Emergent articulation field in existing urban context

Computational typologies with emergent matter

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The main purpose of this research is to introduce and verify selected advanced computational methodologies operating with agent-oriented approach that are applicable within the framework of emergent urban design strategies in early stages of zoning proceedings. The aim is to demonstrate that speculative matter of the phenomenon of emergence in terms of design thought driven by computational models can also be applicable within real existing urban conditions. The research concurs previous researches in the field of urban pre-reconfigurations in the selected city environments. It concentrates on developing a simulation model as an analytical and generative instrumental platform for architects in early phases of urban design and synthetizes accumulated computational advancements based on agent-oriented approach.

Keywords: *emergence, agent-oriented modelling, urban agency, colonial growth, bottom-up strategy*

INTRODUCTION

The simulation model in the previous phase (Buš 2012, 2013) has documented the dynamic processes in the selected urban place in terms of optimizing walking distances in distribution routes based on different intensities of urban activities attraction which can be interactively parametrically user-defined. The essential methodological approaches have been used for the modelling of agent-based system with Attraction, Path following and Stimergy methodologies that led to interaction of agents with selected environment bringing preliminary graphical outputs (Shiffman 2012),(Spyropoulos 2013)[1].

In the next phase the research will focus on complementing and synthetisation of other computational typologies that determine and influence the behavior of agents in the urban structure and consequently lead to more complex simulation of emergent behavior of structures with characteristics of non-linearity and unpredictability of reconfiguration of the existing area based on participant's bottom-up stimuli (Spyropoulos 2013).

The Aims of Simulation

The main objective of the reconfiguration simulation of the existing environment (selected territory in

Prague - Southern City with 80,000 inhabitants) is to gain insight into the possibility of developing an optimal urban structure with an emphasis on increasing the quality of residential and public urban environments. The current state of the environment has certain inadequacies that reduce the environmental quality. These are in particular: strong uniformity of post-totalitarian urban environment, the lack of available and city-creating public spaces, approach distances to places of public activities are insufficient in some parts, the environment has a large blank areas that are unrelated and separated by barriers of highways.

The aims of the simulation are mainly:

- Verification of the importance of selected places in the model and their prospective intensification with new urban activities.
- Strengthening the environment diversity, i.e. eliminating the uniformity of the areas.
- Verification of approach distances to urban activities (maximum 10 minutes of walking time, about 700-800 meters or even less).
- Strengthening and possible reconfiguration of communication (distribution) flows.
- Optimal distribution and incorporation of surrounding green areas - forest parks in the environment of existing buildings - land overgrowth into the city.
- Extension of public and private activities with relevant spatial structures with different typological form (new volumes), i.e. completion within the framework of undeveloped land without habitable scale.

METHODOLOGY

For the purposes of the simulation model there were used advanced computational techniques by means of Processing language and developed algorithms to conduct a gent-based system. Simulation model operates with the agent's class from Plethora library [2].

Transcription of the Environment into Agent-based Model

In the first phase it was necessary to interpret the vector GIS data of the current site into Processing environment for the simulation needs into two layers: the vector flow and the cell grid. The cell grid layer represents existing activities and volumes of urban structure, which consists of cell clusters (Batty 2007, 2011). The dynamic processes in the urban environment are interpreted by the vector flow (see figure 1). The agents will respond to attributes of the envi-

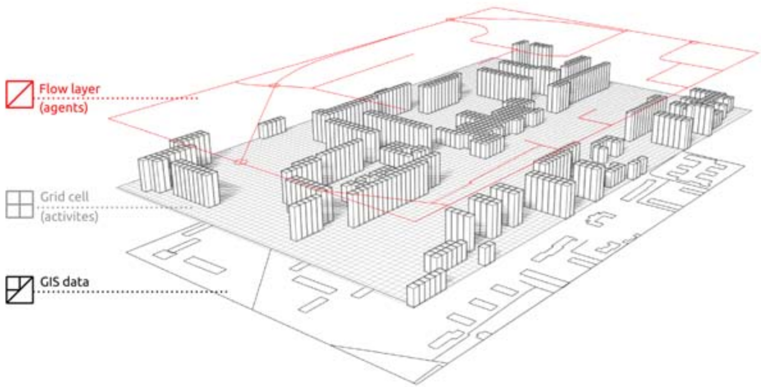


Figure 1
Transcription of the environment into the agent-based model. The diagram contains GIS data, the grid cell layer and the vector agent flow layer.

ronment such as physical barriers or infrastructure by adopting their behavior to the features of the modeled environment (Stanilov 2012). Both layers are in mutual interaction.

