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Healing urban tissue damages using artificial morphogenesis

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Abstract

The events of the 20th century – wars, totalitarian regimes, utopian ideas – caused severe damages in the cities of Europe. The historical, organic urban tissues were erased in large areas, sometimes right next to or directly in the city centre. The majority of these areas – especially in the eastern part of Central Europe – is either urban void even today, or a slum with rundown prefab housing. Usually, even the original plots are eliminated. Reconstructing the entire original tissue is impossible and undesirable at the same time. But with the use of the method of integrated urban morphology together with Space Syntax the characteristics of the original tissue can be described, evaluated, and quantified. These data can be used as input for generative algorithms to simulate the organic morphogenesis of the original historical tissues, and with the deliberate definitions of constants, parameters, and variables – incorporating randomness – these damages can be healed. The resulting urban areas will share the characteristics of the original, erased ones, but the new street networks, plot structures, and building formations will fulfil the present needs as well. The current study will discuss the case of the former Gordon neighbourhood in Miskolc, Hungary. This area used to have notably dense urban tissue going back to the 18th century, but now is a prefab housing estate with low density, large parking lots, neglected green areas, four-track roads, and bad reputation.

Keyword: *urban morphology, generative methods, Space Syntax, urban planning, Grasshopper*

Introduction: the problem of damaged urban tissues

In the decades following the World War II the historical urban tissues suffered serious damages in whole Europe, but especially in the Eastern part of Central Europe. The reason of that was only partly the consequences of the war. Ideological considerations, the need of mass housing, the principles of the Modernism, and only partly realised, given up concepts were among the main important factors (Panerai et al., 2004). Nowadays the rehabilitation of these areas is an important topic of urban planning. A desirable goal is to create something similar to the original tissue. But, as Carpo (2011) argues, "similarity and resemblance, however, are not scientific notions, and are notoriously difficult to assess and measure." New methods are needed to restore the continuity of the damaged urban tissues.

Background: introduction of the chosen area

The chosen area for this case study is in Miskolc, a middle-sized city in Northern Hungary. Before the 1970s this neighbourhood was called Gordon, now the area is the Vörösmarty housing estate. The area is almost directly adjacent to the high street of Miskolc, and has been inhabited since the beginning of the 18th century, as it can be traced back on the historical maps (Papp et al., 2015). Its original evolution was organic, resulting an irregular and dense street network with irregular plot structure and one and two storey buildings. **Figure 1.** The area was mainly residential, but the majority of the dwelling houses included workshops as well, as it can be deducted from the names of the original streets or lanes: Butcher, Locksmith, Bricklayer, Hatter, Confectioner, Lathe, etc. Two-storey houses and public buildings were situated mainly on the main streets.

Figure 1. *The original tissue. Drawn by Abdo Mhrez, based on historical cadastral map.*

This organic tissue maintained its archaic shape until the whole demolition of the area in the 1970s, to give space for a new prefab housing estate consisting of 11-storey blocks. **Figure 2.** The whole street structure was eliminated without any strategic planning. **Figure 3.** According to its location, the area should be referred to as part of the city centre, but on the mental map of the citizens of Miskolc it is not a central area. It is now mainly single-use, lacking any urban spaces suitable for quality community life. Its streets serve only the needs of motorised traffic and overground parking. The official reason for the demolition was the presence of social problems in the area, but these problems re-emerged very soon in the new housing estate too (Hajdú and Nagy, 2010).

