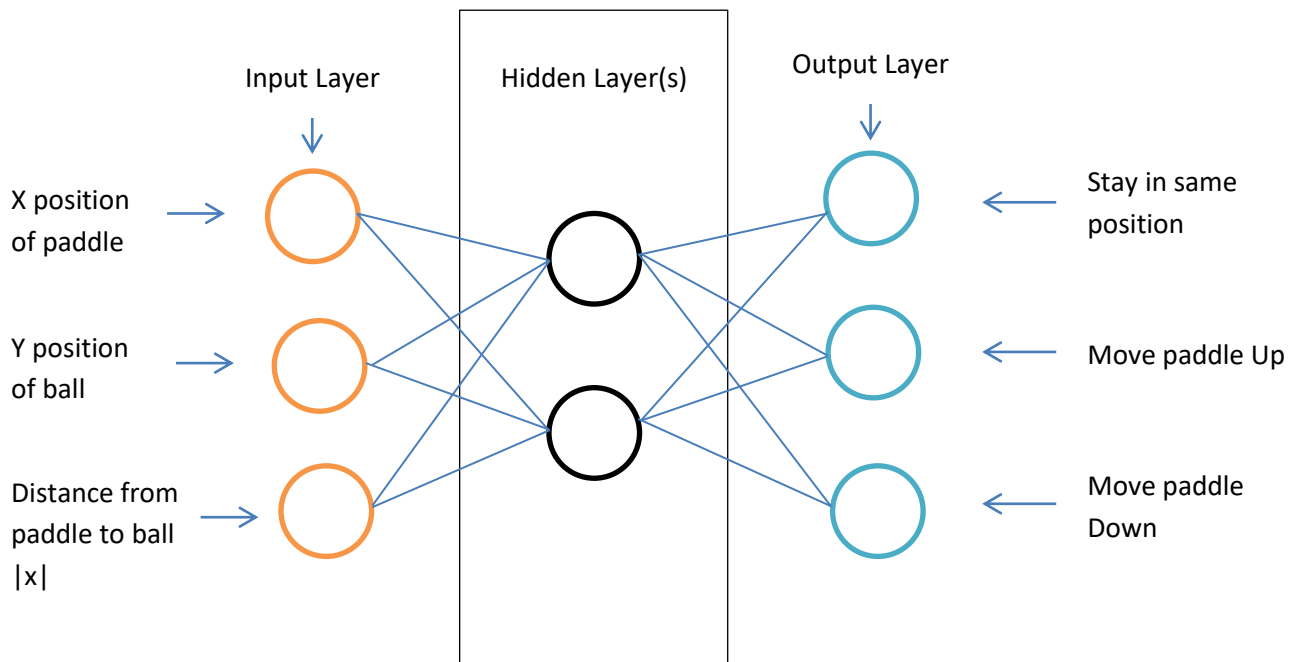


# Pong Game with AI using NEAT (NeuroEvolution of Augmenting Topologies)

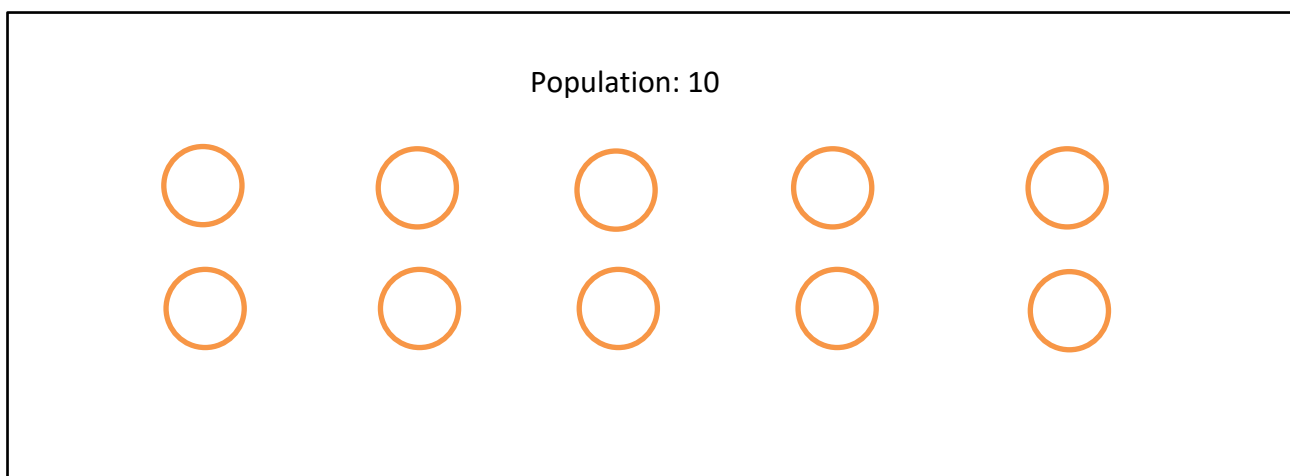
NEAT is a genetic algorithm which takes inspiration from human history and natural selection. NEAT can be identified as a building layer on top of a neural network.

