Neural Network Heuristic Functions: Taking Confidence into Account

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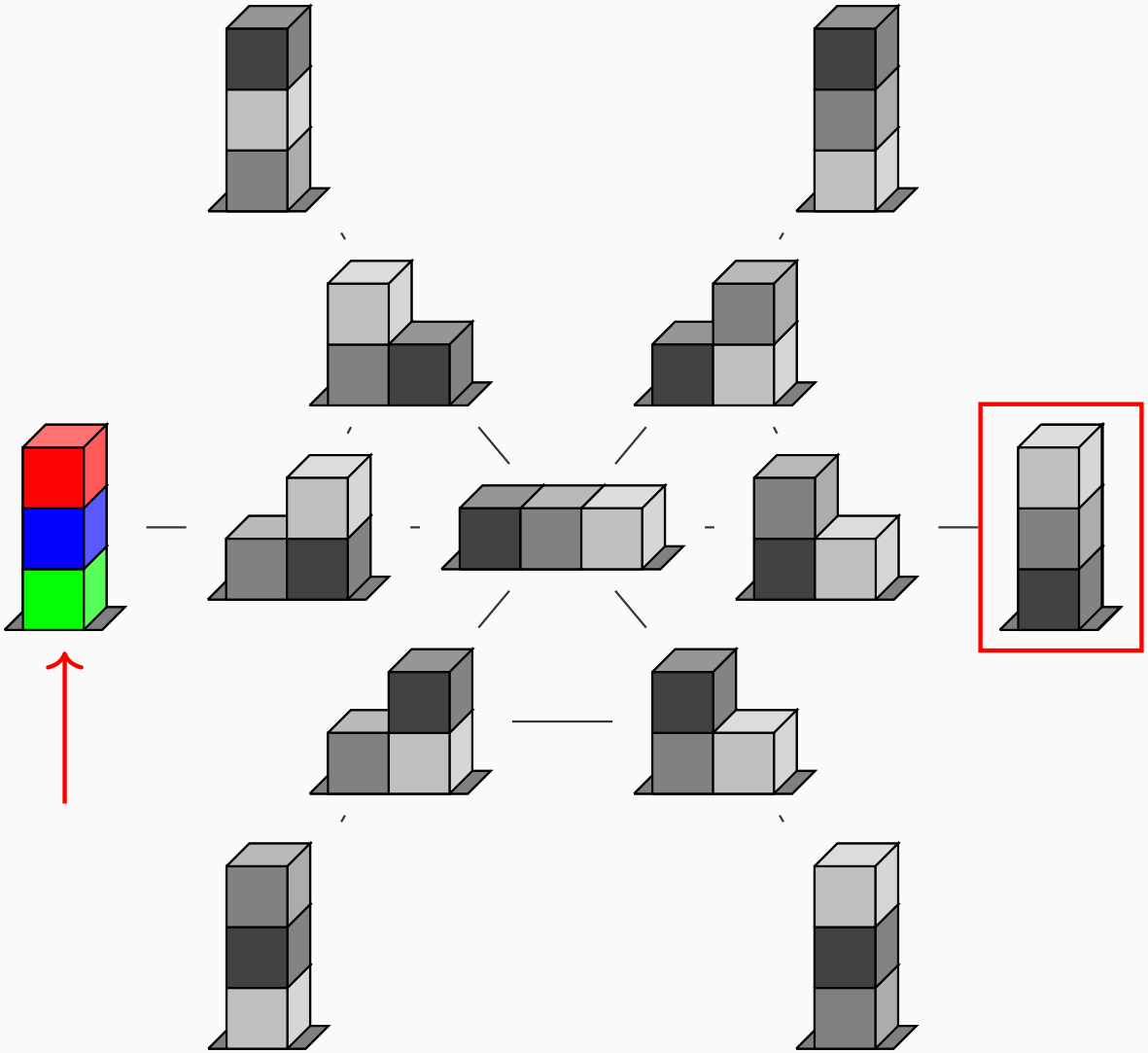
German Research Center for Artificial Intelligence

15th International Symposium on Combinatorial Search

Heuristic Search



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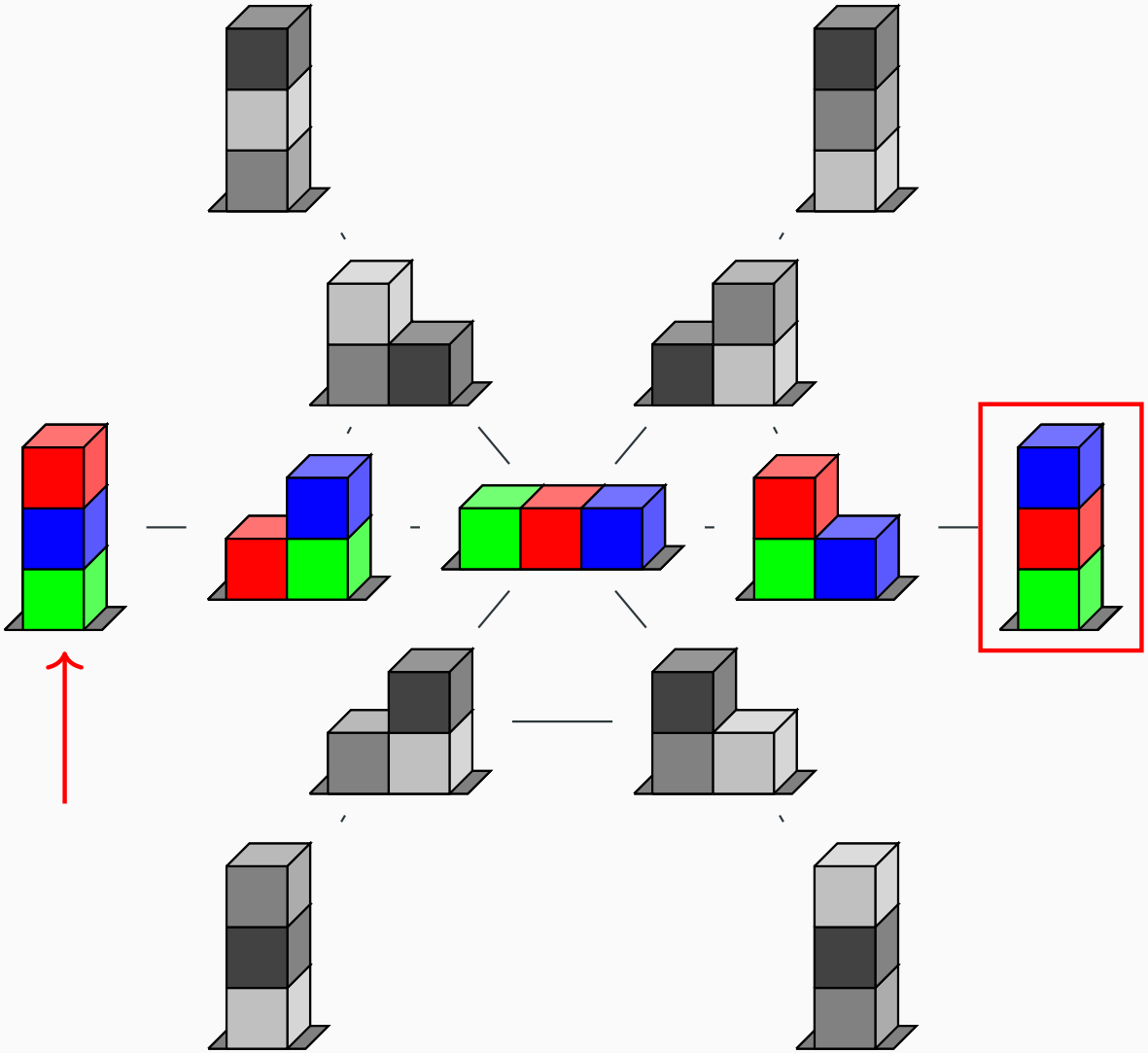

