# Climbing Unimodal Landscapes with Neutrality: A Case Study of the OneMax Problem

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## Abstract

We investigate fitness neutrality in a Simple Evolutionary Algorithm (SEA) and in a neutrality-enabled evolutionary system using the OneMax problem. The results show that with the support of limited neutrality, SEA is less effective than our system where a larger amount of neutrality is supported. In order to understand the role of neutrality in evolutionary search of this unimodal landscape, we have created a theoretical framework that gives the number of gene changes under different levels of neutrality. The interim results of this theoretical work are also presented.

## 1 SUMMARY

OneMax was devised by Ackley as one of the benchmark problems to test the generality of his stochastic iterated genetic hill climbing search algorithm. This problem has a simple formula: for a binary string $x$ of length $l$, the problem is to maximize:

$$\sum x_i,\ x_i \in \{0, 1\}^l.$$

There is only one optimum solution in this problem: the binary string with all its bit values equal to 1. This unimodal search space is most suitable for hill climbing search algorithms. As expected, he reported that hill climbing methods outperform genetic and simulated annealing search methods on this problem.

Although not an ideal problem to demonstrate the strength of Genetic Algorithms (GAs) , OneMax has been used by many researchers to study different aspects of GAs because of its simplicity. For example, (Bäck, 1992) studied optimal mutation rates and their interaction with selection and self-adaptation on this problem, while (Giguere and Goldberg, 1998) used this problem to investigate the sampling size and selection scheme in GAs. The purpose of these studies was to gain understanding of how GAs perform search, not to assess the search ability of GAs against other methods.

In this work, we investigate solving the OneMax problem using an evolutionary system that supports neutrality. The goal of this study is twofold:

- To assess the generality of the neutrality-enabled evolutionary system.
- To understand the search behavior of the neutrality-enabled evolutionary system on this problem.

Previously, we have devised an evolutionary system whose genotype representation contains extra inactive genes. Mutations acting on these inactive genes have a neutral effect on the genotype's fitness. However, neutral mutations can change the dynamics of the evolutionary search process. When applied to a Boolean function and four needle-in-haystack problems, the results show that higher search success rates were obtained when a higher amount of neutral mutations were permitted during search (Yu and Miller, 2001; Yu and Miller, 2002). These results encourage us to test the system on different kinds of problems to assess its generality. OneMax is chosen because its unimodal landscape has not been investigated previously.

The search behavior of the neutrality-enabled evolutionary system has been analyzed quantitatively using the ratio between active and inactive gene changes. Previously, we conducted experiments for empirical study of these ratios. In this work, we attempt a theoretical approach by formulating these ratios mathematically. Although this is a challenging task, our interim results indicate that it is achievable for the simple OneMax landscape.

### References

Yu, T. and Miller, J. (2001). Neutrality and the evolovability of Boolean function landscape. *In Proceedings of the Fourth European Conference on Genetic Programming*. Pages 204-217.

Yu, T. and Miller, J. (2002). Finding needles in haystacks is not hard with neutrality. In *Proceedings of the Fifth European Conference on Genetic Programming*. Pages 13-25.