There are urban activities defined as attractors and initial positions of agents in the cell grid and these attractors influence behavior of agents in the flow layer. The cell grid is apposite to the geometric characteristics of the area and contains certain information about the structure (position, height map, characteristic number of agents received into the positions).

The territory will operate with a predefined capacity of the environment for the selected number of agents, while the population of agents is characterized by its objectives for a specific boundary number of places for colonization or area reconfiguration (DeLanda 2011). The environment defined by the cell clusters will operate with proper basic capacity (actual statement of the building) and extended capacity in the case of adding new extensions and volumes (see figure 2).

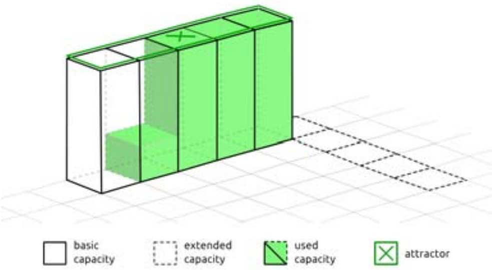


Figure 2
Existing building structure is defined by cell cluster. Cluster operates with basic and extended capacity-it receives specific number of activating agents.

Colonization Simulation - Colonial Growth

The colonization of the area will be conducted by searching of activities within defined approach distances and within unpopulated environment using initial groups of agents - colonizers and then by adding new geometric volumes within a predefined grid through a predetermined rule. The capacity of the agent's population and the environment capacity for a given number of agents are user-defined in the graphical user interface. The environment is able to embrace a predefined number of colonizers that inhabit the territory. The territory is supplemented and thickened with new areas defined on the basis of various capacities of agent population and environment.

The simulation rules according to colonial growth will be as follows (see figure 3):

- From the initial positions in a situation (defined centers of individual environment parts, subway stations) defined number of agents are released. Agents are representing defined number of users (participants in the environment). It is necessary to find level of resolution of the agents (Leach 2009b).
- The agents seek private urban activities in specific time period within approach distance and fill the cluster to its unused capacity (see figure 3a).
- If agents reach the private urban activities, their initial position and nature will change. Agents alter the target of interest and begin to seek public urban activities and continue to colonize the environment from different initial positions represented by already colonized private clusters (see figure 3b).
- In case the basic capacity of the cluster is saturated by the agents, a new extended volume appears. The cluster attraction is removed from the original position and located to a new extension until it is saturated and subsequently it disappears (see figure 3b, c).
- In case the agent fails to reach the activity within the approach distance, a new volume is established (see figure 3c).

OBSERVATION AND EVALUATION

The developed simulation model has been tested with several different input parameters and user-defined parameters interactively during the simulation in order to control agent movement using different flow algorithms (Path following, Stimergy,

