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A Model of Virtual Training Application for Simulation of Technological Processes

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Abstract

Productivity of technological processes crucially depends on its continuity and absence of any malfunction. However, operating personnel should be trained for the cases of any emergencies and under conditions as close as it possible to real ones. That is why, companies require high quality training simulators. This paper is devoted to solve this problem, presenting a model of virtual training application (VTA).

In this paper, taking into account the technical regulations, requirements to both workflow processes and training simulators, design of VTA is discussed. Moreover, by analysis of uranium in-situ leaching process, the application of this simulation technology is introduced in detail. Proposed model of VTA is designed to assist training operator personnel to understand and simulate the workflow of in-situ leaching process without acting on real system and without stopping workflow.

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1. Introduction

Modern computer trainers by the principle of structures and functioning can be divided into several types: (1) electronic examiners, (2) static or (logical-dynamic), and (3) dynamic.

The first type of trainers is quite simple and primitive. Main function of which is replacement of live examiner. This kind of software contain a set of questions, which may accompanied by graphical and video illustrations and it control the correctness of entered answers as well. The answers can be selected from a list of possible answers, or specified by trainee.

Static trainers instruct and allow to control the accuracy and procedure of actions. They do not contain mathematical models and can therefore be used in training well-defined sequence of actions. Although the sequence of actions may branch depending on logical conditions (logical-dynamic) they are still remaining rigidly defined. This is the main drawback of such trainers.

Dynamic trainer is a highly professional tool for simulation in terms of personnel training. It is a specialized didactic system of hardware and software, with a given accuracy implementing the interface and mathematical models of technical and physical nature of the energy system "power facility - environment - operator", all the necessary information and ergonomic relationship in this system, and meant for forming and improving trainees' skills and abilities they need to manage energy facilities in regular, non-regular and emergency conditions by their multiple executions inherent to the real object control.

In technological process automation systems computer control systems (CCS)\(^1\)-\(^5\), modern SCADA-systems, which are integral systems, are introduced widespread. In preparing the operating personnel of industrial enterprises it is necessary not only to familiarize students with the current state of automation devices, but also to develop their practical skills in operating the CCS. The training methodology for operating personnel to control technological process of in-situ uranium leaching is developed using computer trainers\(^6\)-\(^7\). And on the basis of this methodology a virtual trainer application (VTA) for objects is created to provide computer training of operating personnel working with the major subsystems of workflow control systems automation (WCSA) and to develop skills of operating personnel in safe and efficient process control through reconstruction and analysis of situations that may arise both under the regular mode and under failures and emergencies. In the following section we present the model of VTA.

2. The Model Description

2.1. The general properties

The organizational structure of VTA "In-situ leaching of uranium" determines the composition and the relationship of the VTA (see Fig. 1.), which should be based on rational organization of labor to ensure effective management of production.

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Fig. 1. The model of the VTA.  
Fig. 2. Subsystems of virtual learning system.
The scope of functions is determined by the services regulations and personnel job descriptions, approved by the company's management.

This document provides solutions for organizational support of VTA "In-situ leaching of uranium".

Operational control of VTA "In-situ leaching of uranium" is carried out under the virtual training instructor’s supervision. Personnel’s working mode - 8 hours a day.

Virtual training application "In-situ leaching of uranium" provides the following maintenance work:

- Daily maintenance of equipment
- Identification of faulty modeling blocks and restore them, launch the software when replacing the blocks
- Replacement of faulty equipment and PC
- Maintenance or adjusting work

Service personnel functions are coordinated by job descriptions, which are developed in accordance with the requirements of the operational documentation.

Specialists who serve VTA "In-situ leaching of uranium" should have the skills and knowledge to work with the computer and be trained at courses provided under the contract and held by VTA "in-situ leaching of uranium" provider.

After successful completion of the above mentioned courses, training level of specialists according to the profile of their work must meet the requirements for the implementation by them the functions of operational administration and technical support of the virtual training application as follows: (1) Servers used to run the virtual training application (VTA); (2) Real-time databases; (3) Applied computing tasks; (4) User workstations of VTA; (5) Software of VTA "In-situ leaching of uranium"; (6) Industrial networks.

Qualification of VTA "In-situ leaching of uranium" system administrator, should meet the requirements performance of functions as operational manager: (1) servers used to run the VTA and (2) software of VTA "In-situ leaching of uranium."

The qualifications of VTA "In-situ leaching of uranium" instructor must meet the requirements for the performance of his functions as operational manager: (1) servers used to run the VTA and (2) software of VTA "In-situ leaching of uranium."

Design decisions to change the organizational structure of the object control and their reasoning for full-grown work of the VTA "In-situ leaching of uranium", there are embedded computer technology means with advanced software including:

- Operating systems for top-level hardware and accompanying them editors, loaders, system services, etc.
- Database management system
- Operating system and accompanying it loaders, drivers for low-level hardware
- SCADA system for the design of data processing systems and control, as well as the design of interfaces of user workstations
- MatLab application package for modeling technological parameters of the real object in the lower level of the trainer

Figure 2 illustrates sequences of integrated subsystems and links between them in virtual learning system. For learning on the trainer, the normal operation of the main and auxiliary equipment of VTA "In-situ leaching of uranium" and other devices must operate continuously and ensure measuring accuracy. Operation and working capacity of VTA "In-situ leaching of uranium" are provided by: (1) trainer instructor and (2) system administrator.

