Simulation in steering of complexity and self-organization in the city

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BACKGROUND. In recent decades there have been constitutional changes in urban form, centrality, the role of periphery and location principles of activities, turning the city to a *Metapolis* of today. Theories of complexity have provided a framework for understanding the unpredictability, chaotic nature and complexity of self-generative urban systems. These mechanisms are crucial for city economies, innovation and evolution. From the theoretical point of view, complex theories are already getting mature, but the planning practice today operates still mainly according to the modernistic paradigm, trying to control generative features of urbanity solely from top down. We can assume that even though very strict control hinders self-organization, certain restriction and feed back from the system's level is needed. Thus the dynamics would not benefit from total liberation from regulation either. We need to study these mechanism of self-organization to better understand them, explore novel methods to outline the balance between control and freedom to be able to suggest directions for planning in context of complexity.

PROBLEM STATEMENT

- PLANNING IS NOT ABLE TO RESPONSE TO SELF-ORGANIZATION OF CITIES
- SELF-ORGANIZATION IS A COMMON FEATURE BUT NOT THOROUGHLY UNDERSTOOD IN URBAN STUDIES
- CITY ECONOMIES NEED MORE ENABLING FOR ENHANCE CREATIVITY AND INNOVATION

Thus, I suggest that we need more understanding of self-organization mechanisms and new methods for steering them to enable more flexible planning.

RESEARCH QUESTIONS

Is it possible to simulate certain type of self-organizing, emergent agglomeration behavior with a *cellular automaton* -based model in special type of generative areas? And, specifically,

1. What is self-organization, and how can these mechanisms be defined and recognized in specific areas? What kind of self-organizing mechanisms are there in the target area, if any, and how these areas emerge from combination of lower level agents' interactions and higher level feedback?
2. What kind of a dynamic model do we need to be able to simulate this type of self-organizing behavior?
3. What is the relationship between planning and self-organization today and what role can this dynamic model have in planning praxis?

These questions are explored in a context of Nekala industrial are, Finland, which has demonstrated high capacity for self organizing adaptive behavior.

Identifying self-organization

Self-organization is a basic mechanism of how the complex urban systems organize. This mechanism emerges from individual agents' local interactions, often with unpredictable consequences on the regional level. These emergent regional patterns cannot be controlled with traditional hierarchical methods, but they can be steered and encouraged towards desirable goals. The concept is still today often used as an allegory for all "unplanned" activity in cities. We need to enhance our understanding of the actual mechanisms of self-organization in cities to link the theory of self-organization to planning praxis .

In the first part of my work I explore the key features of open dynamic systems that have been identified in the literature as indicators of self-organizing capacity. I study their applicability in urban planning, and suggest that a set of characteristics - high *potential relative accessibility, increasing complexity and internal order* - can be used for estimating potential self-organization of urban activities in a city.

The methods
First, to analyze potential relative accessibility I used accessibility network analysis based on space syntax method (Figure 1.) . Secondly, I estimated similar actors' agglomeration tendency which referred to autonomous *internal order* (Figure 2.). Finally, *increasing complexity*, referring to *furcative*, critical points and emergence of new 'categories' of activities, was estimated applying loosely Shannon's theory of information.

The results indicate, first of all, that that the target area of interest, Nekala, has relatively high accessibility in all scales (figure 1., red-orange colors). Nekala is the only area of its kind in the whole region. Secondly, the probability for activities to cluster was higher (96%) than random (66%). only 4% of activities were outside the clusters (Figure 2.). Finally, results refer to the potential for self-organization by indicating increasing information and decreasing entropy, as well as high capability to adapt and reflect the global "phase transitions".

Validation. The results were validated by estimating whether they follow the power laws typical to these type of critical systems in natural sciences. The degree of criticality was plausible considering significant differences between human and natural systems.

Figure 1. Generic accessibility of Tampere, Finland

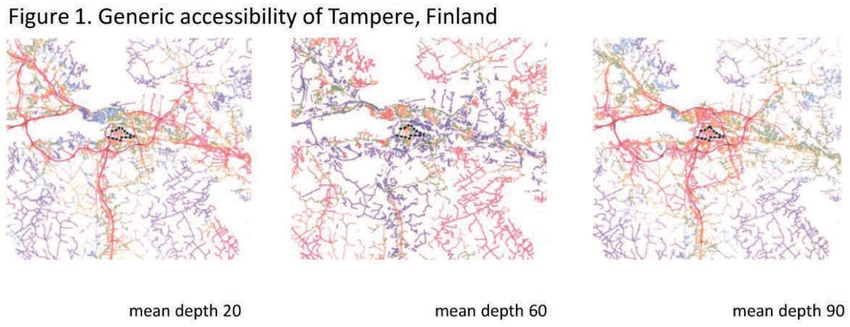


Figure 2. Agglomerations of industry, in Nekala area.

Simulating self-organization

In complex systems the flexibility and adaptivity to changes are crucial for the systems dynamic stability. Due to the high degree of complexity of the dynamics in the area, a computer model was considered the most appropriate tool for estimating its future progress. In this study the main focus is on temporal dynamics of the pattern formation process, which is studied using an irregular *cellular automaton*-based model. The premise of the model which is based on prior empirical findings is that urban activities interact with each other according to their proximity. It is assumed that by exploring the dynamic states of the model resulting from different border conditions it is possible to discover favourable set(s) of rules which encourage the existing self-organizing dynamics in the modelled area.

