Extreme Engineering: Extreme Autonomy in Space, Air, Land and Underwater

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Until now robotics systems have found application primarily in highly structured environments, e.g., manipulators in an assembly line, where robotics tasks are highly repetitive and can be largely pre-programmed, and the environment is carefully controlled. In the few instances where robotic systems are operated "outside of the factory floor," they usually rely on close human supervision. However, recent breakthroughs in decision-making, perception architectures, and mechanical design, among others, are paving the way for *autonomous* robotic systems carrying out a wide range of tasks of unprecedented complexity. Examples include autonomous space vehicles, drones, self-driving cars, and unmanned underwater vehicles. The goal of this session is to provide a representative overview of the recent algorithmic and mechanical advances that are enabling the design and deployment of robotic systems **where autonomy is pushed to the extreme**, resulting in exciting innovation that borders on science fiction. Specifically, this session will highlight breakthroughs at the interface of advanced decision-making and bio-inspired mechanical design that are enabling first-of-a-kind applications of autonomy in space (pinpoint landing of space rockets), in air (design of micro unmanned aerial vehicles), on land (high-performance legged robotic systems), and in water (autonomous underwater vehicles).

Our first speaker, Dr. Lars Blackmore from Space Exploration Technologies (SpaceX), will start off by discussing autonomy in space. He is the co-inventor of the G-FOLD algorithm for precision landing on Mars and his team recently completed the first precision landing of a booster stage. He will discuss his work on the autonomous precision landing technology for the Grasshopper and F9R-Dev rockets. Next David Lentink from Stanford University will discuss autonomous, bio-inspired micro flying robots. His leading innovations are revolutionizing the design of these robots, and he will discuss the ideas that made it possible. Our third speaker, Sangbae Kim from MIT, will discuss autonomy on land. He along with other researchers at MIT have created the robotic cheetah, "the first four-legged robot to run and jump over obstacles autonomously." Sangbae will discuss how this robot is able to manage highly dynamic activities like balance, energy and impact without human interaction. Finally, Derek Paley, from the University of Maryland, will discuss autonomy underwater, specifically his work on motion guidance for ocean sampling by underwater vehicles.