Virtual Reality's Technologies Use in E-learning

ARNIS CIRULIS
Latvia University of Agriculture
2 Liela Street, Jelgava LV-3001
LATVIA
arnis.cirulis@va.lv http://www.llu.lv

KRISTAPS BRIGMANIS, EGILS GINTERS
Sociotechnical Systems Engineering Institute
Vidzeme University of Applied Sciences
4 Cesu Street, Valmiera LV-4200
LATVIA
{kristaps.brigmanis, egils.ginters}@va.lv http://www.va.lv

Abstract: Nowadays it is getting more and more evident that educational and training institutions use different e-learning solutions. Various technologies and approaches are combined for creation of these solutions including learning management systems (LMS) and benefits provided by m-learning and tv-learning, and new training methodologies. Nevertheless, usages of virtual and augmented reality’s (VR/AR) technologies are not so widespread, for all that usage of these technologies increase training effectiveness. The aim of this paper is to give comparative analysis of VR/AR solutions, which are used in e-learning, to clarify advantages and disadvantages.

Key-Words: E-learning, virtual and augmented reality (VR/AR), immersive environment, VR/AR classification, VR/AR authoring tools.

1 Introduction

The fundamental role of education for successful development of country, have never been under question. Frequent economical and structural reforms and technological changes regularly remind the importance of learning in all levels of educational system. Considerable changes appeared when first LMS appeared in schools, unfortunately offer with these solutions was pure and expensive, although the functionality was satisfying. Big push in usage of LMS turned up thanks to rapid growth and development of open source projects. Thanks to this turning-point in software development, e-learning got other shape in schools, improving traditional computer based training with interactive course materials, variety of assignments and assessments, surveys, chats, forums, collaboration tools, videoconferencing and other possibilities.

Over the years some new functionality have appeared as mobile and wireless technologies (m-learning) and digital television’s provided possibilities for interactive study materials management (tv-learning). New options for training process acceleration are offered by VR/AR technologies.

Unfortunately due to lack of standards, compatibility problems and expensiveness VR/AR solutions are rare used as a part of e-learning process. The aim of this paper is to summarize latest VR/AR solutions which are used for training and classify them. Sociotechnical Systems Engineering Institute looks forward and works on new e-learning technology respecting individuality of trainee [1].

Integral part of this technology will be VR/AR environment - portable and mobile system, which can be used in any classroom, auditorium, working place and home, replacing computer monitor, keyboard and mouse with more modern, interactive and immersive input/output devices.

2 E-learning structural model

Still today e-learning is a term which is commonly used, but does not have a universally accepted definition, but it can be considered as technology-enhanced learning, where all types of digital technologies are used to support the learning process [2].
The architecture of e-learning system (see Figure 1) can be described as $A = (L, F)$, where:

$L$ – logical structure (rules, algorithms, methods, approaches, instructions, directives etc.) – the essence of the e-learning system;

$F$ – physical structure (software, hardware (data processing and visualization equipment, communication subsystem, measurement and control equipment)) – the environment for $(L)$ deployment.

The first step in modern e-learning development was LMS deployment on the Internet, which was typical for beginning of XXI century. Imaging on the screen the information stored in databases replaced reading the lectures and training books. Sometimes the material was supplemented with audio and video clips improving perceptibility of the information (see Figure 2).

Development of mobile and wireless technologies allowed mobile phone and PDA use in training processes. Unfortunately, visualisation of complete training material was problematic due to limited screen size, but knowledge refreshing and some new skills development were possible.

Such a process can be considered as m-training. At this step was evident that simple change the books to databases does not enough, but amount of readable information must be reduced and training methodologies must be improved.

Technology changes in some industries were very rapid. New terms appeared which explanation sometimes was critical for employee, for example in Intelligent Transportation Systems area. Using advantages provided by GSM (TDMA) mobile cellular network solutions GSM/HSCSD/GPRS/EDGE was possible to organize on-line communications with an applicant in m-consultation regime. Especially interesting were forms of combined e-learning/m-training/m-consultation.

Nowadays VR/AR tools open new possibilities for training technologies development. Now it is possible that in some branches long-time studies can be reduced giving to employee only general knowledge about the class of objects. If the implementation of special operations is necessary,
then wearable computers combined with VR/AR tools and operating in wireless and/or UMTS (CDMA) network can be used.

