CREATING NEW CITIES

Cellular automata & Social Condensers

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Abstract. This paper presents a further step of a study that is exploring the potential of applying computational strategies to design and evaluate solutions for urban development and planning in the context of contemporary China. This exploration used a city design competition brief in China to check the feasibility of shaping future cities by the use of an automated system based on high-density urban types. The necessity of relying on digital tools is due to the need to encapsulate and translate into one single process the wide range of different parameters taken into account during the design development, in our case environmental data, big data, blockchain technology and Chinese regulatory frameworks as envisioned by the Chinese 13th five year plan. We thus build an algorithm that creates new cities driven by the aforementioned parameters. The last step of the process is based on the application of a social condenser that aims to create an overlapping merging among the defined functions. In parallel the algorithm uses a Cellular Automata strategy to develop an urban fabric.
The outcome of the paper is an algorithm who gathers all the data as mentioned above and outputs a masterplan making use of the Cellular Automata paradigm.

Keywords. Cellular automata; lattice path; urban density; generative urbanism.

1. Introduction

Urban development is a key strategic tool for the government of China in fostering economic growth and raising people out of poverty. After decades of accelerated urban development on the east coast of China, the 13th five year plan discusses in chapter 33 the creation of city clusters in the hinterland. One of those clusters lies in central Guizhou, where the local government decided to launch an international design competition to create a new city, in the core area of Qiushui Lake, at the Yilong district in Guizhou (NPCC 2016).

We decided to enter the competition to test a series of algorithms we had developed earlier in producing dense urban agglomerations (Dounas et al, 2017), properly configured so that they create new cities rather than urban clusters. The fit of the strategies we developed with the theme of the competition was evident from the framework of the competition: a contrast and collaboration between a 'traditional' oriental landscape and a futuristic city. Within the word oriental the competition description classifies then the mountainous natural landscape of Guizhou, and makes the point of discussing city life founded on nature.

The focus then becomes within the competition description the creation of a new relationship between the local typical Chinese landscape and the futuristic city development. In parallel one of the main axis that the Chinese government was framing Guizhou industries for were Big Data, particularly data centres for information processing, and the related service industries. This is characteristic of the Chinese government tactic on development in the heart of the Chinese mainland: the move, establishment and focus of resources of key industries in specific cities and city clusters.

These descriptions fit the directive of our first algorithm in urban densities: the increase of urban density, while at the same time maintaining building and urban footprint, arresting the erosion of agricultural land at the periphery of Suzhou, in Jiangsu province. Hence our strategy for entering the competition would be the creation of a new version of the algorithm, to include characteristics of the Chinese government directives and the frame for the competition on balancing the natural landscape with an accelerated economic growth.

2. Site and competition directives

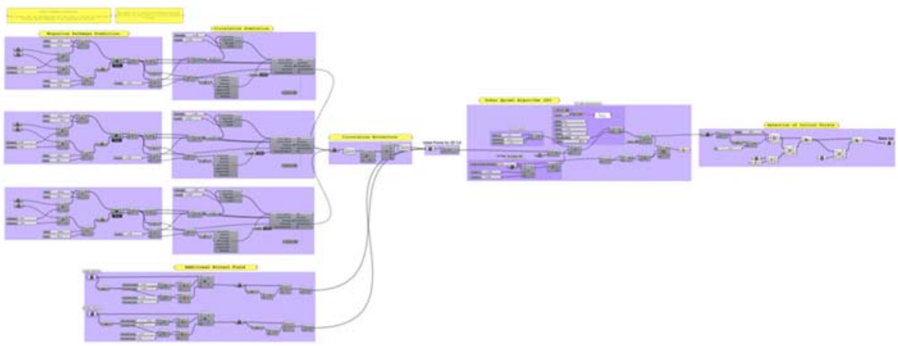
The Yilong District is one of the areas in China that are facing deep changes in terms of urban design and provides the perfect situation for planning a futuristic city. Indeed it confronts with the typical problems of contemporary city like traffic congestion, urban homogenization and pollution, and it is characterized by specific natural issues like a constant water erosion with a peculiar network of underground water canals that makes the area fragile and with relatively low space for construction. At the same time any intervention and opportunity for growth faces the erosion of the picturesque natural local landscape of the mountain area of Guizhou. Still the competition developed with the directive of housing in the new city 800.000 people, a moderate amount for Chinese standards but still complex enough to create bottlenecks and contrast in the process.

3. Implementation of the algorithmic design process

The neutrality of data (Tedeschi and Lombardi, 2018) as well as their inner mathematical nature, perfectly fit the need of merging different requests and constraints, leading us to choose the algorithmic language as main tool to face the amount of information to deal with.

