COMP6026: Assignment 2

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1 Introduction

Powers, Penn, and Watson [2007] show that environmental conditions need not be externally imposed in order to promote the evolution of cooperative traits. They present a model which permits suitable conditions to arise via individual selection, and show that even in environments that initially select for selfish behaviour, a niche construction process can allow for cooperative behaviours to be ultimately successful. This paper reimplements the algorithm provided by Powers et al. [2007], and exends the model to show not only that the process is accelerated by the introduction of mutation to the model, but also that a side-effect of the niche construction process then favours selecting against individuals that are able to mutate, resulting in a more stable niche.

2 Reimplementation

In Powers et al. [2007], an algorithm is presented which demonstartes that under the right circumstances, individuals can select for environments that promote cooperation

$$r_i = \frac{n_i G_i C_i}{\sum_j (n_j G_j C_j)} R \qquad (1)$$

$$n_i(t+1) = n_i(t) + \frac{r_i}{C_i} - K n_i(t) \qquad (2)$$

1. **Initialisation:** Initialise the migrant pool with N individuals.

2. **Group formation (aggregation):** Assign individuals in the migrant pool to groups, as described in the main text below.
3. **Reproduction:** Perform reproduction within groups for t time-steps, as described in the text above.
4. **Migrant pool formation (dispersal):** Return the progeny of each group to the migrant pool.
5. **Maintaining the global carrying capacity:** Rescale the migrant pool back to size N, retaining the proportion of individuals with each genotype.
6. **Iteration:** Repeat from step 2 onwards for a number of generations, T.

2.1 Representation

For an efficient and quick algorithm, correct representation is important First we did this then we did this Allowed quick computation, hooray

2.2 Parameters

We used the parameters as in the original paper, plus these

Behaviour parameters	Cooperative	Selfish
Growth rate, G_i	0.018	0.02
Consumption rate, C_i	0.1	0.2

Size parameters	Large	Small
Group size, S_i	40	4
Resource influx, R_i	50	4

Global parameters	Value
Population size, N	4000
Generations, T	120
Reproductions, t	4
Death rate, K	0.1

Table 1: Parameters from Powers et al. [2007], used throughout the reimplementation.

2.3 Results

1 page

All of the other genotypes eventually die out permanelty due to being outcompeted for resources (mention across and between groups varience) and then being scaled away in step 7[TODO: check]
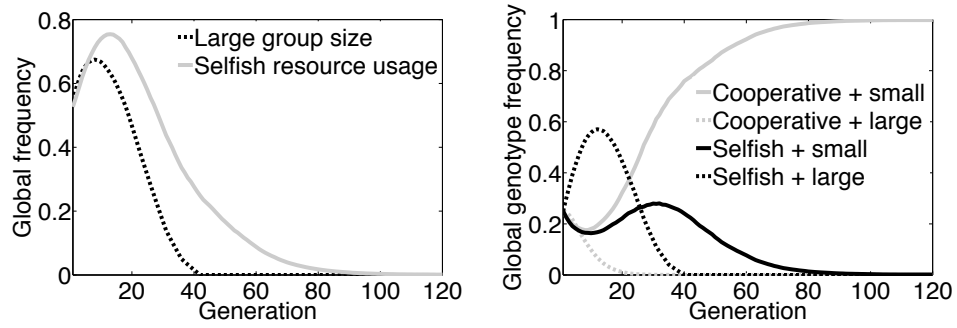
Figure 1: Left-hand plot: average environment and strategy through time. Right-hand plot: change in genotype frequencies over time. (Original figure [Powers et al., 2007])
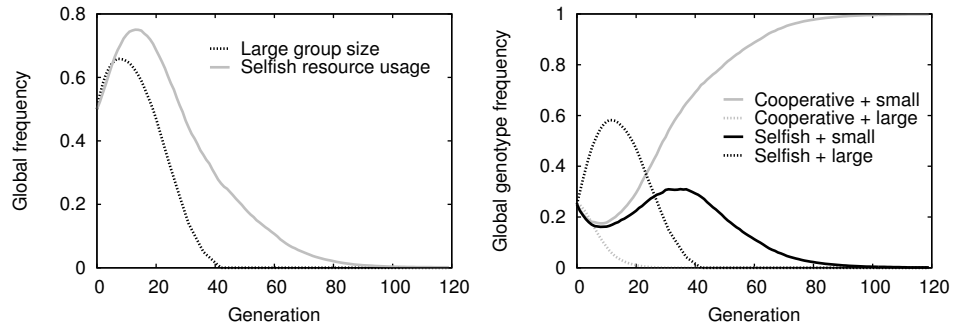

