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Immersive VR Decision Training: Telling Interactive Stories Featuring Advanced Virtual Human Simulation Technologies

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Abstract
Based on the premise of a synergy between the interactive storytelling and VR training simulation this paper treats the main issues involved in practical realization of an immersive VR decision training system supporting possibly broad spectrum of scenarios featuring interactive virtual humans. The paper describes a concrete concept of such a system and its practical realization example.

Keywords:
Immersive VR, decision training, interactive storytelling, virtual human simulation

Categories and Subject Descriptors (according to ACM CSS): I.3.7 [Three-Dimensional Graphics and Realism]: Virtual reality; I.3.6 [Methodology and Techniques]: Interaction techniques; I.6.3 [Simulation and Modeling]:Applications

1. Introduction

The very recent advancements in the computer 3D graphics technology, and in particular, the latest appearance of a powerful and affordable 3D graphics hardware, brings a fresh wave of interest to immersive VR applications that target rapidly growing educational and training needs of the modern information society.

From the economical and technological point of view immersive VR technologies, once affordable to few research laboratories and government based organizations, become widely available. As a result the VR systems, being until recently of mostly research and prototypical nature, show a new potential to proliferate as more common tools for institutions offering educational and training services.

From the sociological standpoint an increasing importance and acceptance of interactive digital storytelling technologies becomes ubiquitous. Especially for the younger generations, computer games, interactivity, immersion in synthetic scenarios, are as normal and accessible as other medias like internet, television, radio or books.

In short, the above two processes result in the appearance of a new type of user who is far from being afraid to face and explore growing technological potential. Going further, we may expect that soon this new user will actively demand, rather than passively accept, novel technological approaches that will aid him in the daily assignments.

That growing potential seems to be coherent with one of the most rapidly rising needs of the modern information society: efficient training. The rapid technological progress demands always more advanced training methodologies concerning broad and continuously growing spectrum of human activities. Using those novel methodologies individuals should be able to learn and then continuously maintain and upgrade their knowledge and skills.

One of the practical answers to this problem can be the use of immersive VR in combination with interactive storytelling technologies. Nowadays this approach is being tried by growing number of researchers based on the premise of a substantial synergy between interactive story telling and training [1; 7; 8].

2. Immersive VR and Training

There is some evidence that immersive VR, compared to conventional training methods, can raise interest and motivation of trainees and in effect increase knowledge transfer and retention. Still, the practical potential of VR is being explored and presents a challenge for both technology providers and evaluators [1].

Immersive VR is able to provide a rich, interactive and engaging training context that in reality would be too dangerous, too expensive or simply impossible to access. In addition, performing tasks enhances the learning process providing learning by doing medium through a first-person experience [2].

When building immersive VR training systems, it is important to keep the focus on the needs of the trainee rather than on the technology itself, which is one of the common mistakes in system design. The aim is at empowering the learner by maximizing the opportunity for learning [3]. Ideally the enabling technology should be hidden and used only to expose the trainee to the immersive experience leading to the Sense of Presence (SoP) which as defined by Slater [4] includes the following three main aspects: a) "sense of being there", b) the extent to which Virtual Environment (VE) becomes dominant, c) remembering VE as having visited the place rather than having seeing images of the place. According to Sastry[5], the Sense of Presence, especially in case of real world applications, is more influenced by the level of interaction than by richness or faithfulness of sensory experience. As defined by Lombard & Ditton [6], the immersive VR should provide to the trainees the "perceptual illusion of non-mediation" and let them "suspend disbelief".

2.1. On-Job Training

Nowadays common training methods include formal classes, books, multimedia applications, interactive simulations, on-job training, etc. The latter, on-job training, is particularly effective in complex tasks where a great deal of independence is granted to the task performer. Unfortunately, on-job training is the most expensive method. Furthermore, and maybe what the most important, it is limited by frequent unavailability of the training context itself.

In order to address the problem of on-job training, many VR solutions have been proposed in recent years. An overview of concrete applications and techniques used to implement VR training systems in different domains is given in [1; 23; 24]. Successful use cases as well as new attempts can be found in a very broad range of domains such as space and aviation (e.g. flight and space mission simulators [11]), military (mission training [14; 15], nuclear weapon disassembly [13]), medicine (e.g. gunshot wound surgery [16], bone dissection surgery [17], virtual endoscopy [18; 19], arthroscopic knee surgery [20; 21], palpation of subsurface breast tumors [22]), industry (e.g. machine operation, mining), psychology (e.g. public speech training), emergency [8] (e.g. fire fighting [12], mining, health emergency [9; 10]), etc.

