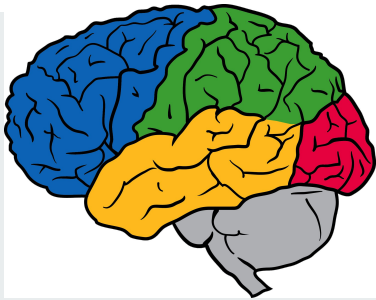


# Weight Agnostic Neural Networks

Adam Gaier[1,2], David Ha[1]

[1] *Google Brain,* [2] *Inria / CNRS / Université de Lorraine / Bonn-Rhein-Sieg University of Applied Sciences*

# Innate abilities in animals

# Innate abilities in machines

**Super-resolution**

Corrupted

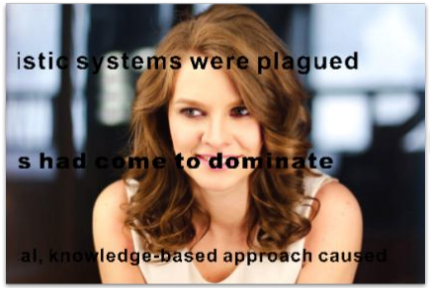
Deep image prior

**Denoising**

Corrupted

Deep image prior

**Inpainting**




Corrupted

Deep image prior

**Inpainting**

Corrupted

Deep image prior

Ulyanov, D., Vedaldi, A., & Lempitsky, V. (2018). Deep image prior. In *Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition (CVPR)*

# To what extent can neural net architectures *alone* encode solutions to tasks?

# A Different Kind of Neural Architecture Search

## Search for networks that perform without training

- Judge networks on expected zero-shot performance
- Performance with randomly initialized weights

## Single shared weight value used for all connections

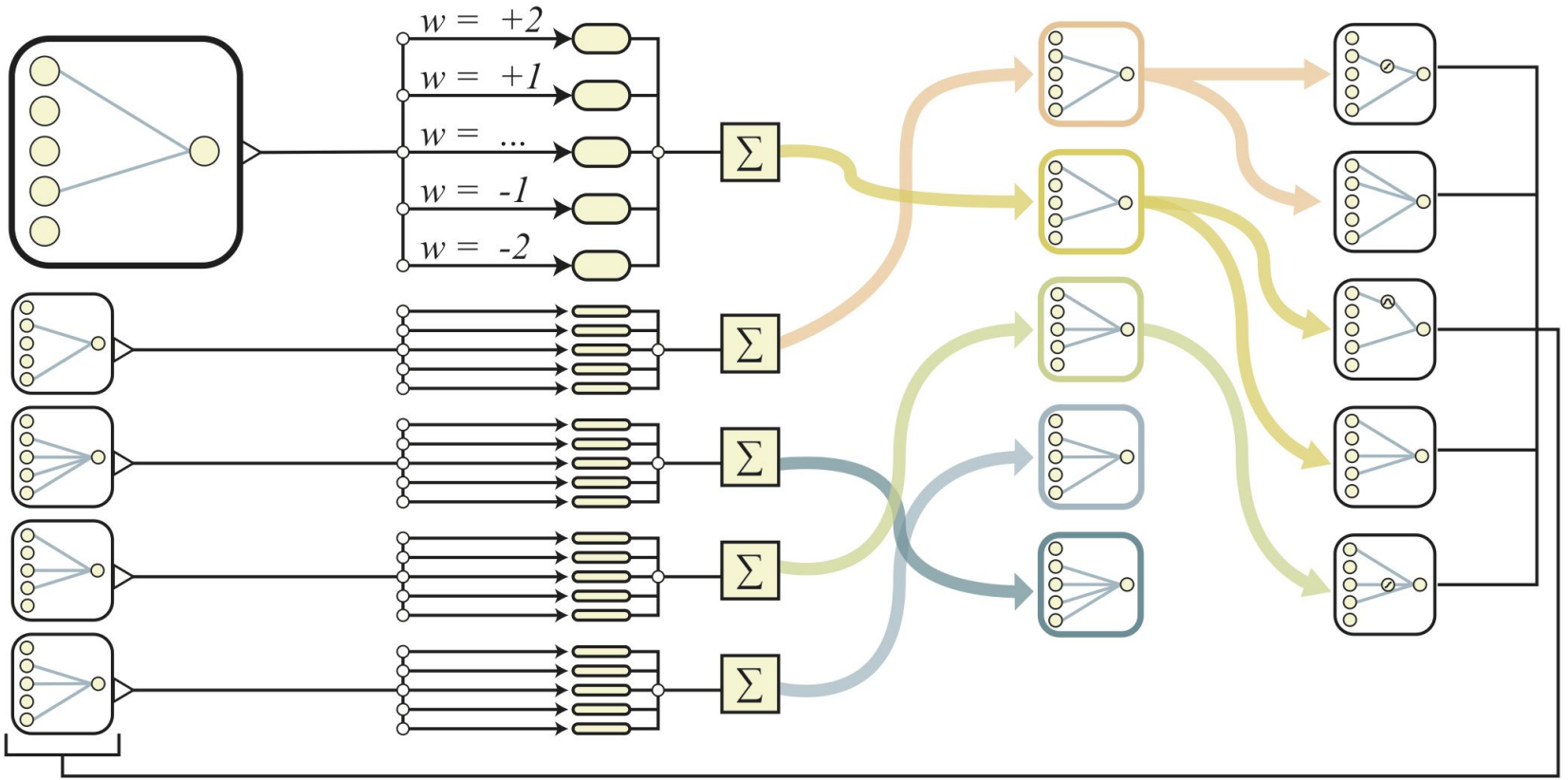
- Reduces number of weight parameters of network to 1
- Weight value selected from a distribution at each trial
    - Reliable expected reward of topology

