Genetic Game of Life

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Abstract

Conway’s Game of Life (GoL) cellular automaton is extended to allow evolution by the addition of genetic information to all live cells. Just as biological evolution constantly discovers innovations in the space of chemical and physical functionalities that it controls, we seek to explore how the addition of genetics to the game of life can display the same type of discovery process, where the genetically controlled innovations are now spatially local modifications to the game of life local dynamical rules. Complex cellular automaton dynamics of the game of life become the default “chemistry and physics”, and local genetic modifications that persist are the innovations discovered by evolution. In the work presented here, systematic genetic variations near to the game of life rule are investigated and found to produce signs of computational complexity with an abundance of glider structures.

# Introduction

Conway’s Game of Life (GoL) is a deterministic dynamical system that takes 2d spatial patterns of ones (‘live’ sites) and zeroes (‘dead’ or empty sites) to new patterns as time progresses, through the action of a local rule; each site’s state at *t+1* is dependent on its state at *t* and the state of its nearest neighbors at *t*. In Golly’s compact notation for life-like 2d cellular automaton rules, the game of life is denoted by the code S23/B3, meaning that a live cell survives (one at a site at time *t* goes to one at that same site at time *t+1*) if there are either 2 or 3 neighbors alive in the 8 cells surrounding the site and otherwise dies (goes to zero at time *t+1*), and an empty cell undergoes birth (zero at a site at time *t* goes to one at that same site at time *t+1*) if there are exactly 3 neighbors alive, and otherwise remains zero.

Here, we enhance the deterministic GoL dynamics to create an evolutionary system, by adding a genetic code to all the live states, and prescribing extra-GoL rules that specify how the genes affect the GoL dynamics and how genetic information is transferred from one time step to the next.

Regarding the transfer of genetic information, a deterministic selection mechanism is realized, so that mutation provides the only source of random variation in the dynamics. Four levels of perturbations on the B3/S23 standard GoL rules are investigated: (0) genetic selection on the GoL, with the genes not influencing the GoL rules (1) genetic selection on GoL-like rules, e.g. S2gb3gB2g3 ∈ {S(2g(b))(3g(b))/B(2g)3(g)}, with conditional rules depending on genes denoted by g and survival rules involving birth overwrites denoted by b (2) genetic modulations of the live neighbour counting process that allow different numbers of live neighbours a) for specific 2nd neighbour ring configurations b) using masks on 1st neighbours encoded by the existing live neighbours c) with the gene specifying the allowed numbers directly (3) limitations of the influence of arbitrary gene encoded rule departures in varying symmetries through the requirement that state changes induced by a non-GoL rule inhibit further rule departures in their neighbourhood until corrected by a regular GoL rule. Whereas many perturbations of the GoL rules either quickly die out or proliferate rapidly to fill space with reproducing structures, a family of interesting dynamical systems is found, and its tendency towards open-ended evolution analysed by means of activity statistics. Note, that while the standard B3/S23 game of life, starting from random patterns of 50% 1s and 0s, in most instances does not produce complex dynamics, the new family does.

Notation: Rule extensions  [Golly](https://en.wikipedia.org/wiki/Golly_(program)) open-source cellular automaton package