Evolutionary Networks

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Starting Point

- Articles by Ana Porto (2002-2010)
  - Compared performance of Artificial Neural Networks (AAN) against Artificial Glial Neural Networks (AGNN)
  - ANN: feedforward network
  - AGNN: attach one astrocyte per neuron
    - ✓ once astrocyte is activated on a slower time scale, the neuron it is attached to and those neurons connected in the forward direction, have their weights increased
- Results: Porto reports improved results in classification problems with AGNN, more improvement for complex sells.

However,

- Adler (undergraduate student), could not duplicate Porto's results.
- He found better performance of her ANN, and his AGNN performed worse

Porto's Results

- Porto was not sufficiently precise in her papers
- I could not get her Ph.D. thesis from her, even after direct communication with her and her advisor
- Conclusion: I do not trust her work

Porto papers

- Artificial Neural Networks Based on Brain Circuits Behaviour and Genetic Algorithms_2005_porto, pazos, araque_chapter.pdf
  A new hybrid evolutionary mechanism based on unsupervised learning for Connectionist Systems_2007_porto, araque, pazos_paper.pdf
- Artificial neuron-glia networks learning approach based on cooperative coevolution_2016_mesejo, et al, porto_paper.pdf
- Artificial Astrocytes Improve Neural Network Performance_2011_porto-pazos_paper.pdf
- Computational Models of Neuron-Astrocyte Interactions Lead to Improved Efficacy in the Performance of Neural Networks_2012_alvarellos_gonzalez_porto-pazos_paper.pdf

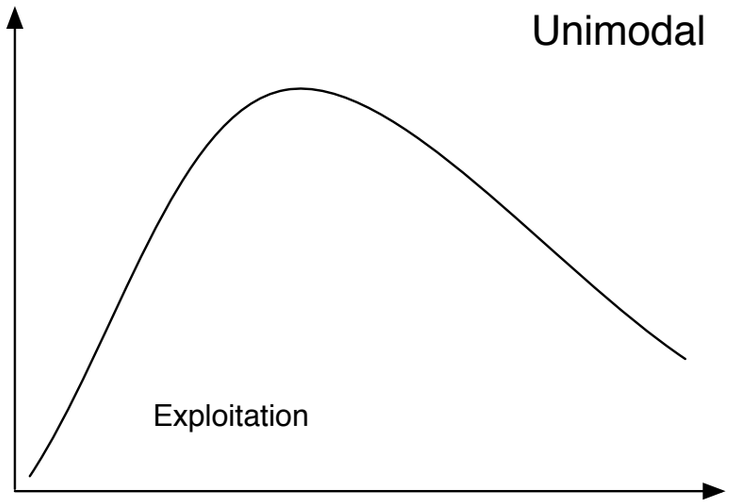
Approach

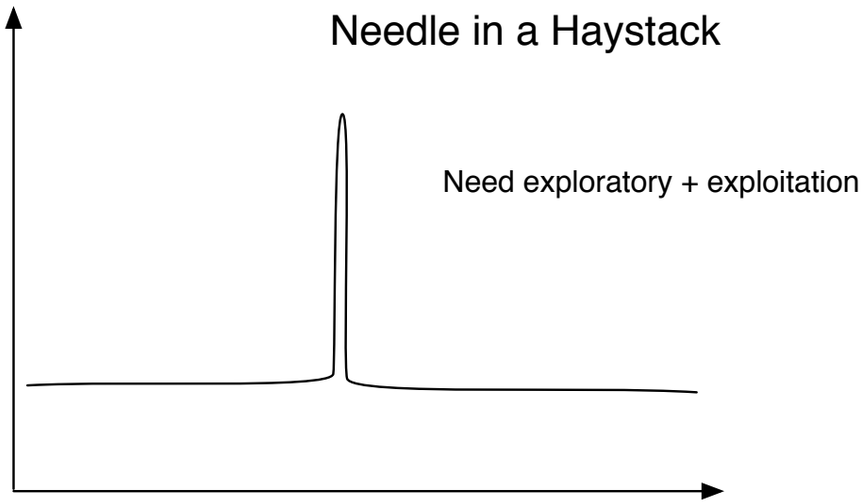
- Backpropagation was used to determine the weights of the ANN
- A genetic algorithm was used to determine some of the parameters of the artificial astrocyte model (I will not describe it here)