**1.) Initialize**
*Create population of minimal networks.*

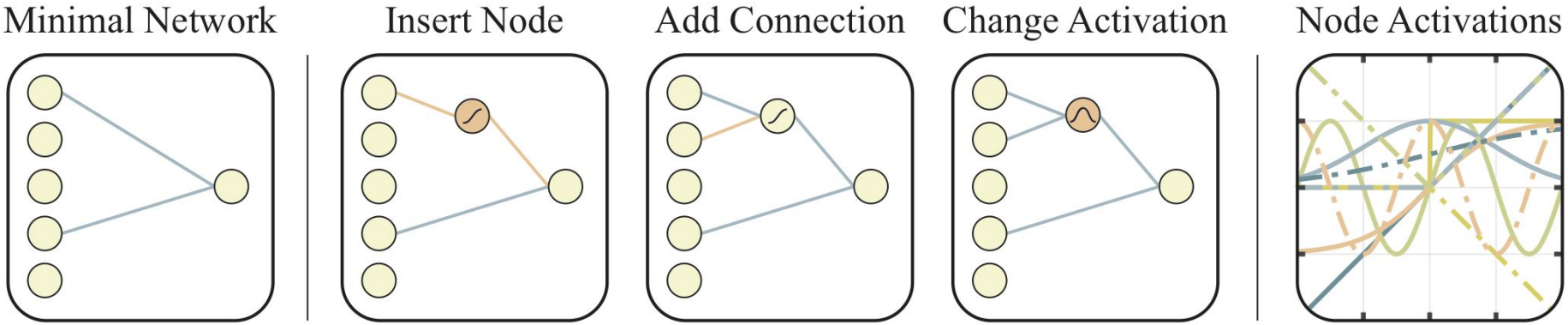
**2.) Evaluate**
*Test with range of shared weight values.*

**3.) Rank**
*Rank by performance and complexity*

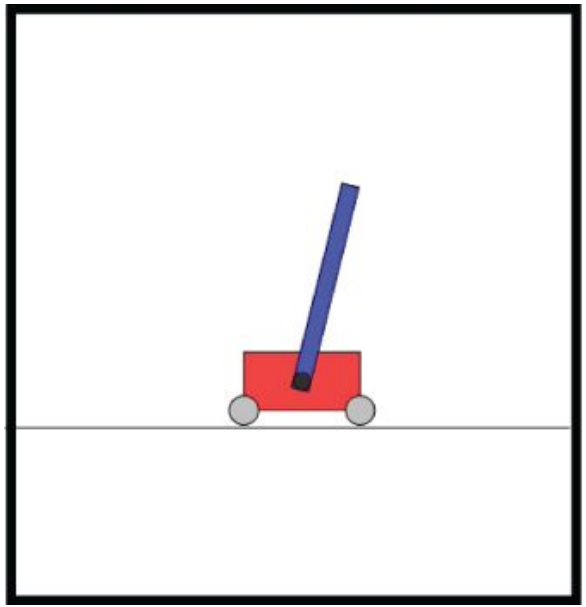
**4.) Vary**
*Create new population by varying best networks.*

