

Towards Self-Assembling Artificial Neural Networks through Neural Developmental Programs

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Background: Indirect encoding

Compress large Neural Networks.

HyperNEAT: describe connection of neuron by function.

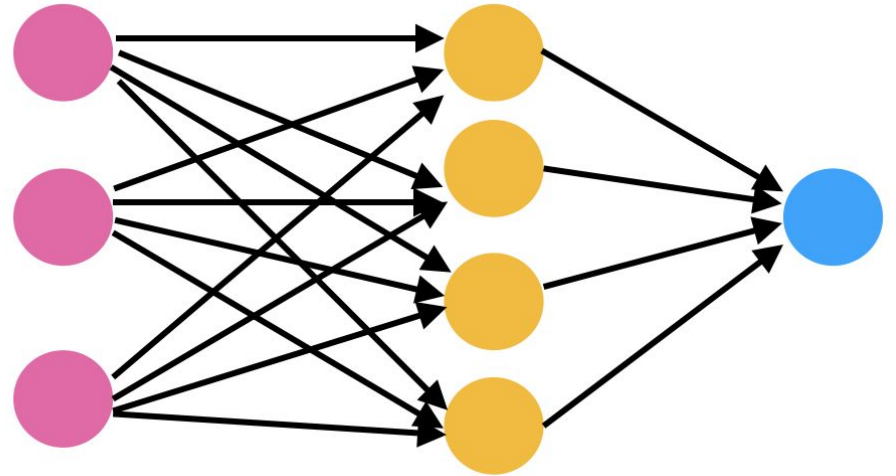
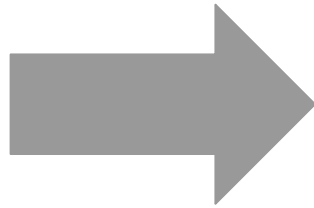
when connection is repeated, the information can be smaller

Background: Developmental Encoding

Similar to Indirect encoding.

Grow the Neural Network from the gene (same gene for all nodes)

