SMASH: One-Shot Model Architecture Search through Hypernetworks

Andrew Brock

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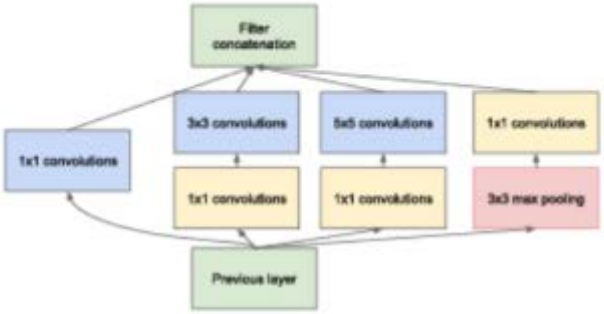
Designing Neural Nets is Hard!



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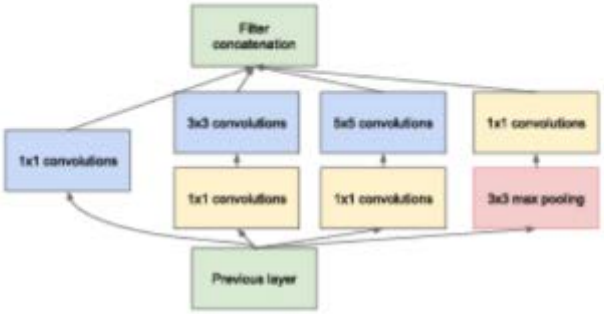

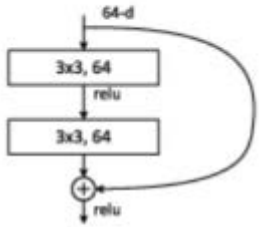

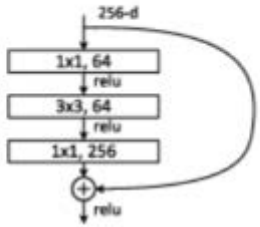

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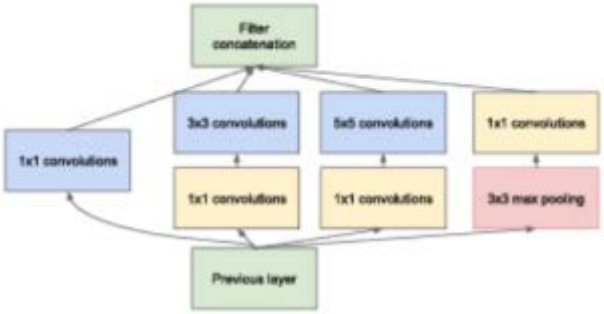

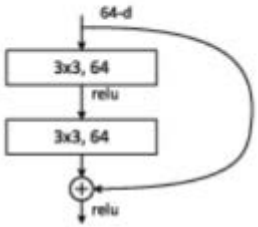

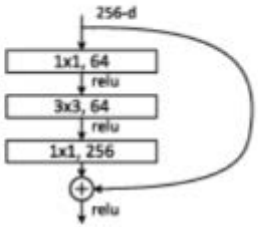

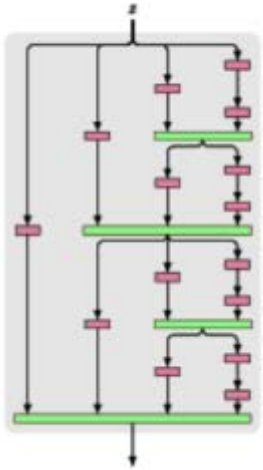

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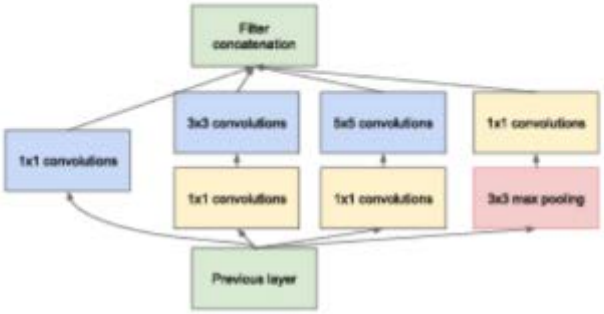

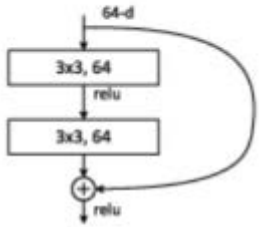

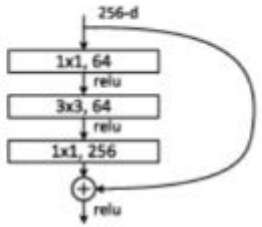

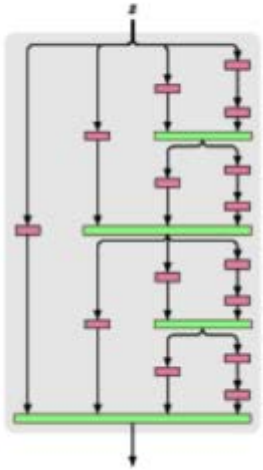

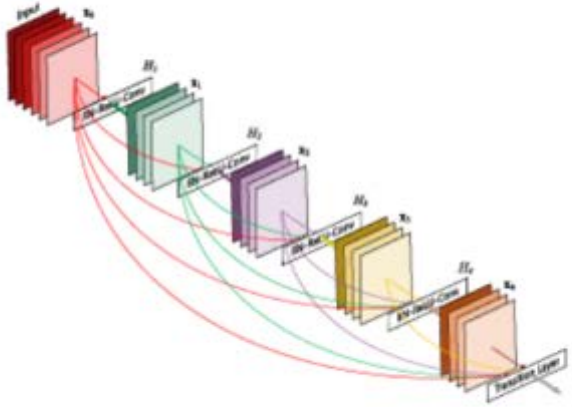

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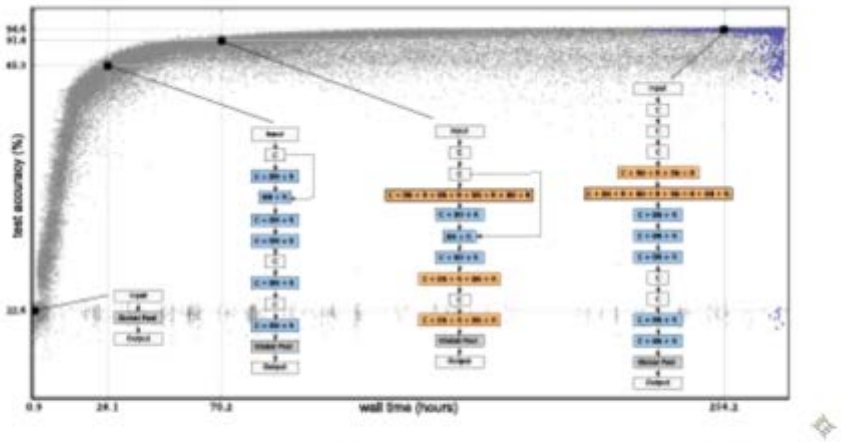
We *can* automate it…