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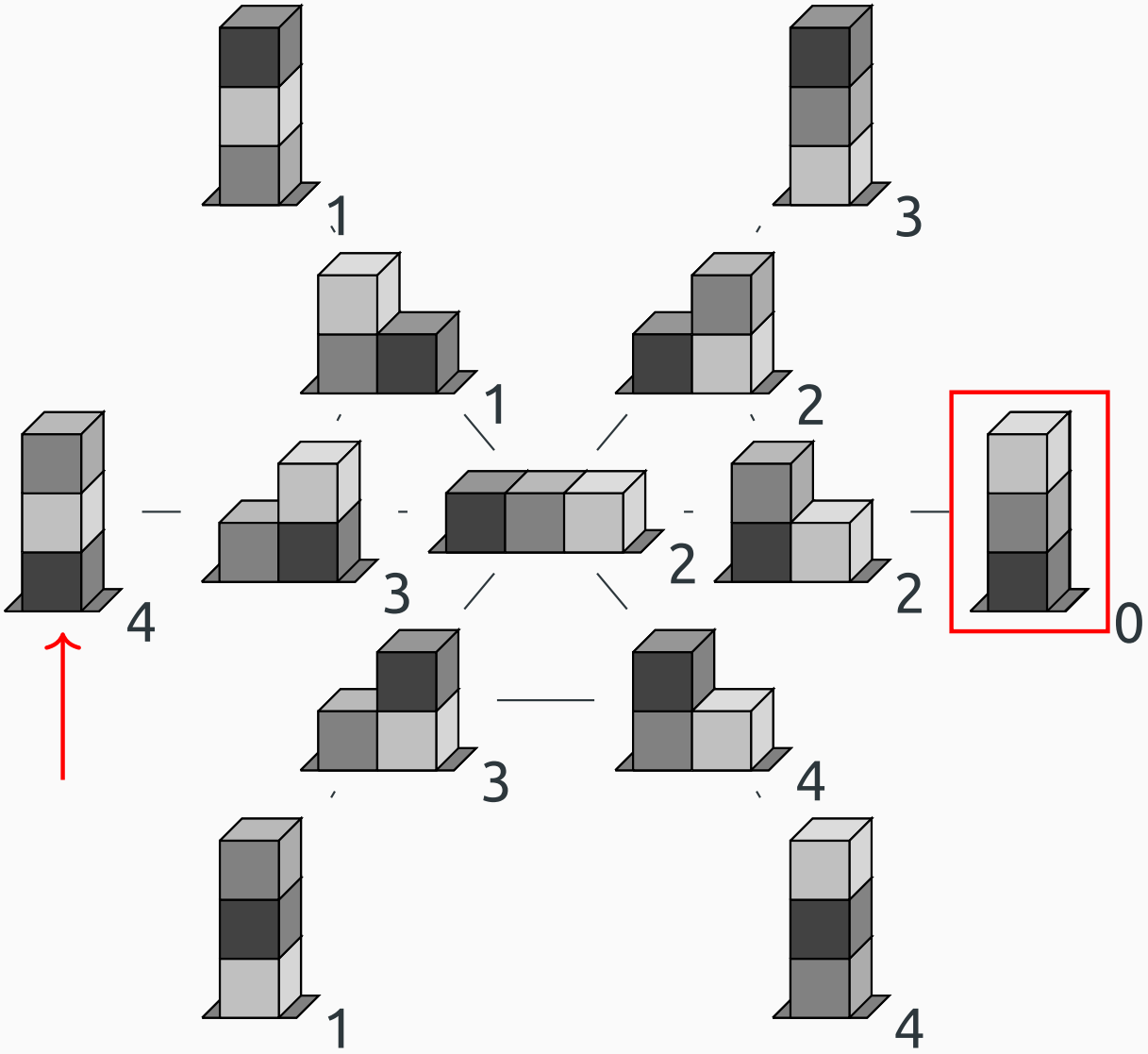

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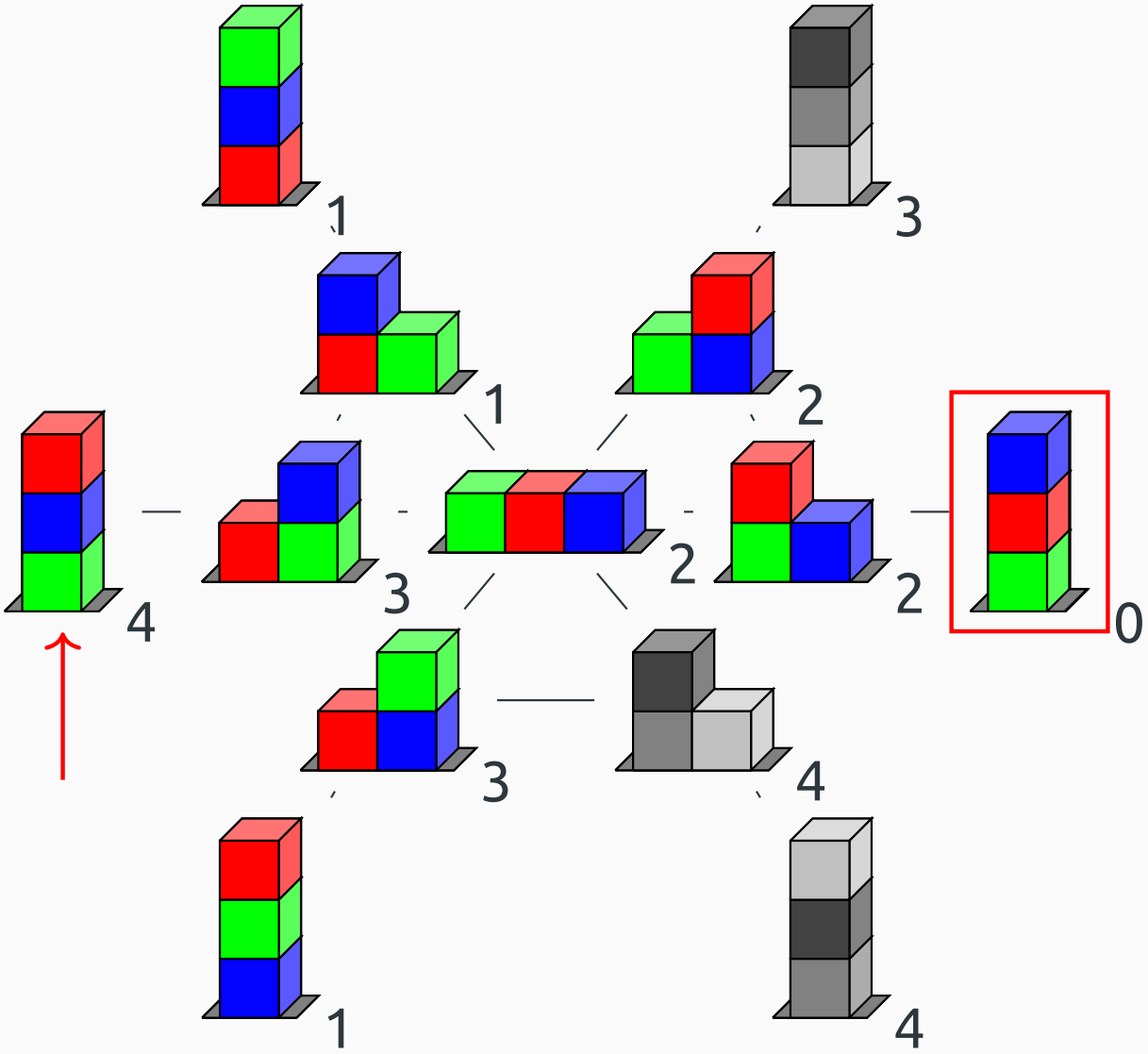

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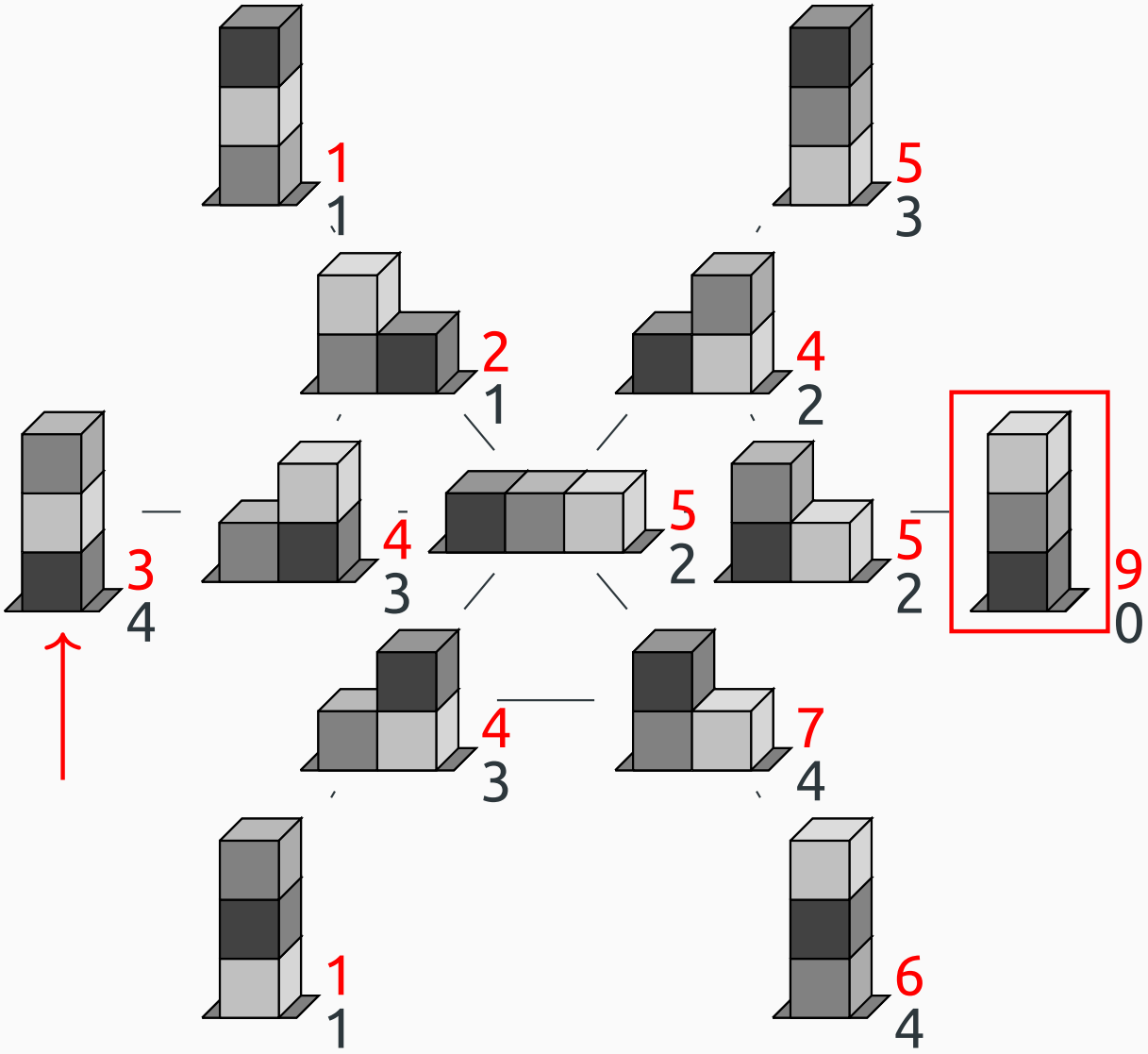

