ACTIVE World: Manipulating Time and Point of View to Promote a Sense of Presence in a Collaborative Virtual Environment for Training in Emergency Situations

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Abstract

The use of virtual environments (VEs) to train members of a team to make good quality decisions is advocated. We have designed a system, *ACTIVE world,* that incorporates some of the strengths of VEs, but also supports various ways of reflecting on aspects of the training process. These additional support mechanisms have been conceptualised by us in terms of additional powers (superpowers) given to the trainees which they can exercise within the training environment. We describe *ACTIVE world* which supports collaboration, provides a sense of presence and some additional powers. How these superpowers interact with the sense of presence and degree of effective collaboration will be the object of our research in the near future.

Training in Virtual Environments and the Role of Presence

In recent years a number of virtual environment have been developed for teaching/training purposes. They are particularly useful when the domain to be learned about is complex and difficult to master, and when the visual features of the training environment are crucial to the success of training (Hansen at al., 1995). This makes virtual environments ideal for practising and learning skills for which the context of the training is not easily made available in nature, such as emergency situations.

A VE has been defined as acting like a transducer extending oneís capability to see, hear and touch data that would normally be beyond the range of our senses. Anything that can be described digitally can be seen, heard, touched and interacted with in a VE, even if it is an object not in the range of our normal experiences (Winn et al., 1999). This makes it possible to examine the training advantages of simplifying and extending the userís control and knowledge of the situation.

One of the strength of a virtual environment as a training tool is immediate visual/audio/haptic feedback. When the learning goal is the correct physical behaviour to solve a problem, feedback that comes from the immediate experience of the results of oneís actions is one of the best self-training tools available.

But one of the most important strength of virtual reality as a training tool for emergency situations, we believe, is the possibility of making a person interact with the world feeling "immersed in the experience" (Kalawsky, 1993). When this happens one can also expect that the experience so acquired will be transferred as knowledge into the real world. This notion of presence is arguably the key to ensure the transfer. It is the sense of presence that gives the "virtual experience" the same value as a corresponding real experience.

This issue is particularly important for the training of firefighters. The major source of knowledge, on which Firefighter Commanders ultimately rely on, is their own experience of dealing with a wide range of different fire situations. A VE can therefore be expected to be an ideal environment for creating experiences, and a strong sense of presence is essential to ensure the quality of the training since the experience in the virtual environment leads to recallable knowledge in the real world as a consequence of an engrossing experience acquired in the ëvirtual worldí (see Romano, Brna, Self, 1998 for more details).

There are examples in the literature of successful training in a virtual world with transfer to the real world. Flight simulators VEs are widely accepted for training, but also several investigations relating to learning spatial information have been performed. Slater, Alberto & Usoh (1995) and Wilson & Foreman (1993) found little difference between spatial information gained from exploring the computer simulation of a building and real exploration.

For navigation skills, examples include the work of Regian, Shebilske & Monk (1993), Bailey & Witmer (1994), and Bliss, Tidwell & Guest (1997) who created a VE to enable firefighters to practice rescue navigation methods in fire conditions. The results indicate that firefighters trained in the VE performed a quicker and more accurate rescue than those without the virtual training,

Kenyon & Afenya (1995) also report success in obtaining transfer by repeating and improving Kozak et al. (1993) experiment that failed to demonstrate transfer of knowledge about picking and placing objects in a virtual environment due to sensory limitations of the environment used. Therefore Kenyon & Afenya suggest that transfer of training from the virtual to the real world can take place under certain conditions. They argue that the most important condition is task fidelity. For example if a spatial sense is needed to accomplish the task, than the one given in the virtual world has to be the same or close to the one in the real world.

Sensory parity with the real world has not been reached, though audio and tactile cues added to the environment improve the virtual experience and reduce the necessity to rely strictly on visual cues. The additional cues do not necessarily add realism to the scene, but increase the sense of presence (Hendrix & Barfield, 1996).

Finally Slater & Steed (1999) report a positive association between presence and hand movement, and they suspect a two-way relationship: high presence leads to greater body movement, and greater body movement reinforces high presence. Achieving the sense of presence in a virtual environment can be seen as feeling that all the senses that would be involved in an equivalent real world are stimulated by the virtual world. The amount of stimulus needed depends on the person.

