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Parametric Approach in the City Planning (Introduction to the Cellular Automata Simulation in the Future Cities and its Integration in the GIS Technology)

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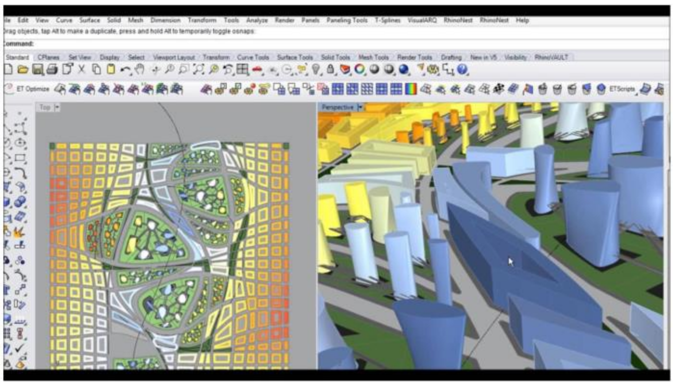
***Abstract*:- Parametric approach in the city planning**
Computer in the field of architecture was used as the "aided tool" which help the designer to avoid the repetitive work in other way help the designer in his design and to increase the productivity. With the advent of the new technology the people are looking forward to use the computer not merely as a helper but have even put the designer to the back seat and come to more complex and random options, within the set prescribed framework for the designers. The software for architecture were developed like grasshopper and Maya, which have unlocked the immense possibilities for the architect to experiment with the built-form, typology, spaces etc. These types of software use the coding or "instruction" given by the person.
It is important to explain that the traditional system of building design also uses the codes, but thesis codes are like golden ration, average height, average distance, building by-laws etc. through this we design the building and even the city spaces. And same computation can be use at the at city level.
The city can't grow in isolation, that's why the effect of the external force is more important than on at the building design level. Forces in cities like, the culture, the price of land, the relation with different type of building, etc. The generative algorithm can be more complex and its outcome could be random. Generative algorithm editor has the graphical tool (grasshopper) to link with 3-d modeling software (Rhino 5) to have a more interactive parametric modeling.2Here the algorithmic coding will not provide the limitation or restriction only, but also set the inter-relationship between the various elements in the city. This will give a new and unexpected result and challenges the narrow minded and standard city planning.
In the standard based planning, we assume the city as a fixed, expected and permanent, which is not true. The research paper aim will be to understand the computation element at the city level and its usages in preparing the Master plan for the city. The paper will highlight the use of GIS technology and Cellular automata modeling at a basic level, for the scope of future city planning. There is the growing curiosity in this field and as a result various method of commuting and concept of city is developing.
Some are the Swarm modeling and genetic algorithm. The city grows and could be understood at all level, human behavior is the most complex form to understand. The computation pattern had also being developed for it. The "Swarm modeling" technique. Often use to understand the pattern of movement during the accident in stadium.
The paper will not go in detail of such complex concept, but will give an overview of it. Apart from understanding the human behavior the computation technique for designing the city also get the inspiration from the nature. This branch of coding is call the "genetic algorithms", where the nature as a model is use to understand the growth of the city and many features is design while considering it. There is various coding technique use to get the desired outcome.
In the 1st section I will discuss the need of parametric urban planning here I have tried to explain the failure of the modernist planning and give some benefit of the computational planning in the age of globalization and uncontrolled growth of cities in India. In the 2nd section I have given an introduction of the "cellular automata" its uses and basic facts of how to use it and importance in simulation. In the 3rd section I have given the importance of the integration of the GIS real world data to the CA simulation modeling. In the last 3rd section I have concluded by giving the criticism and benefits and improvements need in the cellular automata (CA).

