Designing Collaboratively Crisis Scenarios for Serious Games

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Abstract: Numerous studies have explored the using of serious games as methodological tools for improving crisis management. Training in the Emergency Medical Services (EMS) field requires a combination of approaches and techniques to acquire medical skills with unanticipated events and to develop the capability to cooperate and coordinate individual emergency activities towards a collective effort. Crisis management is a special type of collaborative situations that why we propose a participative and knowledge-intensive serious game, as a collaborative e-learning tool for training (EMS). We believe that emergencies doctors learn best through real life experiences and serious games have the ability to simulate situations that are impossible to generate in a real-life exercise due to high cost, safety and complex environment related to situations. However, our approach takes into account the presence of different actors in crisis situation like police and firefighters and the high volume of (medical as well as non-medical) expert knowledge.

1 INTRODUCTION

Today, the term serious game is becoming more and more popular. There are many definitions of the concept. According to (Sawyer, 2007), serious games are "any meaningful use of computerized game/game industry resources whose chief mission is not entertainment". According to (Corti, 2006) game-based learning/serious games "is all about leveraging the power of computer games to captivate and engage end-users for a specific purpose, such as to develop new knowledge and skills". Nowadays, serious games are in many knowledge fields, including defence, crisis management, learning, health, and other areas. According to (Navarro et al., 2010), serious game is an emerging technology for specialized training, taking advantage of 3D games in order to improve the realistic experience of users.

Constructivism theory (Tobias et al., 2009) argues that humans generate knowledge and learning from an interaction between their experiences and their ideas. Serious games offer a constructivist way of learning where the people gain knowledge and experience while interacting with the game. It's difficult to predict how a person will react in an emergency crisis due to many factors involved in decision making.

Decision making in highly dynamic, complex situations is difficult. The literature on complex problem solving and natural decision making provides interesting insights into human error tendencies and has pointed to numerous traps and pitfalls we are likely to stumble into (Dörner et al., 1994); (Frensch et al., 1995); (Dörner, 1996); (Klein, 1997); (Strohschneider et al., 1999). If we translate "complex problem solving" into "management of crises and emergencies" (Danielsson et al., 1997), it has become quite obvious that training and education are mandatory. After all, emergencies and crises are among those situations where deficient problem solving is dangerous and can become extremely costly on different dimensions. The widespread adoption of computer games for entertainment purposes, the continuous decrease of hardware cost and the success in military simulations made gaming technologies attractive to some "serious" industries such as medicine, architecture, education, city planning, and government applications (Smith, 2007). Through the use of serious games, doctors and nurses can gain the benefits of learning and how to cope up with an emergency situation without being exposed to the dangers of real world emergencies. In this way, it's possible to observe how they adapt to new situations and apply the knowledge they have gained to come up with solutions to new problems.

Emergency crisis situations are complex collaborative situations, personnel from different domains (doctors, nurses, police, and firefighters)

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often must work together. The emergency management is based on “staff work” that focuses on planning, coordinating, and monitoring operative procedures (Helmreich et al., 1999); (Helmreich et al., 1993); (Orasanu et al., 1996). Communication and coordination is very important between emergency management teams (Schaafstal et al., 2001). Information presented to the participants of the collaborative staff has to be simple enough to support cooperation between people from different organizations but at the same time be rich enough for an individual from a specific organization to facilitate his decision making. The aim of training is not to teach teams new task knowledge or skills. Instead teams need strategies that enable them to better manage the increases in coordination and information overhead that result from increases in workload and stress (Entin et al., 1999).

Our goal is an attempt to co-develop a learning environment that equips persons working in emergency medical services with the knowledge and skills necessary to act as members of such a staff and deal with rare crises and emergencies.

