Growth Development for Learning Stable Gaits in Bipedal Robots

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Abstract— **Inspired by human development, we explore growth-based morphological development as a strategy to enhance learning efficiency and stability in bipedal robots. We evaluate the impact of morphological growth on locomotion learning through neuroevolution addressing three different tasks: Walking in a straight line, walking in diagonal, and walking laterally. Different development speeds have been evaluated to assess the generalization capacity of the proposed approach. Results indicate that growth-based development significantly improves learning efficiency and stability.**

I. INTRODUCTION

Learning bipedal locomotion remains as one of the most challenging tasks in robotics due to the inherent instability of bipedal morphologies and the dynamic effects involved in movement execution [1]. Inspired by nature, in this article we explore the application of growth-based morphological development as a strategy for improving learning efficiency and minimizing detrimental behaviors that could result in structural damage to robotic systems.

II. EXPERIMENTAL SETUP

Robot: The robot morphology is based on the CoppeliaSim [2] model of the NAO robot (Fig. 1). Its controller is a neural network and the learning algorithm that evolves the weights of the neuronal connections and the topology of the network (NEAT [3]). The fitness value is related to the distance traveled and the possibility of falling.

Learning experiments: Learning address three different walking styles: walking in 1) straight-line, in 2) diagonal walking and 3) laterally (Fig. 1). In addition, there are two morphological configurations that are applied: 1) The no development configuration. Learning takes place with a fixed morphology. It is the adult morphology; 2) Growing morphology, from the initial to the adult morphology. Growth may end at generation 50, 100 and 150.

III. RESULTS

A comparative analysis of the learning results (Fig. 2) show how the implementation of growth-based development demonstrably enhances learning performance, providing o more efficient and reliable walking, as indicated by improvements in both fitness and the number of falls achieved, for the different growth cases against the no development one.

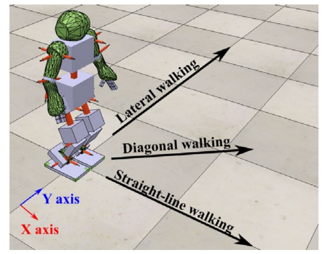

Fig. 1. Bipedal walking tasks the NAO is facing in this article: straight-line walking (over the "x" axis); Lateral walking (over the "y" axis) and diagonal walking (the square root of the distance traveled over the "x" and "y" axis).

IV. CONCLUSIONS

The experimental results presented in this study highlight the effectiveness of growth-based morphological development as a strategy for facilitating learning to walk, particularly in scenarios where gait stability is crucial to preventing falls.

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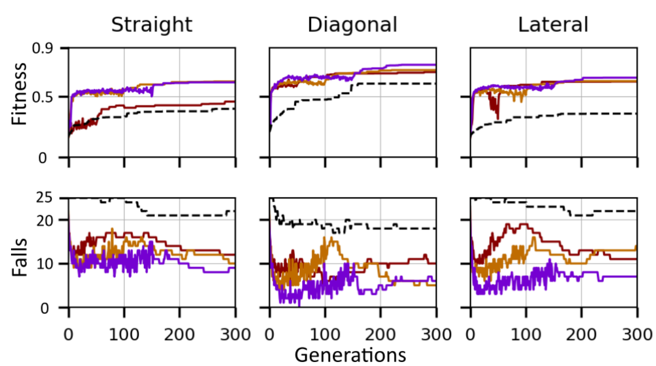

Fig. 2. Median number of fitness (top) and falls (bottom) of the best individuals of 25 independent executions at each generation for walking in straight, diagonal and lateral walking. In black and dashed lines, the no development case. In purple, the growth up to generation 150. In brown, the growth up to generation 100. In red, the growth up to generation 50.

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