1. INTRODUCTION

The city as a machine is the most modernist put forward as the future cities where the city will be the machines in which we live and supported by the technology and mass production. In contrast with the paradigm of mechanization, in 1960 "Metabolism: the proposal for new urbanism" was a major boost for the biological analogies of growth, adaptation and regeneration. This is the result of the uncontrolled urbanism in the japan which is supported by high technology. 4 Despite many theories of the utopia the city failed to conceived or maintained as an ideal to construct. The modernist cities are based on segregation and zoning and focus more in automobiles oriented movement which the old city is completely opposite.5 The Modernist paradigm of "City as a Machine" is completely fail in today's society. The cities are full of complexities and these complexities should be harness for more better improvement in the planning, rather constraining it into standardization . We have now seen the slow transformation of the city from mechanical style of planning to more a biological models which is base not only on the modern thinking and failed concept of modernism. The ancient cities were built with respect to the military walls and the technological advancement. The growth of the city now days also use the information which give Information on how the city evolve over the period of time. One of the guiding principles for the futuristic urban planning is the use of time as another associative component where the growth of city is defined by the flow of information. the organic city will help in bringing the collective information and the producing the masterplan both, on one page. The city is a new kind of man-made nature, increasingly understood and modeled accordingly to the associative logic of natural and biological system.

Over the last several decades, digital tools and technologies have become the norm in architectural culture transforming manufacturing, delivery, assembly and construction. Similarly, environment by enabling us to manipulate and assess interactions in the 21st century. The city is perhaps the most complex entity changing. Parametric design is a process based on algorithmic thinking that enables the expression of parameters and rules that, together, define, encode and clarify the relationship between design intent and design response7 Generative programming is a style of computer programming that uses automated source code creation through generic frames, classes, prototypes, templates, aspects, and code generators to improve programmer productivity.8 Parametric Urbanism is another way of using the codes to defines the cities morphology and constrains .

Incorporating the intelligence into the formation, organization and performance of urban spaces and related to its uses and activities. Coding can inform the pattern of streets, massing morphology, social order, activities and so on. Code-based design can lead to multiple hierarchies and emergent, unexpected patterns. And are interlinked directly and indirectly to many factors. the need for greater organization and control of the growth and its functions has let into the development of new methodologies which focus on self-organization or complex organization, through flow of information.



Source: Arturo De la Fuente, parametric urbanism, youtube image

EARLIER TIMES

Cellular automata (CA) have been in popular use for urban simulation. Computer simulation has made open the possibility of many experiments in the urban filed. The simplicity at bottom level and complexity in the results at top level in other words its connection with the local level (local constraints) till the global level (international or regional level constraints) has put it into the lame light. The computer simulation has brought many complexes, random and unimaginable results and since the city is also a complex entity this simulation exercise could be very helpful in the near future.

CA were originally conceived by Ulam and Von Neumann in the 1940s to know the behavior of the complex system . The concept of self-reorganization, which is one of the main characteristics of complex systems, is central to CA based modeling. Self-organization refers to the tendency of system to spontaneously develop orders patterns, often on a large scale forms the local decision-making process. Thus, CA area able to simulate processes such as urban growth where global centralization order emerges from the local level rules or decentralization.

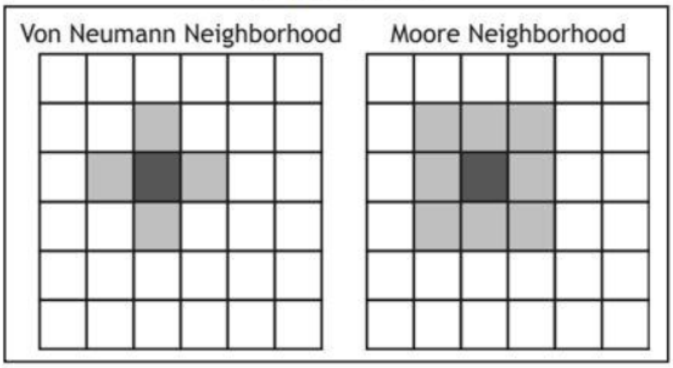
Formally, CA are composed of four elements

First, there are *cells* which are objects in any dimensional space but which must manifest some adjacency or proximity to one another if they are to relate in the local manner prescribed by such a model.

Second, each cell can take on only one *state* at any one time from a set of states which define the attributes of the system. In Life, for example, there are two states: dead or alive.

Third, the state of any cell depends on the states and configurations of other cells in the *neighborhood* of that cell, for example, the cell that are physically close to the central cell, which will influence the state of the central cell in the next step. The neighborhood cell will be governed by the transition rules for every successive step. The type of evolution, whether it will repopulate or diffuse in space will be governed by the neighborhood and rules interacting at the global level.

