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Architecture Search and Reinforcement Learning

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National Tsing-Hua University

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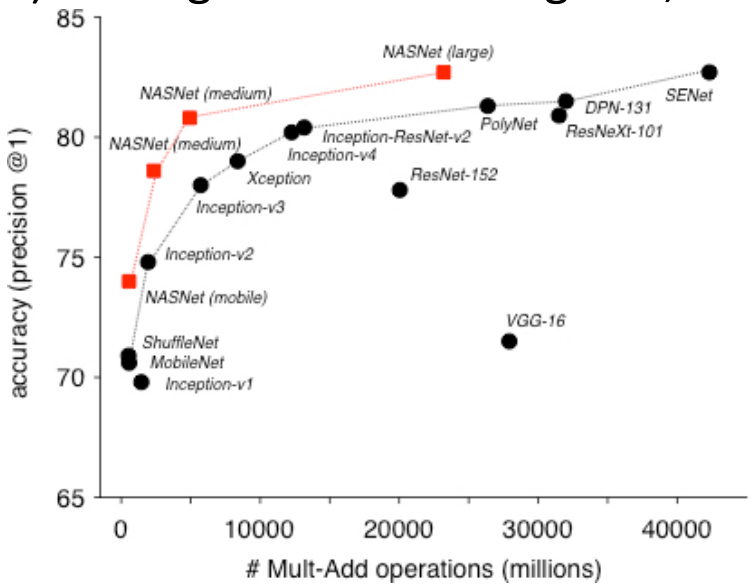
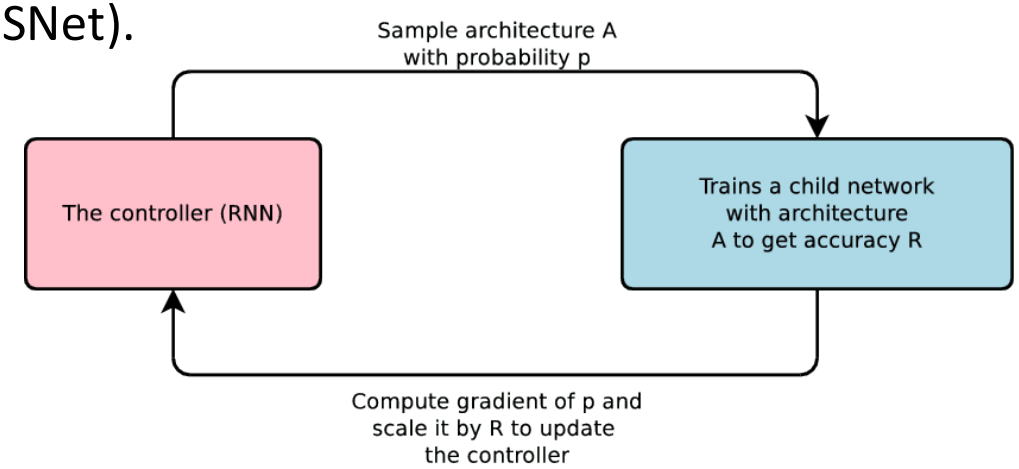
Intuition: Use ML to design ML model?

- Using Machine Learning to Explore Neural Network Architecture.
  - NAS (1611.01578, ICLR'17) - Google Research Blog May, 17th, 2017.
- AutoML for large scale image classification and object detection (fig).
  - NASNet (1707.07012) - Google Research Blog Nov, 2nd, 2017.



Methods

- Reinforcement Learning:
  - Policy gradient (NAS *ICLR'17* / NASNet).
  - Q-learning (Block-QNN *AAAI'18*).

