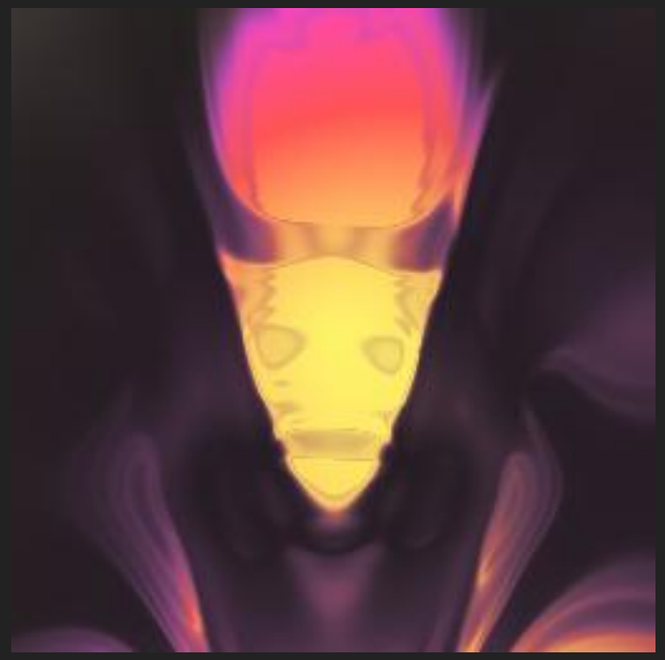
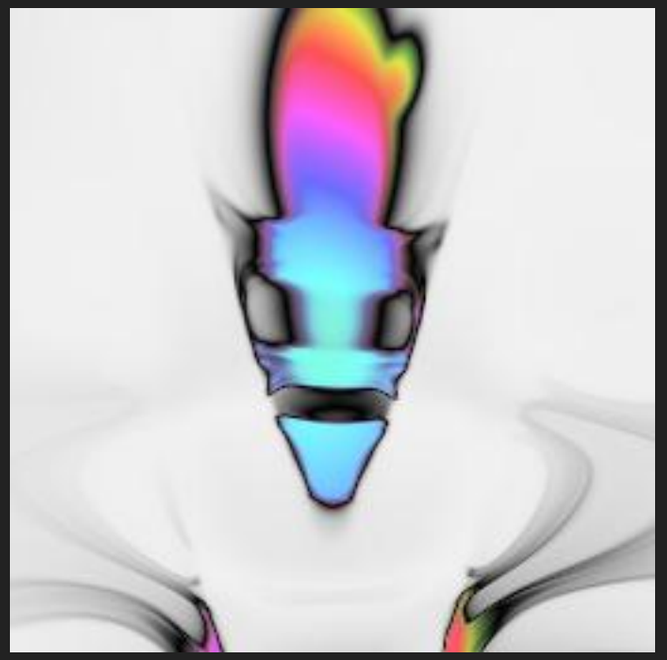
HYPER NEAT

