Comprehensive Review of Plasticity

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1 Background

Phenotypic plasticity is a wide-spread natural phenomenon that refers to an organisms ability to adapt their behavior to an environment, changes within an environment, or to a new environment altogether. Lifetime adaptability is useful not only to natural organisms but software and robotics as well. We assume that many researchers in the field of computer science and robotics are not aware of the different forms of plasticity we see in nature. Similarly, we assume that not all biologist are up-to-date on the extensive amounts of research done within each sub-field of plasticity. As a solution, we propose writing a review that bridges the work done in computer science with current biological results and thus facilitates more productive collaborations.

Biologists classify plasticity using many different matrices, such as trait-based, environmental induced, or ecology induced[15]. We know that both evolution[7] and individual lifetime experiences can shape plasticity, and there are many different forms, like morphology, physiology, or behavior [3]. Another approach is to analysis how well the organism adapts to its environment, rather the changes are needed to adjust to adaptive radiation, population density or a temperature change [3]. Yet another variation is to use the ecological behavior an organism displays, such as how it interacts with predators or the trade off it experiences with exploring/exploiting a resource. Neural plasticity, or the ability to change one's behavior based on past experiences, is also a key to adapting to one's environment [11, 1, 12].

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Evolution and plasticity interact in two ways:

1. To display plastic abilities, the underlying mechanisms must evolve [5].
2. Evolution dynamics can change due to an organisms ability to adapt to an environment [9]. For example, the organism could adopt a bet-hedging survival strategy, leading to an increased rate of fitness valley crossing [9].

Recently neuroscientists have turned to computational modeling to aid in exploring the underlying principles in neural plasticity (aka learning). Many classic computer science methods of machine learning (i.e. data mining, clustering, and classification) have served as the foundation of this research. There are several established models used to study the evolution of plasticity including: artificial neural networks (ANNs)[6, 1], Avida [4, 8], NeuroEvolution of Augmenting Topologies (NEAT) [13, 14], and Markov network brains (MNBs) [10, 2].

2 Aim

The proposed review aims to give computer scientist and biologist alike a comprehensive overview of plasticity including its environmental interactions as well as its evolutionary origins. Computational researchers will be able to create more realistic models, while biologist will gain a greater understanding of how modeling will help their endeavors. Along the way, we will identify open questions within each field that researchers can began to explore.

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