MACHINE LEARNING SIMULATION: TORSO DYNAMICS OF ROBOTIC BIPED

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Thesis submitted to the faculty of the Virginia Polytechnic Institute and State University in partial fulfillment of the requirements for the degree of

Master of Science

In

Mechanical Engineering

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August 10, 2007

Blacksburg, Virginia

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(ABSTRACT)

Military, Medical, Exploratory, and Commercial robots have much to gain from exchanging wheels for legs. However, the equations of motion of dynamic bipedal walker models are highly coupled and non-linear, making the selection of an appropriate control scheme difficult. A temporal difference reinforcement learning method known as Q-learning develops complex control policies through environmental exploration and exploitation. As a proof of concept, Q-learning was applied through simulation to a benchmark single pendulum swing-up/balance task; the value function was first approximated with a look-up table, and then an artificial neural network. We then applied Evolutionary Function Approximation for Reinforcement Learning to effectively control the swing-leg and torso of a 3 degree of freedom active dynamic bipedal walker in simulation. The model began each episode in a stationary vertical configuration. At each time-step the learning agent was rewarded for horizontal hip displacement scaled by torso altitude—which promoted faster walking while maintaining an upright posture—and one of six coupled torque activations were applied through two first-order filters. Over the course of 23 generations, an approximation of the value function was evolved which enabled walking at an average speed of 0.36 m/s. The agent oscillated the torso forward then backward at each step, driving the walker forward for forty-two steps in thirty seconds without falling over. This work represents the foundation for improvements in anthropomorphic bipedal robots, exoskeleton mechanisms to assist in walking, and smart prosthetics.