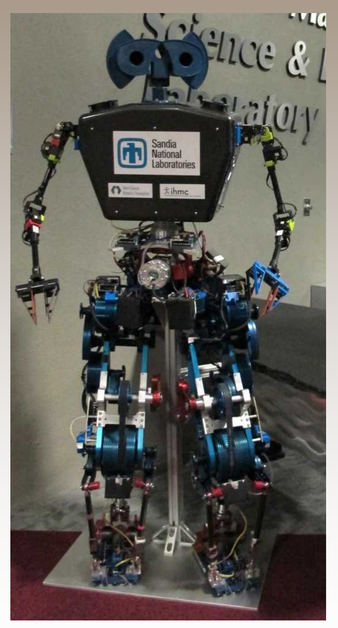
SAND2015-10500C

Exceptional service in the national interest

Sandia National Laboratories

Efficient Bipedal Robots for Disaster Response

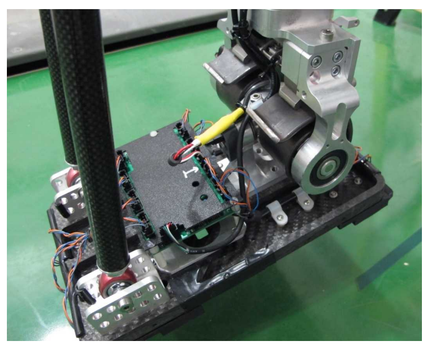
Anirban Mazumdar, Steven J. Spencer, Stephen Buerger

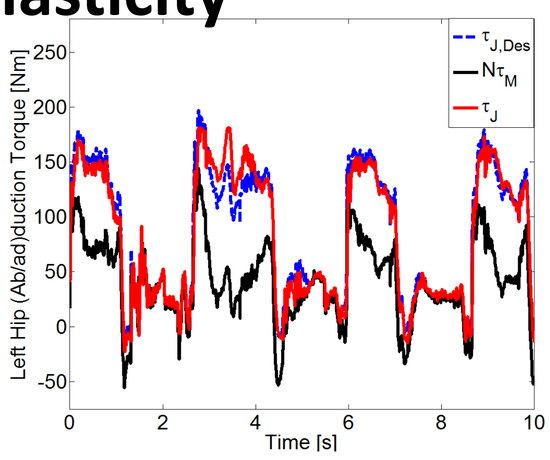


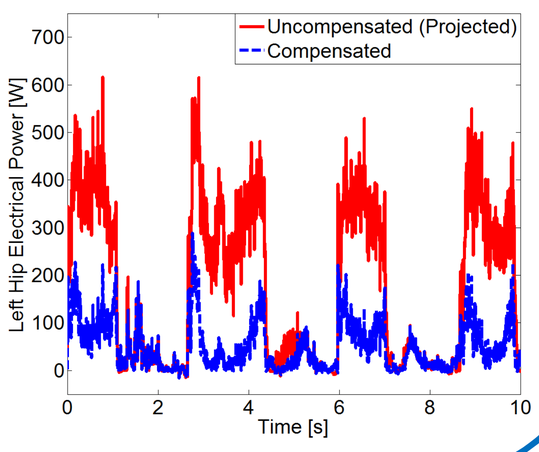
*Legged and bipedal robots provide the ability to traverse unstructured terrain, obstacles, and areas designed for humans. However, current bipedal systems are limited to 30-60mins of operation due to poor energy efficiency. Our team in Sandia's High Consequence Automation and Robotics group has developed an efficient bipedal robot capable of walking for **4+** hours on a single battery charge.*

Parallel Elasticity

Our data driven analysis has shown that parallel springs can considerably reduce joint level energy consumption. The springs unload the motors by taking up some of the joint torque. Parallel springs are implemented at the hip and ankle joints.

