MUSCULAR COMPLIANCE IN BIOINSPIRED SOFT ROBOTS

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A key question is how muscular compliance and its interaction with a skeletal framework dictates the performance of soft robots. Bio-inspired soft robots have been defined in numerous ways. One approach is to use soft actuators within a skeletal framework, which provides the capability to apply or carry loads. At the other end of the spectrum, soft robots are under development where the musculature alone provides the capability to apply or carry load. This talk explores this key trade-off in soft robotics in the context of pneumatic artificial muscles. Pneumatic Artificial Muscles (PAMs) were first conceived by Gaylord in the 1950's, and have since been investigated for use in prosthetic and robotic devices, soft robotics, morphing and nastic structures, and aerospace applications. PAMs possess many attractive characteristics for implementation in soft robots. They are simple, lightweight actuators that produce high levels of force and large, usable stroke at moderate actuation pressures (< 620 kPa). The potential advantages of PAM actuators extend beyond their high performance levels. PAMs are naturally compliant and are highly tolerant to misalignment and impulsive loading. Air can be distributed to PAMs via flexible, lightweight, low pressure tubing, PAMs are highly amenable to distributed actuation concepts. First, the advantages and disadvantages of PAMs relative to other smart material-based actuation technologies is discussed in terms of block force, free contraction, specific actuation force and specific work. The trade-off of muscular vs. skeletal systems when using PAMs in robotics applications in the context of three robots: a bio-inspired manipulator using conventional antagonistic muscle arrangements around a rotating joint, a manipulator inspired by an octopus arm, a bio-inspired starfish robot.

Biosketch: Dr. Wereley's research interests are in dynamics and control of smart structures applied to helicopters, robotics, as well as aerospace and automotive systems. He also has a strong focus on active and passive vibration isolation, shock mitigation (especially occupant protection systems), and actuation systems. Dr. Wereley has published over 200 journal articles, 16 book chapters, and over 250 conference articles. Dr. Wereley is an inventor on 20 patents. Dr. Wereley is Editor of the *Journal of Intelligent Material Systems and Structures* and associate editor of *Smart Materials and Structures*. Dr. Wereley is the recipient of several awards including AIAA National Capital Section Engineer of the Year (2009), AIAA Sustained Service Award (2011), the AHS Harry T. Jensen Award (2011), and the ASME Adaptive Structures and Materials Systems Best Paper Award in Structural Dynamics and Control (2004, 2012). Dr. Wereley is also the recipient of the ASME Adaptive Structures and Material Systems Prize (2012), and the SPIE Lifetime Achievement Award in Smart Structures and Materials (2013). Dr. Wereley is a Fellow of AIAA, AHS, ASME, SPIE, and the Institute of Physics.