BNAS-v2: A Summary with Empirical Improvements

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Binary Networks for Computer Vision
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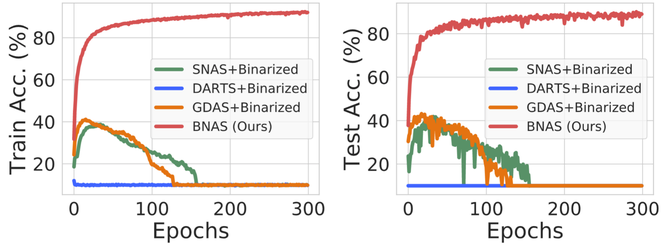
Motivation

tl;dr. A cell-based neural architecture search (NAS) method for binary networks

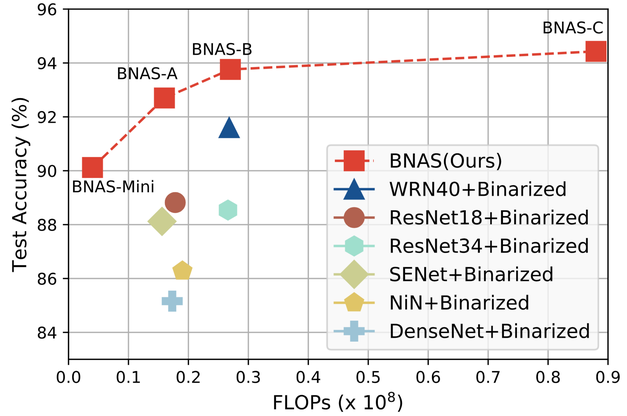
Previously, use FP Architectures as backbone
→ Want to search binary specific architectures

Other NAS Methods & Ours for Binary Networks



→ No consideration for quantization error!

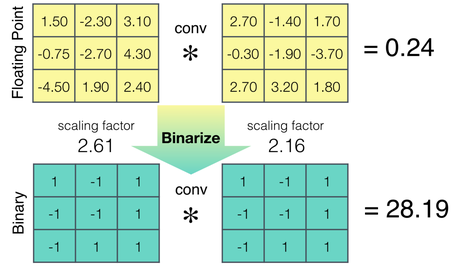
Proposed NAS Method for Binary Networks (BNAS)



Method

Search Space for Binary Networks (S_B)

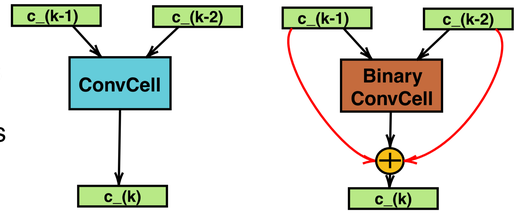
- Zeroise layer may reduce quantization error
  → keep Zeroise layer for the binary case
- More efficient (weights ×)
- Sep. conv will be detrimental
  → show this experimentally



Layer Type	Conv		Dil. Conv		Sep. Conv	
Kernel Size	3 × 3	5 × 5	3 × 3	5 × 5	3 × 3	5 × 5
FP Acc. (%)	61.78	60.14	56.97	55.17	56.38	57.00
Bin. Acc. (%)	46.15	42.53	41.02	37.68	10.00	10.00

Cell Template for Binary Networks (T_B)

- Quantization error
  → unstable gradients
- Add skip-connections
  → stabilize gradients



Search Objective for Binary Networks ($\tilde{L}_S$)

$$\widetilde{\mathcal{L}}_S(D;\theta_{\alpha_B}) = \mathcal{L}_S(D;\theta,p) - \lambda H(p)e^{(-t/\tau)}$$

- Binary convolution layers are severely under-explored early on
- Maximum entropy regularizer
  → encourages the search to explore diverse layer types

Experiments

Classification Results on ImageNet

FLOPs ($\times 10^8$)	Method (Backbone Arch.)	Binarization Scheme	Pretraining	Top-1 Acc. (%)	Top-5 Acc. (%)
∼ 1.48	BinaryNet (ResNet18) [3]	Sign	✗	42.20	67.10
	ABC-Net (ResNet18) [9]	Clip + Sign	✗	42.70	67.60
	BNAS-D	Sign + Scale	✗	57.69	79.89
	BNAS-D-No-Reg	Sign + Scale	✗	61.60	82.91
	BNAS-D v2†	Sign + Scale	✗	63.82	84.25
	BNAS-D v2 Multi-Stage†	Sign + Scale	✓	66.03	85.42
	BATS† [1]	Sign + Scale	✓	66.10	87.00
∼ 1.63	Bi-Real (Bi-Real Net18) [12]	Sign + Scale	✓	56.40	79.50
	XNOR-Net++ (ResNet18) [2]	Sign + Scale*	✗	57.10	79.90
	PCNN (ResNet18) [4]	Projection	✓	57.30	80.00
	BONN (Bi-Real Net18) [5]	Bayesian	✗	59.30	81.60
	BinaryDuo (ResNet18) [7]	Decoupled	✓	60.40	82.30
∼ 1.78	ABC-Net (ResNet34) [9]	Clip + Scale	✗	52.40	76.50
∼ 1.93	Bi-Real (Bi-Real Net34) [12]	Sign + Scale	✓	62.20	83.90
∼ 6.56	CBCN (Bi-Real Net18) [10]	Sign + Scale	✓	61.40	82.80

Ablations on CIFAR10

- Proposed components all contribute to accuracy

Model	Full	No Skip	No Zeroise	No Div
BNAS-A	**92.70**	61.23	89.47	90.95
BNAS-B	**93.76**	67.15	91.69	91.55
BNAS-C	**94.43**	70.58	88.74	92.66

Summary

- Propose a cell-based NAS method specifically for binary networks
- Design a new search space via including the Zeroise layer
- Use new cell template and search objective tuned for binary networks

Updated code will be available →