Incorporating the Analyses of Urban Form into the Geocomputational Modelling

The Morphological Approach

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Abstract **- Geomatics allows for advanced modeling of phenomena in space and for the observation of process development in time. It enables comparative analyses of various aspects of urban-scape, including the social and human dimensions. At this time, the scope of urban data required by legal regulations is limited to basic issues, including land-use zoning, transportation and, cultural/natural values preservation. Successful sustainable urban environmental planning requires concentration on other aspects of city structure, with special emphasis on urban morphology analyses. Such an approach is more appropriate to the mixed used development and revitalisation processes, which take place in urbanised areas. The paper provides insights into the importance and challenges of using urban structure analysis from different perspectives: social, cultural, urban planning and design, and explains the main fields of contemporary urban morphological analyses, reviewing the geomatics use in this field.**

Keywords-urban planning; urban design; urban morphology analyses; geomatics; data modelling; INSPIRE

I. INTRODUCTION

The city - *"a whole"* in Plato's terms - should be considered holistically. The elements of the system are so complex that it is difficult to define them in an explicit way. Geomatics allows for comparative analyses of the distribution of different phenomena in space and for the observation of the dynamics of the processes of development. Contemporary urban planning practise and theory, presenting the holistic approach and underlining the importance of time [4], progressively develop the above qualities. The officially approved scope of urban analyses [1] restricts itself to the level of blocks and refers to the limited quantity of issues: mainly technical, including land-use zoning, transportation and cultural/natural values preservation. The objective to successfully plan the sustainable urban environment requires concentration on other aspects of city structure, with special emphasis on urban morphology analyses.

A. Urban morphology as a repository of socially defined space

When regarding the development of physical structures in relation to culture, the built form constitutes an important repository of cultural information, an artifact of cultures and societies, that created them in a given time [2], [11], [21], [26]. Hillier and Hanson [18] underline the relation of patterns of people movements and physical environment, introducing the concept of spatial logic of space. Thus, the analyses of existing and former urban structures provide an important tool for the creation of new structures, which not only follow the site genius loci and local tradition, but at the same time stay in compliance with the integral cultural patterns of social groups, e.g., the research by Gabaccia [15], cited after [26]. More contemporary research on the social production of space seeks to place the understanding of built form in the larger context of society's institutions and history [27], [26]. Proxemics relates to the human environment with the behavioral patterns proper for distinguished cultures. The above factors remain important when considering the constant displacement of people in an era of globalization, and the requirement to provide an environment, which suits their needs, while at the same time reducing the problems of social adaptation [16].

B. Complexity of urban design and planning

As Carmona et al. [6] suggest, urban design and planning should remain a holistic process including the approaches of different disciplines. The writing of Lefebvre [27] also points at the need for the unity of science in the description of urban systems. The need for the consilience of science is considered indispensable also by scientists of other disciplines, e.g., sociobiology [41].

The current domination of engineering, including individual transportation policies and reducing planning to the definition of land use zoning, leads to the ugliness of urban settlements. As Landry [24] and Florida [14] state, the factor of attractiveness in urban environment is particularly important in cities, which search the development of the creative industries. The development of theories referring to urban perception, starting with Lynch [28], [29] and Debord [9], follows on constantly (e.g., works of Amoroso [3], Kempf [23]). The use of neogeography and mash-ups allows also for the inclusion of lay experience of urban forms in the analyses of urban scapes (e.g., popular competitions for best stories about different cities). Looking at cities through the eyes of citizens plays an important role in the public participation and project implementation process. All of the above issues (attractiveness and perception) refer to the

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urban forms. At the same time attractiveness and beauty remain issues of culture [13]. These complex issues are omitted in the common descriptions of urbanised space referring to a very limited quantity of factors. For some projects, especially realized in the mixed up city cores and the rehabilitation projects, a clear definition of planned land use contradicts the objectives of these projects. In these cases, the description of city structure assumes the form based approach, where the shape of volumes and their scale and relations in space prevail over the definition of functions.

II. BASIC TYPES OF MORPHOLOGICAL ANALYSES

Panerai et al. [34] distinguish three main groups of urban analyses: (1) the general ones which refer to the geographical level, including the analyses of the growth of cities, (2) the analyses of urban landscapes – the sequential ones, and (3) typological analyses, which refer to streets, parcels, and buildings.

