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Neuro-Evolution and Transfer Learning on OpenAIs Shadow Hand Environments

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Abstract

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Chapter 1

Introduction

Neuroevolution is a practice where Deep Neural Networks (DNNs) are optimized by evolutionary algorithms, rather by the usual gradient-based learning algorithms. A paper by Such et al (2017, [1]), states that Genetic Algorithms (GAs) are a competitive alternative for training deep neural networks for reinforcement learning. Neuroevolution can be used to train the weights of a DNN. This can be tested on OpenAI's robotics environment called ShadowHands [2]. These are a set of simulated robotics environments to test reinforcement learning algorithms. There are 4 environments available for use, these can be seen in Table 1.1.

Environment Name	Description
HandManipulateBlock	The ShadowHand must try to rotate a block into the desired position.
HandManipulateEgg	The ShadowHand must try to rotate an egg into the desired position.
HandManipulatePen	The ShadowHand must try to orient a pen into the desired position.
HandReach	The ShadowHand must try to reach a desired position with its fingers.

Table 1.1: The OpenAI ShadowHand Environments

Furthermore, these environments are very similar in terms of the goal that each ShadowHand has, therefore a question arises that if we train a DNN on one of these environments, how will that DNN perform on a different ShadowHand environment? These virtual ShadowHands are based on real-life ShadowHand robots. If the hands can transfer learning across multiple different tasks, this will greatly reduce the training time required for the hands to perform different tasks, which in turn will make them more useful robots.

1.1 Aim of the Project

The aim of this project is to answer the question: **Can we transfer the learning of Deep Neural Networks trained with neuroevolution techniques on one environment to another similar environment?**. This aim can be broken down into some goals which are detailed here:

- Train a DNN using a genetic algorithm to consistently solve the HandManipulateBlock task.
- Use this DNN on each of the 3 other ShadowHand environments.
- Measure how well the DNN performed using different loss metrics.

For this project, I will be using Python to use the OpenAI environments, and TensorFlow to implement the DNN.

Chapter 2

Related Work

Ok, topics I need to talk about here, I'll put them as sections

2.1 Neuro-Evolution

Probably 2/3 papers on what neuroevolution is, how it works

2.2 Transfer Learning

2.3 Other Work with the OpenAI Gym environments

Chapter 3

Design

Chapter 4

Implementation

Chapter 5

Evaluation

Chapter 6

Summary and Reflections

Bibliography

- [1] F. P. Such, V. Madhavan, E. Conti, J. Lehman, K. O. Stanley, and J. Clune, “Deep neuroevolution: Genetic algorithms are a competitive alternative for training deep neural networks for reinforcement learning,” 2017.
- [2] OpenAI, “Ingredients for robotics research.” <https://openai.com/blog/ingredients-for-robotics-research/>. [Online; Accessed 19-04-2022].