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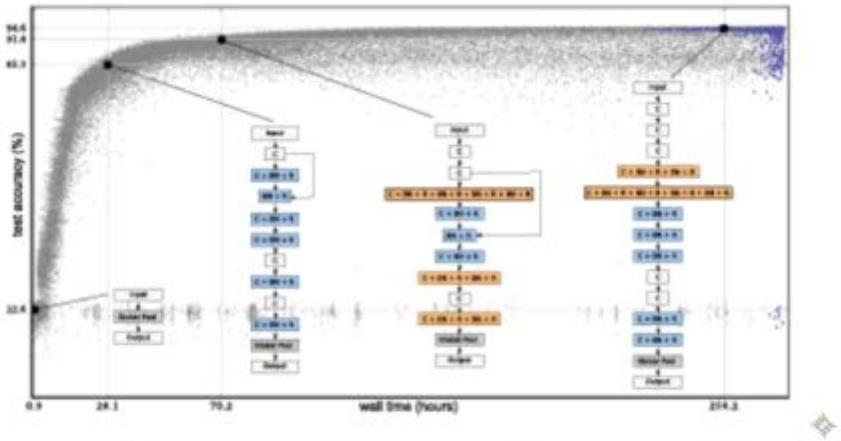

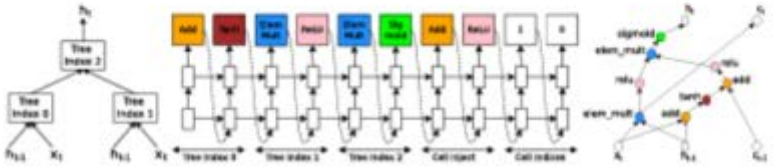

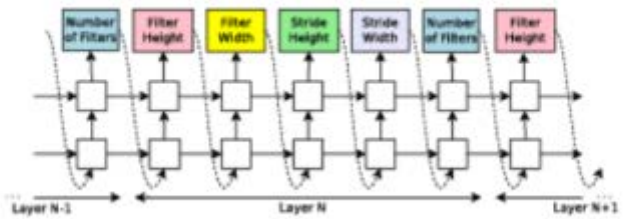

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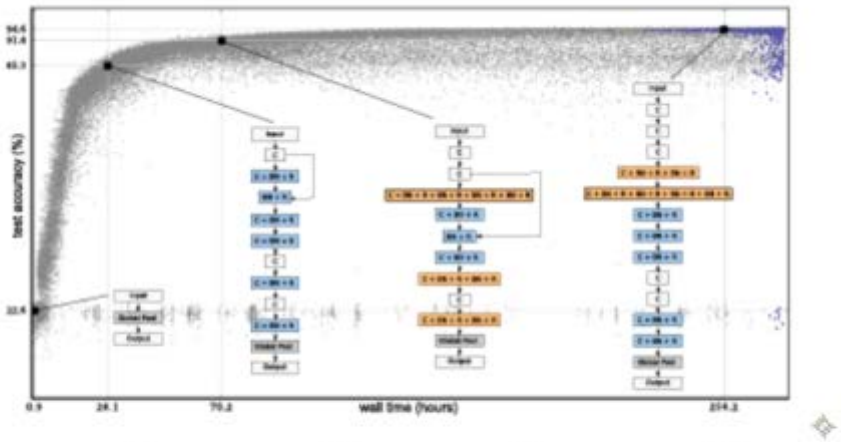
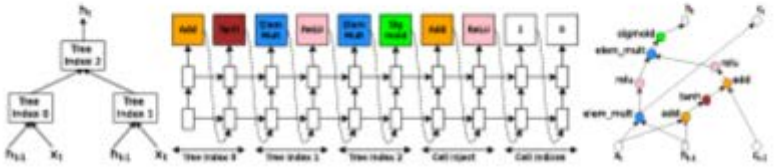
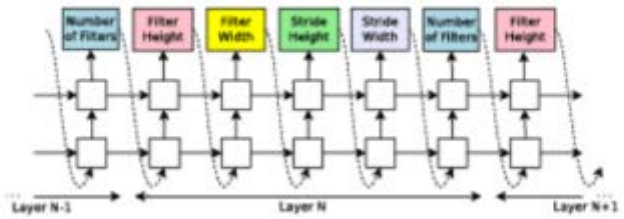
But it can get expensive







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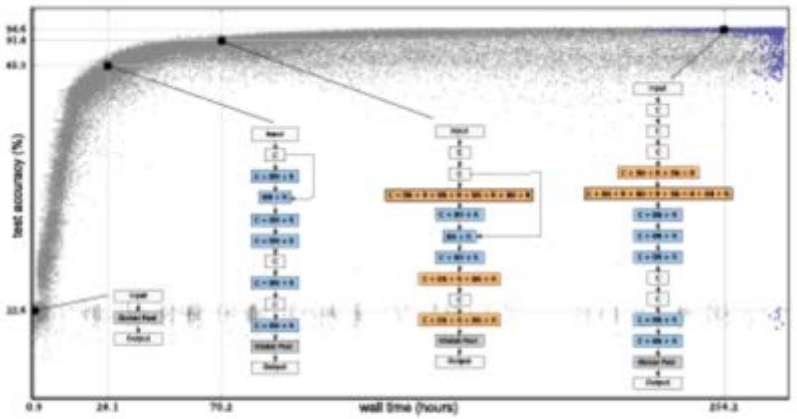

