Coursework 2: Demography and Culture

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March 18th, 2019

1 Introduction

Powell et al. (2009) investigate the effect of migration activity varying different factors such as heterogeneity, sub-populations, and skill complexities. The process of replicating the model revealed incompleteness in the exploration of the effect of migration activity on skill accumulation. As such, we are extending Powell et al. (2009)'s model to a spatial model; exploring the effect of increasing migratory activity that could result in spatial structuring of skill accumulation, while maintaining a fixed single population and heterogeneity. We hypothesise that increasing migration activity will increase skill accumulation.

2 Approach

To quantify the effect of increased migration in relation to skill accumulation in spatial models, we extend Powell et al. (2009) model by utilising the agent-based model developed by Čače & Bryson (2007) as is. This is greatly simplified in comparison to the model provided by Powell et al. (2009), as the simulation describes the problem, by representing simple entities of an actor and detaching from the complexity of the real Late Pleistocene environment discussed in the paper.

The experiment was designed to have migration as the independent variable operating in real time and skill accumulation as the dependent operating in real space, while all other variables were controlled. We interpret increasing migration as increasing the *run-dist* variable in the model, which is defined as the approximate distance each *turtle* moves in space per tick. Skill accumulation is defined as the mean *knowhow* at the end of each simulation, where *knowhow* determines how many different food types it can exploit. Time is represented by the *tick* counter. This spatial model maps the demographic features in Powell et al. (2009) to simulation variables; migration to *run-dist* and skills to *knowhow*, as well as other variables such as food complexities to strategies (*num-food-strat*).

The approach thus far defines the essential features of the environment. We decided to measure skill accumulation as it plays a significant role on cognition through learning and cooperation. Skill accumulation represents behaviours and actions a *turtle* is able to perform. Therefore, learning occurs when *turtles* recognise new food strategies over time. Cooperation represents sharing these skills as they become more skilled.

The experiment starts the *run-dist* variable at 0 and incrementally reaches 5 with 0.5 intervals, whilst measuring skill accumulation over time. At each increment, the simulation is repeated 100 times to produce valid results with less noise, as presented in Powell et al. (2009)'s online supporting material. Each one can not run more than 1000 steps for consistency. If skill accumulation increases directly proportional to migration, then our hypothesis will be proven correct.

3 Results

Figure 1 clearly shows that the more *turtles* migrate, the faster they learn skills on average. At first, *turtles* predictably die with no *run-dist* and those with half survive a few hundred *ticks* more before dying. For example, comparing *run-dist* 1 with 3, the former increases relatively gradually over 1000 *ticks*, while the latter significantly increases in the first 100 *ticks*. This proves our hypothesis and aligns fittingly with the claims put forward by Powell et al. (2009).

Looking at *run-dist* 3 and those higher, there is a notable descent just after 100 *ticks*. Upon further investigation of these simulations, it became apparent that it was due to a considerable dip in *turtle* population where they died along with their *knowhow*, which we suspected was the case as their lifetime was set at 100.

Furthermore, we found that after 600 *ticks* migratory activity reaches a plateau near skill accumulation of 5. However, there was still room for learning to obtain maximum skill accumulation of 8 *num-food-strat*. We decided to test the simulation further with *run-dist* 1.5 as it seemed like the optimal value

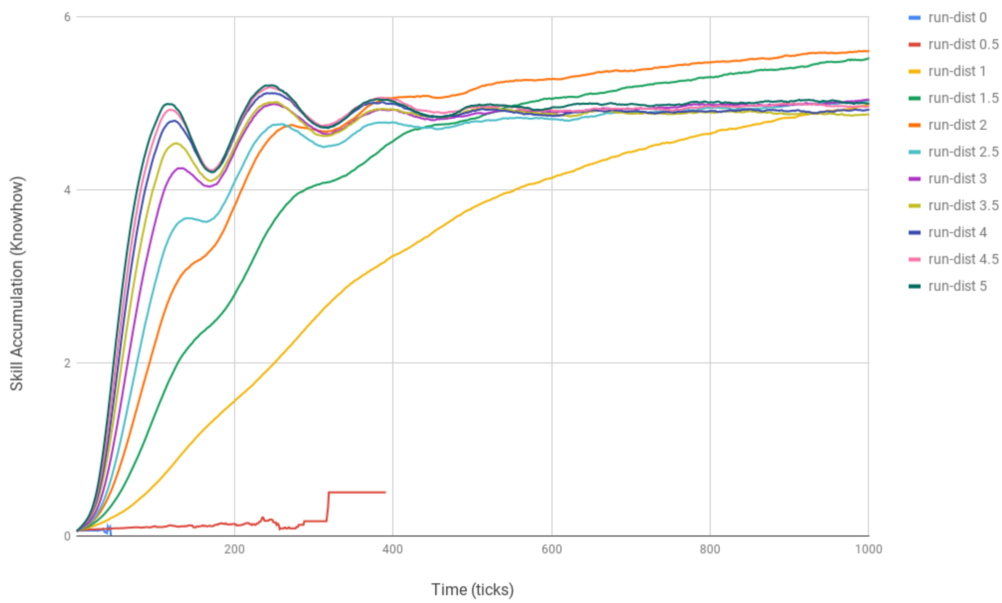

Figure 1: Measuring skill accumulation over time with varying migratory activity.

where skill increases gradually without dips. We doubled the ticks to see where it leads, and found that skill accumulation converges on 6 as opposed to converging on 5 with higher *run-dist* value.
Note that standard deviations never exceeded 0.5 across all simulations, averaging at approximately 0.3.

4 Discussion and Conclusion

Analysing the data from our model, we consider the dip after the first hundred *ticks* as the most interesting to further investigate. Hence, our discussion will mostly be addressing aspects and speculations concerning it. Firstly, the learning rate increases drastically where the migration activity is high. Seeing as it occurred in a short period of time, the *turtles* were not able to share skill knowledge within their lifespan, as such a dip in skill accumulation was observed. Further experimentation could possibly explore the benefit of increased altruistic behaviour to share skill knowledge in the light of this model.

Alternatively, the dip was a product of *run-dist* values that are increasingly higher than the broadcast radius. We speculate that the ratio of *run-dist* to *broadcast-radius* could have an effect on skill accumulation, which can be the topic of a future experiment.

The dip following a continuous increase in skill accumulation draws parallels between cultural and biological change, whereby "cultural change constitutes a Darwinian evolutionary process that shares fundamental similarities with (but also some differences to) genetic evolution" (Mesoudi 2018). Evolution requires variation, reproduction and selection; varying these conditions enables mechanisms for further learning (Dawkins 1989). More experimentation could address this by facilitating a mechanism for transferable skills through genetics, and exploring their consequences.

References

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