



Genetic Algorithms and Feed-Forward Neural Network Training

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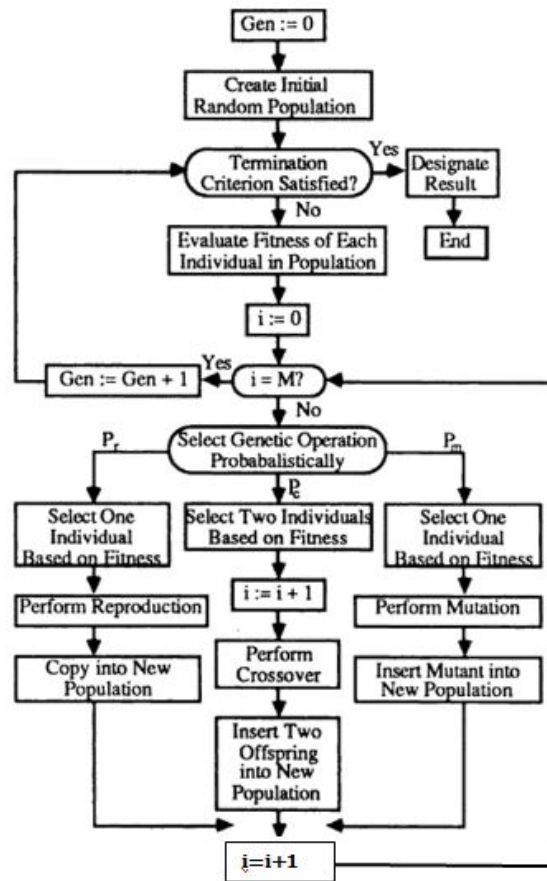
What are Neural Networks?

What problems with Neural Networks are we hoping to address?

What are Genetic Algorithms?

Genetic Algorithms

- We can use individuals to encode information about the neural network:
 - Hyperparameters (e.g., learning rate, batch size).
 - Weight initialization and learning
 - Network architecture (e.g., number of layers, neurons per layer).
- Populations of networks enable exploration
 - Provide diverse opportunities to discover optimal network architectures.
 - Can even outperform backprop



Genetic Algorithms vs. Backpropagation

- The genetic algorithm performed better than backpropagation
 - Only used variation of standard genetic operators
 - Backprop required twice as much computation

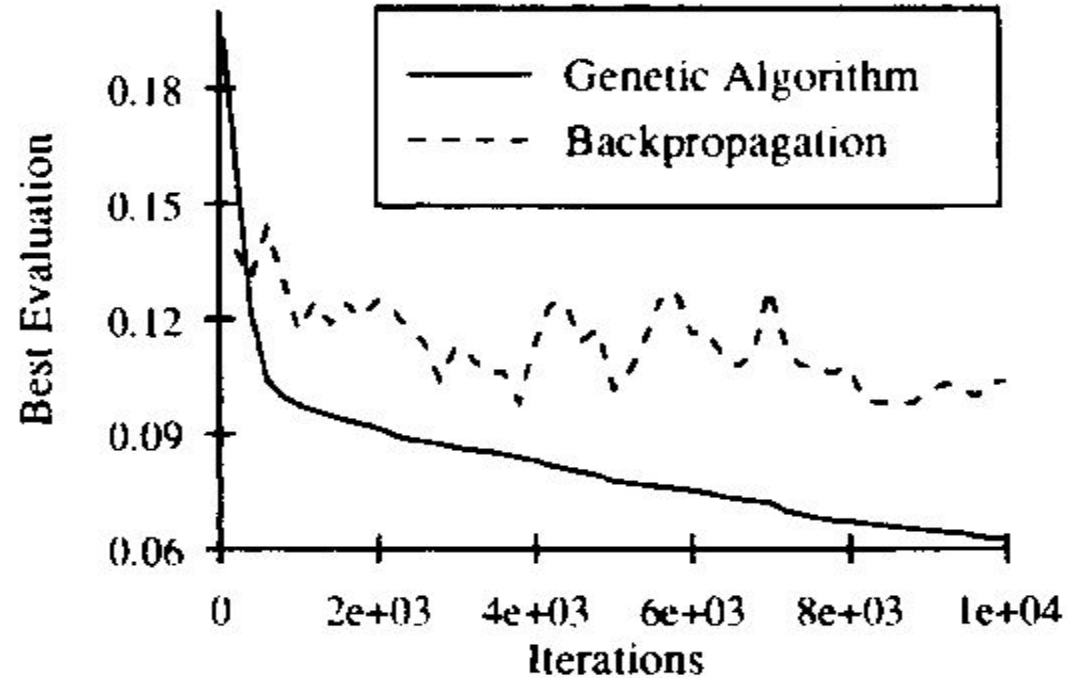
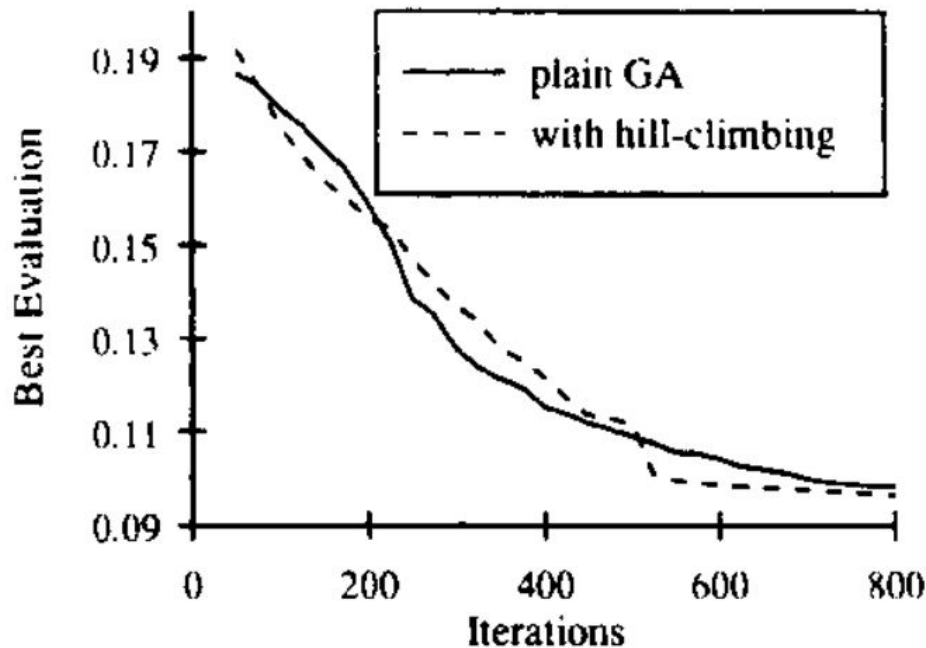


