AutoML: Neural Architecture Search (NAS)

The One-Shot Model

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One-shot models: convolutional neural fabrics [Saxena and Verbeek. 2017]

- A one-shot model is a big model that has all architectures in a search space as submodels
  - This allows weights sharing across architectures
  - One only needs to train the single one-shot model,
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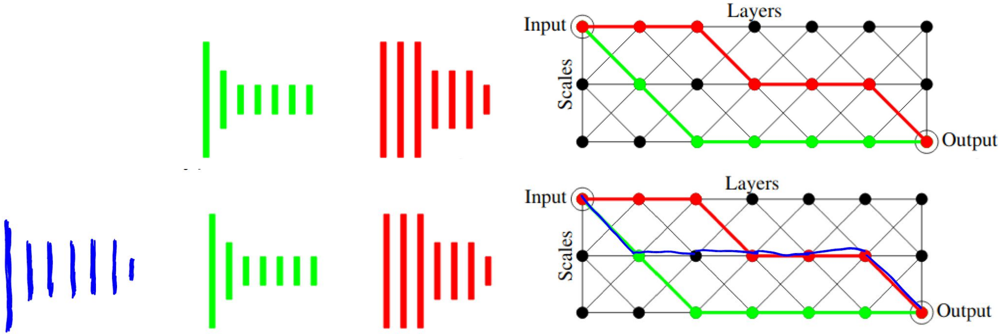

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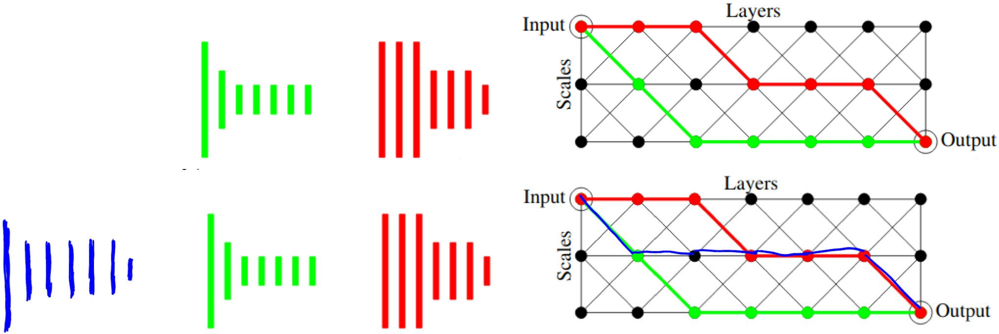

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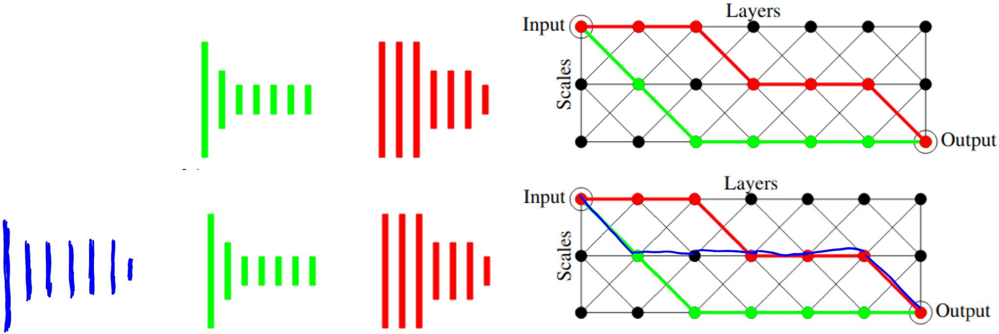