The computer runs. Based on empirical findings, the basic mechanism the transformation rules of this model were based on is a neighbourhood's oscillation between agglomeration and regression. Synergetic or similar activities tend to gravitate to proximity of each other, until the clustering that exceeds the threshold value causes "overpopulation", which leads to some of the activities re-locating themselves. The model was used in Nekala and Vaasa old Garrison area. Several computer runs were carried out using various values defining the actors' interaction to estimate the resulting dynamic states of the system: whether the favourable adaptive and dynamic states – periodic or complex - could or could not be achieved.

The results indicated that the different values of the parameters impacted greatly on the model's dynamics, and generate different dynamic states of the system (Figure 3.). It seemed that the model could produce favourable, dynamic states which may refer to self-organization of the area in the model world. The degree of complexity was evaluated according to the entropy level of the system (figure 4.). Thus the model could help in exploring and understanding the effects of boundary conditions in planning process as various scenarios are tested, and to identify planning guidelines that will support the future evolution of these areas.

Figure 3.

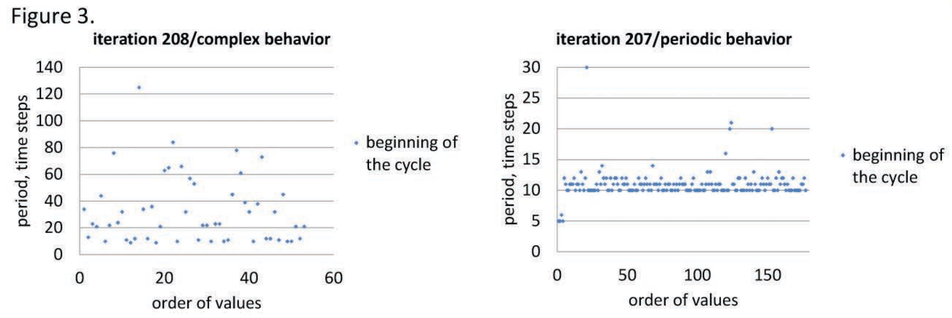
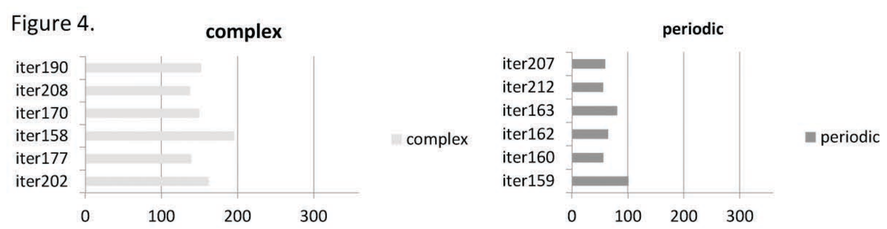


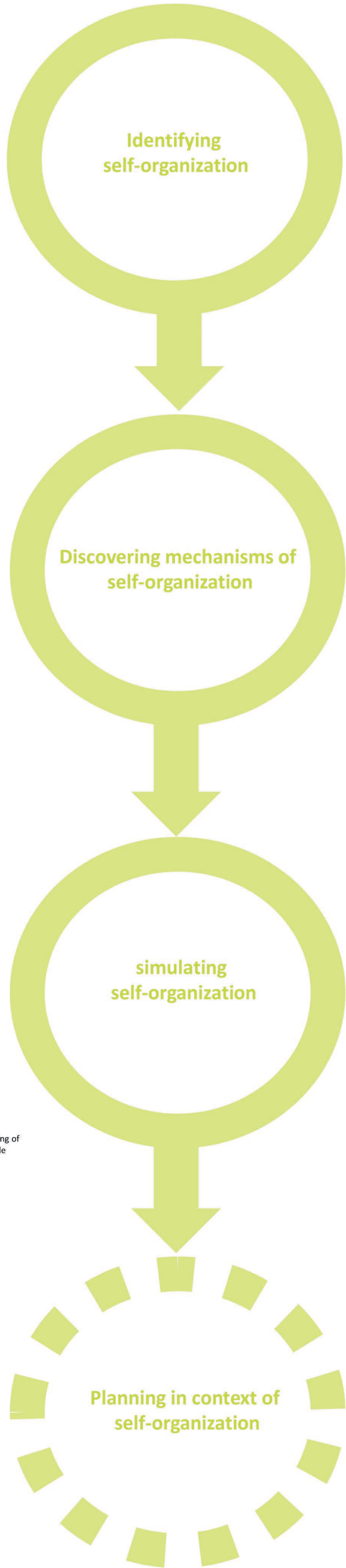
Figure 4.



Entropy values (i) for six iterations visually classified as "complex"; 150 > i > 200

Entropy values (i) for six iterations visually classified as "periodic"; 50 > i > 100.

Planning in the context of self-organization?

In the future I will contemplate in my work the present day situation in planning in the light of complexity theory and the role of self-organization in a planning context. I discuss what could be the role of modeling as a method for exploring the urbanity by studying several aspects of historical and current models, the applicability of different model types in urban studies, and the issue of uncertainty in dynamic models. In this phase I reflect on my modeling experiment in the context of relevant planning and modeling literature.

The research was funded by Tampere University of Technology Graduate School's doctoral program.