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The Discovery of a New Glider for the Game of Three-Dimensional Life

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The two cubic forms of the three-dimensional cellular automaton popularly called *Life* are denoted "Life 4555" and "Life 5766," where the first two numbers give the acceptable number of live neighbor cells required to sustain a (currently) live cell for the next generation, and the second pair of numbers specifies the number of live neighbor cells required to give birth to a currently non-living cell. Life 5766 has been shown to be a three-dimensional analog to Conway's popular two-dimensional version, whose rule can be written "Life 2333." In fact, the entire two-dimensional Conway universe can be simulated in Life 5766 with reasonable efficiency (see reference [1]). It has further been noted that Life 5766 was of interest mainly because of this analogy and that the glider (as well as many other interesting forms) were similar to their two-dimensional Conway counterparts.

Until now, only two gliders (which are merely oscillating forms that translate through the universe) had been discovered — one each for Life 4555 and Life 5766 (see figure 1). Now, however, an entirely new glider has been discovered for Life 5766 that has no counterpart in the two-dimensional Conway analog and thus is an entity in its own right. This object is quite rare (details below), yet does occur "naturally"; that is, one can conduct random experiments and eventually (within a reasonable time) the object shows up.

The new glider has a period of 8, at which time it has moved a distance of two units in a direction parallel to one of the coordinate axes. The eight states are shown in figure 2; note that generations 4–7 repeat generations 0–3 but are reflections. The signature (see [2]) for each state is given directly above the appropriate state. Naturally the signatures for generations 4–7 repeat those for 0–3.

The object was found using a DEC 3100 RISC workstation in the following manner (details omitted). First, a $23 \times 23 \times 23$ "universe" was set to all zero (all cells dead). Then the center $7 \times 7 \times 7$ portion was initialized randomly to a 20% density of live cells. This defined the initial conditions for an experiment, which was run until one of three things happened: (a) all living cells died out or stabilized (this happened most of the time, and after approximately 16 generations); (b) an oscillating form appeared (this happened

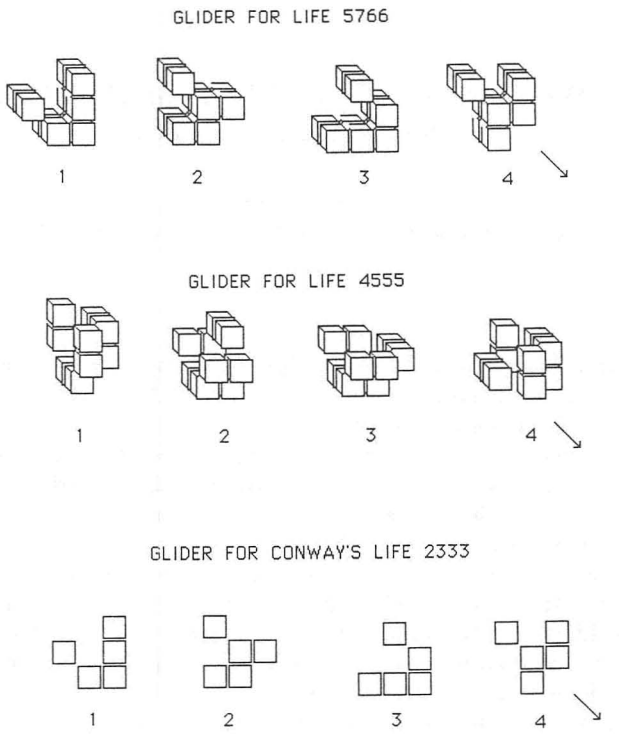

Figure 1: The two previously known gliders for Life 4555 and Life 5766 are shown at the top. The two-dimensional (Conway Life 2333) glider is at the bottom.

