Neural Architecture Search: An Empirical View

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What is Neural Architecture Search?

- Start
  - (ICLR 2017) Neural Architecture Search with Reinforcement Learning
- Automatically design network architectures
  - CNN
  - RNN cell (e.g. LSTM)
- Transfer from hand-crafted design to automatically search

Ingredients

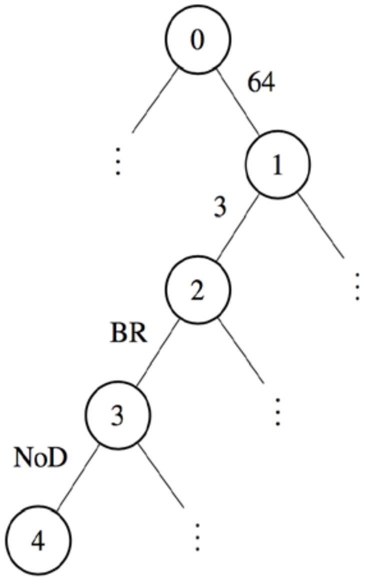
- Search Space
    - Search Tree
    - Computational Graph
    - Memory Bank
- Search Algorithm
    - REINFORCE
    - Tree Search
    - Evolutionary algorithm
- Search Algorithm and Search Space are coupled.

Framework

1. Design a search space
2. Sample models from the search space
    a. random
    b. guided by search algorithm
3. Evaluate the sampled models
    a. train the model for some epochs/time
        i. on standard datasets (e.g. CIFAR10, CIFAR100)
    b. use the validation accuracy at the end as a signal
4. Search algorithm uses the evaluation results to guide further search

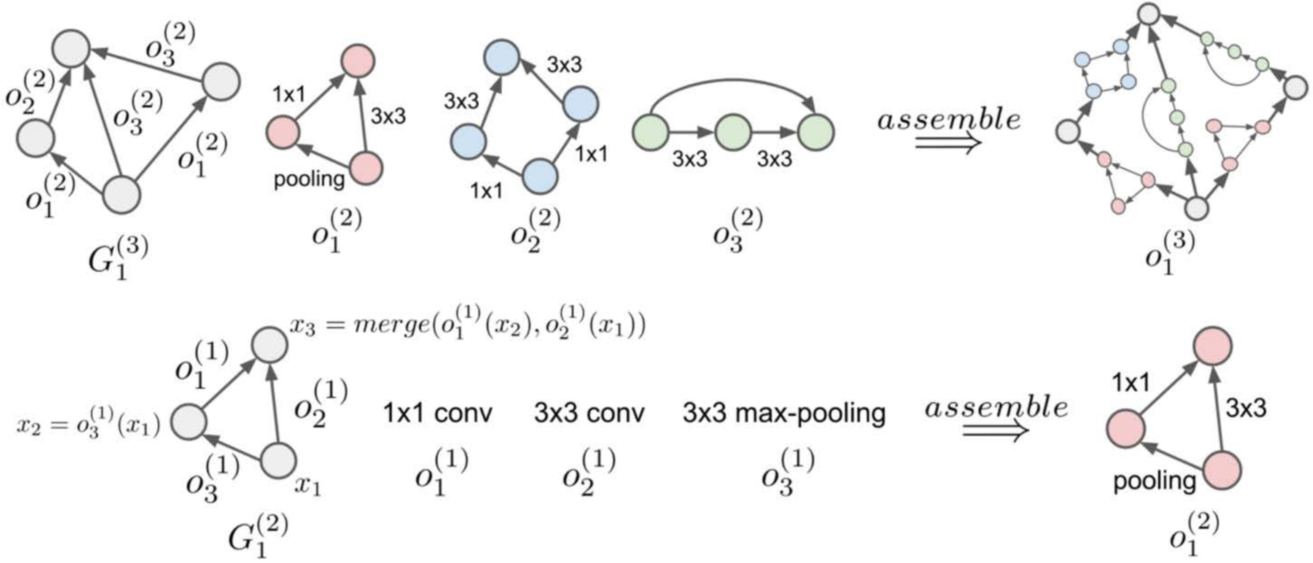
Search Tree

- Search space is represented by a rooted tree.
  - Tree Search Algorithms
- Each edge specifies an assignment.
  - depth
  - activation function
  - filter size
  - and so on ……
- Leaf node represents a specified neural network.



