Evolutionary Machine Learning – HW01
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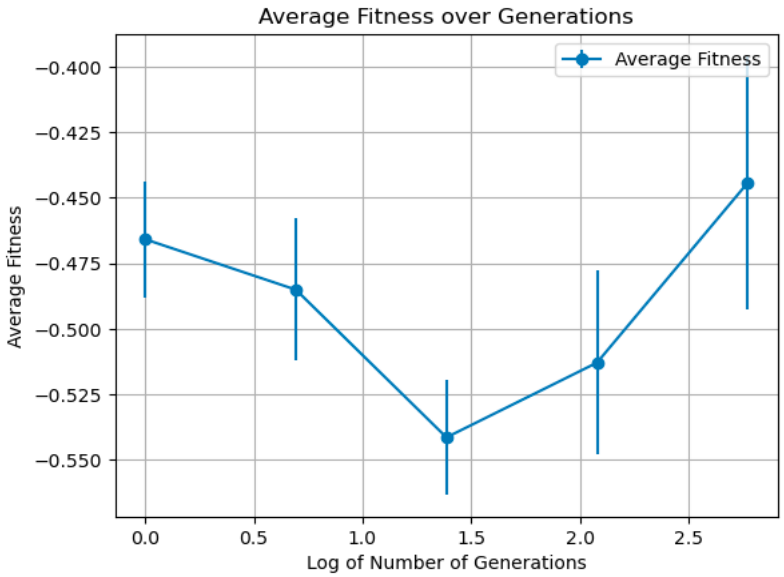
Based on the SUID 386916341 implemented (4+d2) ES as 1%4=1.
The conclusions were derived from 10 trials across 16 generations, with data recorded for generations 1, 2, 4, 8, and 16. This approach was chosen instead of analyzing 256 generations due to the extensive computational resources required.

Conclusion:
The ES method appears to have higher variability and takes longer to potentially converge, with the final model being less accurate than the one produced by backpropagation. The backpropagation method is more consistent and efficient, leading to a better-performing model within the provided dataset and training constraints.



1. How much did results vary between the different trials?
   The variability between trials can be observed through the standard deviations in fitness values at recorded generations. The standard deviation values suggest that there is some variability, but not excessively so. This indicates that while there is some fluctuation in the performance of the ES from one trial to another, the overall trend in performance improvement is consistent.
   Generation 1: Avg fitness = -0.4658511906862259, Std fitness = 0.02212270255676608
   Generation 2: Avg fitness = -0.48508608937263487, Std fitness = 0.027137615044641447
   Generation 4: Avg fitness = -0.5414274454116821, Std fitness = 0.021814564339615598
   Generation 8: Avg fitness = -0.5129102885723114, Std fitness = 0.03506080821500942
   Generation 16: Avg fitness = -0.4443403035402298, Std fitness = 0.04834669593480957

2. After how many generations did the results appear to “converge” with no more progress in ***q*** values?
   The data shows average fitness values and their standard deviations at generations 1, 2, 4, 8, and 16. The average fitness seems to improve initially but then shows some fluctuations, suggesting that there isn't a clear point of convergence within the first 16 generations. More generations might be needed to observe a clear convergence.

