COMP6202: Evolution of Complexity

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January 4, 2019

1 Introduction

Paper re-implemented: *Individual Selection for Cooperative Group Formation* (paper 4)

1.1 The Experiment

The experiment involves creating a 'pool' of individuals. These individuals can either display selfish or cooperative traits. This trait determines the amount of resources they receive and the growth rate of the individual's population. The individuals are sorted into two groups, each consisting of sub-groups of fixed sizes. The first group has large sub-groups, whereas the second has small sub-groups. An individual "picks" the group size they are willing to join. Therefore, an individual has 2 defining features: whether or not it is cooperative and if it joins small or large groups.

The individuals are then reproduced, which involves finding their new populations based on received resource and growth rate. This occurs for T generations. What the experiment shows is that the overall 'pool' converges towards one type of individual; selfish + small. It is an example of niche construction and shows how cooperative behaviour can arise through individual selection.

1.2 Individual Representation

In the re-implementation, each individual in the migrant pool is represented with a 2-bit bit-string. This bit-string correlates to a genotype in accordance to the table below:

11	Cooperative + Large
10	Cooperative + Small
01	Selfish + Large
00	Selfish + Small

The advantage of representing individuals in such a way is that it allows extensions to be implemented effortlessly. If, for example, the genotypes were represented statistically, meaning the proportions of each genotype was stored instead of actual individuals, then it would have been difficult to experiment with aspects such as mutation and crossover.

One disadvantage of using actual individuals was that during reproduction, often the increase in population of a genotype, particularly in small groups, was very small and a fraction of an individual could not be represented. This issue was solved by storing the population of genotypes as a float during the t time steps of reproduction, and then re-populating the groups with the new population rounded to the nearest integer.

2 Re-implemented Results

The initial experiment aimed to recreate Figure 2 from the original paper. Here it is shown as Figure 1. The recreated figures are 2 and 3.

The parameters used in the experiment can be found in the appendix.