For the pong game AI to be able to play with a competitor, the basic neural framework should be as below,



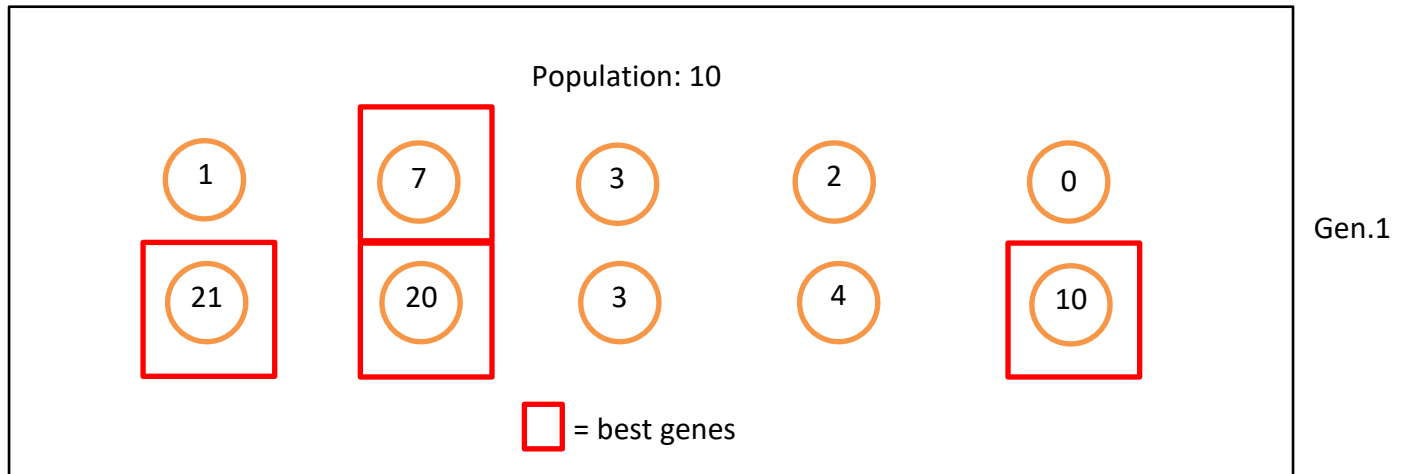
When using NEAT, it creates a set of neural networks with pre-defined features such as input-nodes, output-nodes and hidden-nodes. And some random mutations are being performed to these neural networks. NEAT algorithm only modifies the hidden layer(s) nodes, the amount input and output nodes are kept unchanged.

