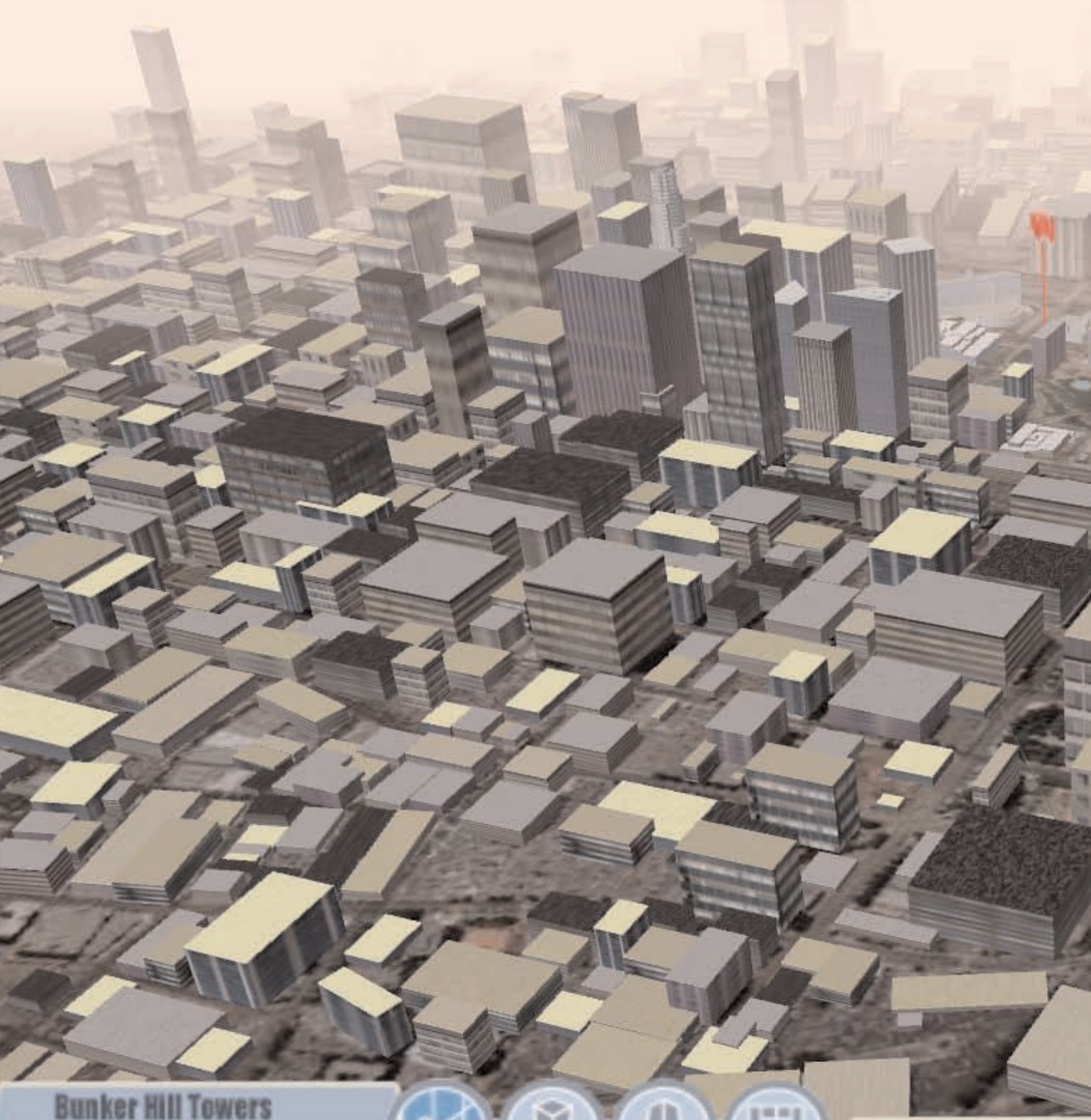
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CREATING A SCIENCE OF GAMES

The same technology that makes interactive 3D games so entertaining in the physical action domain is just as effective in education, training, and other more serious applications.

By MICHAEL ZYDA, Guest Editor

The video game industry will grow to about $60 billion in revenue this year [1], almost the size of the U.S. Department of Defense expenditure on research, development, testing, and evaluation [4]. Game play has begun to surpass television viewing among some segments of the population [3]. Video game development budgets are already the size of motion picture development budgets, on the order of $20 million to $100 million, with expected revenue for a hit game reaching from $250 million to more than $1 billion [2]. The world's youth spends enormous numbers of hours inside games. Massively multiplayer online games involve millions of live, human players participating in virtual worlds of substantial complexity—in which individual games claim some 18,000 to more than 180,000 years of aggregate in-game play. Developers have also begun to

Firescope, a real-time strategy incident-commander training game built for the Los Angeles Fire Department. (Fred Zyda, USC GamePipe Laboratory and USC Center for Risk and Economic Analysis of Terrorism Events.)

create serious games that use immersive entertainment to further government or corporate training, education, health, public policy, or strategic communication objectives.

How might video games provide any or even all K–12 science and math education in the U.S.? With so much play taking place and with video games becoming such a large part of the economy and of our everyday lives, it's time to create a science of games to help in the development of games and their future instantiations. We need to understand what is happening at the game-human interface and provide educational programs that produce graduates who are able to create the technologies critical to the future of the medium.