Healey [17] points at the presence of the three main planning traditions, concentrated on: economy, formal issues, and political processes in planning. Studies of urban form are present in planning in different European countries although they belong to different disciplines, i.e. urban planning, urban design, architecture, and revitalisation projects. Mainstream urban planning at the European level covers the more general considerations, mainly of a geographical nature. The concentration on definition of land use and transportation systems, present in the official planning regulations, is also the consequence and reminiscence of the modernism era, when these two subjects constituted the main area of interests. These derive from modernist principles of separation of uses in the city, underlying the concept of the functional city, which constituted one of the most important rule of the Charte d'Athènes [7]. Planning theory and practice, which continue the approach rooted in the modernism tradition, find out its description in geocomputational models, which refer to a very limited number of issues, exposing the subjects, which are typically of a geographical nature: like land use, growth of cities, transportation, and usually omitting the analysis of urban form.

A. Analyses at the geographic level

The most important body of analyses, which finds its place in mainstream theory and in legal regulations at the European level [1], refers to the general description of the city structure, which is considered in geographical terms. The geographical descriptions usually concentrate on more general units (urban blocks, districts, etc.), although more detailed elements, like public spaces, streets, built up areas, are also present in some treatises, e.g., [25].

The analyses concern the level of metropolitan areas, cities and towns, or districts, the most detailed ones refer to urban blocks. The parcels are usually below levels of concern. Most of the analysis deals with urban functions, urban areas are classified according to their dominant usages and this continues since modernism [5], cited in [34], p.10. Within the city structure the distinguished parts are usually limited to the down-town and suburbs. Development studies, including growth simulations and tracing, constitute a considerable body of knowledge.

B. Analyses of the urban scapes

The analyses of the urban landscapes is the basic method of gathering data for urban projects in urban planning and urban design. Direct contact with the environment allows for observations and validation. The theoretical body for the studies is derived from Lynch's theory [29], in Polish architectural writings the theory of urban composition was developed by Wejchert [40], Szmidt [38] and Żurawski [44]. The theory was further developed in the Anglo-Saxon tradition, e.g., by Venturi et al. with regard to urban stripes [39]. The perception of cities in terms of sequence is not limited to the above authors. Sequential analyses were always present in architectural theory, their comeback started since Sitte [37]. In parallel, the continuation of the British Picturesque tradition was developed by Cullen [8]. Currently, concentration on the human perception of cityscape became quite a common approach, compare [23]. This group of analyses contains also psycho-geographical examinations of cityscape, e.g., [9], [33] or maps of East Paris [32].

C. Typological analyses

There are three basic elements of the urban landscape which are the subject of analyses: streets and public spaces, parcels, and buildings. These basic elements are interrelated, they create patterns, in which relations and hierarchies are also subject to analyses. Public spaces constitute the subject of planning since the very beginning. In the postmodern era, the analysis of public spaces is equalised with the examination of publicly accessible edifices and places (churches, commercial zones), as shown in the famous Map of Rome by Giambattista Nolli, 1748. Streets are examined as subject of sequential analysis, the example of which are transects drawings, compare, e.g., Project 360 degrees on Amsterdam city scapes, containing an assemblage of drawings and photo-collages of the physical materiality of the city, emphasizing signage and infrastructure [10], and as elements constituting patterns [31], [20].

One of the basic units of morphological analyses is parcel: the layout of parcels, their dimensions, shape, correlations. Patterns remain one of the main threads of urban morphology analyses. The requirement of description of the character of space needs the engagement of more detailed observations – concerning the elementary level, which refers to the issues typically, in the Anglo-Saxon praxis, connected with the discipline of urban design.

Lynch and Rodwin [30] distinguish the two general categories: flow systems and adapted space. They may be broken down into more categories, based on the following criteria: elements types, quantity, density, grain, focal organization, and generalized spatial distribution [30]. Element types as well as quantitative analyses are quite common concepts. A density may refer both to the physical structures (the intensity factor) and to the patterns of streets. Grain describes the extent to which the typical elements and densities are differentiated and separated in space. Focal

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organization refers to the key points, which may be the density peaks, concentrations of dominant building types, main open spaces or nodes of the circulation flows and their interrelations. The generalized spatial distribution is a kind of synthesis, which includes patterns of zones taken by different types of development and densities.

