Evolutionary Computation Applied to Digital Entertainment and the Arts

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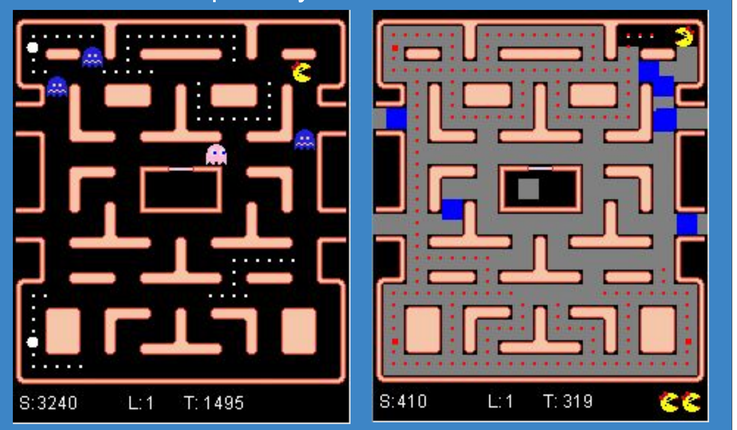
Evolutionary Computation

By simulating the process of evolution, computers are able to create a wide range of intelligent and creative artifacts. An evolved genotype can be a simple list of numbers, or a complex network of artificial neurons. These evolved neural networks can act as brains for intelligent agents in simulated worlds, such as video games. Neural networks can also be used to create vibrant art, and even other neural networks.

Ms. Pac-Man [3]

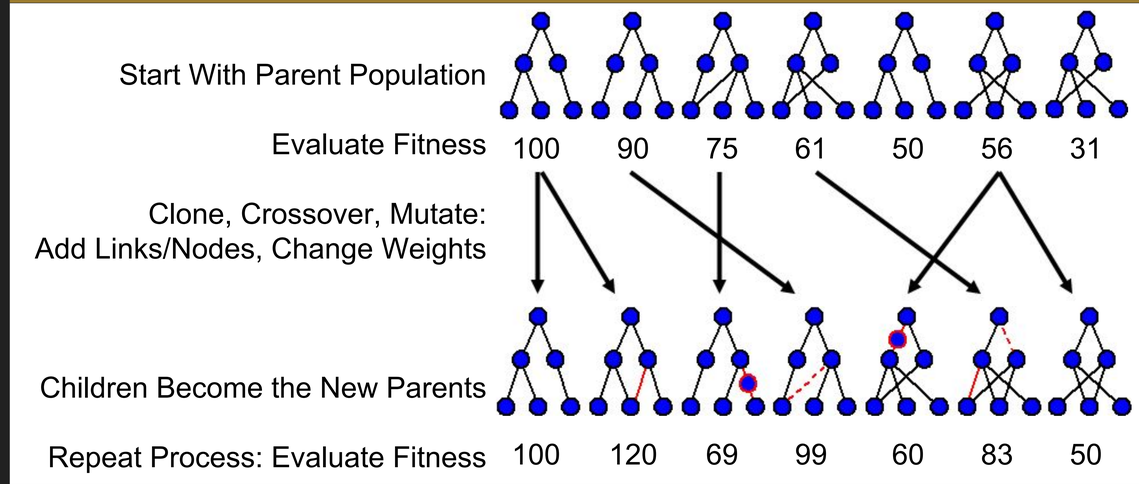
With Will Price

The annual Computational Intelligence in Games conference hosts a competition in which participants design controllers for both Ms. Pac-Man and the ghosts in a challenging partially observable version of this classic video game. A neural network controller for Ms. Pac-Man was evolved using NEAT, and won first place in the 2018 competition. A key enhancement of this entry over previous approaches to Ms. Pac-Man was a ghost model that could reason probabilistically about where ghosts were even when they are not seen. In the future, similar techniques can be applied to evolve controllers for the ghosts, and other agents that must act in partially observable environments.



Fully Observable vs. Partially Observable with Ghost Model

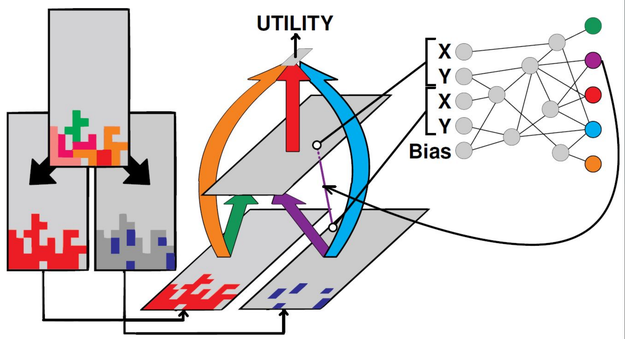
NeuroEvolution of Augmenting Topologies [1]



Tetris [4]

With Lauren E. Gillespie and Gabriela R. Gonzalez

Compositional Pattern Producing Networks (CPPNs) are special neural networks that can define the link weights of much larger neural networks. These larger networks have awareness of the spatial organization of inputs, and are also better at processing raw game state inputs, which means that they can be effective at ranking different possible actions in the game of Tetris.