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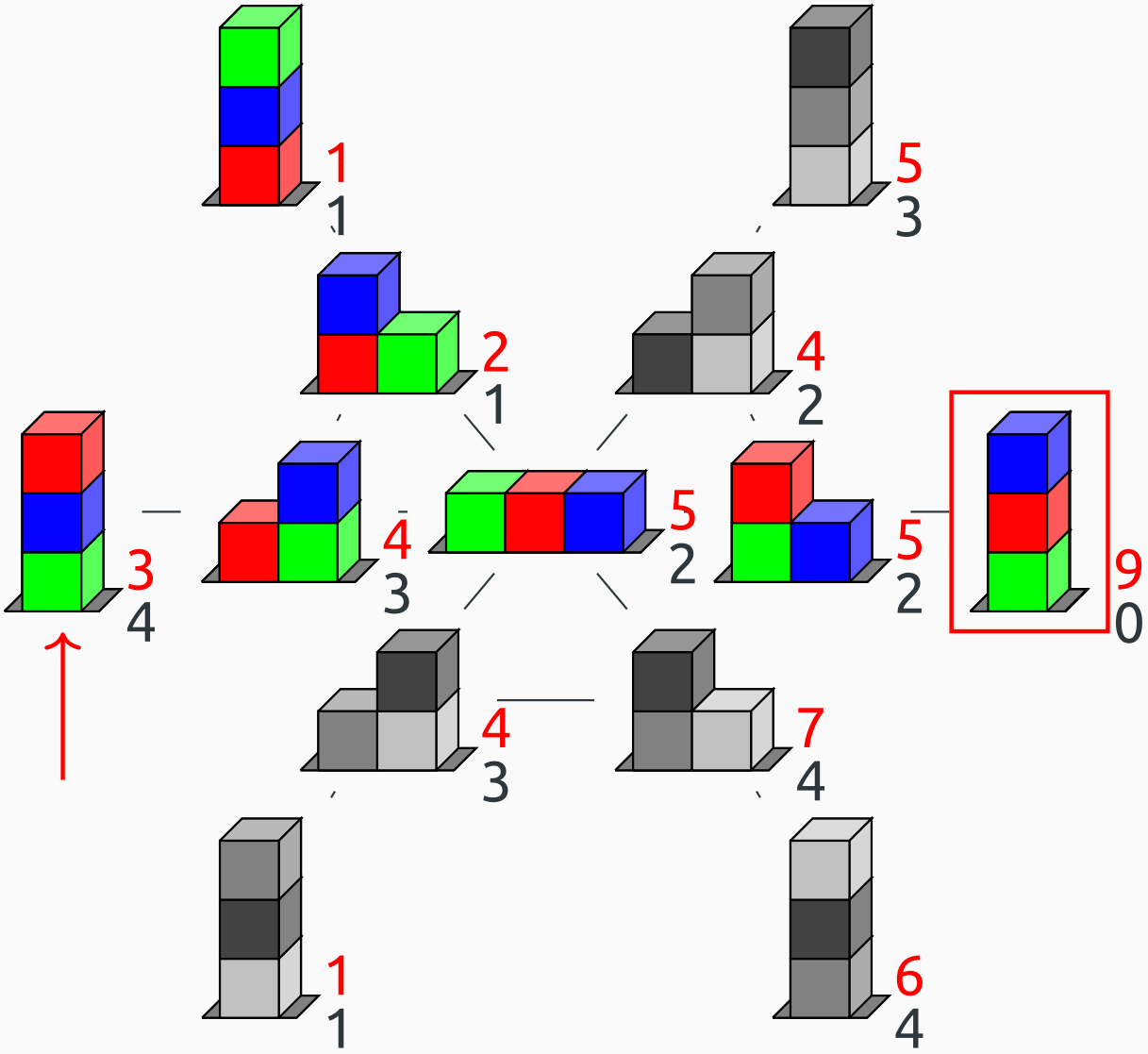

Contribution

Confidence-Aware Search Algorithms

- Mean Threshold
- Adaptive Threshold
- Prioritizing Queue

Out-Of-Distribution Training for Planning

- Uniform Noise
- Weighted Noise

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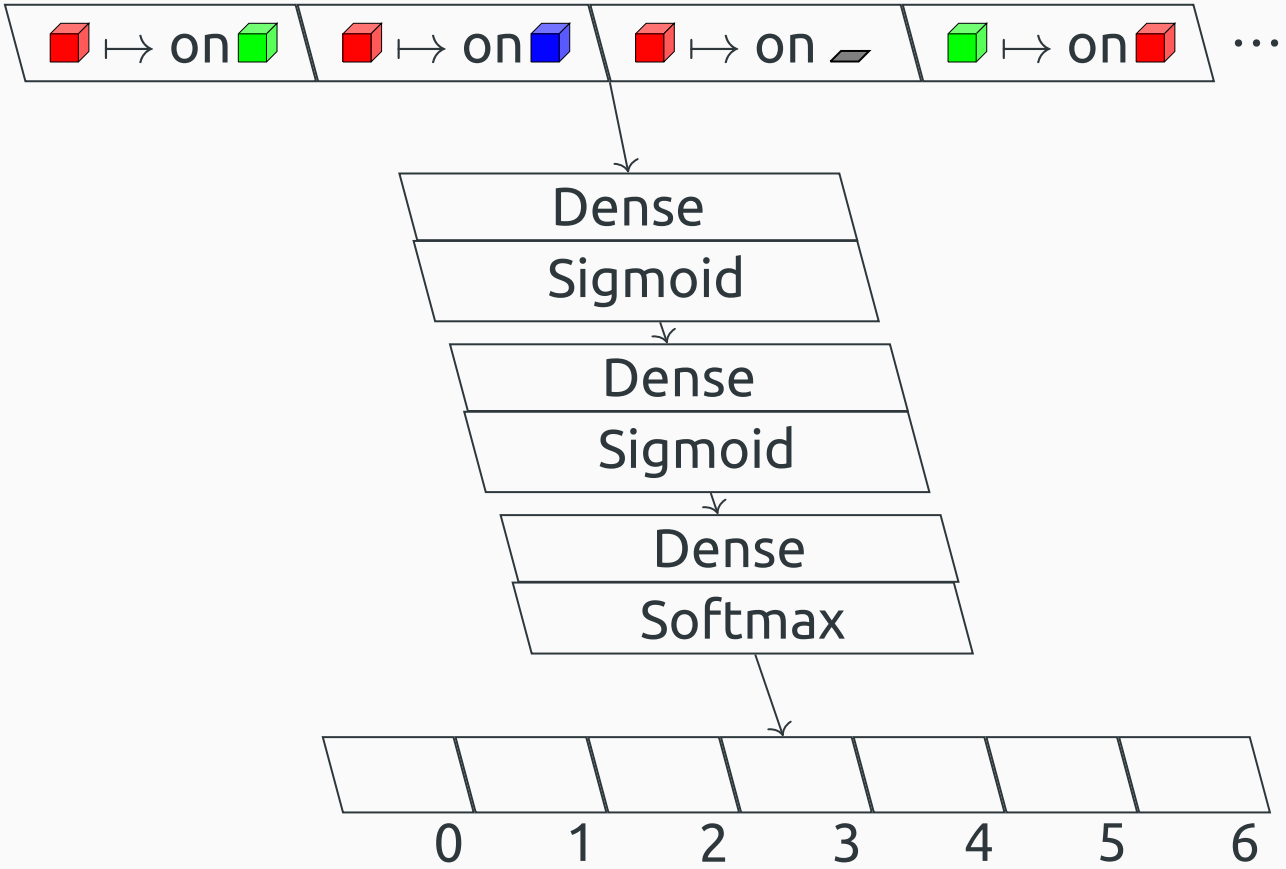
Heuristic

