

Embryological Modelling of the Evolution of Neural Architecture

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The architecture of the human brain, and in particular the existence of functionally specialized neural modules, is becoming increasingly well mapped out. However, some of the early neural computational modelling in this area [1] has been thrown into doubt by more detailed evolutionary simulations [2]. There remain a range of feasible computational approaches to understanding neural architecture [3], and we believe the best way forward is to look at the evolution of these structures at a much lower level of description than is often used.

Embryogeny is the process by which an embryo structure develops from an initial stem state. This genotyping to phenotype mapping process is adaptive in the sense that the rules of growth are dependent upon the state of the system and vice-versa, forming a dynamical system [4]. The modelling of such processes in a simulated evolutionary framework is known as computational embryogeny.

We shall present work where such an approach is utilised to grow neural architectures from an initial stem state based upon a simple model encapsulating individual cell states and diffusion of chemicals in a 3-dimensional space. This computational embryogeny is sufficiently expressive to account for features such as topology and connectivity, and the parameters that specify the initial weights and network learning.

Results will be presented from a systematic series of computational experiments which explore the possibility of using this approach to study the emergence of structures appropriate for the simplified ‘what-where’ task used previously [1,2]. In particular, we consider the impact that different selection pressures towards faster growth and learning might have upon the evolved neural architectures.

For completeness, the resulting structures are then compared against a series of more abstract models of the type studied previously [2], but with a matched evolutionary regime. In this way we can gain a better understanding of the reliability of, and relationships between, models at different levels of description.

References

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