Quantum Annealing and Deep Learning: Advances for Virtual Humans

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Abstract: *Conversation-like exchanges of information between users and computer-generated virtual humans can be computationally demanding. Many of the Grand Challenges facing the simulation community will further stress the concerned computer resources. These computer/human interfaces are currently being enhanced and will require both technical advances and societal changes. This paper offers a list of Virtual Human Grand Challenges, solicited from leaders in the community, for purposes of this discussion. Then the authors report on emerging technologies that will further enhance the "human" qualities of the previously mentioned interfaces. Some of these technologies are hard-ware based while others come from software developments. Further, system engineering advances are presented with the intention of making better use of all the aspects of the system to achieve simulation goals. On the hardware side, there is the emerging technology comprised of several threads of quantum computing, e.g. USC's 2,000 Qubit Quantum Annealer. Software advances of note are discussed in the areas of voice recognition, natural language processing, and deep learning. The use of quantum annealing to enhance deep learning is particularly examined. Systems engineering issues are analyzed, as these emerging technologies do not stand alone and must be integrated into or replace legacy systems, mandating close adherence to a range of standards. In each of these cases, the authors discuss theirs and others' experience with the technologies and explicate both the benefits and the costs of such implementations. The paper is written so as to assist the researcher and the systems implementers in choosing which of the new technologies warrants consideration for inclusion in their own work and which technologies will eventually require adoption in order to stay compatible with other systems. Other technologies may require more effort in implementation than they would provide utility in practice.*

Authors' Biographies

Ke-Thia Yao is a Project Leader and Research Scientist in the Computational Systems and Technology Division of the University of Southern California (USC) Information Sciences Institute (ISI). His primary research interest is in understanding large complex systems and data sets. He teaches data management classes at USC's Viterbi School of Engineering. He is part of the team investigating uses for USC's 2,000 Qubit Quantum Annealer. Dr, Yao was one of the leads on the JESPP project where he analyzed the computational and behavioral properties of large-scale simulations. That project had the goal of supporting very large-scale distributed military simulation involving millions of virtual and constructive entities. He received his B.S. degree in EECS from UC Berkeley, and his M.S. and Ph.D. degrees in Computer Science from Rutgers University.

Dan M. Davis is a consultant for the Institute for Creative Technologies at USC, focusing on large-scale distributed DoD simulations and Virtual Humans. He was the Director of the JESPP project at JFCOM for a decade. As the Assistant Director of the Center for Advanced Computing Research at Caltech, he managed Synthetic Forces Express, bringing HPC to DoD simulations. Prior experience includes serving as a Director at the Maui High Performance Computing Center, at JPL and in industry. As early as 1971, Dan was writing programs in FORTRAN on one of Seymour Cray's CDC 6500's. He saw duty in Vietnam as a USMC Cryptologist and retired as a Commander, U.S.N.R. He received B.A. and J.D. degrees from the University of Colorado in Boulder.

Jeremy J. Liu is a fourth year PhD student at the Viterbi School of Engineering at the University of Southern California. His research interests are quantum computing and deep learning, especially using the former to enhance the latter. He has conducted research into Oil Field Management and has authored papers on that topic. He received a B.S degree in Information and Computer Science from the University of Pennsylvania.

Nicholas Kaimakis is active in research at the Institute for Creative Technologies of the University of Southern California. His current research thrusts are in the use of computer generated avatars or video clips, animated and directed by natural language-optimized Artificial Intelligence (A/I) programs that present a life-like dialogue capability to interact with remote users via the internet. His current project is funded by the Navy and is designed to help improve knowledge of STEM fields. He is an undergraduate student studying Computer Science within the Viterbi School of Engineering at the University of Southern California.