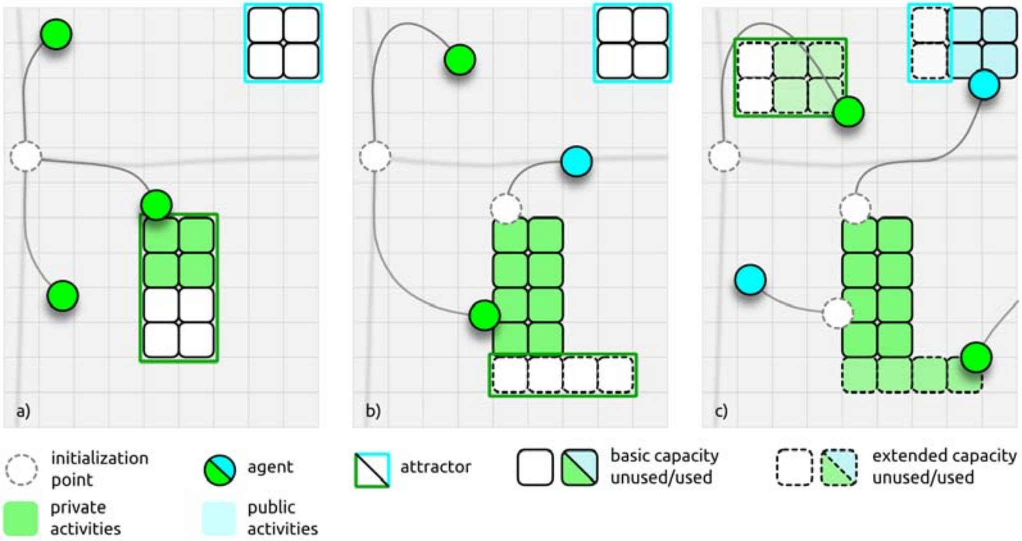


Figure 3
Simulation rules of the colonial growth with initial positions and activated cluster capacities.

Free Distribution flow, Attraction). Four simulation cases have been tested with varied number of agents within 200-2000 iterations (see figures 4, 5, 6, 7).

Model Evaluation in Technological Terms

From a technological point of view, the model is an open-source platform that can be extended by additional parameters and algorithms that will complement its technological potential. The mergence of the grid layer and vector dynamic flow layer in order to generate solid structure in the grid is relevant for future work with the system. Such a system simulates the movements and selected distribution flows in the urban environment in the simplified model. The method of GIS geometry transcription by using the developed algorithm is of a major importance for its application for different environments and spatial case studies. Grid layer allows architects to work with varied scales and typologies. Transcript can be executable by using any other GIS documents with diverse geometrical character.

Interpretation of the Results

The simulated situations must be interpreted and assessed in terms of compliance or non-compliance of the objectives of the simulation mentioned above. For optimal evaluation it is necessary to assess observations separately according to the selected point scale 1-5 (1 - worst rating, 5 - best rating) for each stated objective (i.e. the objectives are the evaluation criteria) and within each iteration (200, 400, 800, 1200, 1600, 2000). The environment quality score is averaged into a single value for each simulated case. The rating is interpreted in the graph (see figure 8) where the curves relate to the time evolution of the model with the quality value of the generated urban environment. In such a way it is possible to interpret the validation of the model as a decision-making tool for the architectural practise.

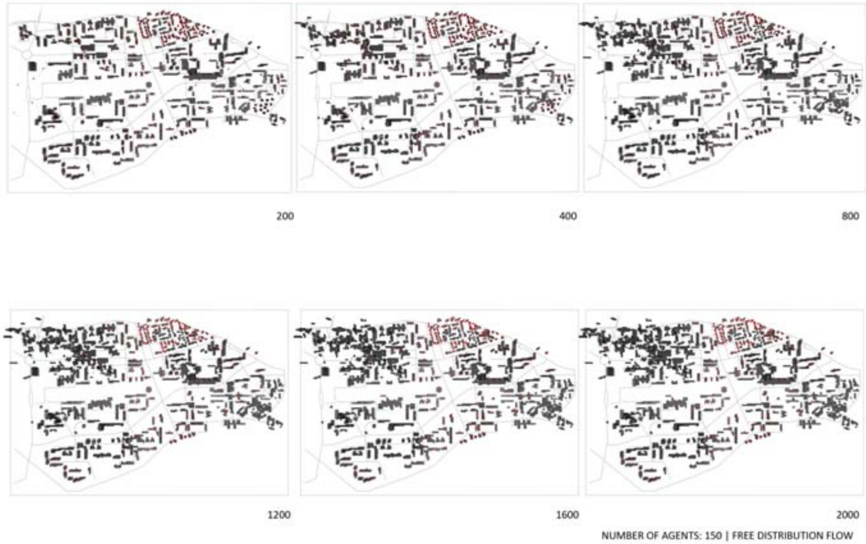


Figure 4
Observation with 150 colonizers. Free Distribution Flow algorithm.