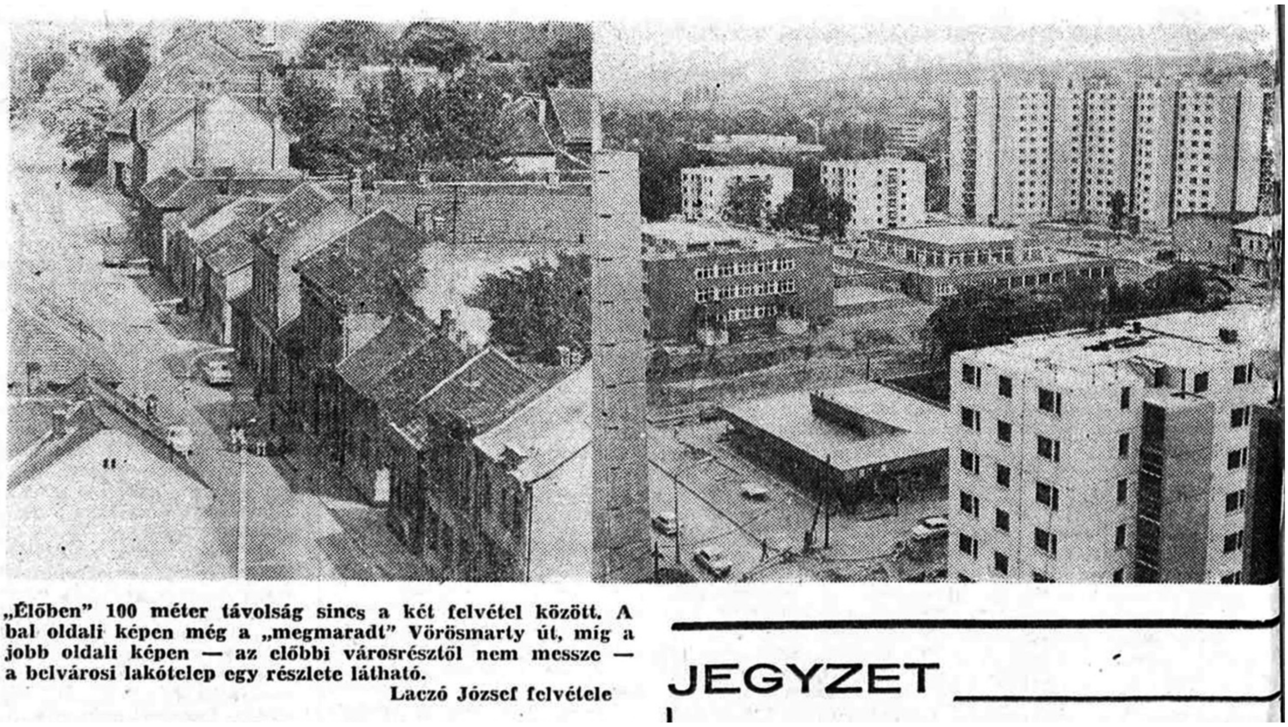

__Figure 2.__ Propaganda from 1977. The caption translates "in real life the distance between the two photos is less then 100 m. On the left the still remaining Vörösmarty street is visible, on the right one part of the City Centre Housing Estate.” Source: Észak-Magyarország, 29 May 1977. Photo: József Laczó

__Figure 3.__ The current tissue. Drawn by Abdo Mhrez.

Methodology

According to Carpo (2011), the current tools and methods of urban planning date back to the time of Le Corbusier and the pioneers of modern architecture, although the current needs and possibilities are very different. The book argues that a new revolution is happening right now, where the main subject of the design in any scale will be not the object itself, but generative algorithms to create them. Generative methods seem especially suitable to create organic shapes through emulating organic processes. (Bereczki, 2020) To assess the aforementioned problem of similarity and resemblance, a key point is to analyse and measure the original tissue, to be able to generate a resemblance in a controlled way. This method can be called *Artificial Morphogenesis*. Its main steps are the following:

1. Quantitative analysis of the original tissue
2. Defining parameters based on the original tissue, but improved
3. Creating generative algorithms
    - Constants: elements of the surrounding tissue, elements to be kept
    - Parameters: inherited from step 2
    - Variables: randomised between pre-defined extreme values, gained from step 2

The goal is to create infinite variety using limited number of elements, not by reconstruction (**declarative** way), but simulating the original generative processes (**procedural** way). The generative geometry is a data flow, using complex data trees.

