Optimizing energy usage through variable joint stiffness control during humanoid robot walking

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Abstract. The objective of this paper and our current research is to optimize energy usage in a humanoid robot during diverse tasks such as basic walking by dynamically controlling individual joint stiffness. In the current work we analyze individual and total usage of current, voltage and power in a NAO V4 humanoid robot joints during short walks around a circle at different speeds and under varying control of joint stiffness. We perform experimental studies to understand the main factors affecting power consumption and energy usage and look at ways to improve overall energy usage. We describe experiments and corresponding results. We discuss the state of advancement of our research.

Keywords. Energy usage, power consumption, joint stiffness, motor control, humanoid robots.

1 Introduction

A critical challenge in mobile robots is the optimization of energy usage during specific robot tasks [1-3]. This is particularly relevant to humanoid robots where the increased number of joints and corresponding DOFs make energy usage hard to analyze and optimize during basic tasks such as walking [4]. In general, battery life is one of the main constraints in the use of robots for extended time. In the context of RoboCup soccer, games last only a few minutes where batteries are usually recharged at half time. As battery usage improves we expect future games to last longer or have power restrictions imposed on teams.

As part of our goal to better understand energy usage in robots and develop appropriate energy optimization algorithms, we present in this paper our initial study on power consumption in the NAO V4 humanoid robot in the context of the Standard Platform League (SPL). We analyze current, voltage and power consumption at individual joints and improve their usage by dynamically modifying motor stiffness without sacrificing task performance. We analyze the effect of variations on walking step frequency and joint stiffness on overall energy usage during simple short walks.

In contrast to other work we develop more in depth analysis of power consumption and energy usage in both individual joint and overall system at various