2.2. Towards Situation Training

There exist some evidence showing that the use of VR is particularly useful when the training domain is complex and difficult to master and when the audio-visual (possibly assisted by haptic feedback) features of the training environment are crucial to the overall training success. This makes virtual environments the solution of choice for practicing and learning domains where the context of the training is not easily available.

Many of the VR training systems realized up to date focus on teaching of particular, *direct physical skills and procedures* e.g. surgery, machine operation, flight simulation. They usually employ highly sophisticated hardware user interfaces providing realistic haptic feedback or/and mimicking real devices. Those *skills training* systems are naturally limited to certain number of well defined scenarios.

On the other end of the spectrum, we identify VR systems helping the trainee in development of his *psychological skills* required to face the reality. Using such systems, the trainee is expected to lower his psychological barriers by going through a semi-real, synthetic experience. In contrast to the *skills training* systems that stress on learning "by doing", here the focus is rather on learning by "living through". Such systems may be classified as *situation training* or in particular as *decision training*.

In the following sections, we will define the challenges posed by a practical realization of an immersive VR decision training system. We first propose a possible approach, then describe its elaboration, and finally conclude by an example of a practical realization.

3. Tradeoffs, Constraints, Open Issues

Taking into account functional features of immersive VR and following the premise of a strong convergence between a decision training and storytelling, we define the core of the challenge as follows: a) provision of an immersive VR decision training system, b) that supports simulation of possibly wide range of interactive scenarios, c) exposing trainees to diverse, highly stressful training contexts, d) and allowing them for situation assessment and decision making.

Specifically it is required that the system supports simulation of the scenarios featuring interactive virtual humans. From the hardware point of view, it is required that the trainee is not overloaded with heavy and cumbersome hardware. Finally, targeting system generality, it is required that the authoring process of an interactive story is defined in the way allowing for efficient production of new scenarios by collaboration of: content designers, software developers and experts from a given training domain [8].

3.1. Immersion

The visual immersion paradigm implemented through a *Head Mounted Display* (HMD) and various combinations of human body tracking technologies introduces many limitations and artifacts. Mapping between the virtual and the real environment, although direct is usually imprecise leading to user confusion. Very limited field of view may lead to cyber-sickness effects [1; 7]. HMD based immersion, even if combined with haptic devices, does not solves the problem of interaction with virtual objects. Currently available devices do not allow for a large scene exploration and a direct manipulation simultaneously. Those two functionalities are actually mutually exclusive because of the haptic feedback kinaesthetic interfaces cumbersomeness. Moreover, use of any haptic devices automatically narrows the number of possible scenario types that the system may support. This conflicts with the main requirement of the situation training generality.

In effects, it seems that the immersion needs to be based on certain metaphors and intensive use of audio-visual sensory channel. Use of the audio-visual sensory channel needs to compensate the other ones, not easily accessible by the VR technologies currently at hand. Ideally, the immersion technology should be hidden as much as possible, the equipment should be light, and the interface intuitive.

3.2. Interactive Scenarios

In majority of the VR applications and particularly in case of the skill training systems the user faces an *interactive scene*. Such a scene contains multiple virtual objects that undergo interaction and respond with certain behaviors (interaction with VR space). In case of the decision training, we need to bring this idea to the higher level: an *interactive scenario*. Ideally, an interactive scenario should tell a timeline story of pedagogical nature leaving at the same time clear places for trainee's interactions and decisions that affect scenario direction (interaction with VR space and time).

Provision of an interactive, multi-path, believable scenario is a very challenging task. The system must seamlessly combine multiple hardware devices and various heterogeneous simulation and interaction technologies that, while being there, must at the certain moment become invisible to the trainee in order to generate a sense of presence. Special attention must be paid to: 3D graphical rendering, 3D surround sound rendering, realistic virtual human modeling and animation, consistent and natural behaviors of the virtual humans and the elements of the virtual scene, intuitive and possibly invisible multi-modal interaction. Finally, a generic decision training system needs to provide necessary semantics and tools allowing for authoring, execution and control of the interactive scenarios.