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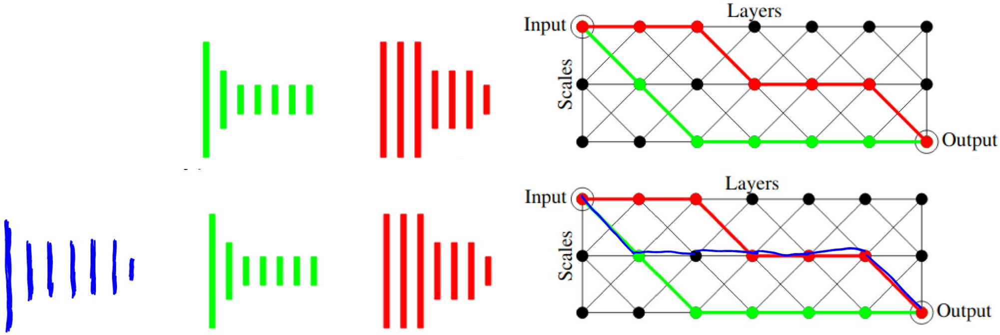
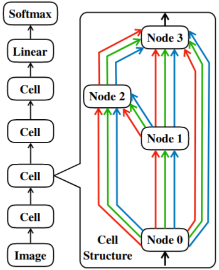


One-shot models for cell search spaces

- Directed acyclic multigraph to capture all (exponentially many) cell architectures
  - The nodes represent tensors
  - The edges represent computations (e.g., 3x3 conv, 5x5 conv, max pool, . . .)
  - The results of operations on multiple edges between two nodes are combined (addition/concatenation)



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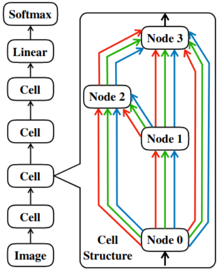
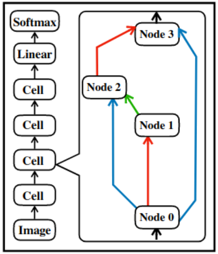
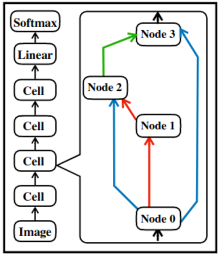
- Individual architectures are subgraphs of this multigraph
  - Weights for the operation on an edge are shared
    across all (exponentially many) architectures that have that edge







Training the one-shot model – standard SGD [Saxena and Verbeek. 2017]

- One-shot model is an acyclic graph; thus, backpropagation applies
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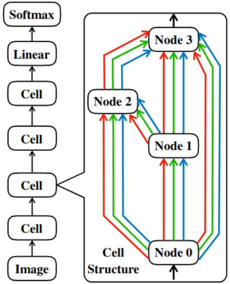

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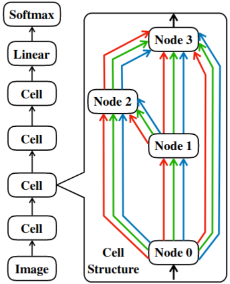
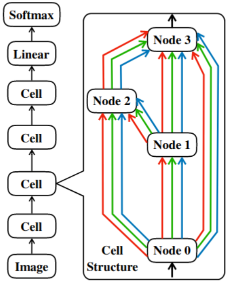
- Potential issue: co-adaptation of weights
  - Weights are implicitly optimized to work well on average across all architectures
  - They are not optimized specifically for the top-performing architecture



Training the one-shot model – DropPath [Bender et al. 2018]

- To avoid coadaptation of weights, we can use DropPath, a technique analogous to Dropout [Srivastava et al. 2014]:



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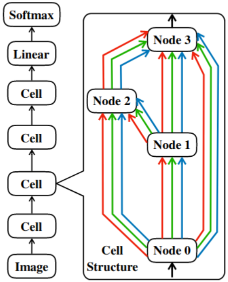

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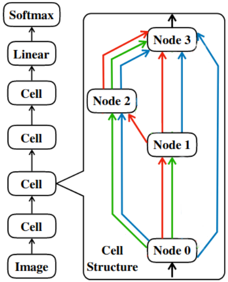
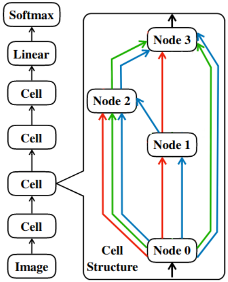


