The DISCOVER simulator – crisis management through collaborative learning

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Keywords: simulator, multi-user, collaboration, offshore

Abstract

This paper describes the design, architecture, and scenario of a novel multi-user simulator that has been developed to train and assess teams of personnel operating in the offshore sector. The simulator is distributed, i.e. the users can be in different locations and still "meet" in a shared, virtual 3D-environment. The users are represented by avatars. They can interact with virtual objects and navigate freely in a virtual 3D-environment that imitates the interior of an oilrig. Training sessions in the simulator allows particular focus on communication, leadership, and collaboration, and enables concurrent tutoring. In a typical scenario, a team faces an emergency involving fire fighting, casualties, and evacuation. Meeting these challenges will require close cooperation between the participants. The offshore simulator supports playback of a given training session, thus enabling a retrospective evaluation and assessment of the team performance. The offshore application presented here is an integral part of the DISCOVER project.

Introduction

Working in the offshore and maritime sectors can be a hazardous occupation. You not only have to take precautions against the perils of the weather and the sea, you are also faced with large and dangerous equipment and machinery. The risk of having accidents is always present, with a potential for disastrous consequences for everyone involved.

To reduce the risk to equipment and people, it is crucial to have offshore personnel trained in crisis management so that they can handle emergencies. Every year considerable amounts of money are spent on such training. Real-time multimedia applications can provide a readily accessible and cost-effective training tool. In particular, distributed virtual environments can provide *teams* of offshore personnel with the opportunity to train together within a safe yet challenging environment.

The aim of the DISCOVER (Developing InduStrial COmpetences through Virtual EnviRonments) project is to train and assess teams of personnel operating in the maritime and offshore exploration and production sectors. Two prototype training applications have been developed, facilitating group interaction in a virtual 3D-environment. The offshore simulator described in this paper is part of the comprehensive DISCOVER system, and has been developed by Telenor Research and Development. The trainees have to pass a theory course before proceeding with the next level, namely the distributed, virtual 3D-environments. The theory course and the administration module are described in a separate paper in these conference proceedings [1].

The offshore simulator immerses multiple users in a shared virtual environment where all the training takes place. The users are represented in the 3D-environment by *avatars*, a visual “handle” in the form of a human-like 3D-figure whose eyes are the participant’s point of view into the virtual world. The avatars can move freely in the horizontal plane of the virtual environment, which is a relatively detailed model of the oilrig interior. The use of avatars enables the participants to observe each others movements and encourages them to communicate. The communication methods mimic that of the real world, including face-to-face conversations, phones, VHF radios and a PA system. The simulator comprises special application-relevant objects such as a fire source, a virtual casualty, fire extinguishers, telephones, and smoke effects.

The scenario that was developed for the demonstration of the project is set on the Statoil oilrig *Statfjord C*. There are four roles that the trainees must fill: a platform manager, two operators of the control room, and a smoke diver. A fire alarm is activated in the control room indicating a fire in the living quarters, and the appropriate steps have to be taken. There is a tutor present in each training session who controls and instructs the trainees. The participants start out in predefined locations in the virtual environment, and should carry out specific duties according to their respective roles. The scenario training aims to elicit the correct actions in a given situation.

System Architecture and Application Design

The DISCOVER offshore simulator was developed using the software development platform *DOVRE* (Distributed Object-oriented Virtual Reality Environment), a tool for distributing 3D-graphics, sound, video, and other multimedia streams over the Internet [2]. DOVRE is a flexible software framework that supports all Win32 platforms (Win95/98, Windows NT and Windows 2000) and UNIX (IRIX and Linux). The DISCOVER application is developed specifically for the Win32 operating systems, but can easily be ported to the other platforms as well. DOVRE runs on both high and low bandwidth networks, and all communication goes through a TCP/IP network, including updates of manipulated objects, avatar positions, 3D-audio, and video. DOVRE supports a variety of different model and image formats, although VRML-models are most commonly used.

