Toward Morphogenetic Engineering: Biological development as a new model of programmed self-organization

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Multicellular organisms are rather unique examples of natural systems that exhibit both self-organization and a strong architecture. Similarly to other bio-inspired methodologies in which principles derived from neural networks, genetics or ant colonies are routinely used in machine learning, stochastic optimization or combinatorial search problems, can we also export the precise self-formation capabilities of biological development to a new generation of algorithmic methods and technological systems?

I present here two related studies in "Embryomorphic Engineering" (an instance of a broader field called "Morphogenetic Engineering"). First, a 2-D/3-D multi-agent model of biological development, based on virtual gene regulation networks, chemical gradients and mechanical forces which can be applied to the self-aggregation or self-assembly of robotic swarms into specific and reproducible superstructures. Second, a related N-D multi-agent model of self-construction of complex but precise graph topologies by "programmed attachment", based on dynamical opening of node ports, spread of gradients and creation of links with potential applications in socio-technical systems composed of a myriad of peer-to-peer mobile devices and human users. In all cases, the challenge is to design, *e.g.* through an evolutionary search, the proper set of local rules followed by each agent of a complex system on how to interact with the other agents and the environment in order to produce global functional architectures.

References

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