If we decide to start with 10 neural networks with NEAT,

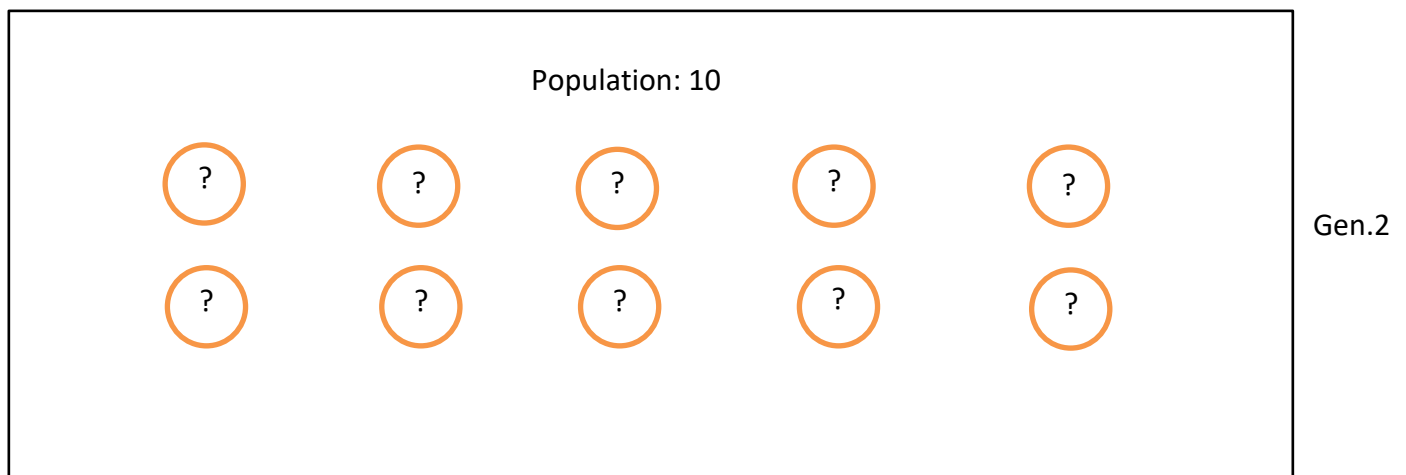


NEAT identifies the above neural networks as Genomes, and allocates a value to each of them, the value is called Fitness. Fitness of a Genome is a score for how it performs the task (as for natural selection – how long a species survive).

**The Fitness score of Genomes of this project = Number of times the AI hits the ball moving the paddle.**



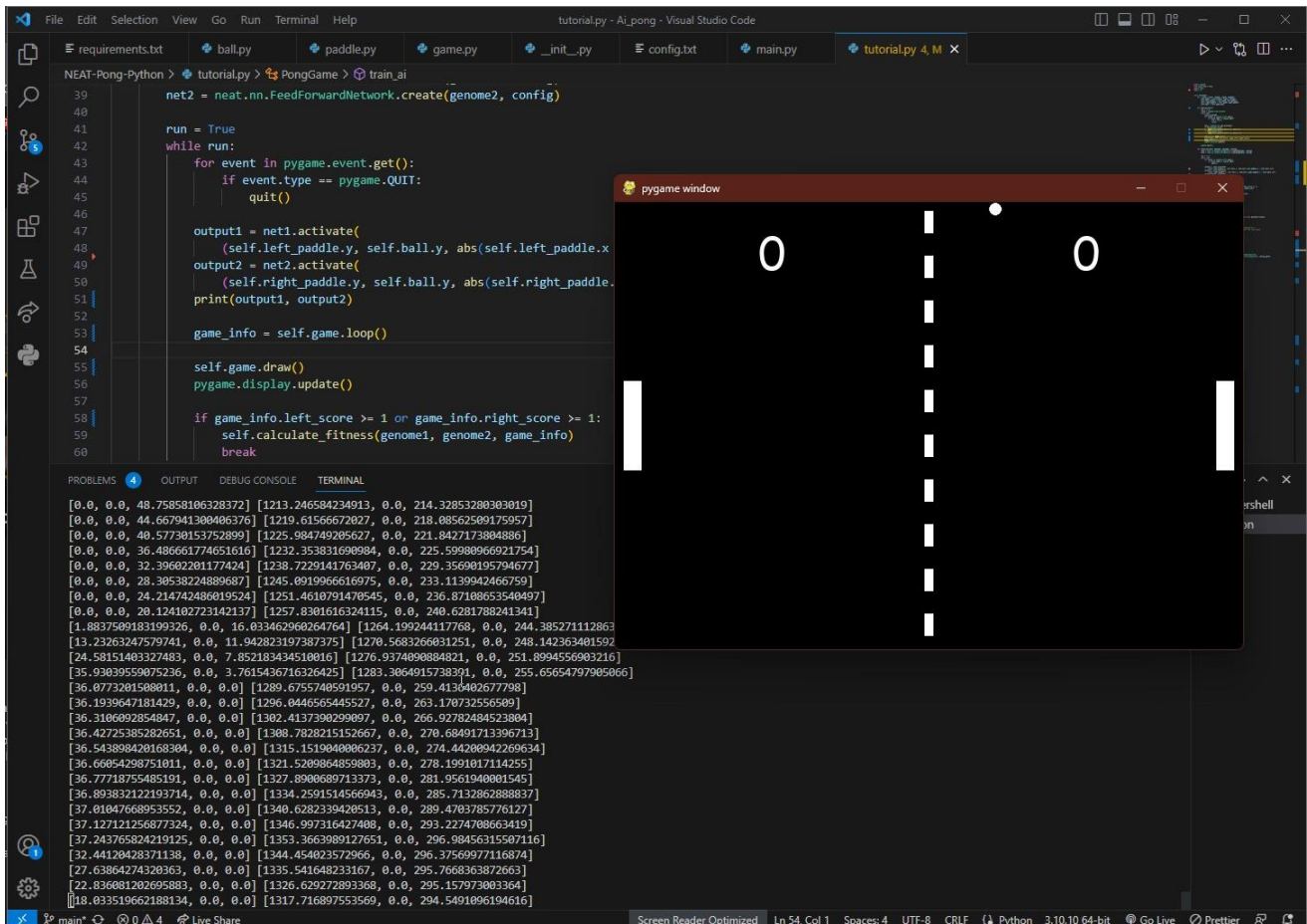
Using these fitness values, we can eliminate some under-performing Genes, and we can breed the best genomes together and to move to the next generation. Then proceed to next generation.



