Applying Morphological Changes During the Evolution of Quadruped Robots Results in Robust Gaits

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In nature, land animals started off with stable morphologies. A good example is the tortoise: its legs are spread out and it has a low center of mass. This made it very stable and therefore suitable for learning robust gaits. Over the course of evolution, land animals slowly grew bigger and their legs grew longer. Consequently, they adjusted their gaits to deal robustly with the locomotion problem on this more complex morphology.

In this work, we verify whether these morphological changes play an important role in learning robust gaits. Using CMA-ES as an evolution strategy (Hansen et al., 2003), it is possible to slowly learn controllers and gaits for quadruped robots. We want to investigate whether the transfer of learned gaits through morphological changes significantly increases the speed and robustness of the resulting gaits, as was reported by Bongard (2011).

Methodology

We build a simulation model of a quadruped robot in Open Dynamics Engine. It has been developed in such a way that small parametric changes to the body can be made during the CMA-ES optimization. So earlier generations in the CMA-ES can start with robust morphologies while later generations are similar to the final robot morphology. These parametric changes include changing the weight of the robot, the leg length and position of the legs as shown in Figure 1. To verify whether this indeed leads to more robust gaits, we will compare gaits which emerged from both evolved and static morphologies.

Discussion

The focus of our comparison is the robustness of the optimized gaits against morphological changes in the robot structure, changes in the environment and errors
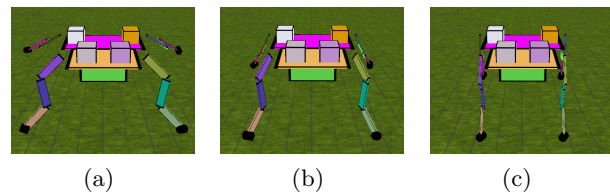

Figure 1. (a): a prehistoric morphology of the robot. It has a lower weight and legs further apart. (b) and (c): the same robot in a contemporary morphology, heavier and with legs closer together. The robot in (a) has a bigger support polygon while resting and is therefore less prone to tipping over than (b) or (c).

in the actuators. We expect that gaits of robots with experience on various morphologies are more robust to unexpected changes than gaits learned based on a single morphology.

Acknowledgment

References

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