Application Of VR And HF Technologies For Improving Industrial Safety

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Abstract*: Safety in industrial environments can nowadays be regarded as an issue of major importance. Large amounts of money are spent by industries on this matter in order to improve safety in all levels, by reducing risks of causing damages to equipment, human injuries or even fatalities. Virtual Reality (VR) has proved to be ideal for providing operational experience without exposing trainees to industrial dangers, thus avoiding serious accidents. VR technologies can offer not only ideal visualisation and interaction features but at the same time offer a significant level of immersion to the trainee. The combination of VR, rule-based technologies and process simulators offers an all inclusive solution towards industrial training, safety management and accident investigation. This paper presents the technologies described above used in the VIRTHUALIS IP for various safety actions in industrial environments.*

Keywords: *Virtual Reality, Virtual Environment, Human Factors, Industrial Safety*

1 INTRODUCTION

Nowadays the industrial sector tends to spend significant amounts of resources in order to reduce accidents in industrial plants, that if occurred would cause property damages, human injuries and even fatalities especially when talking around hazardous material environments. Therefore personnel training under emergency situations, accident investigation and safety management actions can be regarded as critical. These actions involve training of control room operators, emergency teams training, plant modifications impacts and also assisting managers to define the impact of certain decisions on individual (or group of) operators' work.

VR technologies as a rapid and diversifying field can be regarded as one of the key-technologies regarding visualization and is currently used in a wide area of applications such as archaeology[8], entertainment[1], architecture, automotive[6], etc. Its increasing use in various fields has not only aided in major improvements but it has also contributed in the identification of advantages in different application areas. Additionally the usage of VR technologies has been proved ideal as an effective design and training tool thanks to the immersiveness (the sense of "being there") and interactivity support.

The VIRTHUALIS (Virtual Reality and Human Factors Applications for Improving Safety) Integrated Project (IP) is an EC funded project, focusing on industrial safety and currently involves 48 partners including research, industry and other consultation partners ranging in 14 European countries. The main objectives of the VIRTHUALIS IP are to reduce hazards in production plants and storage sites by addressing end-users' practical safety issues through the development of an innovative technology by providing the chemical and petrochemical industries with the necessary tools for efficient life-cycle design, production, use and recovery aiming at sensibly reducing accidents and incidents in the process industry; enhancing system operability within the overall life-cycle and reducing costs associated with safety production [5]. One of the breakthroughs that VIRTHUALIS offers is the combination of VR with Human Factors (HF) technologies, supported by the usage of Rule-Based systems.

2 THE SAFEVR PLATFORM

The SafeVR platform is the basis where the VIRTHUALIS applications will be based. It includes various modules serving different tasks as described below.

2.1 The System as A Whole

A higher-level API called "Delta3D", which provides integration between OpenSceneGraph and other common libraries has been used [3] [4]. This is an open-source project, targeted mainly for complex simulations, which provides various functionalities allowing the VIRTHUALIS team to better focus on the project functionality. The system is based on distributed modules that communicate with each other via a network and has been designed as such to maximize its extensibility. The system has been designed to be operating in from a simple desktop environment to a multi-display environment like a CAVE system. Its main structure consists of two main modules: the master and the satellite applications. Finally, Network communication is handled directly by the Delta3D framework; messages are sent over the network using a predefined mechanism. Below, a simple diagram of the system can be found indicating the main system modules.

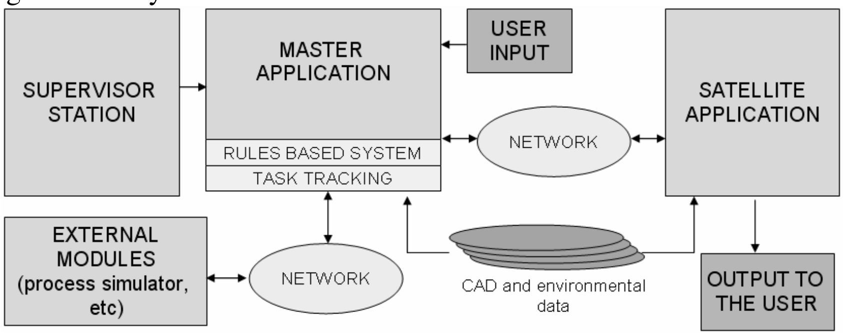

Figure 1 - SafeVR Platform Architecture

2.2 System Modules

2.2.1 Master and Satellite Applications

The Master Application is a program which is in charge of handling the greatest part of the “application” step. It takes care of updating objects’ positions and states, it processes user actions and input from external devices and keeps all the state attributes updated. It has a copy of the scene graph in memory and processes all requests that have an impact on the scene graph from tracking devices, collision detection, and other interactions that may impact how an object is displayed. It communicates modifications that occur to the scene graph to the Satellite Application via a dedicated network protocol. The Satellite Application is an application in charge of handling the “cull” and “draw” steps of the pipeline. It has a copy of the scene graph in memory, which is synchronised with the main one managed by the Master Application via updates received from the Master itself. Note that there can be more than one Satellite Application running on different machines (for multi-display systems for example).