At present interactive story telling is an intensive research topic with promising results but still there is no clear and widely accepted guidelines on how to capture the problem and deliver a practical implementation.

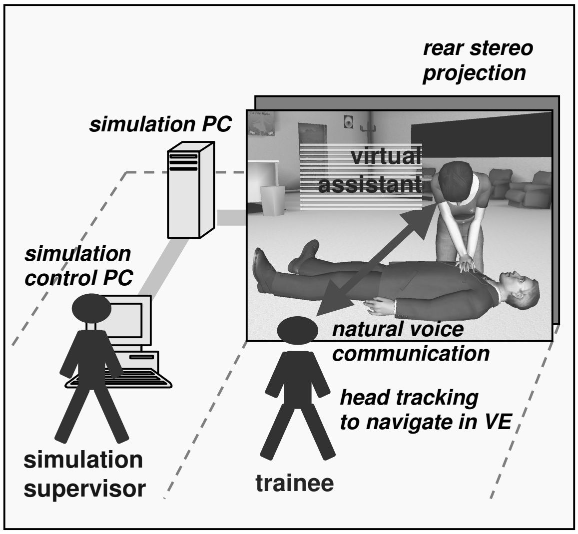

Figure 1 *Immersive VR Decision Training System: concept and key elements*

4. System Concept

Proposal of an immersive VR decision training system concept is presented in the Figure 1. During the interactive scenario, the trainee faces a huge rear-projection screen displaying stereo images of the simulation. He is immersed in surround sound. In course of the simulation he is able to navigate freely around the virtual environment in order to locate the sites of interest. The navigation paradigm is based on a single magnetic tracker attached to the trainee's head. The trainee is interacting with his *Virtual Assistant* (VA) using natural voice commands and hearing respective replies and prompts from VA. The role of the trainee is to assess the situation, make decisions and give respective commands to the VA who is executing them showing proper physical skills. Simulation supervisor stays behind the scenes and has the following tasks: direction of the scenario path, “speech recognition” of the natural voice commands given by the trainee and triggering of respective actions to be executed by VA (the supervisor can be regarded as the “ears of the VA”), putting pressure on the trainee by triggering of prompts spoken by VA or triggering of “disturbing” virtual events.

4.1. Audio-Visual Immersion

The visual immersion is realized through the rear projection and active stereo. The trainee wears lightweight shutter glasses and faces a large screen (~3.0x2.8m). Due to the rear projection, he is able to approach the screen very closely without any shadow. Compared to HMD this solution is less cumbersome. It avoids problems of very limited field of view, cyber sickness (related to the lack of peripheral vision) and claustrophobic effects in case of some more sensitive trainees. The trainee faces the virtual wall being a natural extension of the reality into a different, virtual dimension. Finally, compared to HMD, this solution can offer high scalability from stereo capable high-end CRT project through cheap LCD projector (loosing stereo) to simple monitor.

Concerning audio immersion, the trainee is surrounded by 5.1 home cinema speaker system that can be as well scaled down to simple stereo one.

4.2. Navigation Paradigm: Walking and Looking Around VE

Navigation paradigm is based on a single magnetic tracker attached to the trainee’s head (Figure 2, Figure 3).

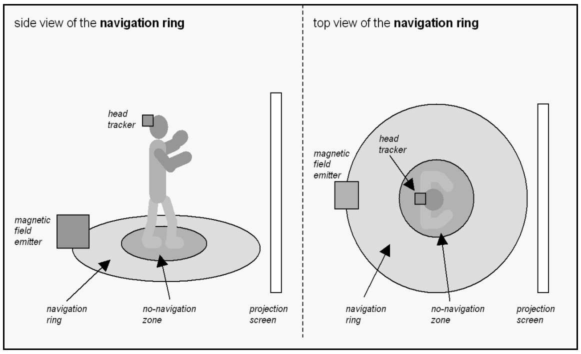

Figure 2 *Navigation Paradigm: “navigation ring” metaphor allowing for “walking around” the virtual environment*

In order to “walk around” the virtual environment, the trainee needs to step into the navigation ring which in effect triggers camera motion in the desired direction. The trainee can move inside the central area of the ring without causing any camera motion. In order to “look around” the trainee needs to look at the margins of the projection screen. This analogously triggers horizontal and vertical camera rotation.

