Weight Agnostic Neural Networks

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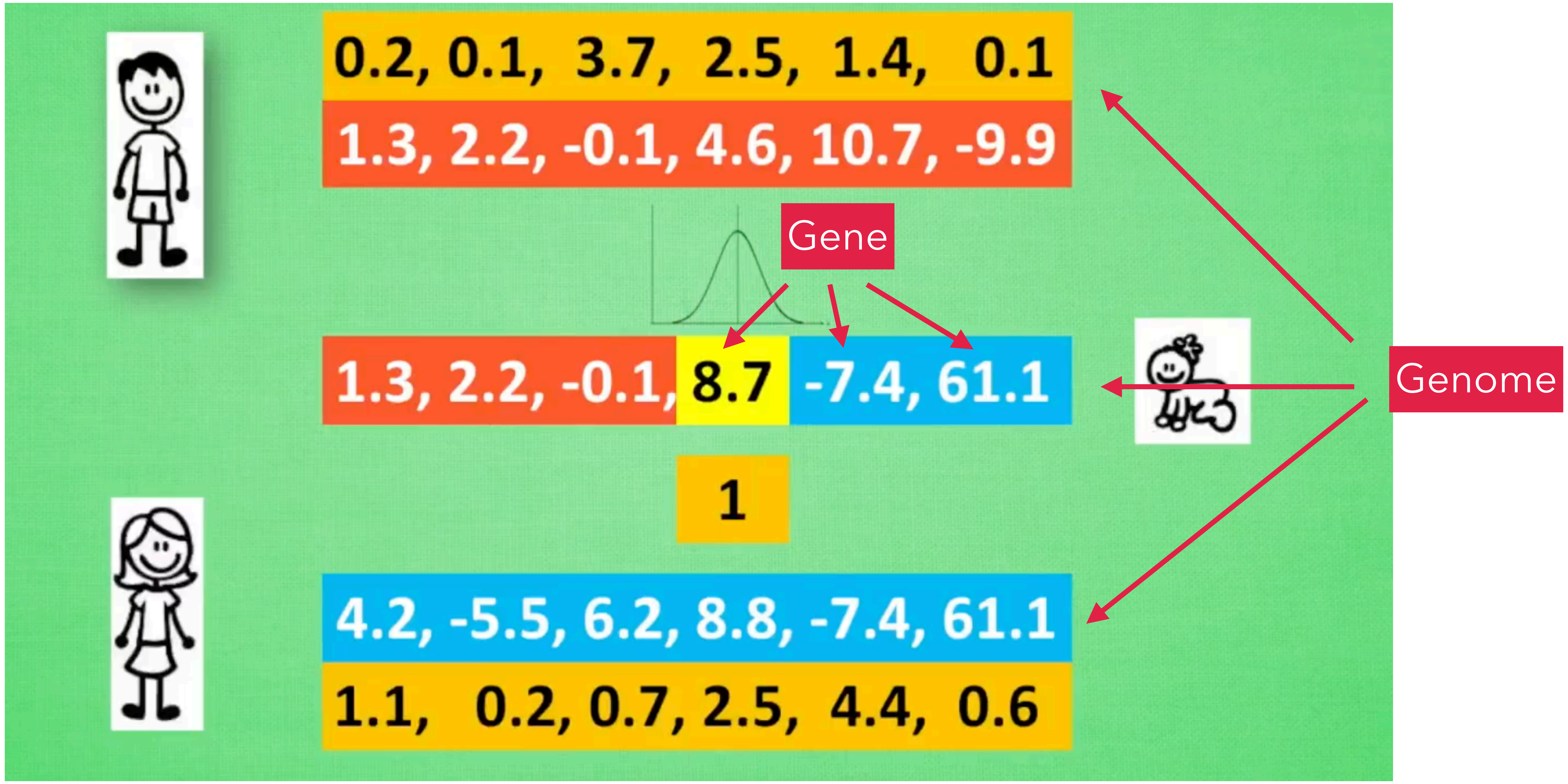
Reporter: Yinghuan Zhang Sep 30th 2020