Architecture for batch 1



Architecture for batch 2

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  - At each mini-batch iteration:
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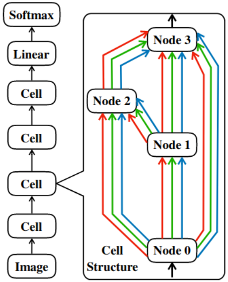
  - ScheduledDropPath: starts with $p = 0$ and increases p linearly to p_{max} at the end of training



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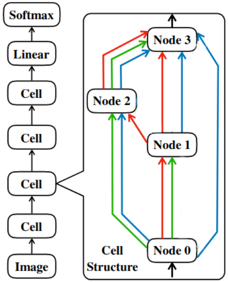

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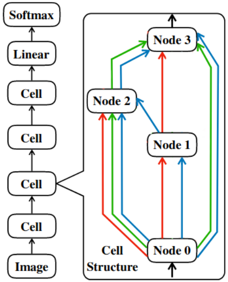

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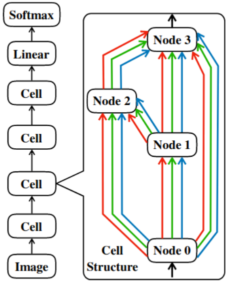

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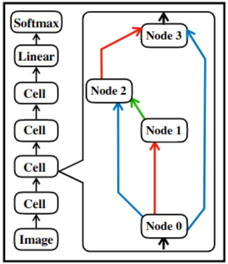

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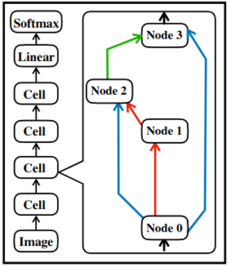

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- At each mini-batch iteration during the training of the one-shot model sample a single architecture from the search space
  - **Random Search with Weight Sharing** [Li and Talwalkar. 2020] ⟶ sample from uniform distribution
  - **ENAS** [Pham et al. 2018] ⟶ sample from the learned policy of a RNN controller
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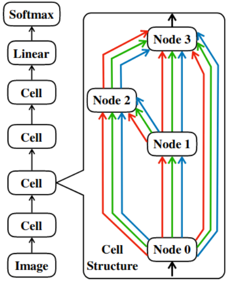

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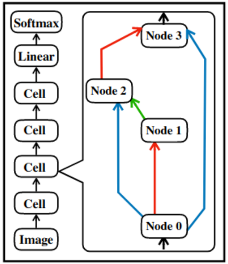

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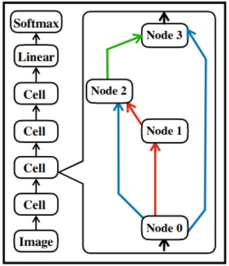

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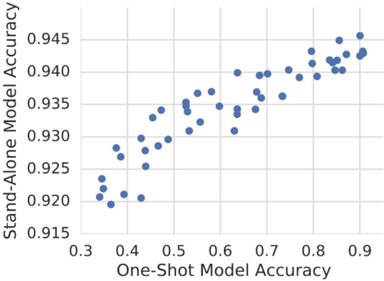
- **Pitfall:** the correlation between architectures evaluated with the one-shot weights and retrained from scratch (stand-alone models) should be high
- If not, **selecting the best architecture based on the one-shot weights** is sub-optimal.



From [Bender et al. 2018]

Questions to Answer for Yourself / Discuss with Friends

- Repetition:
  How are the weights shared in the one-shot model?

- Repetition:
  What is the difference between Random Search with Weight Sharing and ENAS?

- Discussion:
  What migth be some downsides of using the one-shot model for NAS?