Replicating the Sugarscape Model in FrABS

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July 27, 2017

Abstract

This report describes the work and results done to replicate the Sugarscape Model as presented in the book "Growing Artificial Societies - Social Sciences from the bottom up" by Joshua M. Epstein and Robert Axtell [2].

Contents

0.1 Introduction

The Sugarscape model was the most important use-case for driving the research on functional Agent-Based Simulation (ABS). To conduct the research we implemented a library called FrABS which allows to implement an ABS in the pure functional language Haskell. The library is a general-purpose library and thus supports implementing all kind of ABS where some of them may rely on specific time-semantics like the SIR model and others only focus on complex interactions of agents over discrete time-steps like Sugarscape. Especially for the last kind of models Sugarscape served as the primary use-case for developing the FrABS library and drove the development for implementing necessary features which were not present and required in other models:

- Sequential Update-Strategy (as required by the Model)
- Shuffling of Agents (as required by the Model)
- Conversations for synchronized exchange (Mating, Trading, Warfare)
- Complex Environment-Behaviour (regrowing of resources, seasons, pollution-diffusion)
- Monadic programming style (make code more clear and towards a imperative style)

In a first step we just "roughly" implemented Sugarscape without aligning our results with the ones reported in the book [2]. This work now tries to exactly replicate each [1] of the dynamics, shows the generated dynamics and discusses the difficulties encountered.

The actual Sugarscape model is described in the book [2] in the Chapters III to V:

- Chapter II: Life And Death On The Sugarscape
- Chapter III: Sex, Culture, And Conflict: The Emergence Of History
- Chapter IV: Sugar and Spice - Trade Comes to the Sugarscape
- Chapter V: Disease Processes

We structure this report in the same way and ignore the conclusions of the book where further results are given.

[1] With the exception of a few minor cases

0.1.1 Related Work

Due to the importance and influence of the Sugarscape model, others have already tried to replicate the results.

TODO: [1] Replication of Sugarscape Using MASON - Anthony Bigbee, Claudio Cioffi-Revilla, Sean Luke `https://cs.gmu.edu/~eclab/projects/mason/publications/replication2007.pdf`

TODO: [3] The Specification of Sugarscape - Joseph Kehoe `https://arxiv.org/abs/1505.06012v3`

TODO: implementation in netlogo: https://www.openabm.org/model/4688/version/2/view

0.2 Chapter II: Life And Death On The Sugarscape

0.2.1 Carrying capacity

carrying capacity was much higher in my example

TODO: vision & metabolism distributions

0.2.2 Wealth Distribution

Roughly reproduceable TODO: implement gini coefficient

0.2.3 Social Networks of Neighbors

TODO: implement

0.2.4 Migration

couldn't reproduce the 'waves' seasonal migration seems to work polution migration seems to work as well

0.3 Chapter III: Sex, Culture, And Conflict: The Emergence Of History

0.3.1 Secual Reproduction

I was unable to reproduce the Figure III-1, it seems completely unrealistic. Also it contradicts Animation III-2, which looks pretty much like my run: we know that the 2d space is 50x50 = 2500 cells. Now we can roughly estimate that in Animation III-2 Picture 6 the 2d space is covered for more than 50% which would result in at least 1250 Agents alive. This clearly contradicts the Figure III-1. Also when thinking about it Figure III-1 seems not realistic as there will be about as many agents to cover both sugar-hills except the lowest region of

level 1. This is due to the fact that this seems to be enough to sustain them and also they wont move much and just harvest whats there thus accumulating ever increasing wealth and thus being able to mate and give birth to new children. Thus my conclusion: a more realistic value is about 1500 Agents which stays pretty constant.

TODO: export Mean vision and Metabolism as Figure III-2

0.3.1.1 Regimes of Population Dynamics

TODO: experiment with the given parameter to see if it replicates

0.3.1.2 Gini Effect of Inheritance

TODO: implement

0.3.1.3 Genealogical Networks

TODO: implement

0.3.2 Cultural Processes

0.3.2.1 Cultural Dynamics

Couldn't replicate the dynamics of the cultural process as in Figure III-8. both tribes seem to deviate around the same fraction. NetLogoCW also doesn't replicate these dynamics.

Sex is explicitly OFF

BirthOnDeath is not specified but it is probably off, because at this point they haven't explained the inheritance of cultural tags yet Age-Range is not specified but it is probably infinite. Either the Age-Range is infinite or BirthOnDeath is turned on otherwise the agents would simply die out and in the dynamics Figure III-8 they reported to arrive at "all blue" after around 2500 steps

0.3.2.2 Vertical Transmission of Culture

Implemented No dynamics reported

0.3.2.3 Network of Friends

TODO: implement

0.3.3 Combat

References

[1] Bigbee, A., Cioffi-Revilla, C., and Luke, S. Replication of Sugarscape Using MASON. In *Agent-Based Approaches in Economic and Social Complex Systems IV*, Springer Series on Agent Based Social Systems. Springer, Tokyo, 2007, pp. 183–190. DOI: 10.1007/978-4-431-71307-4_20.

[2] Epstein, J. M., and Axtell, R. *Growing Artificial Societies: Social Science from the Bottom Up.* The Brookings Institution, Washington, DC, USA, 1996.

[3] Kehoe, J. The Specification of Sugarscape. *arXiv:1505.06012 [cs]* (May 2015). arXiv: 1505.06012.