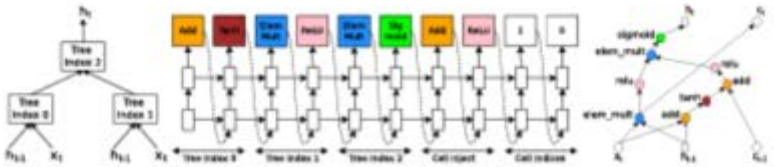

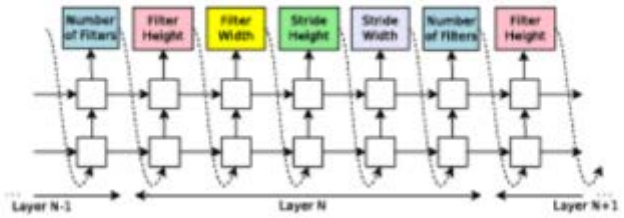

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Reducing the cost

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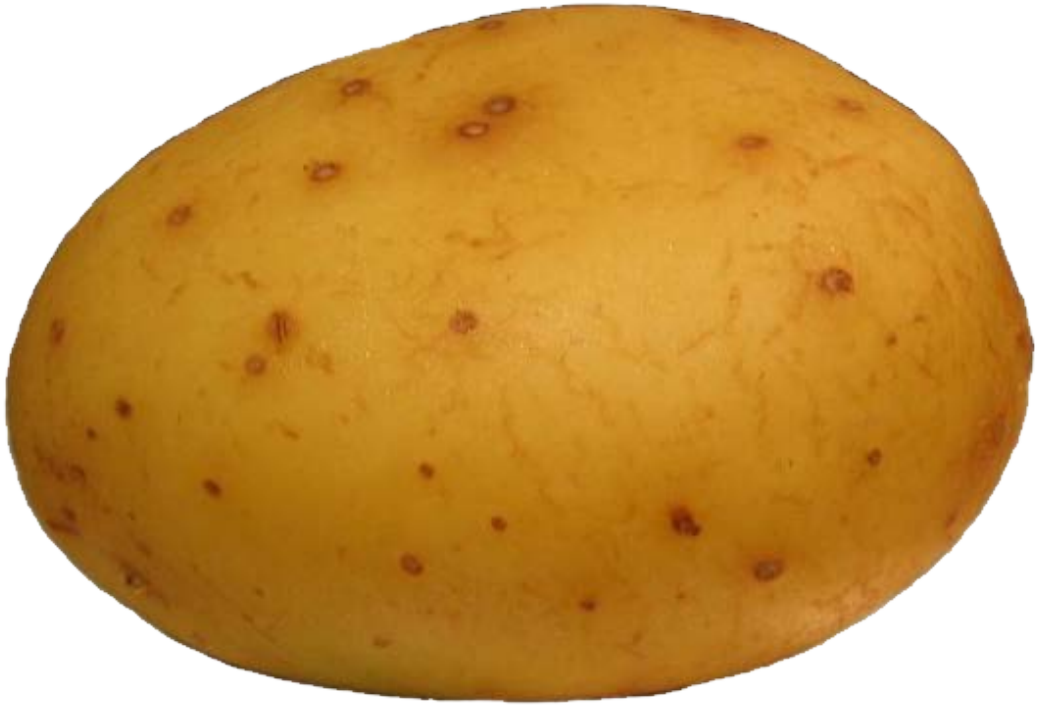

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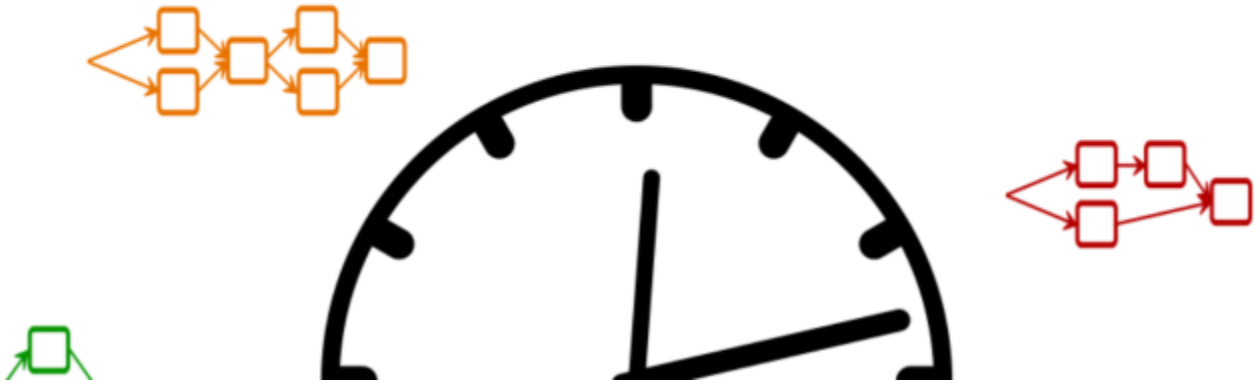

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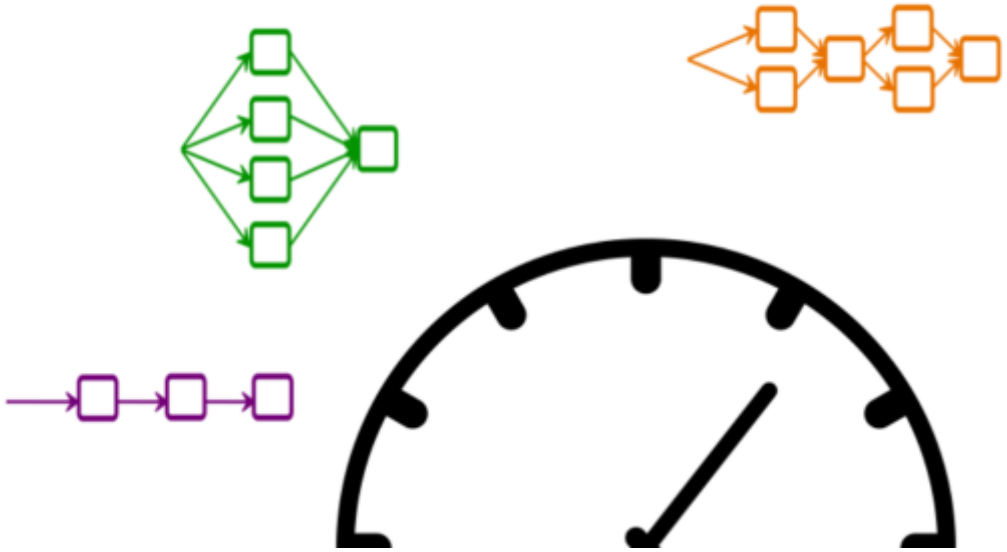