The rest of this paper is organized as follows. From some readings, the section II defines features of a crisis management. The section III proposes a preliminary overview on the use of serious game in emergency health care. The section IV details our scientific positioning and defines our approach of serious games "participative and intensive in knowledge" and our technical architecture, with our developed ARGILE forum intended to illustrate the key concepts. The section V summarizes the conclusions of this paper and presents its perspectives.

2 FEATURES OF A CRISIS MANAGEMENT

Among the five Activities inventoried by Johnson (Johnson, 2000) for disasters and emergency management – planning, mitigation, preparedness, response and recovery – serious game can be principally useful in the preparedness Activity. Crisis management is complex and we do not aim at its complete characterization, but rather outline general issues for designing serious games useful for preparedness. Let’s use a simplified example to help us in this task. The worked example is real; it’s the result of interviews we conducted with trainers at the mobile Emergency Medical Service (EMS) in the (middle town -150 00 inhabitants) hospital participating in our project.

During a winter Sunday, a tank truck transporting potentially toxic material has an accident with a van (see figure 1) on a national highway 25km from the EMS basis. If this toxic material gets in contact with air, it causes a major air contamination. The situation requires the coordinated intervention of multiple units: firefighters trying to avoid contamination; medical units taking cares of victims and police trying to avoid traffic problems. So, we are dealing with a complex problem, and we have different solutions with associated costs and risks.

Figure 1: Crash between a tank truck and a van (image proposed to the learner in the serious game).

The interference between predictable and unpredictable events, the impossibility to only apply predefined procedures, characterizes such a crisis. In our example, accidents involving vehicles transporting toxic material are a well-known problem for which protocols of action are defined. However, nobody can predict when/where this will happen and the context, like type of transported material, weather conditions, victims’ number or population in the area. Toxic risk can happen in combination with other factors (meteorology, organizational problems…). During a crisis, the main problem is divided into many sub-problems, e.g. securing the area, taking care of the victims, putting population in safe conditions, avoiding contamination, contacting the main hospital to accommodate victims and so on. Once the main problem is divided into sub-problems, action has to be planned. Each unit might define plans for sub-problem they have to handle, but with the need to coordinate the effort. Plans have to conform to approved protocols of action. Action leading to an optimal result locally is not always leading to the intended global result. For example, "divert the traffic in one direction might reduce congestion in one area, but create problems to emergency vehicles parked in another road" says a doctor at the EMS of the hospital. Members in a crisis management team need to communicate to coordinate their action. For example, if firefighters are the first to be present in the area, when emergency doctor arrives, he must contact directly the commander of rescue operation (CRO) to know more about the accident. Also, the time is very important for decision making in our example: the tank truck can start spilling out toxic material and contaminate the air if the emergency team is not able to act quickly; or an injured situation may become worse if he doesn't receive first aid quickly. Crises are related to specific social and physical contexts that influence their management. If our example is happening in a highly populated area with schools or university nearby, we are submitted to different requirements than if the accident happens in an isolated area. As we can see crisis management is a task that can rise in complexity very quickly. Emergencies are made up of both predictable and unpredictable elements. Crisis management works exactly anticipating the former in order to minimize the damage (Palen et al., 2007). One of the ways to anticipate unpredictable events is building predictive models or scenarios and uses them for training. Managing unexpected elements requires instead to learn not only how to behave during the crisis, but also the importance of passing the right information, in the right amount, at the right time, from the right place, to the right person (Sagun et al., 2008).

3 RELATED WORK

In this section, we consider previous work concerning serious games for medical emergency domain. Virtual training environments have been developed for traditional emergency services (Jenvald et al., 2004) (Metello et al., 2008), for triage training (Dumay, 1995) (Jarvis et al., 2009) and many industry specific applications (Mallett et al., 2007).

A few knowledge-based systems have been proposed for information and resources management in crises: for example, R-CAST-MED (Zhu et al., 2007) is a system that uses an intelligent agent architecture built on Recognition-Primed Decision-making (RPD) and Shared Mental Models (SMMs) to manage information sharing among geographically-dispersed teams to improve collaboration and coordination in mass casualty incidents, and iRevive (Gaynor et al., 2005) is a robust pre-hospital patient care application that includes wireless sensors to handle coordination among ambulance teams, local site management and a distributed collection of hospitals.