Lukas Meduna

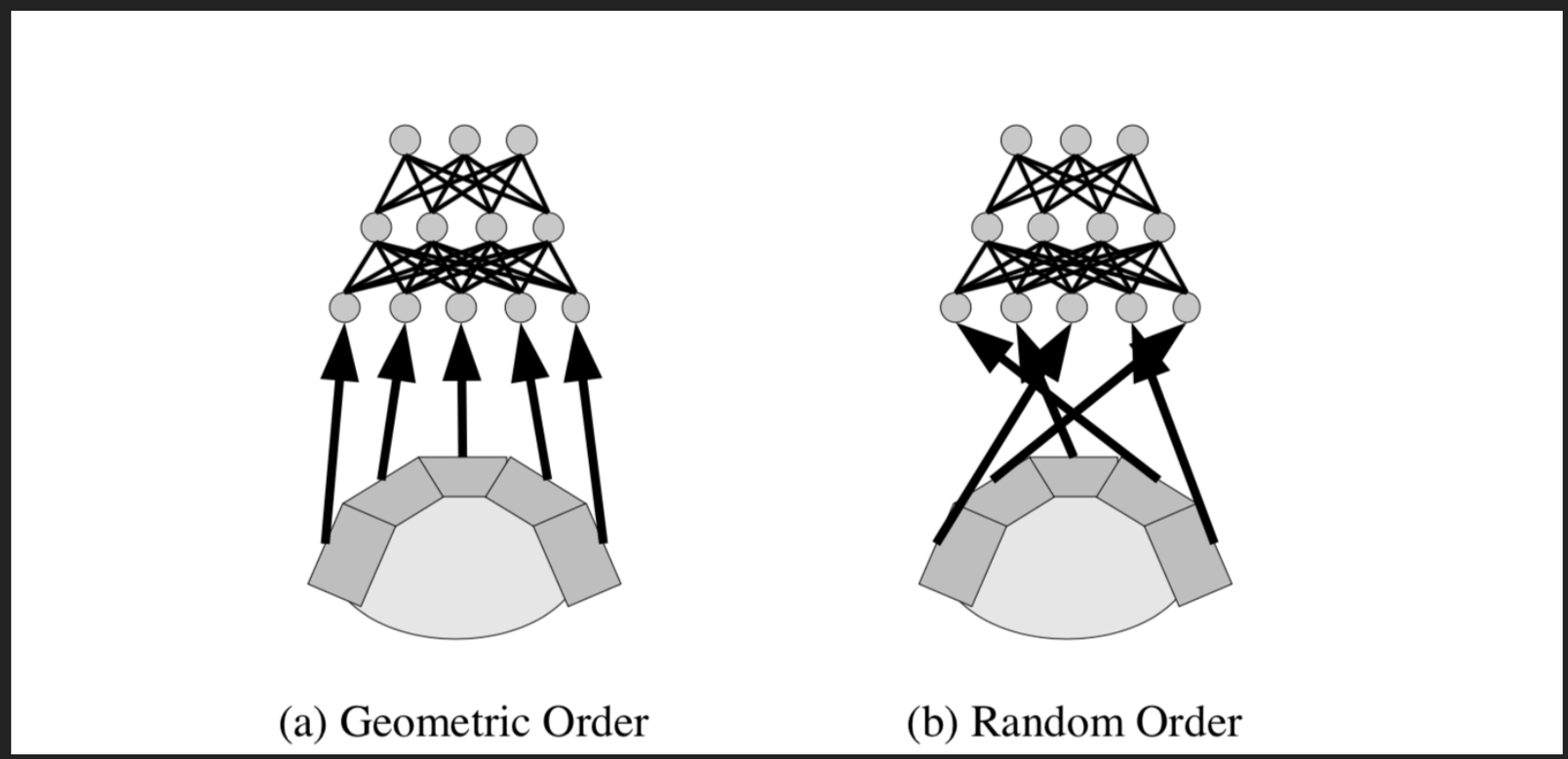
HYPERCUBE-BASED NEUROEVOLUTION OF AUGMENTING TOPOLOGIES





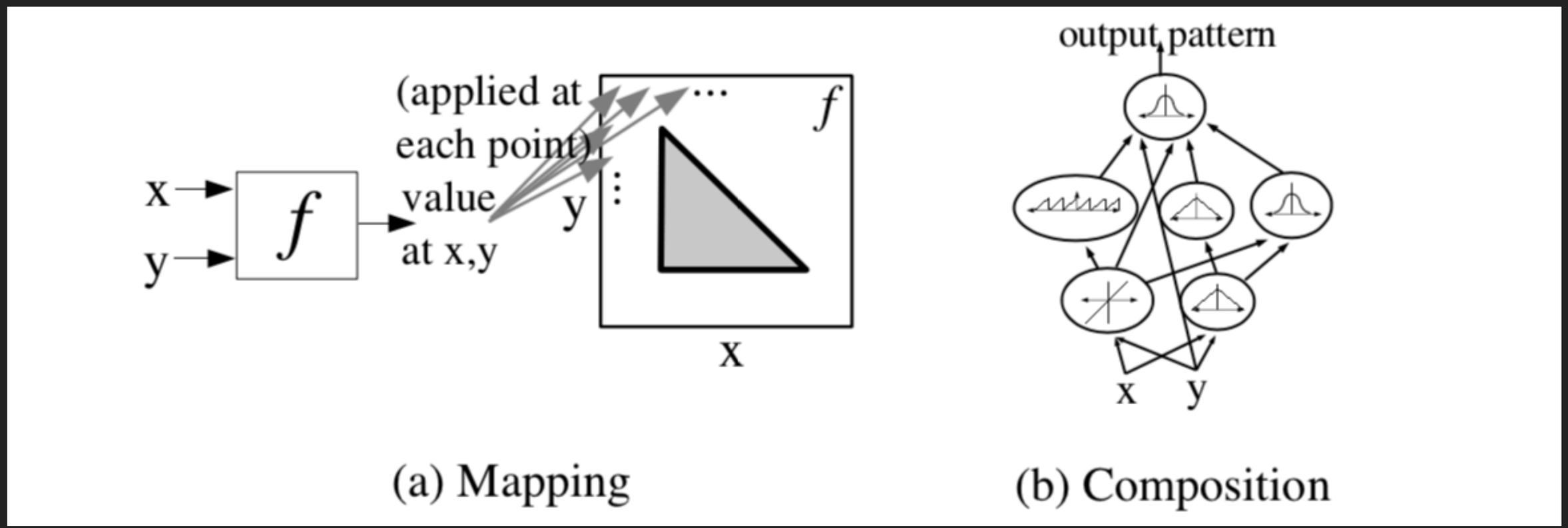
MOTIVATION

- Simulate complexity of brain
- Patterns, regularity
- Reflection of real world geometry



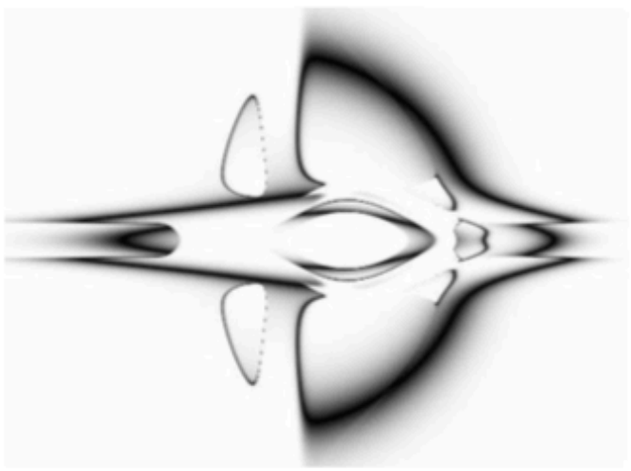
COMPOSITIONAL PATTERN PRODUCING NETWORKS

