AN OVERVIEW OF AUTONOMOUS SYSTEM FOR VIRTUAL REALITY TRAINING

Suman[1], Pinki Rani[2]
[1] M.C.A. Scholar, Department of Computer Science, Kurukshetra University, Kurukshetra, India
[2] M.C.A. Scholar, Department of Computer Science, Kurukshetra University, Kurukshetra, India

ABSTRACT

This paper presents a current overview of the use of autonomous system and data driven training within virtual reality (VR) based training environments. Virtual reality training and assessment is increasingly used for five key areas: medical, industrial & commercial training, serious games, rehabilitation and remote training such as Massive Open Online Courses (MOOCs). Adaptation can be applied to five core technologies of VR including haptic devices, stereo graphics, adaptive content, assessment and autonomous agents. Automation of VR training can contribute to automation of actual procedures including remote and robotic assisted surgery which reduces injury and improves accuracy of the procedure. This research concludes that while it does not exist, an enhanced portable framework is needed and it would be beneficial to combine automation of core technologies, producing a reusable automation framework for VR training.

Keywords: *Virtual reality, Adaptive systems, rehabilitation, remote training, Autonomous System*

1. INTRODUCTION

VR software applications are experiencing demand for increased mobility, including pervasive, ubiquitous, and embedded features, providing virtual training over the Internet and adhoc wireless networks. This leads to increasing demand to deal with handling complexity and achieving quality goals at run time.

The paper will assess current applications for:

- Automating haptic feedback, for guiding novices based on expert knowledge.
- Automating VR training which can lead to automation of actual procedures such as robotic assisted surgery.
- Automating the generation of customised learning content in terms of visual, haptic and audio material to provide scenarios for learning which ideally challenge the individual in the best way to target improvement of their most beneficial skills.
- Automating the assessment and scoring mechanisms, which objectively generate feedback on a trainee's performance. This forms a vital part of generating user-centred content [1].

2. PRINCIPLES OF SELF-ADAPTIVE SYSTEMS

The requirements of self-adaptive software include fulfilling the requirements during run-time even in presence of unforeseen changes. To accomplish this, adaptive systems need to demonstrate resilience to a degree of variability, whilst maintaining ability to overcome deviations from expected context, still reliably achieving goals. Manual management and adaptation of software takes time and has high cost, so the advantage of an automated adaptation mechanism is that appropriate actions can be taken without excessive costs and not taking too much time. This requires the software to monitor the environment, observe changes and choose suitable actions [2].

2.1 Method for generating customised VR training content

Designs for autonomous VR training systems usually contain feedback loops to connect several elements.

(1) Initially the trainee is presented with a particular task which the trainee could attempt to complete.
(2) For assessment on completion, the system assesses or scores the trainee's performance on various factors or modules. Assessment may include accuracy, time taken, or skill in particular aspects.
(3) The autonomous training system selects the next task to be presented to the user based on past performance, targeting the individual's training requirements at that time.

Overall there are various aspects of automating VR training which include:

- Mechanisms for adaptive learning about a user's training requirements.
- Adaptive and reactive features to enhance trainee's learning efficiency.

- Autonomous training using simulation.
- Intelligent monitoring of a trainee's progress.
- Various types of adaptive content can be included.

3. CORE TECHNOLOGIES OF VIRTUAL REALITY TRAINING

There are five technologies which are the core building blocks of VR-based training simulations:
(1) Adaptive technologies
(2) Haptic devices
(3) Head mounted displays
(4) Assessment and scoring feedback
(5) Autonomous agents [3].

3.1 Adaptive technologies for training content

In this, adaptive technology will be used to generate user-centred VR-based training material. Adaptation works with many data stores including the user model and score history, to provide a vital link connecting all technologies together. For example if the trainee interacts with an autonomous agent or haptic device, the stereo display output may adapt in response. The trainee's assessment score can take into account their eye tracking, motion capture and haptic device data, and adaptation will adjust the training difficulty to match skill level.