Other knowledge-based systems focus on triage in EMS: for example, Mobile Emergency Triage MET (Michalowski et al., 2003) is an m-health application that supports emergency triage of various types of acute pain at the point of care. The system is designed for use in the Emergency Department (ED) of a hospital and to aid physicians in disposition decisions. While Automated Triage Management ATM is a decision support model that assists healthcare practitioners to find patients' chief complaints (Guterman et al., 1993). (Gertner et al., 1998) proposed instead the TraumaTIQ knowledge-based system to support physicians in trauma management. Their approach is based on evaluating rather than recommending plans: the system aims at recognizing what plan the physician is following, evaluating it and providing a user-focused critique to the course of actions chosen by the physician if possible problems have been detected. Comments presented by the system are sorted by order of importance and topic.

BioHazard/Hot Zone (Wilen-Daugenti, 2007) was generally created to teach college students introductory college biology and environmental science. It has evolved into a game to help emergency first responders deal with toxic spills in public locations. Players race against the clock to save civilians. The game involves scanning and assessing the situation quickly, teaming; and understanding chemicals, viruses, and symptoms. Individuals also learn how unpredictable behaviors can be in high-stress emergency situations. The aim of the game is to help emergency first responders prepare for potentially catastrophic situations.

Play2Train (Boulos et al., 2009) is a virtual training space in Second Life designed to support Strategic National Stockpile (SNS), Simple Triage Rapid Transportation (START), Risk Communication and Incident Command System (ICS) Training. Play2Train provides opportunities for training through interactive role playing and is the foundation for the emergency preparedness educational machinima. It helps first responders, first receivers and other health care professionals prepare for disasters. According to Dr Ramloll, Play2Train could eventually replace physical dioramas, commonly used by emergency services personnel when they train for disasters, in a way that holds the interest of participants longer than the current training approaches.

Another interactive training game, called Zero Hour (Hom, 2009) was developed through a collaboration between the Chicago Health Department, the U.S. Centers for Disease Control and Prevention and the University of Illinois. It simulates a mass anthrax attack, requiring participants to make critical operational decisions, respond to questions from simulated departments with competing needs, and field simulated phone calls with requests for added equipment. The game is designed to mirror real-world complexity.

Texas A&M University-Corpus Christi develops Pulse!! (McDonald, 2011) which is an important serious game in the area of healthcare. “Pulse!!” is used to train medical professionals on how to handle health emergency situations. The main “purpose” of this game is not to broadcast a message but to improve the player’s cognitive and/or motor skills for precise tasks or applications. EMSAVE, "Emergency Medical Services for the disAbled" (Vidani, 2010) Virtual Environment is a virtual reality system for training in emergency medical procedures concerning disabled persons. It allows users to experience emergency situations involving disabled persons. The simulations take place in a freely explorable virtual environment. The user can choose what actions to perform among a set of possibilities that depends on the difficulty level. Relevant effects of user's actions on the patient (e.g., change in complexion) are simulated by the system. (Sharma et al., 2012) proposed a collaborative virtual environment to study aircraft evacuation for training and education with two types of agents: user controlled agents and computer controlled agents. The idea is to have multiple users enter the virtual aircraft environment as avatars. These avatars would be able to interact with each other and make decisions such as following the directions by the leader and avoid bumping into other agents. There are also computer controlled agent, present in the environment which are programmed and act as obstacles to the user controlled agents.

