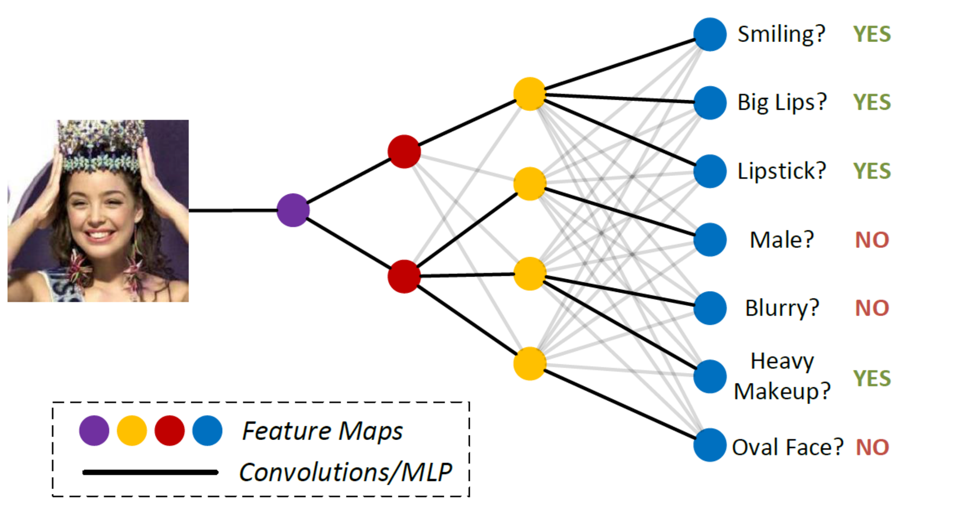
GNAS: A Greedy Neural Architecture Search Method for Multi-Attribute Learning

Siyu Huang[1], Xi Li[1], Zhi-Qi Cheng[2], Zhongfei Zhang[1], Alexander Hauptmann[3]
[1]Zhejiang University, [2]Southwest Jiaotong University, [3]Carnegie Mellon University

Problem Formulation

Goal: To find the optimal tree-like neural network architecture



Difficult black-box optimization problem

- A huge number of candidate architectures
- Huge evaluation cost
  - Training every architecture until convergence

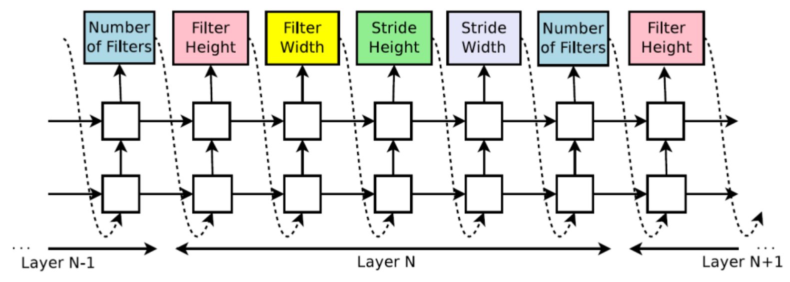
Related Work

AutoML: Towards the automation of machine learning pipelines

- To make ML available for non-ML experts
- To accelerate research on ML

Neural Architecture Search (NAS)

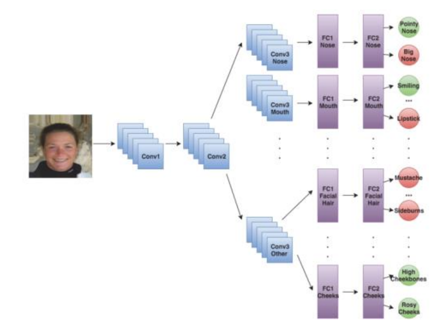
To automate the architecture design of neural networks