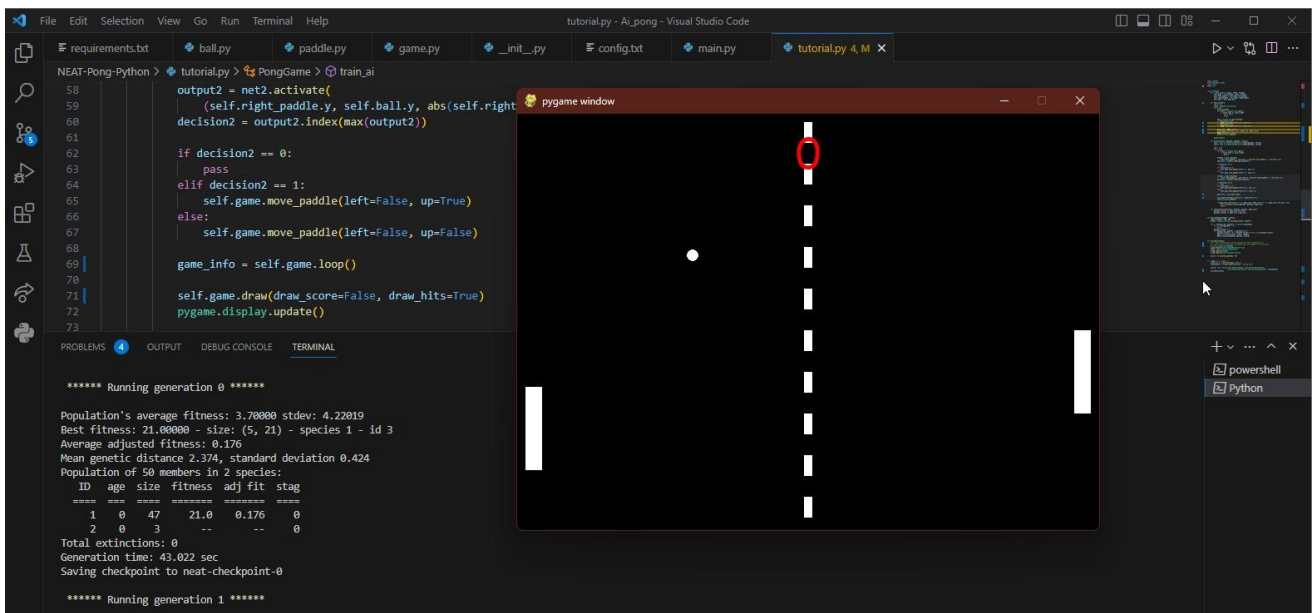
This generation iteration process continues until a neural network satisfies our criteria – in this case a Fitness Level of 100.