The DISCOVER application is a real-time, distributed virtual environment, i.e. several participants can join in and collaborate in the same virtual environment at the same time. This effect is achieved by having a server where one or more clients can connect. Figure 1 shows the DISCOVER network architecture. Using a standard internet connection, the clients communicate with the server, which in turn distributes the information from one client to the others.

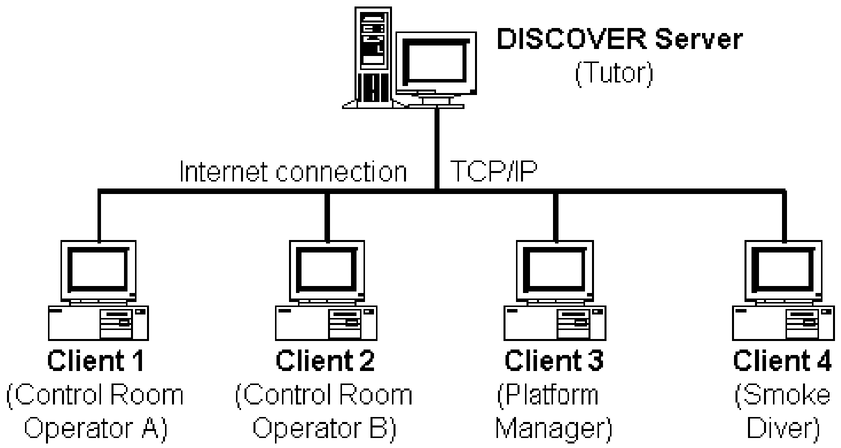

Figure 1. The network architecture of the offshore simulator. The system utilizes a client-server approach.

Although the system can be modified to run on SGI workstations, a PC network makes it more accessible to end-users. The hardware needed for running the application with a sufficient performance is standard high-end, off-the-shelf PC's, the most critical part being the graphics card.

The DOVRE system supports a real-time, distributed 3D-sound system. The participants can communicate in several ways using a microphone and a set of speakers. Anyone within a certain spatial range in the virtual environment can hear what others within the same range are saying, thus simulating face-to-face conversations. On a real oilrig, there are of course other ways to communicate as well, and this is also the case in the offshore application. The real-time sound system can simulate the functionality of a VHF radio (walkie-talkie), a telephone and a personal announcement (PA) system.

The application in itself does not generate much network traffic. However, since the sound is distributed through the network, a good connection is preferable to avoid communication delays. The sound is also dependent on having a low latency (delay) for the communication between the participants to go smooth. This can sometimes be hard to guarantee when using a standard internet connection. In most cases the application will probably be run on a company intranet. This will usually involve more than enough bandwidth and a sufficiently low enough network latency to run the application without any problems.

The VRML97 modeling format [3] was used to create all the visual objects in the offshore simulator (like the models for the platform, doors, chairs, telephones etc.). Advanced functionality and animations were made by exploiting the scripting capabilities of VRML. For instance, the avatar is animated to "walk" when it is moved by the participant.

The file names of all the 3D models are listed in a separate file that is parsed at simulation startup. In this way, both the visual appearance and functionality of the virtual environment can easily be modified.

User Interface

The DISCOVER project has a strong focus on the collaboration and communication skills of the trainees. The graphical user interface (GUI) on the client side was designed to be as simple as possible to ensure that potentially inexperienced users should be able to control the basic functions of the application. Furthermore, navigation of the avatars appears to be a challenge for inexperienced users. For simplicity we adopted the navigation method used in many popular 3D-tools like e.g. the Cosmo-player [4]. As for navigation purposes, interactions between the user and the virtual environment were based on using the mouse. The client application has a drop-down menu system with a few simple commands for communicating with the other participants (like e.g. turn on/off the VHF radio).

The server application is controlled by the simulation tutor. The tutor can move freely around in the 3D-environment. However, there is no avatar representing the tutor, i.e., he/she is invisible to the other participants. The server application is equipped with a 2D-panel, as shown in figure 2.

Figure 2. Screen shot from the DISCOVER server application. The 3D-scene (upper part) is accompanied by a 2D-panel (lower right part) containing an interactive map where the immediate positions of the participants are marked according to the legend next to the map.