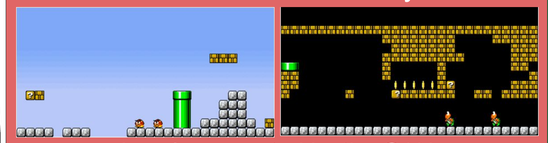


CPPNs create larger networks to evaluate Tetris states

Mario [5]

With V. Volz, J. Liu, S. Lucas, A. Smith, S. Risi

Neural networks can also be trained to generate new content in the style of an existing corpus. Specifically, a Generative Adversarial Network (GAN) can make new Mario levels in the style of original levels given arbitrary number sequences. Then evolution can find specific number sequences that optimize certain properties, such as tile distribution and difficulty.

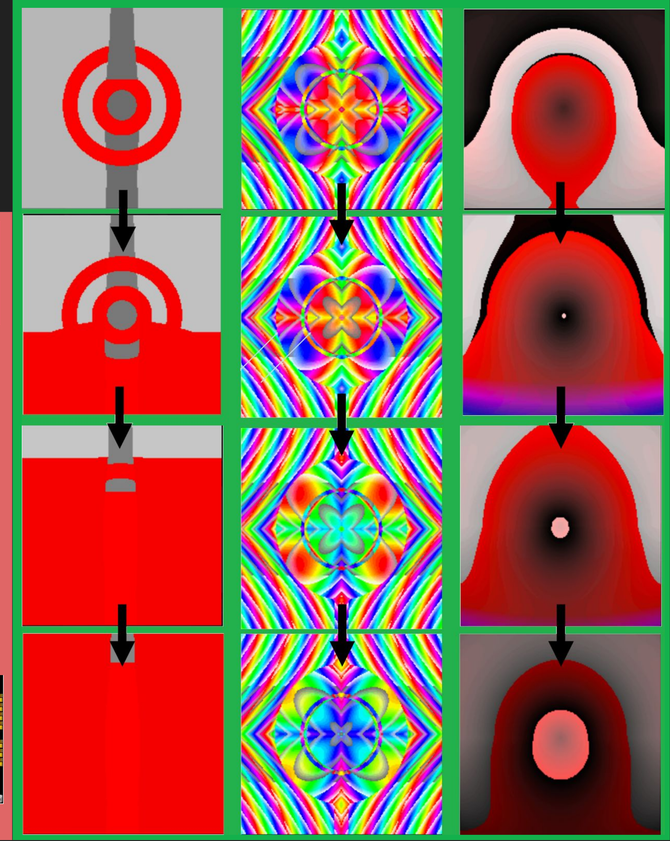


Levels generated by the GAN

Animation Breeder [2]

With Isabel Tweraser and Lauren E. Gillespie

Compositional Pattern Producing Networks can also be used to generate interesting artistic artifacts. Specifically, if a CPPN is told the location of a given pixel, it can assign a color to that pixel. Repeating this process can create an image. Furthermore, if the CPPN is given a time input, then it can designate a different color at each frame, to create vibrant animations.



[1] K. O. Stanley and R. Miikkulainen. 2002. Evolving Neural Networks Through Augmenting Topologies. Evolutionary Computation.
[2] I. Tweraser, L. E. Gillespie and J. Schrum. 2018. Querying Across Time to Interactively Evolve Animations. Genetic and Evolutionary Computation Conference.
[3] J. Schrum and R. Miikkulainen. 2016. Discovering Multimodal Behavior in Ms. Pac-Man through Evolution of Modular Neural Networks. Computational Intelligence and AI in Games.
[4] L. E. Gillespie, G. R. Gonzalez and J. Schrum. 2017. Comparing Direct and Indirect Encodings Using Both Raw and Hand-Designed Features in Tetris. Genetic and Evolutionary Computation Conference.
[5] V. Volz, J. Schrum, J. Liu, S. M. Lucas, A. M. Smith and S. Risi. 2018. Evolving Mario Levels in the Latent Space of a Deep Convolutional Generative Adversarial Network. Genetic and Evolutionary Computation Conference.

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