infrequently and was detected by stopping the experiment after 75 generations of no apparent "progress"); (c) an object hit the edge of the $23 \times 23 \times 23$ universe. This happened even less frequently than (b) and signaled the possibility of a glider. In fact, the vast majority of cases were caused by the fairly common well-known analog of the Conway Life 2333 glider shown at the bottom of figure 1. Nevertheless, there were occasional spurious results caused by more-or-less random configurations that happened to wander to the edge of the $23 \times 23 \times 23$ universe. Hence, before concluding that a glider did indeed cause the (c) result, the object was "normalized" by finding its center of mass and moving it back to the center of the $23 \times 23 \times 23$ universe. The experiment was run again but with the special initial pattern; if an object again struck the edge, then one could assume with virtual certainty that the object was a glider. The signature of the object was then determined and was compared with those signatures already found. If already present, the tally for occurrences of this signature was augmented. If not present, the new signature was added to a table of signatures found so far, along with the coordinates of the live cells comprising the object. After a one-day

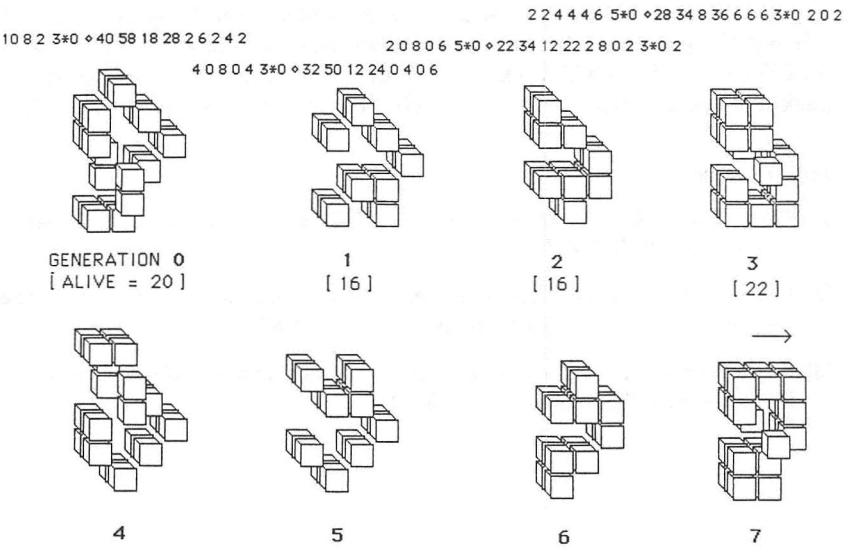

Figure 2: The states of the new 5766 glider are shown above. After eight generations, the glider has moved two cells in the direction of the arrow. Note that the signature is given above each generation. 3*0 means that there are three zero entries. Generations 4–7 are reflections of 0–3.

run of (approximately) four million experiments, the total number of common (Conway analog) gliders found was 2206. This included a few instances where the glider and some other small stable object were both present. The signature-finding routine did not try to separate the two objects and they were included in the signature table even though the signatures thus generated were spurious. However, these situations were easy to spot visually and were so infrequent that their presence did not impair our search for the new glider. In fact, aside from the occurrences of the common glider (including the occurrences of the common glider plus some small stable object), the only other object that got stored in the signature table was a single instance of the new glider shown in figure 1. Thus it would appear that the new glider is roughly 2000 times rarer than the common glider, which appeared about once every 2100 experiments.

It does not stop here. By a collosal coincidence, If we apply the Life 4555 rule to generation zero of the new glider, then after five generations, the 4555 glider appears. This fact is more amazing when one considers that the 4555 glider is rather scarce in its own right — the experimental technique described above produced only one glider per 5000 experiments (roughly).

I should emphasize that more experiments are needed in order to determine a better estimate for the rarity of the new glider. Also some experiments should perhaps be made involving collisions between the new glider and other

objects. Furthermore, now that the new glider has been found, one cannot rule out the possibility of finding other oscillating translating forms — both for Life 5766 and Life 4555. The same techniques can be applied to the "dense packed spheres" games of life — namely Life 3333 and Life 4633 (see [3]).

References

[1] Carter Bays, "Candidates for the game of life in three dimensions," *Complex Systems*, **1** (1987) 373–400.

[2] Carter Bays, "Patterns for simple cellular automata in a universe of dense packed spheres," *Complex Systems*, **1** (1987) 853–875.

[3] Carter Bays, "A note on the discovery of a new game of three-dimensional life," *Complex Systems*, **2** (1988) 255–258.