Recall: Genetic Algorithms

- Crossover
- Mutation
- Selection



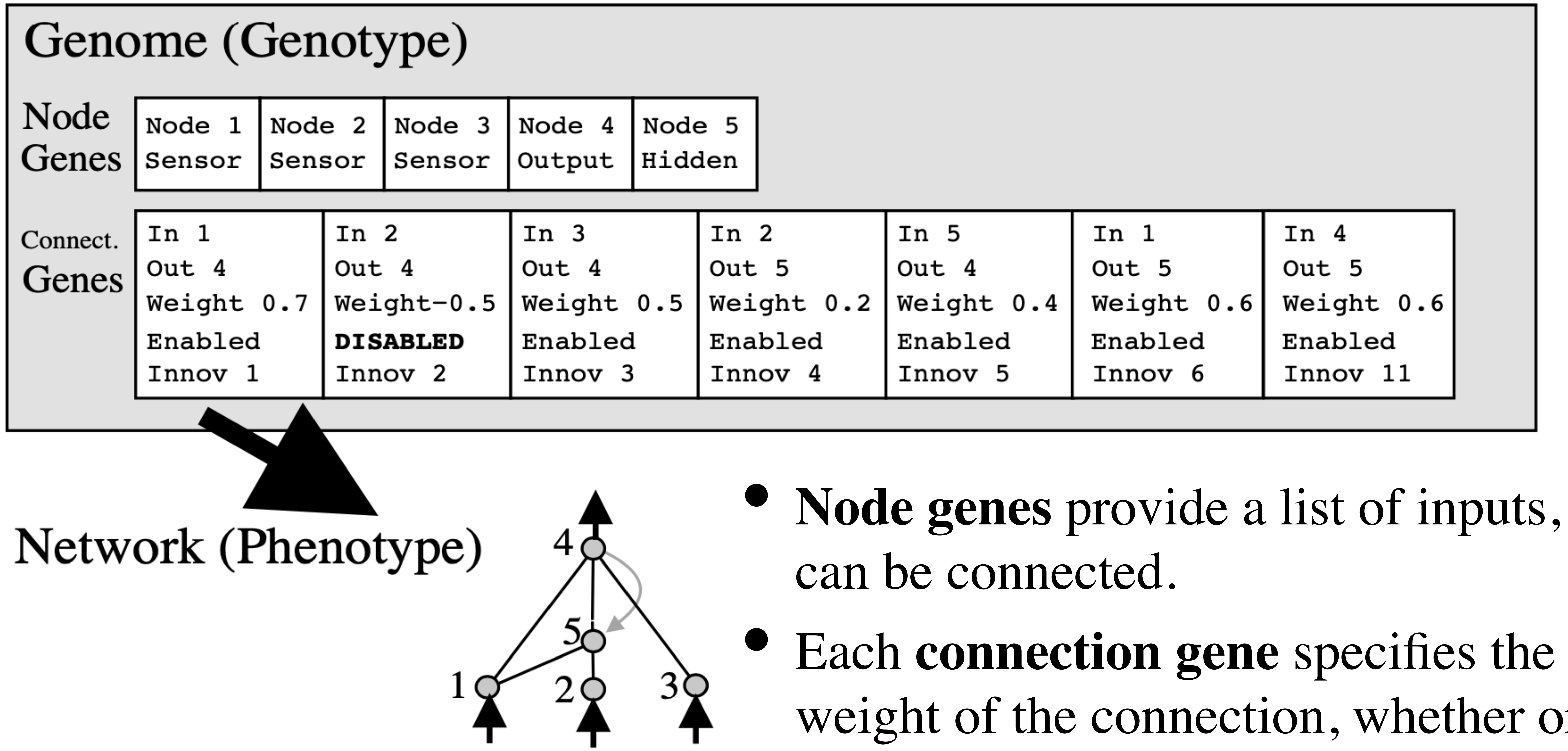
NeuroEvolution

NeuroEvolution(NE): the artificial evolution of neural networks using genetic algorithms.

- Topology evolved before the experiment.
- Weight space explored through the **crossover** of network weight vectors & **mutation** of single networks' weights.
- Topology-fixed optimization in connection weights.

Topology and Weight Evolving Artificial Neural Networks (TWEANNs) : evolve both neural network topologies and weights.

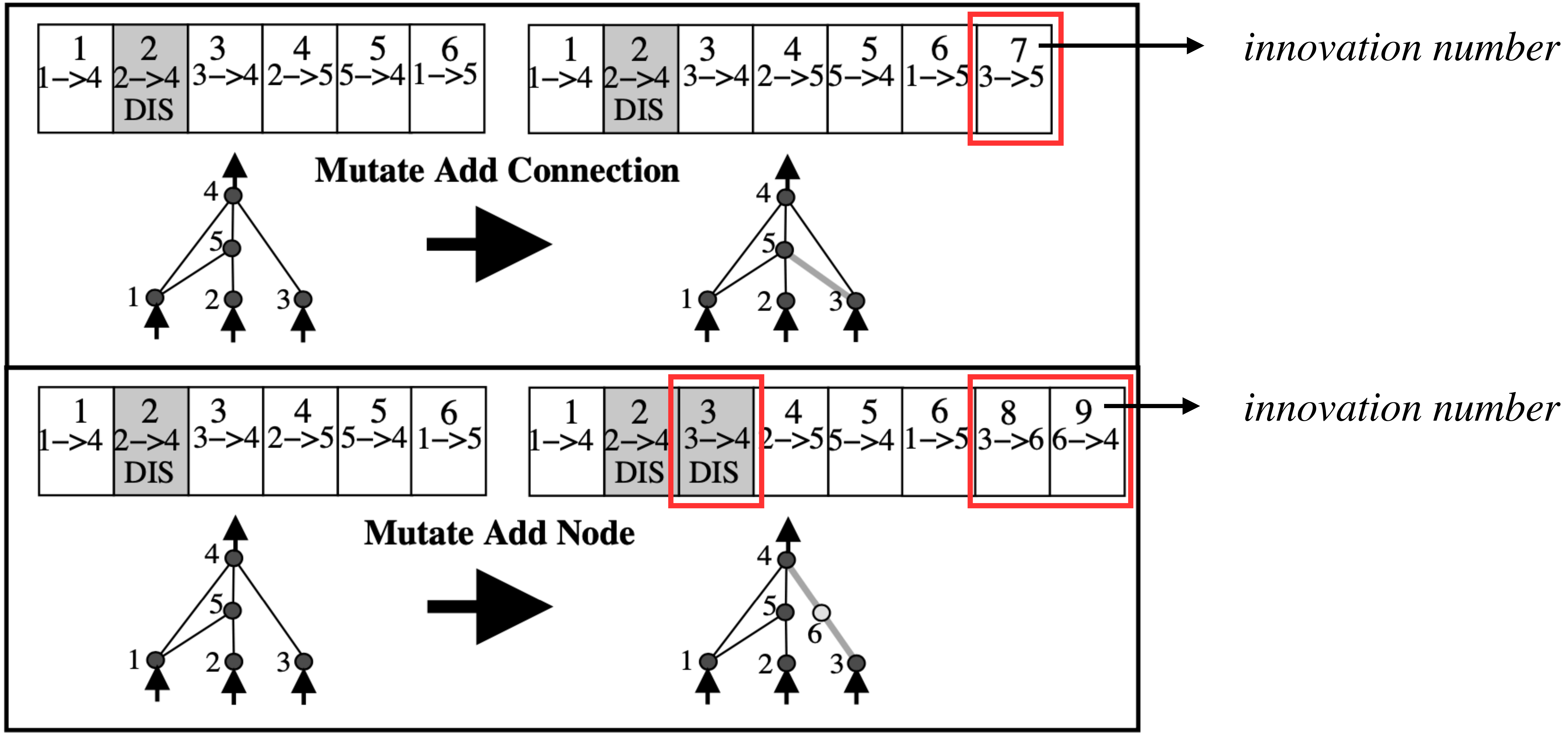
NeuroEvolution of Augmenting Topologies (NEAT)



- **Node genes** provide a list of inputs, hidden nodes, and outputs that can be connected.
- Each **connection gene** specifies the in-node, the out-node, the weight of the connection, whether or not the connection gene is expressed (an enable bit), and an *innovation number*, which allows finding corresponding genes (as will be explained afterwards).