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Reducing the cost

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Meta-Modeling

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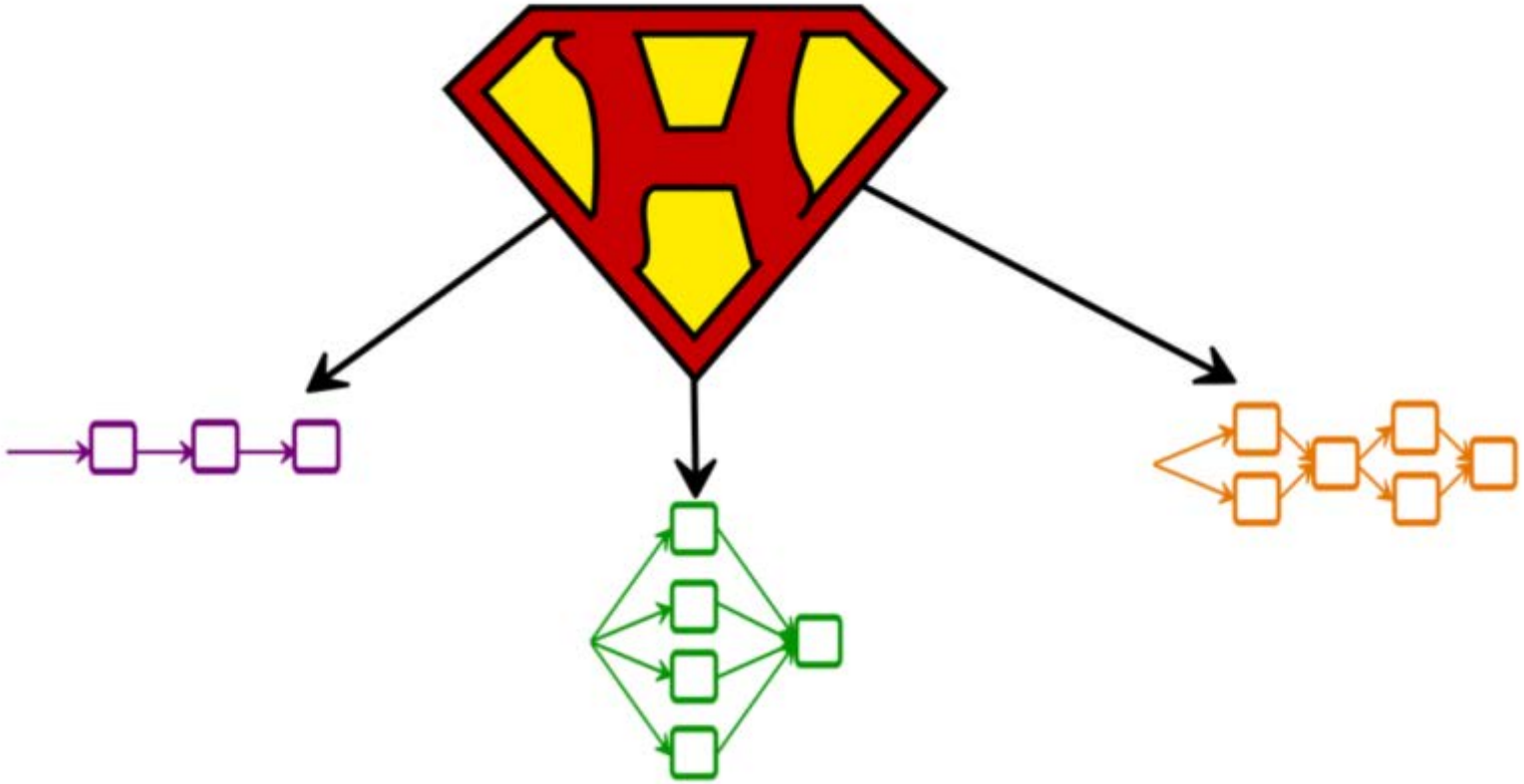
Meta-Modeling



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How's it work?

-Sample a random architecture

-Generate weights conditioned on that architecture, $W=H(c)$

-Train the whole thing end-to-end

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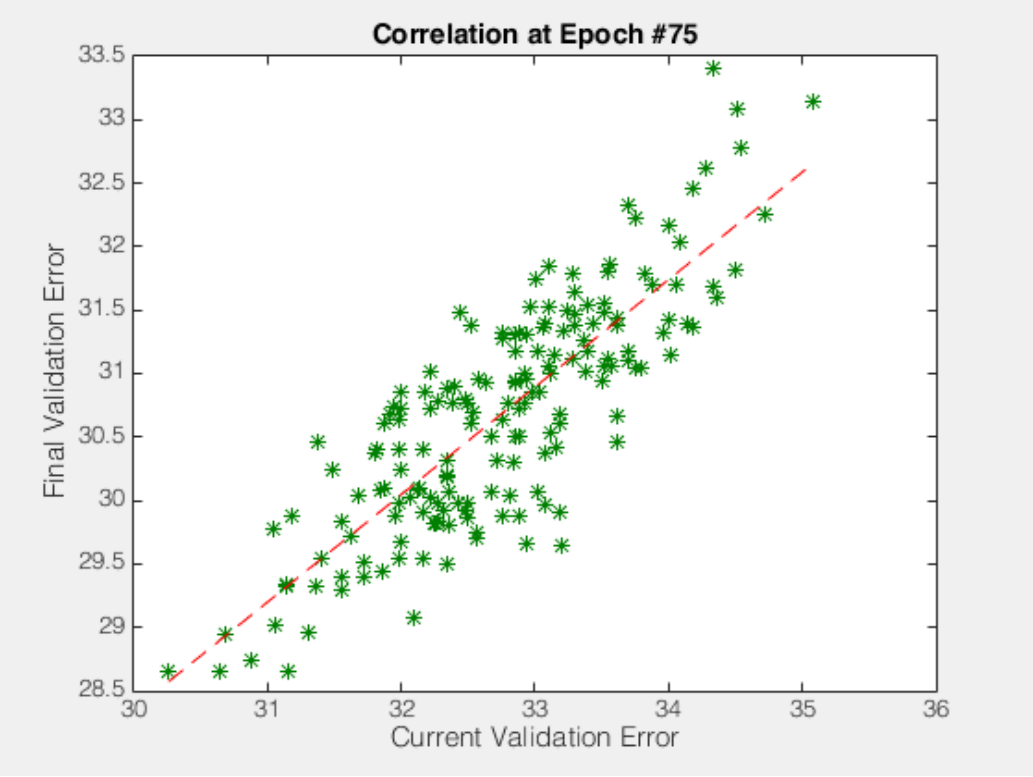
How's it work?

-Fully Convolutional Hypernet

-Weights need only be "close to optimal"



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How's it work?

Okay, great.

But how do we sample random architectures?

