Evolution of Neural Networks
AAAI 2027 Tutorial Outline

Risto Miikkulainen, The University of Texas at Austin and Cognizant AI Lab

1. Motivation (10 mins)
    - Gradient descent vs. exploration
    - Prediction vs. prescription (i.e. agents)
    - Imitation vs. creativity

2. Techniques (20)
    - Fundamentals of neuroevolution:
        - Population-based search
        - Weight optimization
        - Topology evolution (i.e. NEAT)
    - Taking advantage of indirect encodings:
        - Developmental encodings
        - Hypernetworks
    - Taking advantage of diversity:
        - Novelty search
        - Quality diversity (i.e. MAP-Elites)

3. Evolving behavior (30)
    - Control and strategy
        - Extrapolation techniques
        - Multimodal behavior techniques
        - Robotics, Game playing applications
    - Decision making
        - Surrogate modeling techniques
        - Pandemic optimization, climate change applications
    - Collective systems
        - Cooperative coevolution of multiagent systems
        - Competitive coevolution & open-ended arms race

4. Evolving architectures (20)

- Neural architecture search
  - Nodes, modules, topologies, multitask systems
  - CoDeepNEAT, AmoebaNet examples
- Metalearning
  - Loss & activation functions, learning methods
  - Comparison to human designs in age prediction task

5. Synergies with other fields (20)
   - Neuroevolution and RL
     - Combining population and individual time scales
     - Evolving function approximations and starting points
   - Neuroevolution and GenAI
     - Neuroevolution to enhance GenAI (e.g. AlphaEvolve)
     - GenAI to enhance neuroevolution
   - Neuroevolution and Biology
     - Evolutionary origins of circuitry
     - Role of environmental constraints
     - Emergence of intelligence
     - Proposal: Evolution of language
6. Conclusion (5)
7. (Optional) Hands-on exercise (30)
   - Neuroevolution for control
   - Evolutionary model merging
   - Quality diversity