Empirical definition of Interesting CAs

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1 Introduction

When we try to think about general CA, we have an intuition of something interesting vs. boring. For example when we take CA that converts every living cell to a dead cell, and every dead cell to remain dead, we get extremely boring CA that will die the next generation and no information processing will be possible in it. Some less trivial boring cases could be just infinite growth, for example any adjacent cell to a living cell will become alive, and every living cell will remain to live (as well as the dead cell), it would be either very boring empty space or a crystal that growth to fill the whole space. Nothing interesting and unpredictable seems to be happening. It's easy to think of many trivial cases of boring CAs.

So one can start this path of defining interesting CA by what information processing level it contains. For example if was proven CGOL is Turing complete. So lets say that we explore Turing complete CAs. But now one should ask: how do we know if the CA is Turing complete or not? So the thought here is very simple - lets take the most interesting features of CGOL that made it Turing complete and ask a general question: what are the most simplistic features of CGOL which made it TC?

The aim of the article is mathematically define the most simplistic CA features which allowed CGOL its currently known complexity. So the CA class we define in this article, is such the currently known CGOL search methods will be possible to generalize to this CA. Thus making the question of TC very practical one (although it might be discovered the CGOL method won't work, the search method itself will have a meaning).

2 CA space

For this purpose we choose a set of general isotropic (symmetric) 2d CAs. We choose isotropic, because they are more intuitive and aesthetic, and simpler to define (and any practical use of CA research will probably also be of isotropic

CAs) but the mathematical properties of the CA can be generalized to any CA. For example in our case we ask for a glider (a common spaceship), and when the rule is not isotropic a glider should be found in two opposite directions, and one glider in one direction might not be enough for TC. Also we chose 2d because it's the simplest, the definition can be generalized for any dimensions.

How this space is defined is well explained here:
https://www.conwaylife.com/wiki/Isotropic_non-totalistic_Life-like_cellular_automaton

3 Definition

Our definition is an empirical one. One can say we measure interest of CA and not defining it. We start from random soup i.e. a random state in [32, 32] initial rectangle. Each cell has same chance to be live or dead. And start to evolve it. It might either start to expand with c or start to die very quickly, in any case when this happens consistently several times, we say the CA is boring because it grows to infinity or it dies out.

There could be some interest inside agars of an exploding CAs (see rule 110), but we currently focus on non exploding ash generating CAs (at least with some probability).

The second criteria is made to avoid white noise like CAs. We take a square (say the initial [32, 32]), and check its density. If for a while the density is pretty high and consistently high and not periodic for a while, i.e.

$$\text{average density} > 0.3 \text{ for } 1024 \text{ generations}$$

then this CA is considered white noise.

Finally we found not exploding nor dying, not white noise CA. How can we be sure it's something of interest? To be of interest one need to contain common oscillator and common spaceship i.e. a glider.

With high enough probability (exact probability will be established with further experimentation and research) random initial pattern will converge pretty fast, and generate only spaceships and oscillators. It must contain at least one spaceship and at least one oscillator but nothing else (no rakes, guns, natural replicators etc.).

4 Experiment

Random isotropic rule is defined by 98 binary flags which can be on or off representing specific cell constellation to live or die. Random rule is generated by assigning live or dead state to those 98 flags. The probability of assigning dead state called P_{rule}, and in our experiments is 0.6.

For this kind of CA distribution (which seems to generate the most interesting CAs), we get the following statistics:

64% exploding with speed c

30.9% not generating a glider

2.7% white noise

1.6% dying out

0.55% interesting

0.22% other (natural replicator or too long to converge)

Thus our yield of interesting CA is 0.55% of all CAs for $Prule = 0.6$.

5 Next steps

We have found CA which has at least one common signal and one common oscillator. The next step would be to search for a signal reflector. One can simply collide glider with constellation of ash objects and hope the constellation will remain in the same while a signal will be reflected.

Arm movements with glider salve and slow salvo recipes to generate constellations can be searched as well.

6 Source with CAs

The code with CAs can be found on github:
`https://github.com/simsim314/CA_Research`