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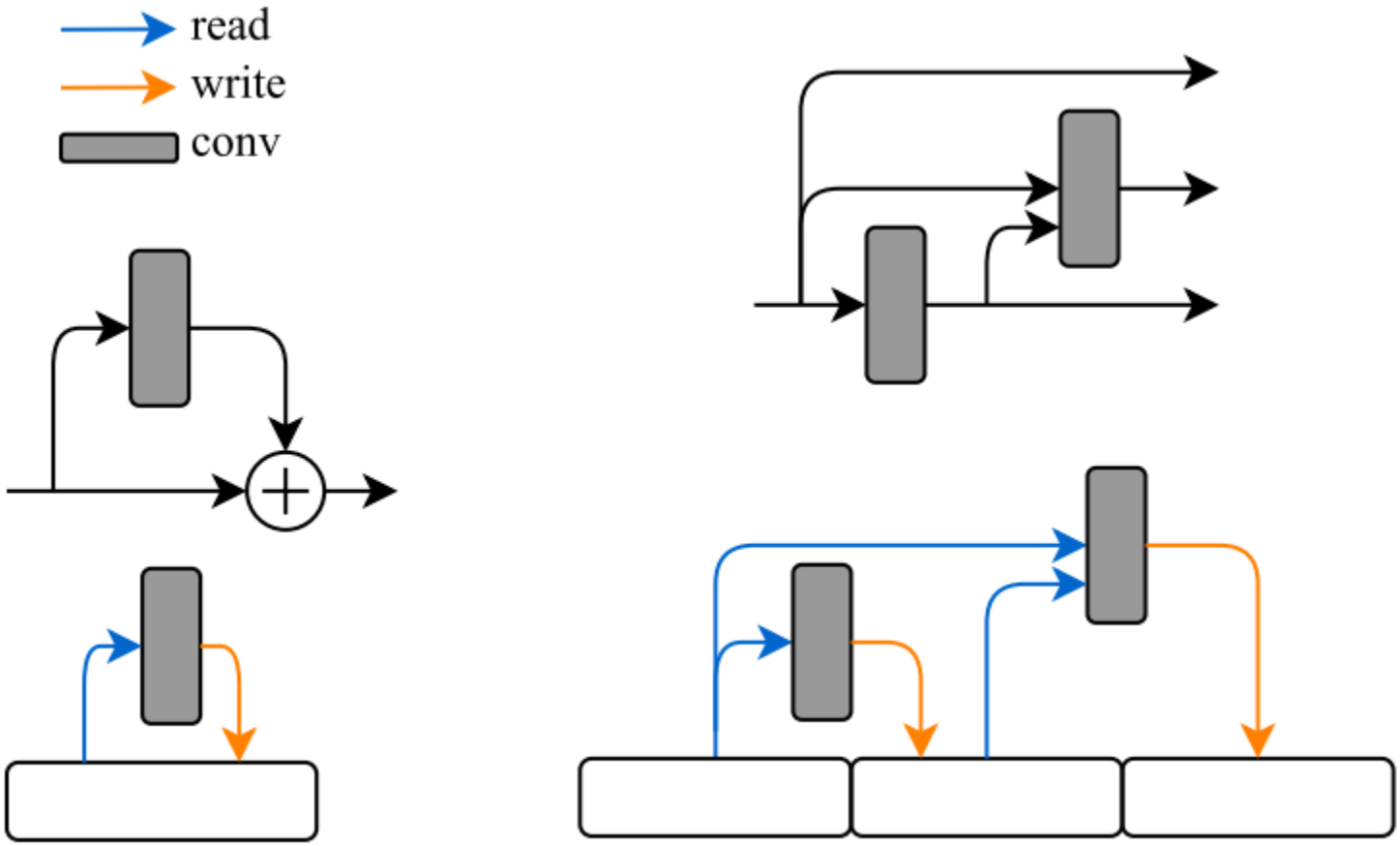
Memory-Bank View



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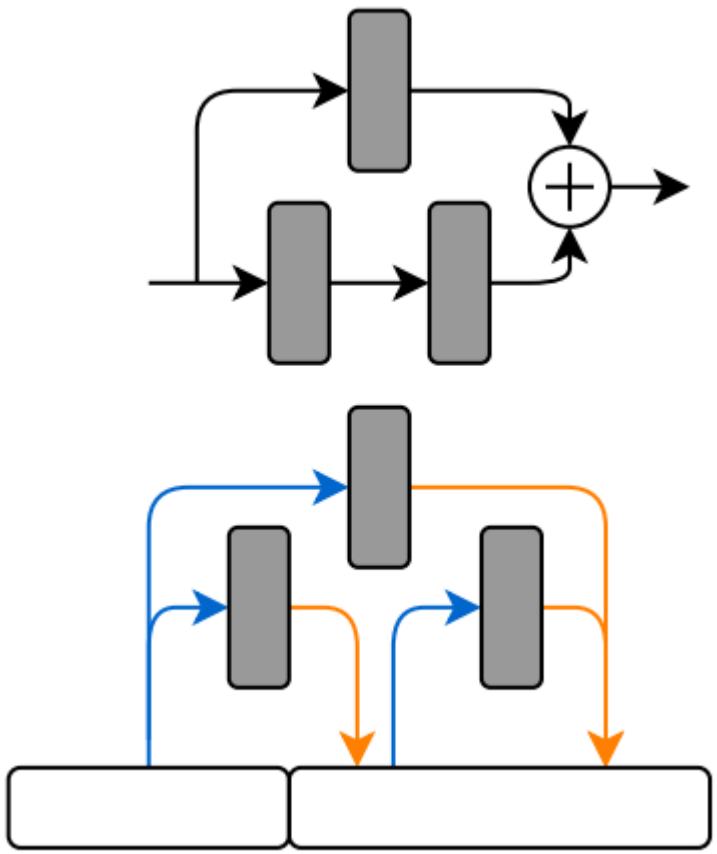

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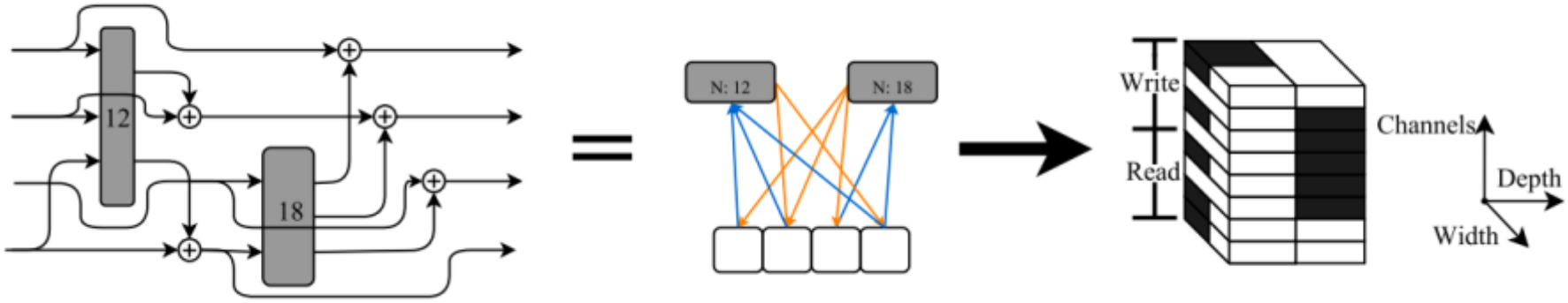
Encoding an Architecture



