The Future of Simulation

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SUMMARY

This short paper outlines some of the author's thoughts on the "future of simulation." After a brief motivation for the article and a recounting of the history of simulation, four major themes are explored: convergent simulations, serious games and simulation, human-simulator interfaces, and computing technology. The article concludes with a "vision" of what a future simulation might be.

INTRODUCTION

Predicting the future has only one certainty—the more specific the prediction, the more likely it is to be wrong. This caveat applies to the contents of this brief paper.

There are a number of past examples in which individuals (usually in panels) were asked to predict the "Future of Simulation". For many years, the annual Winter Simulation Conference[1] has routinely offered a panel discussion on this topic. In most cases the panelists dealt with "simulation in the small" not "simulation in the large". In this paper we will deal primarily with "simulation in the large", moreover, the paper will take the liberty of going beyond the normal boundaries of simulation and also deal with the human-simulator interface, some of the technological underpinnings of simulation, and the relationship(s) of simulation to entertainment.

The future of simulation will, in this author's opinion, be determined, not by a systematic, well-coordinated effort of a body of academic researchers, rather it will be determined by forces beyond the control of any individual or small group of researchers—world events and public demand for entertainment will play the predominate role in shaping the future of simulation.

Finally, a disclaimer is in order: the ideas presented here, unless specifically cited as those of another, are the author's own, and he will graciously accept the ridicule of the readers, both now and when he is proven wrong.

[1] See, for example, http://www.wintersim.org/prog03.htm#FS

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A BRIEF HISTORY OF SIMULATION

By any measure, simulation has a long history. Humans are natural "simulationists". Young children will make or use models (dolls and other toys) to execute a simulation (play). Games such as Chess (in the West) and Go (in the East) have served for hundreds of years as simulations of warfare. There is ample evidence in the historic record that live simulation has been employed for at least two thousand years.[2] Formal use of "wargaming" by the military became common in the nineteenth century. The beginning of the modern era of simulation, however, is usually associated with the advent of flight simulation in the early twentieth century. Computer-based simulation began in the 1950's and, of course, is now commonplace. In almost every case simulation has been a response to a perceived problem (*e.g.*, plane crashes due to pilot inexperience or the need for improved decision making). In the past few decades we have seen the advent of distributed simulation[3] and the development of virtual environments[4] as an alternative human-simulator interface.

CONVERGENT SIMULATIONS[5]

A distinct thread in the evolution of simulation is *convergence*. Historically, distinct simulation approaches (*e.g.*, discrete and continuous) have been conceived and applications developed in a relatively independent manner. The demand for simulation applications that serve more than one audience and/or more than one purpose has led to the convergence of heretofore distinct simulation approaches. A current example of significant interest to the military is the convergence of live, virtual, and constructive (LVC) simulation within the Joint National Training Capability (JNTC)[6]. Traditionally, the military has used live simulation as a primary means of training. With the high cost of such training and the growing shortage of adequate space for its conduct, constructive simulation and, more recently, virtual simulation have become increasingly important. The convergence of LVC simulation provides the military (and others) with the ability to "mix and match" simulation methodologies to meet both the training objectives of the commander and the constraints (time, space, cost) imposed by the training context. The ultimate goal of the JNTC effort is to deliver, for the commander, the needed training with the optimal mix of LVC any place, any time.

SERIOUS GAMES[7]

Modern computer-based games are often predicated on the marriage of simulation (and computer graphics) and entertainment. Such games have been wildly successful and have led to the production of very low-cost delivery platforms that are characterized by high performance computing and graphics. Profits are derived from economy of scale, driven by the huge demand for products. Many within the military have watched this

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[2] See, for example, Josephus. *The Wars of the Jews or the History of the Destruction of Jerusalem*, Book III, Chap. 5, Sect. 1. (*circa* 70 A.D.)

[3] See, for example, E.A. Alluisi. The Development of Technology for Collective Training: SIMNET, a Case History. *Human Factors 33* (3), pp. 343-362 (1991).

[4] See, for example, N. Durlach and A. Mavor (Editors). *Virtual Reality: Scientific and Technological Challenges*. Washington, DC: National Academy Press, 1995.

[5] This was a term used by the author for a presentation: Convergent Simulations: Integrating Deterministic and Interactive Systems. Human Performance and Simulation Workshop, Alexandria, Virginia, July 30, 1997.

[6] See http://www.jfcom.mil/about/fact_jntc.htm

[7] Information on the Serious Games Summit, one of the current venues for discussing serious games, can be found at http://www.seriousgames.org/index2.html

development and have recognized the potential of game platforms (and the underlying game engines) as a means of delivering, again at a low cost, games that can provide some types of training. The challenges lie in (1) the insertion of appropriate instructional design methods into game development, (2) the demonstration of the efficacy of game-based training, and (3) recognition that some (many?) training applications, even in the military, may have limited audience size or require frequent updating.

A current example of a game-based training system is Pulse!![8], under development by Texas A&M University-Corpus Christi and Breakaway Games, led by Claudia Johnston. This game/trainer is using a commercial game engine to build scenarios that deal with trauma care. The graphics and capabilities of the system are on a par with the best games available today.