Figure 8: Results of Experiment 5

Gradient-Based Approach to Improve Performance

Gradient-Based Performance Tuning

- Uses a global normalized gradient, unlike backpropagation.
 - Different from backprop gradient
- Dynamically increases step size if error improves.
 - Similar to momentum



Neuroevolution

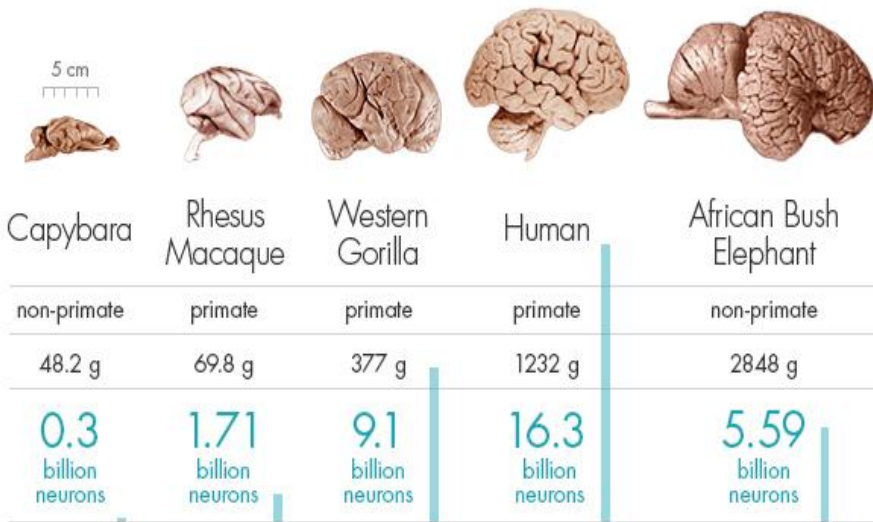
Using evolutionary algorithms
with neural networks

The combination of genetic algorithms and neural networks forms a subset of the broader field of neuroevolution.

What is Neuroevolution?

BRAIN SIZE AND NEURON COUNT

Cerebral cortex mass and neuron count for various mammals.

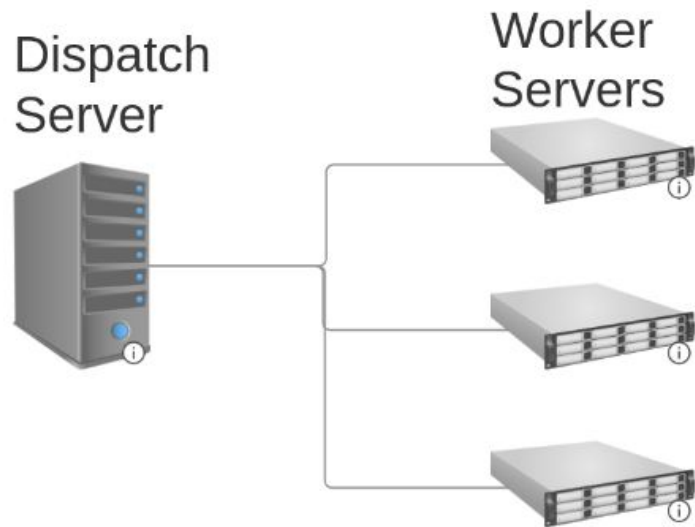


Early Approaches in Neuroevolution:

- Initially focused on evolving weights as an alternative to backpropagation.
- Later efforts became more sophisticated, aiming to replicate nature by evolving entire network architectures.