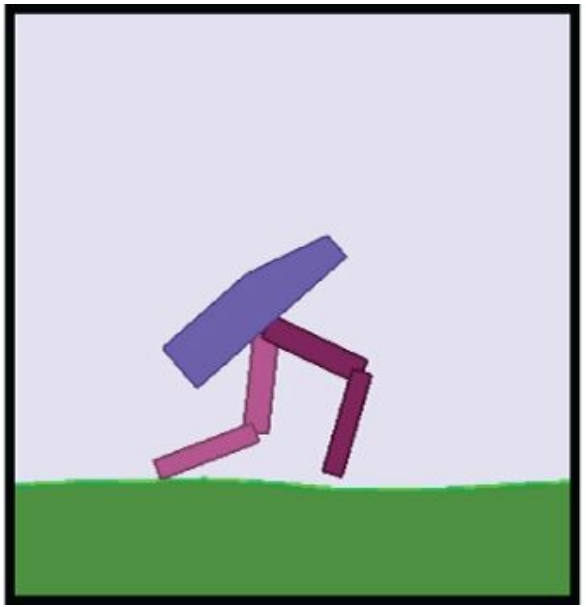


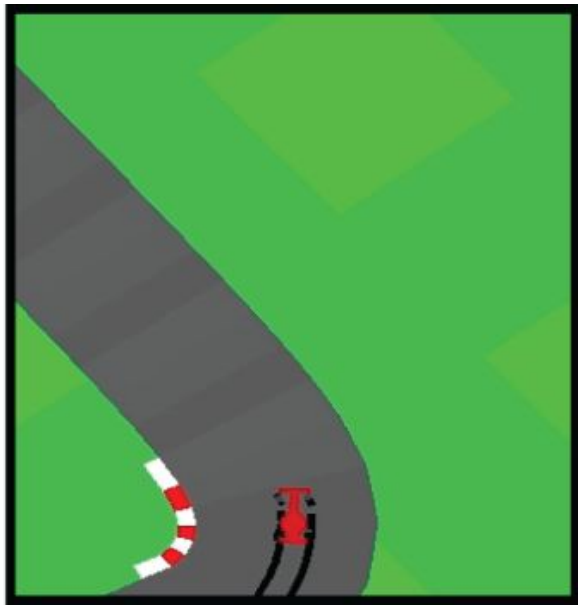
# Topology Search



# WANNs find solutions in variety of RL tasks







# WANNs perform with and without training

| **Swing Up** | Random Weights | Random Shared Weight | Tuned Shared Weight | Tuned Weights |
|---|---|---|---|---|
| WANN | **57 ± 121** | **515 ± 58** | **723 ± 16** | **932 ± 6** |
| Fixed Topology | 21 ± 43 | 7 ± 2 | 8 ± 1 | 918 ± 7 |

| **Biped** | Random Weights | Random Shared Weight | Tuned Shared Weight | Tuned Weights |
|---|---|---|---|---|
| WANN | **-46 ± 54** | **51 ± 108** | **261 ± 58** | 332 ± 1 |
| Fixed Topology | -129 ± 28 | -107 ± 12 | -35 ± 23 | **347 ± 1** |