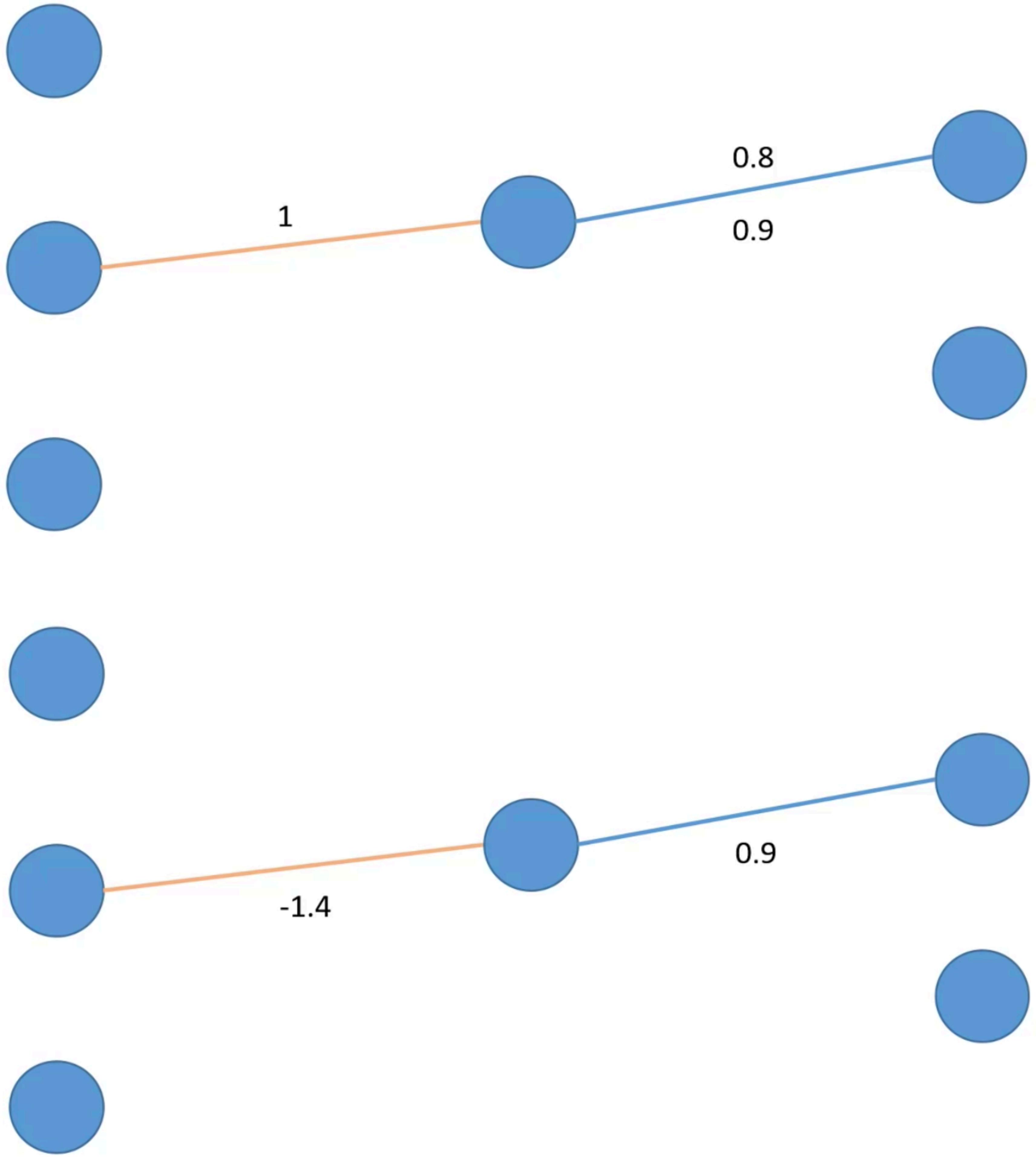
Evolving Neural Networks through Augmenting Topologies

NeuroEvolution of Augmenting Topologies (NEAT)



Evolving Neural Networks through Augmenting Topologies

NeuroEvolution of Augmenting Topologies (NEAT)