$$h : S \to \mathbb{R}_0^+ \cup \{\infty\}$$

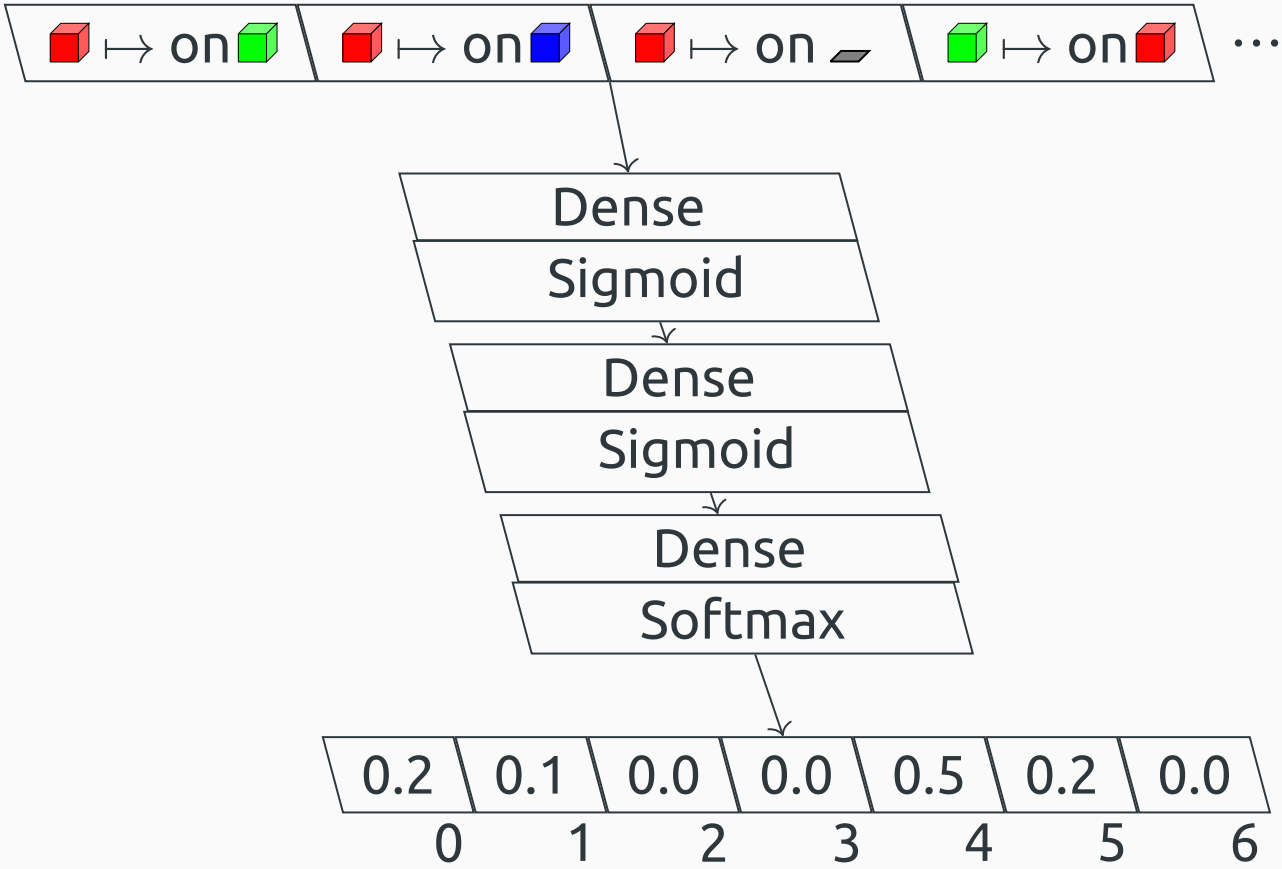
$$c : S \to [0, 1]$$

Neural Network Heuristic



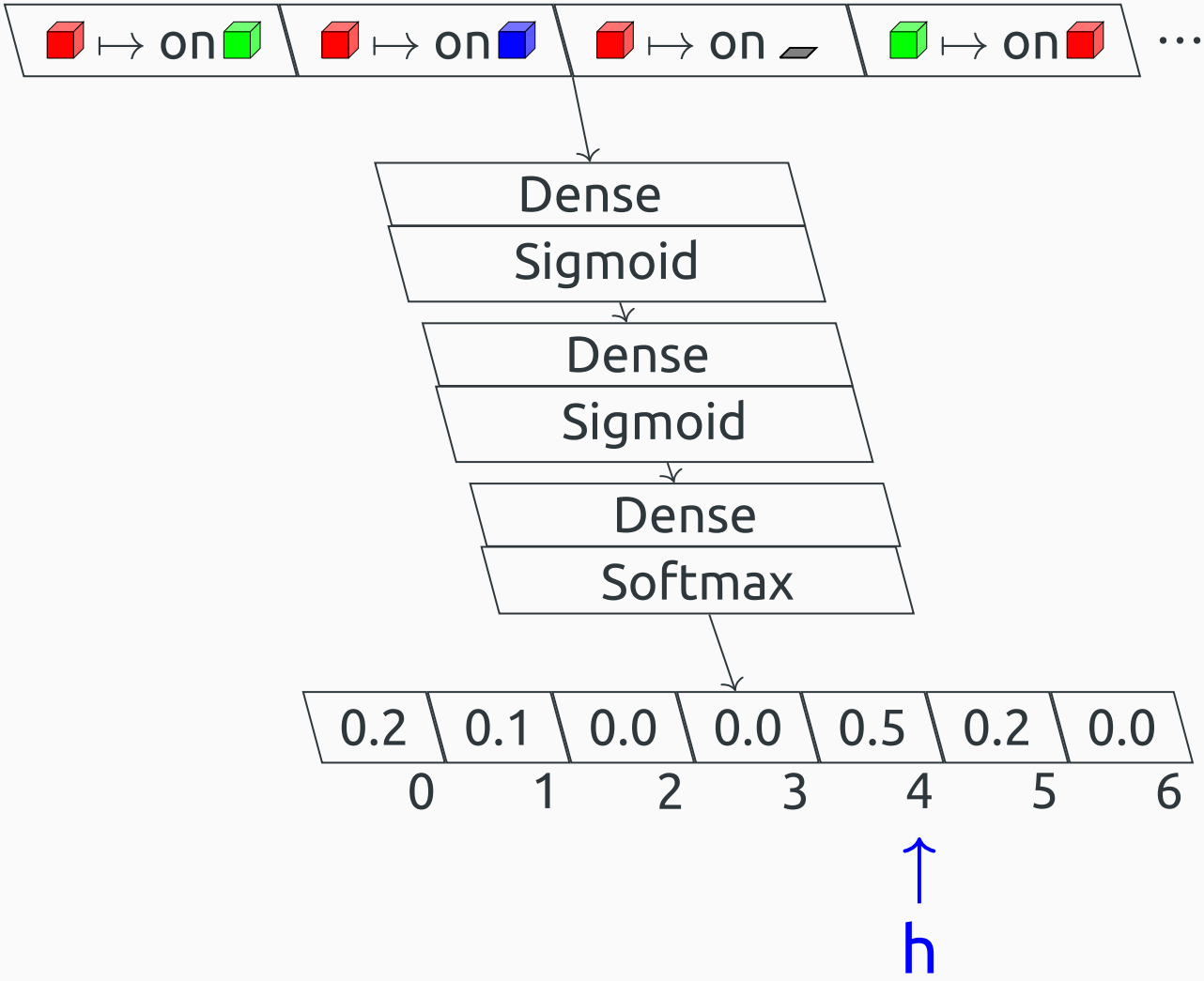
[Ferber *et al.*, 2020]

Neural Network Heuristic



[Ferber *et al.*, 2020]

Neural Network Heuristic



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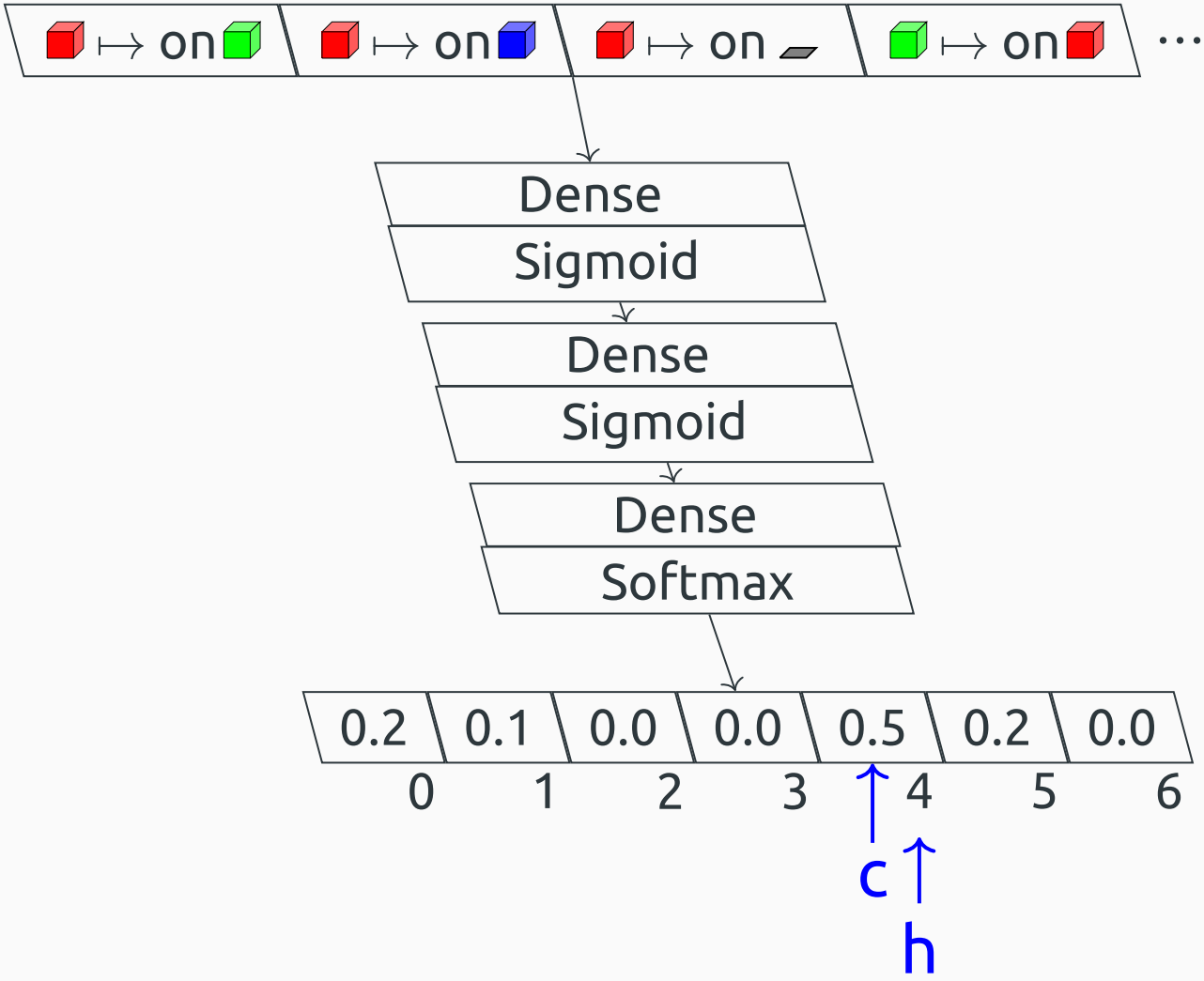
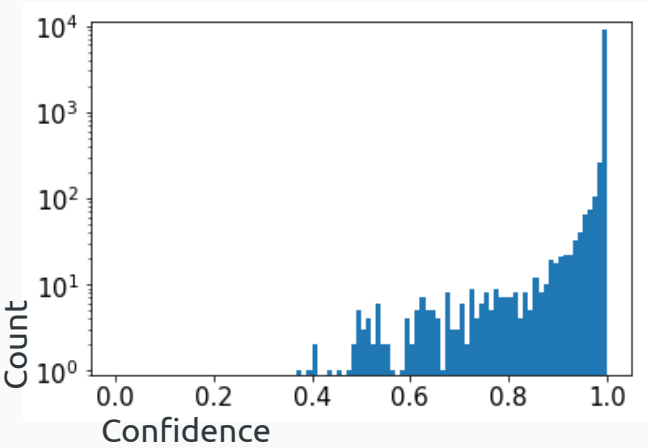
Neural Network Heuristic