Computational Graph

- Use primitive computation to form complex computational graph
  - Evolutionary algorithms



Memory Bank

- Represent network architectures as memory read/write operations.

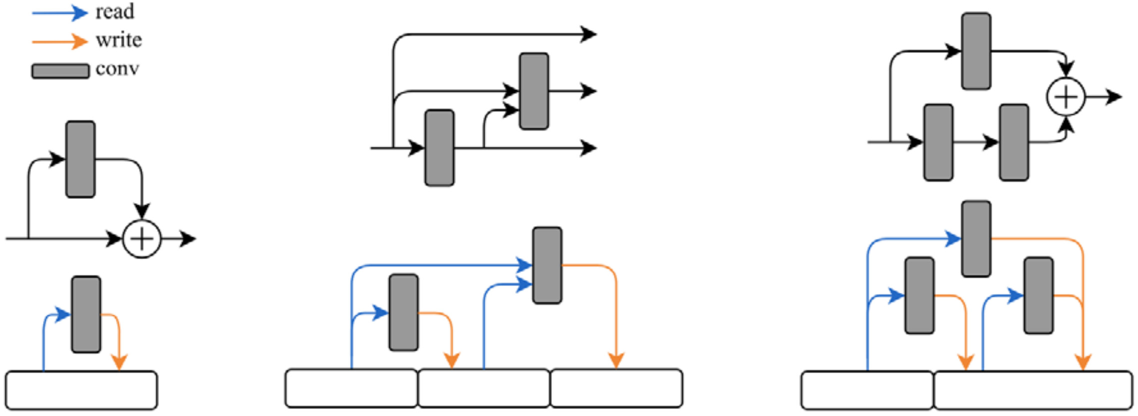


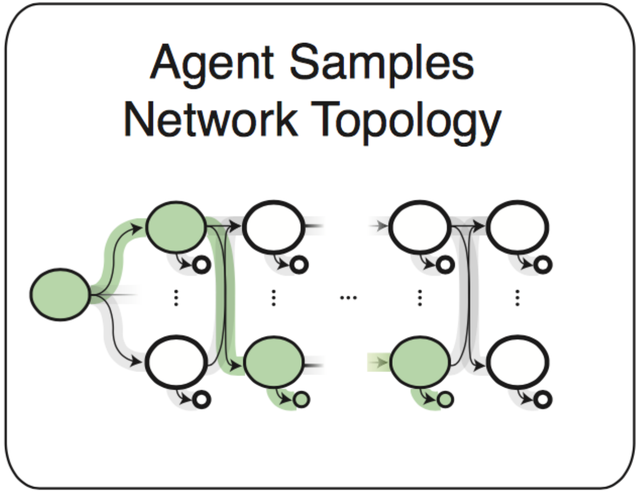
Figure: a memory bank representations for Resnet/DenseNet/FractalNet

Pitfall & Insight

- Decouple depth from the search space.
  - Going deeper, the training tends to get longer.
  - If not given enough time resource, it could add potential bias to the search process.
    - shallow model
- Encourage the algorithm to learn complex cell structure.
  - Advantages:
    - generalize to deep model easily (e.g. stacking)
    - transfer to other tasks (Imagenet)
- Different search space allows for different specialized algorithms.