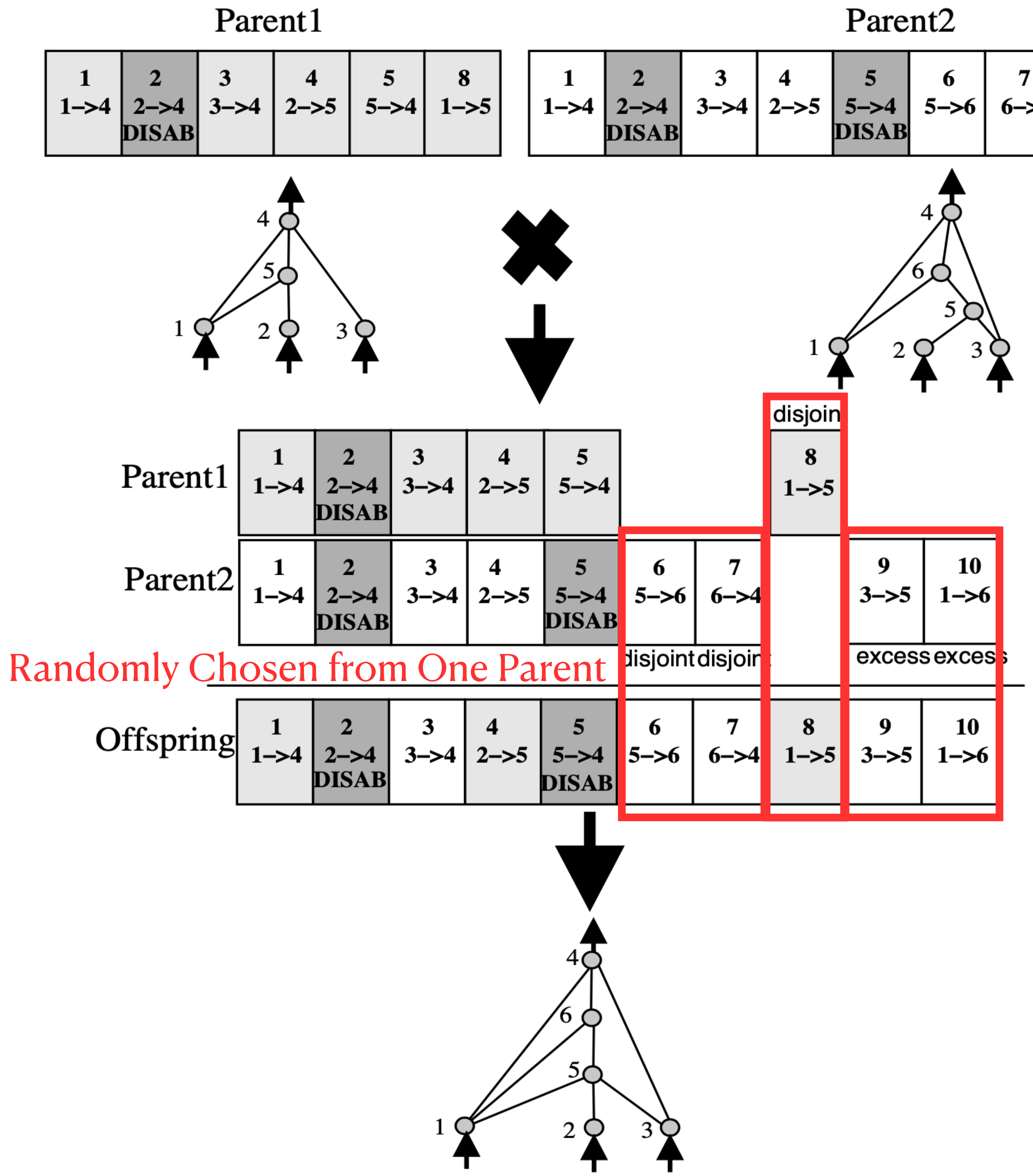
weight_shift: shift the original value to a nearby value according to a pre-selected distribution

weight_random: randomly decide a weight value between -2 and 2

NeuroEvolution of Augmenting Topologies (NEAT)

compatibility distance

$$\delta = \frac{c_1 E}{N} + \frac{c_2 D}{N} + c_3 \bar{W}$$



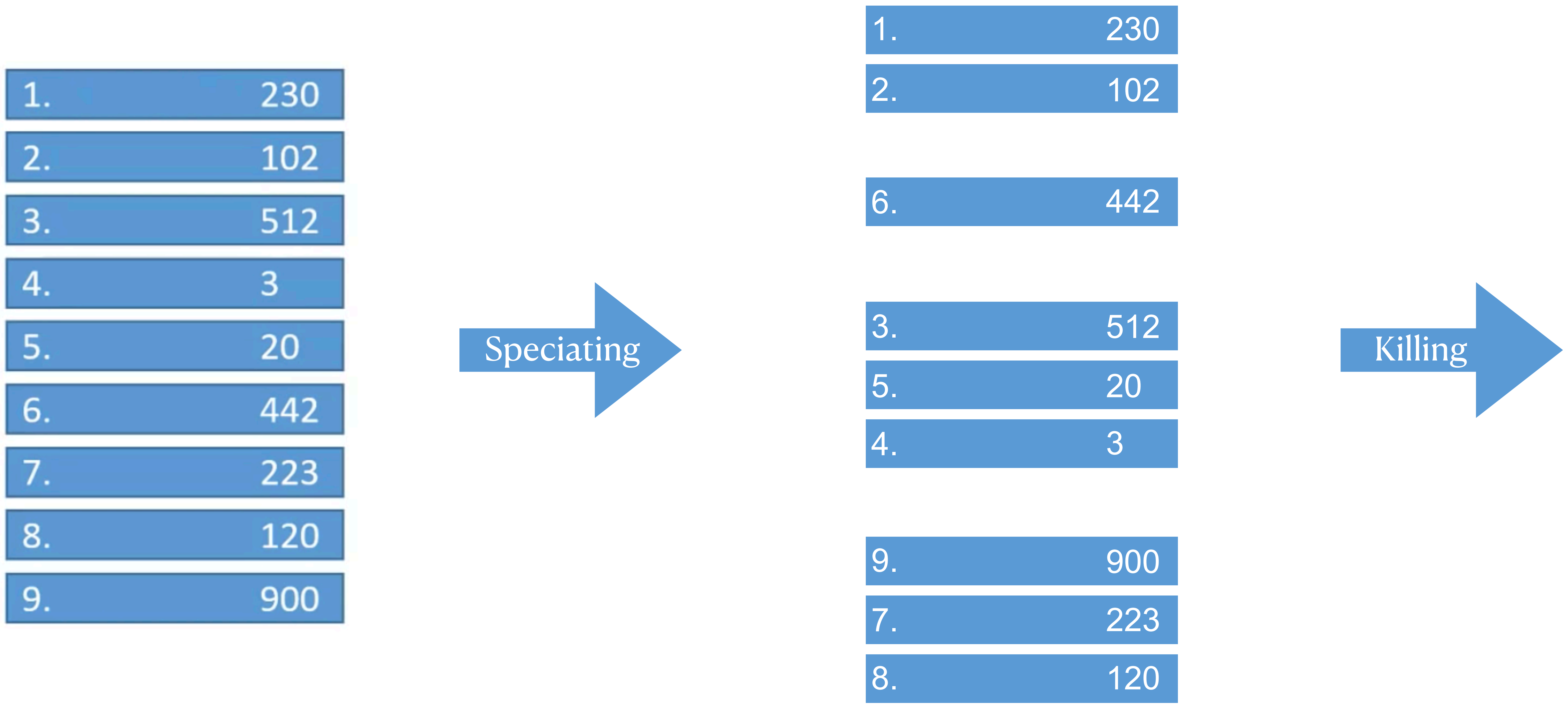
E: the number of excess genes

D: the number of disjoint genes

$\bar{W}$: the average weight differences of matching genes, including disabled genes