- Indirect genetic encoding
- Non-sigmoid functions
- Uses NEAT for ANN evolution

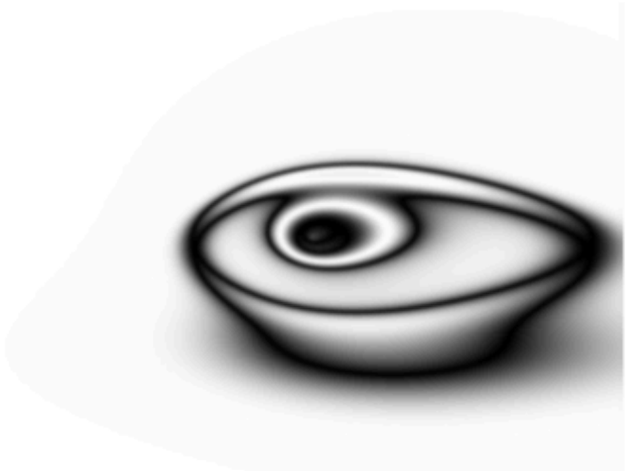


COMPOSITIONAL PATTERN PRODUCING NETWORKS

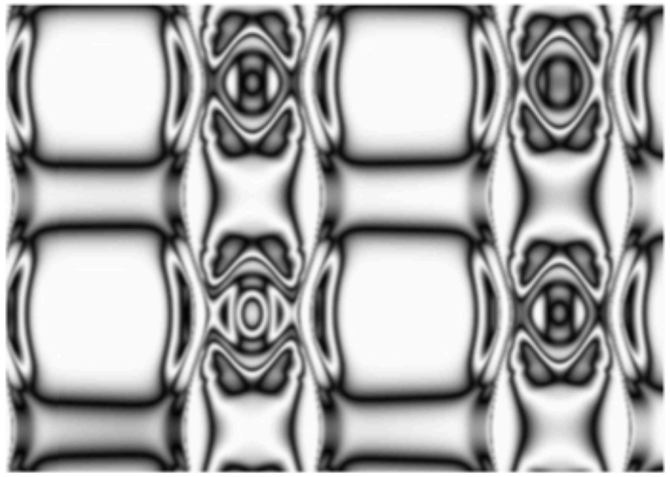
- simple canonical functions, encodes fundamental regularities
- Evolved using NEAT
- Activation function from given set