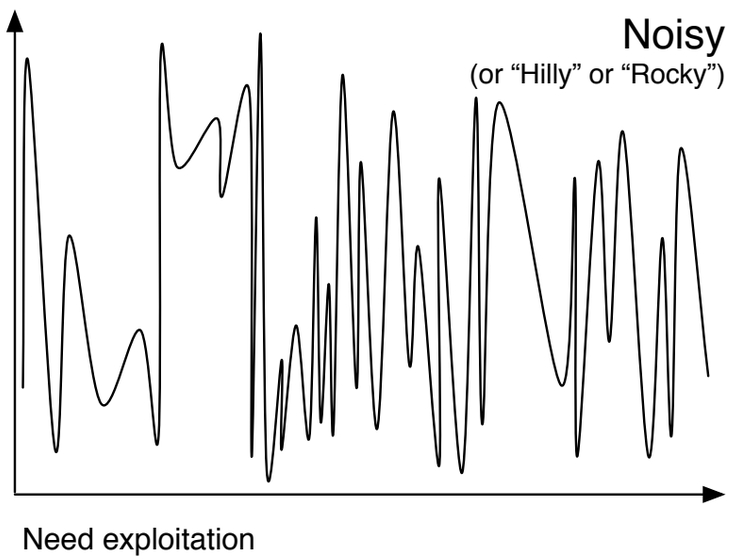
Generally

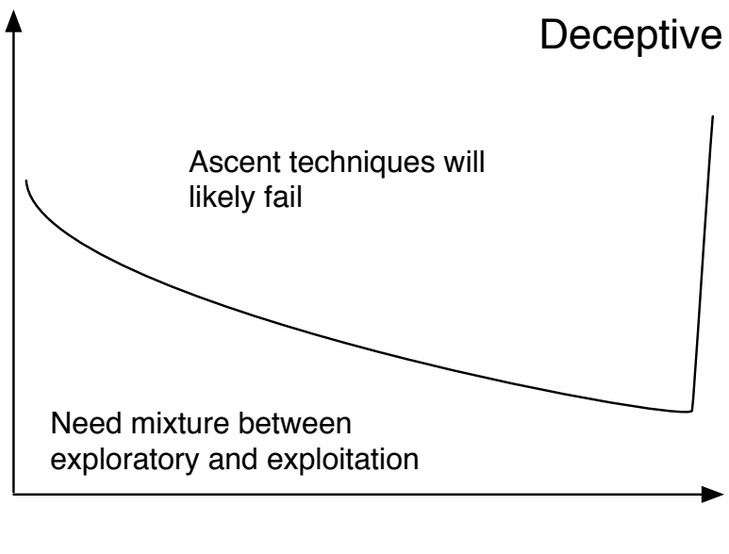
- Search algorithms are a balance between
  - exploration
    - ✓ cover parameters space
  - exploitation
    - ✓ exploit local structure of optimization landscape