Quantitative analysis of the original tissue with the tools of Space Syntax and integrated urban morphology

The configuration of the original street network of the area was analysed with the tools of Space Syntax. On the integration map of the **Figure 4** it can be seen that the area had two, slightly curved main streets with high integration values, some – secondary – streets with lower values, and some, usually short streets with low values.

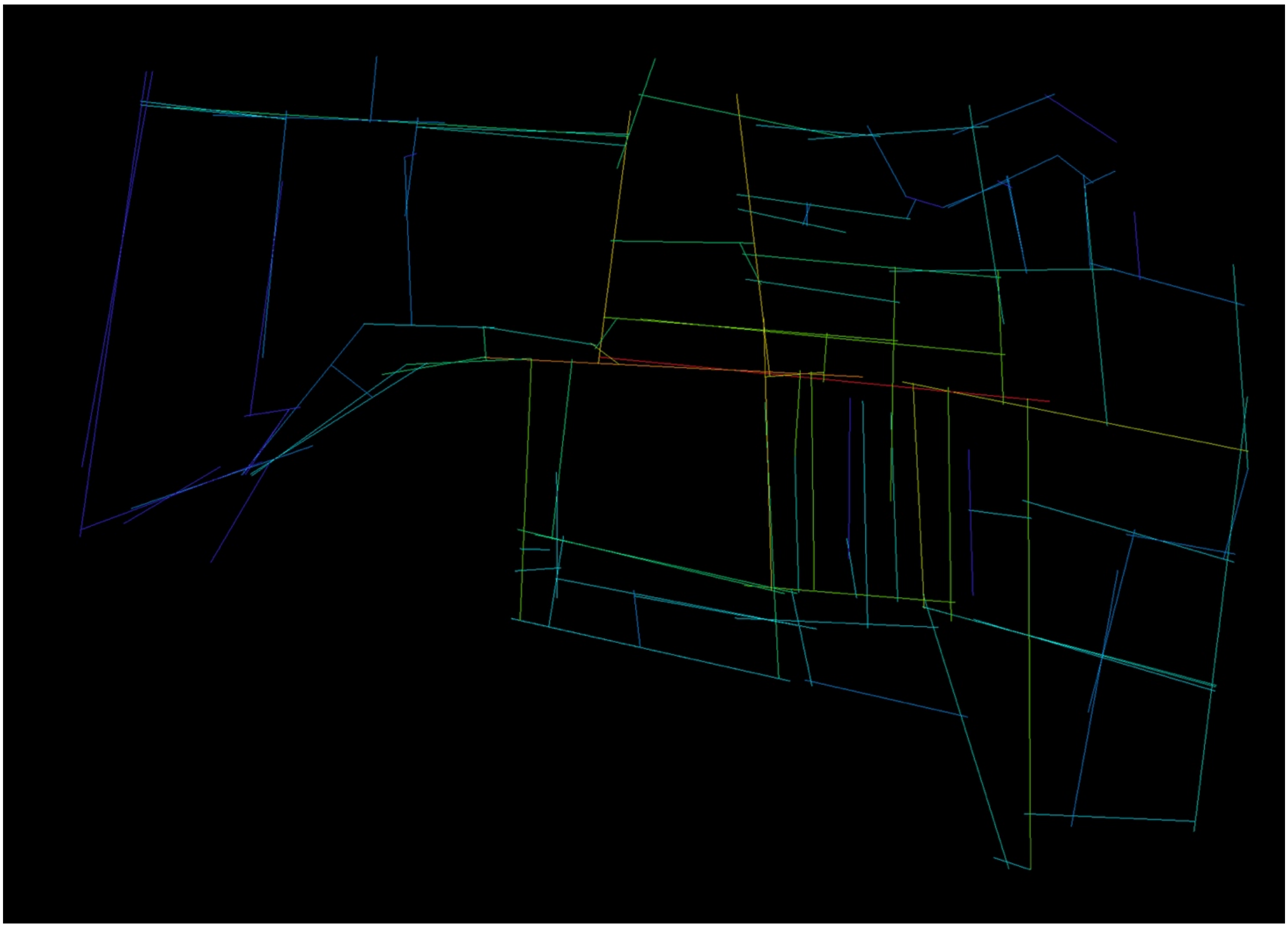

Figure 4. *Space Syntax analysis of the original tissue: axial integration. The fewest line map was created using DepthMapX.*