(a) Symmetry



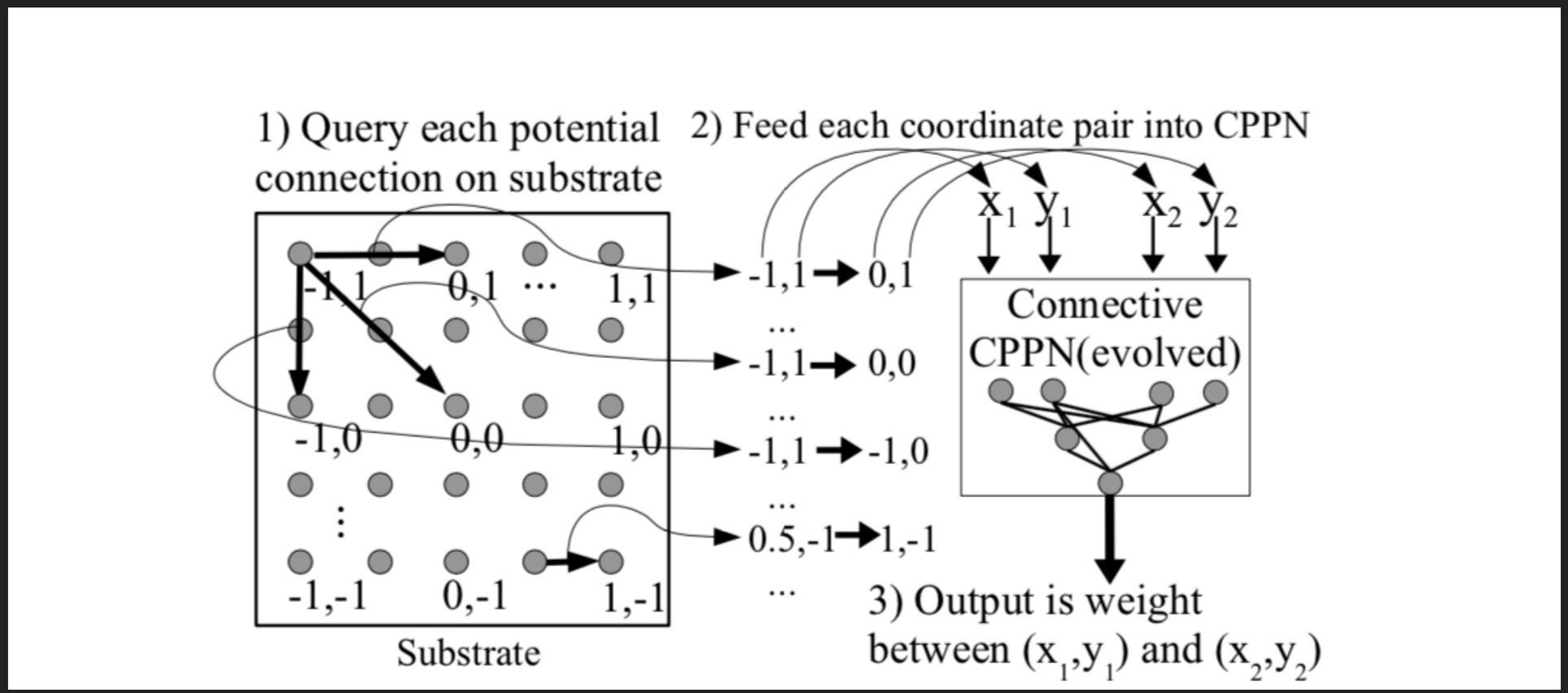
(b) Imperfect Symmetry



(c) Repetition with Variation

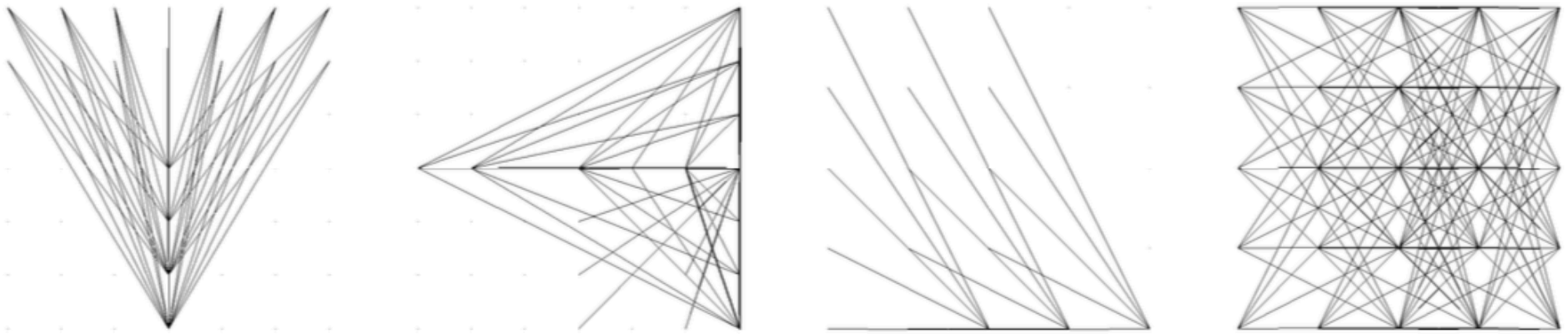
HYPER NEAT