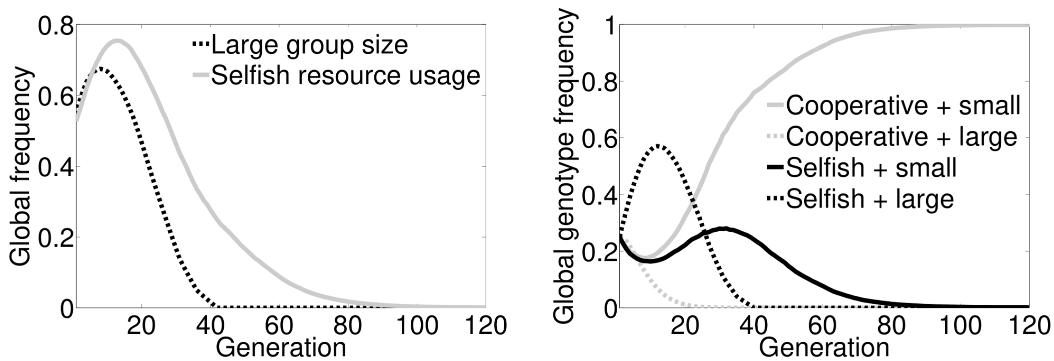

Figure 1: Figures from the paper which were to be re-implemented

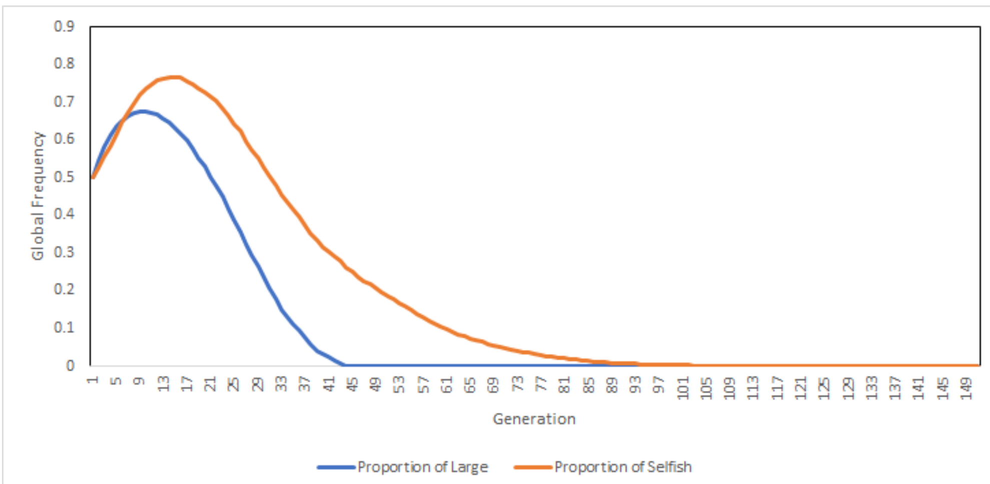

Figure 2: Proportions of selfish and large genotypes in the migrant pool

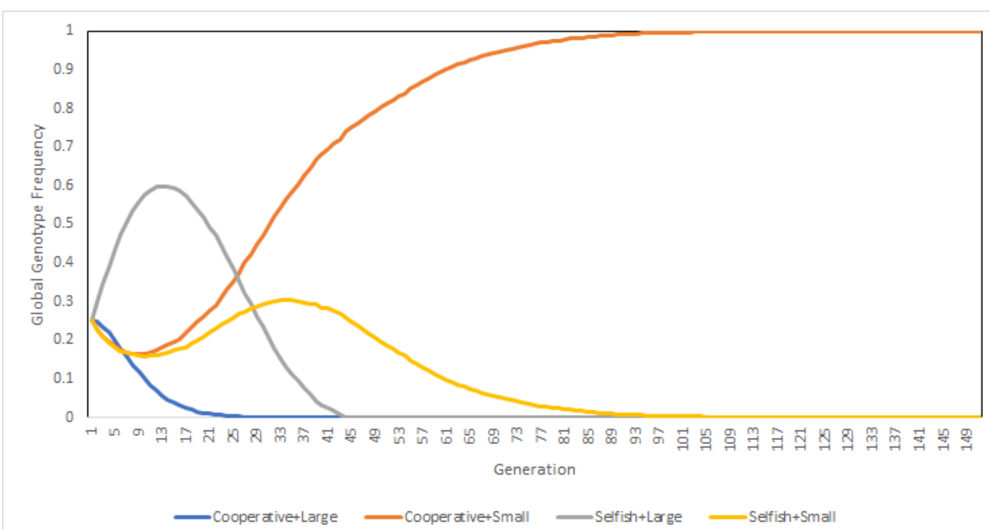

Figure 3: Population of each genotype over generations

3 Extension

The title of the extension is:
"Studying the effects of a diverse population on the frequency of cooperative behaviour"

3.1 Hypothesis

Hypothesis: in a population where the "level" of cooperative behaviour of an individual varies between individuals, the population should converge towards an ideal level of cooperation.

The expected results are similar to that of the original paper, where the cooperative and small individuals slowly become the majority, however there may be some changes. For example, the most common individual by the end of the simulation may be slightly more selfish than the most cooperative individual. This is because they may have the advantages of being cooperative in small groups but the slightly higher selfish trait may mean they perform better than a completely cooperative individual. Obviously, this advantage will be lost when the other individuals 'die' out.

On the other hand, a different scenario would be that the upper-hand of cooperative behaviour in small groups may be lost when there is a large diversity in the population. That is to say, "when everyone is at least a little selfish; the most selfish will win". If this scenario is correct, then one would expect to see the selfish trait become the majority.

3.2 Implementation

The experiment could be implemented in a similar way to that of the original paper with some important changes; regarding how individuals are represented and how one's level of cooperative behaviour is calculated.

The individual is represented as a bit-string of n length, (for the experiment n=8). On top of this, there is a character appended to the end of each individual representing the group size the individual belongs to. This can either be L or S, for large and small respectively. Although the size parameter could have also been a bit, there would have been no programmatical advantage and this method is more human-readable.

An example of an individual is "**11111111S**".

The number of 1s on the individual signifies how cooperative it is. If an individual has 8 1s then it has the base 'growth rate' (G) and 'consumption rate' (C) values, meaning it is the most cooperative it can be. An individual with 8 0s has the maximum G and C values, making it the most selfish. Individuals with a number of 1s and 0s in-between 8 will have G and C relative to the number of each. For example, an individual "**00001111S**" will have a G and C which is the half-way point between base and max. The formula for calculating G is given below:

$$G_i = G_b + (Z_i * (G_m - G_b)/n)$$

Here, G_b is base G, Z_i is the number of 0s in the individual, G_m is max G and n is the length of an individual's bit-string. The formula for calculating C is similar.

The migrant pool is initialised with an equal number of each genotype. After this they are sorted into their retrospective groups and reproduced for t steps (similar to the original paper). Their resource allocation is calculated based on the number of each genotype in the group. Since each genotype is sorted to put the 0s in front of the 1s, there is no issue of a incorrect counting, i.e. '10101010S' and '00001111S' are exactly the same. This can be done as only the number of 1s and 0s matter rather than their order. Finally, the individuals are returned to the migrant pool and the pool re-proportioned. This is repeated for T generations.

3.3 Results

The results do not support the hypothesis.
Possible explanation
Trying different values
Seeing how proportions change

3.4 Ensuring Correctness

4 Conclusion

Evaluation
Future work

References

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5 Appendix