Figure 5
Observation with 300 colonizers. Path Following algorithm.

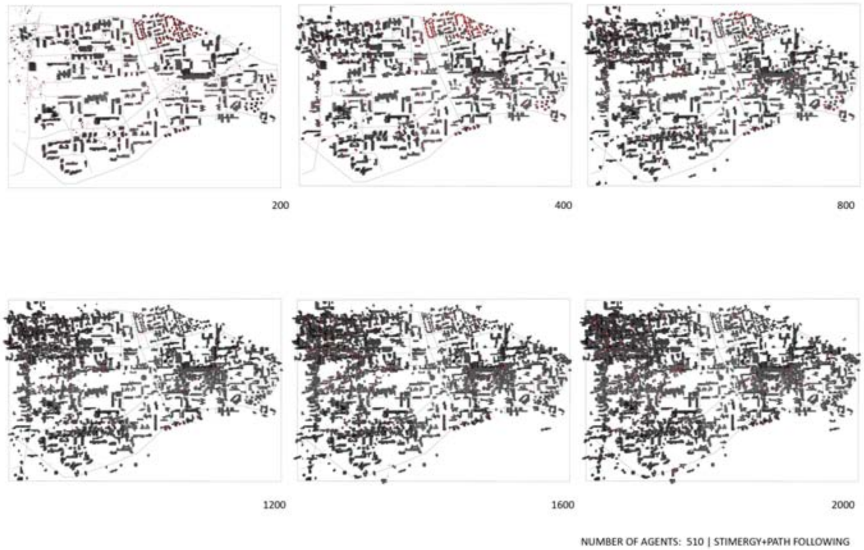


Figure 6
Observation with 510 colonizers. Stimergy and Path Following algorithm.

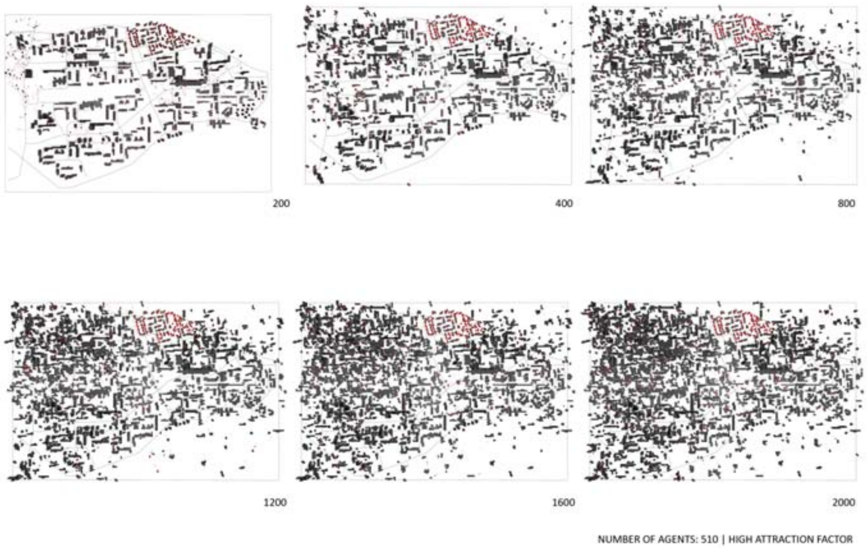
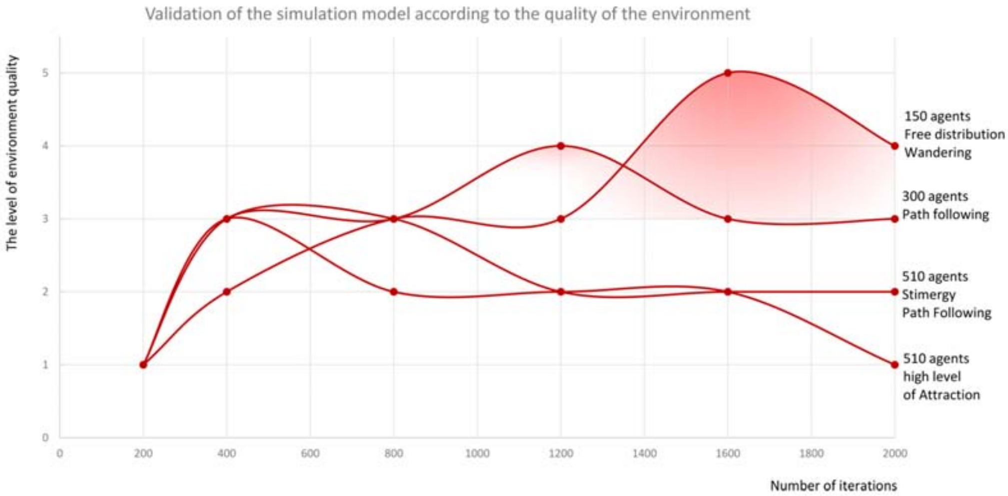


Figure 7
Observation with 510 colonizers, high level of Attraction algorithm which leads to decay of urban structure.

Figure 8
Validation of the simulation model according to the quality of the generated urban environment.



FUTURE WORK

It will be essential to test a diverse number of transmitted agents of a particular type (public, private), the measure of approach distances and the measures of the population capacities influencing the volume sizes and environment capacity as well and observe the differences in structure and compare them. The simulation would be tested with the same general inputs and parameters several times. It is also essential to compare models with different input settings to see whether the structure will develop differently or in the same way. By executing this computer-based model several times, with different initial settings, we may discern patterns and regularities that recur in the results (Holland 1998). Architects can verify several spatial scenarios of the environment development by observing the differences between the results of simulation and look for optimal structure, which creates a habitable environment and captures a sufficient volume required facilities.

The future work will include following steps:

- Testing other user-defined urban typologies. Typology volumes and configurations of urban growth figures can vary within a predefined pattern formation by specified stand-off distance and height of the buildings.
- Testing the validity of the model in various combinations of parameter values.
- Implementation of new rules, i.e. lighting requirements, height zoning, mutual stand-off distances in terms of parametrically user-defined regulations.
- On-line publication as a standalone application.
- A comparative study with other existing city or cities in terms of pattern formation of urban settlement.

CONCLUSION AND DISCUSSION

There has been established a spatial non-linear simulation platform of reconfiguration of urban structure using a combination of several computational strategies that lead to a simulation of colonial growth. It is necessary to continue with the simulation of reconfiguration of entire urban activities and observe the results of emergent behavior in the model. Its development can be interactively influenced according to user input requirements, features and requirements of agents that represent certain number of participants.

It is vital to determine the evaluation criteria for such a model from multiple perspectives. One of them is the issue of a real-life application. Simulation model definitely does not simulate all the complex dynamic phenomena in urban environments simultaneously, however, it is offering a certain systematic solution where individual dynamic phenomena of the environment can be interpreted according to needs representing, in a particular way, respective solutions that can be used by architects or serve as a preliminary predicative tool in design process.

By means of different values of the individual features of the agents (communication flow speed and agent population measures, distribution rate and degree of attraction and connectivity) it is possible to change the nature of the environment and thereby reach diverse predictions in urban structure configurations. Another criterion might be the quality of the built environment, which can be assessed in terms of architectural and urban perspective (habitability, spatial quality, diversity of the environment, aesthetic requirements, etc.). The above computational model has been providing an insight that can be characterized in terms of the real and exact application to some extent speculative. Anyway, it is a platform that explores the behavioral relationships of participants in the environment and therefore it tends to approximate to the real demands of population of the urban environment. The model can be used also for other spatial case studies.

The agent-based methodology in the existing urban environment for the creation and reconfiguration of optimized built environment is applicable within real urban context. It will be useful in a particular observation of the selected bottom-up participant´s stimuli.

It is assumed that the multilevel scenario development of the existing environment would be readable, receivable and intelligible. This assertion is needed to be verified by extended functional simulation model of the area.

Utilizing the emergence phenomenon as a paradigm in the design and reconfiguration environment in the existing urban context is presumed and characterized as speculative in certain way, but offers a legitimate insight and a possibility for another understanding of social and environmental interactivity in terms of urban design thought using the agent-based methodology.

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