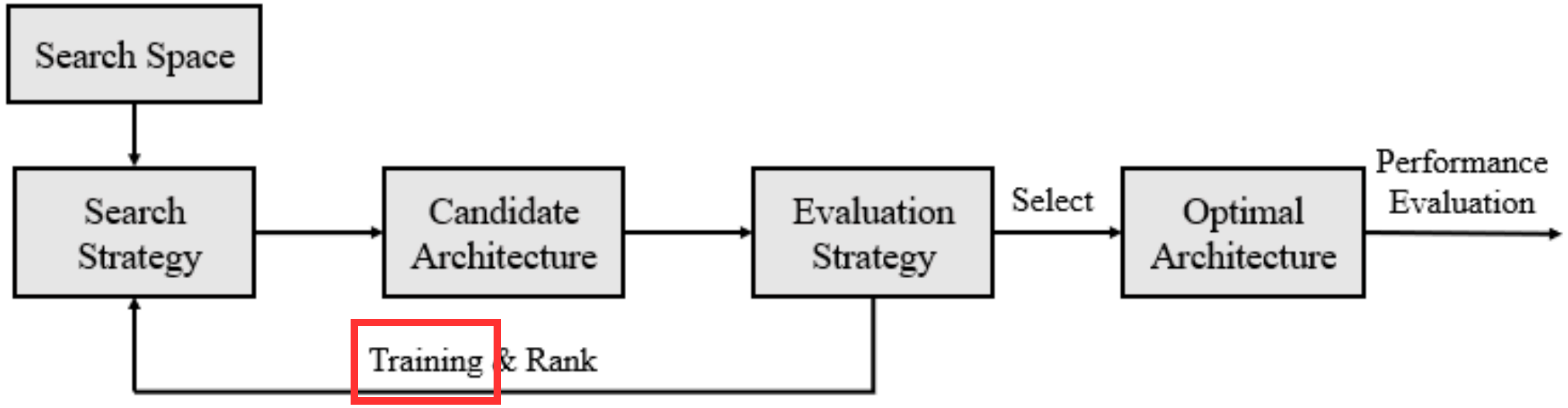
Evolving Neural Networks through Augmenting Topologies

NeuroEvolution of Augmenting Topologies (NEAT)