| **CarRacing** | Random Weights | Random Shared Weight | Tuned Shared Weight | Tuned Weights |
|---|---|---|---|---|
| WANN | **-69 ± 31** | **375 ± 177** | **608 ± 161** | 893 ± 74 |
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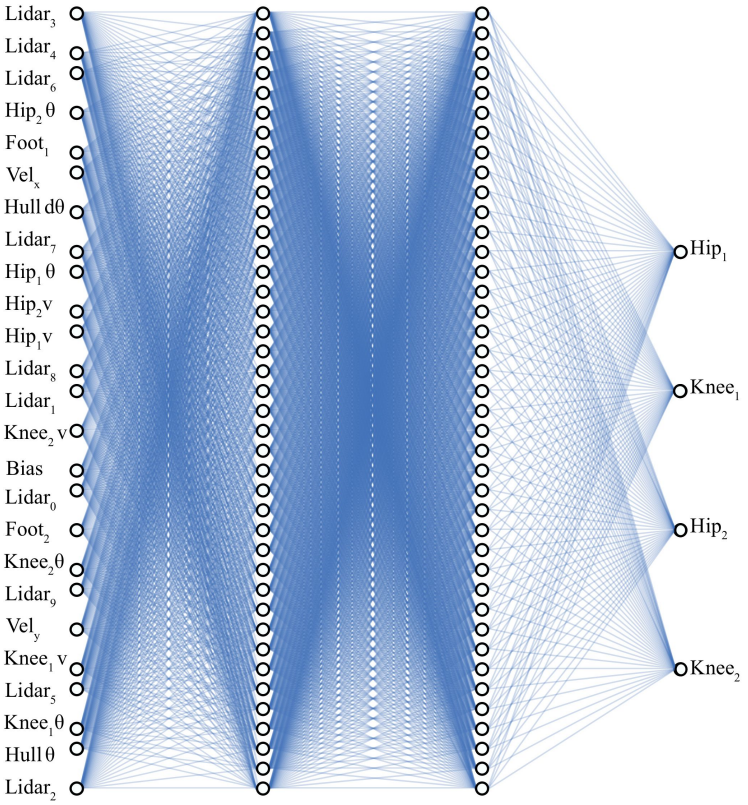
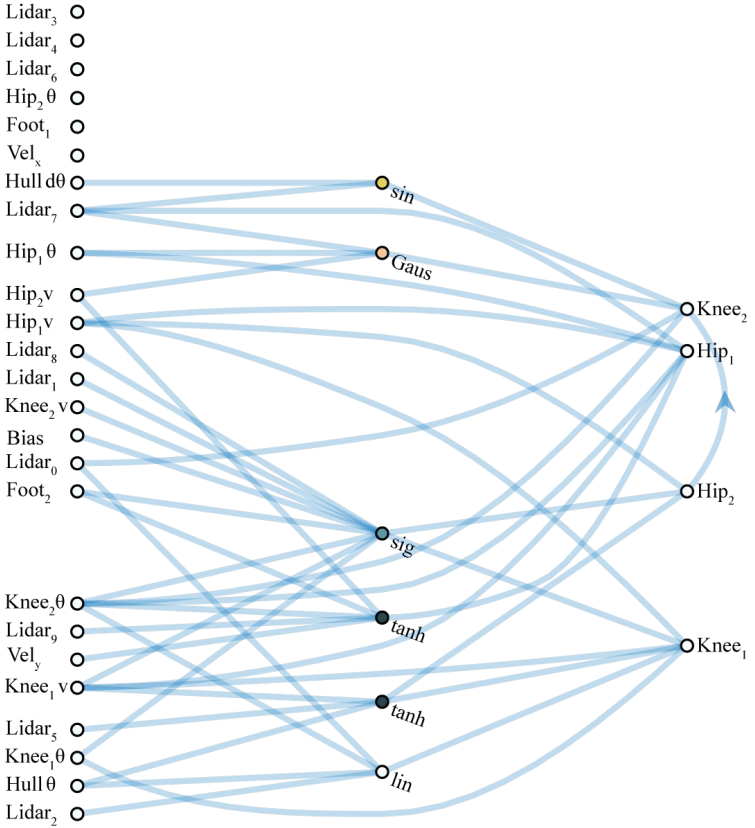
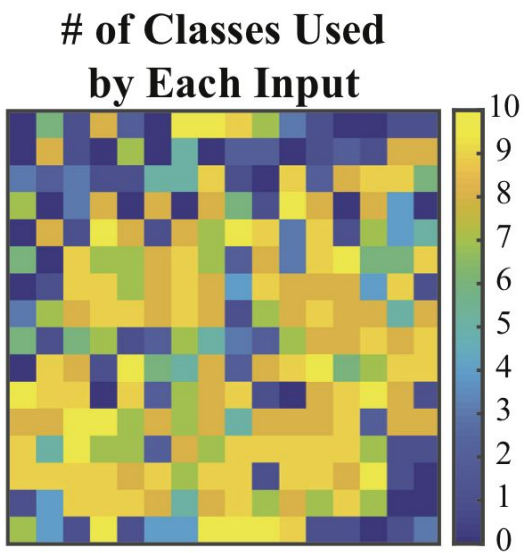
# *ANN Bipedal Walker (2760 connections, weights)*