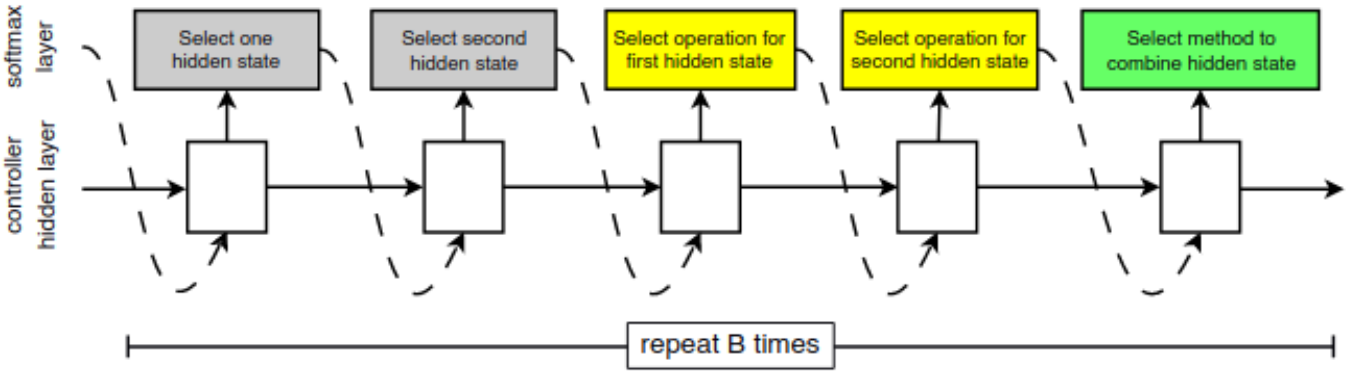


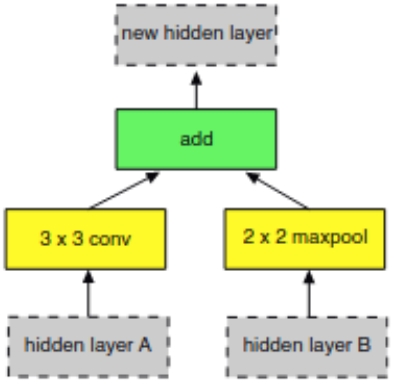
(Additionally)

- Evolutionary Algorithm:
  - Hierarchical Representations for Efficient Architecture Search (1711.00436).
- Others:
  - Progressive Neural Architecture Search (SMBO) (1712.00559).

Policy Gradient: NASNet Controller

- Select 2 hidden layers, 2 operations and combining method.



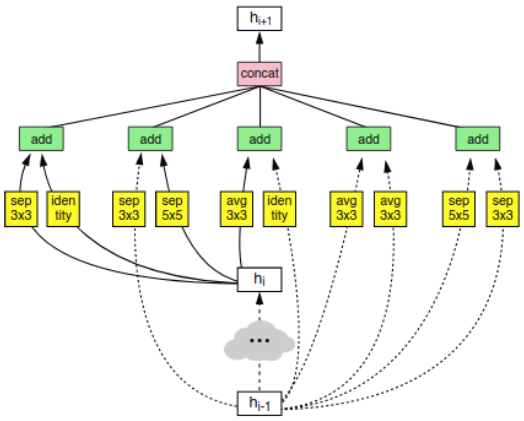


- Product of 2 *(N/R cell)* * 5 * B softmax predictions -> compute gradient.
- The gradient is scaled by the reward (accuracy).
- Employ PPO for faster and more stable training.

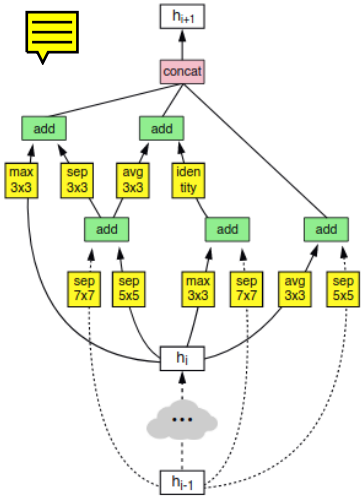
Policy Gradient: NASNet Search Space

- Convolutions, Pooling, etc.
- Fixed cell order:
  - n*Normal + 1*Reduction
- NASNet-A:
  - B = 5

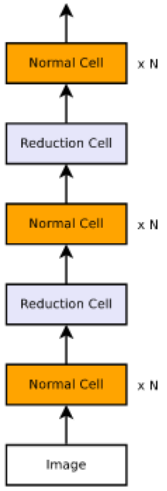
- identity
- 1x7 then 7x1 convolution
- 3x3 average pooling
- 5x5 max pooling
- 1x1 convolution
- 3x3 depthwise-separable conv
- 7x7 depthwise-separable conv
- 1x3 then 3x1 convolution
- 3x3 dilated convolution
- 3x3 max pooling
- 7x7 max pooling
- 3x3 convolution
- 5x5 depthwise-seperable conv



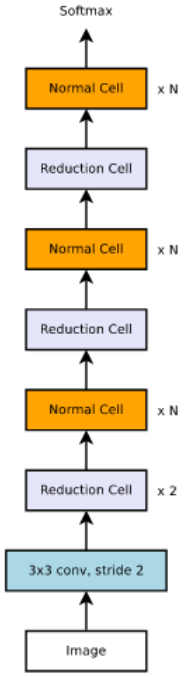
Normal Cell



Reduction Cell



CIFAR10 Architecture



ImageNet Architecture

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Q-Learning: Block-QNN Controller

- The search space is very similar to NASNet -> only search for a **block**.