Advantages of Neuroevolution

- **Highly Parallelizable**
 - Evaluations can be distributed across worker servers
 - Most operations occur independently, unlike backprop, which is sequential and depends on forward propagation.
- **Better Exploration of Search Space**
 - Larger populations help avoid local minima through greater diversity.



Advantages of Neuroevolution (Continued)

Hyper parameters define the architecture of neural networks. *Most networks rely on well chosen hyperparameters as they dictate performance—but ironically, they don't train themselves. So, how do we find them?*

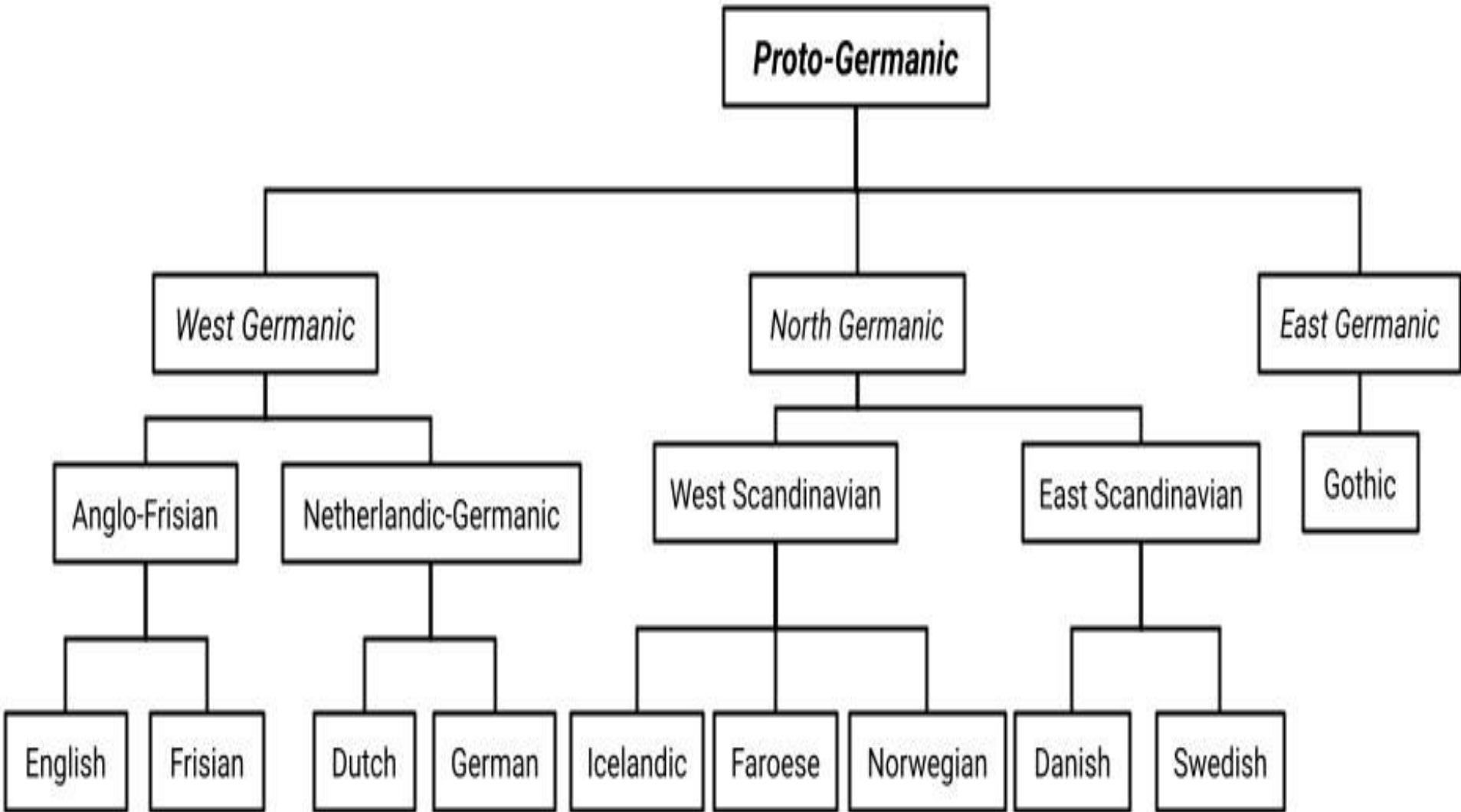
- Small models can be manually tuned
 - This isn't possible on larger networks
 - hyperband or Bayesian optimization techniques commonly used
 - What about genetic algorithms?