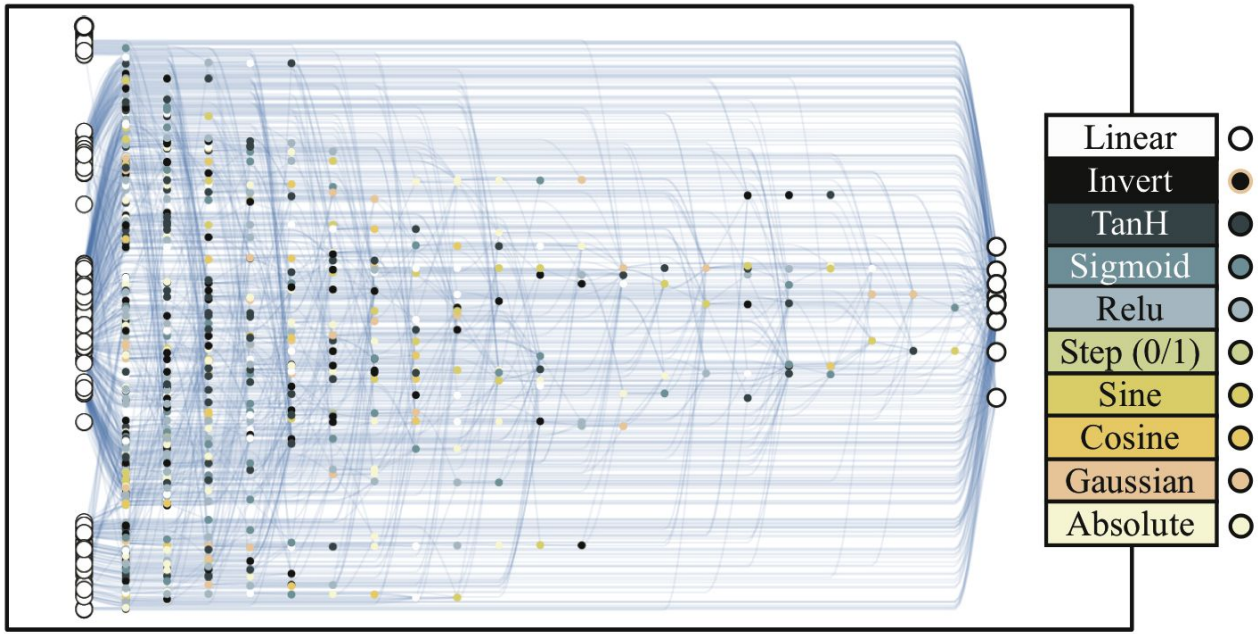



# WANN Bipedal Walker (*44 connections, 1 weight*)



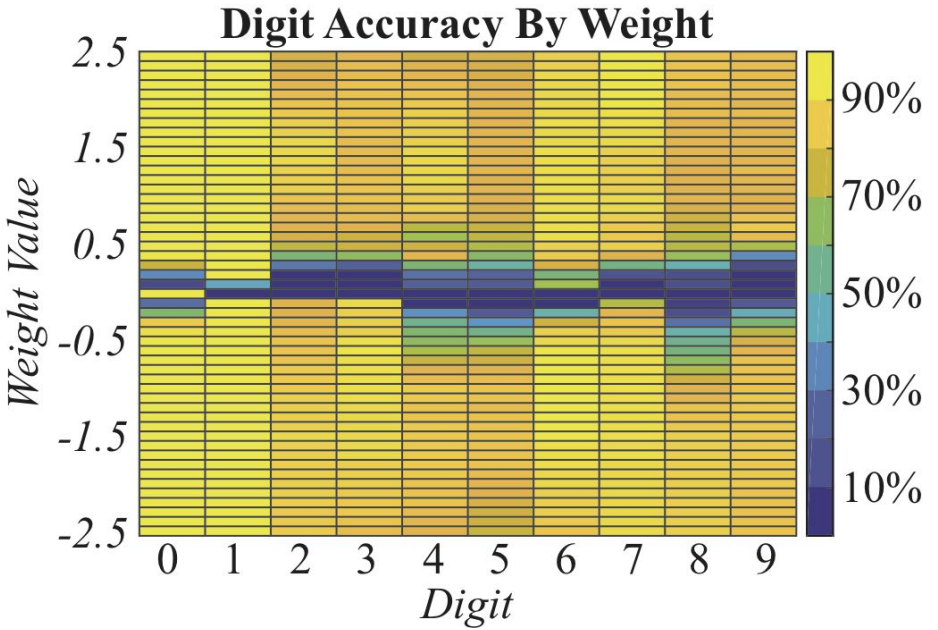
# Can we find WANNs outside of reinforcement learning domains?


# of Classes Used
by Each Input
10
9
8
7
6
5
4
3
2
1
0


Linear
Invert
TanH
Sigmoid
Relu
Step (0/1)
Sine
Cosine
Gaussian
Absolute

| WANN | Test Accuracy |
|---|---|
| Random Weight | *82.0% ± 18.7%* |
| Ensemble Weights | *91.6%* |
| Tuned Weight | *91.9%* |
| Trained Weights | *94.2%* |

| ANN | Test Accuracy |
|---|---|
| Linear Regression | *91.6%* [50] |
| Two-Layer CNN | *99.3%* [12] |