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Encoding an Architecture

```
self.hyperconv(embedding).squeeze(0)\
                         .transpose(0,1)\
                         .contiguous()\
                         .view(self.N_max, int((slice_index + 1) * self.depth_compression* self.N))\
                         .index_select(1, V(torch.LongTensor([i for item in
                                                [range(q, (slice_index + 1) * self.depth_compression * self.N, slice_index + 1) for q in range(slice_index + 1)] for i in item]).cuda()))\
                         .transpose(0,1)\
                         .unsqueeze(2).unsqueeze(3)\
                         .contiguous()
```

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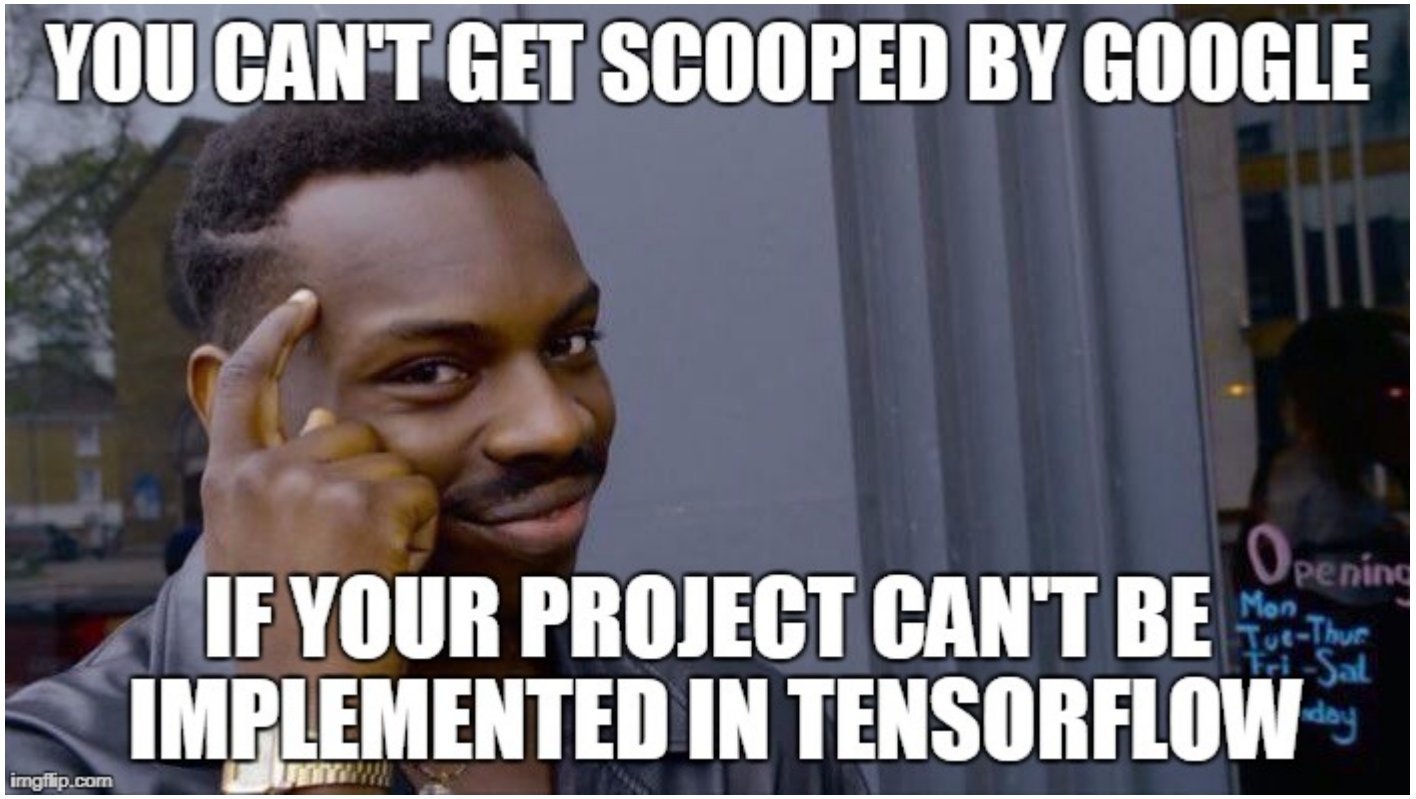
Implementation