2.2.2 Player Manager Module

This module is responsible for interpreting user input from the satellite application and computing the system response. This involves a number of navigation modes, namely First Person view, Third Person view and Birds inspection view, as well as features enabling interaction with the environment. The latter is not confined only to collision detection and response which is necessary for the navigation but introduces features that allow for dynamic modification of the environment. Designated objects which are tagged as interaction points crucial to the simulation's state can be manipulated using any of the hardware input devices like joysticks, joypads, trackers or other VR peripherals that are supported by the VRPN library.

2.2.3 Rule Based Module (CLIPS)

This module couples an existing rule-based system with the SafeVR toolbox (CLIPS). First, the module can be used as a replacement for an external process simulator where one does not exist. When a Player performs an operation, instead of invoking a simulator, this module can react in a predefined way as specified in the rule-base ("scenario-based simulation"). Also, the module can indicate how the environment is affected due to the operating condition. Additionally, the module can be used to implement plant logic. Closing, it can be used to monitor user tasks. If required, it can send warning (or other) messages to the users [3].

2.2.4 Task Modeling and Tracking

Based on the related module of the Delta3D platform, this module has been created and is responsible for (ordered) task following inside the applications. It is a module that allows for three types of ordered actions: Atomic (single), Group of actions (of atomic), and sets of group actions. The module has XML files as input where all the configuration of the tasks is taking place.

2.2.5 Process simulator

The Process Simulation module acts as the bridge between the SafeVR platform and an external Process Simulation engine, thus providing realistic, dynamic plant and process behaviour to SafeVR applications. Of course, the link between this module and the actual process simulator depends on which specific simulator is chosen. The process component will be loaded on the server Game Manager and it will process messages to and from the external process simulator. The initial application plant chosen in VIRTHUALIS uses the Dynsim Process Simulator.

2.2.6 Supervisor Station

The main purpose of this module is to act as a monitoring tool by allowing the simulation supervisor to oversee all activities. Furthermore, it provides the means for manipulating the environment at real time thus affecting the course of the simulation. Consequently the Supervisor Station can be regarded as the interface between the industrial expert and VIRTHUALIS. It is the means through which, all data destined for the user can be published and essentially promotes decision making and the extraction of useful conclusions. The Supervisor Station lies on top of the SafeVR platform utilizing it in order to enable real time monitoring of the 3D environment. In addition to that, it implements a graphical user interface (GUI) that provides the user with overall control of the tool's functionality.

2.2.7 Logging/Recording Module

The Recorder is implemented as a distinct component and it derives from the standard Delta3D functionalities and is the module responsible for recording all system states, actions, messages etc over time. This module keeps a log of those information and stores them so that they can be used later at any stage, even for results evaluation or for scenario re-play or playback.

2.2.8 Plant Model Builder

The Plant Model Builder (PMB) is an application used to prepare the scenes for the simulations in the SafeVR platform and its safety applications (tools). The use of this application includes the availability of the component library (incorporating components and elements to be used in the scene) and also the geometry files (or 3D models) of the actual components (supported formats are: OSG, 3DS, OBJ, and IVE). The Plant Model Builder consists basically of three layers (parts):

- Viewport which displays the plant and its individual components (objects);
- Model Browser for importing and modifying component libraries as well as editing the hierarchy of the objects in the scene;
- Property Editor for displaying and editing the properties (e.g., temperature, pressure, status, etc.) of each 3D-object in the scene.

3 THE DEMONSTRATOR

The Demonstrator is a compilation of the above applications in order to indicate the particular features that the system supports right now. Having described the system as a whole the bullets below can summarize its capabilities and features up to its current state:

- Realistic simulation of the industrial environment (supporting fire, smoke, light conditions, etc);
- User interaction supporting VRPN devices;
- Advanced user interface (UI) for tasks execution and scenario start/stop;
- Communication to external process simulators;
- Interface to related CAD systems and plant creation tools;
- Rule-based computing mechanisms to implement scenario-driven dynamic simulations;
- Logging and re-play functions.

4 HUMAN FACTORS ROLE

HF experts inside the consortium have been working in close collaboration with the development teams to ensure that HF methodologies are perfectly applied for a synthesis of safety analysis methods with human factors knowledge that can adequately represent the dynamic nature of human and system performance but at the same time to evaluate and integrate the peculiarities and goals of HF methods and VR technology for enhancing safety actions through VR.

5 CONCLUSIONS AND FURTHER WORK

The work that has been described in this paper regards the creation of a 3D interactive distributed system, developed to improve various safety actions concerning industrial safety. The basic elements have been presented and illustrate the functionalities by the integration of VR, rule based and HF technologies. The tool will not only form the basis for developing training applications; it will be a platform based on which more advanced systems and wider applications can be developed. The system will be applied in reducing hazards in production plant and storage sites by addressing end-users' practical safety issues.

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