In our work, we refer to serious games for training emergency medical services for many reasons. First of all, the use of serious game ensures in the preparedness phase a more extensive control in complex and knowledge-intensive situations. It is difficult to control variable like wind direction, rain, snow, the position of large good vehicles and the consecutive occurrence of multiple events in real life simulation. The control and the combination of these different variables are very important to generate different scenarios for pedagogical aims. Serious gaming environments can be simultaneously complex and controllable and computerized standardization makes serious gaming experiments also repeatable. Control and repetition offer great opportunities for training. In addition, serious games have the ability to simulate situations that are impossible to generate in a real-life exercise due to high cost, safety and complex environment related to situations (Corti, 2006) (Squire et al., 2003). Although virtual reality isn’t real, fire shown in virtual environments can have more resemblance with real fire or smoke than the means used to imitate fire and smoke during many real-live exercises (Jenvald et al., 2004).

In our work, we are interested in serious games for training experts in EMS. This domain is based on complex knowledge and interdisciplinarity that is why experts must be the game designers. In addition, scenarios in this context depend on many factors (like weather, victims type, hour where the accident happens ...) and if we use a classic approach of serious game, we could treat only some scenarios due to the high cost. We need a new approch wich covers a large number of scenrios and which allows to experts to add easily a new scene, item and knowledge in the game whithout the need of IT specialists.

4 A PARTICIPATIVE ARCHITECTURE ADRESSING CRISIS MANAGEMENT E-TRAINING CONSTRAINTS

In this section, we justify and present our detailed approaches of the co-design system and the learners’ forum before explaining our technical infrastructure.

4.1 Co-designing the Serious Game Elements with the A.R.G.I.L.E System: Why and How?

First we propose in the A.R.G.I.L.E system (Architecture for Representations, Games, Interactions, and Learning among Experts) a participative approach to associate EMS experts into an efficient writing of crisis scenes scenario. Developing Serious Game sequences for numerous cases (including cases at a very low probability) is necessary, but very expansive with traditional game editors (El Mawas et al., 2012). It is easy with traditional methods to formalize well established prescribed procedures, but a characteristic of a crisis is precisely that prescribed procedures often are not sufficient, and have to be completed by experience. To involve experienced EMS people in the scenario design is a good means to capitalize Knowledge and transmit it to novices. Actions that are almost easy for experimented emergency doctors might be extremely challenging for newcomers, both technically and in terms of emotional response (especially if the crisis is rarely to happen). That's why experts have to be active in the co-design process we propose.

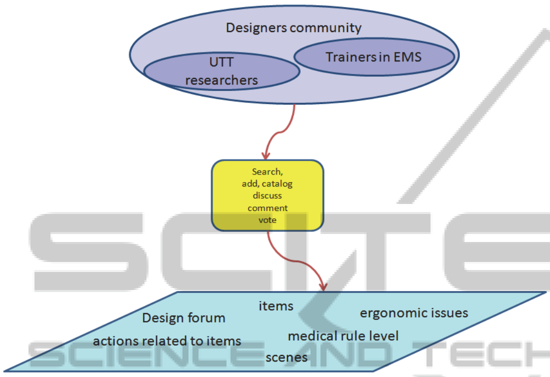

Figure 2: Participative architecture.

Our challenge is to transfer the accumulated knowledge flowing from concrete experiences, well-documented and discussed by trainers in EMS (in other words, reliable data), to a training model in which actors will be actively engaged. These knowledge are neither stabilized nor unanimous, but on the contrary dynamics and in continuous evolution. The actor does not make his decisions according to pre-established recipes. He mobilizes all his intelligence, to proceed by trial and error, to communicate with his peers and to discover continuously the suitable solutions in complex situations proposed to him.

The innovation in our approach is the co-conception of rules and certain objects of the game by the trainers of the domain. We make the hypothesis, that rules, knowledge and objects of the game can be written, commented, discussed easily and modified by trainers in EMS, with the help of the researchers (cf. Figures 2,3), but without to delegate the design to IT specialists and specialized software editors. We also wont to verify the hypothesis of a better quality of the knowledge for crisis management "on the field", if co-designed by this way.

