Rich Locomotion Skills with the Oncilla Robot

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1 Motivation

We are motivated to better understand how adaptive locomotion (rough terrain locomotion, turning, gait transition, etc) can be realized using a quadrupedal platform with constrained resources. These constraints include computational power limitation, no accurate force/torque sensing, and partial sensing of robot's kinematic states. These constraints arise from the fact that we are designing and experimenting with autonomous light-weight and (comparatively) cheap quadruped robots. The practical benefit of such robots is fast experimentation: experiments can be safely done with presence of one or two humans, and repairs are cheap and quick.

2 State of the Art

There have been several quadruped robots exploring complex locomotion tasks like rough terrain locomotion including LittleDog [1], BigDog [2], Tekken [3], HyQ [4] and StarlETH [5]. A variety of control strategies has been used on these robots including Central Pattern Generators (CPG), inverse dynamics control, and operational space control. In most of these cases however, the control is designed to be either fully model-free (e.g. [3]) or fully model-based ([1]).

3 Methodology

We propose a hybrid model-free-model-based control approach for adaptive locomotion. Coupled morphed oscillators [6] implement the underlying model-free part, and encode the nominal locomotion gaits. This module can generate (flat-ground) locomotion patterns even in the absence of sensory input, and acts as a Central Pattern Generator (CPG). Model-based posture control is then implemented which generates feedback signals which are fed to the oscillator module [7, 8]. There are additional modules for fast reflexes, gait control (including transitions), etc. All the control is done in position control mode, and there is no requirement for torque control (nevertheless, such capability would be beneficial). Figure 1 illustrates the control schema.

4 Results

We implement the proposed methodology on the Oncilla robot [9] (Figure 2). Oncilla is a quadruped robot of about the weight and size of a house cat. Legs follow a three segmented pantograph mechanism. Legs are passively compliant. Each leg has three active degrees of freedom, namely hip (shoulder) abduction/adduciton and protraction/retraction, and knee (elbow) flexion/extension. The movement of the ankle is coupled to the knee (elbow), and toes are not actuated and are equipped with pre-loaded torsional springs. The robot is equipped with an IMU, encoders for joint angle sensing (not on the toe and abduction/adduction joints), and load cells on the hip (shoulder) axes.

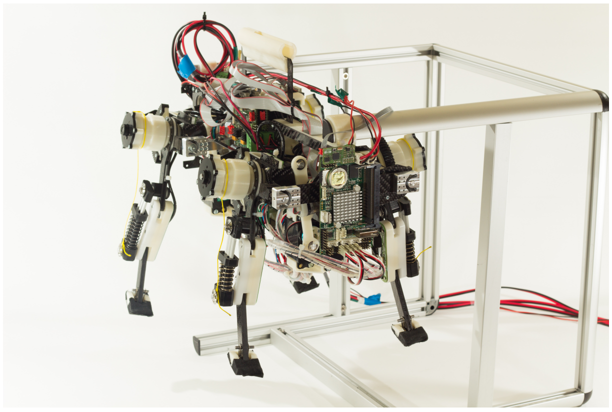

Figure 2: The Oncilla robot.

The initial results can be found in `https://www.youtube.com/watch?v=wNE2EmtnZck`. Oncilla can go outside the lab environment, and trot on different surfaces. It can turn by either asymmetrically shortening the stride length, or by utilizing the abduction/adduciton degree of freedom. It can turn as fast as 90 deg/s.

We are now conducting experiments regarding more difficult rough terrain scenarios, including uneven terrain with height variations up to 10% of the leg length, and slopes up to 30%.

Preferred Presentation Format: We would like to present our results in form of a poster accompanied by hardware demonstration.

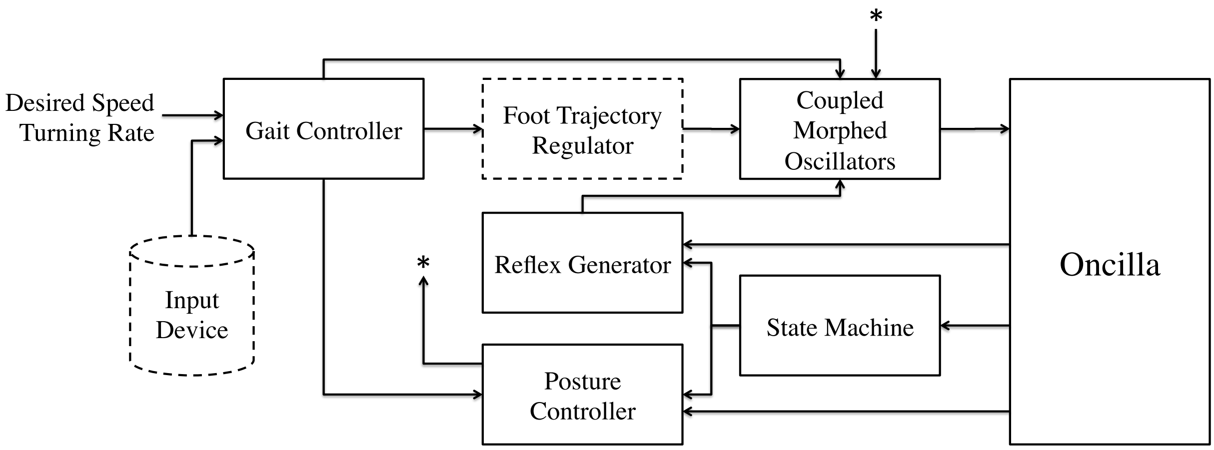

Figure 1: The control architecture. The gait controller receives user input and requests the oscillators phase synchronization, desired body rotation respective to the heading direction (posture controller), and any needed adjustment in the foot trajectory. State machine controls if posture controller or reflexes should be active. Posture controller keeps the trunk stabilized, while reflex generator activates fast corrections like stumbling correction reflex. Finally the coupled morphed oscillators receive all the feedback, integrate them into the oscillator dynamics, and generate the position control references.

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