# An Application of NEAT and HyperNEAT in Solving A Sliding Tile Puzzle

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The purpose: Create agents that can generalize and play 2048 using genetic algorithm

#### **Travelling Salesman Problem**







- Make use of natural selection
- Have a population of possible solutions
- Each candidate has genotype and phenotype
- Guided by the fitness function
- Make improvement using selection, crossover and mutation

#### Genetic Algorithm



# Neuroevolution of

# **Augmenting Topologies**

(NEAT)

#### What is neuroevolution?

- Is a form of artificial intelligence that uses evolutionary algorithms (eg: genetic algorithm) to generate artificial neural networks.
- Used in tasks like hyperparameter optimization, topology finding and; RL control tasks such as pole balancing or game playing...
- Applied in evolutionary robotics, artificial life...

#### Why neuroevolution in game

- Is a perfect test-bed for AI
- Game agent is sought in industry



## Prior neuroevolution algorithm

- Focus on weights rather than topology
- Has complex structure
- Can't protect innovation from disappearing prematurely

#### NEAT | Genetic Encoding

Geno	ome (O	Gen	oty	ype)						
Node Genes	Node 1 Sensor	Node Sens	e 2 sor	Node 3 Sensor	Node 4 Output	Nod Hid	e 5 den			
Connect. Genes	In 1 Out 4 Weight 0.7 Enabled Innov 1		In 2 Out 4 Weight-0.5 <b>DISABLED</b> Innov 2		In 3 Out 4 Weight 0.5 Enabled Innov 3		In 2 Out 5 Weight 0.2 Enabled Innov 4	In 5 Out 4 Weight 0.4 Enabled Innov 5	In 1 Out 5 Weight 0.6 Enabled Innov 6	In 4 Out 5 Weight 0.6 Enabled Innov 11

Network (Phenotype)

#### NEAT | Historical Marking Crossover



#### **NEAT | Speciation & Fitness Sharing**

- Topological innovations are protected when competing in their own niches
- Species is divided using the number of excess gene, disjoint genes and average weight difference.

$$\delta = \frac{c_1 E}{N} + \frac{c_2 D}{N} + c_3 \cdot \overline{W}.$$

#### NEAT | Minimal Initial Structure

- Start with the initial population of uniform networks with zero hidden nodes
- Minimal search space
- New structures are introduced incrementally as structural mutation occurs



#### Modularity and Regularity in Nature









#### **Compositional Pattern-Producing Network**





PicBreeder.org

### HyperNEAT

- Use the same technique as NEAT
- Evolve CPPN
- Create weight for the network through applying input to CPPN

## **The Experiment**

#### 2048



- A single-player sliding tile puzzle
- The objective is to achieve the number 2048
- One can continue playing to achieve a better score

	NEAT	HyperNEAT
Number of generation	20/100	20
Population	200	200
Add edge mutation probability	0.5	0.5
Add neuron mutation probability	0.2	0.2
Weight mutation probability	0.8	0.8
Speciation threshold	1.0	1.0
Weight of edges	[-30, 30]	[-30, 30]
Activation Options	sigmoid	<b>tanh</b> , gauss, sin
Elitism	10	10
Max Stagnation	8	5
Species Elitism	2	5

#### **NEAT Graph 100 Generations**



#### **NEAT Graph 100 Generations**



#### NEAT vs HyperNEAT 20 generations





Population's average and best fitness

#### NEAT vs HyperNEAT 20 generations



#### Conclusion

Because of the random nature of 2048, it makes it hard for the algorithm to master the game.

HyperNEAT performance decays on irregular or task that requires a complex solution.

#### Thank you for listening

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