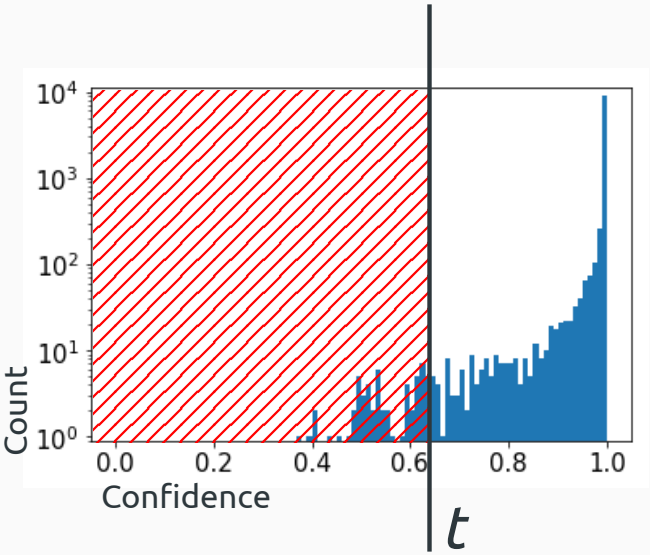


[Ferber *et al.*, 2020]

Mean Threshold



Mean Threshold



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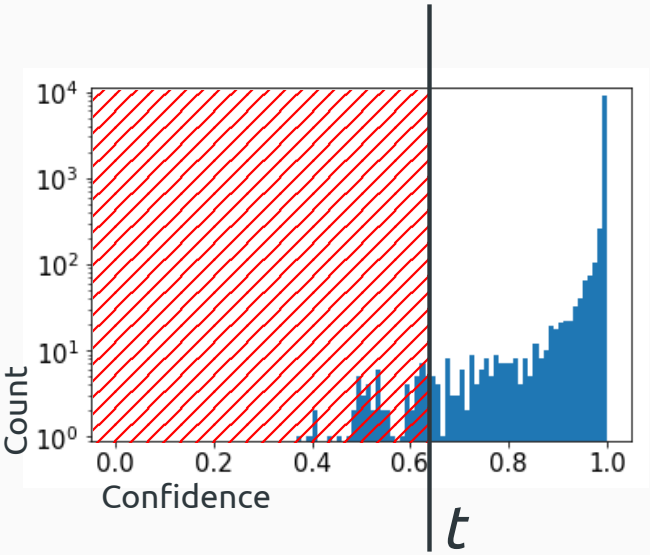
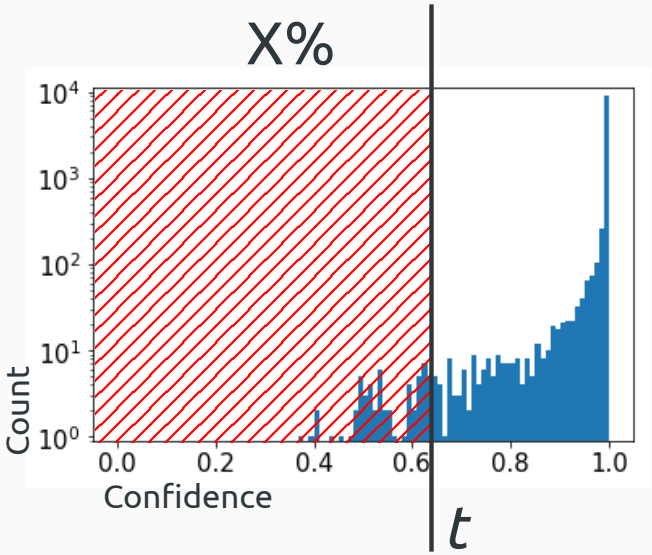
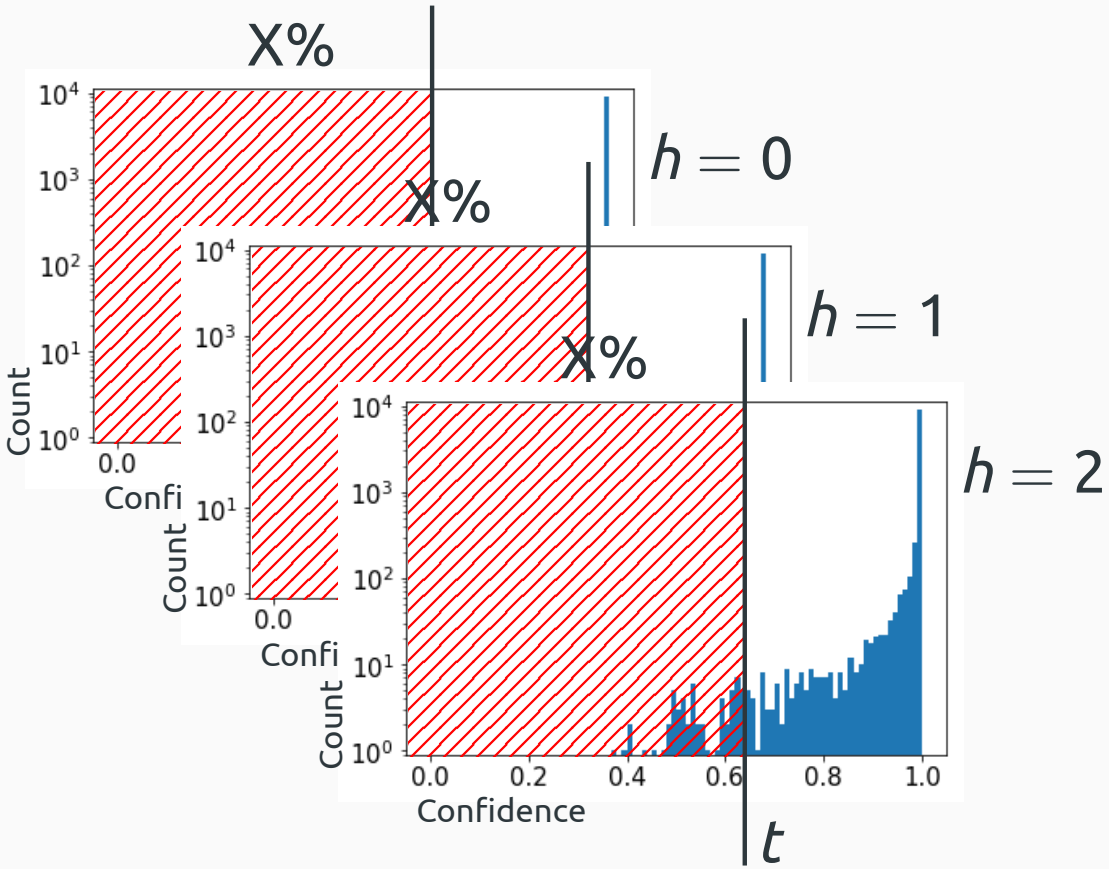


