VR, HF and Rule-Based Technologies Applied and Combined for Improving Industrial Safety

Konstantinos Loupos[1], Luca Vezzadini[2], Wytze Hoekstra[3], Waleed Salem[4], Paul Chung[5], and Matthaios Bimpas[1]

[1] Institute of Communication and Computer Systems (ICCS), Athens, Greece
[2] Virtual reality & Multimedia Park (VRMMP), Turin, Italy
[3] TNO Defense,Security and Safety, Netherlands
[4] Fraunhofer-Institut für Fabrikbetrieb- und automatisierung IFF, Magdeburg, Germany
[5] Loughborough University, Leicestershire, England

Abstract. Industrial safety can be regarded as a major issue of industrial environments nowadays. This is why industries are currently spending huge amounts of resources to improve safety in all levels by reducing risks of causing damages to equipment, human injuries or even fatalities. This paper describes how Virtual Reality, Human Factors and Rule-based technologies are used in the framework of the VIRTHUALIS Integrated Project towards industrial training, safety management and accident investigation. The paper focuses mainly on the VR system specification and basic modules, while at the same time it presents the main system modules that synthesize the tool as a whole.

Keywords: Virtual Reality, Virtual Environments, Human Factors, Rule based technologies, industrial safety.

1 Introduction

It is widely known that any wrong operation or mal-function in any industrial environment can lead to accident causing property damages, human injuries and even fatalities, especially when discussing over industries involving dangerous or explosive materials or substances. Therefore nowadays there are significant amounts of money spent from industrial sectors in order to reduce accidents and the reasons that may lead to possible accidents.

Some of the typical and practical safety issues currently present into industrial sites can be listed below:

- Training for control room operators;
- Emergency teams training;
- Assessment of the impact of plat modifications
- Managers' assistance in defining the impact of their decisions on operators' work

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

C. Stephanidis (Ed.): Universal Access in HCI, Part II, HCII 2007, LNCS 4555, pp. 676–680, 2007.

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. In general, VIRTHUALIS aims in providing the chemical and petrochemical industries with the necessary tools for efficient life-cycle design, production, use and recovery.
The project scientific and technological objectives can be summarized as follows:

- To sensibly reduce accidents and incidents in the process industry;
- To enhance system operability within the overall life-cycle;
- To reduce costs associated with safety production.

VR technology as a rapid and diversifying field can be regarded as one of the key technologies regarding visualization and/or user interaction through massive advances in computer science, human/computer interfaces and visualization technologies. Its increasing use in various fields has not only aided in major improvements but it has also contributed to the identification of advantages in different application areas (sych as the industrial sector). Additionally the usage of VR technologies has been proved ideal as an effective design and training tool thanks to the immersivity (the sense of "being there") and interactivity support. VR technologies are currently used in a wide area of applications such as archaeology [4], entertainment [5], architecture [6], automotive [7], etc. VR simulator users can use the technology and interact with the virtual world in a variety of ways and this is what indeed defines the technology versatility. In a typical VR system, the user can have fully immersive view with the aid of Head Mounted Displays (HMDs) while at the same time interacts with the system/virtual world via an interaction device.

One of the breakthroughs that VIRTHUALIS offers is the combination of VR with Human Factors (HF) technologies to achieve the aforementioned objectives, supported by the usage of Rule-Based systems. HF technologies in general represent studies on how humans behave physically and psychologically related to particular environments, products and services [2]. By immerging sharp-end operators, teams, safety analysts, managers into Virtual Environments (VEs) suitably modelled for the specific analysis to perform, it will be possible to experience safety-critical situations amplifying people capabilities and enabling them to suitably exploit HF concepts when performing safety analyses. At the same time the support from Rule-Based technologies comes when there is need to make the system as dynamic as possible and create rules that it must comply with and follow. This provides the ideal solution since the information (or rules) are not "hard" coded into the system but can be altered and adjusted depending on the exact application or application scenario (case study).

This paper provides a description of the overall system focusing on VR technologies and their widening when combined with HF and Rule-Based technologies.

2 System Description and Modules

2.1 Main System Modules

The system is based on distributed modules that communicate with each other via the network communication and has been design as such to maximize its extensibility.

Ideally the system has been designed to be operating in a desktop or CAVE system. Its main structure consists of two main modules: the master and the satellite applications. These are supported by some more external modules that provide additional capabilities to the system as a whole. The diagram below shows the main system architecture and main modules included in it.