A SeeMe diagram (Herrmann et al., 2000) is used for the roles, the activities and the entities presentation (see figure 4). We distinguish several roles in this model: the initial designer, the other designers, the board administrator and the forum moderator. To note that designers have on the forum a discussion thread for every scene object or action related to an item in the scene. Every time that an initial designer creates a scene/object/action discussion, designers are notified to participate in the discussion.

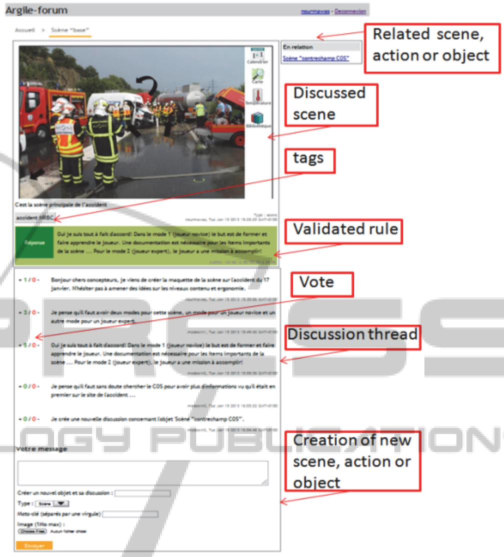

Figure 3: Discussion forum.

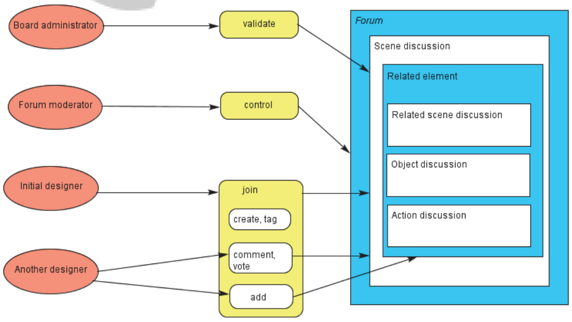

Figure 4: Model of designers' activity (SeeMe diagram).

The proposed architecture offers to the designers a Web-based working system which articulates:

- A specification system directed to teamwork susceptible to associate skills of experimented emergency doctors and nurses
- A navigation system in the game objects (this point is particularly crucial in the applications of knowledge-intensive in game, which contain numerous objects and rules),
- A discussion forum type: crisis management games rules depend on places, seasons, physical and social context and many other factors. That is why for a designer who builds objects and

rules of a scene, it is important to have a design forum for the discussion between peers.

All designers are invited to join the “design forum” to discuss new scenes, actions and objects before implementing them in the game. Figure 3 shows an example of a designer who creates a scene discussion (“Crash between a van and a truck”), uploads the correspondent mock-up, tags the created scene (accident NRBC: Nuclear, Radiological, Biological or Chemical). He invites other designers to discuss different elements, add an action/ object related to this scene or add a sub-scene that shows various cameras angles and may complicate or change the situation. Another designer comments that adding a scene where we can see the CRO is important; due to his active role in crisis situation. All designers can vote for any comment/rule. The board administrator validates a rule after discussion and it will appear on green background. In crisis situations, knowledge is in continuous evolution, so rules that are validated now may be invalidated later. Through the forum, we can have successive versions of a rule and traces of rules amelioration.

Hospital emergency trainers involved in the project don’t prefer that the won/lost points system appears to learners in the game. “The won/lost points system is important for us, as trainers, at the debriefing phase. We prefer that it will be hidden to learners because it will influence on them” says a doctor at the hospital EMS. We are in the context of interactive pedagogy, so trainer watches players/learners where they are playing and can add in real time new items or messages or sounds to complex the situation and to teach specific knowledge.