PYTORCH



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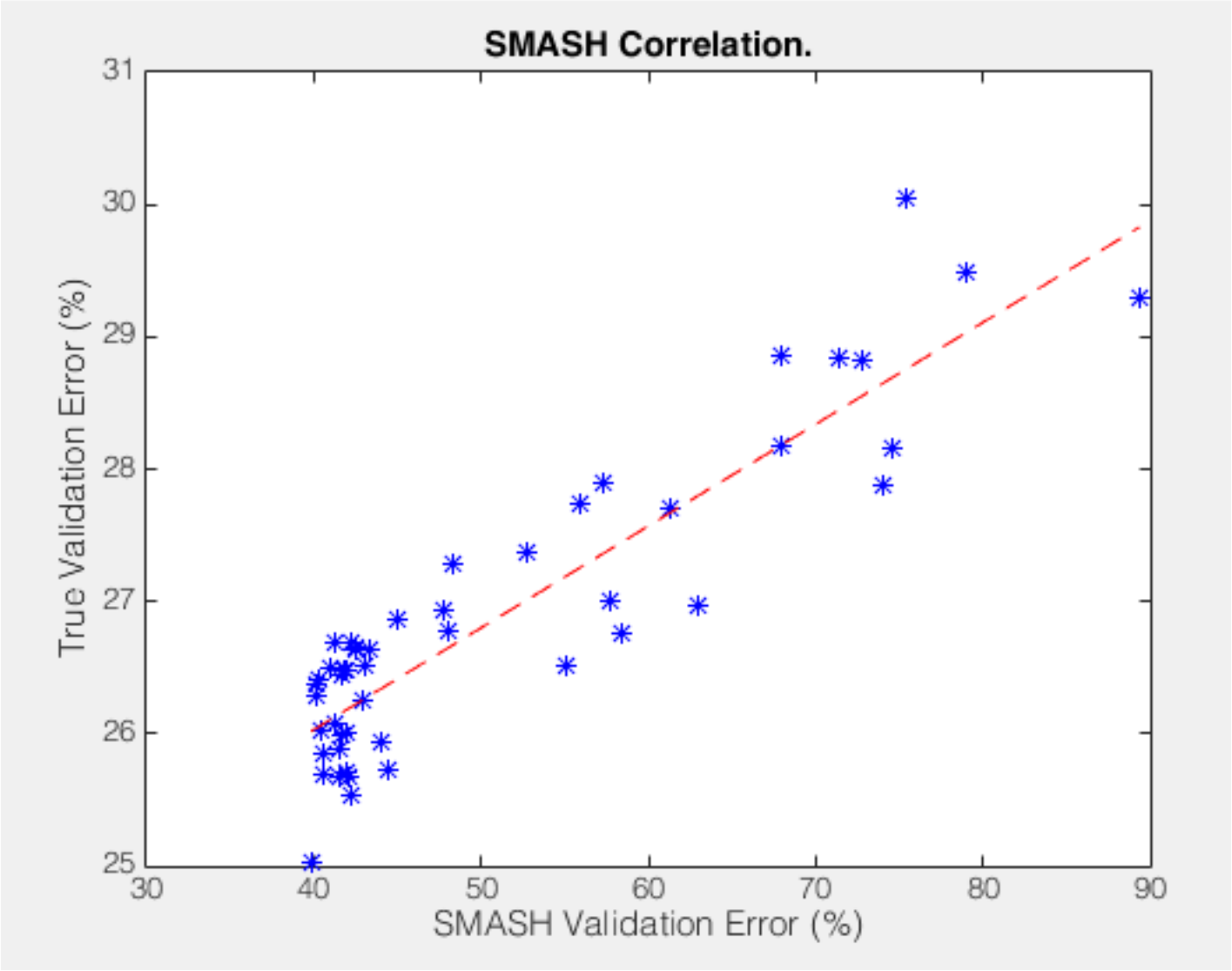
Evaluation



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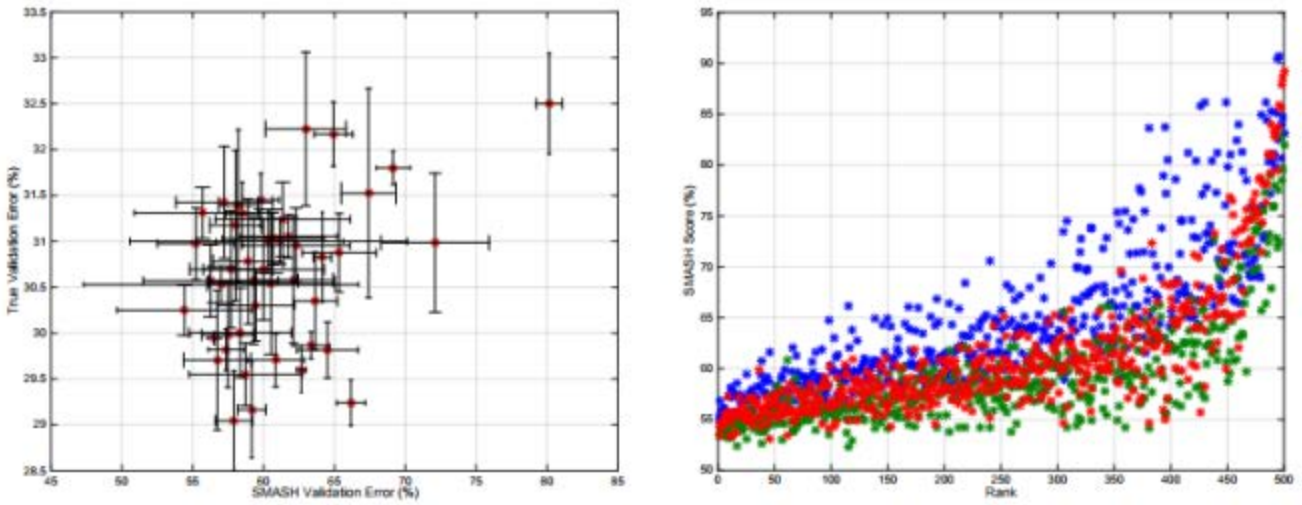

(a) (b)

Figure 5: (a) SMASH correlation with a crippled HyperNet. Error bars represent 1 standard deviation. (b) SMASH scores vs. rank using average scores from three HyperNets with different seeds.

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Evaluation: Mapping C to W

-Perturbing c without changing the architecture reduces SMASH scores

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Evaluation: Mapping C to W

-Perturbing c without changing the architecture reduces SMASH scores

-If the net really has learned a good mapping W=H(c), does dE/dc provide a meaningful gradient for the architecture?

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Evaluation: Mapping C to W

-Perturbing c without changing the architecture reduces SMASH scores

-If the net really has learned a good mapping W=H(c), does dE/dc provide a meaningful gradient for the architecture?

-Architectural gradient descent by proxy

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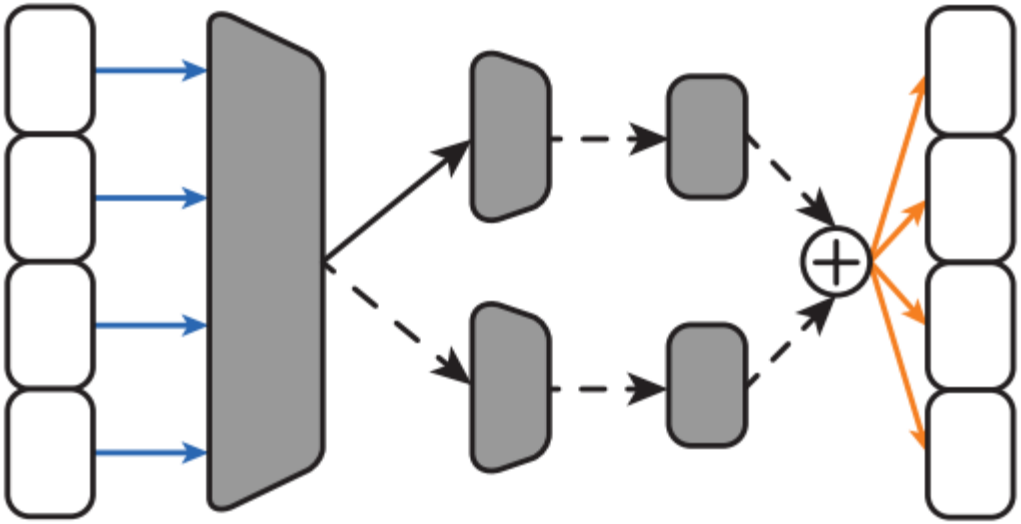
Evaluation



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Evaluation

Table 1: Error rates (%) on CIFAR-10 and CIFAR-100 with standard data augmentation (+).