The urban generation algorithm then follows a two-stage process: the first one for retrieving the centres of the new city and the second to obtain the buildings' distribution.

The first phase combines a strategy for minimizing the distances between the further boundaries of the initial area with a Cellular Automata algorithm to define the initial urban sprawl. The minimal path is retrieved relying on a digitalization of the well-known Frei Otto's (2011) minimal path approach[Lopez et al]: the opposite sides of the Yilong area are divided in a defined number of points and interconnected in order to create a first rigid net. The obtained net goes under a further process of high-density subdivision that provides the necessary points where to apply the attraction forces who will



transform the rigid net into a minimal lattice path. The parameters to control the strength of the physical process have been set up accordingly to the geometrical characteristics and extension of the area. Lastly the lattice geometry has been evaluated in order to obtain a point in each interconnection. Those points, because of their crucial position within the lattice, represented the starting spots where the CA's algorithm will generate the new city and become the pivotal point for applying the social condenser technique. (Figure 1).

Figure 1. Stage 1 of the algorithmic process.

The second phase is based on the creation of a bi-dimensional grid that will work as masterplan for the 3D development of the city. The urban sprawl has been calculated defining first the driving rules of the process and the starting grid where the first generation of CA has to sprout up. A series of tests have been conducted applying different time steps to the developing process of the CA. The determination of the optimal layout has been conducted analysing that the position of the cells would fall within specific areas of the city. The presence of specific constraints avoid the algorithm to build within the bodies of the water or the lakes and allows to leave a lot of the area unbuilt in order to give way to the natural landscape to develop.

Once the first layer of cells has been defined the algorithmic process goes ahead to define the actual new city with building characterized by different heights. The basic idea was to adapt the city so that its shape can fit the surrounding landscape through three different types of organizations: areas with dense building as high as the hills, areas with buildings that follow the outline of the hill and areas with the presence of mega structures that connect the lower layer of the city with its highest points (Figure 2).

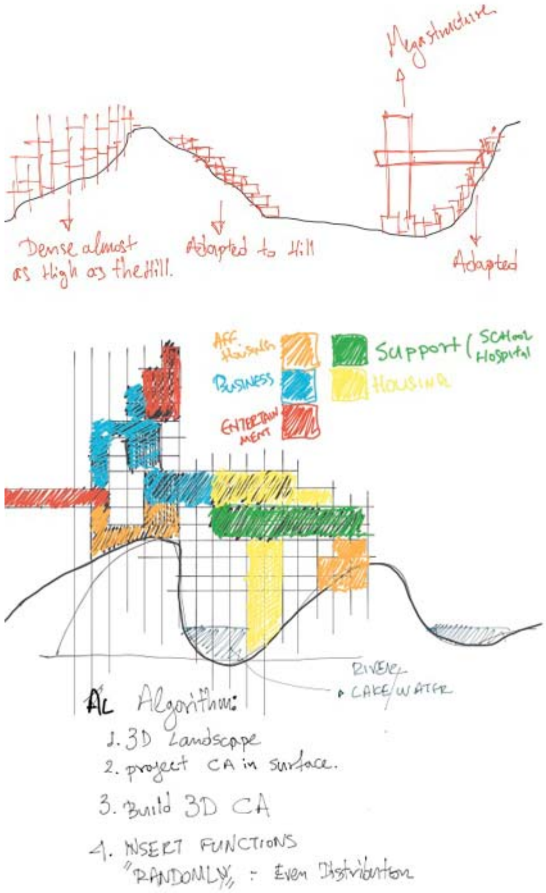


Figure 2: Schematic of the process.

The three-dimensional urban development is then based on a CA algorithm that starts from the centre defined in the 2D study. To ensure an amplified urban density to the city a lower value has been defined as survival level for the CA. As well as in the previous analysis different timings have been set up and tested to verify how different CA distributions would respond to the starting parameters. In the 3D design stage too, a key role as been played by the analysis of the position of the cells that helped with the selection and removal of those elements that did not respond to the functional plan of the geographical aspects of the site (Figure 3)

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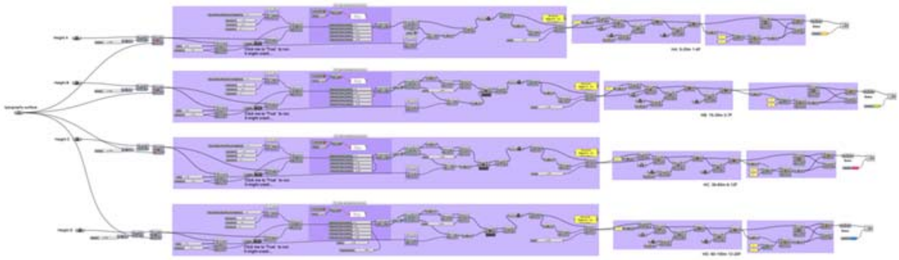

Figure 3. Stage 2 of the algorithmic process.