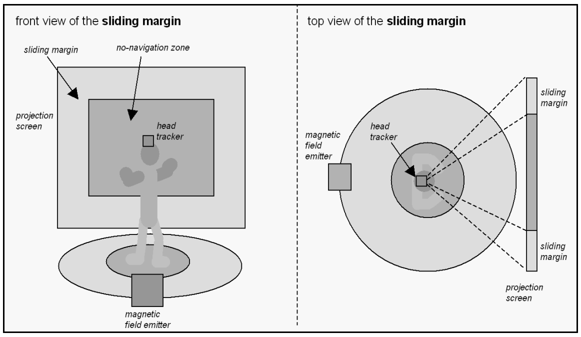

Figure 3 *Navigation Paradigm: “sliding margin” metaphor allowing for “looking around” the virtual environment*

The paradigm is lightweight and intuitive to understand. Moreover, if necessary this solution shows scalability as the magnetic tracker can be replaced by a wireless hand held mouse or a normal mouse in case of scale down.

4.3. Mediated Physical Interaction: Concept of a Virtual Assistant Agent

When targeting decision training, we had to address the inherent lack of generic haptic feedback solution that could support the required broad spectrum of scenarios and simulation contexts. In order to do so, we propose to clearly separate *decision making* from *decision execution* by introduction of a semi-autonomous *Virtual Assistant* (VA) agent. The respective roles and mutual relationships between the trainee, VA and the simulation supervisor are presented schematically in Figure 4.

In course of the simulation, a trainee (the decision maker) is accompanied by his VA. The trainee navigates, assesses the situation, makes the decisions and issues natural voice commands to his VA.

VA (as decision executor) waits for commands and executes them showing expected physical skills. It may refuses to execute erroneous decisions prompting the trainee for retrial. In case the trainee is slow in decisions, the VA prompts him to hurry up. In case the trainee is unable to act, the VA auto-executes proper actions when time expires.

A simulation supervisor plays the role of the VA’s *ears*. Standing behind the scenes and listening to the commands of the trainee, he is responsible of the interactive scenario execution by triggering respective actions available at a given scenario step. This kind of solution requires of course a corresponding approach to the problem of interactive scenario definition and representation (discussed in the following section). Use of automated speech recognition is avoided on purpose as it is impractical in case of a decision training system : the trainee is supposed to operate under certain stress, uses different kind of wording to express the same commands, he may speak slowly, fast, with changed pitch or even in different languages. Currently the automated speech recognition solutions lack robustness as they operate on the level of sound and not on the level of meaning.

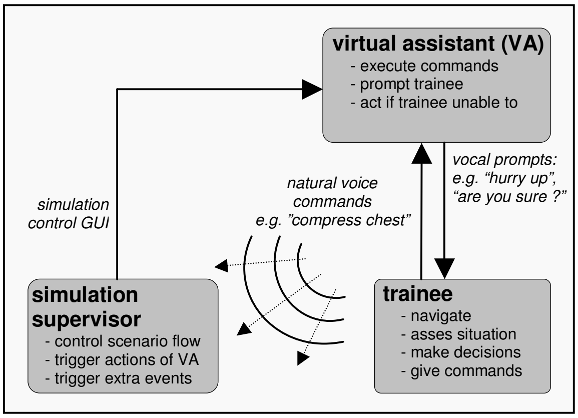

Figure 4 *Trainee, VA, Simulation Supervisor: their roles and mutual relationships.*

In our case, the trainee may use any wording to express commands (e.g. "perform 5 chest compressions" or "compress the chest 5 times"). In this way the interaction is robust and natural. It does not require voice training or use of specific, artificial commands that could spoil the immersion effect by making interaction unnatural. Another important advantage is an easy language localization capability.

To summarize, the *Virtual Assistant* is perceived by the trainee as a semi-autonomous agent executing orders but able as well to prompt the trainee, make the correct auto-decisions and execute respective actions autonomously. We may say that the *physical interaction* of the trainee with the virtual environment is *mediated* through the Virtual Assistant agent.