The two commonly use neighborhood are the Von Neuman and Moor neighborhood.



A 3x3 cell von Neumann and Moore neighborhood *Units*

The central cell is under considerations and the surrounding cell of Von neighborhood and Moore neighborhood will be govern by the rules set in the neighborhood can also extended from their 3x3 cells to other larger odd numbered sizes (eg.5x5,7x7,9x9, and so on)13

Finally, there are transition *rules* which drive changes of state in each cell as some function of what exists or is happening in the neighborhood of the cell. The future state or form or in simple word presence, will be determined by the transitional rules, which is governed by the time factor. Each cell will change its state in the time frame as a function of the state of its immediate adjacent neighbors, which are updated at each iteration. The function, which is used to

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change the cell states between the time steps, is called as transition rule and give change to infuse the urban theory directly into model. In the sequence of time (t, t+1, t+2,..) which is treated as discreet, each cell in the CA lattice updated its state based on the transition rules. The general definition in mathematical notation is

Hence, it is the capacity to integrate spatial and temporal

$$\{S_{t+1}\} = f\,(\{S_t\}\{I^h_t\})$$

Where

$\{S_{t+1}\}$ is the state of the cell in the CA at time (t+1)

$\{S_t\}$ is the state of the cell in the CA at time (t)

$\{I_t^h\}$ refers to the neighbourhood,

f () denotes the transition rules

t is the time steps in temporal space

h is the neighbourhood size

dimensions that makes CA very intriguing for the development of the urban models. Another important things regarding rules which should be noted is that the key elements which define a strict cellular automaton are that the rules must be *uniform*, they must apply to every cell, state, and neighborhood.

They uses the cells space as a residential lots and the cell state as the general quality of the dwelling unit and family characteristics. The transition rules which he set in regard of this, is governed by the ethnicity of the neighborhood.

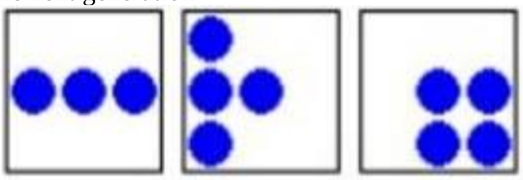
In 1937 a mathematician Jon Conway has derived a rule for the cell to grow and die. His simulation model is call “Game of life” he by doing this and using these simple rules, they try to explain the level of complexity which if use these rules, in Cellular automata, could get unexpected results.

Some rules are:

1) Each cell will have 8 neighbors

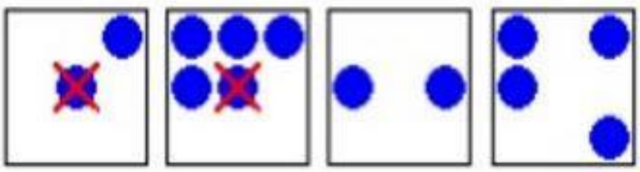
2) Each cell can evolve accordingly to 1 of the 3 rules:

a. Survival: - every cell with 2 or 3 neighbors cell survive for the next generation

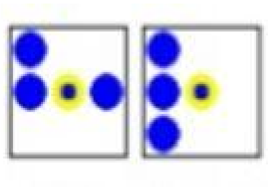


b. Death: - Each cell with 4 or more neighbors will die due to “overpopulation”

c. Each with 1 neighbor or none will die due to isolation



d. Birth: each empty cell adjacent to exactly 3 neighbors is a birth cell



These rules can see rapid population explosion where cell populates and rapid depopulation where cell dies. These kinds of rules can be applied in the cellular automata modeling where you can get enough complexities from the simple

rules you made. The simple constrains your device will have a complex result.

From the simplest CA, it is easy to show that complex global patterns can emerge directly from the application of such local rules and it is this property of emergence which makes CA so intriguing.

