Measuring Energy Expenditure in a Robotic Arm to Determine Optimal Trajectory

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Research

Title: Measuring Energy Expenditure in a Robotic Arm to Determine Optimal Trajectory

This research addresses the challenges of creating the optimal trajectory of a robotic arm. Our research lab is comparing robots and humans' energy expenditure. Robotic arms depend on mechanical power and heat in a circuit (see Figure) while human arms depend on mechanical power and the heat generated by the arm's muscles as well as the basal metabolic rate (resting rate expenditure). Understanding energy expenditure in both humans and robots is essential for optimizing energy usage. Knowledge of most efficient trajectories can be applied to many industries to reduce energy usage in robotic systems. In this experiment, 18 static tests and 25 dynamic tests were performed on a 2-DOF robotic arm, consisting of an elbow and a shoulder, to calculate current, voltage, power, and energy. The static tests were at different angles ranging from 5° to 90° in increments of 5°. The dynamic tests included five trajectories at five different speeds for each path. The test results are useful to our research lab because they can be applied to a least squares algorithm to mathematically predict an optimal trajectory in a robotic system. The methodology, results, and discussion in greater details of these tests are documented in the full report.

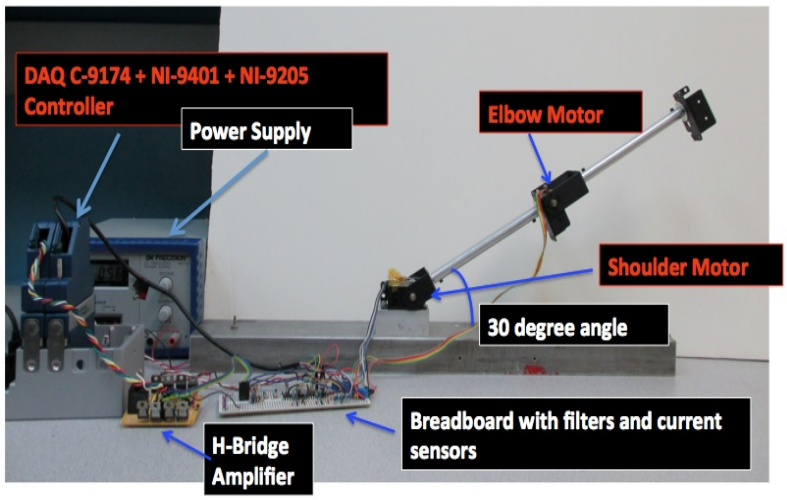

Figure: Hardware for the experiment

Lesson Plan

Title: Create a Safe Bungee Cord for Washy!

Students learn about how engineers and mathematicians play a role in developing the perfect bungee cord length. They infer and collect data by simulating the process using washers and rubber bands. They analyze the data using scatter plots and calculate the slope, linear equations of the line of best fit, and the spring constant using Hooke's Law. They learn about the physics of this experiment by studying force and displacement. Civil engineers plan and design large construction projects such as airports, tunnels, and bridges. They must learn to

interact with and articulate their ideas and designs to other engineers. When developing bungee cords, they must have a general understanding of overextension and tension. Civil engineers require extensive knowledge of calculus and linear equations. Students play the role of civil engineers as they design and simulate bungee cords. Students apply linear equations when making plans for the bungee cord.

Figure: One person is dropping the washer and the second is observing and recording the displacement of the washer.