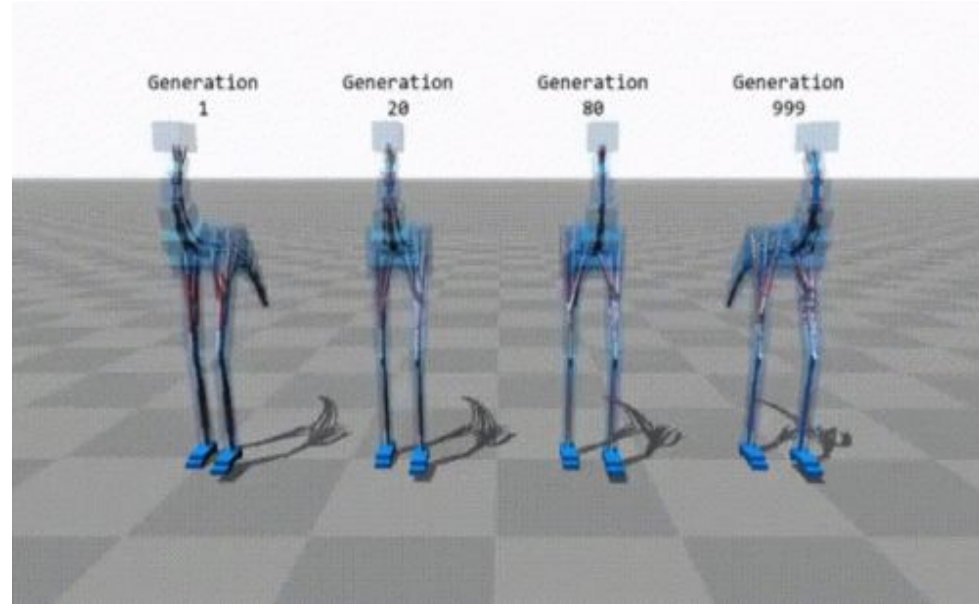
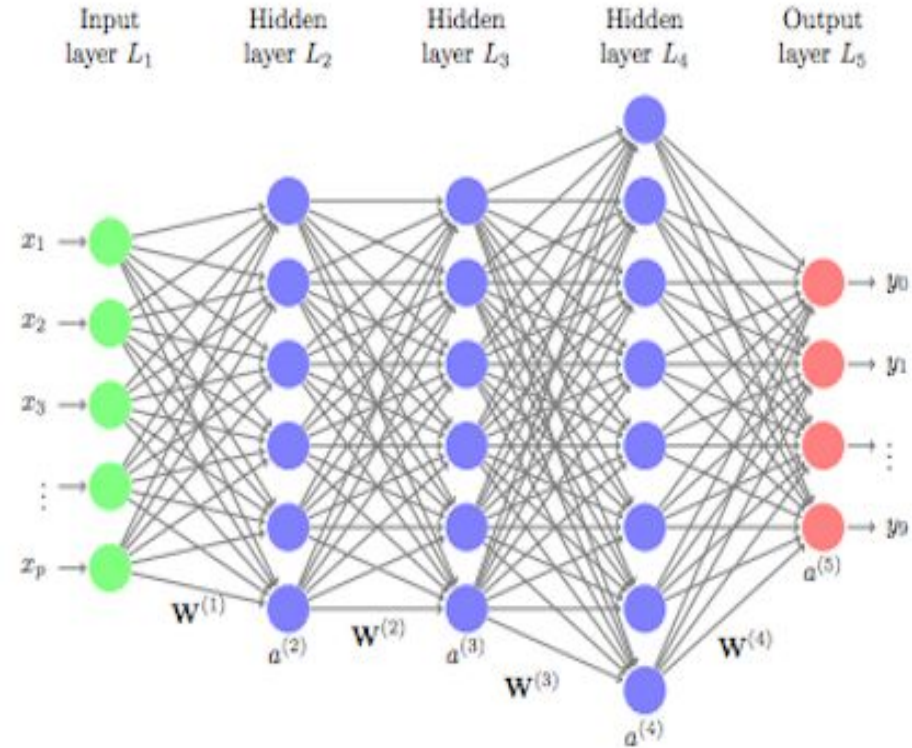
Applications for Neuroevolution

- Robotic Control Systems
 - Robotic Dogs!
- Multitask Neural Networks
 - Use neuroevolution to generate multiple output layers for different problems with similar patterns.
- Natural Language Processing





Conclusions



References

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