Simulation in Cellular automata through GIS technology

A number of CA models of urban systems have been developed, together with several modeling systems. Tobler was the first to propose a cellular approach to geographical modelling, and his idea was followed up by Couclelis and later Takeyama. Couclelis uses the ideas of CA modelling to explore the nature of space and spatial relations in

the context of dynamics, but does not attempt applications to specific cities. However, she points out that while standard spatial interaction-based approaches to the modelling of urban and regional systems postulate a relational

space, usually of low resolution, in which absolute location is virtually irrelevant, GIS (Geographical Information Systems), on the other hand, presuppose an absolute space, and one of very high resolution. Both approaches are appropriate for certain problems, but an adequate representation of a city will involve both relational and absolute spaces.

The GIS has the large source of data to its detail level and CA has the ability to analysis the complex system with taking care of the global state and considering the time factor. Knowing both the power can be useful to integrate them and bring out more improved version of simulation. A more and more data can be retrieve form the GIS, the factors which effect the growth can be easily quantify and analysis for the future growth. The interaction of the dynamic nature of CA and the spatial nature of the GIS can be use in great strength for the future cities. Another importance of this combination is the use of the various local level factors to the future evolution of the city. CA can be used to bring forward a more complex dynamics of urban land use change which cannot be seen in the traditional models.

One most important reason to incorporate the CA and GIS is important in the Indian context also. The India has facing a massive explosion of the population which is turning the landcover character in a drastic and inappropriate way. This simulation can guide the planners for the future expansion and help them to device the policy and device a

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better urban management. The sensitive green cover can be protected in the better way. The fertile land can be protected and manage at the scale for the future population and environmental balance. Another is the incorporation of various kinds of constraints in cellular automata can enable planners to compare the costs and benefit of different development.

Cellular automata strength and complexities

1) CA assumes that the cell state will be either true or false or in other word either dead or active. This is explained in CA in this level of simplicity but if we super impose the real-world data of GIS on the CA model. You can find the cell could be of two state at one time. Cell could be at neutral state. A piece of land could be occupied or vacant or could be taken into consideration of being used in future, or a river which is flowing in one direction could change its direction due to unforeseen circumstances. Another problem is the cell size in the GIS could not be equal to cell size of CA. it will be approximate. Thus, giving the approximate result of the activity happening on the real world.

2) Urban simulation models are abstract, simplified versions of real-world objects and experiment which of such is done to know every changing city is more complex work. The framework is too simplified and constrained to represent real cities. Indeed, radical modification is necessary before CA can approximate even a crude representation of an urban system. This often necessitates the introduction of additional components to add functionality to the basic CA framework.

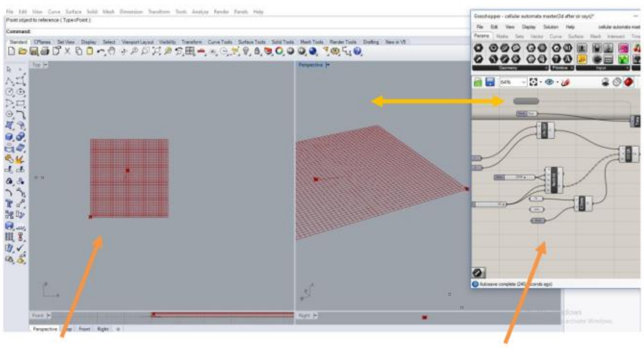
3) Another problem which the CA faces is that it uses the bottom up approach and define the global output on the basis of the local constrains and rules. Which in the real world is not possible because the global economy, globalization, etc. also effect the city planning and its growth

4) If we see the strength of CA it is that it can be modified in to unimaginable complexities and the result could be come to near possible and realistic. The CA should be equipped with more flexibility and controls so that the result should be appreciable in the complex city environment.