compatibility distance threshold δ_t

Neural Architecture Searching

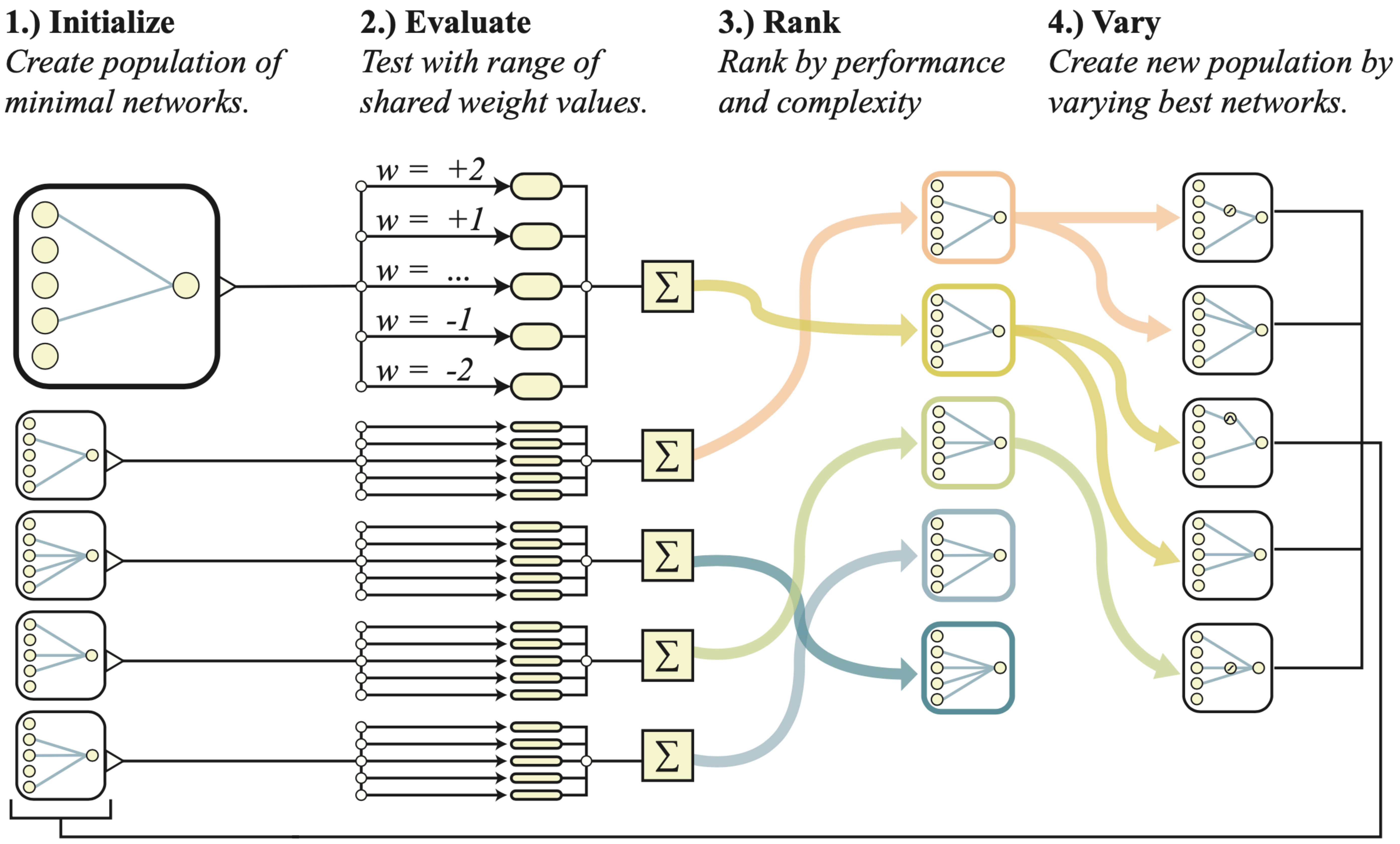


The General Framework of NAS

Before WANN: To produce architectures which, once trained, outperform those designed by humans.

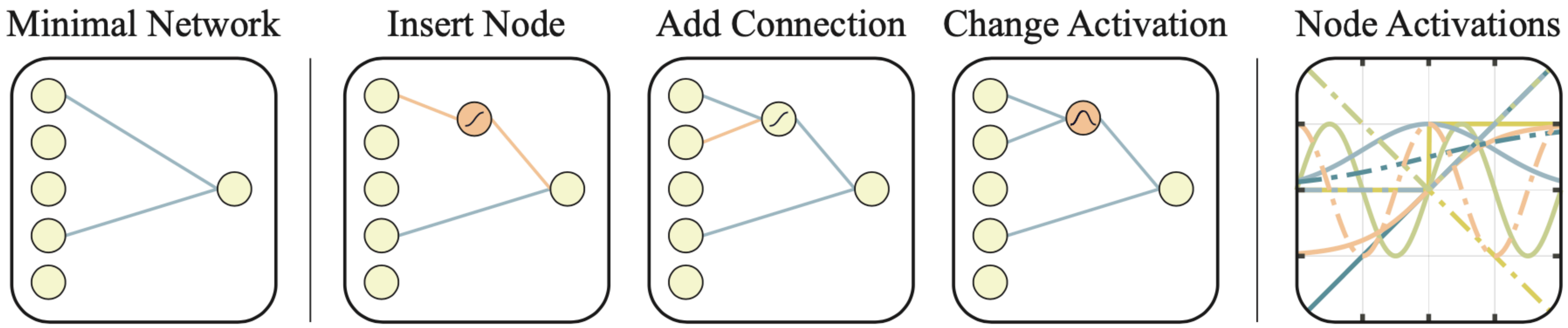
WANN: To produce architectures that themselves encode solutions.

Weight Agnostic Neural Network(WANN) Search



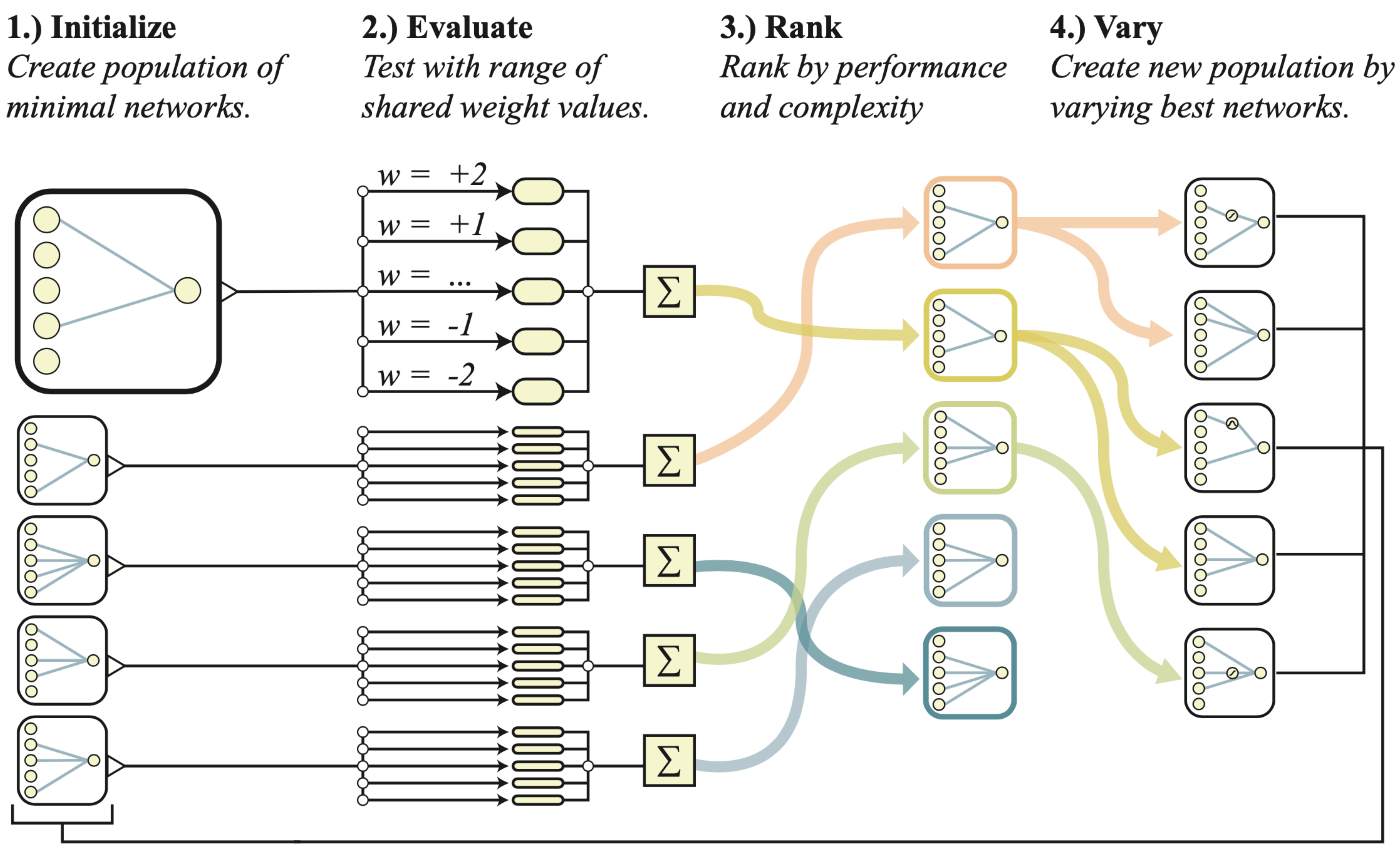
Overview of Weight Agnostic Neural Network Search