poor performance, not researched

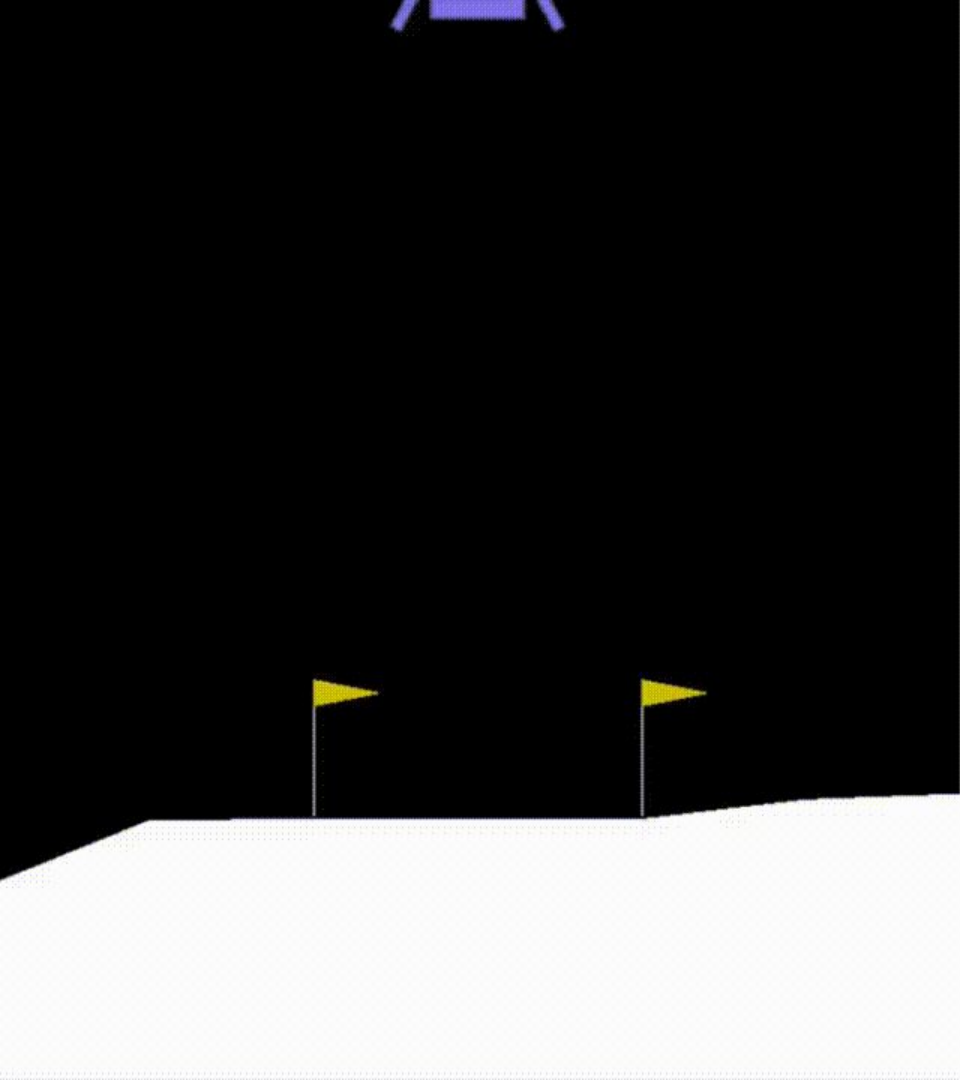


Goal

Achieve high performance with Developmental Neural Network
in various environment

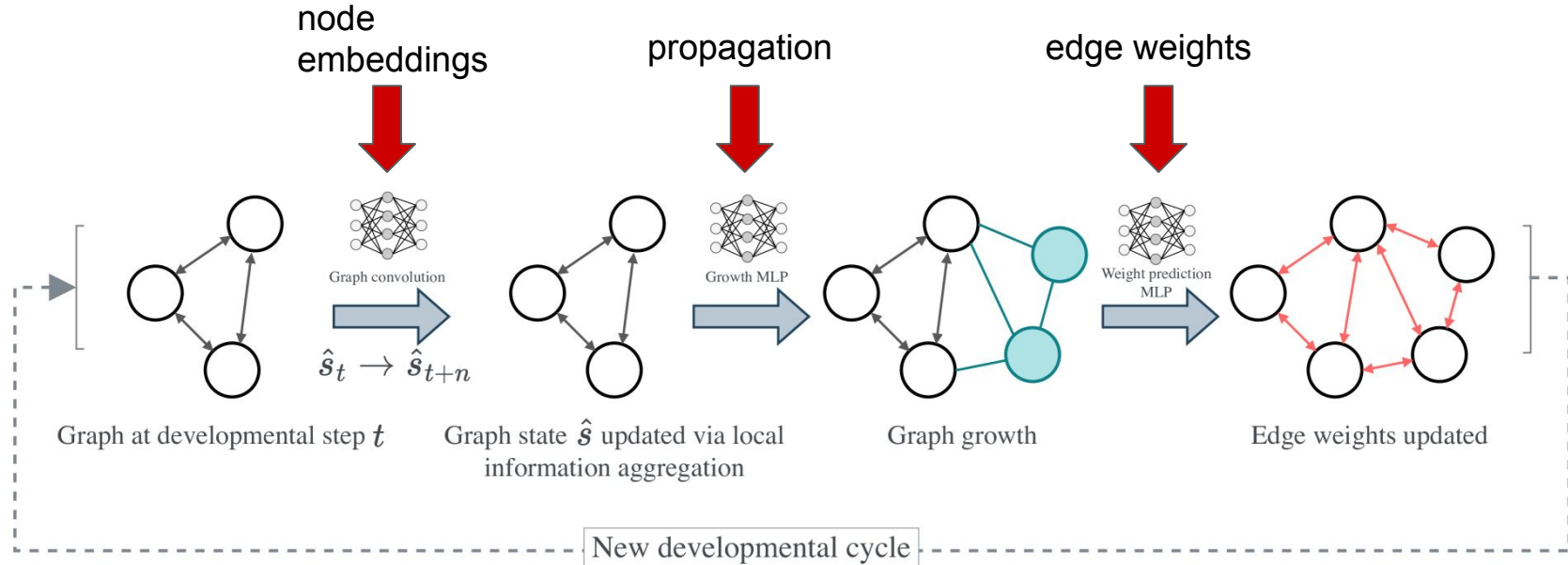
Traditional method: Grow regardless current Network state

New approach: adapt the growth rule to suit task



Cycle of NDP (Neural Developmental Program)

NDP is 3 types of MLP (Multi-Layer Perceptron)



NDP (Neural Developmental Program)

- Evolutionary-based
 - easily explore different architectures without having to worry about their differentiability

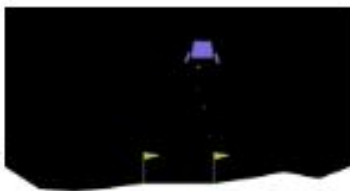
- Gradient-based
 - sample efficient, allow scaling to higher dimensions
offline reinforcement learning.

