Towards Robotic Morphosis

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“Morphosis” is a biological term used to describe the way in which an organism changes form during development. Similarly, the term “robotic morphosis” is coined to indicate organism-like growing processes in robots. The model organism selected is the African clawed frog (or “Xenopus Laevis” in most literature). The aim is to understand “how to learn with a growing body?” and “how can growing accelerate learning?” by build robots imitating the metamorphosis of the African clawed frog with increasing physical and neural complexity as Figure 1 shows.

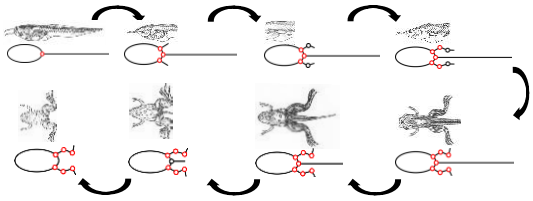

Figure 1. Metamorphosis of African Clawed Frog [1]

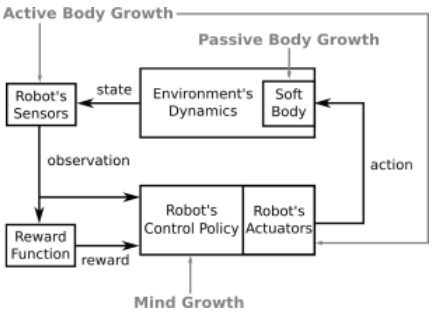

Figure 2. Model-Free Reinforcement Learning for Robotic Morphosis

The learning here refers to the robot’s ability to do task-oriented optimisation for sequential decision making by interacting with its environment, namely the reinforcement learning problem [2]. The highly non-linear and non-stationary natural of soft robot’s body and its environment issues a challenge for model-based policy learning: ad hoc constraints imposed heavily depend on the designer’s expertise in the task and nearly ideal laboratory conditions. Assumptions adopted might become invalid as robot’s and environment’s dynamics shift. As Figure 2 shows, we approach this problem by treating soft robot’s body as part of its environment and applying model-free reinforcement learning techniques.

Currently, we are trying to apply Proximal Policy Optimization [3] to the multi-link pendulum swing-up problem as the first step towards the robotic morphosis problem, which we plan to show at the workshop.

References:

[1] Pieter D Nieuwkoop and Jacob Faber. *Normal table of Xenopus laevis (Daudin): A Systematical and Chronological Survey of the Development from the Fertilized Egg till the end of Metamorphosis*. 1994.

[2] Deisenroth, M.P., Neumann, G. and Peters, J., 2013. A survey on policy search for robotics. *Foundations and Trends® in Robotics*.

[3] Schulman, J., Wolski, F., Dhariwal, P., Radford, A. and Klimov, O., 2017. Proximal policy optimization algorithms. *arXiv:1707.06347.*