Literature Review

# Plan

1. What is Neuroevolution
2. When did neuroevolution start becoming a thing
3. Why neuroevolution what do we use it for
4. How is nueroevolution implemented
5. How is nueroevolution more beneficial than others in its field how does it compare?
6. What are its disadvantages?
7. What is its potential?
8. Whats the future of neuroevolution?

**What is Neuroevolution?**

* The general idea of Neuroevolution is Darwinian principles being applied in computer algorithms and artificial neural networks combined with this is and deep learning and neurocomputation is neuroevolution. The intersection of neural networks and darwinan principles being applied in computer algorithms is neuroevolution.
* Neuroevolution is a subdivision of Artificial Intelligence that looks at employing evolutionary algorithms to determine the architecture of neural networks. The evolutionary algorithms are used to define the topology of the artificial neural network.
* Evolutionary computing uses the same characteristics as biological evo- lution to search for optimal solutions to computational problems. Neuroevo- lution is a method to train neural networks by using this problem-solving technique. The goal of this paper is to present an overview of all the neu- roevolution techniques and to give a summary of this promising training method. ()
* **What is an artificial neural network topology?**
* **What is an evolutionary algorithm or evolutionary computing methods?**
  + In [artificial intelligence](https://en.wikipedia.org/wiki/Artificial_intelligence), an **evolutionary algorithm** (**EA**) is a [subset](https://en.wikipedia.org/wiki/Subset) of [evolutionary computation](https://en.wikipedia.org/wiki/Evolutionary_computation),[[1]](https://en.wikipedia.org/wiki/Evolutionary_algorithm#cite_note-EVOALG-1) a generic population-based [metaheuristic](https://en.wikipedia.org/wiki/Metaheuristic) [optimization](https://en.wikipedia.org/wiki/Optimization_(mathematics)) [algorithm](https://en.wikipedia.org/wiki/Algorithm). An EA uses mechanisms inspired by [biological evolution](https://en.wikipedia.org/wiki/Biological_evolution), such as [reproduction](https://en.wikipedia.org/wiki/Reproduction), [mutation](https://en.wikipedia.org/wiki/Mutation), [recombination](https://en.wikipedia.org/wiki/Genetic_recombination), and [selection](https://en.wikipedia.org/wiki/Natural_selection). [Candidate solutions](https://en.wikipedia.org/wiki/Candidate_solution) to the [optimization problem](https://en.wikipedia.org/wiki/Optimization_problem) play the role of individuals in a population, and the [fitness function](https://en.wikipedia.org/wiki/Fitness_function) determines the quality of the solutions (see also [loss function](https://en.wikipedia.org/wiki/Loss_function)). [Evolution](https://en.wikipedia.org/wiki/Evolution) of the population then takes place after the repeated application of the above operators.
  + Evolutionary algorithms are search algoirthms gleaned from organic evolution. These algorithms were developd more than 30 years ago when researchers were trginy to come up with ideas to solve problems to imitate the intelligent capabilities of individual brainds and populations. The former approach, emphasizaing an indiviuals intelligence, led to the developement of research topics such as ANN and knowledge based symbolic artificial intelligence. Modelling organic evolutioj provides the basis for a variety of concepts such as genotype, genetic code, phenotype, self adapatation etc. all of these concepts were incorporated into evolutionary algorithms. Nature is the inspiration. Biomimicry and them tings there. (Evolutionary Alogirthms in Theory and Practice, Evolution Strategies)
  + This is how evolutionary algorithms work in principle: They model the collective learning process within a population of individuals, each of which represents a search point in the space of potentiaial solutions to the given problem. The starting population is initialised by an algorithm dependent method and evolves towards successively better regions in the search space by means of crossover, mutation and selection. The environ,ent delviers a quality information(fitness value) for new search points and the selection process favours those individuals of higher quality to reproduce more often than worse indivuals. The recombination allows for mixing of parental information while passing it to their descendants and mutation introduces innovation to the population. In an evolutionary framework the fitness of an individual is measured by its proprensity to survive and reproduce in a particular environment.
  + Pseudo code: Step One: Generate the initial [population](https://en.wikipedia.org/wiki/Population) of [individuals](https://en.wikipedia.org/wiki/Individual) randomly. (First generation) Step Two: Evaluate the [fitness](https://en.wikipedia.org/wiki/Fitness_function) of each individual in that population (time limit, sufficient fitness achieved, etc.) Step Three: Repeat the following regenerational steps until termination: Select the best-fit individuals for [reproduction](https://en.wikipedia.org/wiki/Reproduce). (Parents) [Breed](https://en.wikipedia.org/wiki/Breed) new individuals through [crossover](https://en.wikipedia.org/wiki/Crossover_(genetic_algorithm)) and [mutation](https://en.wikipedia.org/wiki/Mutation_(genetic_algorithm)) operations to give birth to [offspring](https://en.wikipedia.org/wiki/Offspring). Evaluate the individual fitness of new individuals. Replace least-fit population with new individuals.
* **How do neural network topology and evolutionary algorithms work to form neuroevolution?**
  + **Neuroevolution uses evolutionary algorithms to develop artificial neural networks, with meta optimal parameters, topologies and rules. It uses the mutating and selecting concepts of evolutionary algorithms to select the best performing neural networks.** neuroevolution seeks to develop the means of evolving neural networks through evolutionary algorithms.

