Practical Assignment

Evolutionary Algorihtms Course, LIACS, 2022-2023

October 6, 2022

Abstract

This practical assignment asks searching a well-performing neural architecture using evolutionary algorithms. The submission requires the implementation and results of a genetic algorithm and an evolution strategy. The algorithms will be tested on the NAS-bench-101 benchmark, which addresses the problem of Neural Architecture Search (NAS). Submissions will be graded based on the submitted algorithms' performance ranks and the report. The deadline is December 7th.

1 Introduction

1.1 Neural Architecture Search

Neural network has achieved significant success in applications of various domains, and this success requires novel and proper architecture designs. Neural Architecture Search (NAS) address the technique of automatically learning and constructing a well-performing architecture for specific tasks. The NAS-Bench-101 provides a dataset mapping neural architectures to their training and evaluation metrics. It allows us to evaluate various neural architectures quickly and test NAS algorithms within a limited time.

NAS-Bench-101 restricts the search space of NAS in feedforward structures. Practically, it limits the size of the space as follows:

- Using only $L = 3$ operators: 1) 3×3 convolution; 2) 1×1 convolution; and 3) 3×3 max-pool.
- Consisting of directed acyclic graphs on $V = 7$ nodes.
- Maximal number of edges is 9

NAS-Bench-101 represents the 7-vertex directed acyclic graph using a 7×7 upper-triangular binary matrix and uses a list of 5 labels indicating the operation for each of the 5 intermediate vertices. Detailed description of NAS can be found at [1]

1.2 IOHprofiler

IOHprofiler is a benchmarking platform for evaluating the performance of iterative optimization heuristics (IOHs), e.g., Evolutionary Algorithms and Swarm-based Algorithms. It aims to the integrate various elements of the entire benchmarking pipeline, ranging from problem (instance) generators and modular algorithm frameworks over automated algorithm configuration techniques and feature extraction methods to the actual experimentation, data analysis, and visualization.

We apply two components of IOHprofiler, IOHexperimenter and IOHanalyzer, for this assignment. IOHexperimenter is for generating benchmarking suites, which produce experiment data, and IOHanalyzer is for the statistical analysis and visualization of the experiment data. Usage examples will be presented in the workgroup session. The complete tutorial of IOHprofiler is available at https://iohprofiler.github.io

2 Optimization Problem

We replace the encoding of the NAS problem in this assignment by a binary string. In practice, this assignment asks to solve a 26 dimensional discrete optimization problem, which the first 21 variables $x_i \in \{0, 1\}, i \in [1..21]$ represent the upper-triangular binary matrix of NAS, and the last 5 variables $x_i \in \{0, 1, 2\}, i \in [22..26]$ represent the operations of the 5 intermediate vertices of NAS.

A solution $x = \{x_1, ..., x_{26}\}$ maps to a structure of NAS as follow:

$$\text{Adjacency matrix} = \begin{bmatrix} 0 & x_1 & x_2 & x_3 & x_4 & x_5 & x_6 \\ 0 & 0 & x_7 & x_8 & x_9 & x_{10} & x_{11} \\ 0 & 0 & 0 & x_{12} & x_{13} & x_{14} & x_{15} \\ 0 & 0 & 0 & 0 & x_{16} & x_{17} & x_{18} \\ 0 & 0 & 0 & 0 & 0 & x_{19} & x_{20} \\ 0 & 0 & 0 & 0 & 0 & 0 & x_{21} \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix},$$

$$\text{Operations at the 7vertices} = [\text{INPUT}, x_{22}, x_{23}, x_{24}, x_{25}, x_{26}, \text{OUTPUT}],$$

3×3 convolution, 1×1 convolution, and 3×3 max-pool will be operated at the corresponding vertex when $x_i = 0, 1,$ and $2, i \in [22..26]$, respectively.

3 Requirements

- Implement a Genetic Algorithm (GA) and an Evolution Strategy (ES) using IOHexperimenter.
- Test the performance on the NAS problem, analyze your implementations using IOHanalyzer, provide the suggested parameter settings if necessary, and report at least the average best-found fitness values and AUC values.
- Use a maximum of $5,000$ function evaluations for each run, and report your results averaged over 20 runs.
- Submit implementations of the two algorithms and one report.

Deadline: 7th December 2022, 23:59
Please attend the workgroup session!!! A tutorial on IOHexperimenter and the NAS benchmark will be given there.
Follow the given latex example to finish your report.
Make sure the submitted implementations can be executed successfully without giving any arguments.
Follow the guidelines in the workgroup slides

References

[1] Chris Ying, Aaron Klein, Esteban Real, Eric Christiansen, Kevin Murphy, and Frank Hutter. Nas-bench-101: Towards reproducible neural architecture search, 2019.