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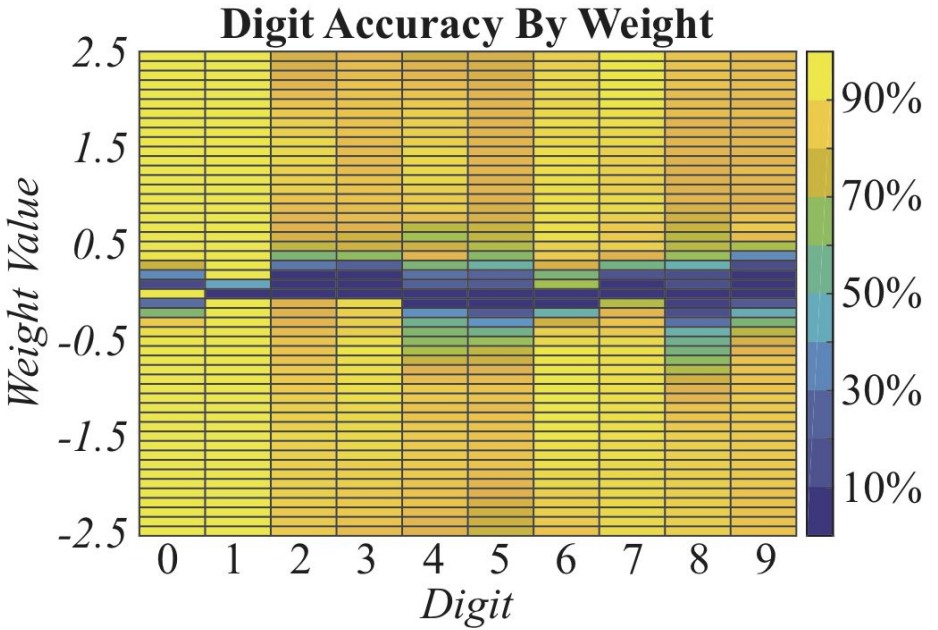

# Searching for Building Blocks

## First steps toward a different kind of architecture search

- Network architectures with innate biases can perform a variety of tasks
- ...and these biases can be found through search

## Weight tolerance as a heuristic for new building blocks

- ConvNets and LSTMs can work even untrained
- Finding novel building blocks at least as important as new arrangements of those which already exist

interactive article @:

**weightagnostic.github.io**

poster @:

**wednesday 10:45**