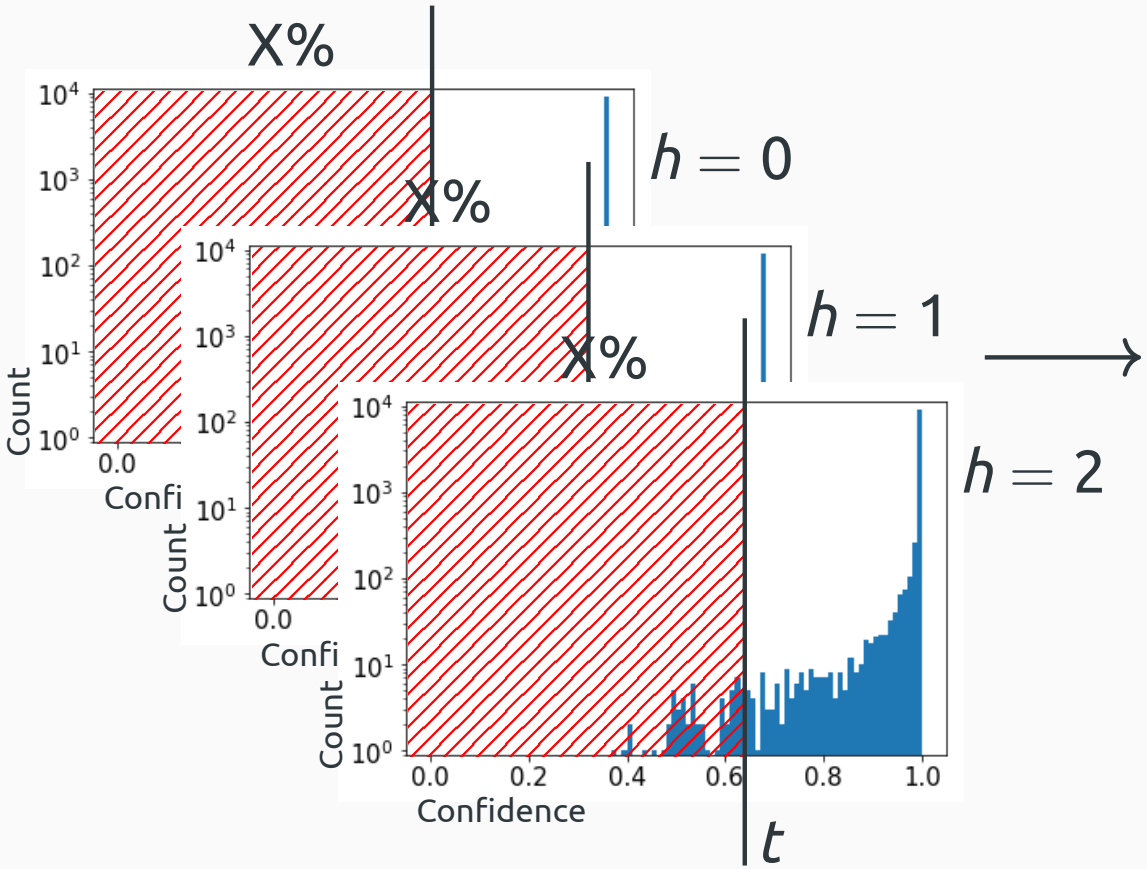
Mean Threshold

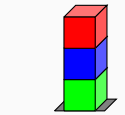


Adaptive Threshold



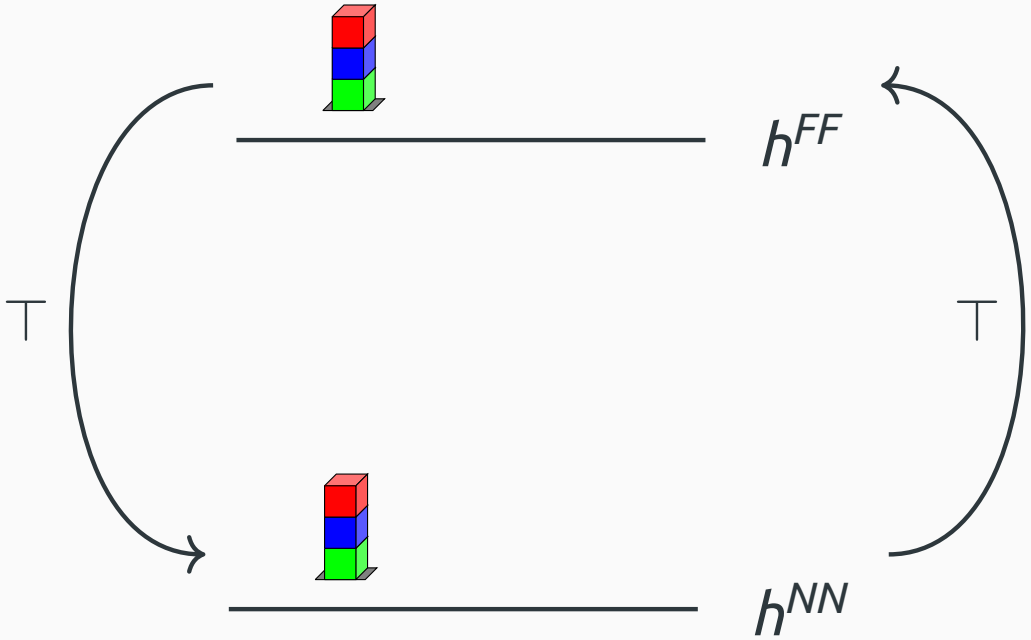
Adaptive Threshold



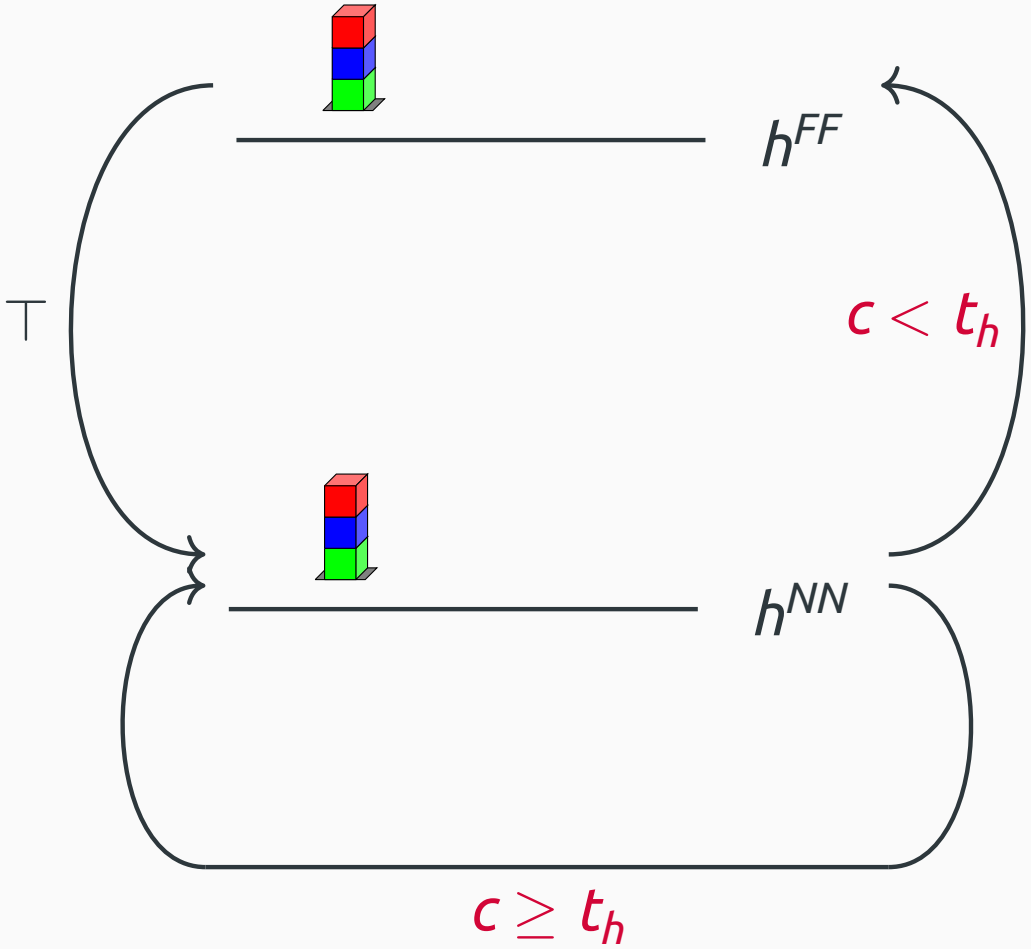


$h, c \geq t_h$

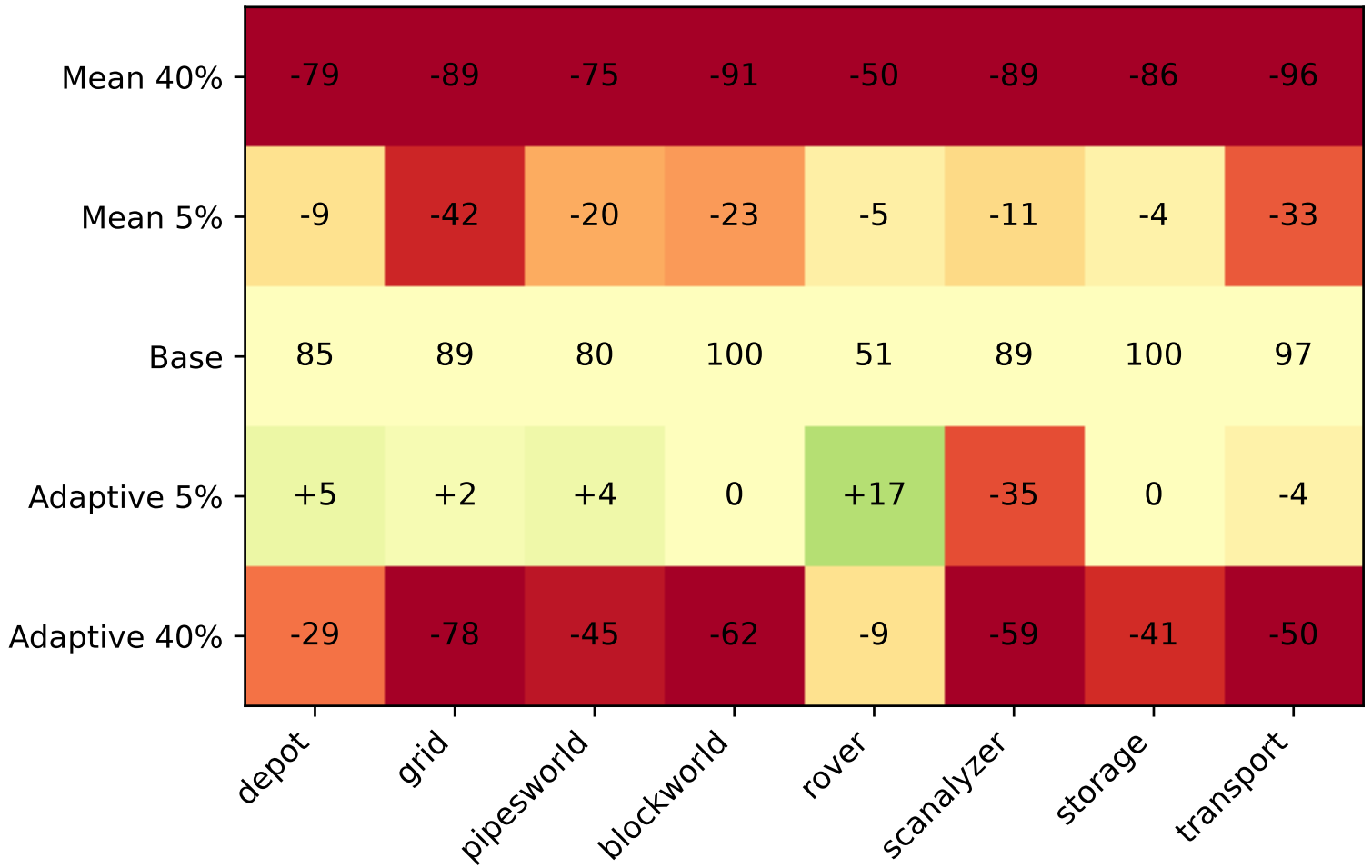
Prioritizing Queue



Prioritizing Queue



Effect on Coverage: Single Queue



Contribution

Confidence-Aware Search Algorithms

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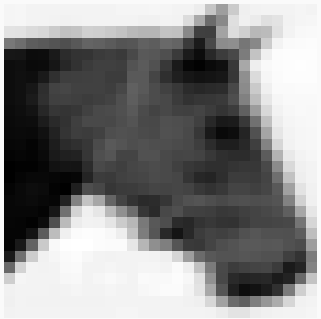
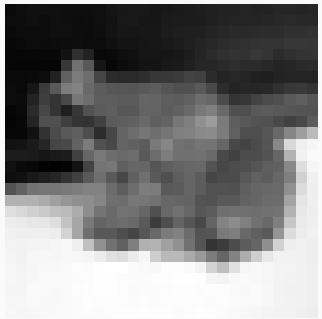
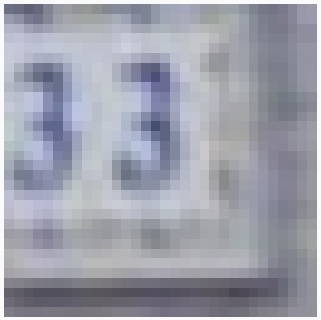
- Adaptive Threshold
- Prioritizing Queue

Out-Of-Distribution Training for Planning

- Uniform Noise
- Weighted Noise

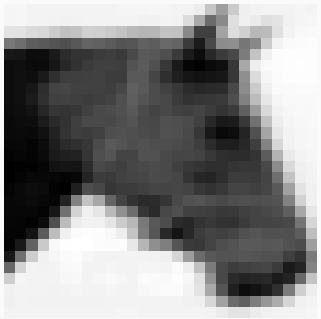
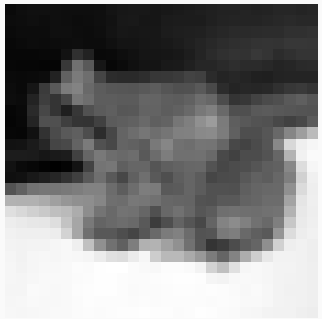
Overconfidence

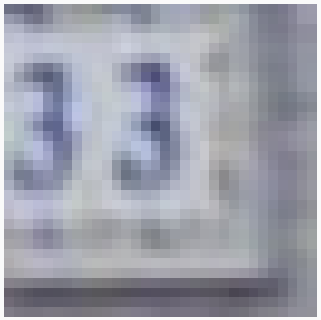


[Hein *et al.*, 2019]