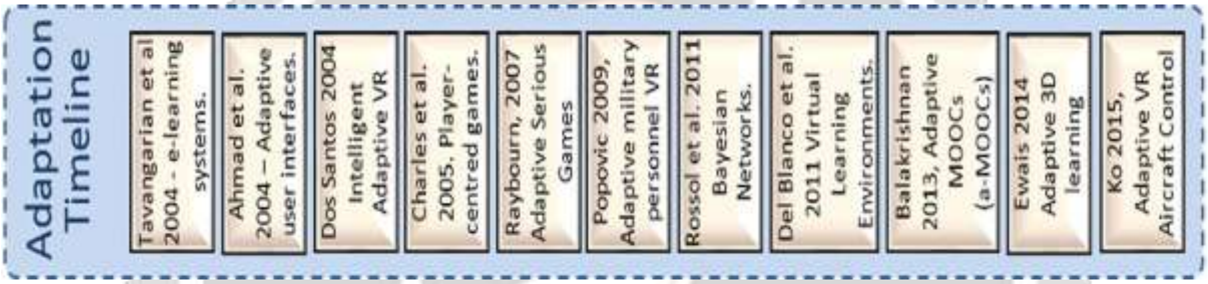

Fig. 1: Time-line of developed adaptive technology within VR-based training.

In Fig.1, Each timeline in the review represents key developments in the 12 years between 2004 and 2016. The timeline gives an insight into the recent developments and highlights key research publications applying adaptation. This time-line summarises the technology trend evolution, considering commercial, academic and patents.

3.2 Head mounted displays (HMDs), stereo-graphics, eye and head tracking

Head Mounted Display (HMD) systems often work in parallel with head motion tracking or eye tracking for enhanced realism. HMDs are often both an input and an output device. Inputs can include head motion tracking sensors, eye motion tracking, gyroscopes and accelerometers. The outputs are the two graphical displays, one for each eye. These inputs provide context-rich data which could be analysed by computational intelligence algorithms to spot behaviour patterns within the data.

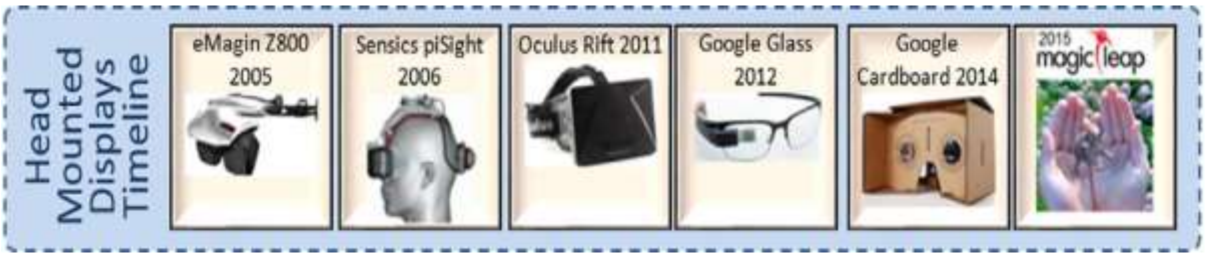

Fig. 2: Time-line of developed HMDs for VR-based training.

Fig. 2 Highlights the time-line of technology improvement within head mounted displays or stereo graphics used within VR-based training systems.

3.3 Haptic devices for VR-based training

Haptic feedback is used within VR to train tactile skills, making VR especially useful for learning physical skills where feeling and touch are important. Haptic devices have often been custom designed for particular training applications using motors with gears, electro-magnetic or electro-static forces for vibration or by modifying existing haptic devices such as Novint Falcon [4].

Fig. 3: Time-line of developed haptic devices for VR-based training.

3.4 Assessment and scoring feedback

Quantitative and qualitative assessment and scoring feed-back is essential for several purposes:

(1) To enable trainees to understand their performance.
(2) To enable adaptive systems to automate user targeted training content.