The plot structure and building/block shapes and positions can be described with the methods of the integrated urban morphology discussed in Lovra (2019). As a first step in this typo-morphology the towns and neighbourhoods are distilled to their base fabric, considering the most important forming elements: street networks, plot series, green spaces, and so on. Based on those and on their relationship the main dominant urban tissue types are identified, and defined with a code on small diagrams with definitions. The original tissue can be classified in this system with the tissue type encoded *Ac*. Its description is the following: "elongated rectangular plots with regular geometry, dynamics of the plot series are rhythmical/regular: width of the plots and the placement of the buildings are almost identical. The property consists of the main building and some additional buildings (outbuildings), that partially surround the inner courtyard. The buildings are adjusted to the line of the street, coherent free space is between the street line and the development in unbroken rows. The unbroken row of buildings is disrupted by open courtyards. Yards could be divided into two parts depending on the location (front and back yards): the two sections are separated by buildings and the fence." (Lovra, 2016) **Figure 5**

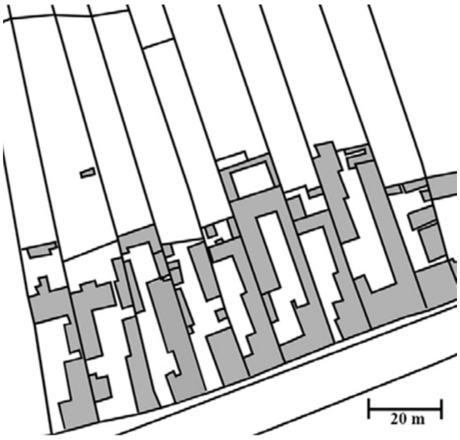

Figure 5. *The diagram of the tissue type 'Ac'. Source: Lovra (2016)*

Generative algorithm to establish the new tissue

Using the result of the above analyses as input, spatio-temporal embodiment and randomly operating background process (this duality is discussed in Hillier and Hanson, 1984) is created in order to produce the proposed street network, plot structure, and buildings.

The algorithmic levels are the following:

1. Street structure
   - input data: boundary of the area, entry points of the primary streets
2. Plot structure
   - input data: boundary of the blocks (defined by the streets)
3. Buildings
   - input data: boundary of the plots

Since each level inherits its input from the previous one, and the variables are randomised in each instance, only three algorithms are needed to generate the entire neighbourhood. This way the resulting urban area will share the characteristics of the original, erased one, but the new street networks, plot structures, and building formations will fulfil the present needs as well, and infinite variation can be reached with limited elements. Some examples for the newly generated street network can be seen on **Figure 6.** (Since this is an ongoing project, the generation of the plot structure and the buildings – steps 2 and 3 – are still work in progress.)

In this solution the area is divided into four parts by two primary streets, similarly to the original situation. The entry points of these streets are predefined based on the adjacent existing streets. The curvature of them can be adjusted using sliders. The street network of the resulting four parts is populated using the same algorithm, but with different input parameters and random variables. As the curvature of the primary streets is changing, so is the street network of the four areas, since the main input parameter of them is the boundary of the area surrounding them. The starting points of these secondary streets are distributed randomly around the perimeter. Their distance is between 45 and 90 meters, these values are taken from the original tissue. Since the original tissue omitted perpendicular junctions, the starting angle of these streets is also randomised, between predefined extreme values deducted from the original network. In some places tertiary streets connects the secondary ones. Their starting points are also randomly generated, using restrictions.