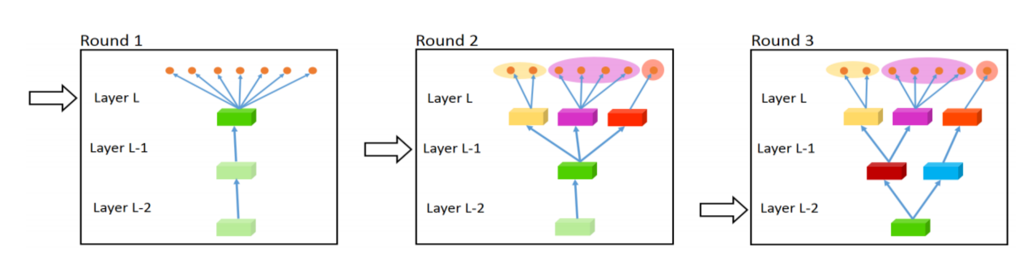
RL Controller [*Zoph and Le, ICLR'17*]

Multi-Attribute Learning

Group	Attributes
Gender	Male
Nose	Big Nose, Pointy Nose
Mouth	Big Lips, Lipstick, Mouth Slightly Open, Smiling
Eyes	Arched Eyebrows, Bags Under Eyes, Bushy Eyebrows, Eyeglasses, Narrow Eyes
Face	Attractive, Blurry, Heavy Makeup, Oval Face, Pale Skin, Young
AroundHead	Balding, Bangs, Black Hair, Blond Hair, Brown Hair, Earrings, Gray Hair, Hat, Necklace, Necktie, Receding Hairline, Straight Hair, Wavy Hair
FacialHair	5 o'clock Shadow, Goatee, Mustache, No Beard, Sideburns
Cheeks	High Cheekbones, Rosy Cheeks
Fat	Chubby, Double Chin



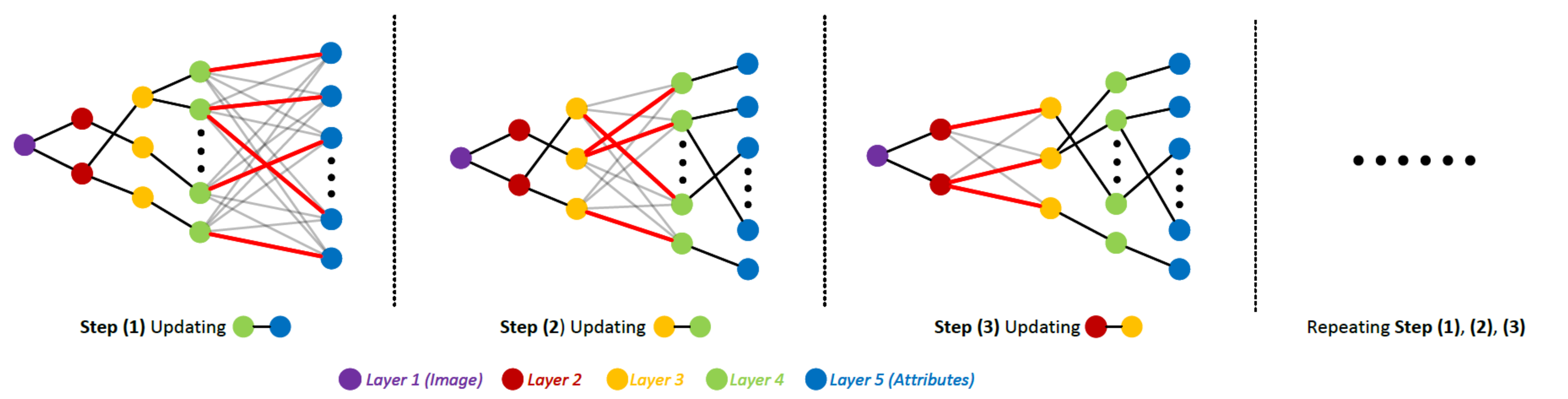
Hand-crafted [*Hand and Chellappa, AAAI'17*]



Learning-based [*Lu et al., CVPR'17*]