4.4. Interactive Scenario

4.4.1. Scenario Semantical Components

The fundamental building blocks of a scenario are *decisions*. A *decision* is the expression of the choice made to perform an *action*. An *action* is defined as a Finite State Machine (FSM) featuring the following possible states: *idle, activating, active, terminating*. *Actions* allow for bundling of heterogeneous simulation activities like animations, sounds, behaviors. For example an *action* when triggered may cause a virtual human to get up, walk to the window and then continuously look around until the action is stopped explicitly, the timeout occurs or a certain event happens. Taking a *decision* provokes the execution of an associated *action*. *Decisions* also form a logical abstraction layer allowing to define and control the scenario *difficulty levels* by making a list of selectable *decisions* per *difficulty level*. During scenario execution the user may choose only available *decisions* (from the list) and other *decisions* are executed automatically (as they are considered too difficult for the user). As a particular case, one may play a scenario with an empty *difficulty level* decision list and will see the scenario execute itself in a demo-mode.

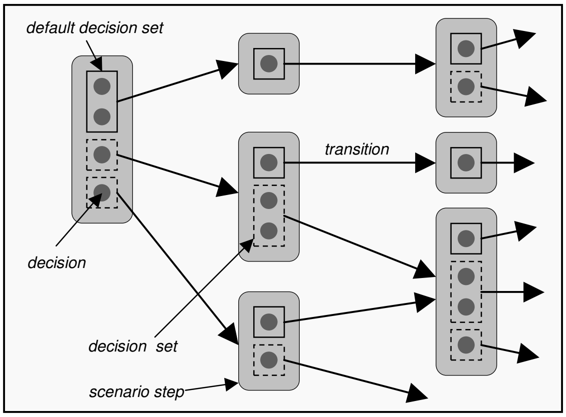

Figure 5 *Interactive Scenario Semantics: scenario graph, scenario steps, (default) action sets, actions, breakpoints.*

As shown schematically in Figure 5, an interactive scenario skeleton is defined around a graph of *scenario steps*. Each *scenario step* may contain one or more *decision sets*. Each *decision set* is connected to the next *scenario step* by a transition that occurs only when all *decisions* of a given *decision set* has been taken. As a particular case, a *decision set* may contain a single *decision*. In this case, the *decision* leads to the next *scenario step*. *Decision sets* also allow for clustering of actions that need to be all executed as a group at a given *scenario step*, but where the order of their execution is not important. For example in case of a health emergency decision training scenario, "check pulse" and "check breathing" actions may be executed in arbitrary order and thus they will be grouped inside a single *decision set*.

The multiplicity of *decisions* in the *scenario steps* makes the variety of choices the user can take, whereas the number of *scenario steps* defines the duration of the scenario. In addition, one *decision set* is defined as default in each *scenario step* in order to facilitate the decision making for pedagogical reasons.

Optionally each *decision* may have a timeout defined. In this way, authors may impose time constraints on a decision training scenario. If in course of a simulation a trainee is slow in decision making or simply unable to make one, then the expiry of a *decision* timeout leads to the automatic execution of its *action*, and may lead to the transition to the next *simulation step*.

4.4.2. Authoring Process: Reusing Components

Following the requirements, the semantic components defined above support definition of a clear *scenario authoring process* that allows content designers, software developers and training domain experts to communicate efficiently when elaborating new interactive scenarios. The process relies on the reusability of *actions* and whole scenario graphs that can be combined and tested on runtime with dedicated authoring GUIs.

When creating a new decision training scenario, the domain experts work on the high abstraction level of their domain. Using dedicated authoring GUIs they capture structured training procedures in from of the scenario graphs. In effect of this process *scenario steps*, *action sets*, *actions* and *difficulty levels* (locations of breakpoints) are identified.

Once the graph is defined, the content providers are able to identify required content elements: 3D scenes, 3D object models, virtual human 3D models, sounds, voice recordings, animations, motion capture sequences needed, etc. In parallel, software developers may focus on development of new *actions* that are necessary. Usually they first prototype *actions* in form of flexible Python scripts and, after testing, convert them if necessary to C++ code to increase performance. Although prototyping and coding of *actions* may be arbitrary complex, a proper middleware solution (discussed in the implementation section) usually makes the job fairly easy by offering proper abstraction level (e.g. allowing developers to order virtual humans to "walk to", "look at", "move to", instead of manipulating the scene graph directly).

Once the first development iteration of the content and the *actions* is ready, the simulation supervisors may start tests of the immersive VR decision training scenarios giving back feedback to content providers and developers.

Given underlying semantics and the authoring process the reusability can be defined on three separate levels: scenario graphs (formalization of the structured training procedure), *actions* (atomic software components) and content (interchangeable data on which *actions* operate).

