

Computer Graphics for Defense Applications

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Research in computer graphics owes much to early and continued developments in military systems ranging from command and control displays in the 1950s to flight simulators and image generators in the 1970s. For example, graphics pioneer and Turing Award winner Ivan Sutherland had a close relationship with the military. After graduating from the Massachusetts Institute of Technology in 1963, Sutherland accepted a US Army commission, and at age 26, First Lieutenant Sutherland became the head of the US Department of Defense (DoD) DARPA Information Processing Techniques Office. (For more details about Sutherland, see http://amturing.acm.org/award_winners/sutherland_3467412.cfm.)

Sutherland also developed the first virtual reality display helmet at Harvard in the 1960s with funding from the DoD. His head-mounted display (HMD) concepts became widely used in military and commercial simulators, and thanks to videogames, the HMD is now becoming a consumer device. Another invention, Sketchpad, the first computer graphical user interface, employed a light pen and was originally developed for the Semi-Automatic Ground Environment (SAGE) air defense system. We continue to see Sutherland's work embodied in VR devices, user experiences, and video games.

National security continues to push many advancements in our field, and this CG&A special issue explores the implementation of computer graphics for defense applications. The work addressed in this set of special issue articles has

largely been funded by the US Army and Navy. Understanding the direction of military-related computer graphics research can provide insight into future civilian uses as well as provide a path to novel ideas.

In This Issue

Amela Sadagic's article "Design and Choice of Visual Display Solutions in the Training Domain" provides insight into the challenges and potential solutions that face military training system developers given the plethora of visual display choices available today. Twenty-five years ago, few military training systems used computer graphics, but graphic-based systems have now become ubiquitous and as complex as the weapons and command and control systems they are often simulating. This rapid progression has come about because of the high value the military puts on training and the symbiotic advancements in consumer-related computer graphics applications.

At the Naval Postgraduate School, Sadagic is fortunate enough to have access to a large number of military subject-matter experts that can help evaluate why a particular visual display is useful and usable. This allowed her to develop four case studies that show the complexity of modern visual display choices, ranging from the traditional desktop to mobile, mixed-reality, and immersive systems.

In "HuSIS: A Dedicated Space for Studying Human Interactions," Ryan Schubert, Greg Welch, Salam Daher, and Andrew Rajj discuss the design and implementation of a facility that enables the


efficient implementation of user studies involving human surrogates, which are used extensively in training by the US Navy and Marine Corps. They show that the need for human-performance studies of interaction with surrogates leads to a diverse set of requirements for display options and behavioral measures. In addition, the authors utilized participant “pipelining” strategies in their environmental designs in an effort to eliminate as many unintentional influences on participants’ behavior as possible. The result is a robust space for conducting these important studies on the usability of the technology. Implications of their research reach far beyond the use of human surrogates.

Aniket Bera, Sujeong Kim, and Dinesh Manocha’s article “Interactive Crowd-Behavior Learning for Surveillance and Training” addresses the challenge of learning crowd behavior in order to improve surveillance and training applications. Crowd simulation has a long history in computer graphics, notably for games, urban planning, and animated effects in movies. Such simulations are also important in military training (of urban operations, especially noncombat operations). Learning crowd behaviors from videos enables more realistic simulation. The authors’ approach applies to both indoor and outdoor crowds, achieves interactive performance (and does not require a large database for offline learning), and can handle crowds of moderate density. Using particle filters as the underlying algorithm for multiperson tracking, the authors model pedestrian behavior at the individual and group level. This in turn assists with applications such as the detection of anomalous behavior within a crowd, which is a critical aspect for defense applications.

Moving Forward

All three articles in this special issue show the progress and influence that defense-funded research has had on broad areas within the field of computer graphics. However, we would be remiss if we did not note others who were deeply influenced by Ivan Sutherland and in turn influenced all the authors (and the guest editors) of this special issue: Fred Brooks and Henry Fuchs of the University of North Carolina at Chapel Hill. Brooks said about his experience with Sutherland that he “was in the process of looking for his next research agenda when he heard Ivan Sutherland give a speech in 1965 at a computer conference that laid out his vision for the future of virtual reality. Sutherland said that you shouldn’t think of a computer screen as a way to display information, but rather as a window into a virtual world that

could eventually look real, sound real, move real, interact real, and feel real.”¹

In a similar way, we hope this special issue provides a window into the world of computer graphics research for defense applications. However, it’s obvious that the research moves in tandem with commercial and academic developments with knowledge immediately distributed globally. Moreover, the research has become more transdisciplinary over the last 50 years, moving graphics technology simply beyond display interfaces and into areas as diverse as psychology, artificial intelligence, robotics, medicine, and big data. These trends will make for exciting new opportunities for defense organizations as well as potential challenges over the next 50 years. 

Reference

1. K. Bye, “Fred Brooks on Ivan Sutherland’s 1965 ‘Ultimate Display’ Speech,” Road to VR, 10 May 2016; www.roadtovr.com/fred-brooks-ivan-sutherlands-1965-ultimate-display-speech/.

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