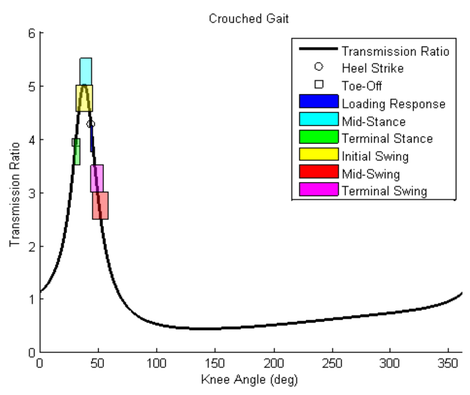


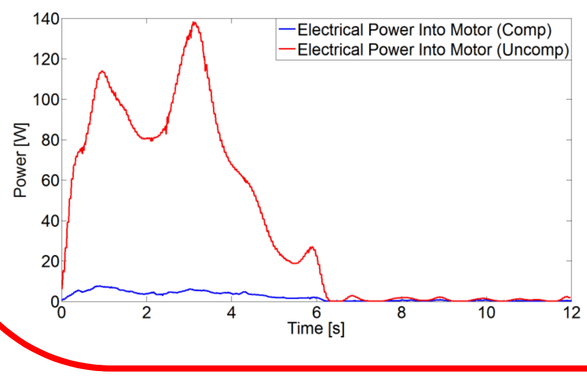


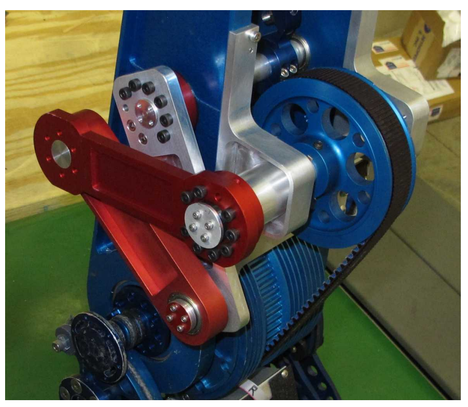


Position Dependent Gearing

Position dependent gearing can dramatically reduce energy consumption. Optimization techniques are used to generate a 4-bar linkage design that provides high gear ratios where high torques are needed and lower gearing where high speeds are required. This mechanism is used at the knee.

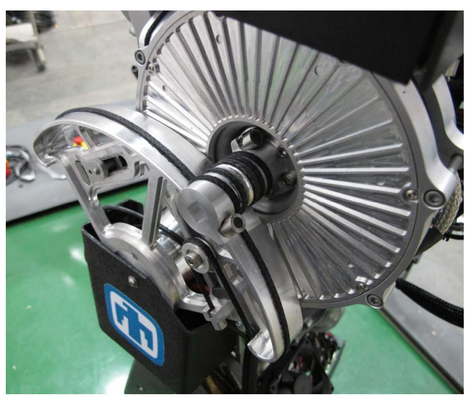


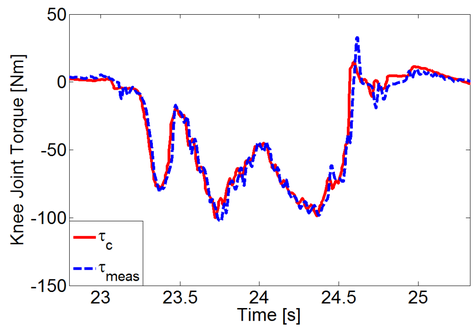


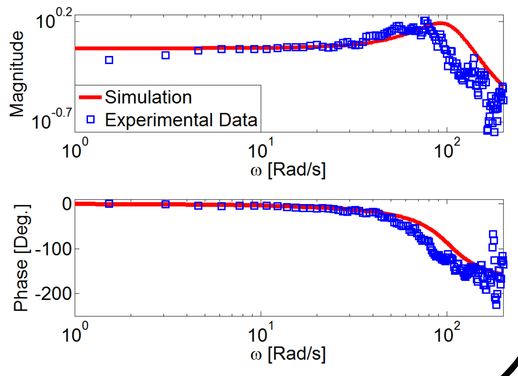


Synthetic Rope Transmissions

Synthetic cables provide strength to weight ratios and bend radii that exceed the performance of steel cable. Our robots use Vectran cable to achieve highly efficient and quiet transmissions at all the leg joints. These drive systems also provide high bandwidth torque control.

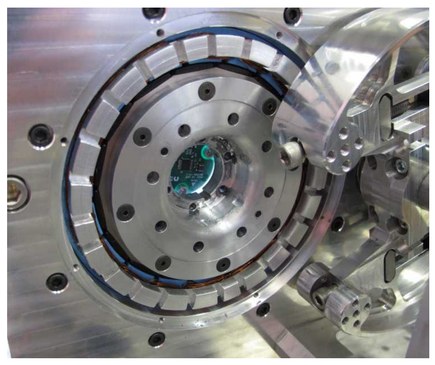


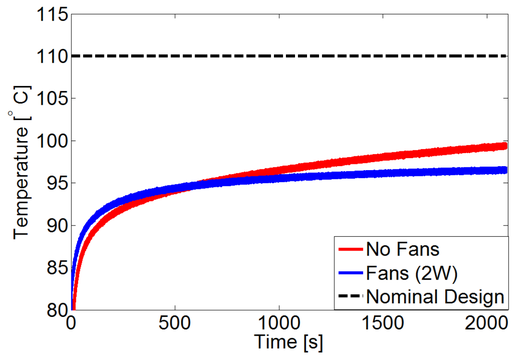




Powerful, Cooled DC Motors

High-torque motors are combined with low gear ratios to achieve good torque control. The motor housings are designed to provide improved heat transfer, thereby increasing the torque capacity of the joints. We also show that thermal management improves energy efficiency.





U.S. DEPARTMENT OF ENERGY

National Nuclear Security Administration

Sandia National Laboratories is a multi-program laboratory managed and operated by Sandia Corporation, a wholly owned subsidiary of Lockheed Martin Corporation, for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.
SAND No. 2011-XXXXP

Patent Pending: "Energy efficient robot," United States Patent *pending*, Application #14/794,666.