2010 DARPA Neural Engineering, Science, and Technology Forum

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The mission of the Defense Advanced Research Projects Agency (DARPA)—to prevent strategic surprise by U.S. adversaries while maintaining the scientific and technological superiority of the United States—is reflected in the agency's programs that lie within the field of neuroscience. These research and development efforts range from basic research to investigate and model the dynamic neurobiological processes that underlie the sensorimotor and cognitive function, to the development of applied systems for clinical and operational neuroscience.

Importantly, many of the fundamental principles revealed by DARPA's basic neuroscience research can be applied to a variety of applications across the multidisciplinary field of neuroscience. For example, dynamic models of multiscale neural activity developed under DARPA's programs, such as Reorganization and Plasticity to Accelerate Injury Recovery (REPAIR) and Restorative Encoding Memory Integration Neural Device (REMIND), can be used to predict changes in brain networks that occur during learning or following injury and to elucidate new therapeutic techniques to accelerate learning and recovery from injury. These models are providing new insights on the ability to restore tactile sensation in war-fighter amputees, a goal of the Revolutionizing Prosthetics program, and to develop improved training paradigms to accelerate learning in both individuals and teams, pursued by the Accelerated Learning program. These fundamental neurobiological mechanisms can also be used as a foundation for developing novel neuromorphic system architectures, such as those developed under the Systems of Neuromorphic Adaptive Plastic Scalable Electronics (SyNAPSE) and Neovision2 programs, which drastically speed up computational processing and enable machine learning by mimicking the brain's plasticity and processing efficiency. Furthermore, these basic neuroscience principles can be applied to operational human-in-the-loop systems, such as those developed under the Neurotechnology for Intelligence Analysts (NIA) and Cognitive Technology Threat Warning System (CT2WS) programs, which leverage the human brain's adaptability for detecting visual targets of interest. Finally, DARPA's neuroscience programs have revealed the need for new neural sensors and interfaces, such as portable imaging techniques to detect changes in neurochemical concentrations that are characteristic of brain injury as well as reliable neural interfaces that can withstand physical and functional changes in the brain that occur over long-term use. Such developments are now taking place in the Quantum Orbital Resonance Spectroscopy (QORS) program, which is combining recent advances in quantum photonics with current magnetic resonance imaging techniques, and through a suite of Reliable Neural-Interface Technology (RE-NET) programs that aim to develop reliable interfaces for chronic use with the central and peripheral nervous systems.

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Due to the widespread applicability of the research developments across DARPA's neuroscience programs, DARPA hosted its first-ever Neural Engineering, Science, and Technology (NEST) Forum in November 2010. The forum brought together DARPA Program Managers as well as academic, commercial, and government organizations funded under DARPA's neuroscience programs, with a goal of transferring knowledge and fostering new collaborations among attendees. In the months following the 2010 NEST forum, it was brought to my attention that upon learning about a novel nonlinear mathematical modeling technique presented at the NEST forum by a researcher in one DARPA program, a researcher funded under a separate DARPA program applied the technique to his own team's models and achieved remarkable success in improving the model's predictive capabilities. This is just one example that illustrates the impact of the NEST forum on the future direction of DARPA's neuroscience programs. It is my hope that the mathematical models developed under DARPA's neuroscience programs will go on to impact not just the field of neuroscience but will also be applied to large-scale dynamic networks found within biology, social sciences, and other domains that support U.S. defense.

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Digital Object Identifier 10.1109/MPUL.2012.2188759
Date of publication: 22 March 2012