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APPLICATION OF CELLULAR AUTOMATA IN 3D ENVIRONMENT USING MAXSCRIPT

SECKAR, J[an] & POKORNY, P[avel]

***Abstract**: This article describes the expansions possibility of classical cellular automata to 3D using MAXScript environment. This implementation allows to set and animate the cellular automata rules and also the specific applications like for example well known Conway`s Game of Life and its formations of oscillating and gliding structures expanded to 3D environment.*

***Key words:** 3D structures, cellular automata, rule based modeling, MAXScript*

1. INTRODUCTION

Cellular Automata is n-dimensional grid of cells with the finite number of states and set of rules that are parallel applied to all cells and determine the new state of the grid (Deussen & Lintermann, 2005).

It was described in 40s by John von Neumann as attempt to create self-replicating system. Later in 70s two dimensional two state versions with specific set of rules was published by John Conway. This application is known as Game of Life.

This algorithm is one of first rule based modeling methods that creates patterns considered as natural structures (Neumann, 1951).

Cellular automata is most usually applied as two-dimensional grid with two states of cell (live/death), that determine possible states of the grid. By applying rules that are consisted of neighbor cell state and its according action is the change and evolution of grid specified.

Basically we can classify rules as totalistic, that uses specific rules based on exact values of exact cells in the defined neighborhood, and deterministic, which sum states of neighbor cells.

Most usually is used Von Neumann neighborhood, consisted in two-dimensional environment by orthogonally surrounding cells and Moore neighborhood that is expansion of Von Neumann's neighborhood by corner cells. That gives amount of eight cells in neighborhood of two-dimensional grid.

Grid can be implemented as finite or infinite. Both of grids are defined by its dimensions that describe the amount of cells and by that the environment of algorithm. In finite grid application the problem appears to handle the border cells that do not have the same amount of neighbors. There is difference in the amount of neighbor cells at the borders and in the rest of grid therefore the cells at borders do not behave the properly. In certain applications this could be advantage or required effect. The infinite grid application solves the problematic by using toroidal arrangement of grid and therefore the neighbor amount is same for all cells.

2. GAME OF LIFE

Game of Life is classified as zero-player game, that means that user defines initial state and then the game is independent on any other user operations. It uses Moore neighborhood consist of ring of eight cells (Guy et al., 1982). The rules used for this method are just three:

- Live cell with less than two and more than three neighbors dies
- Death cell with exactly three live neighbor cells become alive
- In other cases the state remain the same

By experimenting with initial state of grid interesting patterns were discovered. In general we can divide them as still lives, oscillators, gliders and breeders.

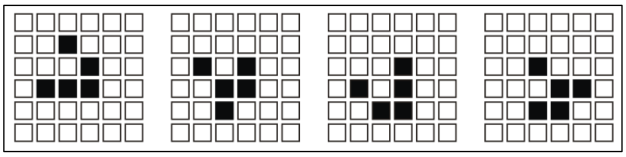

Fig. 1. Glider evolution in two-dimensional Game of Life

3. MAXSCRIPT

For implementation of cellular automata and Game of Life the MAXScript was used. MAXScript is a built-in scripting language that can be used to automate repetitive tasks, combine existing functionality in new ways, develop new tools and user interfaces. It was used for this application as environment that would represent result of algorithm calculations by standard objects of 3Ds Max, therefore it is suitable to represent the three-dimensional cellular automata.

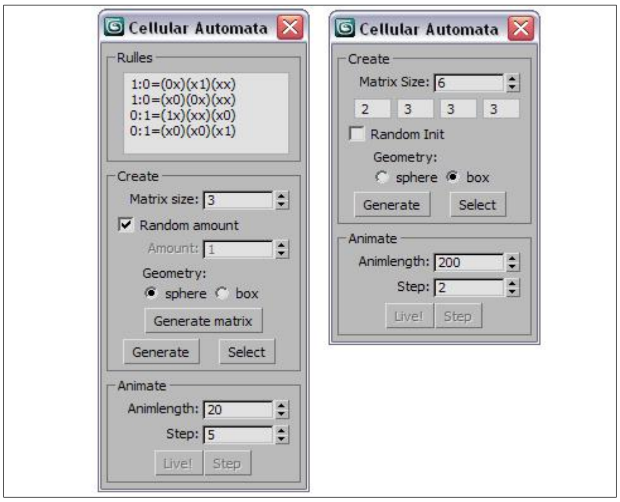

Fig. 2 Cellular automata script with totalistic rules (left); Cellular automata with deterministic rules (right)

4. DISCUSSION

Extension of most used 2D version of cellular automata and its functionality by additional dimension was allowed by its general definition that make the process achievable.

The rule type remains the same. Therefore there is no need to change this part of algorithm (totalistic or deterministic rule type were implemented).

Neighborhood types have to be altered because of increment of dimension. Actual types of neighborhoods have to be extended but their nature is unchanged. This extension leads to increase of neighbors at Von Neumann to six cells and at Moore to 26 cells. As we can see the possibilities of combinations increase and more sophisticated structures can be created. On the other hand, complexity of initial setup design process and rule definition increase as well.

