# Morphological Development at the Evolutionary Timescale: Robotic Developmental Evolution

by Fabien C. Y. Benureau and Jun Tani

*Evolution and development operate at different timescales; generations for the one, a lifetime for the other. These two processes, the basis of much of life on earth, interact in many non-trivial ways, but their temporal hierarchy—evolution overarching development—is observed for most multicellular life forms. When designing robots, however, this tenet lifts: It becomes—however natural—a design choice. We propose to inverse this temporal hierarchy and design a developmental process happening at the phylogenetic timescale. Over a classic evolutionary search aimed at finding good gaits for tentacle 2D robots, we add a developmental process over the robots' morphologies. Within a generation, the morphology of the robots does not change. But from one generation to the next, the morphology develops. Much like we become bigger, stronger, and heavier as we age, our robots are bigger, stronger, and heavier with each passing generation. Our robots start with baby morphologies, and a few thousand generations later, end-up with adult ones. We show that this produces better and qualitatively different gaits than an evolutionary search with only adult robots, and that it prevents premature convergence by fostering exploration. In addition, we validate our method on voxel lattice 3D robots from the literature and compare it to a recent evolutionary developmental approach. Our method is conceptually simple, and it can be effective on small or large populations of robots, and intrinsic to the robot and its morphology, not the task or environment. Furthermore, by recasting the evolutionary search as a learning process, these results can be viewed in the context of developmental learning robotics.*

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Final camera-ready paper can be downloaded here: https://arxiv.org/abs/2010.14894v2

This article deals with morphological development: robots that grow up, and how it affects their ability to evolve. As we remark in the article (page 2, second paragraph), there is, for our method, a direct transposition of the evolutionary algorithms over a population of robots to a learning algorithm for a single robot. Our results therefore inform how growing up can enable robots to learn better. We study how morphological development impacts how exploration is performed in the search space and show that it can significantly improve learning performance. We believe that this subject is sit squarely in the middle of the interest of the ICDL conference and community, as well as create a bridge between the developmental robotics community and the evolutionary robotics community.