**Game of Life:**

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1. **Review & introduction**

1. Classic game of life (GoL):

* 1. Live=1, dead=0
  2. Live cell with 2 or 3 live neighbors continues to live, otherwise dies
  3. Dead cell with exactly 3 live neighbors comes alive, otherwise stays dead.

2. Add genetics: think of the transition from dead to live as a birth process, passing genetic information from living neighbour parents to the newly born child. Genetic information takes the form of departures of the local rule from GoL local rule. From **D** below:

a. some rules creating live cells from 2-live neighbourhoods are required

b. …

1. **Analysis of Live Site Maintaining/Generating Configs**

Consider separately the local neighbourhoods for 2 live neighbours and 3 live neighbours:

1. 2 live sites in 8-neighborhood

Up to reflection and rotation symmetries the following 6 configurations are involved,

4 of them symmetric (2,4,5,6), 2 asymmetric (1,3).

XX0 X0X X00 X00 0X0 000

000 000 00X 000 X00 X0X

000 000 000 00X 000 000

1. 3 live sites in 8-neighborhood

Up to reflection and rotation symmetries the following 10 configurations are involved

XXX XX0 XX0 XX0 XX0 XX0 X0X X0X X00 0X0

000 00X 000 000 000 X00 000 000 00X X0X

000 000 00X 0X0 X00 000 00X 0X0 0X0 000

Note it is the 3 live site neighbourhoods that cause birth in the classic GoL.

1. **Deterministic gene replication rule**

Non-random inheritance possibility:

If there are two symmetric sites (in 5 cases, 6,7,8, 9 and 10) take instead the third.

Otherwise, take the genome of the neighbour closest to middle of three live neighbours.

X**X**X X**X**0 X**X**0 X**X**0 **X**X0 **X**X0 X0**X** X0X **X**00 0**X**0

0**X**0 0**X**X 0**X**0 0**X**0 0**X**0 X**X**0 0**X**0 0**X**0 0**X**X X**X**X

000 000 00X 0X0 X00 000 00X 0**X**0 0X0 000

ncm ncm ncm ncm ncm sym sym sym sym sym

So it is possible to create a deterministic gene replication rule for the GoL.

I would recommend that we work with this, since it avoids introducing additional stochasticity through the choice of ancestor in replication.

1. **Influence of genes on Game of Life**

An initial objective was to avoid the reduction of GoL random configs statistically with high probability to absorbing local states: e.g. 0 or blinkers. A second objective is to allow the genes to influence the dynamics. The idea was to allow rare departures of change of state rules, which by and large preserve symmetry of number of creation and destruction events. If the departures only take place when the genes are identical or close to one another, then since this is much more likely if local patterns stagnate than if globally communicating patterns are occurring, this effectively provides a local rule counteracting stagnation of the game of life patterns.

Note that some rules creating live cells from 2-live neighbourhoods are required, rather than just additional destruction rules, otherwise the tendency will be towards even more absorbing zero state configurations. We could introduce creation rules from 1-live neighbour states, but this seems like a very strong departure from spirit of GoL and a major perturbation. Rules creating live cells from 0-nb states would lead to ubiquitous spontaneous generation of random information: this is not of interest.

The rare birth from 2-live neighbour configs cannot be made deterministic in gene parentage if all configurations are permitted, since 4 configs are symmetric in two neighbours. We could:

1. Relax totalistic (dependence on number of ones only) nature of rules, and only consider asymmetric configs as candidates for replication. Then chose the closest gene to central site (i.e. non-diagnonal neighbour)
2. Consider replication as sexual (but this introduces additional random component)
3. Abandon correcting the two-neighbour rule and instead work with an intrinsically asymmetric rule involving another number of ones in the neighbourhood, such as 1,(3 already used),5 or 7. The choice of appropriate neighbour for gene is in all cases deterministic and simply defined. I guess I would be tempted to try 7. It would be useful to collect some statistics on the number of occurrences of cases 7-neighbours-on and 5-neighbours-on when running Conway’s GoL. Note that High Life has been defined and studied which adds an additional birth rule for 6 live neighbours: interestingly it supports a replicator and has much in common with normal life.

Norman: As you can tell, I am confused about the proposal to form a deterministic version of genetics by “taking parent as nearest on neighbour”. A related rule might be to list distances of neighbours (will be either 1 lattice unit or lattice units), and take the unique one (either near or far) as parent. All local configurations have a unique one except 7 and 10 (my extra config).

John: Should be clear now. My deterministic rule works (when stated carefully!) because in any 3-configuration either one neighbour is unique in being not related to another by symmetry or in the case of all 3 being unique by symmetry (rotation and reflection) there is a unique one closest to the centre of mass. You could also choose a unique one being nearer or further, but always taking the closer to centre of mass appears more natural for replication.

In short the rule is:

*take the different one, or if all three are different, take the closest to centre of the cluster*

One further comment:

The rules of 3-color *Immigration* life and 4-color *QuadLife* are somehow primitive precursors to genetics, just adding additional colors (like primitive genes) to normal running life. [See the Wikipedia page under Variations]

[https://en.wikipedia.org/wiki/Conway%27s\_Game\_of\_Life - Variations](https://en.wikipedia.org/wiki/Conway%27s_Game_of_Life" \l "Variations)