Actual implementation in MAXScript was realize by creating GUI that allows based on type of rules (totalistic, deterministic) give the appropriate possibilities to set rules (Fig. 2), determine grid size and generate it, set initial state of grid by random, defined amount of live cells, or specify state by manual selection of cells and then start the process of evaluation by one step or by defined length of animation that can be generated and reviewed afterwards.

All the calculations are executed on grid dimension size matrix and displayed by standard objects of software (only Box and Sphere was implemented). Animation is created by setting the key frames and actual status (size) of displayed objects.

5. RESULTS

The earlier mentioned expansion of dimension and connected complexity of problematic creates the space for exploration. For easier orientation and setup the deterministic rules with Moore neighborhood was used for search of life-like patterns.

The application of original Conway's Game of Life with original set of rules is possible with use of toroidal grid of cells and even number of cells (Fig. 4). In every second layer we set the traditional patterns that were described earlier and therefore the original rules can be applied.

If we use just one known initial pattern the process fails because of additional dimension cells get born on unexpected positions and therefore it change evolution of pattern.

To create different life-like patterns is possible to alter the rule set and therefore change environment reaction on the setup and therefore we can utilize the three-dimensional space. But the process of development is highly complex and to achieve some valuable result is problematic.

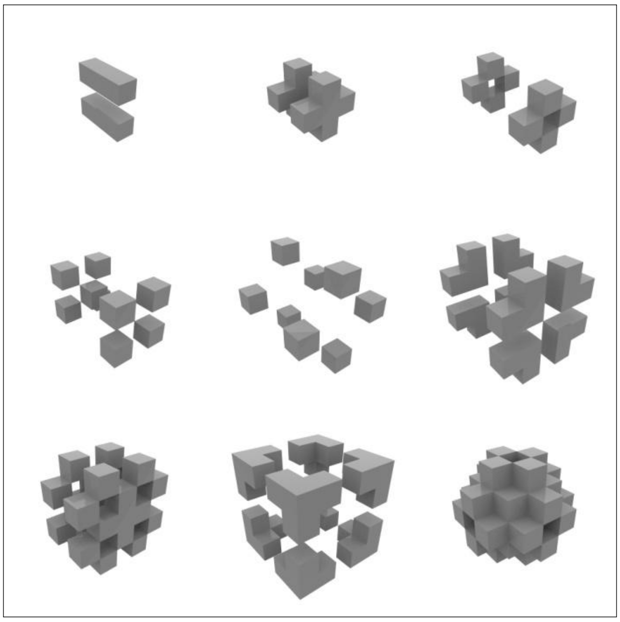

Fig. 3. Evolution of pattern based on rules (1 1 4 4)

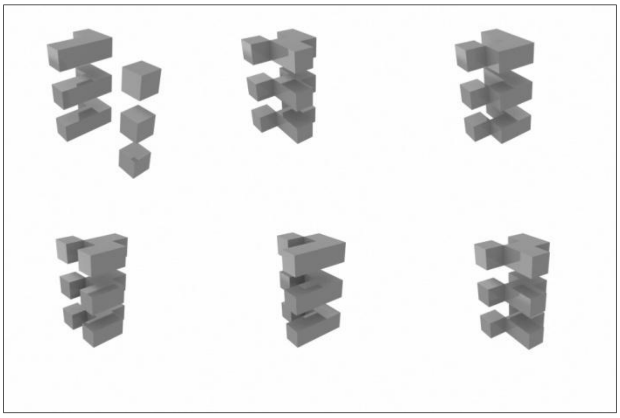

Fig. 4. Evolution of glider from Game of Life in 3D with original set of rules

6. CONCLUSION

Implementation of cellular automata using the MAXScript is quiet trivial and there are no big problems in this process. More challenging is on the other hand creation of functional patterns and setup of rules that would lead to some interesting results in the meaning of static repeatable patterns in defined environment. There exists several patterns that will behave specifically, but there was not founded that robust setup like at Game of Life which allows to create big set of different structures with specific properties. This is caused by significantly higher complexity of three-dimensional environment. The experimentation is difficult, time consuming and in three-dimensional environment harder to observe.

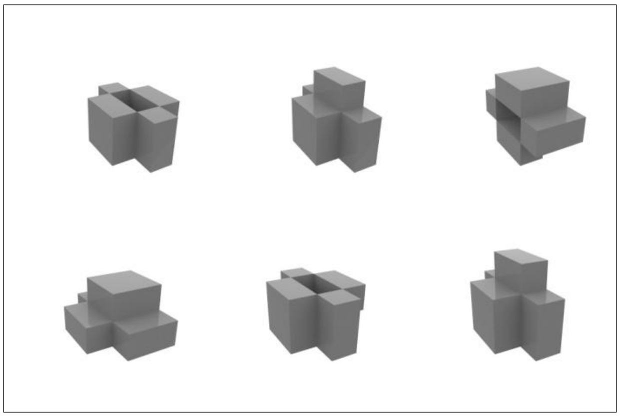

Fig. 5. Evolution of 3D glider using setup of rules (4 5 5 5)

7. ACKNOWLEDGEMENTS

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