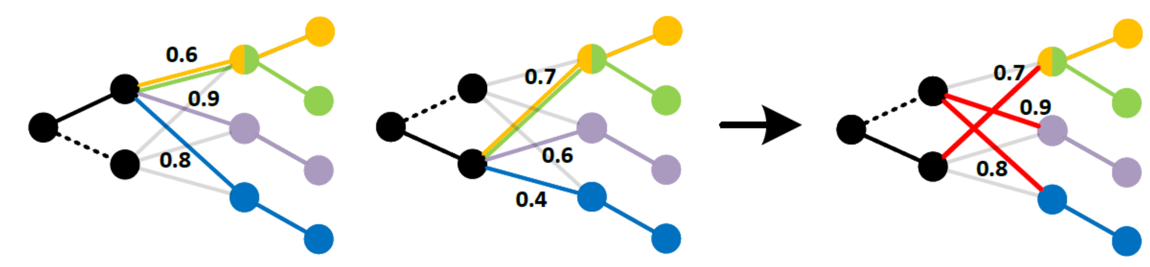
GNAS Framework

GNAS Strategy 1: Global —> Layers



Architectures of the other layers are fixed

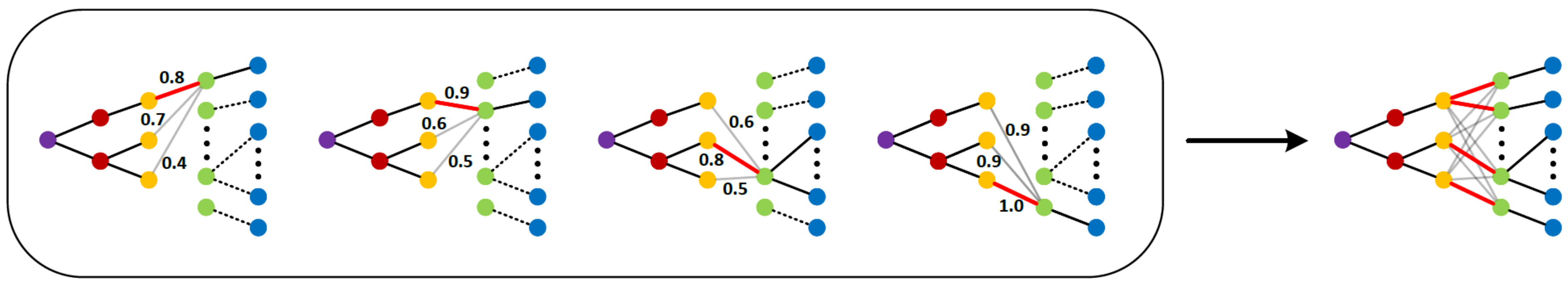
GNAS Strategy 3: Evaluate connections in together



Number of candidate architectures within one layer:

$$B_l^{B_{l+1}} \rightarrow B_l \cdot B_{l+1} \rightarrow B_l$$

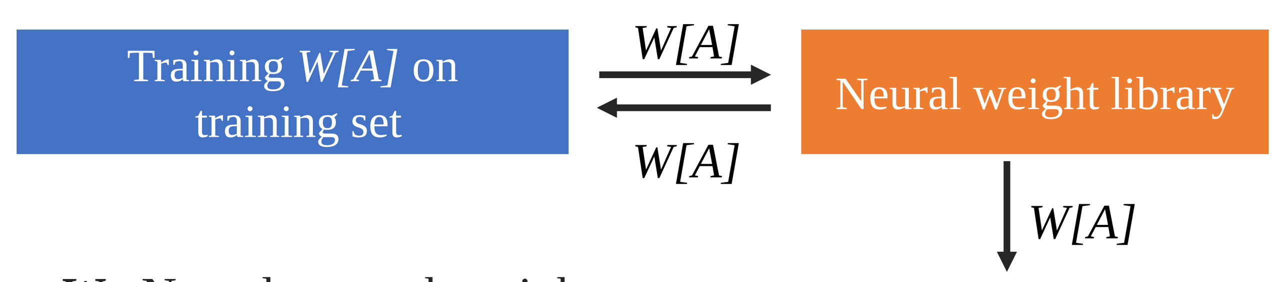
GNAS Strategy 2: Layer —> Connections



To find the best-**1** connection w.r.t each attribute

Number of candidate architectures within one layer: $B_l^{B_{l+1}} \rightarrow B_l \cdot B_{l+1}$