Ultimately a VE has great potential as a tool for assessment. A session can be recorded and played back for further reflection and interpretation of skills and knowledge (Roussos et al.,1998).

Learning in Virtual Environments and ACTIVE world

Theories of learning stress the distinction between tacit learning through experience and more symbolic, reflective forms of learning.

Most virtual environments give a representation with a level of physical fidelity that matches the requirements for the worldís purposes. This desire for representing exactly the objects of the world, or their accepted abstractions/metaphors, can lead to the neglect of the role of reflection in the training experience.

On the other hand, the standard way of providing team training in fire situations, that does not depend on physical training, is to avoid representing the world with physical, perceptual fidelity to concentrate more on the cognitive issues in command and control situations. An example of such a system is the computerised evolution of the standard "paper support" in use in more traditional fire training is the VECTOR Operational Command Training developed by Colt. VECTOR provides a series of static pictures with different fire scenarios and allows fire and smoke to be placed anywhere on the pictures to reflect on the possible consequences of fire in the different location in the building. The system also offers the possibility of switching to different roles and provides an on-line help with the guidelines for that role.

We have designed a system that takes a "third way", a virtual environment that supports situation awareness called *ACTIVE World (Action Control Training In Virtual Environments*). We intend this virtual environment to have the strengths of virtual environments that provide a close physical resemblance to the real environment, immediate feedback, and a strong sense of presence; but we also intend the system to support various ways of reflecting on the relationship between the elements of the dynamically changing situation and the learnerís goal which has been defined as situation awareness (Bass, 1998).

These additional supports have been conceptualised by us in terms of additional powers (or superpowers) given to the trainees that they can exercise within the training environment.

We argue that, by providing both superpowers and a 3D virtual environment, we will be able to achieve higher quality training in decision making in emergency situations. The problem is to engineer the system in a way such that situation awareness and presence are both achieved: the key research issue is to identify the criteria needed to optimise such a training process.

At this stage in our research we have a prototype system which has been designed to encourage a reasonable degree of presence and to allow various reflective activities via a small range of superpowers.

Since we are in a team-training context, with our system we intend to support a sense of presence through both individual perception and group awareness, owing to the need for a shared environment in which team members can reflect together and collaborate in resolving the problems that arise in the fire fighting task and acting out their decisions.

ACTIVE world *and its Superpowers*

ACTIVE world can be viewed as a game in which the players can experience the situation but with no real risks. From this perspective we see that even the most simple character driven computer games provide a (limited) range of tools for the main characters (players) to deal with the environment, such as extra lives, unnatural capabilities and various objects to use. This suggested to us that we should investigate the tools that could improve the learning experience and enhance reflection. We wanted some superpowers that would allow the learner to be in charge of their learning experience, in an exploratory, manner exploiting peer supported learning rather than overt tutoring.

The three-dimensional visualisation of the world, the possibility of having first person as well as general views, and environmental audio, have been introduced to stimulate a sense of presence in the environment. Detailed graphics and believable movements of the objects in the world, in particular of the fire, are used to support the believability of the experience. Some allowance has been made for the limitations of the modelling tools available and the power of the personal computer used.

ACTIVE world itself is a 3D desktop environment that reproduces an office and a warehouse going on fire. The buildings are located in a green area near a motorway exit. There are two main ways of accessing the site, from the motorway and from a standard road.

At the current stage of development a 2D interface allows manipulations in the environment giving the player the ability to specify an action to be taken on the elements of the environment as well as providing a number of superpowers.

A view of ACTIVE world at the current state of development

After a preliminary experiment in which we used a shared 3D game environment to establish the relationship between Collaboration, Presence and performance (see Romano, Brna, Self, 1998) we decided to implement the following superpowers:

- Collaborate with fellow learners
- Manipulate simulation time
- Change point of view and roles in the environment
- Use agents

The Effect of Collaboration in the Training Environment

As already explained, resolving a fire situation is the result of teamwork. This emphasises the need to provide a group experience in a shared world - a Collaborative Virtual Environment (CVE).

We found in a preliminary experiment (Romano et al., 1998) that team members reflecting together and collaborating to resolve a problem in a dynamically changing virtual environment obtained improved performances compared to a solo individualís performance. They also always reported a feeling of shared presence as well as individual presence when collaborating.

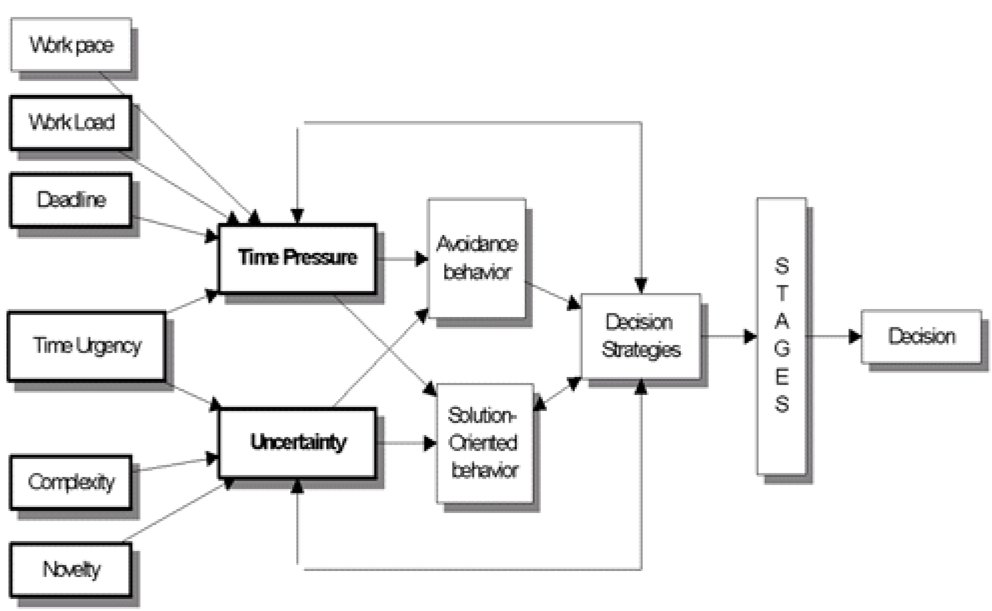
This result is supported in the literature: the quality of individual learning can be improved through collaborative work (Damon & Phelps,1989 provide a revue of the benefits of peer-peer collaboration). Therefore providing support for a collaborative experience is an important aspect of learning problem-solving strategies, particularly when peersí feedback can have an important role in making real progress with learning to make more effective decisions.

The Role of Time in Training Emergency Skills and the Effect of Time Manipulation

Decision skills in emergency situations are influenced by various factors such as the uncertainty of the ways in which objects in the environment might change, and the stringent time pressure under which the decisions have to be taken. In these cases, if not adequately trained, the subjects are likely to feel stressed and might reach a state in which they feel unable to take the right decision at all. "Stress occurs when there is a substantial imbalance between environmental demand and the response capability of the focal organism." (McGrath, 1970).

Firefighters deal with a dynamically changing environment and choose the best course of actions based on their own perceptions of the environment. The importance of each evaluative dimension (such as saving lives, preserving structures, minimising risks for himself and other members of the team, conserving resources, keeping fire from spreading) and the weight in the decision making process is subjective (Orasanu & Connolly, 1993). A right decision at one time could lead to a failure, while the same decision at a different time can become the best course of action.

In a fire situation major sources of stress are: too much or too little information coming at one time; complex and dynamically changing situations that result in uncertainty; and working against time that results in time pressure - the difference between the amount of available time and the amount of time required to resolve a decision task (Rastegary &Landy, 1993). A relationship between all those factors is shown in the figure below.



A time limitation restricts the decision-maker in collecting the information needed to make a judgement and contributes to uncertainty. The amount of information necessary to formulate a decision depends on the personal predisposition (Action Control) and experience (Kuhl, 1994; Stiensmeier-Pelster & Schurmann, 1993).