The instructor’s responsibilities include the following functions:

- Maintaining the VTA control and training from the server
- Supervising the work of trainees and their correct use of the VTA
- Launching the VTA
- Taking measures to eliminate minor damage to property
• Calling by a network administrator in cases of serious damage or malfunction, threatening disruption of learning, emergency or accident

The trainer administrator responsibilities consist of the following functions: (1) Ensuring reliable and proper operation of the software; (2) State control and providing reliable operation of all software and devices of VTA "In-situ leaching of uranium"; (3) Recording and storing all available operational documentation on magnetic media and hard copies; (4) Ensuring the correct use of the VTA; (5) Restarting the system or system component.

A mnemonic scheme of the in-situ leaching of uranium process is presented in the Fig. 3. The simulation model of this process is implemented on Matlab / Simulink software package. After simulation all data carried to the global network with physical address for each user. Each user has his/her personal session, and they can track training progress (see Fig. 3.).

2.2 Decomposition of entire system

First decomposition block represents simulation of the process of underground filtration based on Darcy Law (Fig. 4,a). The purpose of this simulation is to study the filtration rate and saturation velocity of mining solutions in various areas of the ore body.

This simulation allows maximally imitate real in-situ leaching process, which gives dynamise developed virtual trainer. To implement it we developed the model of in-situ leaching of the cellular ore body.

This simulation allows to imitate the real process of in-situ leaching, which in its turn gives the dynamisation of being developed VTA.

The second process is intended to simulate the work of automation hardware (Figure 4,b). A modeling system provides simulation of physical and chemical properties of uranium, as well as the state and behavior of devices and sensors in the work process. The accuracy of the simulation is ensured by choosing the mathematical modeling system based on Matlab / Simulink.

Main functions of MatLab in VTA:

- modeling of various physical, chemical and other properties of the system
- modeling nodes of geotechnical field
- modeling of the state of regulating valves to filling solutions into the borehole
- modeling of pumps’ state for pumping out solutions from the boreholes
- modeling the control and measuring devices
- integration with the visualization system
All simulations are based on deterministic mathematical models of the process. Mathematical models are represented as transfer functions converted by Laplace. The aperiodic links of relevant orders were used for each object particularly. This kind of approach enables the simulation of real-time operation of the automation hardware.

Informational communications between the elements of the system are provided through the use of common global variables and internal software-logical signals. Intersystem connections are supported using distributed system of the information collection and transmission.

The elements of the visualization system provide informational connection with the operator-technologist via input-output devices.

Integration of computers into a single system is performed using the Ethernet network with TCP/IP protocol. The network operates on the Server-Client principal. In this case, instructors’ PC has the status of a Server and endowed with administrative rights. The status of the trainees’ PC is referred as Client.

The block executes the following main functions: (1) joining of modeling and visualization systems are provided via OPC-server and (2) the session initialization of technological objects control (Figure 4,c).

The fourth block presents SCADA systems, which is an extremely advantageous way of running and monitoring processes. They are great for small applications such as climate control or can be effectively used in large applications such as monitoring and controlling a nuclear power plant or mass transit system.

SCADA can come in open and non-proprietary protocols. Smaller systems are extremely affordable and can either be purchased as a complete system or can be mixed and matched with specific components. Large systems can also be created with off the shelf components. SCADA system software can also be easily configured for almost any application, removing the need for custom made or intensive software development.

SCADA provides:
- Collection and display of data object (on video screens and in the form of documents)
- Controlling user access and their authority
- Designing the system of acquiring, processing, analyzing, visualizing, recording and archiving data both the primary, transmitted through measuring channels from sensors, and computational ones
- Development of the users’ workplace interfaces
- Programming the control algorithms

Design the system of dispatcher’s impact on the technological control object (automotive control). The system has capabilities to record respective impacts.
Web-interface uses a Web browser, such as, as Firefox, Google Chrome, Opera, Internet Explorer and others, to provide real-time Object Linking and Embedding for Process Control (OPC) applications. The proposed model of Web-interface will load all required components applications eligible with HMI/SCADA from a centralized Web server for automatic installation to any PC running any browser. The application will provide worldwide access to train/exercise different simulated emergency conditions of in situ leaching and SCADA functions (e.g., building control, manufacturing, and process monitoring). Except that, the suggested system will save web-sessions of trainees and their training results. So there will be no need to install any software onto remote client machines or export them, because Web-interface will do it using Human Machine Interface (HMI) standard components, based on ActiveX technology. Throughout, we can say that the Web-interface will turn a Web browser into an OPC client when the browser views Web pages located on any Web-interface server.

3. Conclusions

Currently leading companies use variety of training methods and techniques as well as software products which generate and increase professionaly-oriented skills, to improve the competences and experience of specialists, both in regular and emergency situations.

Presented VTA is significantly differs from other virtual training systems because it use SCADA as development environment. The SCADA is tied to the physical hardware and simulates in real-time to approximately integral time of opening or closing of the control valve. Thus, operator (may react) can be trained as close to the technological processes. A remote access allows students to practice the system by mobile way, as well as developers (coaches) to monitor and upgrade the system conveniently.

In this paper we have proposed a model of virtual trainer application for simulation of in-situ leaching process and technological environment using web services.

The designed VTA allows personnel to react adequately and take timely measures in emergency or any non regular situations.

The VTA includes conventional tools such as SCADA, mathematic modeling instruments, etc. Moreover, considering the state-of-art technologies, the VTA integrates the learning system into web-technologies.

Future works can utilize the main findings of this paper for simulating other technological processes.

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