GNAS Strategy 4: Neural weight sharing [*ENAS, ICML'18*]



W: Neural network weights
A: Neural network architecture

Performance of GNAS

Facial Attribute

Method	Mean Error (%) CelebA	Mean Error (%) LFWA	Params (million)	Test Speed (ms)	Adaptive?
LNets+ANet [14]	13	16	-	-	No
Separate Task [22]	9.78	-	-	-	No
MOON [22]	9.06	-	119.73	12.53	No
Independent Group [6]	8.94	13.72	-	-	No
MCNN [6]	8.74	13.73	-	-	No
MCNN-AUX [6]	8.71	13.69	-	-	No
VGG-16 Baseline [15]	8.56	-	134.41	12.60	No
Low-rank Baseline [15]	9.12	-	4.52	6.07	No
SOMP-thin-32 [15]	10.04	-	0.22	1.94	Yes
SOMP-branch-64 [15]	8.74	-	4.99	5.77	Yes
SOMP-joint-64 [15]	8.98	-	10.53	6.18	Yes
PaW-subnet [5]	9.11	-	0.27	-	Yes
PaW [5]	8.77	-	11	-	Yes
GNAS-Shallow-Thin	8.70	13.84	1.57	0.33	Yes
GNAS-Shallow-Wide	**8.37**	**13.63**	7.73	0.64	Yes
GNAS-Deep-Thin	9.10	14.12	1.47	0.87	Yes
GNAS-Deep-Wide	8.64	13.94	6.41	0.89	Yes

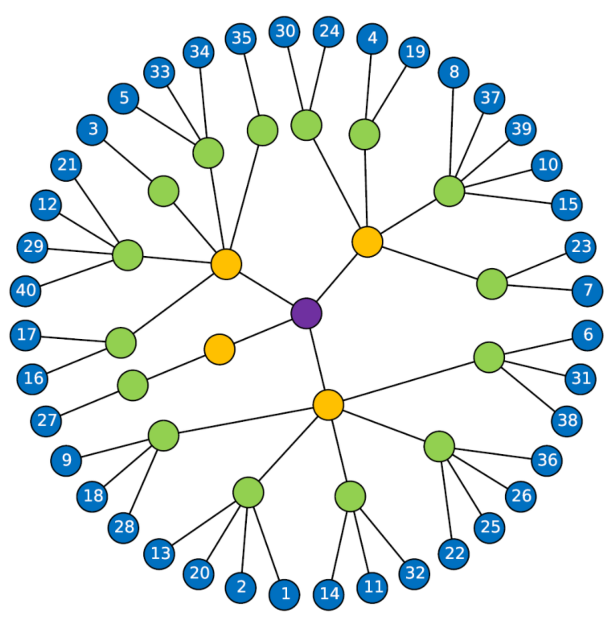
Person Attribute

Method	Market-1501 (%)
Ped-Attribute-Net [14]	13.81
Separate Models [8]	13.32
APR [14]	11.84
Equal-Weight [29]	13.16
Adapt-Weight [8]	11.51
Random-Thin	11.94
Random-Wide	11.42
GNAS-Thin	11.37
GNAS-Wide	**11.17**

