HYPERCUBE-BASED NEUROEVOLUTION OF AUGMENTING TOPOLOGIES
MOTIVATION

- Simulate complexity of brain
- Patterns, regularity
- Reflection of real world geometry
COMPOSITIONAL PATTERN PRODUCING NETWORKS

- Indirect genetic encoding
- Non-sigmoid functions
- Uses NEAT for ANN evolution
COMPOSITIONAL PATTERN PRODUCING NETWORKS

- simple canonical functions, encodes fundamental regularities
- Evolved using NEAT
- Activation function from given set

(a) Symmetry  (b) Imperfect Symmetry  (c) Repetition with Variation
HYPER NEAT

- Input coordinates of two points into CPPN
- Output is weight of connection
- CPPN computes function \( CPPN(x_1, y_1, x_2, y_2) = w \)
HYPER NEAT

- Connectivity pattern is *Substrate*
- Spacial x connectivity pattern
SUBSTRATE

- Configuration
- Input & output
- Resolution
**BASIC ALGORITHM**

**Input:** Substrate Configuration  
**Output:** Solution CPPN  

1. Initialize population of minimal CPPNs with random weights;  
2. while Stopping criteria is not met do  
   3. foreach CPPN in the population do  
      4. foreach Possible connection in the substrate do  
      5. Query the CPPN for weight \(w\) of connection;  
      6. if \(\text{Abs}(w) > \text{Threshold}\) then  
      7. Create connection with a weight scaled proportionally to \(w\) (figure 3);  
      8. end  
   9. end  
   10. Run the substrate as an ANN in the task domain to ascertain fitness;  
11. end  
12. Reproduce CPPNs according to the NEAT method to produce the next generation;  
13. end  
14. Output the Champion CPPN;  

**Algorithm 1:** Basic HyperNEAT Algorithm
VISUAL DISCRIMINATION EXPERIMENT

- Task: find center of the biggest black object
- Neuroevolution needs to find the pattern
- HyperNEAT x P-NEAT
FOLLOWING DEVELOPMENT

- evolvable-substrate HyperNEAT
- quadTree division
- density is following the information
- Multiagent system
- learning of policies
- Autonomous Evolution of Topographic Regularities in Artificial Neural Networks, *Jason Gauci, Kenneth O. Stanley*

- A Hypercube-Based Indirect Encoding for Evolving Large-Scale Neural Networks, *Kenneth O. Stanley, David D’Ambrosio, Jason Gauci*

- Enhancing ES-HyperNEAT to Evolve More Complex Regular Neural Networks, *Sebastian Risi, Kenneth O. Stanley*