Gait optimization for horse inspired quadruped robot

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Abstract. Bio-inspired science has become an effective way to develop new locomotion systems that can overcome the limitations of the most efficient wheeled locomotion. Nature, through evolution, has perfected different gaits for legged locomotion that aim at energy efficiency. The paper goal is to study and optimize the gait characteristics of the horse, in different ranges of speed, through the development of dynamic and kinematic model of a 2D quadruped robot. The genetic algorithm is used to find parameters of the reaction force profiles, minimizing the cost of transport (COT). Eventually, the results are discussed and compared to the biological observations.

Introduction

Legged locomotion has become increasingly common to transport and assist humans in complex environments. Even though legged locomotion does not correspond to the most efficient transportation system, in some circumstances it is the only reasonable option to overcome obstacles, as stairs, or to move on rough routes, as slippery and uneven surfaces. As nature has provided ad-hoc solutions, results of the optimization process of the evolution, engineering and robotics have often found inspiration in locomotion capabilities of animals. Many quadruped robots imitate classical gaits like walking, trotting and galloping depending on the imposed locomotion speed [1-3].

Despite extensive studies, there are still some questions that have to be answered about whether or not their locomotion represents the global optimum for energy consumption with respect to a fixed forward speed. Finding optimal gaits for a multi-legged system presents high complexity of kinematic and dynamic modelling of legged locomotion. The paper goal is the study and optimization of energy efficient gaits of a 2D quadruped robot motion with a novel approach, consisting on combination of forces and torques applied directly to the body without any notion of leg kinematics. Pre-imposed forces profiles are morphologically modified through a parametric optimization to guarantee the body attitude, moving at a certain speed. The optimum is determined, over a time period, to minimize the Cost of Transport (COT), i.e. the amount of energy used per distance travelled. Despite the huge time taken by the evolutionary algorithms for optimization, the gait optimization is performed by using genetic algorithm (GA), due to its robustness in search and optimization problems. Eventually, a consistent kinematic mechanism is identified to recreate the optimal force profile and a non-linear optimal control is used to move the legs accordingly (Figure 1). The control, developed by the authors, is called *Feedback Local Optimality Principle (FLOP)* and belongs to the class of variational controls. The advantage of this new method is the opportunity to consider non-linear dynamics in the model, allowing a better performance in achieving an imposed target.

Although we can expect that the gaits resulting from years of evolution will also be effective in robotics, the proposed method is able to exploit the same principle, through genetic algorithm, and eventually find new systems of locomotion or improve the ones existing in nature.

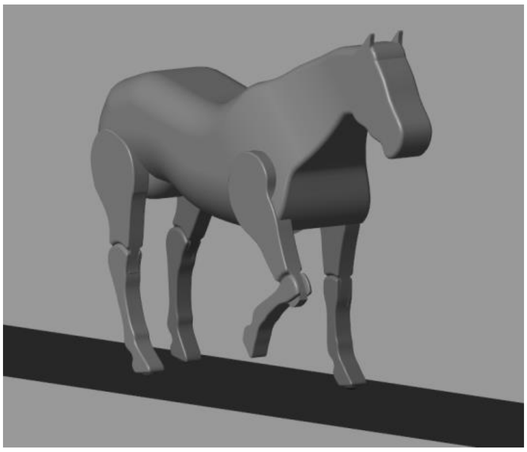

Figure 1: Horse model that recreates optimal force profiles.

References

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