3.5 Autonomous agents

Autonomous agents within virtual training are computer rendered animated characters. They can act as embodied conversational agents (ECAs), intelligent virtual agents (IVAs) or embodied pedagogical agents (EPAs). Autonomous agents are increasingly used to enable interaction with the trainee within VR training. Agents interact with the trainee inside virtual environments to aid or adapt the user's interaction with learning content. The following figure highlights the time-line of improvement for autonomous agents within VR-based training.

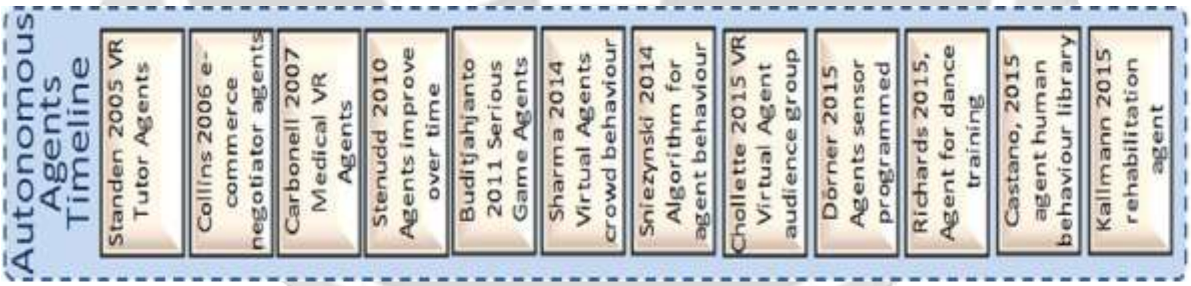

Fig. 4: Time-line of developed autonomous agents within VR-based training.

3.6 Multimodal technologies combination

Multimodal technology aims to achieve a multisensory, immersive and highly visual VR environment, for example combining quadrophonic audio with stereo graphics and haptic feedback. Multimodal virtual reality enhances the effectiveness of learning from multimodal sensory integration. An example is multimodal driving simulators which combine eye tracking with haptic controls and steering wheels. Eye-tracking during driving is used to analyse the driver's attention hotspots, detect driver fatigue to assist the driver's safety. Eye-tracking enables comparison of novice and expert drivers [5].

4. EXISTING VIRTUAL REALITY TRAINING SYSTEMS

There is a review of existing virtual reality training systems and their technological features. The simulators are arranged within a variety of topics. There are Five main VR-based training systems:

(1) Medical VR
(2) Industrial and Commercial VR
(3) Collaborative VR and MOOCs
(4) Serious Games
(5) Rehabilitation [6].

4.1 Medical VR-based training

Medical training simulators have been developed for many procedures. Simulation-based medical education (SBME) includes simulators with various levels of fidelity. High fidelity simulators contain technology based physiological qualities such as blood pressure or heart rate, which react to physical involvement.

Features of medical VR training:

- assessment and scoring
- repeated task training
- measuring effects
- simulator realism
- learning and conserving skills
- training experts

4.2 Industrial and commercial VR

Significant recent research on industrial virtual training has focused on spatial manipulation for assembly tasks. The primary focus of recent research within VR for assembly tasks focuses on developing robust and real-time collision detection, assembly path planning and physics modelling.

4.3 Collaborative and remote VR training and MOOCs

Collaborative virtual training is useful in medical procedures where a surgery requires two people, for example one person may hold the gall bladder whilst another cuts the connective tissues. Clinicians are now increasingly able to remotely monitor patient health, give consultations and advice and prescribe medicine. Teki is a tool which uses an Xbox games console for remote monitoring patients by collecting data from medical devices, enabling staff to monitor patients remotely [7].

4.4 Serious VR games for training

Serious games can enable learning through playing and encourage the repeating of tasks to reinforce learning. Rewards are built-in, including goals, narratives, rules, multisensory cues and interactivity which aim to inspire users to keep playing.