4.4.3. Scenario Execution

Before starting the discussion of a scenario execution, it is important to notice that a simulation supervisor is not required to have an expertise in VR simulation technologies. He is rather expected to be an expert in the individual training domain in order to be able to assist the trainee in course of the simulation in case of questions related to that domain. A snapshot of a GUI used by the simulation supervisor in course of the simulation is shown in Figure 6.

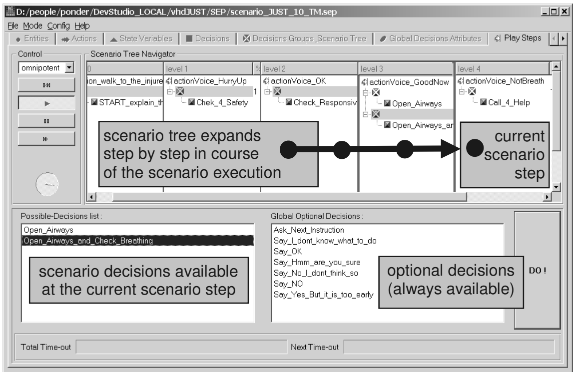

Figure 6 *Scenario Execution: the main GUI used by the simulation supervisor to direct the decision training scenario execution*

During the execution, the decision training scenario advances along the transitions defined by a scenario graph. At each *scenario step* the execution is paused and the trainee is supposed to make a proper decision reflecting certain structured procedure being trained (e.g. in case of health emergency training it could be e.g. "Do chest compressions", "Check responsiveness", "Make mouth to mouth breathing", etc.). If the decision is correct (i.e. there is corresponding action available on the current *scenario step*) then the simulation supervisor triggers respective *decision* which advances the scenario to the next *scenario step*. As explained before, the *action* is executed by the VA agent assisting the trainee during the whole training simulation.

Only correct *decisions* are available on each *scenario step*. In this way the trainee is protected from making bad decisions which has a very important educational impact. Still, if bad decision is attempted, the supervisor may trigger one of the *optional decisions* that make the VA say e.g. "No, I do not think I should do that", "Are you sure?", etc. Those *optional decisions* are stored in a separate list in the scenario (outside the graph) and are always available to the simulation supervisor. They are used in general to prompt the trainee to hurry up which puts some additional pressure on the trainee e.g. "OK, and now ?!", "Hurry up, tell me what to do!". *Optional decisions* are as well used to trigger some unexpected, additional simulation events that distract the trainee from the main plotline of the simulation making the experience more stressful hence closer to the objective of "facing reality".

In case the trainee is not able to make a correct decision, the supervisor advances the scenario further automatically using the default *scenario decision set*, which is yet another stress generating factor for the trainee who starts to understand that he cannot keep up with the scenario pace.

Apart from the tight time constraints and attention distracting events the trainee usually has to face as well uncertainty of the situation, shortage/surplus of data, misleading information, etc. which all add to the overall stress increasing emotional involvement and sense of presence thus making the experience more real.

4.5. Implementation Details

The system concept presented above has been practically implemented on a PC platform with the use of off-the-shelf VR devices: AscenssionTech magnetic tracker, CRT projector, rear projection screen, active stereo shutter glasses. The system has been deployed on two networked PCs running under Windows 2000. One of the PCs equipped with the high-end graphics board (Quadro4 900 XGL) and EAX compatible 5.1 surround sound board (Sound Blaster Audigy) is responsible for the hosting and execution of the simulation. Another, standard PC, is responsible for simulation control and display of the respective control GUIs operated by simulation supervisor. The system rendering ~100k-polygons featuring multi-textured environment, from 2 to 15 virtual humans (depending on scenario) with deformable skins, faces, speech, runs at ~20fps performance.

From the software middleware point of view the system is based on the VHD++ real-time development framework [9]. Being a proprietary middleware solution of both MIRAlab and VRlab laboratories, VHD++ is a highly flexible and extendible real-time framework supporting component based development of interactive audio-visual simulation applications in the domain of VR/AR with particular focus on virtual character simulation technologies. It uses C++ as the main implementation language and allows for automatic exporting of its components' APIs to the Python scripting layer. The most important features and functionalities of the VHD++ framework are: a) support for real-time audio-visual applications, b) extendible spectrum of heterogeneous simulation technologies provided in from of plug-able *vhdServices*, c) extendibility and scalability, e) runtime flexibility: XML based system and content configuration, f) complexity curbing: multiple design patterns improve clarity while abstraction levels simplify implementation constructs, g) large scale code reuse: fundamental components providing core system level functionalities and readymade components (*vhdServices*) encapsulating heterogeneous simulation level technologies: 3D stereoscopic rendering, 3D surround sound, VR navigation, Virtual Humans animation (keyframes, procedural walking engine, animation blending, etc.), skin deformation, face animation, speech, behaviors, interactive scenario authoring and execution, etc.