WANN Search, Topology Search



Operators for Searching the Space of Network Topologies

Weight Agnostic Neural Network(WANN) Search



Networks topologies are judged based on three criteria

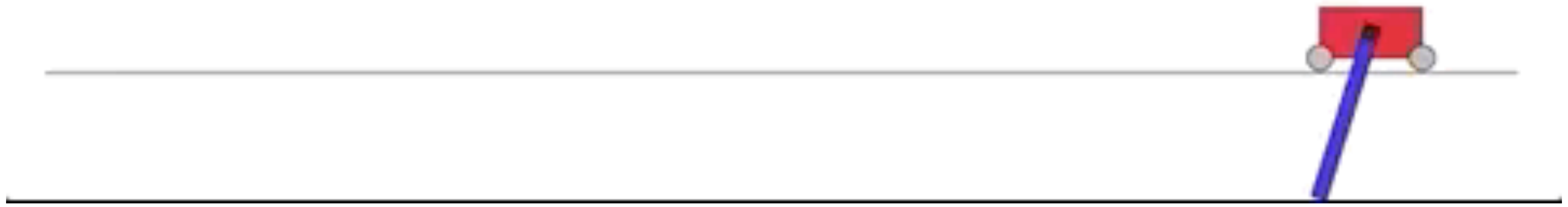
- mean performance over all weight values

  (a fixed series of weight values [−2, −1, −0.5, +0.5, +1, +2])
- max performance of the single best weight value
- the number of connections in the network

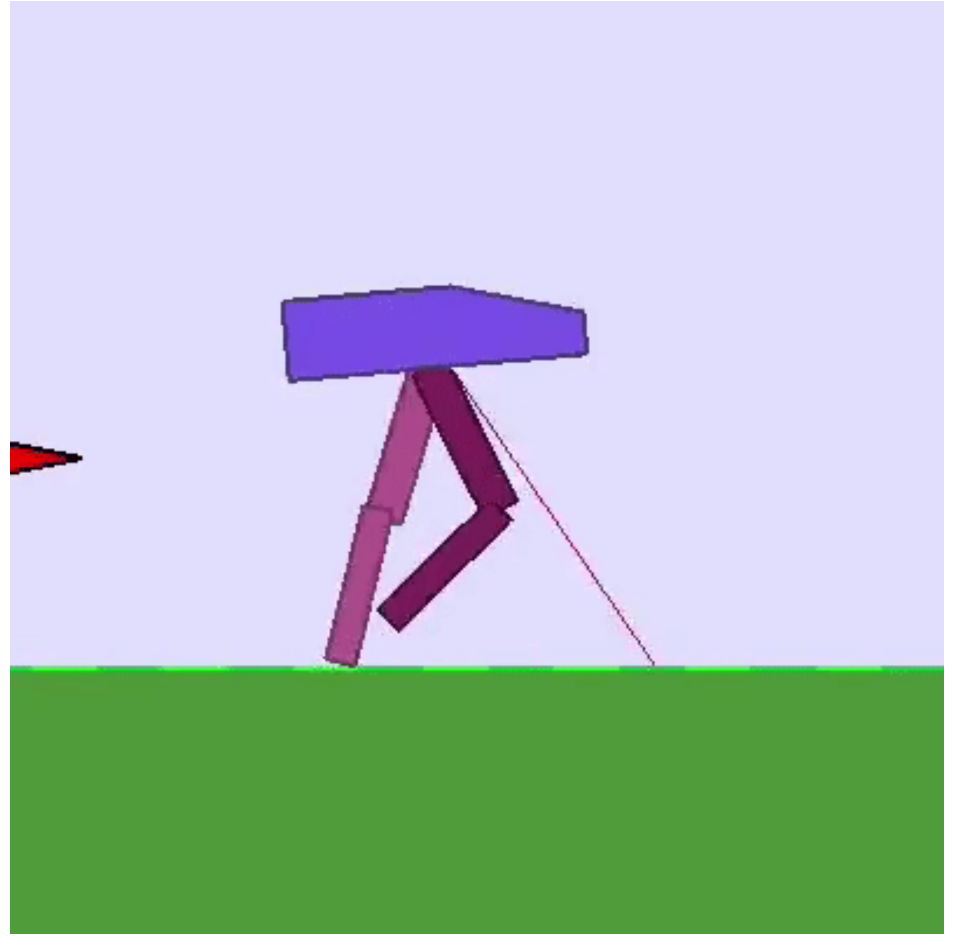
Overview of Weight Agnostic Neural Network Search