Four fitness landscapes









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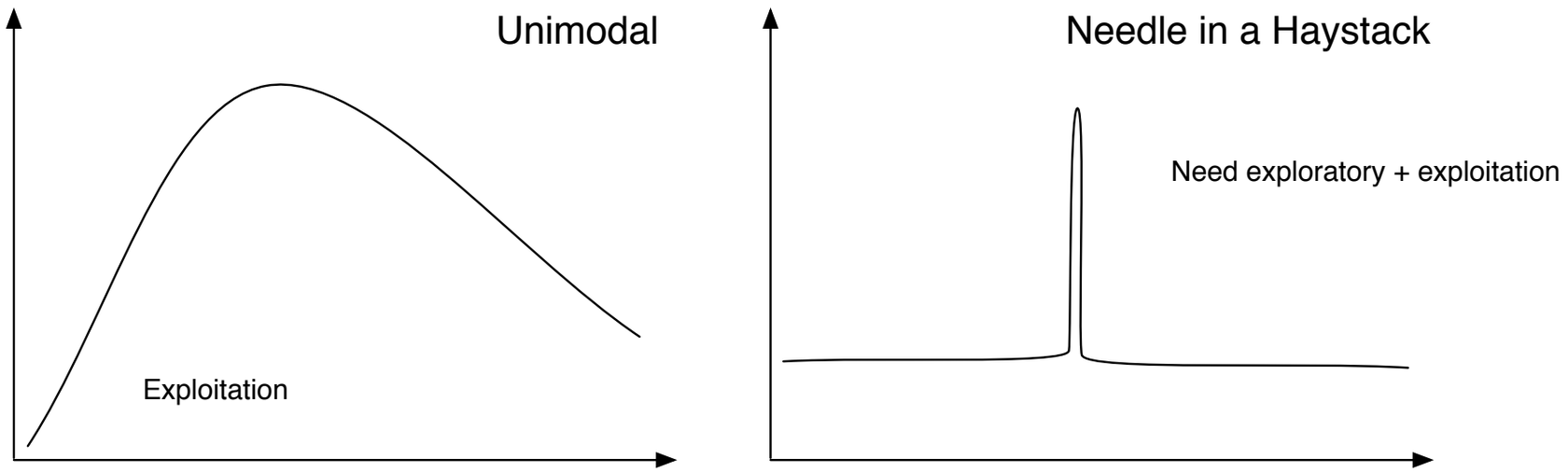
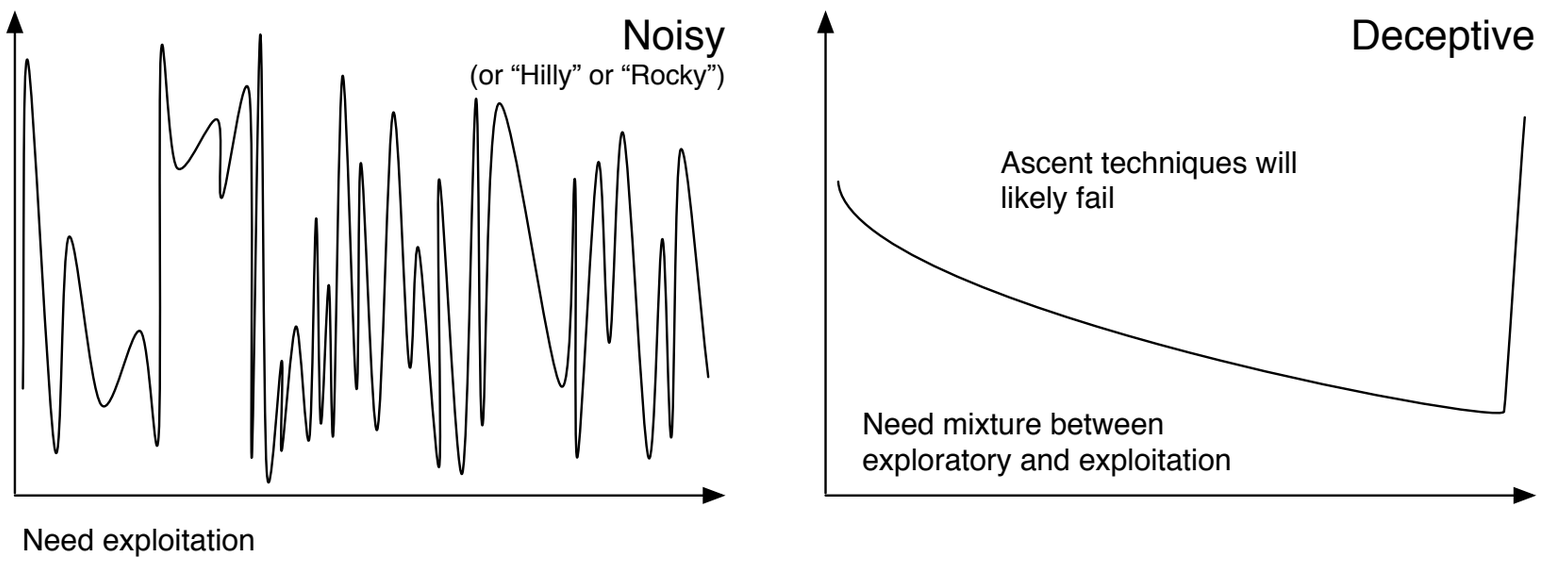
1D landscape

Single parameter





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Imagine 20 paramters

20-D space!!!

This got me thinking

- Evolve the topology of the network
- Evolve the astrocyte model
- Run unsupervised networks
- Evolve the evolution rules themselves

Variety of approaches

- Hill climbing and variants
- Genetic Algorithms
- Ant colony optimization
- Monte-Carlo and variants
- Simulated Anhealing
- etc.