4.5 Rehabilitation VR

VR games are well suited for rehabilitation because:

- They engage the users.
- Games can contain intelligent systems to adapt to the user's progress.
- Rehabilitation games can be used at the patient's home.

Analysis of SWOT (Strengths, Weaknesses, Opportunities, and Threats) identifies that VR has significant positive impact on rehabilitation. Virtual reality rehabilitation systems are incorporating adaptation to meet the changing requirements of patients and therapists [8].

5. FUTURE TECHNOLOGY IN VR TRAINING

One of the future visions of physiology driven adaptive VR "is endowing the computers with automated emotion recognition capabilities, in order to facilitate a range of applications in which the computers respond appropriately to the emotions of their users". Digital human modelling is increasing used within VR. The IOWA Interactive Digital-Human Virtual Environment popularised the use of digital human modelling within VR by use of kinematic modelling of human. This is a special application with digital humans in virtual reality and can be used to enhance various applications in current and future research [9].

6. CONCLUSION

This paper has summarised the state of the art virtual reality training systems using self-adaptive technology. There is not yet a common infrastructure making the automated technologies more combined and portable. Currently many implementations of adaptation within VR are independently developed. A key step forwards would be to produce a portable framework for VR automation combining adaptation with each core technology within VR training. This would enhance the benefits of automation and make adaptation more accessible for a variety of VR training [10].

REFERENCES

[1] Z. Merchant, E.T. Goetz, L. Cifuentes, W. Keeney-Kennicutt, T.J. Davis, Effectiveness of virtual reality-based instruction on students' learning outcomes in K-12 and higher education: A meta-analysis, Comput. Educ. 70 (2014) 29–40.

[2] H.U. Ko, H.C. Kim, A. Kafy, S.Y. Kim, J. Kim, Array haptic actuator for flight simulator, in: SPIE Smart Structures and Materials+ Nondestructive Evaluation and Health Monitoring, 94340Y, International Society for Optics and Photonics, 2015.

[3] J. Novak-Marcincin, M. Janak, J. Barna, L. Novakova-Marcincinova, Application of virtual and augmented real-ity technology in education of manufacturing engineers, in: New Perspectives in Information Systems and Tech-nologies, Vol. 2, Springer International Publishing, 2014, pp. 439–446.

[4] S. Stenudd, Using machine learning in the adaptive control of a smart environment (Thesis), VTT Publications, 2010, p. 751.

[5] D. Weyns, M.U. Iftikhar, D.G. de la Iglesia, T. Ahmad, A survey of formal methods in self-adaptive systems, in: Proceedings of the Fifth International C* Conference on Computer Science and Software Engineering, ACM, 2012, pp. 67–79.

[6] MSDN, 2012. http://blogs.msdn.com/b/kinectforwindows/ archive/2012/08/22/nissan-pathfinder-virtual-showroom-is-latest-auto-industry-tool-powered-by-kinect-for-windows.aspx?Redirected=true (Accessed October 2015).

[7] J.P. Rolland, F.A. Biocca, T. Barlow, A. Kancherla, Quantifica-tion of adaptation to virtual-eye location in see-thru head-mounted displays, in: Proceedings of the IEEE Virtual Reality Annual International Symposium'95, IEEE Computer Society Press, Los Alamitos, CA, 1995, pp. 55–66.

[8] T.R. Coles, D. Meglan, N. John, The role of haptics in medical training simulators: a survey of the state of the art, IEEE Trans. Haptic. 4 (1) (2011) 51–66.

[9] J. Wyatt, D. Spiegelhalter, Field trials of medical decision-aids: potential problems and solutions, in: Proceedings of the Annual Symposium on Computer Application in Medical Care, American Medical Informatics Association, 1991, p. 3.

[10] J. Yang, K. Abdel-Malek, K. Farrel, K. Nebel, The IOWA interactive digital-human virtual environment, in: ASME International Engineering Congress, The 3rd Symposium on Virtual Manufacturing and Application, Nov. 13–19, 2004, Anaheim, California, USA.