Experiments

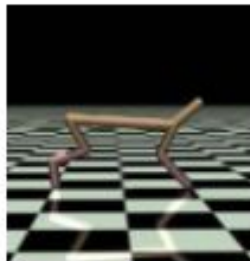
- continuous/discrete action tasks
- classification



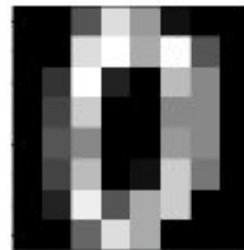
(a) CartPole



(b) LunarLander



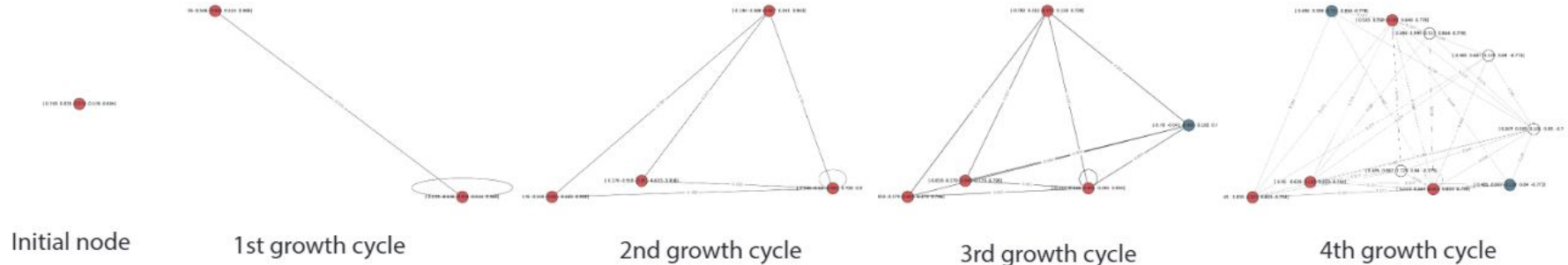
(c) HalfCheetah



(d) 8x8 MNIST Example

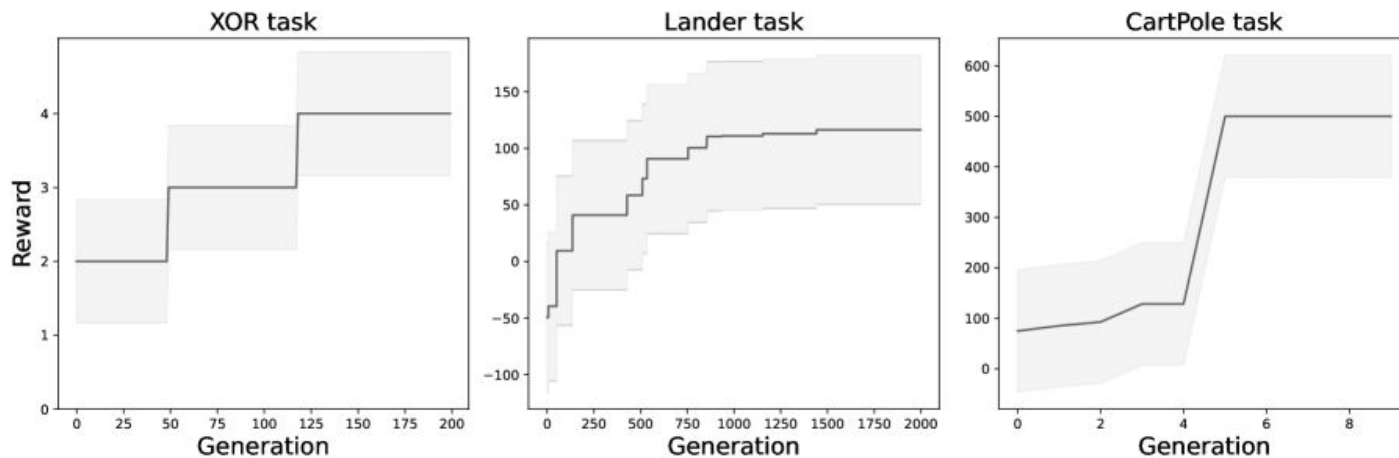
Results: Evolutionary-based

CartPole training results



Results: Evolutionary-based

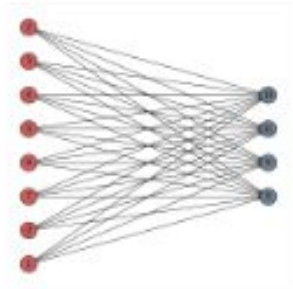
Evolutionary-based training results



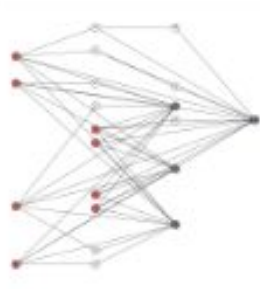
Results: Gradient-based

Growth of NN for Lunar Lander task.

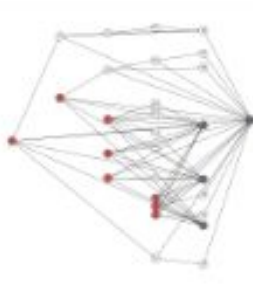
Gradient-based performed better when initialized by fully-connected input/output



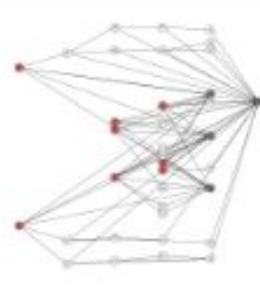