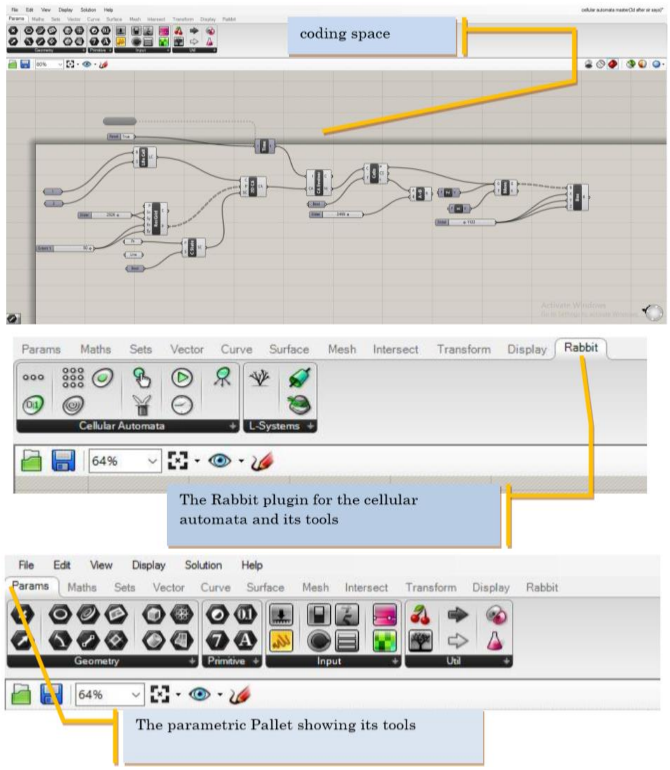
SIMULATION EXAMPLES –

The Rhino5 software and its plugin Grasshopper and its plug Rabbit 3.0 is use to generate the output for the cellular automata. They both is inter connected. The codding is done in the grasshopper and is visible in the rhino5 window.

Introduction of the Interface of simulation software:



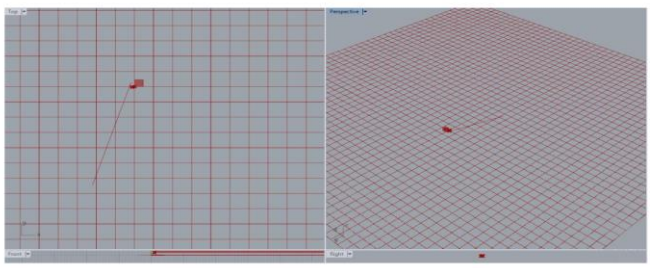
Rhino 5 Interface   Grasshopper Plugin Interface



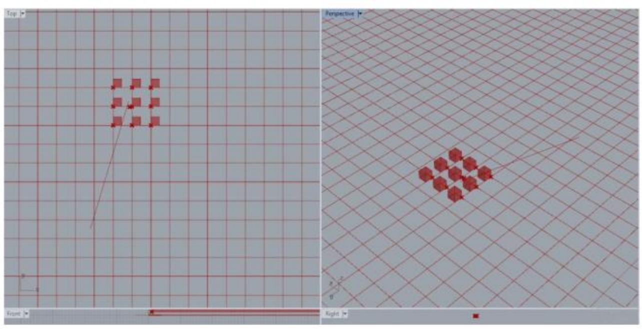
GROWTH PATTERN 1: -

The point of starting is at the center of the plan
Rule: -
Born- If the cell is surrounded by 1 cell
Survive - If the cell if surrounded by 2 neighbors
Time frame is taken to 5 secretion in the Simulation model
The number of growth point is only one at the center and no restriction is set on the plan. The growth is seen in 2d level and will be modified to 3rd also with more complexities added
to it. The software uses to generate is Rhino5 with grasshopper plugin and Rabbit add on.