Overconfidence


”2“ (99.6%)



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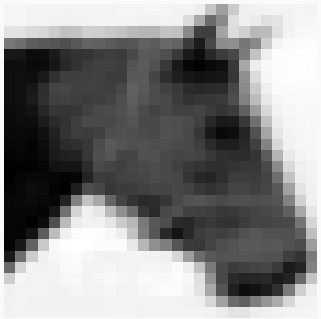

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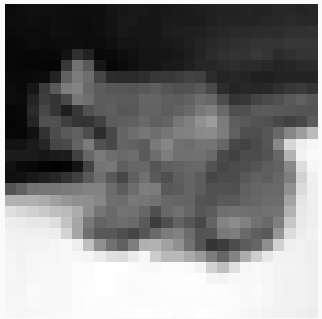
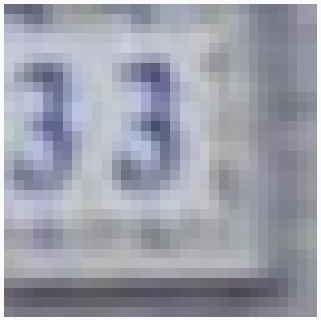


”2“ (99.1%)



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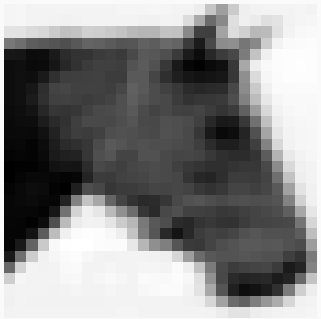

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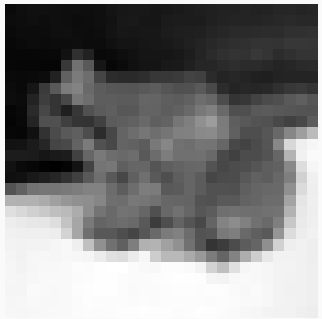
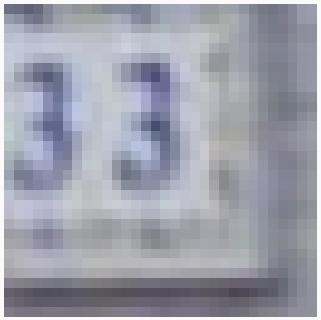


”2“ (99.1%)

”7“ (99.0%)



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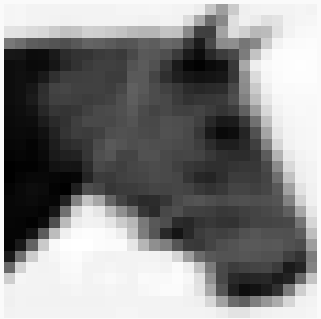

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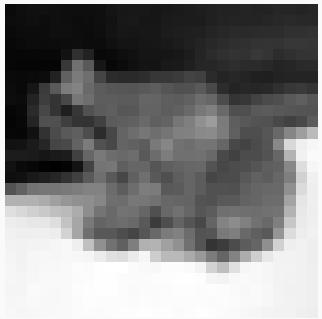

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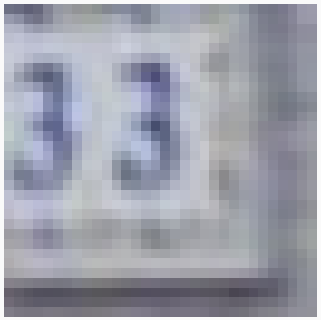


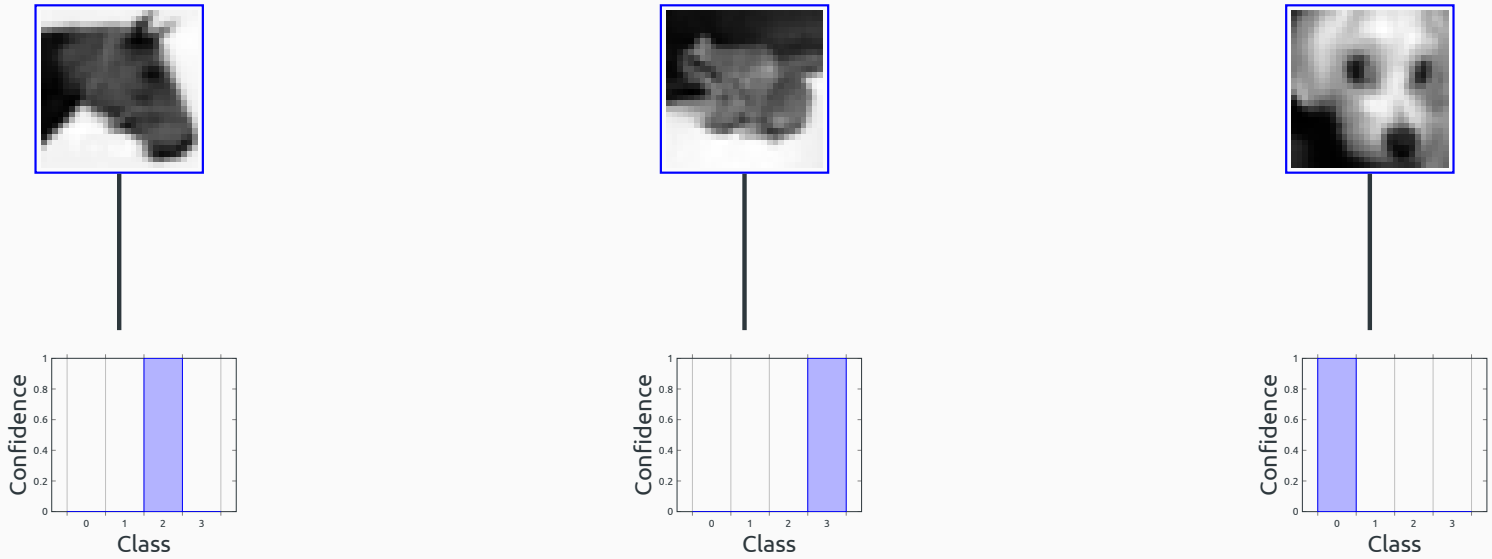
Dog (100.0%)