**History is Neuroevolution? – (https://www.oreilly.com/ideas/neuroevolution-a-different-kind-of-deep-learning)**

* The first neuroevolution algorithm appeared in the 1980s. At the time, its small group of practitioners thought it might be an alternative to the more conventional ANN training algorithm called backpropagation (a form of stochastic gradient descent).

**Why neuroevolution what do we use it for**

* Reinforcement learning.
* (**https://www.oreilly.com/ideas/neuroevolution-a-different-kind-of-deep-learning**)Underneath the hood of deep learning which is responsible for so much distruptive and innovative technologies, such as … , is the latest form of Artificial Neural Networks (ANN). ANN is an attempt to simulate a collection of neuron like componenets that send signalas to each other. That is the underlying mechanism behind deep networks in deep learning. Where do these connections come from? Our brains is year of evolution so we want to do the same for the neural networks.­ The 100-trillion-connection architecture of our human brain evolved through a Darwinian process over many millions of years. (use a reference here). In short, the brain – including its architecture and how it learns, is a product of natural evolution, and neuroevolution can probe all the factors that contribute to its emergence.
* It a way of opitmiatisation as opposed to other popular optimisation techniques such as gradient descent and more.

**How is it being implemented, what are people doing? – (https://www.oreilly.com/ideas/neuroevolution-a-different-kind-of-deep-learning)**

* Kenneth stanely, NEAT, HyperNEAT, novelty search
* How do you evolve an artificial brain to solve a problem? Example if you want to evolve a neural network to control a robot to walk, we will have a robot body in a physics simulator, some ANNs and because we don’t know how to solve the task, we generate a population of 100 random ANNs. ~~Thus a fixed topology of ANNs, the weights of the predetermined architecture would be randomized in each of the 100 indivuals in the population.~~
* The application of neuroevolution methods to RL is not a new phenomenon ([18], [19], [20]), but they were only recently shown to be competitive with the Deep RL approach in [21],

and [16]. In the aforementioned papers, evolutionary methods were used, Natural Evolution Strategies in [21], and a Genetic Algorithm in [16], to determine the parameters of neural networks to play Atari games, and for agent locomotion in a simulated physical environment.In both papers, these approaches yield results that are comparable to Deep RL, and even better in a few cases. One advantage is that evolutionary methods are highly parallelizable, since evaluation does not need to be carried out in a sequential fashion, meaning they do provide a significant speedup when it comes to learning. Unfortunately, this parallelization requires access to a lot of computational power to realize this advantage. For example, in [21] the task of 3D humanoid locomotion was evaluated at different numbers of CPU cores, and reaching a predetermined score takes 11 hours using 18 cores, and 10 minutes using 1440 cores. The speedup is significant but quite costly.

**How is neuroevolution more beneficial than others in its industry?**

**What are its disadvantages? – (**[**https://www.oreilly.com/ideas/neuroevolution-a-different-kind-of-deep-learning)**](https://www.oreilly.com/ideas/neuroevolution-a-different-kind-of-deep-learning))

Over the decades since the first fixed-topology neuroevolution algorithms began to appear, researchers have continually run into the frustrating reality that even as the algorithms create new possibilities, the brains they can evolve remain far from what evolved in nature. There are many reasons for this gap, (maybe give some reasons??) but a fascinating aspect of the field is that every so often a surprising new insight into the workings of natural evolution emerges, resulting in a leap in the capability of neuroevolution algorithms. These results highlight the complexity of my God, and the ‘mysteriousness’ (maybe use another word?) of nature.

What does it mean to make progress in neuroevolution? In general, it involves recognizing a limitation on the complexity of the ANNs that can evolve and then introducing an approach to overcoming that limitation.