Neural Architecture Search using Deep Neural Networks and Monte Carlo Tree Search

Linnan Wang, Yiyang Zhao, Yuu Jinnai, Yuandong Tian, Rodrigo Fonseca

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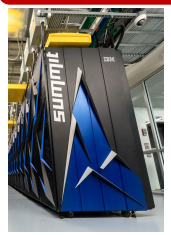
facebook research

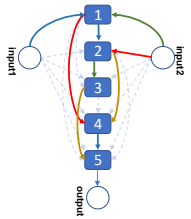
Motivation



Computing Cluster

Search Methods

NAS Agent



Target Architecture

Problems:

- Low efficiency
- Expensive training

Our solutions

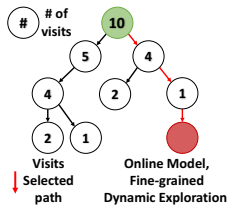
- Monte carol tree search
- Transfer learning

Why MCTS?

Methods	SMBO	sampling mechanism	scalable to $\|\Omega\| \sim 10^{20}$	global search
HyperBand (Li et al., 2016)	X	successive halving	✓	X
BOHB (Falkner et al., 2018)	✓	non-convex optimization	X	X
SMAC (Hutter et al., 2013)	✓	non-convex optimization	X	✓
TPE (Bergstra et al., 2011)	✓	non-convex optimization	X	✓
RE (Real et al., 2019)	X	top-k random	✓	X
Random (Li & Talwalkar, 2019)	X	random	✓	✓
MCTS (Wang et al., 2018)	✓	UCB and search tree	✓	✓

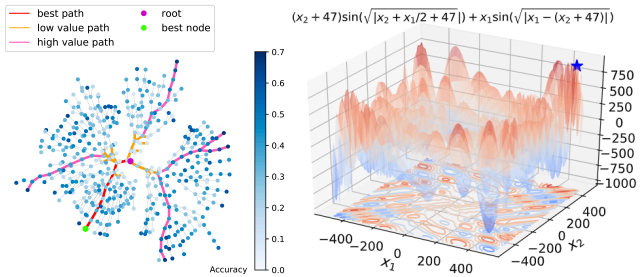
SMBO: Sequential Model Based Optimizations
$|\Omega|$ is the size of search space

1. Fine-grained adaptive exploration



2. Sample proposal:

MCTS traversal down the tree **V.S.** **Bayesian** Max $\phi(x), \forall x \in \Omega$, ϕ is acquisition, e.g. EI



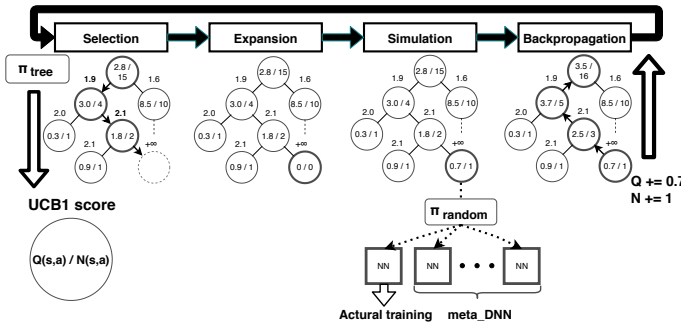
Easy reach of good region, regardless of dimensions