Table 1: Neural Block's structure Code Space. K is the number that less than the number of current layer.

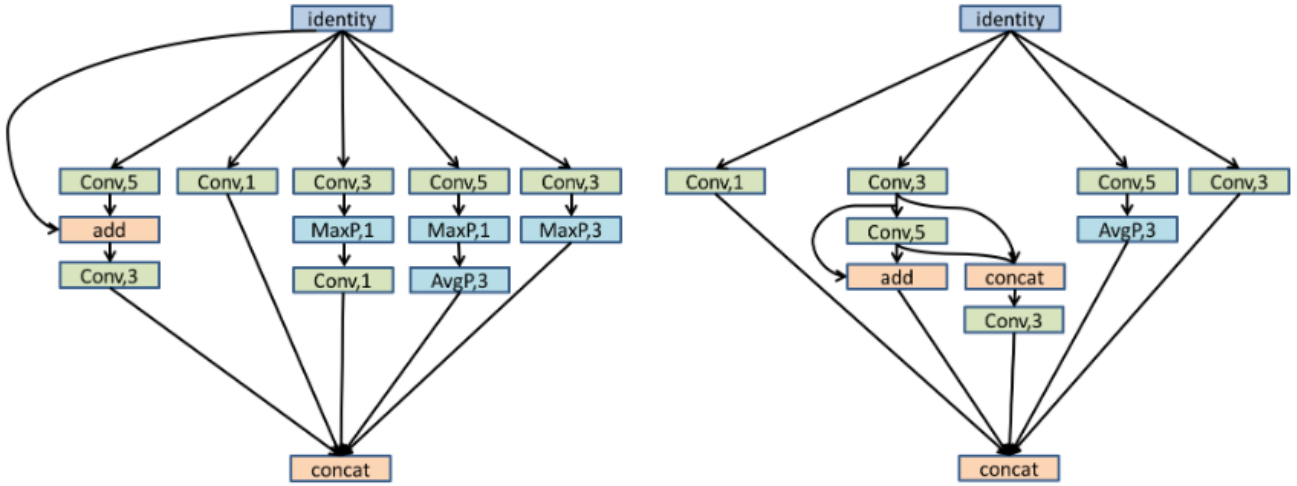
Layer Type	Convolution	Max Pooling	Average Pooling	Identity	Elemental Add	Concat	Terminal
Kernel Size	1, 3, 5	1, 3	1, 3	0	0	0	0
Connection 1	K	K	K	K	K	K	K
Connection 2	0	0	0	0	K	K	0

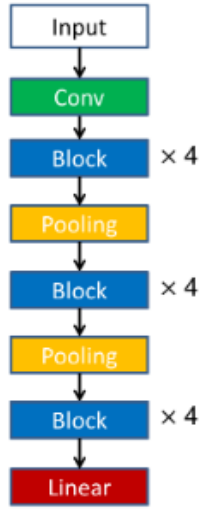
- State: the current layer in block.
- Action: the next layer the agent choose.
- Agent: generates block by selecting the action with highest value.
- Reward: accuracy – log(FLOPS) / 2 – log(density) / 2

$$Q_{t+1}(s_i,u) = (1-\alpha)Q_t(s_i,u)+\alpha[accuracy+max_{u' \in U(s_j)}Q_t(s_j,u')]$$

Q-Learning: Block-QNN Search Space

- The search space and the best architectures found.





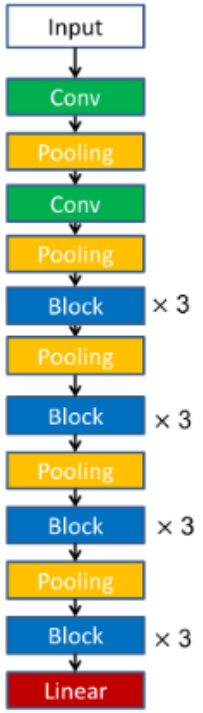


Figure 5: Topology of the Top-2 block structures searching on CIFAR-10 dataset.We call them Block-QNN-A and Block-QNN-B.

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Comparison

- The numbers are best reported results (few variations for ImageNet)

Model	CIFAR-10 Error rate	ImageNet Top-1 Error rate	ImageNet Top-5 Error rate	GPUs	days
NAS *ICLR'17*	3.65	-	-	800	24
NASNet	2.4	17.3	3.8	500	4
Block-QNN *AAAI'18*	3.6	24.3	7.4	32	3

- **Google releases official NASNet CNN architecture (not the controller) in the tensorflow models repository on github.*