LVC Training Environment for Strategic and Tactical Emergency Operations

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ABSTRACT

The application of Information and Communication Technologies in emergency management environments is a challenging research topic; particularly, the applicability of C4ISR (Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance) systems specifically designed for these environments. A key aspect in emergency management is the training of operatives at all levels, from intervention to operational, including tactical command and control. Virtual reality is widely used for training and learning purposes, but the interaction of real and virtual worlds with new standards (i.e. MPEG-V), going a step further from the traditional approach to create virtual environments based in expensive simulation dedicated equipment and allowing data streaming between both worlds, has not yet been exploited in training for emergency management. This paper proposes an architecture for a C4ISR training system providing interoperability between real and virtual worlds using the MPEG-V standard and allowing simultaneous and real time training of both real and virtual units.

Keywords

Command and control, interoperability, MPEG-V, tactical operations, training, virtual worlds.

INTRODUCTION

A virtual world is a simulated environment based in computers where people interact through avatars and intelligent agents. The simulated environment is based on the real world and thus the rules from the real world will be applied to it (Jovanova and Preda, 2010). Nowadays applications using virtual worlds go beyond merely entertaining purposes, as they have become a powerful tool to implement systems that can be applied, among many others, in developing training scenarios for crisis management. The goal is to help trainees learn and practice how to perform physical or procedural tasks (e.g. operating and maintaining medical equipment, evacuating a building…) while working toward animated agents that can collaborate with human trainees in the virtual worlds (Rickel and Johnson, 2000). The main objectives pursued with training using virtual worlds for crisis management include the realization of joint exercises that would otherwise be unfeasible due to their high cost in transportation of personnel and equipment utilization and to set up a variety of scenarios and conditions with a flexibility that does not exist in the real world so that first responders can practice and evaluate their response to unforeseen events in stress situations.

This paper describes an ongoing project to create a LVCTE (Live, Virtual and Constructive Training Environment) between virtual worlds and C2IS (Command and Control Information Systems) for training in crisis management, implementing standardized data formats and providing a middleware in which different applications can interoperate. The interactions of each participant (whether they are virtual or real entities in the training environment) are seamless in order to maintain the necessary coherence during the whole simulation. The proposed system includes the deployment of equipment on the field and the interaction of these units with virtual units generated within the system; the real units will act as mobile sensors and actuators in the mitigation of the simulated crisis, feeding the system with real data and responding to the orders of the crisis managers of the virtual world. The training system will also include a gateway to interconnect the virtual training environment with the real world communication environment; the MPEG-V standard is the key component of the interoperable communication system, streaming data between both environments, and will make independent the real command and control system from the virtual world generator. The LVCTE will allow personnel training in virtual environments with the same tools they would use during the real crisis mitigation.

The three base hypotheses to develop the proposed system are: (i) traditional training simulated-based systems are expensive and offer little flexibility (e.g. it is not possible to simply burn up a building every time a drill is carried out); (ii) real training in the field of emergency management is very expensive and complicated regarding the harmonization of procedures between agencies; and (iii) a network-based system that integrates reality and simulation will be, on the one hand, relatively cheap because all expenses that real in-site training entails (such as moving many people, vehicles) are reduced and, on the other, will facilitate the interoperability and harmonization of procedures between agencies.

MOTIVATION AND TECHNICAL CHALLENGES

The Live, Virtual and Constructive Training Environment (LVCTE) developed by the research team has as main aim the use of virtual reality to reproduce real environments and to create immersive training exercises for human beings. Virtual agents and personnel cohabit in a 3D, interactive, simulated model of a real scenario (Le Parc, Pardo, Touil and Vareille, 2010). All elements and their possible actions can be represented within the virtual world and people can interact, among them or with any objects, using the equipment they already have (a relevant consideration to design and develop the system. In the case of emergency management, the LVCTE has been used to implement a training system where personnel from different areas (paramedics, firemen, etc.) can carry out drills of emergency situations and learn or practice responses, actuations, etc.