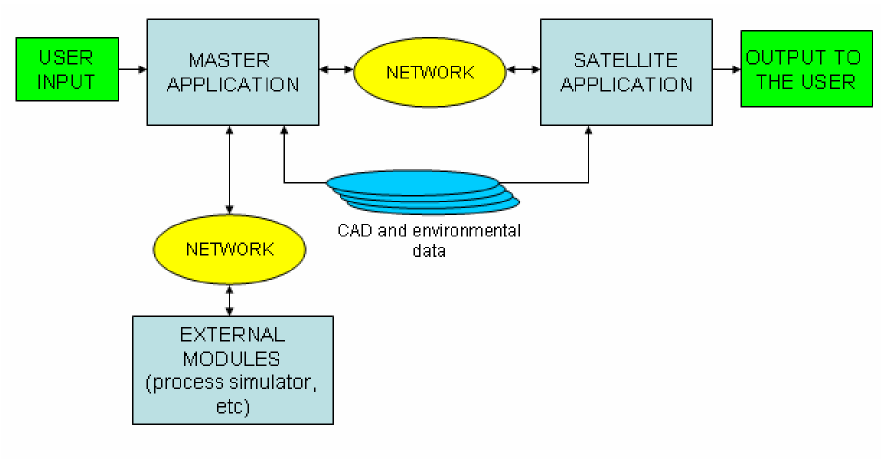

Fig. 1. Main System Architecture

The master application is the module responsible for handling the main part of data processing. It handles all models' states, user actions (including user interface) and keeps all system state attributes up to date. It is not handling any model or image rendering but rather keeps in memory of the scene graph sub-module that is kept synchronized with the related sub-module of the satellite application (mainly done in order to improve overall system performance). At the same time the master application monitors the user responses/actions and reacts to update the suitable sub-modules. This synchronization is achieved through network communication. The master application (and the satellite application as well) also include a logging sub-module responsible for logging all user actions and system states in order to keep an exact log of the simulation for replay or other functions.

The satellite application is the module in charge of handling and rendering the visualization data. This module receives the transmitted data over the network and then the synchronized scene graph sub-module (in synch with the master application's same module), updates the local data, renders the related models and outputs the result on the output device (monitor, projection, etc).

2.2 Additional System Modules

Apart from the master and satellite applications (modules), there exist some system modules that operate in parallel but are not directly linked to the system's operation as a whole. These are the recording module, the process simulator and the rule-based computing system.

The recording module is responsible for monitoring all system actions/states and receiving data from both the master and satellite applications (can be one or more). The module is “smart” enough for being able to select and filter if a message sent from the master or any satellite application has to be recorded or not. This module can be used for helping trainees and trainers to evaluate the operation of the system and monitor the user performance or reproduce/replay the whole simulation.

The particular function that the process simulator is responsible for is to simulate the chemical process performed in the plant (in the absence of the actual plant). The system (master application) communicates with the process simulator to update it (on user actions, etc) and be also updated (on system state changes). For instance whenever the user opens a valve, the master application notifies the process simulator of this (via the network) and the simulator takes this under consideration in the simulation of the whole chemical process. It then, in turn communicates the results of these actions to the master application so that the whole simulation cycle is updated (on the results of the user action – valve opening).

Finally the Rule-Based module is the module responsible for responding in predefined ways when certain (user or system) conditions occur and is the module that has been designed using rule-based technology. The general idea for its operation is that it includes an internal set of attributes representing the parameters to be monitored. In case that an event occurs (user or system internal action) the module checks if the action is related to any rules and acts accordingly. This module can be used in various ways: as a process simulator substitute, to affect the environment, to apply plant-specific behavior and to help monitor the execution (and right order) of procedures [2].

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 various tasks execution and scenario start/stop;
- Communication to external process simulators (for plant operation simulation);
- Interface to related CAD systems and plant creation tools;
- Rule-based computing mechanisms to implement scenario-driven dynamic simulations;
- Logging and re-play functions;

3 Conclusions and Future Works

This paper has described the general architecture including main building blocks for an interactive 3D system that is currently being developed to improve training for process industry. To ensure adaptability and maximize extendibility, the system has been based on distributed architecture and independent modules. The system is based on three main modules: the master application, the satellite application and the external modules, while the communication and synchronization between them is achieved via usage of advanced networking protocols.

The system under development is expected to be applied to industrial sites in order to reduce hazards in production plants and sites. This will be done with the construction of some applications applied mainly to the "Risk Assessment" safety action. Later this application will be enhanced such as to support other safety actions (Training, Safety management and accident investigation). The first prototype for the first aforementioned safety action ("Risk Assessment") is expected to be completed in the next four months.

References

1. http:// www.virthualis.org
2. Salem, W. (et al) - Enhancing the Trainee's Awareness in a Virtual Training Environment. IMCL, conference, April 19-21, 2006, Amman, Jordan (2006)
3. Prof. Paul Chung (et al) – The Integration of VR and Rule-Based technologies to improve process safety. ESREL, 18-22 September 2006, Estoril, Portugal (2006)
4. Sideris, A., Roussou, M., Gaitatzes, A.: Virtual Reconstruction of the Hellenistic Asklepieion of Messene using Scientific and Educational Scenario-based Approaches. In: Proc. 9th Annual Meeting of the European Association of Archaeologists, St. Petersburg, Russia, September 10-14, 2003 and Imeros Journal for Culture and Technology (4) (2004)
5. Bates, J.: Virtual reality, art, and entertainment, Presence: Teleoperators and Virtual Environments. Winter 1(1), 133–138 (1992)
6. http://www.uwm.edu/People/jstagg/
7. INTUITION NoE WG –CRF: Research Position Paper: Towards Virtual Product Creation: the role of VR in the Automotive & Transport Industry, 21/02/, INTUITION NoE WG2.3 (2006)