Editorial
Multiplicity Has More Potential Than Singularity

THE term "Singularity" is used to describe a hypothetical punctuation point sometime in the future where Artificial Intelligence (AI) will surpass human intelligence. The concept has been popularized by science fiction author Vernor Vinge and Ray Kurzweil. "Superintelligence," a 2014 book by Nick Bostrom, explores a similar theme. Recently, Stephen Hawking, Elon Musk, and Bill Gates publicly expressed fears about the dangers of post-Singularity AI and robotics.

My sense is that the Singularity is distracting attention from a far more realistic and important development that we might call "Multiplicity." Multiplicity characterizes an emerging category of systems where diverse groups of humans work together with diverse groups of machines to solve difficult problems. Multiplicity combines the wisdom of crowds with the power of cloud computing.

Rather than viewing robots and automated machines as isolated systems with limited computation and memory, "Cloud Robotics and Automation" describes a new paradigm where robots and automation systems exchange data and perform computation via networks. Extending earlier work that links robots to the Internet, Cloud Robotics and Automation builds on emerging research in cloud computing, machine learning, big data, open-source software, and major industry initiatives in the "Internet of Things," "Smarter Planet," "Industrial Internet," and "Industry 4.0."

Google's James Kuffner coined the term "Cloud Robotics" in 2010. Cloud Robot and Automation systems can be broadly defined as: any robot or automation system that relies on data or code from a network to support its operation, i.e., where not all sensing, computation, and memory is integrated into a single standalone system.

Consider Google's autonomous cars. They use the network to index maps, images, and data on prior driving trajectories, weather, and traffic to determine spatial localization and make decisions. Data from each car is shared via the network for statistical optimization and machine learning performed by grid computing in the Cloud. Another example is Kiva Systems approach to warehouse automation and logistics using large numbers of mobile platforms to move pallets using a local network to coordinate platforms and share updates on floor conditions.

There are many potential advantages to robots and automation systems using the Cloud: 1) Big Data: access to updated libraries of images, maps, and descriptive data about objects and products; 2) Cloud Computing: access to parallel grid computing on demand for statistical analysis, learning, and motion planning; 3) Collective Learning: robots and systems sharing trajectories, control policies, and outcomes; and 4) Human Computation: use of crowdsourcing to tap human skills for analyzing images and video, classification, learning, and error recovery. The Cloud can also provide access to: a) datasets, publications, models, benchmarks, and simulation tools; b) open competitions for designs and systems; and c) open-source software. Cloud Robotics and Automation also raises critical new questions related to network latency, quality of service, privacy, and security.

This Special Issue of the Transactions on Automation Science and Engineering (T-ASE) is timely and provocative. I'm grateful to Markus Waibel for proposing it, Lead Guest Editor Javier Civera for his expert leadership, Guest Editors Matei Ciocarlie and Kostas Bekris, Editor Sanjay Sarma, Editorial Assistant Samantha Jacobs, and to all the authors and reviewers for their contributions. The creation of this Special Issue demonstrates the concept of Multiplicity: a diverse group of humans working together with a diverse group of machines to generate new ideas.

KEN GOLDBERG, *Editor-in-Chief*
IEEE TRANSACTIONS ON AUTOMATION SCIENCE AND ENGINEERING
College of Engineering and School of Information
University of California at Berkeley
Berkeley, CA 94720-1758 USA
goldberg@berkeley.edu

Digital Object Identifier 10.1109/TASE.2015.2408458