Hybrid training systems including data from real sources (Verdot, Saidi and Fournigault, 2011) enhance and extend the training capabilities of traditional virtual systems. The LVCTE allows the interacting user to gather information about its state through sensor values, video streaming or specific messages (e.g. this kind of information is critical in fire squad operations (Le Parc et al., 2010; Querrec, Buche, Maffre and Chevaillier, 2004)). The main technical challenges and goals of the system are:

1. Reflect the reality with high fidelity for strategic and tactical crisis managers as well as for first responders to help them develop actuation strategies and homogenize procedures based on realistic environments.
2. Enable collaboration among teams of humans, software agents and virtual avatars. Crisis management personnel from different organizations and locations should be able to collaborate in developing strategies.
3. Provide interaction and overlapping between virtual and real worlds using MPEG-V standard to stream real data inside a virtual world and vice versa, contributing to an interoperable training environment.

The LVCTE requires accurate representation of the environment including audio and video depiction of features, and users' avatars should also represent accurately their actions, movements and characteristics in order to be realistic. Resources for crisis management include first responders on foot, vehicles, deployed sensors (like mobile sensors in UAVs and other unmanned vehicles or static sensors), and surveillance systems based on video streaming. Emergency management officials may use a variety of mechanisms and software tools for communicating and achieving situational awareness. The virtual environment must represent a range of strategies that officers and first responders may employ, including communication facilities.

RELATED WORK

Research related with the ongoing work presented in this paper goes in several directions: (i) representation of virtual environments; (ii) architectures; (iii) strategies and methodologies; (iv) navigation guidance and support; (v) addition of life to the environments; and (vi) interoperability.

Current models to represent real elements into virtual worlds describe the worlds so that browsers can visualize their geometry and, in some cases, support low level interactivity (Ibanez and Delgado-Mata, 2011). A high level representation semantic model is desirable, to support much richer user interactions at a more abstract level as well as to deploy intelligent agents (Querrec et al. 2004). The first effort to create a standardized format of representation is MPEG-V (ISO/IEC, 2011), released with the goal to create a solid technical basis for immersive and multi-dimensional multimedia services and applications. On the other hand, the use of ontologies providing a set of concepts and terms for describing some domain is very appropriate for virtual environments because they can represent really complex relations (Pellens, Bille, De Troyer and Kleinermann, 2005).

Different ad-hoc architectures have been used for developing virtual training environments. Normally a middle layer is the interface between the agents and the virtual world and it models the world through a semantic representation built by instantiating a set of ontologies. This kind of architecture is reusable and allows decoupling the graphical representation from the semantic representation of the environment. Thus, agents can interact directly with the semantic layer and process the semantic representation of the world (Ibanez and Delgado-Mata, 2011). Our approach extends this architecture; we propose a middle layer (interconnection gateway) with semantics based in the MPEG-V standardized format. A similar architecture (Rickel and Johnson, 2000) proposes separate components running in parallel as separate processes which communicate by exchanging messages through a message dispatcher, increasing modularity (one component need not know the interface to other components). The decision making process is based on decision cycles: take feedback from the previous cycle and make the necessary adjustments.

Navigation guidance and support is required in virtual world related projects because often users experience difficulties and can easily become disoriented and lost in complex virtual environments for a variety of reasons; including those common to real world environments (e.g. a fireman gets trapped in a room when evacuating a burning house), as well as some problems unique to virtual worlds, such as lack of landmarks and reduced level of detail (Ibanez and Delgado-Mata, 2011). Animated agents can serve as navigation guides preventing users from becoming lost (Rickel and Johnson, 2000). As for navigation support, there are many methods and techniques that may be combined depending on the application.

The addition of life (human beings, animals) improves the user experience and realism of the simulation, whether the application is immersive or not. A series of smart-world applications have been developed modeling the real world by associating ontology concepts with objects and locations (Eno and Thompson, 2011).