- 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

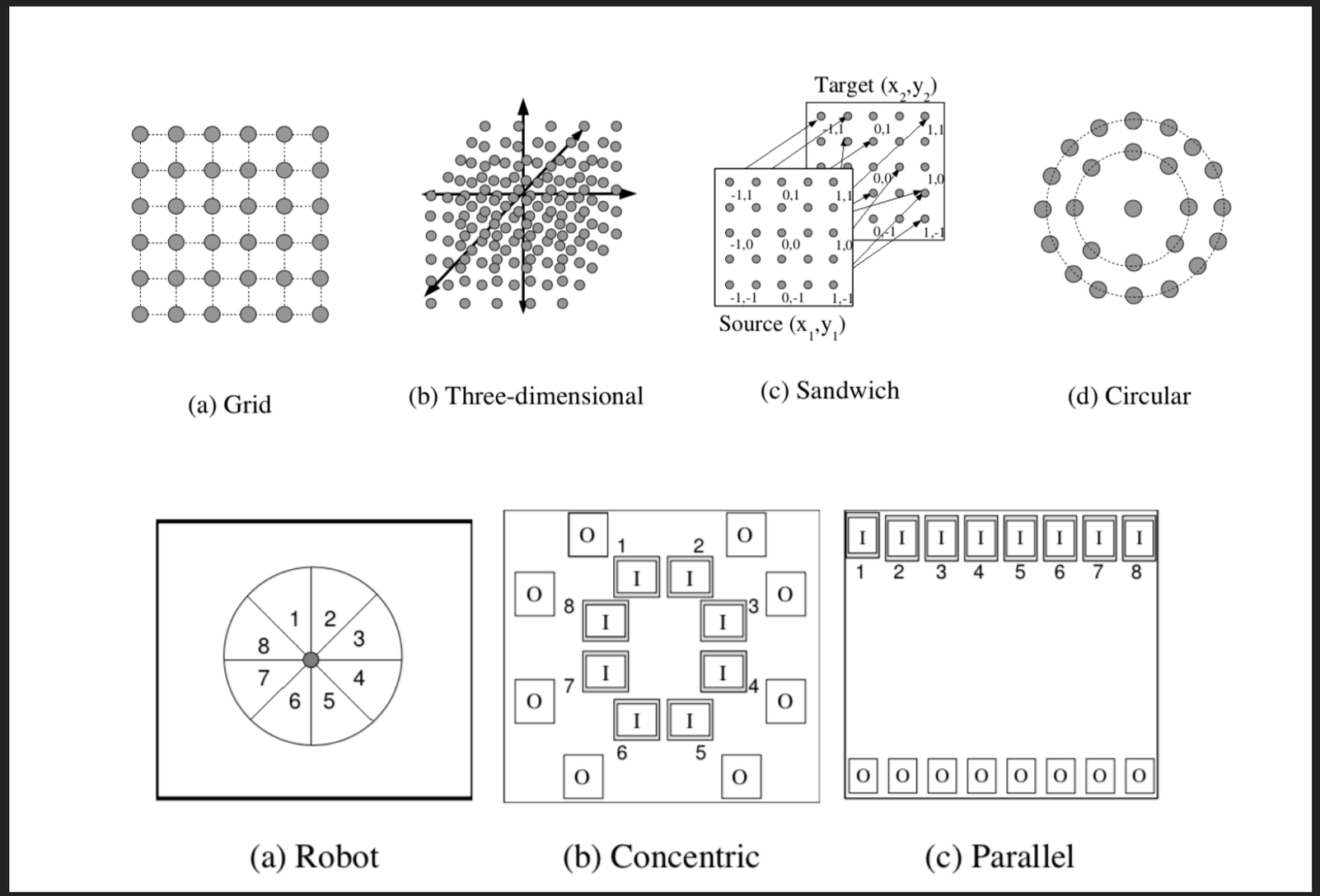
- Connectivity patern is *Substrate*
- Spacial x connectivity pattern