5. Case Study: Health Emergency Decision Training

The immersive VR decision training concept presented above has been confronted with a concrete case: training of the health emergency first responders.

In health emergency care, a clear distinction is made between a) the advanced training aimed at highly qualified professionals and b) the training of para-medical personnel (including citizen volunteers). The scope of the second type of training includes the following three key aspects: knowledge, skills and on-job training. While knowledge and skills can be efficiently acquired through the methods currently at hand (e.g. courses, books, multimedia applications, use of manikin and real devices, etc.), the third aspect of the training is still being achieved through the risky, leaving no place for mistakes, on-job training.

In course of the on-job training, the real emergency situation is usually difficult to predict for training (e.g. day, night, busy street, metro station, apartment, empty park, crying people, etc.). The main stress factors are mainly the uncertainty of a health emergency situation (limited cues, confusion), the pressure of passing time and the consequences of mistakes (risk, responsibility). In such conditions, the trainee should be able to assess the situation and make a sequence of decisions in order to perform the most suitable medical rescue procedure. In effect of an on-job experience, a trainee is supposed to lower psychological barriers, handle stress, use knowledge, make decision, take responsibility and as a result build self-confidence. Unfortunately the main inherent problems of the on-job training are: no room for mistakes, not easily available training context (random, not controlled). In effect, on-job training is very risky, long and expensive. In the light of the above discussion immersive VR decision training seems to be a promising option to address this problem.

At the current state, the immersive VR training system offers two interactive scenarios built around Basic Life Support (BLS) medical procedures and involving cardiac arrest. The first scenario takes place late at night, on the empty office floor. The second scenario is situated in a city park at night. Snapshots showing system in use and the two respective scenarios are presented in the appendix.

Medical users expect highly realistic simulation, particularly in case of the virtual human body appearance and behaviors. This conflicts with the real-time requirements of such interactive applications and thus must lead to certain quality-performance trade-offs in visualization of virtual humans. Still a lot of effort has been invested in precise modeling of virtual human meshes allowing for realistic animations, skin deformations, facial animations, etc.

Given current state of the art of the motion capture technology (we used optical Vicon motion capture), it is still effort intensive to generate high-quality human motion data required to visualize precise medical procedures. It is specifically extremely difficult to obtain satisfactory animations of hands and fingers. However it seems to be of secondary importance in case of decision training where the focus is on situation assessment and decision taking. It is as well hard to synchronize such high-quality motion data when played at the same time on two virtual humans (e.g. *Virtual Assistant* (VA) applying chest compression to the victim).

From the preliminary investigation it seems that the usability tests and assessment of the health emergency decision training case may be difficult due to the lack of similar systems that could be used as a reference for comparison.

6. System Use and Authoring Experience

After the first tests, the system seems to be easy to use and maintain. Navigation and interaction paradigms are intuitive and trainees get used to them quickly. As the system supports scalability it is possible to use it equally with high-end VR immersion hardware as well as in the desktop configuration by just changing configuration files. The technology is hidden from the trainee and the use of trainee-VA natural speech communication, as expected, is natural and robust.

The authoring process featuring component based reuse of scenario graphs, *actions*, and content occurred very efficient and helpful in communication among content providers, software developers and domain experts. It saved a lot of time during conceptualization, development and testing of scenarios as every team member could focus on his own expertise while communicating using scenario authoring semantics defined by the system. Creation of the case study scenarios discussed above involved collaboration of two health emergency domain experts, three software developers, two graphical content designers and two sound designers. The iterative nature of the scenario authoring process defined by the system allowed for quick prototyping of the first working version of the scenario and then for gradual improvements of the quality of its building blocks (models, animations, sounds and logic of actions) until satisfactory quality/price ratio was reached.

7. Conclusions

In this paper we have presented the main requirements, constraints and challenges involved in the practical realization of an immersive VR decision training system using interactive storytelling to support possibly diverse spectrum of scenarios featuring advanced virtual human simulation technologies.