During the work session, the employee can receive on-line step-by-step instructions how to implement given operation. It means that employee often develop their skills and learn during real m-Work session (see Figure 2).

Nowadays VR/AR tools became an integral part of advanced e-learning systems architecture (see Figure 1). It means that \((VR/AR) \in (A)\), but the platforms would be various and heterogeneous.

3 Multiformity of VR technologies
Potential of VR/AR technologies is huge; there are lots of ways how person can interact with virtual environment. These categories of interaction, although implemented in widely different ways and perceived by different senses, still incorporate most of the basic features of VR/AR: interaction, immersion, group work and scenario.

As definition of VR states that physical immersion and highly interactive simulations are key components of the medium. Thus, the physical structure \((F)\) of VR system involves hardware devices that monitor the user in order to provide the user information necessary to make a display physically immersive [4].

To provide interactivity there are many possibilities of input devices (see Fig.3) for users real time monitoring.

There are active devices, which allow for the user to tell the system what they want and passive input devices, which track at least some part of user’s body.

Different combinations of input devices are available and they must support monitoring process of user, which is continuous tracking of both user movements and user-initiated actions, such as pressing a button or issuing voice command to the system [4, 5, and 6].

To support next key feature of VR/AR system there is a need also for output devices, which prescribe how user perceives the environment.

These hardware devices present information to one or more of the user’s senses through the human perceptual system (visual, auditory, haptic and vestibular) [4, 5] (see Fig.4).

To control all these input/output components in VR/AR system and interact with the e-learning management system, special software is required. This includes rendering, modelling, sampling, hardware drivers.

There are also special software tools or libraries in VR/AR systems required for importing CAD models, behaviour programming, scenarios composition, placement of three dimensional (3D) models, creation of menus and publishing.

Fortunately new software platforms are developed, called VR/AR authoring platforms, which include
mentioned features, providing easier creation of VR/AR world.

Nevertheless such platforms provide also new possibilities, like content reusability, storyboarding, modular training procedures and new features programming.

To find interconnections among all components it is important to determine the logical structure (L) which prescribes the physical structure (F). To do this we can start with identifying the set of criteria for evaluation of VR/AR systems. To reduce a scope, there will be examined only VR/AR systems which are used for training of different technological processes control.

4 VR learning solutions classification
VR/AR systems which are used for learning differ in various ways, in what field it is used, complexity of study scenarios, technical realization, etc.

Accordingly it is possible to make classification using following criteria, which were generalized analyzing twenty VR/AR systems created with different authoring tools, like Virtools, EON Reality, VR4MAX, WorldViz, VDT and PTC, and different sets of input/output devices.

According to aggregated results (see Tab. 1) important criteria arises from the discipline where VR/AR system is used.

Table 1. List of VR/AR systems physical architecture’s criteria

<table>
<thead>
<tr>
<th>Nr</th>
<th>Criteria</th>
<th>Explanation (example)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Discipline</td>
<td>Professions and applied sciences</td>
</tr>
<tr>
<td>2</td>
<td>Methodology</td>
<td>Tasks, assignments, guides</td>
</tr>
<tr>
<td>3</td>
<td>Participants</td>
<td>Active users (one, two, several)</td>
</tr>
<tr>
<td>4</td>
<td>Mobility</td>
<td>Participants movements’ freedom</td>
</tr>
<tr>
<td>5</td>
<td>Safety</td>
<td>Nausea, simulator sickness</td>
</tr>
<tr>
<td>6</td>
<td>Software</td>
<td>Features and functionalities</td>
</tr>
<tr>
<td>7</td>
<td>Hardware</td>
<td>Sets of input/output devices</td>
</tr>
<tr>
<td>8</td>
<td>Performance</td>
<td>Usage of CPU, RAM, network</td>
</tr>
<tr>
<td>9</td>
<td>Portability</td>
<td>Accessibility, location/displacement</td>
</tr>
<tr>
<td>10</td>
<td>Environment</td>
<td>Open space, closed room</td>
</tr>
<tr>
<td>11</td>
<td>Mode</td>
<td>Real time, virtual simulation</td>
</tr>
<tr>
<td>12</td>
<td>Immersion</td>
<td>High, middle, low</td>
</tr>
<tr>
<td>13</td>
<td>Objects</td>
<td>Graphics, size, count, complexity</td>
</tr>
<tr>
<td>14</td>
<td>Senses</td>
<td>Visual, auditory, haptic</td>
</tr>
<tr>
<td>15</td>
<td>Dimensions</td>
<td>2D, 3D, 6DoF</td>
</tr>
<tr>
<td>16</td>
<td>Compatibility</td>
<td>Standards, software modules, libraries, Hardware interfaces, drivers, Rendering plug-ins</td>
</tr>
</tbody>
</table>

Different fields have varied demands. For example, medical training [7], military training [8], rescue crew training [9], car industry [10]. Also many industrial training solutions for operating ships’ cranes [11], transformers’ repair and maintenance [12], assembly of different products [13] and others.