Perception plays a central role in defining time pressure. Time pressure arises when the time available is "perceived" to be insufficient. To feel time pressure a subject has to recognise that the imposition of a time limit is obligatory and that the violation of that limit will lead to failure (Rastegary & Landy, 1993).

The challenge, and purpose of our work, has been to design a virtual environment that helps: provide desirable experiences in dealing with complex fire incidents; relieve some of the stress, allowing the trainees to manipulate the time constraints (stopping time, going back in time, going forward). Time manipulation supports reflection about the learnerís owns actions and therefore should lead to improved situation awareness. The players can see immediately what happens if a particular decision is made, the world is modified at each decision point. If the results are not the predicted ones then the players can reflect on what could have been done differently and when it should have been done if the decision was the right one.

Going back in time allows the player to undo and re-play a decision if at any point in time he realises that a previous decision was wrong. Going forward to after a specific decision point shows the player the consequences of his actions.

Relief of time pressure should not only improve their understanding of cause and effect of a decision, but it should also relieve uncertainty which should allow all the elements involved in the scene to be discovered with plenty of available training time.

The Effect of Changing Points of View and Roles in the Environment

The possibility of allowing one player see what another player sees, and having different perspectives on the environment, including those that are hazardous or not available in the real world, should improve understanding of the complexity of the problem. In *ACTIVE world* a learner can play in a different sector of the fire scene, and in a different role (simple firefighter, sector commander, incident commander) in the simulation.

A learner can swap roles with a fellow learner and or with a software agent (see after for agents). A learner can change role at any time (if such a role is available) and in a future development of the *ACTIVE world* it will be possible for more than one view to be available at the same time.

The Use of Agents in the Active World

Currently, ACTIVE world is intended for use with two players, but in the real world an incident such as the one that we are modelling requires at least five teams of firefighters (one per sector) as well as the sector commanders. In addition there is an incident commander and the associated communication team (called MACC).

To reduce the complexity of the task of dealing with the decision regarding all the sectors at the same time, the players can decide to delegate the control of the decisions in one or more sectors to a purpose built software agent. The software agent will assume the responsibility of dealing with the fire in the area he is called to cover acting as a sector commander, while the players are experiencing the decision regarding the fire on other fronts.

Such agents will be programmed to have a random distortion in the decision chart, so that they do not always make the right decision. This is to be able to generate different fire scenarios every time and also not to give away easily the solution to the learner who could otherwise just let the agents play and watch to learn the course of actions.

A future development could consider building agents with a stronger educational role, either acting as a fellow learner with more or less experience, obviating the inconvenient of missing players, or having a clear tutor's role.

Conclusion: Superpowers and the Sense of Presence

As stated previously, the problem and challenge of our research is to engineer the system so that reflection and presence are both achieved.

On the one hand, we want to relieve the pressure of time - allowing the trainee to stop the simulation to reflect, go back and forward in time to see the effect of his actions, change point of view and roles; on the other hand we want the learner to feel present in the environment. But what happens to the sense of presence when a trainee, for example, stops the time?

Will using the superpowers make learner lose his sense of personal presence in the environment, or are the environmentís settings sufficient to keep him engaged even if, for example, the time in the simulation (voluntary action on the environment non available in nature) is modified?

Slater and Steed (1999) suggest that we can think of presence as a selector amongst the virtual and the real environment to which to respond, it switches dynamically from moment to moment.

"If it were possible to `freeze time' at a specific instant, then the individual would be paying attention and responding to a set of stimuli corresponding to one environment, not paying attention to all the other stimuli, or interpreting stimuli from one environment in the context of the currently present one (for example interpreting a sound from the real world as belonging to the virtual world)." (Slater & Steed, 1999).

If this is true, than we should expect that the use of superpowers in the *ACTIVE world* will not interfere with the sense of presence, but be a way of displaying this selection of stimuli, stopping those coming from the environment to reflect on what it has been just experienced.

Also we already know from our previous study that collaboration enhances the sense of shared presence. We are now going to investigate the effect of time manipulation, change of view, role swapping and the use of agents on the perception of shared presence during collaboration.

We hope in the near future to conduct an experiment that will clarify all the above relationships and give us a feedback quality of training and performances in an environment such as *ACTIVE world*.

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