4.2 Knowledge in EMS

In EMS, knowledge is in procedural or declarative forms. Anderson (Anderson, 1993) underlines that knowledge starts with declarative actions, the conscious and control; and this control paves the way for procedural processes. Moreover, he argues that declarative knowledge forms the basis of knowledge transfers. Procedural knowledge is about how to think (Heyworth, 1999). It is linked with the performance change in knowledge, skills and tasks (LeFevre et al., 2006). It is the knowledge that explains how to perform an action within the framework of clear procedures.

In other words, Declarative knowledge is knowledge about something and procedural knowledge is knowledge of how to do something. For example, declarative knowledge enables a doctor in EMS to describe the rule "victims’ evacuation" in crisis situation. Procedural knowledge enables him to apply the evacuation in real crisis. We use the expression “advanced doctor” for a doctor with minimum 5 years of experience in emergency service and “beginner doctor” for a doctor with unless than 5 years of experience.

The aim of the scene presented in figure 1 is to train doctors how to deal in rare crises like NRBC accident. We believe that our training tool must not contain the same knowledge for advanced and beginner doctors. That’s why we have the game with 2 modes (see figure 5) depending on knowledge level of player. In mode 1, players are beginner doctors in EMS so the knowledge implemented in the game are declarative knowledge. The player can click on any scene item to have documentation about it. For example he can click on the CRO to know who he is, what his background is and what his role is in an accident.

In mode 2, players are advanced doctors so they have already the declarative knowledge through their experiences. The knowledge implemented in the game is procedural knowledge. The number of clickable items in mode 2 is reduced in comparison to mode 1. For the same item CRO, player in mode 2 will hear a voicemail message about the situation and then a question appears. He must complete missing fields about the 5 important topics in the CRO message. In general, we use pedagogical tools in mode 2 like multiple choices or Yes/No quiz, action on an item…

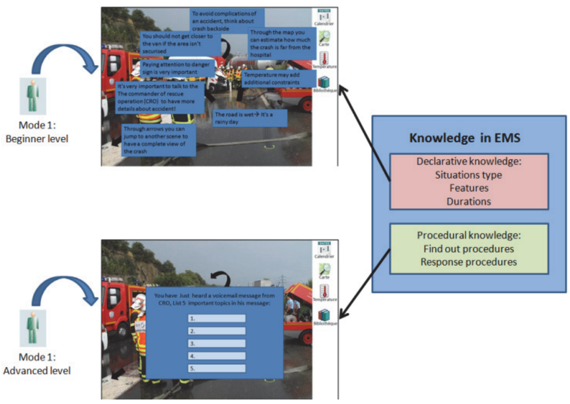

Figure 5: 2 Modes of the game depending on doctor’s level.

5 CONCLUSIONS AND PERSPECTIVES

In this paper, we proposed for Crisis Management (in the preparedness stage) a new approach of participative and knowledge-intensive serious games where scenarios are designed collaboratively. We proposed, with the A.R.G.I.L.E architecture functional and technical solution elements, by indicating on some examples why this solution is the most suitable to these games service. This reflection comes along with a work plan for the architecture implementation which allows us to validate gradually certain underlying hypotheses in our proposal.

Our first objective is to validate the practicability of the co-design approach of the participative and knowledge-intensive serious game. We would like to verify that the proposed co-design method allows a better precision for described knowledge elements, especially for common ground EMS non-procedural crisis management "on the field" knowledge. We presently are already implying EMS-trainers as co-designers, so they define scenes, create and modify them continuously, according to the proposed rapid prototyping and co-building method.

Now, we are developing, in our discussion forum, a space for learners to discuss scene/object/actions once they play. We think that these discussions will thread as resource to play better and to exchange hints and tips. In an experiment envisaged in September 2013, we are interested in the player's learning and his/her progress through the discussion forum and not only through the game itself. For that purpose, the learning will be estimated by placing the players in two configurations, without and with the discussion forum, and the results will be compared to evaluate our hypothesis: by using the discussion forum, we have a better learning.

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