HUMAN-SIMULATOR INTERFACES

Flight simulation has typically used replicas of aircraft cockpits as the interface between the human and the simulation. Products like Microsoft Flight Simulator™[9] have, in the interest of accessibility, developed very high-fidelity simulators with interfaces based on the keyboard/mouse with the possible addition of other relatively low-cost interface devices. Future simulations will most likely rely on *adaptive interfaces*—interfaces that are reasonably generic, at least within a given domain, and that can be readily adapted to a range of simulations. To accomplish this capability, one needs access to a variety of displays: visual (three-dimensional, wide field-of-view), haptic, vestibular, olfactory, and (perhaps) gustatory. In the intermediate term, we can expect display *devices* that couple directly or closely to the human sensory system. In the visual domain an example of this type of device is the retinal display[10], under development (and available in limited capability versions) from Microvision[11]. The concept is simple: use one or more color lasers and a raster device to "write" images directly on the human retina. Sophisticated, but highly constrained, haptic displays are also commercially available[12]. Vestibular displays[13] (*e.g.*, motion bases) are also available as are a few examples of olfactory displays[14]. While serious engineering is still needed, there is the potential for these displays to mature to the point where their cost, ease of integration, and robustness is sufficient to serve as interfaces to simulations in a variety of application areas.[15]

In the longer term, we will see the introduction of the means to directly connect to the human sensory system. At least one example has been in place for some time—a vestibular display[16] developed by the U.S. Air Force. This display directly stimulates the human vestibular system. One can conceive of a family of such devices

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[8] For a press release from Breakaway Games, see http://www.breakawaygames.com/news/2005/pulse.shtml

[9] See http://www.microsoft.com/games/flightsimulator/

[10] See, for example, http://www.cs.nps.navy.mil/people/faculty/capps/4473/projects/fiambolis/vrd/vrd_full.html

[11] See http://www.microvision.com/

[12] See, for example, http://www.sensable.com/

[13] See, for example, http://www.inmotionsimulation.com/

[14] For pointers to examples of olfactory displays, see Donald A. Washburn and Lauriann M. Jones. Could Olfactory Displays Improve Data Visualization? *Computers in Science and Engineering 6* (6), pp. 80-83 (November/December, 2004).

[15] For a somewhat more discursive discussion of multi-sensory display technologies, see R.B. Loftin. Multisensory Perception: Beyond the Visual in Visualization. *Computers in Science and Engineering 5*(4), pp. 565-58 (July/August, 2003).

[16] J.D. Cress, L.J. Hettinger, J.A. Cunningham, G.E. Riccio, M.W. Haas, and G.R. McMillan. Integrating Vestibular Displays for VE and Airborne Applications. *IEEE Computer Graphics and Applications 17* (6), pp. 46-52 (November, 1997).

that are directly coupled to the human sensory system and, in principle, could provide the ultimate display capability (with all due respect to Ivan Sutherland)[17].

COMPUTING TECHNOLOGY

Over the past twenty years we have seen an extraordinary evolution of computing capability. Nonetheless, the simulation community has often been ahead of the curve. That is, as soon as we can simulate, in real time, 100k entities, the community demands that we simulate 500k or 1,000k entities with the same speed. The current frontiers of computing technology are focused on quantum computing[18] and biological computing[19]. In either case, there is the potential for several orders of magnitude improvement in computing capability with a concomitant reduction in the size and power requirements of the devices. This opens the opportunity for essentially unlimited entity count and performance on the compute side while enabling simulation to become truly portable.

THE FUTURE OF SIMULATION

How can we envision the influence of developments, along the four dimensions explored above, in the creation of a future simulation? First, let us focus on a specific application of simulation: training. With this in mind, we must think in terms of a seamless mix (or convergence) of live, virtual, and constructive elements with the fewest participants in the live and the most in the constructive domains of the simulation. However, *from the users' perspectives*, they will not be able to identify which entities are real participants in a real-world setting, which are real participants in a virtual environment, and which are computer-generated entities in a virtual environment. Second, we can assume that we will take advantage of advanced computing technologies and serious gaming techniques that provide the real participants in the virtual environment with a world "virtually" indistinguishable from the real world in terms of its sensory fidelity and interactive responsiveness. Third, the users will interact with both virtual environments using interfaces that are tightly integrated with their own sensory systems and that do not intrude in ways that render the virtual world any less believable than the real world. Finally (and again) computing technology will allow essentially unlimited entities in both the virtual and constructive components while enabling truly adaptive capabilities in terms of the evolution of the simulation in response to user actions. The resulting simulation will, if properly designed and executed, provide the ultimate in training efficacy, any place, any time.

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[17] Sutherland, I. E. The Ultimate Display. In Proceedings *of the International Federation of Information Processing Congress 2*, pp. 506-508 (1965).

[18] See, for example, Mika Hirvensalo. *Quantum Computing*. Second Edition. Berlin: Springer-Verlag, 2004.

[19] See, for example, Leandro N. de Castro and Fernando J. Von Zuben. Recent Developments in Biologically Inspired Computing. Hershey, Pennsylvania: Idea Group Publishing, 2005.