The tutor can change the communication methods by clicking on the radio buttons available to the left of the map. In the interactive map, each client is represented with a colored dot. In this way, the tutor can observe the position and dynamics of all the trainees participating in the simulation. It is also possible for the tutor to quickly jump from one location to another by clicking the instructor dot and dragging it with the mouse to the desired location. In addition, the tutor can double-click any of the other dots and observe the activities through the "eyes" of the respective participant. Now, everything that the user does will be visible to the tutor, and if the user moves, the tutor moves with him.

Application Walkthrough

In the example scenario, four roles are to be filled in addition to the tutor. Figure 3 shows representative screen shots from a typical simulation session. The participants appear in different locations of the virtual oilrig when the simulation starts. The two control room operators appears in the control room, the platform manager is located in the operator room, and the smoke diver is in one of the corridors.

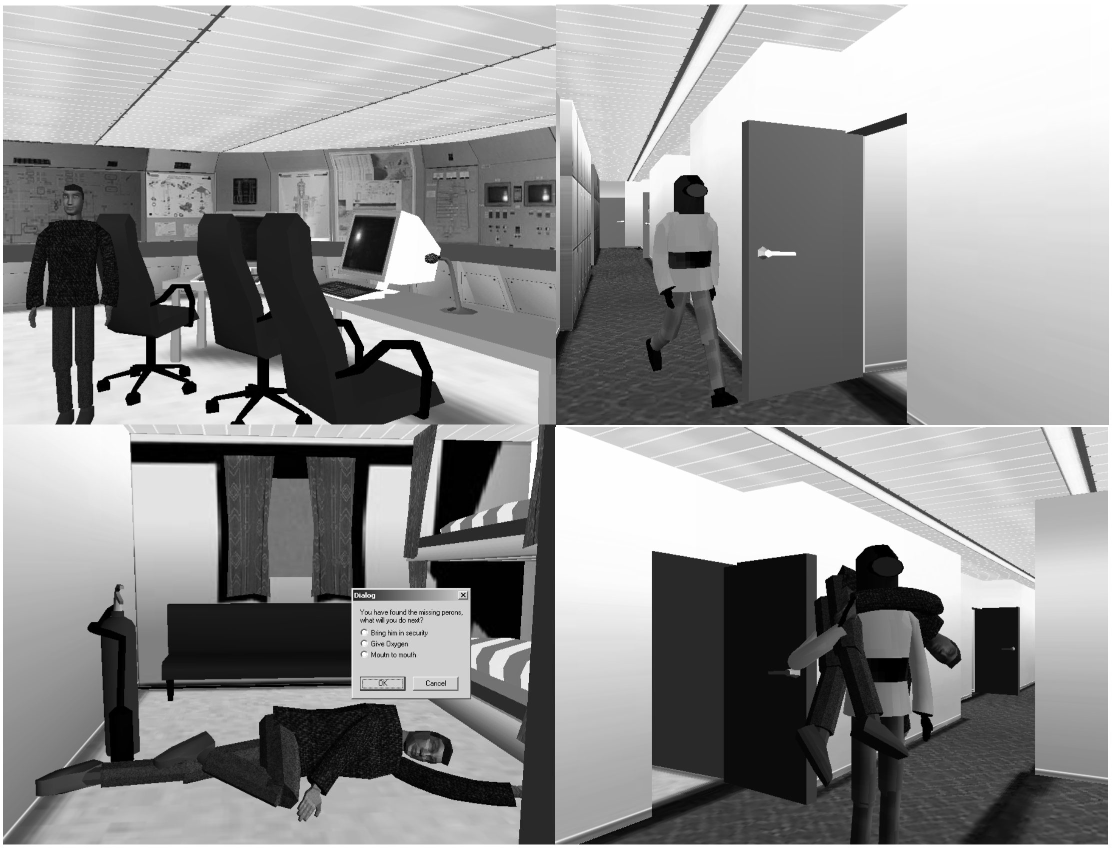

Figure 3. Screen shots from the client applications during a simulation: One of the operators in the control room (upper left), the smoke diver in the corridor of the living quarter (upper right), the casualty in a cabin (lower left), and the smoke diver evacuating the casualty (lower right).