Method	Depth	Params	C10+	C100+
FractalNet [20]	21	38.6M	5.22	23.30
with Dropout/Drop-path	21	38.6M	4.60	23.73
Wide ResNet [43]	16	11.0M	4.81	22.07
	28	36.5M	4.17	20.50
DenseNet-BC ($k = 24$) [15]	250	15.3M	3.62	17.60
DenseNet-BC ($k = 40$)	190	25.6M	3.46	17.18
Shake-Shake [11]	26	26.2M	**2.86**	**15.85**
Neural Architecture Search w/ RL[44]	39	32.0M	3.84	-
NASNet-A	20	3.3M	3.41	-
MetaQNN [3]	9	11.18M	6.92	27.14
Large-Scale Evolution [26]	-	5.4M	5.40	-
	-	40.4 M	-	23.7
CGP-CNN [38]	-	1.68M	5.98	-
SMASHv1	116	4.6M	5.53	22.07
SMASHv2	211	16M	4.03	20.60

Table 2: Error rates (%) on STL-10.

Model	Params	Error
WRN-40-4	8.95M	**35.02 ± 1.14**
WRN-28-10	36.5M	36.69 ± 2.06
SMASHv2	16.2M	41.52 ± 2.10
SMASHv2 (3x3)	4.38M	37.76 ± 0.58

Table 3: Error rates (%) on Imagenet32x32.

Model	Params	Top-1	Top-5
WRN-28-2	1.6M	56.92	30.92
WRN-28-5	9.5M	45.36	21.36
WRN-28-10	37.1M	40.96	18.87
SMASHv2	16.2M	**38.62**	**16.33**

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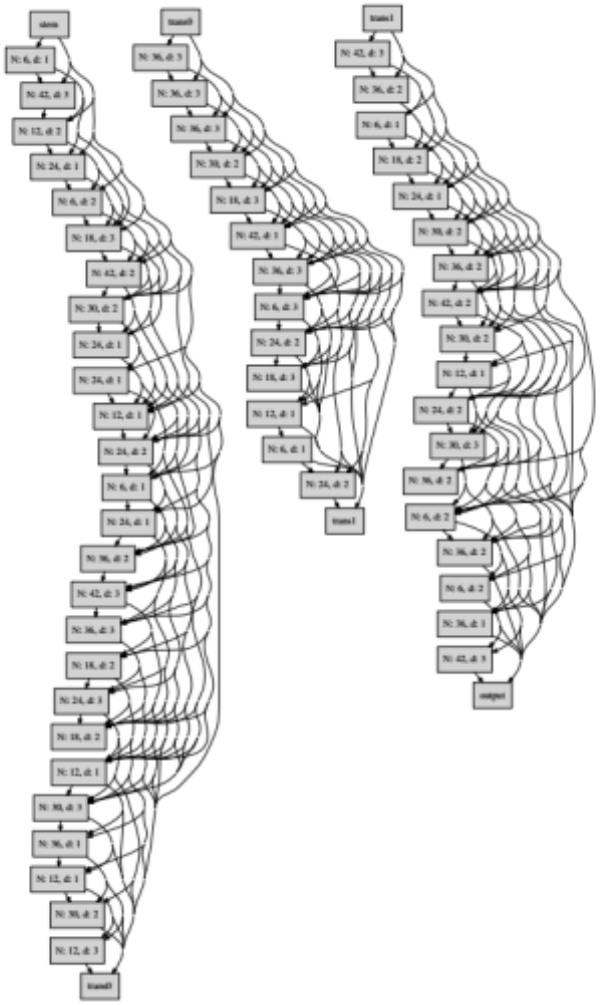
What does a SMASH net look like?



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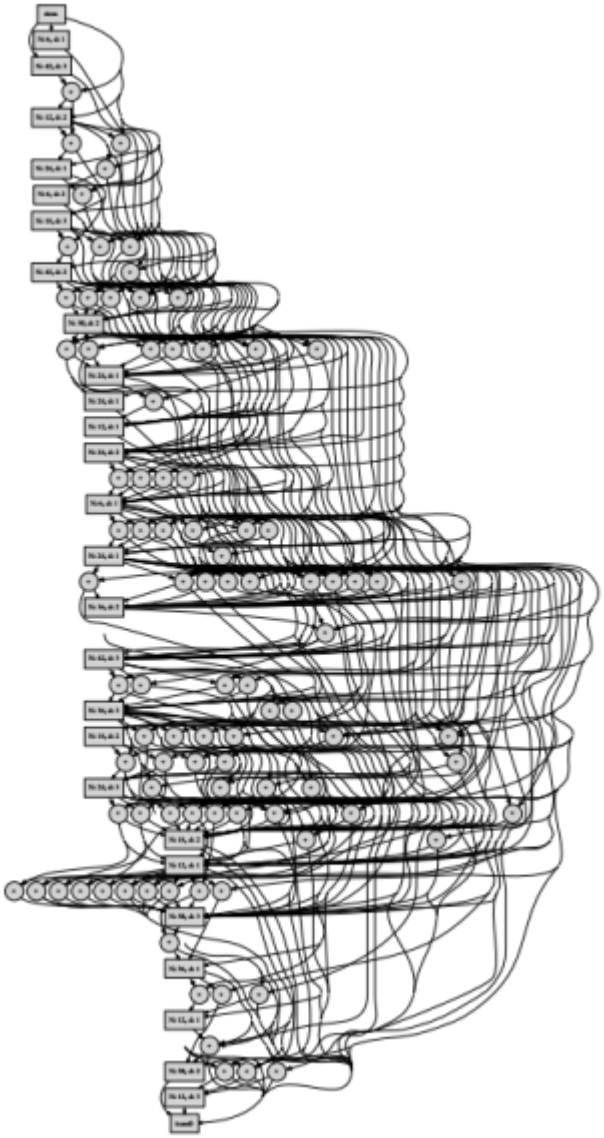

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What's Next?

-More rigorous investigation of HyperNet capacity

-Different search spaces

-Better sampling (RNN-based)

-Harder problems!

Thanks!

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