(a) Symmetry (b) Imperfect Sym. (c) Repetition (d) Rep. with Var.

SUBSTRATE

- Configuration
- Input & output
- Resolution



BASIC ALGORITHM

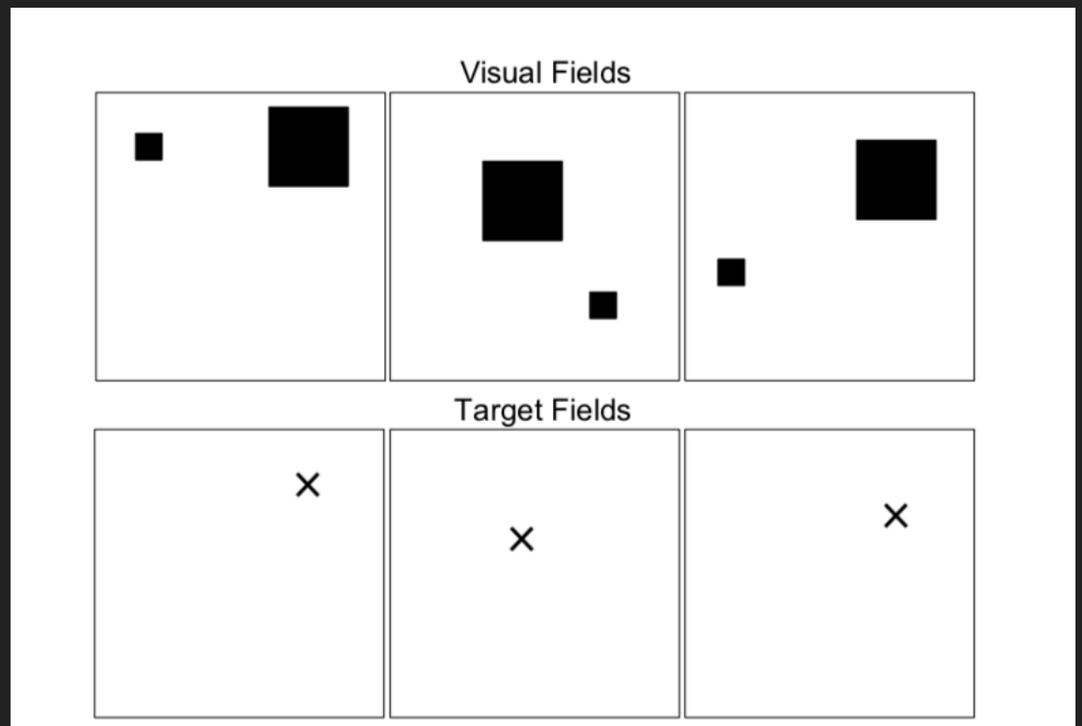
Input: Substrate Configuration
Output: Solution CPPN