Stage 1



Stage 2



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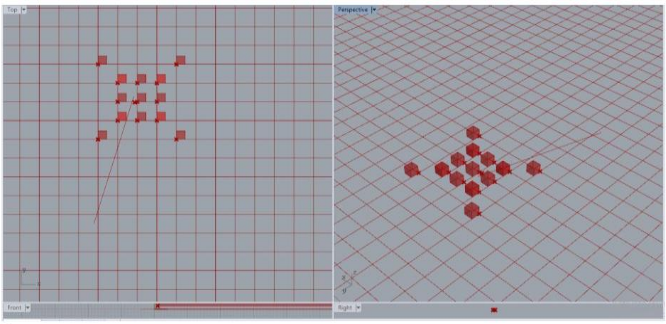
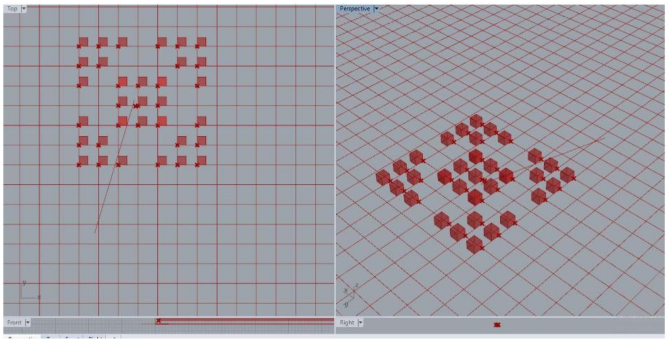
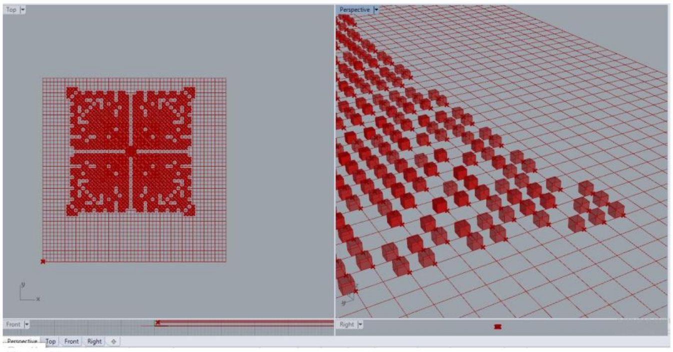


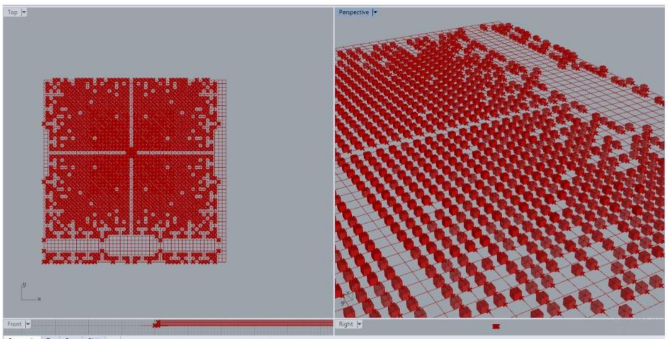
Stage 4



Stage 5



Stage 6



GROWTH PATTERN 2

The point of starting is at the center of the plan

Rule:-

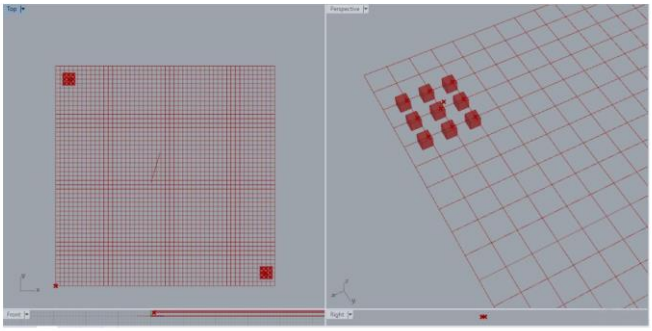
Born- If the cell is surrounded by 1 cell

Survive - If the cell if surrounded by 2 neighbors

Time frame is taken to 5 secetion in the Simulation model

The number of growth point is TWO at the corner at the center and no restriction is set on the plan. The growth is seen in 2d level and will be modified to 3rd also with more complexities dded to it. The software uses to generate is Rhino5 with grasshopper plugin and Rabbit add on.

Stage 1



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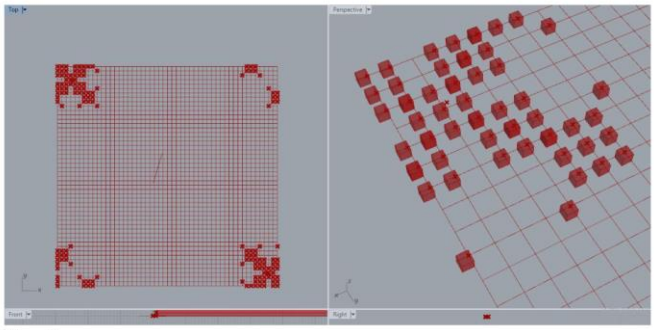