Intractable for high dimensional tasks

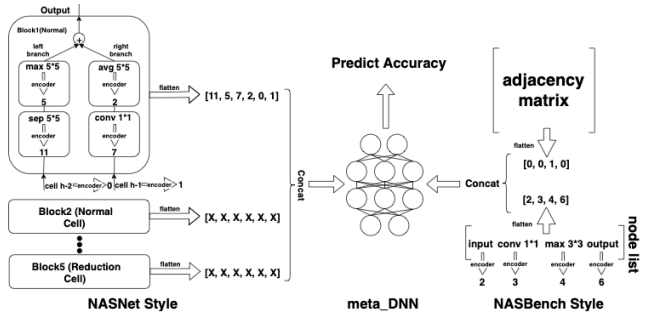
Methodology

1. MCTS agent

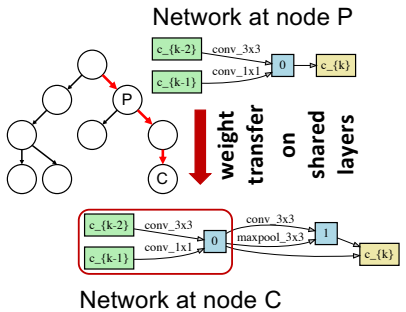
- Selection: traverse down with UCB.
- Expansion: add a new node into the tree.
- Evaluation: ***value function predictions*** and ***training***.
- Back-propagation: back-tracks to update #visits and value



2. Value function prediction:

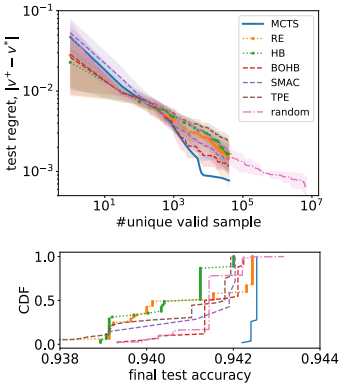


3. Transfer learning in training:



Experiment Results

1. NASBench evaluations



2. In practice

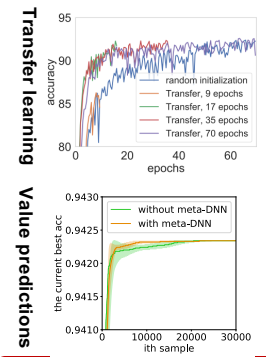
Cifar10

Model	Params	Err	GPU days	M
NASNet-A+cutout (Zoph et al. 2017)	3.3M	2.65	2000	20000
AmoebaNet-B+cutout (Real et al. 2018)	2.8M	$2.55_{\pm 0.05}$	3150	27000
DARTS+cutout (Liu et al. 2018)	3.3M	$2.76_{\pm 0.09}$	4	-
RENASNet+cutout (Chen et al. 2019)	3.5M	$2.88_{\pm 0.02}$	6	4500
AlphaX+cutout (32 filters)	2.83M	$2.54_{\pm 0.06}$	12	1000
PNAS (Liu et al. 2017a)	3.2M	$3.41_{\pm 0.09}$	225	1160
ENAS (Pham et al. 2018)	4.6M	3.54	0.45	-
NAONet (Luo et al. 2018)	10.6M	3.18	200	1000
AlphaX (32 filters)	2.83M	$3.04_{\pm 0.03}$	12	1000
NAS v3 (Zoph and Le 2016)	7.1M	4.47	22400	12800
Hier-EA (Liu et al. 2017c)	15.7M	$3.75_{\pm 0.12}$	300	7000
AlphaX+cutout (128 filters)	31.36M	$2.16_{\pm 0.04}$	12	1000

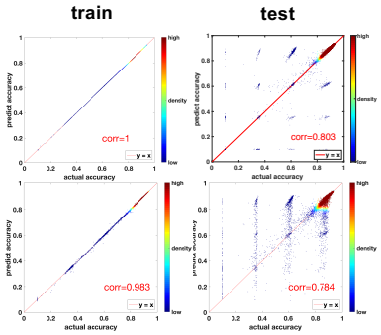
ImageNet

model	multi-adds	params	top1/top5 err
NASNet-A (Zoph et al. 2017)	564M	5.3M	26.0/8.4
AmoebaNet-B (Real et al. 2018)	555M	5.3M	26.0/8.5
DARTS (Liu et al. 2018)	574M	4.7M	26.7/8.7
RENASNet (Chen et al. 2019)	574M	4.7M	24.3/7.4
PNAS (Liu et al. 2017a)	588M	5.1M	25.8/8.1
AlphaX-1	579M	5.4M	24.5/7.8

3. Design validations



4. Ablations of predictors



Applications

1. Neural style transfer:

Content Style VGG AlphaX

2. Object detection:

MobileNet AlphaX MobileNet AlphaX