Figure 6. *Generated street networks.*

A rough Space Syntax segment analysis (connectivity) of one generated network can be seen on **Figure 7.** It cannot be directly compared to the one on the **Figure 4**, since there a fewest line map was auto generated from the digitised cadastral map (drawn by Elif Sarihan) to serve as a basis of the analysis, while in this case a segment map was exported from the generated network, but, as Turner (2005) discusses, the segment maps produce fairly similar results as the axial maps. It can be observed that the most important elements are similar on the original and the generated network, but on the latter in a clearer way: the two, slightly curved main streets with high integration values, some – secondary – streets with lower values, and some shorter streets with low values. The final goal is to establish these kind of similarity with the two other algorithmic level, and to extend this method to other tissue types.

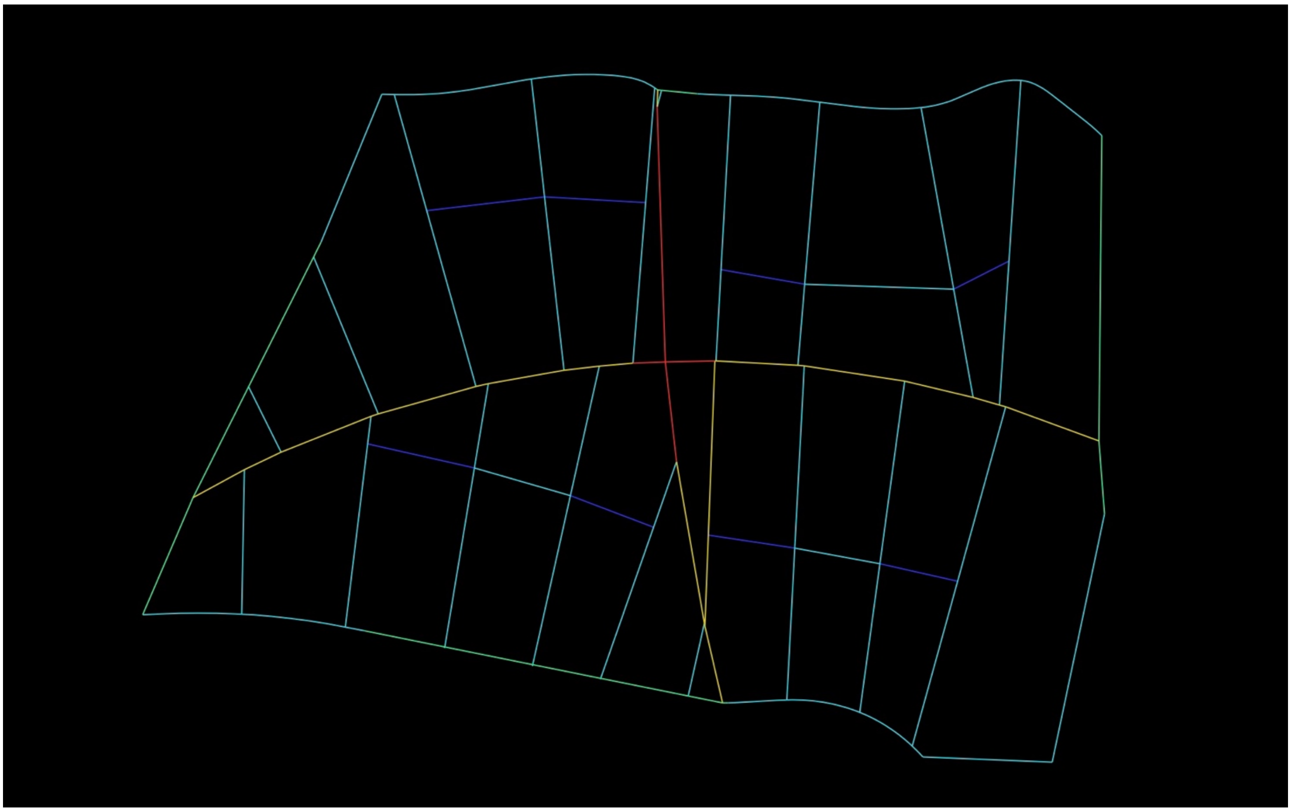

Figure 7. *Generated street networks.*

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