SYSTEM DESCRIPTION

MPEG-V: Interoperability between Real and Virtual Worlds

The standard ISO/IEC 23005 (MPEG-V – Information Technology – Media context and control) has the goal to offer a solid technical background for applications and multimedia immersive and multidimensional services (ISO/IEC, 2011). MPEG-V provides an architecture and specifies associated information representations to enable the interoperability between virtual worlds, for example, a digital content provider of a virtual world, serious gaming, simulation; and with the real world, for example, sensors, actuators, vision and rendering. It defines an XML-based base schema containing a root element and a set of elements within it, called top-level tools, along with their associated attributes and admissible values. Virtual world entities are classified as Virtual Objects and Avatars. An avatar is, in general, a computer based graphic representation of a user (Le Parc et al., 2010) and by which the user exists in the virtual world and interacts with it; they are usually human representations. Virtual Objects are all other objects in the virtual world, such as buildings, cars, etc.

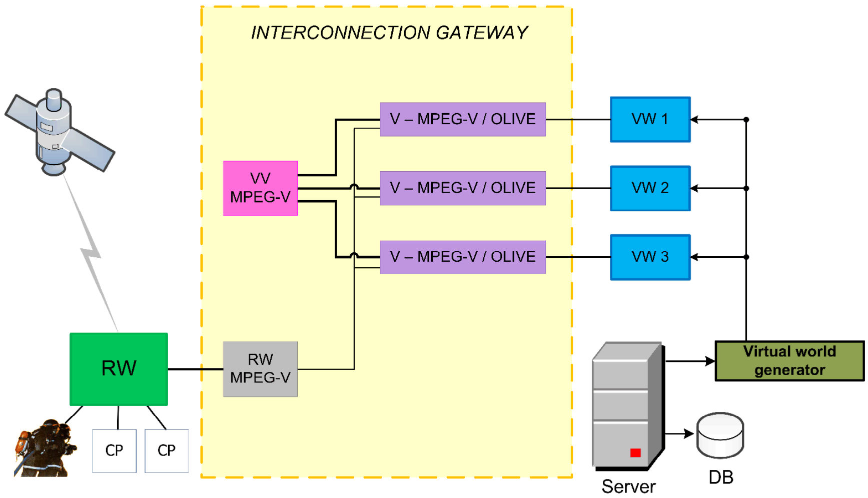

Figure 1. MPEG-V Interconnection Gateway

A new and outstanding contribution of this work is the deployment of a MPEG-V gateway (Figure 1) for interconnecting virtual and real worlds (hereinafter, the terms *VW-VR Gateway, MPEG-V Gateway* and *Interconnection Gateway* shall be used indistinctly). The gateway implements a customized data model, which allows parsing information between real world elements and events and virtual worlds, and has been developed using web services and query-response patterns. Its role in the proposed system will be further explained later.

Live, Virtual and Constructive Training Environment

The main feature and use case of the LVCTE is the interconnection of command and control systems, operating in the real world, with virtual world systems. The interoperability architecture proposed (Figure 2) is based in extensive use of MPEG-V standard and the basic consideration of C2IS architectures that reflect two main dimensions: the organizational structure and the communication network structure. Thus, the proposal is an architecture with three main components: (i) Tactical Manager Server (TMS), that allows the interconnection of virtual and real worlds and where the MPEG-V gateway runs; (ii) Tactical Trainer Client (TTC), which is the client subsystem used by the training nodes and includes both a command and control system of the real world and a virtual world client; and (iii) Virtual Video Server (VVS) which is the system of management, distribution and playback of video generated by the sensors involved in the operations, from both real and virtual sources.