Genetic Algorithms

- One of many evolutionary algorithms
  - encodes parameter problems in some representation
    - ✓ string of floats, string of bits, graph, etc.
  - establishes a population of problems
- Requires a fitness function

Genetic Operators

- Fitness selection from a population
- Mutations
- Crossovers

Advantage of genetic algorithms

- A problem can be parametrized by "n" parameters
- The problem need not depend continuously on these parameters
- However,
  - GAs are stochastic in nature
  - results not guaranteed

NEAT framework

- Evolution of Neural Networks
- Uses genetic-like algorithm
- Designed to evolve topologies
- Mutation operator (add nodes, add edges)
- Crossover operator (create a new topology from two old ones)

History Marker

- Given two topologies, how to create an offspring?
- Keep track of when nodes and edges are added with a historical marker
- Use the marker to create new topologies in such a way that local sections of the topology have a change to evolve and prove themselves rather than be destroyed immediately

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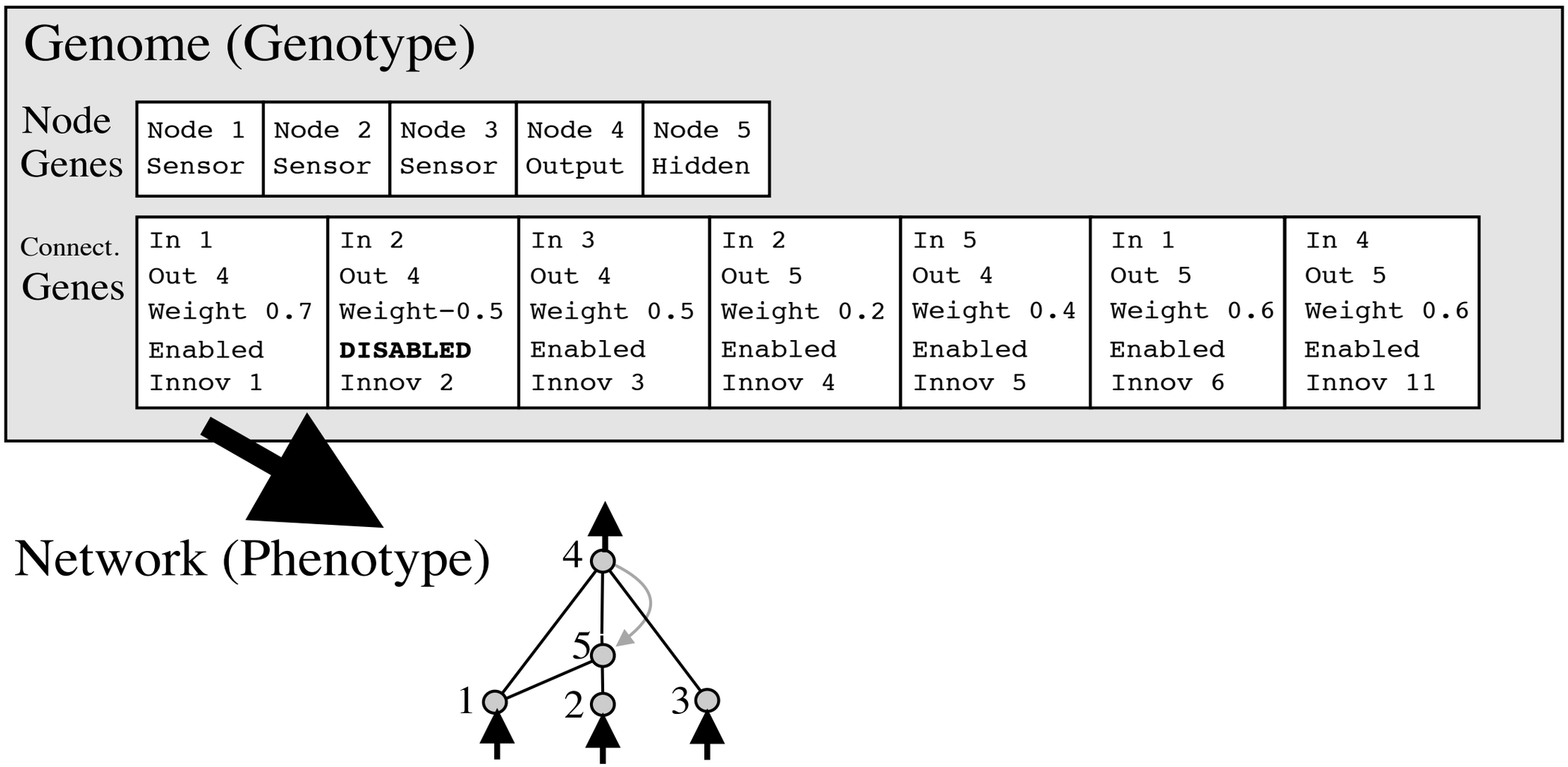
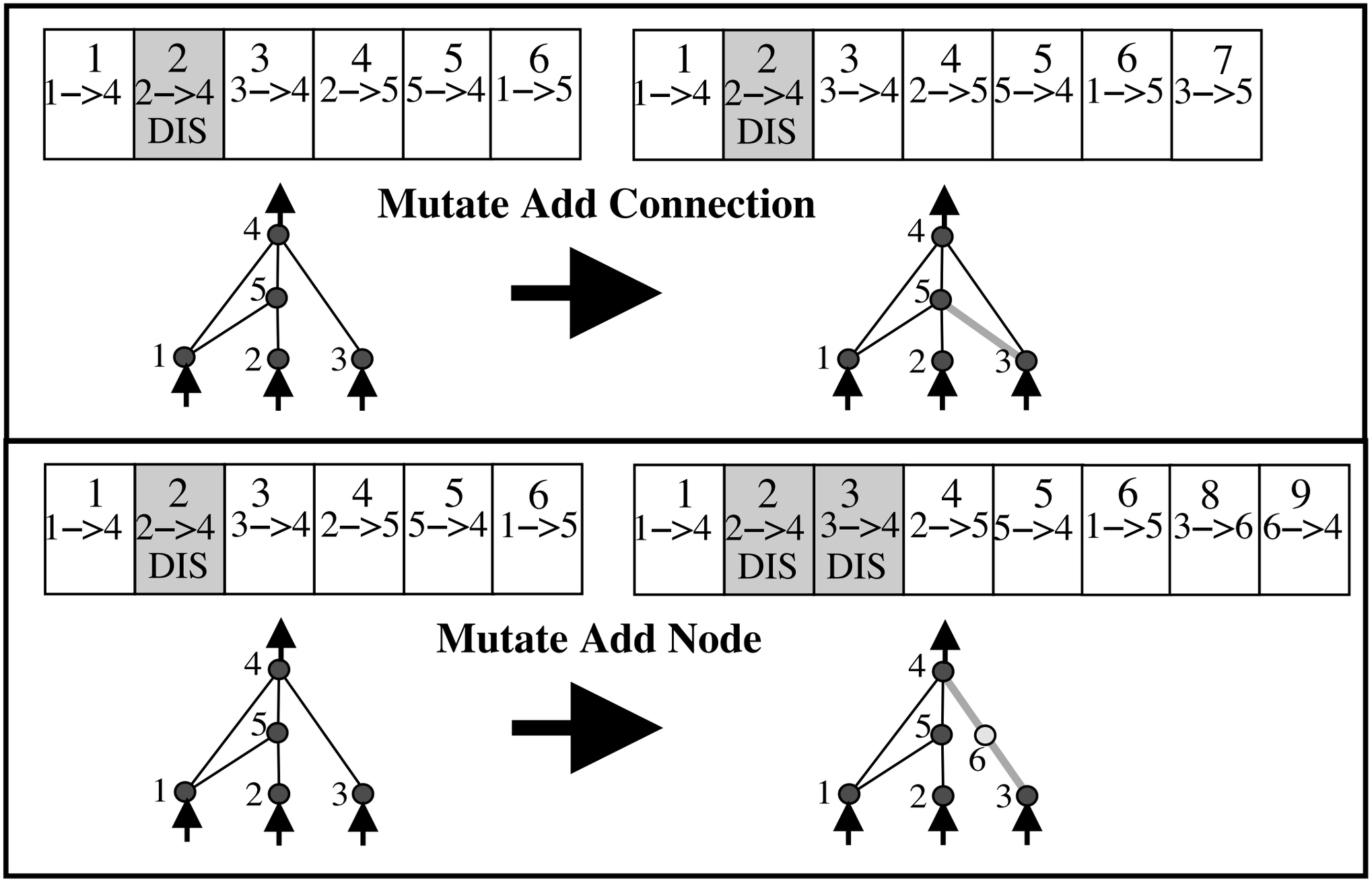
- The chapter on Representations discusses different ways of encoding information for evolutionary information (lists of parameters, graphs, etc.)