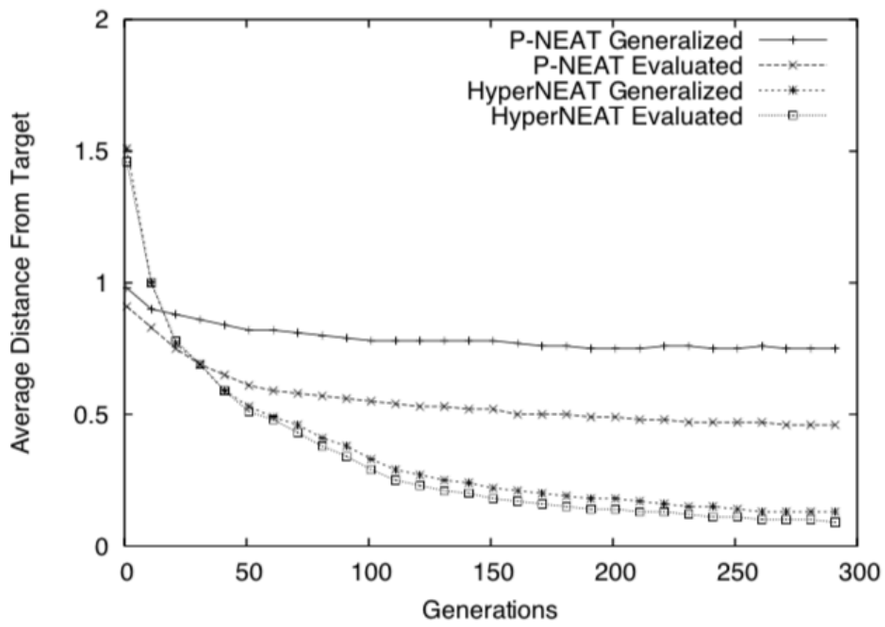
```
1  Initalize population of minimal CPPNs with random weights;
2  while Stopping criteria is not met do
3      foreach CPPN in the population do
4          foreach Possible connection in the substrate do
5              Query the CPPN for weight w of connection;
6              if Abs(w) >Threshold 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;
```