Per-attribute Performance

Attribute \ Method	LANet	Inde.	MCNN	M-AUX	PaW	GNAS
5'o Clock Shadow	9.00	6.06	5.59	5.49	5.36	**5.24**
Arched Eyebrows	21.00	16.84	16.45	16.58	16.99	**15.75**
Attractive	19.00	17.78	17.06	**16.94**	17.14	**16.94**
Bags Under Eyes	21.00	15.17	15.11	15.08	15.42	**14.13**
Bald	2.00	1.15	1.13	1.10	1.07	**1.04**
Bangs	5.00	4.01	3.96	3.95	4.07	**3.80**
Big Lips	32.00	29.20	28.80	28.53	28.54	**28.21**
Big Nose	22.00	15.53	15.50	15.47	16.37	**14.90**
Black Hair	12.00	10.59	10.13	10.22	10.16	**9.76**
Blond Hair	5.00	4.12	4.03	3.99	4.15	**3.89**
Blurry	16.00	3.93	3.92	3.83	3.89	**3.58**
Brown Hair	20.00	11.25	11.01	10.85	11.50	**10.25**
Bushy Eyebrows	10.00	7.13	7.20	7.16	7.38	**7.01**
Chubby	9.00	4.45	4.34	4.33	4.54	**4.07**
Double Chin	8.00	3.57	3.59	3.68	3.74	**3.52**
Eyeglasses	1.00	0.33	0.37	0.37	0.41	**0.31**
Goatee	5.00	2.87	2.70	2.76	2.62	**2.41**
Gray Hair	3.00	1.93	1.80	1.80	1.79	**1.63**
Heavy Makeup	10.00	9.05	8.63	8.45	8.47	**8.18**
High Cheekbones	12.00	12.66	12.45	12.42	12.56	**11.95**
Male	2.00	1.98	1.84	1.83	1.61	**1.50**
Mouth Slightly Open	8.00	6.01	6.26	6.26	5.95	**5.84**
Mustache	5.00	3.33	3.07	3.12	3.10	**2.97**
Narrow Eyes	19.00	12.78	12.84	12.77	12.44	**12.34**
No Beard	5.00	4.07	3.89	3.95	3.78	**3.70**
Oval Face	34.00	25.30	24.19	**24.16**	24.97	24.43
Pale Skin	9.00	2.93	2.99	2.95	2.92	**2.76**
Pointy Nose	28.00	22.53	22.53	22.53	22.65	**21.76**
Receding Hairline	11.00	6.59	6.19	6.19	6.56	**6.06**
Rosy Cheeks	10.00	4.98	4.87	**4.84**	4.93	4.99
Sideburns	4.00	2.23	2.18	2.15	2.36	**2.04**
Smiling	8.00	7.35	7.34	7.27	7.27	**6.76**
Straight Hair	27.00	17.38	16.61	16.42	16.48	**15.23**
Wavy Hair	20.00	16.76	16.08	16.09	15.93	**15.48**
Wearing Earrings	18.00	9.65	9.68	9.57	10.07	**9.02**
Wearing Hat	1.00	1.03	0.96	0.95	0.98	**0.88**
Wearing Lipstick	7.00	6.20	6.05	5.89	5.76	**5.59**
Wearing Necklace	29.00	13.59	13.18	13.37	12.30	**12.39**
Wearing Necktie	7.00	3.29	3.47	3.49	**3.15**	3.24
Young	13.00	12.02	11.70	11.52	11.41	**11.11**
Ave.	12.67	8.94	8.74	8.71	8.77	**8.37**

GNAS architecture
1) Better performance
2) Fewer model parameters
3) faster forward speed