3. How did the final confusion matrices compare, between ES and Backpropagation?

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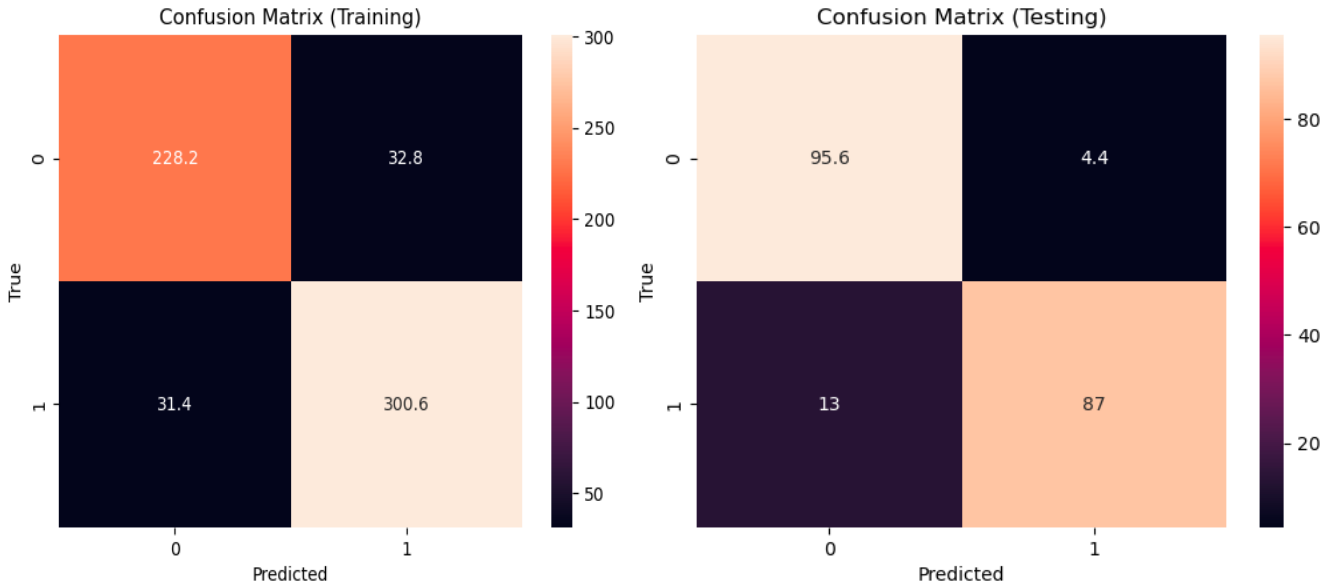
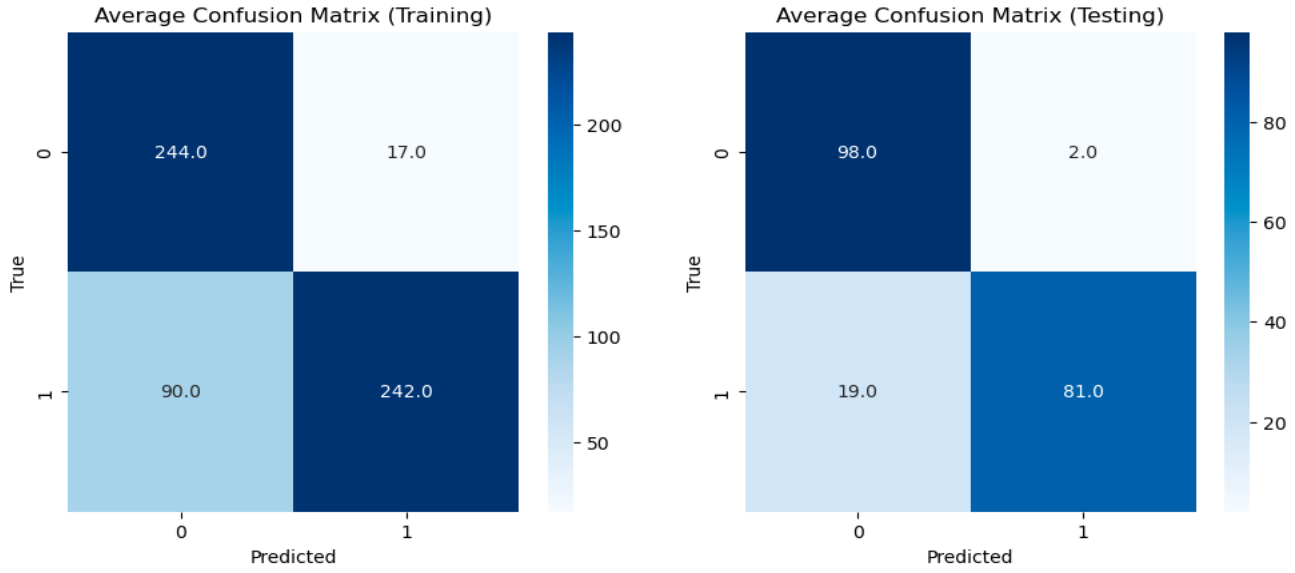
The confusion matrices from HW00 with Backpropagation show higher accuracy on both training and test data with a more balanced classification between the classes. There are fewer false negatives and false positives. In contrast, the confusion matrices from HW01 with ES show a higher number of false negatives on the training data and a slightly higher number of false positives on the test data. This indicates that while ES has learned to classify the data to a good extent, it has not achieved the same level of accuracy as the backpropagation model.

HW00 - Backpropagation



HW01 – ES



4. How long did the ES take, compared to Backpropagation, to achieve similar results?

The ES takes significantly longer to run, with each trial taking upwards of 430 seconds to complete just 16 generations. This indicates a substantially higher computational cost compared to backpropagation, as typically, neural network training with backpropagation does not take as long to run.