Genotype to phenotype



Mutations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Mutate Add Connection
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Mutate Add Node
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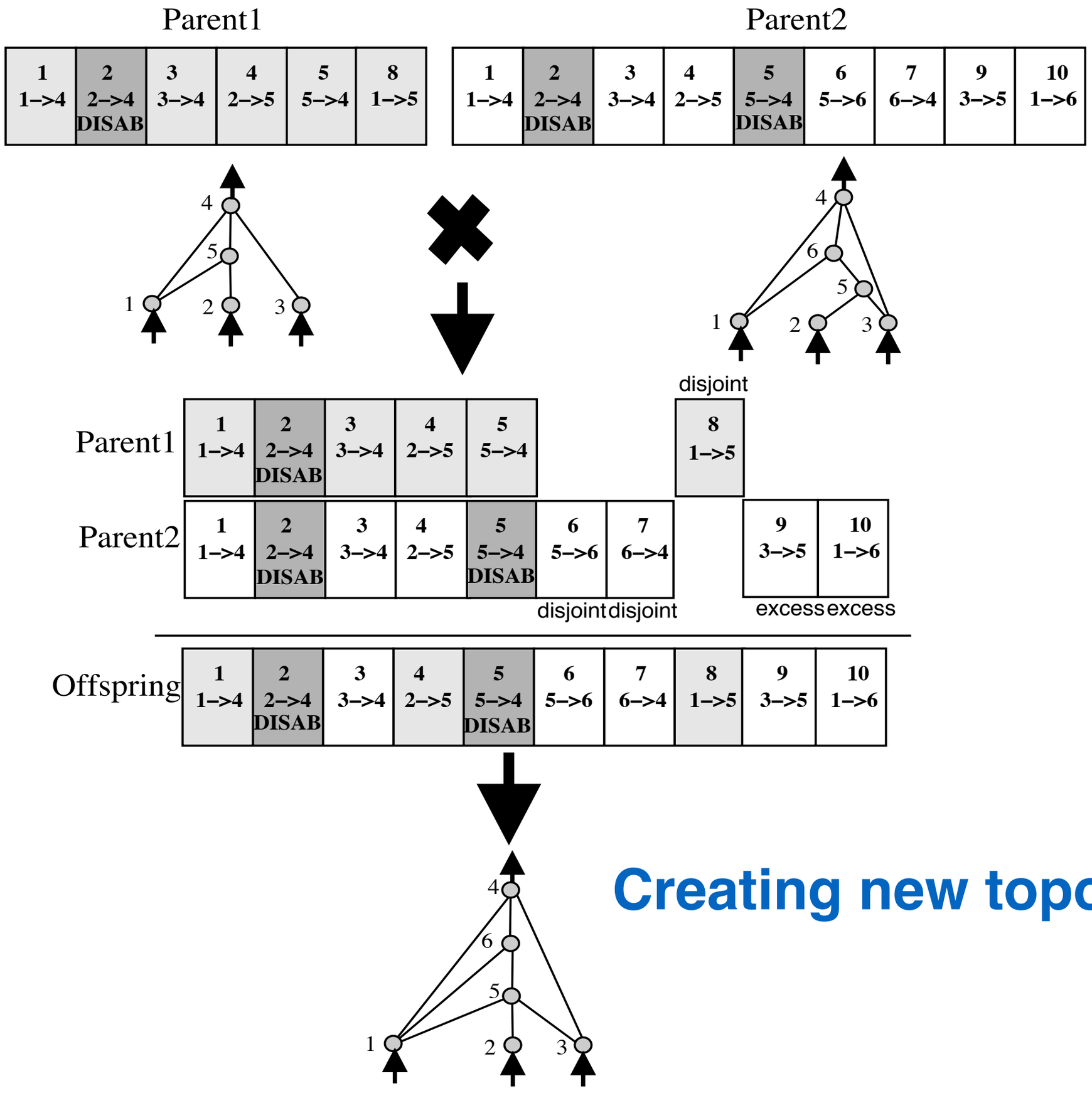

Creating new topologies