Bird (100.0%)

Airplane (100.0%)

[Hein *et al.*, 2019]

Out-Of-Distribution Training



$$\frac{1}{N}\sum_{i=1}^{N} L_{CE}(y_i, f(x_i))$$

[Hein *et al.*, 2019]

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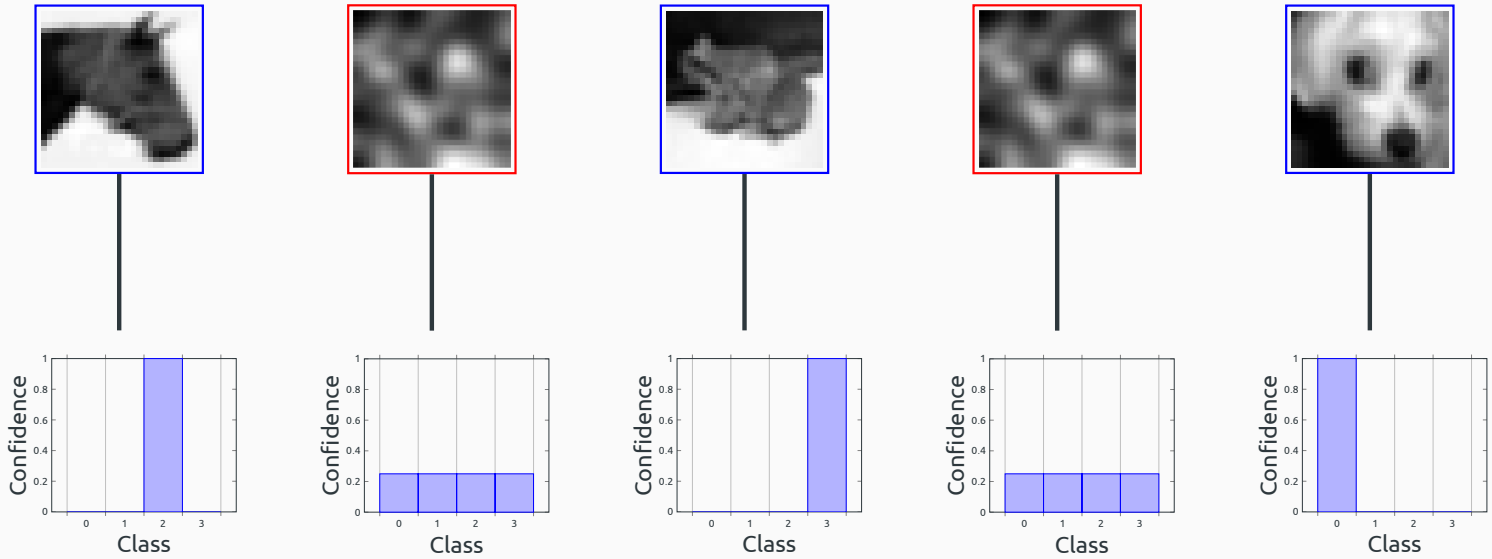
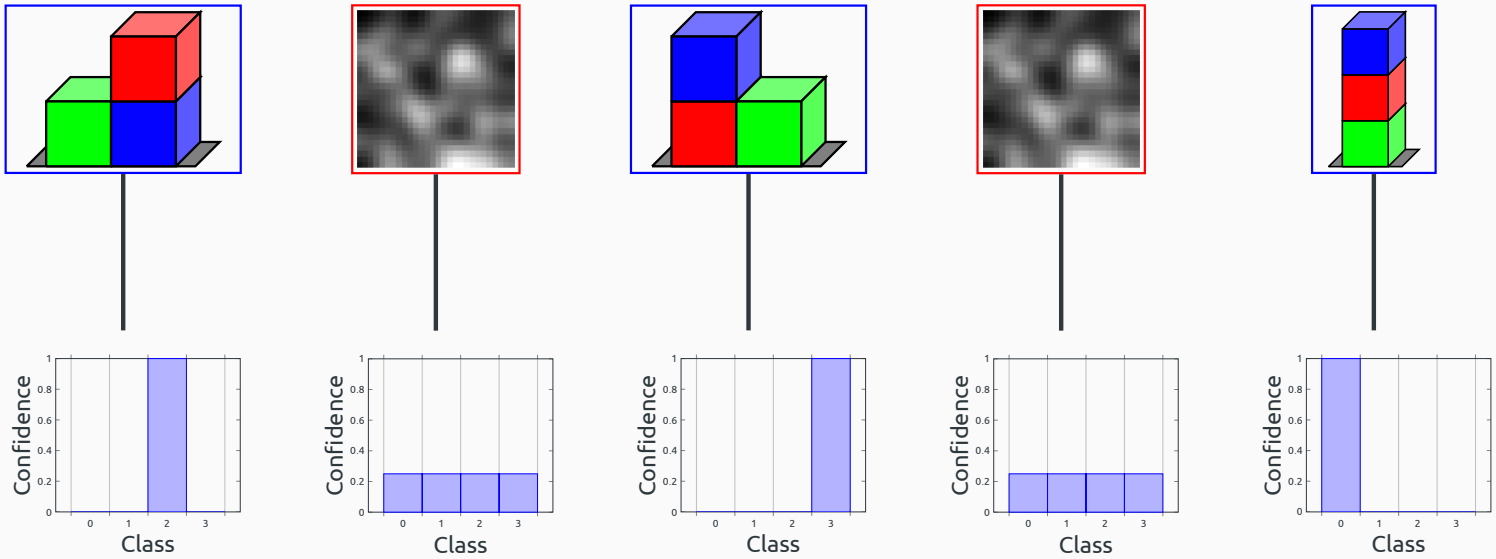


$$\frac{1}{N}\sum_{i=1}^{N} L_{CE}(y_i, f(x_i)) + \lambda \max_k log(f(x_i)_k)$$

[Hein *et al.*, 2019]

Out-Of-Distribution Training



$$\frac{1}{N}\sum_{i=1}^{N} L_{CE}(y_i, f(x_i)) + \lambda \max_k log(f(x_i)_k)$$

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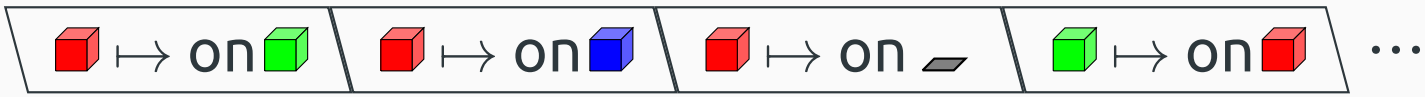
Out Distributions

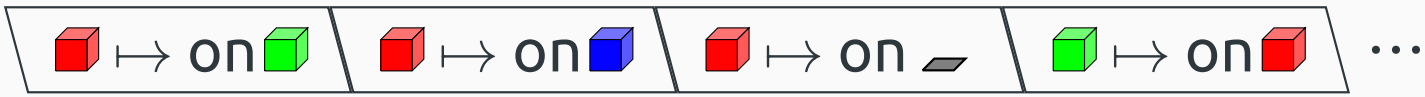
Uniform



Weighted

Out Distributions

Uniform 50% 50% 50% 50%



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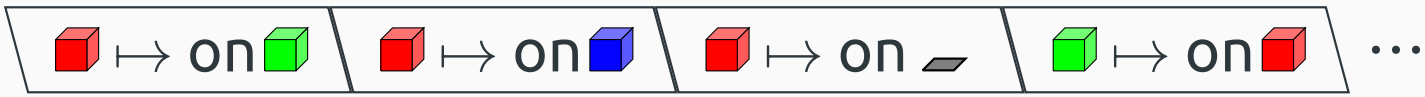

Weighted p_1 p_2 p_3 p_4

Effect on Confidence

Training Method	Confidence In	Confidence Uniform	Confidence Weighted	Ranking Coefficient
Standard	29.3	14.5	10.9	84.1
Uniform 50	30.0	0.5	12.0	84.0
Uniform 90	30.8	0.4	12.2	84.1
Weighted 50	29.0	10.9	1.1	84.6
Weighted 90	29.2	5.5	0.6	84.5

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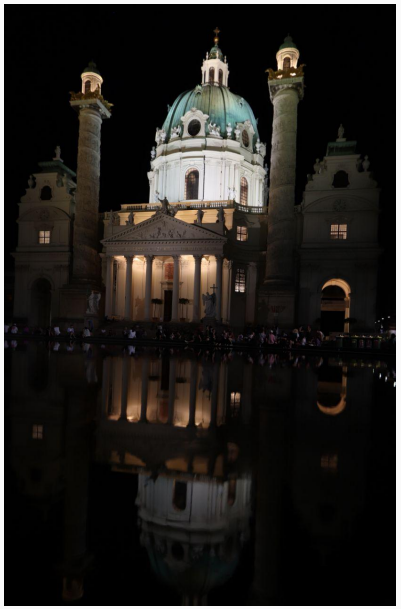
Effect on Coverage: Noise

Summary

- Confidence-awareness improves search
- Adapt out-of-distribution training for planning
- Improving confidence did not yet improve search



References

Patrick Ferber, Malte Helmert, and Jörg Hoffmann. Neural network heuristics for classical planning: A study of hyperparameter space. In Giuseppe De Giacomo, editor, *Proceedings of the 24th European Conference on Artificial Intelligence (ECAI 2020)*, pages 2346–2353. IOS Press, 2020.

Matthias Hein, Maksym Andriushchenko, and Julian Bitterwolf. Why relu networks yield high-confidence predictions far away from the training data and how to mitigate the problem. In *Proceedings of the IEEE/CVF Conference on Computer Vision and Pattern Recognition*, pages 41–50, 2019.