A fire alarm has been activated and smoke starts to emerge from one of the cabins in the living quarters. A message from one of the muster stations informs the trainees that a person is missing. One of the control room operators alerts the smoke diver. The smoke diver surveys the corridor and tries to locate the missing person. The unconscious person is located in the cabin with the fire. The simulation session involves a number of events and procedures to which the trainees must respond. The two main events involve the rescue of the casualty and the evacuation of the oilrig. Table 1 lists some illustrative examples of events from the scenario, along with their appropriate actions.

Event	Action	How?
Contact the smoke diver.	Use the personal announcement (PA) system in the control room.	Click the button on the PA-microphone ("select mode").
Inspect the corridor.	Navigation in the 3D-scene. Opening and closing of doors.	Use the left and right mouse buttons. Click on the door object.
Discuss the situation with the platform manager.	Use one of the telephones.	Click on the telephone object.
Put out the fire	Use the fire extinguisher located in the cabin.	Click on the fire extinguisher object.
Save the unconscious person.	Find the right cabin. Start rescue procedure. Choose from three alternative actions. There is built-in feedback functionality when choosing alternatives from the dialog box.	Click on the injured person. This brings up a dialog box. Click the radio buttons in the dialog box.

Table 1. The left column describes some events from a simulations session. The center column describes the expected actions from the participant. The right column shows how to perform the action.

Discussion and Future Directions

This paper describes the details of the offshore simulator that has been developed in the DISCOVER project. The advantage of the offshore application lies in the *distributed* form of the simulator, i.e. the participants can train and collaborate as a multidisciplinary *team*. The use of advanced 3D-technology enables training and interactions in a realistic environment. The use of real-time graphics helps trainees gain a realistic sense for the amount of time that passes, thus increasing the possibility for adopting experience from the simulation into real-life situations.

Traditional hands-on training for improving safety-critical skills, such as fire fighting and sea rescue, are an obvious part of the compulsory training for most offshore personnel. With the DISCOVER offshore simulator, we are not aiming at skills-training. Instead, the focus is on *team performance* when handling an emergency. To aid the evaluation of the team performance, the tutor has the ability to make a complete recording of the training session. The avatars navigation, their interaction with the 3D-environment, and the communication that has taken place can be stored for later analysis. This replay functionality enables a retrospective "fly-on-the-wall" view of the training session, and can be observed from any angle and perspective.

The replay functionality can also be used as an educational tool. One could, for example, record a team that does everything the right way, showing it to students as an example of how it should be done. It can also be used as an example of how not to do it, or as a “spot the five mistakes” type of exercise.

Designing a good learning environment for understanding complex information is a complex task [5]. Although much work remains to address collaborative learning in virtual environments [6], the DISCOVER offshore application should serve as a valuable supplement to the more traditional learning resources such as theory courses and hands-on simulations. The continuing research in the DISCOVER project will focus more closely on the impact of this distributed multimedia application. Results from the DISCOVER project may be applicable in other fields where collaboration is important.

The DISCOVER project is partly financed through the EU program, and involves both academic and applied research institutions in Europe.

Acknowledgement

The virtual oilrig, including models and textures, was created by Ivar Kjellmo, Telenor R&D. We gratefully acknowledge the contributions from Atle Westvang, Marintek, Norway, and Statoil, for providing the material that the modeling work is based upon. Special thanks to Espen Ottar, John Arthur, Iver Grini, Bendik Bendiksen and Siri Fagernes for applications development and help with the manuscript.

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Author biographies

Simen Hagen is a research scientist in Telenor Research and Development. He received his M.Sc. in computer science from the University of Pittsburgh in 1995. He is the main developer of the DOVRE platform, and his research focus is on application development, 3D-technology, graphical user interfaces, and human-computer interaction.

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