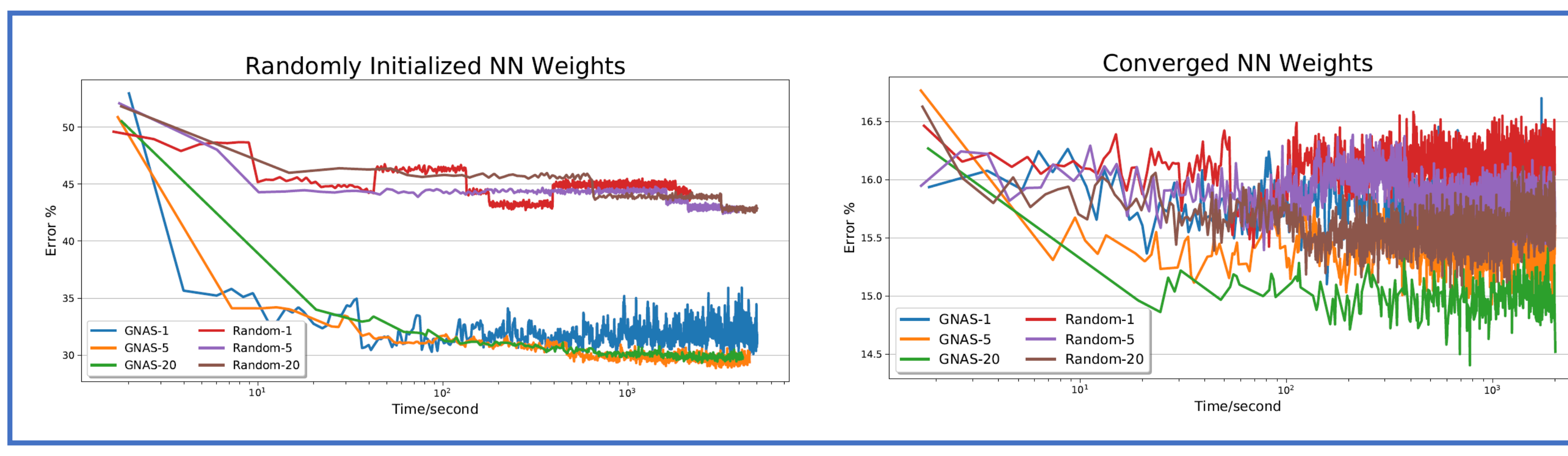


Related attributes grouped hierarchically

1 *5'o Clock Shadow* 2 *Arched Eyebrows* 3 *Attractive* 4 *Bags Under Eyes* 5 *Bald* 6 *Bangs* 7 *Big Lips* 8 *Big Nose* 9 *Black Hair* 10 *Blond Hair* 11 *Blurry* 12 *Brown Hair* 13 *Bushy Eyebrows* 14 *Chubby* 15 *Double Chin* 16 *Eyeglasses* 17 *Goatee* 18 *Gray Hair* 19 *Heavy Makeup* 20 *High Cheekbones* 21 *Male* 22 *Mouth Slightly Open* 23 *Mustache* 24 *Narrow Eyes* 25 *No Beard* 26 *Oval Face* 27 *Pale Skin* 28 *Pointy Nose* 29 *Receding Hairline* 30 *Rosy Cheeks* 31 *Sideburns* 32 *Smiling* 33 *Straight Hair* 34 *Wavy Hair* 35 *Wearing Earrings* 36 *Wearing Hat* 37 *Wearing Lipstick* 38 *Wearing Necklace* 39 *Wearing Necktie* 40 *Young*

Efficiency of GNAS

Training cost: 1 GPU * 1 day on LFWA (6k images), Market-1501 (17k images)
1 GPU * 2 days on CelebA (180k images)



GNAS vs. Random Search

Results
1) GNAS has better performance and faster convergence speed
2) Better with larger validation batch

References

[1] B Zoph and QV Le. Neural architecture search with reinforcement learning. In *ICLR*, 2017.
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[3] Hand et al. Attributes for Improved Attributes: A Multi-Task Network Utilizing Implicit and Explicit Relationships for Facial Attribute Classification. In *AAAI*, 2017.
[4] Lu et al. Fully-adaptive Feature Sharing in Multi-Task Networks with Applications in Person Attribute Classification. In *CVPR*, 2017.

Contact

Siyu Huang
siyuhuang@zju.edu.cn
siyuhuang.github.io