Such criteria like participants or active users, which are involved in training process:

- One participant interacting with learning system (turbine assembly, transformer’s repair [10,12];
- Two participants, where usually one is trainee and the other is instructor. They both can interact with system and with each other (operating ship’s double cranes [11]);
- Several participants, this includes group work or collaboration. Also instructor can be one of the participants (rescue crew [9]).

An important criterion (see Tab. 1.) is software used for creation and exploitation the VR/AR system. It includes modularity, support of various CAD
The correct choice of input/output devices is also a difficult task, so it is crucial to analyze the application’s goals and its underlying operations and tasks to obtain direction in choosing an appropriate device set.

Other criteria will not be outlined in this paper, but certainly will be used for further classification and research.

Interesting that neither in hardware, nor in software part does not appear main system (computer, server) which control whole process. That is because it is more appropriate not to comprehend it as physical device, but rather a logical structure (L), which determines rules and algorithms for VR/AR system’s creators, as well as methods, approaches and instructions how components of physical structure are controlled (see. Fig.5).

Necessary methods, approaches and algorithms are integrated in plug-ins and libraries developed usually by C++ programming language.

Control of logical components in VR/AR system mostly is realized by scheduling and prioritizing. For example, Virtools [14] authoring platform does not leave to the operating system the decision of what amount of CPU to assign to each algorithmic element. Real real-time operating systems do not exist and this way its engine precisely controls its own time. It means that all the active behaviours are executed, one after the other, using a complex prioritizing scheme: first the priority of the objects is considered, and then the ones of the scripts attached to the objects, then the behaviour units and graphs inside the scripts [14, 15]. This is rough scheme and deeper logical schemes’ classification will be done in future.

5 Common tendencies of VR systems

After analyzing VR/AR technologies usage in learning environments, it is possible to distinguish several tendencies of system development.

Data display and output technologies are used to maximally effectively virtual objects draw nearer real world’s objects. There are good result for visual and auditory senses, but haptic and kinematics technologies meet different limitations and difficulties and still lot of research must be done to improve these technologies.

Data input technologies provide more and more immersive solutions like data gloves and pinch gloves. There were lots of motion tracking possibilities which works quite well and choice depends on field of participant’s movement. Nevertheless latest motion capturing technologies try to analyze smallest movement of some body part, for example, movement of eyes to identify the direction of sight more precisely than using head tracking systems.

Regarding to software, it is developed in such manner, that it could be used by specialists, who have no programming skills, but anyway it is useful to understand at least principles of object oriented programming. Observing authoring tools, they have tendency to use modularity to support system’s many needs. The priority is given to more universal tools, rather then specific, thereby it can be used to develop solutions with different aims. If something can not be provided, it is always possibility that modern VR/AR authoring tools support their own application programming interface (API) or software development kit (SDK) useable for new components designing. Also frequent CAD formats can be supported and wide set of VR/AR devices which are available on market can be used.

Still tendency of using complex all-in-one platforms keep exist, such solutions (hardware, software) are usually delivered by one provider. Of course more privileges have such platforms which are not fully
closed and let do maintenance, upgrade and configuration by platforms user.

From learning system’s point of view such platforms still require ability to compose more complex and detailed scenarios (adjustment guidelines) and possibility to improve the functionality of authoring tool also for nonprogrammers.

6 Conclusion
Some descriptions on VR/AR solutions available on the Internet in field of industry and technological processes training were analysed to summarize general criteria (Tab. 1).

After comparative analysis and inquiry, next step is to analyse an algorithms, approaches and methods for training scenarios planning, equipment selection and authoring a VR/AR system for specified discipline and profession. The possibility of VR/AR systems integration in existing e-learning management systems will be considered as well.

References: