Emergent Urban Strategies

Rules of city reconfiguration

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Abstract. This paper presents the results of partial research in the area of designing processes and methods of spatial and social interaction of multi-agent system with its environment in the city urban structure. According to the logic defined by the intrinsic rules of the simulation model of the selected area, there will be verified and tested the emergent phenomena resulting in changes in the configurations of urban structures.

Keywords. Emergence; multi-agent modeling; bottom-up; city reconfiguration, collective design.

INTRODUCTION

“Our new understanding of how cities function is predicated on action from the bottom up. Cities are built by actions exercised by individuals on behalf of themselves or larger collectivities, agencies and groups mainly configured as local actions. Global patterns emerge, best seen in how different parts of the city reflect the operation of routine decisions which combine to produce order at higher and higher scales. Cities are fractal in their form and function(...).Traditional planning and design that fights against such self-organization will fail and in this, the best principles for design must reflect organization form the bottom up: the metaphor is evolution, the way nature works is magic”( Batty and Hudson-Smith, 2012; Pasquero and Poletto, 2012, p. 18)

A city as a complex phenomenon and an entirety of events, its invisible communication flows (information and data telecommunication networks and their access points), energy, goods and materials distribution and movement of users themselves and their spatial interactions with the environment nowadays no doubt has been creating new conditions and demands on the city’s spatial organization, infrastructure, its organic growth and its thickening.

Urban space today is an aggregate of complex dynamic processes, which contribute to its configuration and mutually influence each other. Thus, urban environment shows emergent qualities and contains multi-layer scenarios of its own development and reconfiguration in time. This stratification is impossible to be comprehended by a linear model of a single predicted concept (top-down strategy). Architects and urban planners may, however, cover these specifics by a prediction of space development with a multi-layer result that would take into account the requirements and demands of users at the lower level (bottom-up strategy).

The aim of the research is therefore a spatial simulation of environment development in time for a specified time period, which, based on the require-
ments of the lower level, would simulate the complexity of the environment, its growth, thickening and reconfiguration. This spatial simulation would serve as a decision-making tool for architects when applying various alternative scenarios of environment development and thereby it would create a basis for spatial planning decisions in subsequent stages of zoning proceedings.

The final result of this research shall therefore be a visualised algorithm in a simulation geometrical model of spatial environment reconfiguration that could be serviceable also in the internet environment. This result implemented in a software tool with own GUI can also serve as a creative generative platform for designing urban structure based on simple rules of a lower level, that would, however, consequently simulate the complex and comprehensive urban entirety.

**RESEARCH PROCEEDING**

This research aims to track and simulate the above mentioned urban dynamic processes using a case study of a particular selected and already existing site.

The city part Prague - Jižní Město (Southern City) has been selected for its potential for further development and re-configuration in future time horizons. It is a urban residential satellite characterized by overwhelmingly uniform living features with a population of 80,000 and the good traffic accessibility as well as public transport links to the city centre (Figure 1).

The research in the case study focuses on the potential for further growth, re-configuration and transformation of the environment, targeting mainly at complementing and expansion of urban activities, additions and changes in infrastructure, communication and distribution flows to strengthen the dynamics of growth or thickening of the environment using parameters that express specific user requirements for their environment, respectively demands of investors and developers.

Research proceeding is as follows:

1. determining the lower-level simulation rules of reconfiguration within the existing bottom-up strategy;
2. application of the rules of reconfiguration to the existing urban situations using relevant algorithmic methods utilizing scripting techniques, and development of the simulation model;
3. testing the simulation model of the existing environment, complementing selected parameters;
4. evaluation and on-line publication of the simulation model.

This paper focuses on partial determination and definition of the internal logic of simulation rules for the reconfiguration of urban structure within its interaction with the behavior of a multi-agent system representing some selected dynamic processes in the urban environment as a possible method for re-configuring an existing simulation environment for monitoring and testing the emergent phenomena in the urban structure.

**SIMULATION RULES**

The examined city urban structure is composed of communication traffic flows, block and solitary buildings, in which housing is the predominant function, while the built-up area also consists of urban services, administrative activities, environment and public spaces for leisure and rest activities.

For the purposes of determining simulation rules of reconfiguration it is necessary to define which aspect needs to be reconfigured, based on the needs of participants-users. In the first step, it shall be the walking distance to sites of respective activities and hence the reconfiguration of the communication flows. The next step will be to monitor the changes in positions of respective activities, their strengthening, growth and changes of structures in their shape and volume. This monitoring will be based on the interaction of agent-based system representing the needs of participants seeking sites of their activities with respective elements of urban structure. One of these aspects or combination thereof may cause the reconfiguration and re-
modeling of the existing environment.

The simulation model will be working with a group multi-agent system composed of several groups of dynamic agents (office seeker, school seeker, rest-activity seeker) with a defined percentage of the population distribution, constituting a representative sample of the real-life population. Each group of agents will track its common activity which will be placed in the existing urban structures in accordance with real situation. The model will contain structures that shall represent the various components of the urban environment (activities, parcels, buildings, built-up area) as well as the original existing communication flows (traffic, infrastructure).
The simulation rules will be as follows:

1. The agents are moving within the existing communication flows and are seeking their places of interests (activities) (Figure 2).
2. An activity (parcel, building) attracts agents with a specific degree of attraction. The degree of attraction will be parametrically variable in the model (Figure 3).
3. An agent leaves behind a pheromone trail that shall be followed by other agents that are attracted by their matter of interest and create a new communication flow beyond the already

Figure 2
Rule 1: Path following test. Agents are moving along all possible / selected paths in the site. Path following algorithm was used for study test.
existing one. If the track will not be filled by another agent within a defined period of time, it will gradually cease to exist (Figure 4).

4. If the tracking will go through an existing parcel, the agent will interact with it - which will result into dividing the parcel into smaller sections or parts. After evaluation, the newly formed parcel may assume a different form or nature (inner courtyard, corner parcel, L shape, etc.) and it may be used for relevant development according to L area, solitaire, block, cell, cell with courtyard, etc.)

5. If the agent reaches its target interest (i.e. location of a required activity in the model) the
volume of built-in areas that is attributable to a respective activity will increase by the desired value. If the flow of agents is higher at some sites due to their importance and level of attraction, the volume appropriately adapts to this phenomenon by increasing or changing itself and by adding new activities that will attract a new group of agents. Adding volumes will be defined parametrically in the desired range. If increasing volumes of built-in areas reach a certain separation distance in a defined range, the volumes will get interconnected.
**Transforming rules into the simulation model, methodology**

For the development of the simulation model and its graphical expression using the above defined rules, we have selected using computational scripting techniques in the programming language Processing with the use of algorithms and relevant strategies [1] in the field of Path following algorithm, partially flocking algorithm (spacing distances between elements), attracting (seeking targets) and pheromone path following (simulation of motion and communication distribution flows, accumulation of activities at the site).

Algorithms of vector agent simulation [1] mentioned above approximate the most to the spatial expression of the dynamic processes that are taking place in an urban environment with communication and distribution flows and which involve interaction of the particular inhabitant with the environment or the interaction of inhabitants between each other, or, respectively, the mutual influence of the elements of the environment.

**DISCUSSION AND CONCLUSION**

Rules defined for urban reconfiguration aim to simulate an “ideal” city, which emerges based on the interests of the participants, who seek their subject of interest - in this case an urban activity (office, school, leisure). Each agent is driven by its own desire to search a target and thereby a comprehensive platform of urban reconfiguration arises from communication flows (infrastructure) and from the reconfiguration of urban structure (division of parcels, shape and volume changes of the built-in areas).

This procedure is presented as a possible method for non-linear re-modeling of an already existing urban area using multi-agent system that can be applied also to other urban units. This non-linear model, however, will need to be tested, refined, and complemented with other features that will either simulate the behavior of the user in the urban environment or relate to interactive input of preliminary ranges of values of the respective parameters (e.g., attraction intensity, activity positioning, initial positions of agents, ratios and sizes of volume units, size of agent populations). So far, a simulation model has been tested only under the path-following algorithms and based on attraction of agents to individual attractors with preliminary graphical output, but further research has the potential to operate with the above mentioned rules and that will lead to a more complex simulation.

**FUTURE WORK**

The future research shall focus on the re-configuration terms and conditions arising from the evaluation of the data in the first part of the research:

1. the typology of buildings and their volumes, shapes and sizes will vary depending on the accumulation of the individual activities and user requirements or depending on an interactive parametric assignments specified by the architect (investor, collective decision-makers of the company or municipality);
2. the model will include a number of typology options within the defined growth building units (compact built-up area of blocs, multiple types of solitaires, high-rise buildings, public space) which are suitable for the specific living environment in the urban area.
3. the simulated movement through the distribution and communication networks will dynamically affect the geometric growth of activities and volumes or their accumulation on the basis of parametrically defined values of the intensity of neighborhood attraction (i.e., each activity can vary in the intensity of its attraction). Simulation platform may contain even more detailed interactive possibilities of intuitive supplementation in the simulation model, namely:
4. changes in the spatial positions of the selected activities and changes in the communication flows and their nodes by means of the UPD communication protocols using between other graphical modeling applications (Rhino, Grasshopper) or directly in the model by defining the coordinates;
5. the parameters of the values of the accessing and spacing distances of respective elements from each other according to the requirements of the architect (user).

**Simulation model of the territory with a graphical user interface (GUI)**

Simulation platform with its own graphical interface of the individual parameters containing the remodeling of the environment on the basis of a lesser degree rules has the potential to become a tool for the observations of the unpredictable processes of urban environment evolution, and it may represent certain future time horizons.

The advantage of such a platform is its application to simulate the evolution of the environment of the already existing urban areas that have the potential for further development and re-configuration in time and on the basis of the requirements of their existing users or the requirements of an architect or interest groups of investors and developers. This model could be perceived as an urban machine which represents the action of the individual units on a local scale but, at the same time, it can take into account even the requirements of larger collective decisions in a broader context.

For the time being the research has been investigated in a theoretical sense, by means of multi-agent system and its potential with behavior within several selected algorithms (flocking, path following, attraction, pheromone following strategies). This would lead to automated generation of urban form. Adding more of the above mentioned characteristics and complementing the simulation model with interactive input of selected parameters shall result into a model simulation platform that can later be utilized and tested by users also on-line.

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