Biologically Inspired Miniature Mobile Robots

Abstract:
Biological systems have evolved to find just-good-enough solutions to survive. By understanding and adapting the underlying principles of these solutions to engineering systems, new miniature mobile robots that can operate in unstructured environments robustly and efficiently are investigated in this presentation. First inspiration by nature is repeatable attachment mechanisms to develop robust, energy efficient, and agile miniature climbing robots. Using micro/nanoscale foot-hairs, geckos are very agile and robust climbers on wide range of smooth and slightly rough surfaces. Understanding the principle of gecko foot-hair adhesion, synthetic fibrillar adhesives are designed and fabricated. Polymer elastomer micro-fiber arrays with mushroom shaped tip endings are demonstrated, which are as sticky as biological gecko foot-hairs on smooth surfaces. Such new fibrillar gripping materials are applied to new miniature climbing robots and medical robots. Next, miniature robots with legged locomotion on water are proposed inspired by water striders and basilisk lizards. Water striders can stay on water surface using surface tension based lift forces due to their very hydrophobic hairy supporting legs and can move on water up to 1.5 m/s speeds by rowing two side legs. On the other hand, basilisk lizard uses very fast rotation of its two legs with a specific elliptic trajectory at 6-10 Hz frequencies. By slapping and stroking their feet into the water, the lizard affects a momentum transfer, which provides both forward thrust and lift. Legged robots utilizing similar principles on water surface are discussed, modeled, and demonstrated. Finally, design, manufacturing, and control of hummingbird or insect inspired flying robots with flapping wings are discussed. Such highly dynamic robots are complicated to fabricate and control for hovering and highly maneuverable forward flight applications. Above miniature mobile robots could be used in health-care, environmental monitoring, entertainment, education, search and rescue, inspection, and space exploration applications.

Short Bio:
Metin Sitti received the PhD degree in electrical engineering from University of Tokyo, Japan, in 1999. He was a research scientist at University of California at Berkeley during 1999-2002. He is currently a professor in the Department of Mechanical Engineering and Robotics Institute at Carnegie Mellon. His research interests include micro/nano-robotics, bio-inspired miniature robots and materials, and micro/nano-manipulation. He received the SPIE Nanoeengineering Pioneer Award in 2011. He was nominated for the World Technology Award related to health care and medicine in 2009. He has been appointed as the Adamson Career Faculty Fellow in 2007. He received the National Science Foundation CAREER award in 2005. He was elected as the Distinguished Lecturer of the IEEE Robotics and Automation Society for 2006-2008. He received the Best Paper Award in the IEEE/RSJ International Conference on Intelligent Robots and Systems in 2009 and 1998, the second prize in the World RoboCup Nanogram Demonstration League in 2010 and 2007, the Best Biomimetics Paper Award in the IEEE Robotics and Biomimetics Conference in 2004, and the Best Video Award in the IEEE Robotics and Automation Conference in 2002. He was the Vice President of the Technical Activities in the IEEE Nanotechnology Council for 2008-2010, and he is the co-editor-in-chief of Journal of Micro/Nano-Mechatronics and an associate editor for the IEEE Trans. on Robotics and ACS Applied Materials and Interfaces.