Search Algorithm

- Tree search
  - Monte Carlo Tree Search
- Reinforcement Learning
  - Q-learning
  - REINFORCE
- Evolutionary Algorithm
- and so on ……



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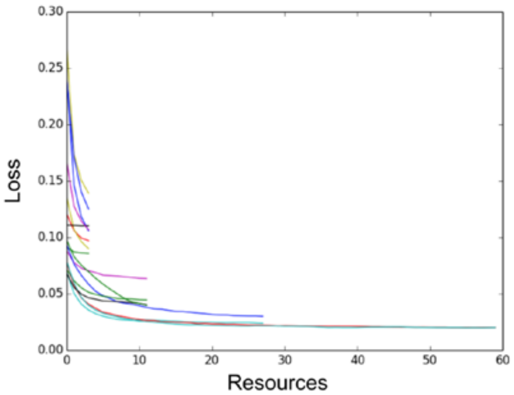
Acceleration

- Traditional Paradigm
  - Train each sampled model for a fixed epochs/time
  - Problem:
    - Waste time on bad models.
- Why important?
- Accelerating technique
  - Early Stopping
    - Idea : Make use of early information
  - One-shot evaluation
    - pre-trained parameters

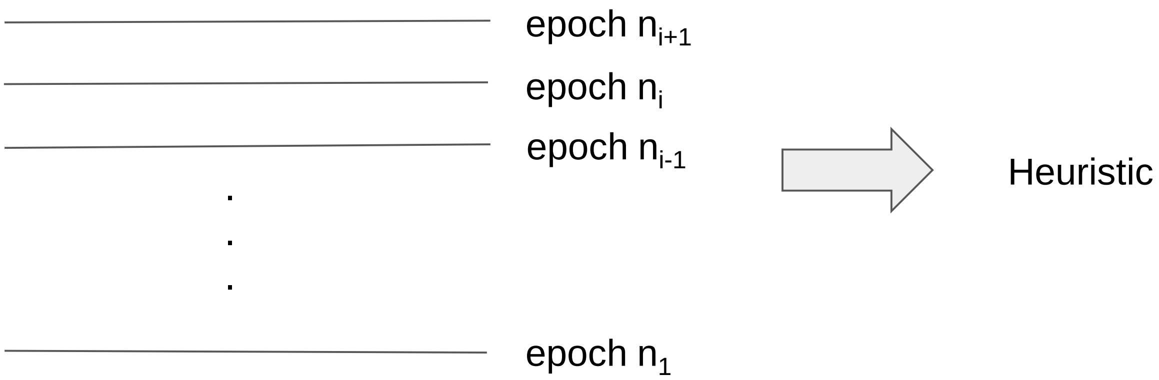
Early Stopping

- Origin
    - used as a way to prevent overfitting in neural networks
- Help accelerate search by pruning bad models
    - Hyperband (Li, et.al)
    - Population based training (DeepMind)
- Illustration



An unified view of Early Stopping

- Pre-define the “training hierarchy”
- At each epoch in the hierarchy, use heuristics to decide whether to continue training.



Heuristic

- Performance Prediction
  - Use a pre-trained model to predict the final performance.
  - Continue if the predicted performance is good.
- Comparison Based
  - Procedure:
    - Evaluate a set of models in parallel.
    - Keep training models with good performance from the set.
  - Advantages:
    - An adaptive approach: No need to design complicated heuristic

Other techniques & Discussions

- Other techniques:
  - One-shot evaluaton:
    - Use pretrained parameters
- Discussions:
  - Can we beat random search?
    - Pruning technique is the key to beat random search.
  - Challenges:
    - Design efficient search space representations
    - and so on …….

References

1. Baker, B. et.al (2017) Designing Neural Network Architecture Using Reinforcement Learning
2. Brock, A. et.al (2017) SMASH: One-Shot Model Architecture Search through HyperNetworks
3. Li, L. et.al (2017) Hyperband: A Novel Bandit-Based Approach to Hyperparameter Optimization
4. Jaderberg, M. et.al (2017) Population Based Training of Neural Network
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Q&A