UNVEILING GENETIC VARIATION PATTERNS IN SIMULATED ALTRUISTIC POPULATIONS USING DEEP LEARNING

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1. Introduction

Altruism is a behavioural phenotype characterized by sacrificing one's lifetime fitness to enhance another's. Despite its seemingly **counter-intuitive** nature, numerous theories have emerged to elucidate the viability of this behaviour.

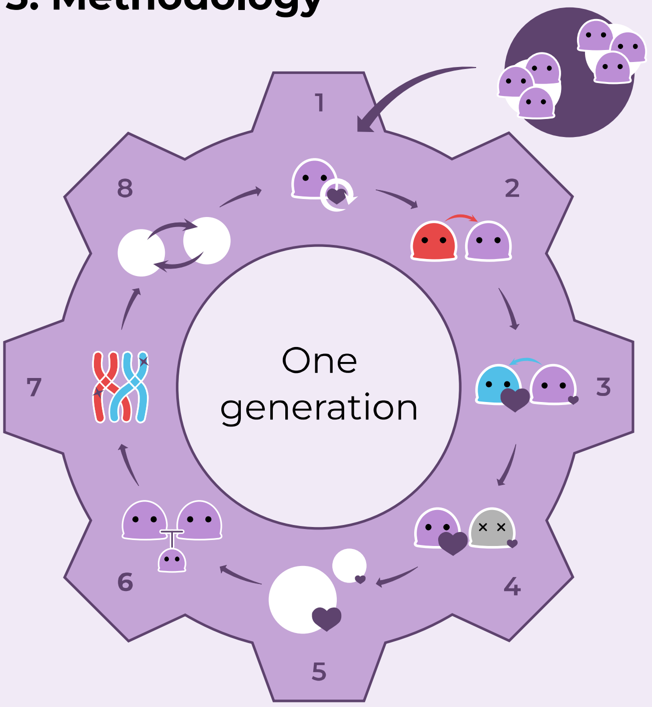
Among these theories, two main perspectives have garnered attention. Kin selection theory posits that altruism thrives due to altruists assisting **genetically related individuals**, while group selection theory attributes its success to the **differential group fitness** observed in populations with varying proportions of altruists between groups.

2. Objectives

The primary goals of this project are twofold. First, we aim to develop a **simulation tool** capable of generating **realistic and configurable** populations with altruistic behaviour.

Second, we seek to leverage the power of deep learning techniques to uncover the specific conditions that foster the **coexistence of altruism and selfishness**, shedding light on their intricate dynamics; as well as **identify genetic variation patterns** at altruistic loci by simulating a genome following the infinite sites model, providing valuable insights into the genetic basis of altruism.

3. Methodology



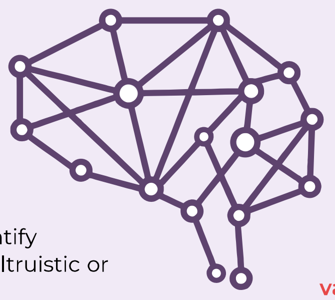
The simulation is initialized by populating the groups with individuals having identical genomes.

1. The survival probability (proxy for fitness) is **reset**.
2. **Altruists** sacrifice one's fitness to enhance another's.
3. **Selfish** individuals compete with others for fitness.
4. Individuals **survive** or **die** based on their fitness and age.
5. **Group fitness** is adjusted based on the average fitness within the group.
6. Individuals **reproduce** generating offspring.
7. The inherited haplotypes undergo **mutations** and **recombination**.
8. **Migration** between groups occurs.

4. Ongoing

To determine the optimal conditions for the **coevolution** of altruism and selfishness, our approach involves using **12,000 simulations** initialized with **randomly generated parameters** from a normal distribution to train a neural network that will predict the fixation of either allele given a set of parameters.

A series of **statistical analyses**, including **Principal Component Analysis (PCA),** will be performed to the results of the simulations to identify clusters of parameter values that made either the altruistic or the selfish allele to become fixed.



Using the previously trained neural network, optimal parameter values that allow both alleles to coexist will be used to simulate a population with **genetic variation** at both the **altruism-associated** locus and a **neutral** locus.

Individuals will carry two **haplotypes** per locus. Subsequently, the resulting haplotypes from both loci will serve as training data for a **convolutional neural network**, enabling the detection of genetic variation patterns **associated with altruism**.

5. References

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2. Sober, E., & Wilson, D. S. (1999). Unto Others: The Evolution and Psychology of Unselfish Behavior. Harvard University Press.
3. Stevens, E., Antiga, L., & Viehmann, T. (2020). Deep Learning with PyTorch. Manning Publications.