Initial seeding graph.
13 Nodes.



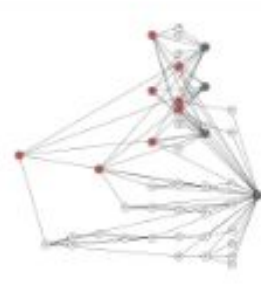
16 growth steps.
21 Nodes.



32 growth steps.
29 Nodes.



48 growth steps.
37 Nodes.



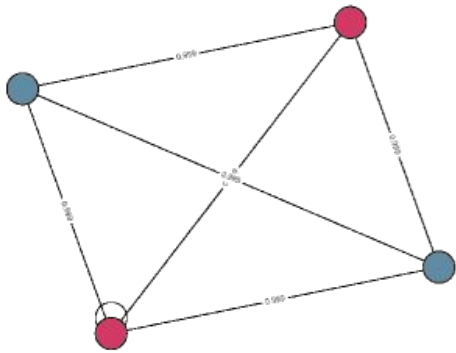
64 growth steps.
45 Nodes.



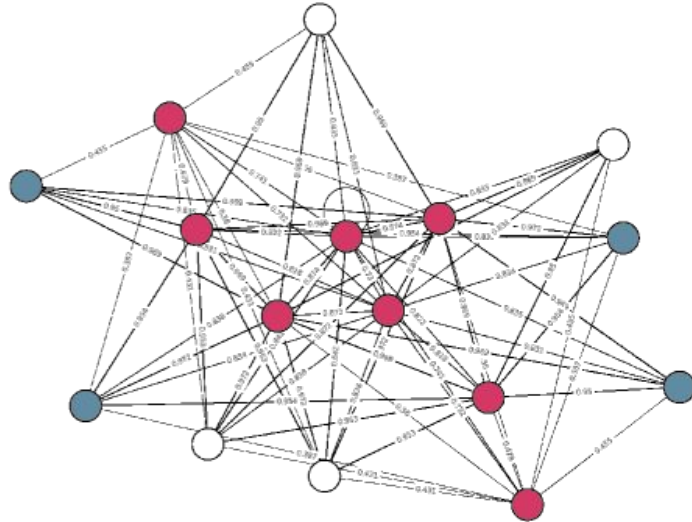
Results: Gradient-based

Reaches comparable performance to the evolutionary-based

Deteriorate after certain growth steps



XOR gate



Lander

Discussion & Future work

Unlike Developmental Encoding in related research, NDP required more information than the resulting network. However, this is not a problem as the focus is on performance.

Add activity-dependent growth like biological systems

Thank you for your attention.