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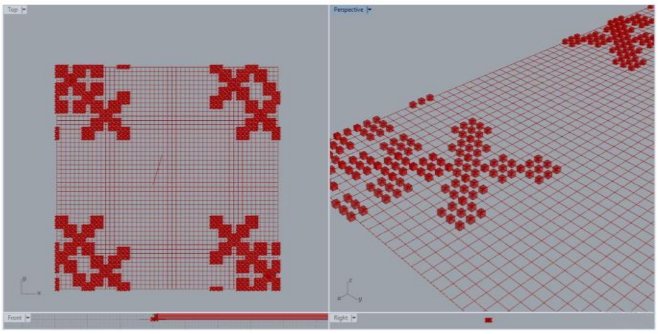
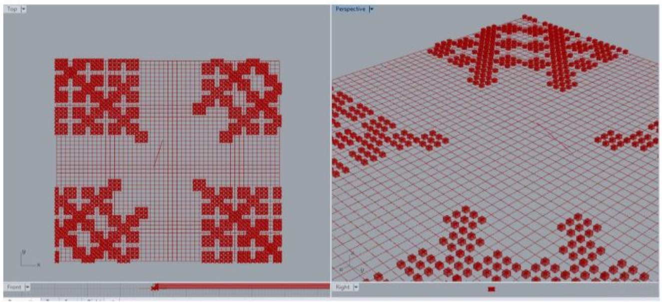
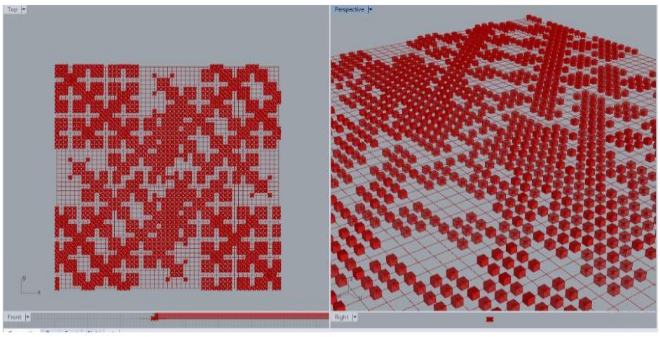


Stage 4



Stage 5



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STRENGTH OF SOFTWARE:

1) The basic simulation can be done
2) The starting point of this concept, need much elaboration in the coding field
3) Can help in understanding the complexities at the basic coding level also.

LIMITATION OF IT ARE:

1) The plugin is at very basic stage
2) The advance connection with the GIS is not possible here, but could be done if the software advances
3) The complexities can be generated with the help of points and lines only but in real life the complexities is affected from the external forces like globalization, international market, land use policy, etc. which is not able to demonstrate here in this software

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Ar. Mohd Rehan Khan

REFERENCES

[1] Verbes, tom , Mater planning the adaptive city
[2] Why New Urbanism Fails by Christopher DeWolf
[3] Verbes, tom , Mater planning the adaptive city
[4] Woodbury, Robert (2010). Elements of Parametric Design. Routledge
[5] Issa, R, Essential Mathematics for Computenational Design, second edition, Robert McNneel & Associates, 2009.
[6] Verebes, T, "Experiments in Associative Urbanism"
[7] Parametric Modeling for Advanced Architecture by M. Stavric and O. Marina
[8] Kelly, Out of Control, 7–36
[9] Tom Verebes , COMPUTATIONAL URBANISM , CHAPTER 15 , page 182
[10] Application of Cellular Automata and GISTechniques in Urban Growth Modelling:A New Perspective Dr. Sandeep Maithani
[11] Application of Cellular Automata and GISTechniques in Urban Growth Modelling:A New Perspective Dr. Sandeep Maithani
[12] Game of life, Maths in nature and biology, European commission report (Slide share.com)
[13] Cities and cellular automata, White,Roger, December 1997
[14] URBAN GROWTH MODELING USING GENETIC ALGORITHMS AND CELLULAR AUTOMATA; A CASE
[15] STUDY OF ISFAHAN METROPOLITAN AREA, IRAN, by Mahmoud Reza
[16] Environment and Planning B: Planning and Design 2001, volume 28, pages number 163 -168