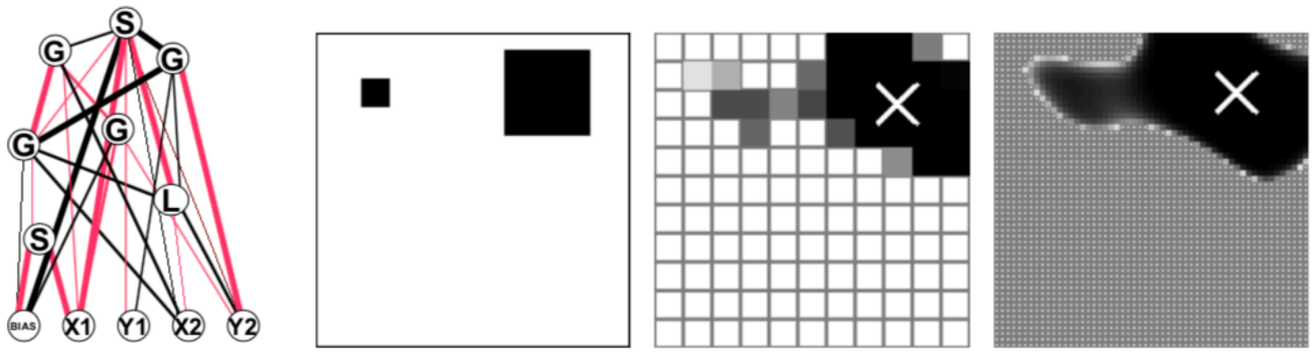
Algorithm 1: Basic HyperNEAT Algorithm

VISUAL DISCRIMINATION EXPERIMENT

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



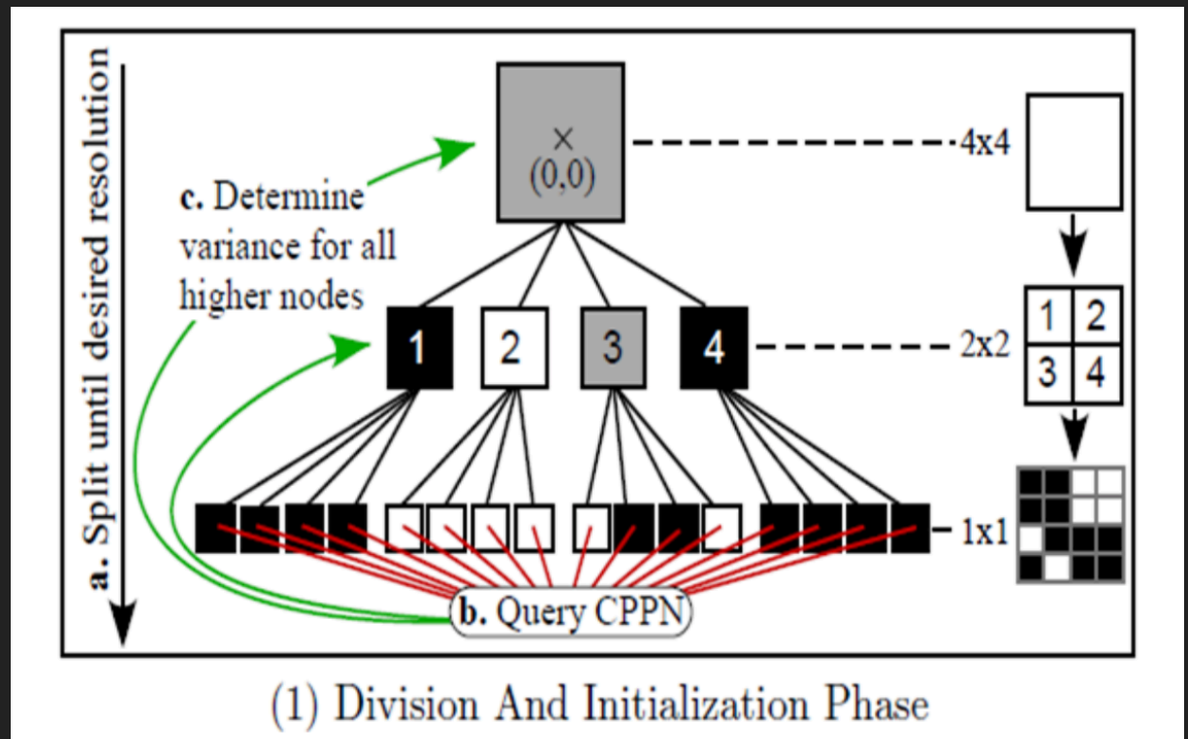




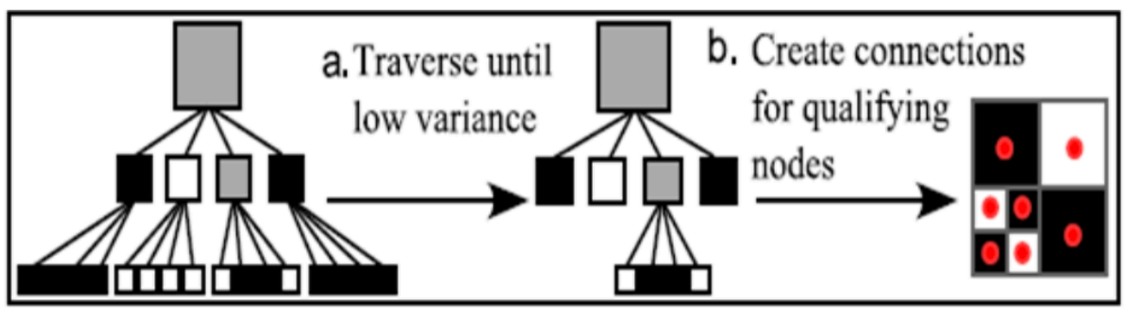
(a) CPPN (b) Input Pattern (c) 11 × 11 Output (d) 55 × 55 Output

FOLLOWING DEVELOPMENT

- evolvable-substrate HyperNEAT
  - quadTree division
  - density is following the information
- Multiagent system
  - learning of policies



(1) Division And Initialization Phase



(2) Pruning And Extraction Phase

SOURCES

- Autonomous Evolution of Topographic Regularities in Artificial Neural Networks, *Jason Gauci, Kenneth O. Stanley*
  - http://eplex.cs.ucf.edu/papers/gauci_nc10.pdf
- A Hypercube-Based Indirect Encoding for Evolving Large-Scale Neural Networks, *Kenneth O. Stanley, David D'Ambrosio, Jason Gauci*
  - http://eplex.cs.ucf.edu/papers/stanley_alife09.pdf
- Enhancing ES-HyperNEAT to Evolve More Complex Regular Neural Networks, *Sebastian Risi, Kenneth O. Stanley*
  - http://eplex.cs.ucf.edu/papers/risi_gecco11.pdf