Figure 2: My plot.

3

3 Extension

1 page

a numenbt or extensiotns of the original paper exist Powers [2010] recommends altering the numebr of generations before breeding, or restiriction miigrations thise papers have done these things

The original result can be shown to be quite robust: even in the case of severe imbalance in the inital genotype distribution, it is generally seen that the cooperative + small genotype successfully forms a niche and eventually fixes (Appendix A, figure [TODO]). However, this is only possible when there exists a critical minimum population of cooperative + small individuals to [TODO: swanky phrase about beating the initial disadvantage]. In the model as presented, if a particular genotype dies out or does not exist in the initial genotype distribution, then it is never possible for it to (re)enter the gene pool. In certain situations, this can be seen as disvantageous - for example, in the original model, if the cooperative + small individuals were able to form larger groups again once the selfish allele had been eradicated, then they could reap the resource bonus without exploitation by selfish individuals (as in Appendix A, figure [TODO]).

As an extension to the original model, this paper then presents analysis of cases where individuals are allowed to change size preference, behaviour and their own mutation rate, in a manner similar to a low rate of mutation across the whole population.

In the original paper, once a specific genotype has fixed, it is impossible for any other genotype to invade. Specifically, in order for any genotype to fix, all other genypes must be extinct. What happens if we add mutatoin? Are the results from the original paper robust in the face of new condidiotns Several scenarios to consider: mutation only on size: predicatble results: once the selfish allele has died out, large + cooperative individuals that arise via mutation of the dominant small + cooperative genotype are able to flourish, and outcompete the other genotypes until they reach relative fixation (absolute fixation does not occur due to the occasional mutation of small + cooperative individuals). Mutation only on behaviour, and mutation on size and behaviour: i think leads to large + selfish near-fixation. Allowing individuals to select for the ability to mutate

3.1 Representation

Once again, individuals are represented by genotype as populations of identical clones. As there are three distinct alleles,there are now eight separate

populations

Ochoa et al. [2000] notes that 'optimal per-locus mutation rates depend mainly on $1/L$ (the reciprocal of the genotype length)'. In this model, the length of each individual's genotype is only 3, and a mutation rate of $1/3$ is high enough to cause no significant solution to arise. However, the original reasoning behind the heuristic leads to a more effective value for mutation within the model. The use of a mutation rate of $1/L$ is intended to result in an average of one change to one gene in the individual per reproduction - in the model presented [TODO]on the order of one change in one group per cycle of reproduction, and so a value of $1/num\_groups$ is more appropriate. Though the actual number of groups fluctuates based on prevailing group size preference, 550 groups may be taken as a reasonable approximation[1]. A mutation rate M of $\frac{1}{550} \approx 0.002$ is therefore used throughout the rest of the paper.
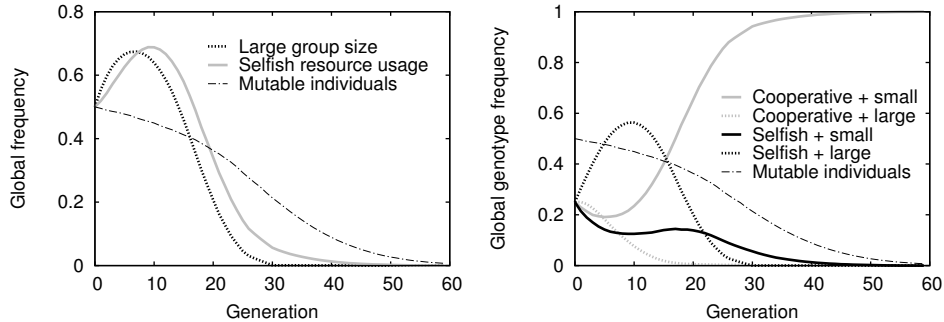
3.2   Results