We showed that despite of the revolutionary technological progress in real-time graphics and VR simulation technologies, still many open issues remain and they are related mainly to the VR immersion, haptic feedback, interactive scenario (as opposed to the interactive scene) and limitations of the current multi-modal interaction technologies.

Nevertheless, we show that some of the problems can be avoided by careful system conceptualization, selection of proper hardware and implementation of suitable interaction paradigms. In particular introduction of a Virtual Assistant agent concept allows for mediation of interaction between real and virtual environment.

We show as well that by introduction of proper interactive scenario semantics it is possible to improve production efficiency which relays on good communication among the team members and broad reuse of components.

Concerning the future developments we plan to a) elaborate more complex and diverse decision training scenarios, b) investigate system usability in more detail (Sense of Presence, educational aspects, stress factors), c) investigate further interactive story telling itself and its applicability to training and possibly mental health related applications like treatment of phobias, etc.

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APPENDIX: VR Decision Training of Health Emergency First Responders

For captured in real time videos of the immersive VR health emergency decision training system please refer to the following URL http:// vrlab.epfl.ch /~ponder/VHDPP_MOVIES/

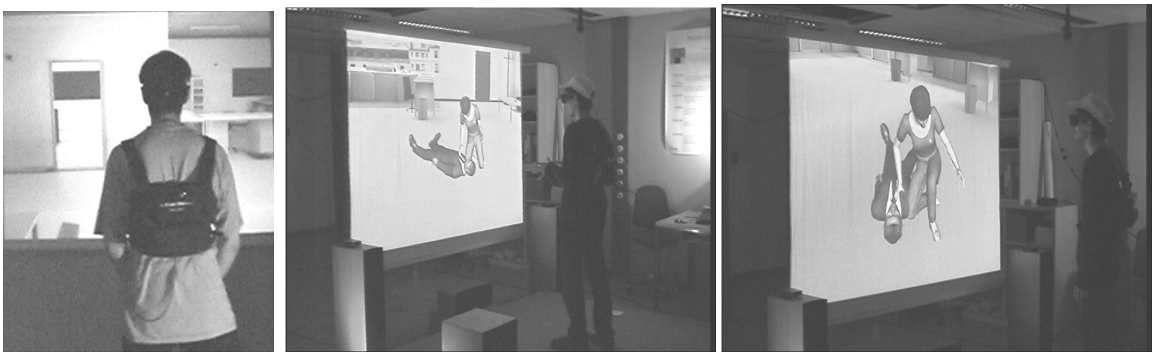

Figure 7 *A trainee interacting with the system: hiding technology, stereoscopic immersion using rear projection and active stereo shutter glasses, natural voice interaction with the virtual assistant, intuitive navigation in virtual environment using wireless magnetic head tracking.*

Figure 8 *Crating a health emergency situation training context: late evening, empty office, the trainee and his virtual assistant try to help the victim found on the floor.*

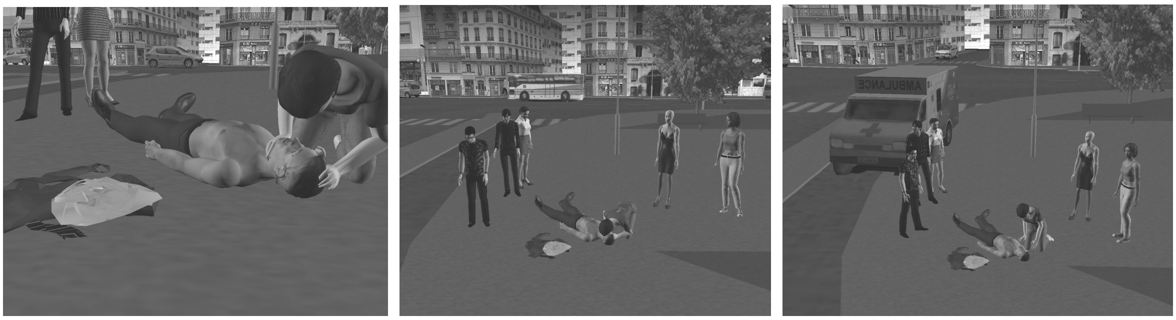

Figure 9 *Creating a health emergency situation training context: city at night, a victim found in the public park, the trainee and his virtual assistant try to assess the situation and handle the emergency situation.*