Genetic Drift

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May 7, 2025

1 Introduction

Genetic drift is an evolutionary process that causes random fluctuations in allele frequencies. Natural selection is a mechanism in which allele frequencies are systematically influenced as offspring inherit the most advantageous alleles. In this paper, we will analyze the dynamics of allele frequency by introducing fitness as a metric, where advantageous alleles are favored and deleterious alleles are phased out. We will assign each allele a numerical fitness value, f, where $f > 0$ indicates an advantage, $f < 0$ indicates a disadvantage, and $f = 0$ represents neutrality. This framework will allow us to understand how even slight differences in fitness scores, over multiple generations, can reflect selective pressure on alleles.In our findings, we observe that allele frequencies either prevail, increasing in frequency and prevalence, or are phased out, decreasing and eventually becoming obsolete; Very much aligning with the concept of ”survival of the fittest”.

2 Results

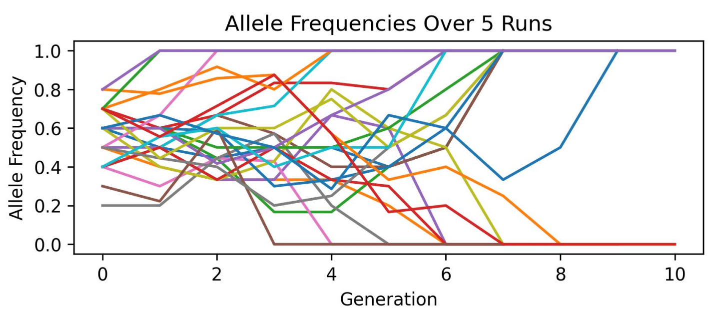

Figure 1: Allele Frequencies with Fitness Metric

In a mating simulation where alleles and mate pairings are stochastically chosen but assigned deterministic fitness scores, alleles with higher fitness generally yield more offspring in the next generation. The simulation was constructed as follows: 10 samples, 5 sites, a mean of 2 offspring per pair, a standard deviation of 1, 10 generations, a fitness score of 0.3, and 5 runs.

3 Methods

The simulation began with the stochastic initialization of a population, where each individual's genotype was randomly assigned an allele value of either 0 or 1. A fitness score was then applied to influence offspring output based on the numeric value of the allele. Each offspring inherited a random allele from either the mother or the father. Pairings for mating were also determined stochastically. After each generation, the old population was replaced by the offspring, which then formed the basis for the next generation. To account for variability, multiple simulation runs were performed, and the results were aggregated. As shown in the line plots, the trajectory of allele frequencies over generations demonstrates that alleles can eventually become either fixed or completely absent.

This simulation framework highlights the systematic impact of fitness on allele frequency. When individuals with high fitness scores mate, they tend to produce more offspring that inherit similarly advantageous traits.

To reproduce the simulation, follow these steps:

```
$ clone git@github.com:cu-compg-spring-2025/assignment-3-drift-MatFit.git
$ cd drift/src
$ python af.py \
  --num_samples 10 \
  --num_sites 5 \
  --mean_offspring 2.0 \
  --stdev_offspring 1.0 \
  --max_generations 10 \
  --out_file af.png \
  --fitness 0.3 \
  --num_runs 5
```