1.5 pages

Figure 3: Wonderful 60gen proof of all that is beautiful.

4   Conclusion

1 page Increases stochasticity - particularly among mutability. As it has no inherent effect on fitness, it is self reinforcing. Often it'll select towards non-mutability as there is bias in that direction INvestigat the deffects of different/a range of mutation rates

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[1] using the parameters in table 1 with equal distribution of genotypes: $\frac{2000}{40} + \frac{2000}{4} = 550$
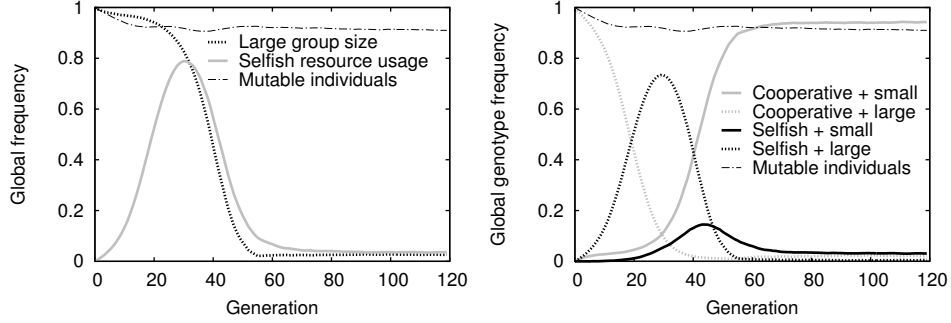
Figure 4: Robust to completely evil.

References

G. Ochoa, I. Harvey, and H. Buxton. Optimal mutation rates and selection pressure in genetic algorithms. In *Proceedings of the Genetic and Evolutionary Computation Conference*, volume 1, pages 315–322. Citeseer, 2000.

S. Powers, A. Penn, and R. Watson. Individual selection for cooperative group formation. *Advances in Artificial Life*, pages 585–594, 2007.

S.T. Powers. *Social niche construction: evolutionary explanations for cooperative group formation.* PhD thesis, University of Southampton, 2010.
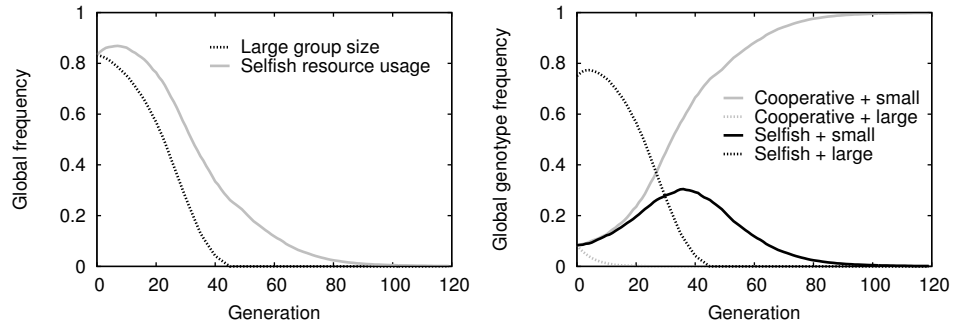
A   Additional cases TODO
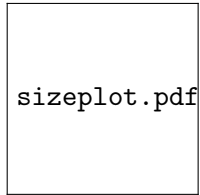

Figure 5: Robust to 3/4 evil.

Figure 6: Mutation on size only.

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