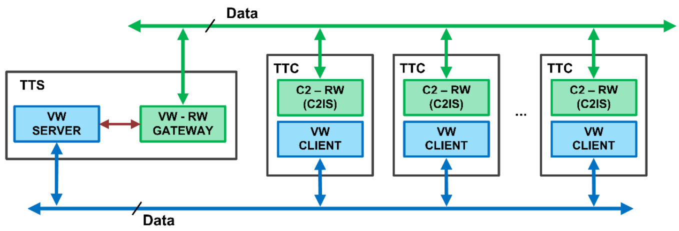

Figure 2. Virtual Trainer architecture

Another significant contribution is the inclusion of the Virtual Video Server (VVS), a subsystem for streaming, displaying and recording video flows from both real world cameras and virtual world live streams. The VVS gathers video flows from real world sensors as well as from the virtual clients output. Those flows can then be streamed to any video client, such as the one embedded in a TTC, displayed in real time in the VVS interface or stored for post operation analysis. In our opinion, seeing with one's own eyes what is going on in the operation hot-spot, both in the real world and on its virtual representation, enhances considerably the training process and also contributes to improve the situational awareness, critical in C2IS and emergency management. On the other hand, one key contribution of the VVS is that it decouples consumers from producers, guaranteeing scalability by reducing bandwidth consumption as there is just one video flow from producer to VVS, regardless the number of clients that request that particular flow. Moreover, the system is designed to support the connection of several VVS serving video flows among them and their respective clients.

Human-Machine Interface (HMI) overview

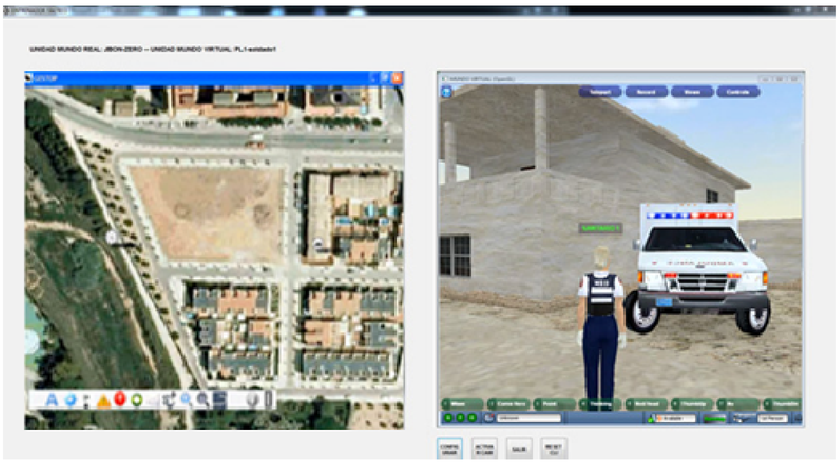

Figure 3. Human-Machine Interface. Combines views of the C2IS tool (left) and the virtual world (right).

A user connected to the LVCTE may be a virtual user (in the virtual world) or a real user (on the training field). Both may have access to two kinds of information: from the C2IS and from the virtual world. Thus, the HMI (Figure 3) has two elements: a C2IS screen (left) with all the required information of such a system: messaging, geolocated units, alerts, objects, etc.; and (right) the virtual world information representation. A direct link exists between geographical position (GPS based) and representation in the virtual world, so as each element performs any action, information is streamed using the MPEG-V intermediate format. An administration tool allows configuring the command structure, communications and training scenario.Moreover, Figure 3 helps illustrate an example use case. There is a first responder and a vehicle. The first responder, who exists in the real world, has his/her corresponding avatar in the virtual world and is continuously sending his/her position and actions from the real world to the virtual world. On the other hand the vehicle is virtual (it is not actually present in the real world), but is needed for the training exercise so it is created within the virtual world and represented in the C2IS system as existing. The system is scalable, admitting hundreds of real/virtual trainees and objects to interact with, but saving the associated costs that would rise if the same number of elements were to be held in a real scenario drill.

CONCLUSION

The analysis and preliminary implementations have been performed using OLIVE's virtual world engine and development environment. The MPEG-V gateway developed by the research team acts as a middleware connecting a C2IS for emergency management with a virtual world that simulates accurately the real world where the C2IS is operating. It currently performs data streaming between real and virtual worlds. Our future plans are to continue exploring different platforms for virtual worlds management, including the following steps: (i) integrate stationary sensors and UAV; (ii) develop virtual environments representing different types of real environments; (iii) test new virtual worlds engines (e.g. OpenSim); and (iv) evaluate the inclusion of video streaming from real cameras in the virtual world using MPEG-V data flows.

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