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The purpose of this special section is to share significant recent research and vision at the forefront of the creation of the new science. We link it directly with the field of computer science, as computing is the underlying required technology, even as we acknowledge that some of the science of games is beyond the traditional boundaries of computer science. But boundaries between disciplines are not immutable. In fact, the most interesting work in technology development is often cross-disciplinary. We begin with computing as a starting point and understand we will quickly transcend its nominal boundaries.

My personal motivation for wanting to create a science of games is that the new gaming medium is still in the hands of risk-averse entertainment corporations. We get great game entertainment from giants like Electronic Arts, Activision, and Sony but not much in the way of R&D or creativity, new genres, exploration of emotion-cognizant games, novel input devices, or rapid game development tools. Basically, we get Spider-Man n, Need for Speed n+1, and Grand Theft Auto n+2. By the way, these are great franchises, but there are entertainment genres beyond the physical action domain, and we need to explore and create them. The entertainment industry won't do it on its own.

The game industry also won't explore the idea of serious games. There are, however, great reasons to want to understand how to deploy immersive storytelling in service to society in the interactive realm. My crazy dream is that someday we'll replace the education system everywhere with emotion-cognizant video games that children demand to play even in their spare time. Such games would be played with a sensor suite that provides a real-time stream of human-state data as input to the game. Games then become human-state aware and adapt directly to the live player, understanding when the student is/is not learning, and with what level of difficulty. With emotion-cognizant games, we might potentially reduce the school system to a tutoring service for questions and answers not yet incorporated into the online edusphere.

Today's game industry will not build a game-based learning infrastructure on its own. It got killed in the early days of edutainment (2000–2004), and shareholder lawsuits continue to prevent game industry executives from attending conferences where the topic of games for education might be headlined. So, computer scientists must be responsible for making this happen and not wait for the risk-averse to come around.

To be able to deploy the new medium for societal good, we need a well-defined R&D agenda. In [6], the GamePipe Laboratory at the University of Southern California defined the basic research directions as infrastructure, cognition, immersion, and serious games. These directions continue to be valid. We also need educational programs that produce graduates who are able to engineer games, game designs, and next-generation technologies. The mix of articles here covers the gamut, from research to game development education to how to keep students in the field of computer science so we have a future at all.

Merrilea J. Mayo of the National Academies looks into the learning literature on games, from their potential role in education to scientific studies of learning outcomes from games. Her citing the fact that "video games stimulate chemical changes in the brain that promote learning" should make us all

wonder why we are not already running toward a game-based education future. I truly want to augment (even replace) large parts of the education system with immersive games.

To temper my enthusiasm for games for education, I sought out Ralph E. Chatham, a program manager at the Defense Advanced Research Projects Agency, to address the idea of games for military training. His mission is to determine whether games can play a role and, if so, what it should be. He dispels several myths about games for training, including that they are: cheap to create, deploy, and maintain; effective for training for the real world; trainerless, providing unsupervised learning; and work on just about any PC anywhere. Nonetheless, he has persevered and has had great luck with games developed in his program, including the Tactical Language and Cultural Training System and DARWARS Ambush! He learned lesson number one in the games world—that the game wants the whole computer—and more than he could ever want to know about game engine licensing. His experience should be studied by all government program managers thinking of becoming game developers.

In parallel with DARPA's effort, Henry Kelly et al. of the Federation of American Scientists joined with Brown University and the University of Southern California to create Immune Attack, a game designed to teach immunology to high school students and college freshmen. I asked him and his team to detail their experience working with game developers far-removed from their own disciplines, urging them to do it while their thoughts on translating medical science to gameplay were fresh. Funded by the National Science Foundation, Immune Attack appears to be one of the first major NSF forays into game development.

Randy Pausch and Don Marinelli of Carnegie Mellon University's Entertainment Technology Center describe their two-year game-development master's degree program. We include it here because other universities may want to learn how to establish their own game development programs that could further be used as a basis for creating a science of games program. The Center is very different from traditional stovepipe university degree programs. Note, for example, that they view themselves as the Eating and Traveling Club. The network of contacts it generates is enormous, delivering a useful message to universities building such programs not directly associated with the game development industry.

Caitlin Kelleher and Randy Pausch of Carnegie Mellon University reflect on how college freshmen in North America selecting computer science as their major dropped by 70% from 2000 to 2004 [5], discussing how to motivate children's interest in computer science through storytelling and game technologies. We await the results of their effort but believe it is on the right track to meet future growth projections in the game-development domain or even have a game future at all.

Finally, Nikunj Raghuvanshi et al. of the University of North Carolina at Chapel Hill explore the methodology and techniques they've developed for synthesizing physically based sounds in games and other virtual environments. Rather than using prerecorded, static sound files, the idea is to generate sounds from objects interacting based on their physical properties and on how collisions with the objects move the air around them. Despite this computationally demanding result, it takes only 10% of available CPU cycles. As game technology progresses, providing more and more immersive reality, we will continue to consume all available CPU cycles.

Conclusion

We hope these articles influence your personal research in the direction of games, helping you understand why computer science must be willing to support games' R&D and societal missions. It's been great fun for me to waylay these fellow games researchers and educators into sharing their ideas and insight. Their work represents initial steps on the continuum of research and education necessary to create the new science. With them, we position ourselves to begin to understand and repurpose this vibrant interactive medium. C

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Michael Zyda (zyda@usc.edu) is the director of the GamePipe Laboratory, a professor of engineering practice in the Department of Computer Science, and a staff member of the Information Sciences Institute at the University of Southern California, Los Angeles.