The final result of the algorithm then develops from there. Buildings are extruded according to function, and very simple connectivity is established according to functional areas of the city, without prejudice on the type of connectivity as it can be from a road to urban trains to underground (Figure 4).

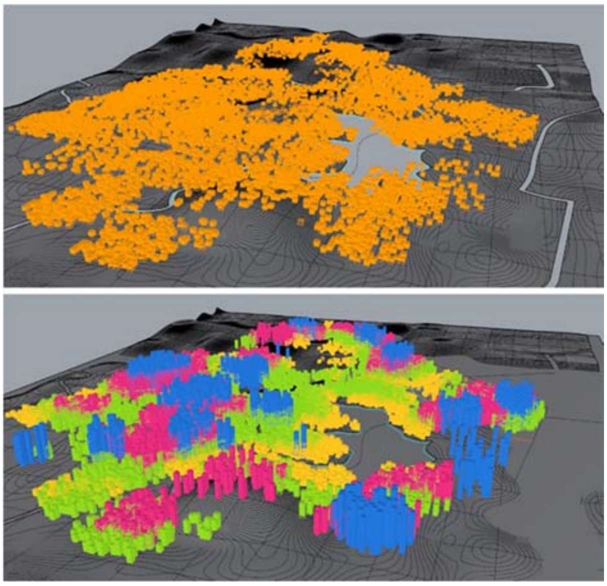

Figure 4. CA's distributions after first and second stage.

4. Conclusions and further development

This paper presented the workflow designed to plan a new city in the Yilong District relying on the computational power of the algorithms and implementing environmental data, regulatory framework and big data.

As an exercise in re-using design strategies and algorithmic ideas about design, our experimentation with the Chinese city scale proved successful as the proposal was awarded the third award in the competition out of 1052 teams. It further consolidated our position that futures innovative urban design and experimentation will ever increasingly take place in China as the country faces unique challenges of urbanization. The city that our algorithm creates is one of pure programme, pure density, pure organisation and no form. Within that position we envision out future work to continue with the urban density algorithm to enable designers by building highly capable frameworks for architectural production, in complex parametric spaces.

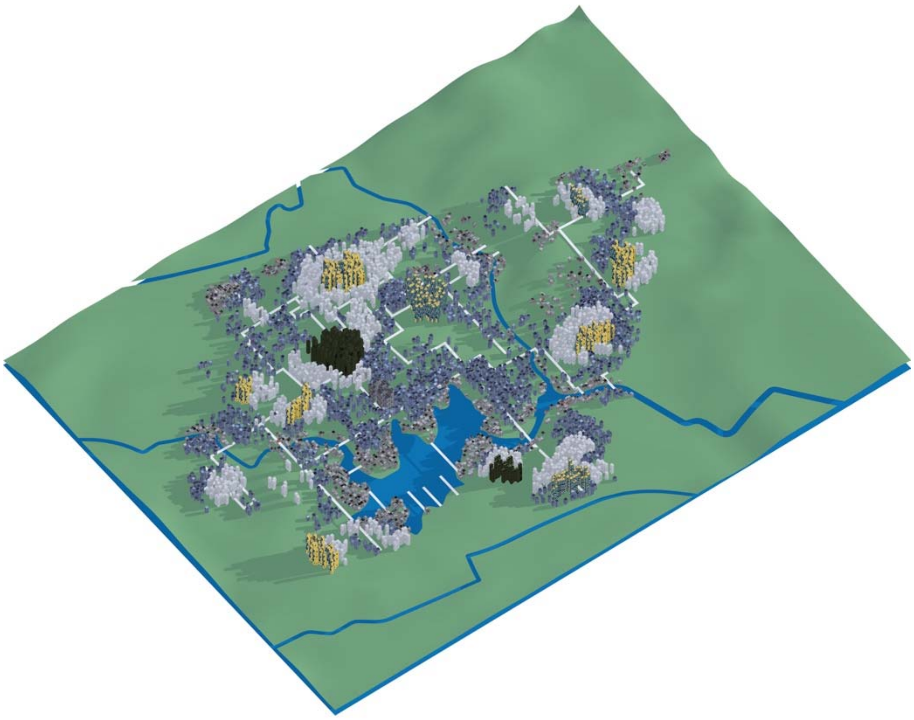

Figure 6: axonometric of the final result

This study is then a new starting point for a research that will then explore the possibility given by the integration of novel web-based technologies with the realm of the built environment. The application of a new workflow adapted to work at a lower scale will be studied to evaluate new design processes in the field of housing as well as possible connections related with the BIM.

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