**NOTE:** NEAT does more advanced operations behind the curtains, such as grouping genomes – that will protect species without leading them to extinction, how long an under-performed genome is kept alive in the algorithm, adding random mutations to the off-spring genomes from later generations etc.

## The very first training session to match the paddle positions



## The generational iterative training for the neural network



The very first 5 generational iterative training results:

\*\*\*\*\* Running generation 0 \*\*\*\*\*

Population's **average fitness: 3.70000** stdev: 4.22019

**Best fitness: 21.00000** - size: (5, 21) - species 1 - id 3

Average adjusted fitness: 0.176

Mean genetic distance 2.374, standard deviation 0.424

Population of 50 members in 2 species:

ID	age	size	fitness	adj fit	stag
1	0	47	21.0	0.176	0
2	0	3	--	--	0

Total extinctions: 0

Generation time: 43.022 sec

Saving checkpoint to neat-checkpoint-0

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\*\*\*\*\* Running generation 1 \*\*\*\*\*

Population's **average fitness: 5.64000** stdev: 6.59927

**Best fitness: 28.00000** - size: (5, 21) - species 1 - id 58

Average adjusted fitness: 0.129

Mean genetic distance 2.448, standard deviation 0.457

Population of 50 members in 2 species:

ID	age	size	fitness	adj fit	stag
1	1	41	28.0	0.211	0
2	1	9	2.0	0.048	0

Total extinctions: 0

Generation time: 48.620 sec (45.821 average)

Saving checkpoint to neat-checkpoint-1

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\*\*\*\*\* Running generation 2 \*\*\*\*\*

Population's **average fitness: 5.36000** stdev: 6.36478

**Best fitness: 35.00000** - size: (5, 21) - species 1 - id 58

Average adjusted fitness: 0.173

Mean genetic distance 2.204, standard deviation 0.863

Population of 50 members in 2 species:

ID	age	size	fitness	adj fit	stag
1	2	27	35.0	0.142	0
2	2	23	14.0	0.203	0

Total extinctions: 0

Generation time: 46.647 sec (46.096 average)

Saving checkpoint to neat-checkpoint-2

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\*\*\*\*\* Running generation 3 \*\*\*\*\*

Population's **average fitness: 6.48000** stdev: 9.27629

**Best fitness: 63.00000** - size: (5, 21) - species 1 - id 3

Average adjusted fitness: 0.103

Mean genetic distance 1.859, standard deviation 0.926

Population of 50 members in 2 species:

ID	age	size	fitness	adj fit	stag
1	3	25	63.0	0.099	0
2	3	25	18.0	0.108	0

Total extinctions: 0

Generation time: 52.892 sec (47.795 average)

Saving checkpoint to neat-checkpoint-3

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\*\*\*\*\* Running generation 4 \*\*\*\*\*

Population's **average fitness: 6.70000** stdev: 5.91016

**Best fitness: 27.00000** - size: (5, 20) - species 2 - id 161

Average adjusted fitness: 0.248

Mean genetic distance 1.868, standard deviation 0.746

Population of 50 members in 2 species:

ID	age	size	fitness	adj fit	stag
1	4	20	17.0	0.139	1
2	4	30	27.0	0.357	0

Total extinctions: 0

Generation time: 53.284 sec (48.893 average)

Saving checkpoint to neat-checkpoint-4

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\*\*\*\*\* Running generation 5 \*\*\*\*\*

Population's **average fitness: 7.02000** stdev: 6.91228

**Best fitness: 34.00000** - size: (5, 21) - species 1 - id 58

Average adjusted fitness: 0.218

Mean genetic distance 1.966, standard deviation 0.779

Population of 50 members in 2 species:

ID	age	size	fitness	adj fit	stag
1	5	26	34.0	0.276	2
2	5	24	19.0	0.160	1

Total extinctions: 0

Generation time: 54.251 sec (49.786 average)

Saving checkpoint to neat-checkpoint-5

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Even as per the first 5 generations of training, the average Fitness score can be seen increasing, this means the AI manages to hit the ball using it's paddle, meaning the AI learns through playing the game.

***Project:*** Pong Game with AI using NEAT (NeuroEvolution of Augmenting Topologies)

***By:*** Bawanga Senevirathne

***Project Aim:*** Learning and experimenting

--End--