Weight Agnostic Neural Networks

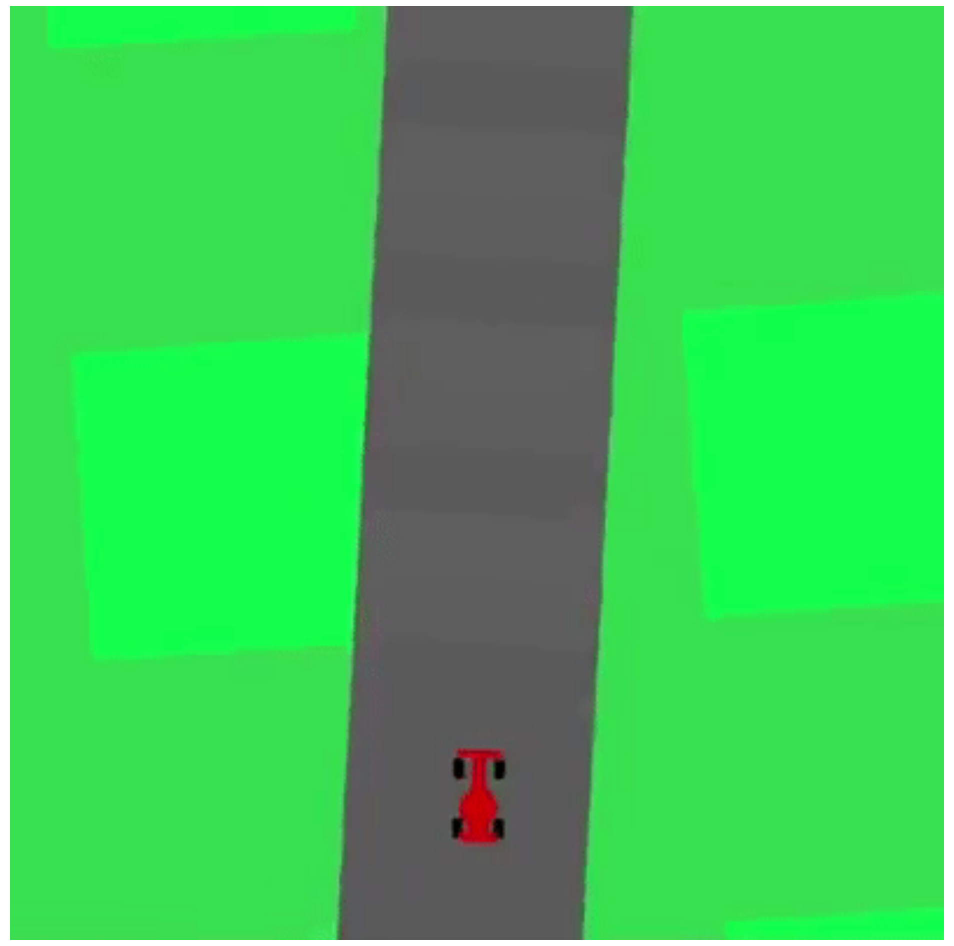
WANNs find solutions in variety of RL tasks



CartPoleSwingUp



BipedalWalker-v2



CarRacing-v0

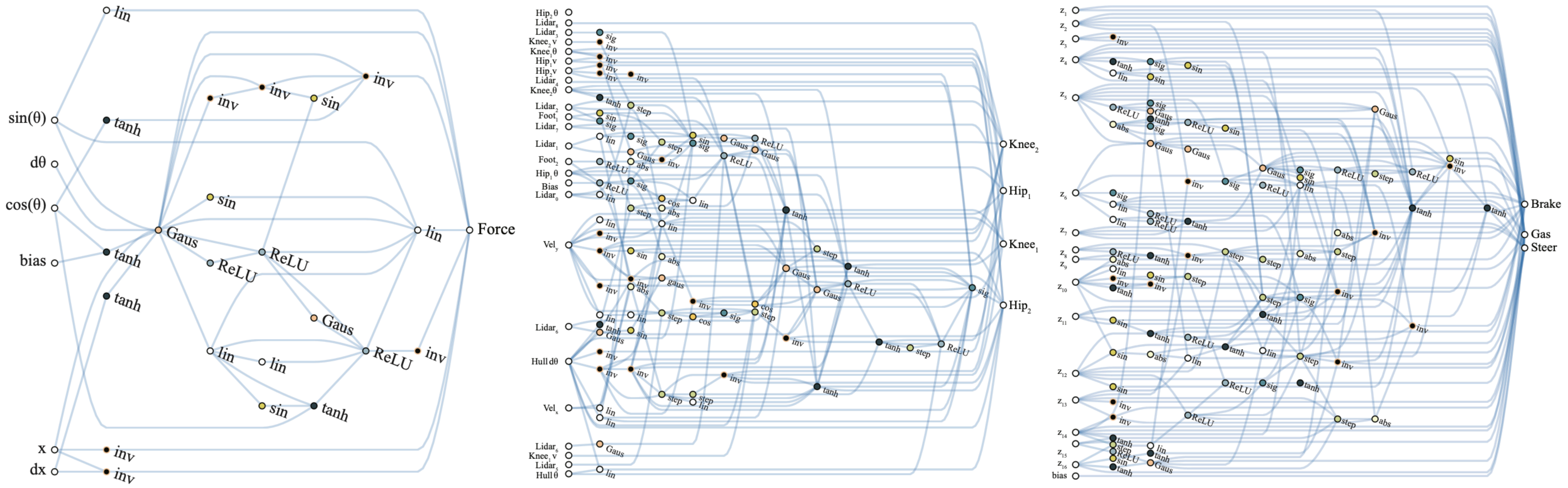
Experiment Result

Table1: *Performance of Randomly Sampled and Trained Weights for Continuous Control Tasks*

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** [38]
CarRacing	Random Weights	Random Shared Weight	Tuned Shared Weight	Tuned Weights
WANN	**-69 ± 31**	**375 ± 177**	**608 ± 161**	893 ± 74
Fixed Topology	-82 ± 13	-85 ± 27	-37 ± 36	**906 ± 21** [39]

1. *Random weights*: individual weights drawn from $\mathcal{U}(-2, 2)$;
2. *Random shared weight*: a single shared weight drawn from $\mathcal{U}(-2, 2)$;
3. *Tuned shared weight*: the highest performing shared weight value in range $(-2, 2)$;
4. *Tuned weights*: individual weights tuned using population-based REINFORCE [123].

- The biped controller uses only 17 of the 25 possible inputs, ignoring many LIDAR sensors and knee speeds.
- Only 210 connections
- 2804 connections in SOTA baseline



Champion Networks for Continuous Tasks

Thank You!

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