; Doyle, D.; and Cunningham, P. 2004. Representing similarity for cbr in xml. In *ECCBR*, 119–127.

[Coyle, Hayes, & Cunningham 2002] Coyle, L.; Hayes, C.; and Cunningham, P. 2002. Representing cases for cbr in xml.

[Dautenhahn 1998] Dautenhahn, K. 1998. The art of designing socially intelligent agents: Science, fiction, and the human in the loop. *Applied Artificial Intelligence* 12(7-8):573–617.

[Gonzalez & Ahlers 1998] Gonzalez, A. J., and Ahlers, R. 1998. Context-based representation of intelligent behavior in training simulations. *Trans. Soc. Comput. Simul. Int.* 15(4):153–166.

[Kofod-Petersen & Mikalsen 2005] Kofod-Petersen, A., and Mikalsen, M. 2005. Context: Representation and Reasoning – Representing and Reasoning about Context in a Mobile Environment. *Revue d'Intelligence Artificielle* 19(3):479–498.

[Kokinov 1997] Kokinov, B. 1997. A dynamic theory of implicit context.

[Mendes de Araujo & Brézillon 2005] Mendes de Araujo, R., and Brézillon, P. 2005. Reinforcing shared context to improve collaboration. *Revue d'Intelligence artificielle*.

[Pomerol & Brézillon 2001] Pomerol, J.-C., and Brézillon, P. 2001. About some relationships between knowledge and context. In Akman, V.; Bouquet, P.; Thomason, R.; and Young, R. A., eds., *Modeling and Using Context: Third International and Interdisciplinary Conference, Context 2001*, 461–464. Berlin: Springer-Verlag.

[Querrec *et al.* 2004] Querrec, R.; Buche, C.; Maffre, E.; and Chevaillier, P. 2004. Multiagents systems for virtual environment for training. application to fire-fighting. *Special issue "Advanced Technology for Learning" of International Journal of Computers and Applications (IJCA)* 1(1):25–34.

[Rickel & Johnson 1998] Rickel, J., and Johnson, W. L. 1998. Steve (video session): a pedagogical agent for virtual reality. In *AGENTS '98: Proceedings of the second international conference on Autonomous agents*, 332–333. New York, NY, USA: ACM Press.

[Rognin, Salembier, & Zouinar 1998] Rognin, L.; Salembier, P.; and Zouinar, M. 1998. Cooperation, interactions and socio-technical reliability: the case of air-traffic control. comparing french and irish settings. In *Proceedings of the European Conference on Cognitive Ergonomics (ECCE9)*.

[Schuler & Namioka 1993] Schuler, D., and Namioka, A., eds. 1993. *Participatory Design: Principles and Practices*. Mahwah, NJ, USA: Lawrence Erlbaum Associates, Inc.

[Turner 1993] Turner, R. M. 1993. Context-sensitive reasoning for autonomous agents and cooperative distributed problem solving.

[Turner 1998] Turner, R. M. 1998. Context-mediated behavior for intelligent agents. *International Journal of Human-Computer Studies* 48(3):307–330.

[Woods 1988] Woods, D. D. 1988. Coping with complexity: the psychology of human behaviour in complex systems. *Tasks, errors, and mental models* 128–148.