Bio-Inspired AI through Developmental Neural Networks

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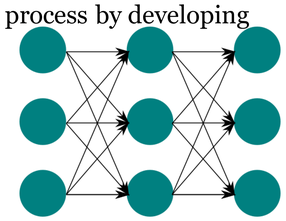
Problem

Catastrophic forgetting: networks tend to forget previous trained task after being trained on another different task

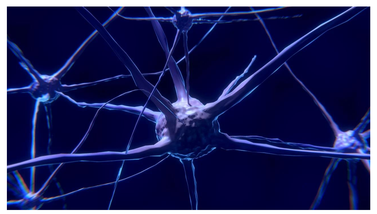
Motivation

- AI Models are effective at certain tasks weak at learning multiple things
- Humans are good retaining multiple tasks and reusing information
- Including more parts of the learning process by developing weights may improve AIs



Goals

- Capture developmental mechanisms that increase robustness in neural networks
- Explore methods structural development
- Investigate effects of development on networks



Development

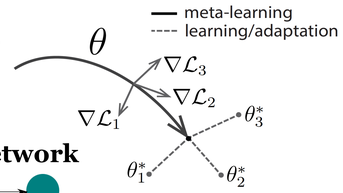
- Morphological and Cognitive
- Allows for change and adaptation
- Feedback loop between environment and developing system

Methodology

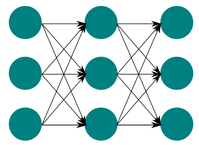
Task

Meta-learning, Learning to Learn

- Learning algorithm: MAML (Model-Agnostic Meta-Learning)
- Task: Image recognition



Starting Network

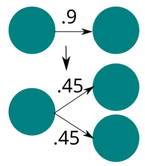


Train Starting Network on Task A | **Train Starting Network on Task B** | •••

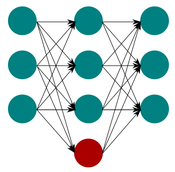
Optimize Starting Network from average accuracy across all tasks

Check Growth Rules

- Time
- Performance - Plateaus
- Weights – High Magnitude



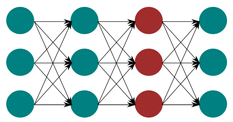
Split Weight



New Weight

- Random
- All zero – No change to output

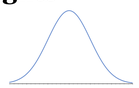
Add Node



Add Layer

New Layer Weights

[.2 .4 .1]
[.9 .7 .3]
[.9 .2 .6]
Random initialization



Normal Distribution

[0 0 0]
[0 1 0]
[0 0 0]
Identity Filter for convolutional

[1 0 0]
[0 1 0]
[0 0 1]
Identity matrix

Check Pruning Rules

- Time
- Performance - Overfitting
- Weights – Low magnitude

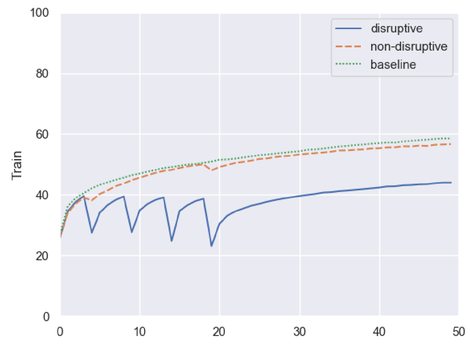
Select Weights to Prune

- Low magnitude
- Random
- Advanced Score

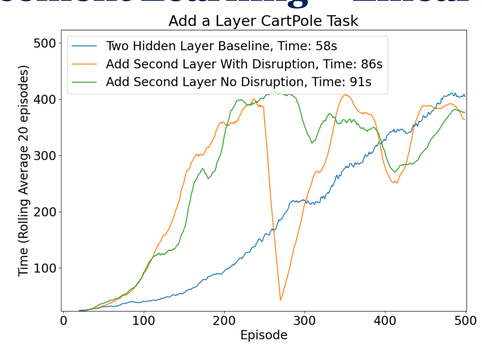
Update Starting Network and repeat for X steps

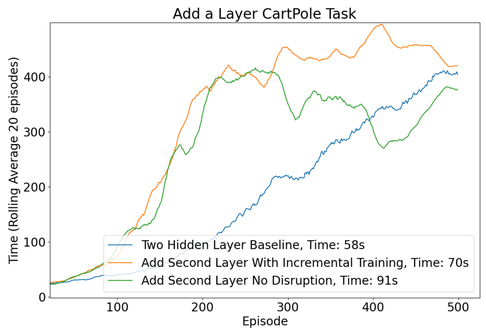
Results

Supervised Learning – Convolutional Network



Reinforcement Learning – Linear Network





Layers can be added in with minimal impact on training in both linear and convolutional networks, we may see more impact in more difficult tasks such as online-meta learning where smaller networks are not as capable, and optimal network size is unclear. Combining growth with pruning may allow important weights to develop and unimportant ones to be pruned away.