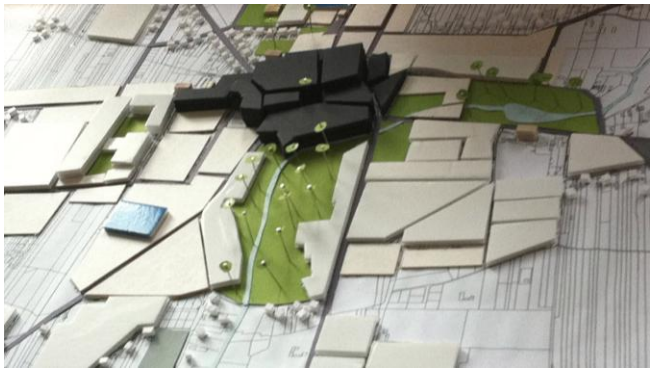

Figure 1. Central part of Brzeziny, close to Lodz – model by students of the second year of Architecture Engineering course, International Faculty of Engineering, Technical University of Lodz, for the Urban Design classes. Synthesis model presenting the generalised spatial distribution of densities and basic elements of town structure. Model by students: I. Sikirycka, D. Pogorzelska, M. Socha, A. Salamończyk, tutor: M. Hanzl

D. Analysis of morphological development

The comparison of the layout of the city structure in different periods allows for the tracing of the development. It allows also for the comparison of the intercultural differences.

This is particularly visible when analysing the cities - like Lodz, Poland, where the consecutive structures were the result of different urban theories and building cultures implementation. In case of Lodz 'Old Town' the former rural Polish town was at the end of XIX century converted, preserving part of its former fabric, into the heart of the Jewish district, constituting a part of a big industrial city. During the World War II, it was partly demolished by Nazis and the Jewish ghetto was created there. After the War the demolitions were continued and part of former structures were replaced with socio-realist and modernist structures, as shown in Figs. 2 to 5.

Figure 4 shows the perception analyses of the former Jewish district in Lodz, currently nonexistent, using the Lynch criteria [29]. The comparison to the current state proves the loss of street space definition in the eastern part of the area. The after war transformations utterly changed the former appearance of this part of the city. The land-use parameters remained the same, though the character of the district was altered.

Figure 2. The comparison of built up area and parcellation in the central part of the Old Town of Lodz, Poland – the former Jewish District between the II World War and currently: 1. Buildings 1939, 2. Buildings 2010, 3. Parcellation 1939, 4. Parcellation 2010. Street names – 1939 (in the paranthesis – current names).

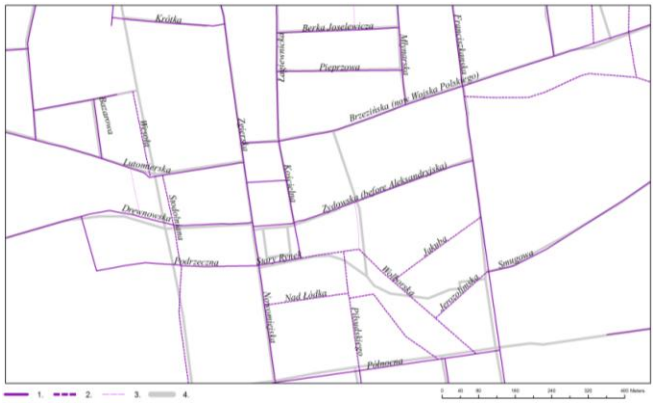

Figure 3. Street layout for the central part of the Old Town of Lodz, Poland – the former Jewish District between the II World War and currently: 1. Streets 1939, 2. Streets 1939, which do not exist anymore, 3. Passages, 4. Streets 2010. Street names – 1939.

Figure 4. Nonexistent appearance of the central part of the old Jewish district: 1. frontages, 2. distant landmarks, 3. landmarks, 4. special places, 5. buildings in 1939, 6. parcellation in 1939

Figure 5. Not existing appearance of the central part of the old Jewish district contrasted with the contemporary figure-ground map: 1. lines of frontages – 1939, 2. buildings in 1939, 3. buildings in 2010, parcellation in 2010

III. URBAN MORPHOLOGY AND GEOCOMPUTATION

In the above context, traditional morphological analyses of urban structure, which remain as the basic tool in urban planning praxis, takes on importance and should be considered principal in geocomputational modelling, along with the description of land use definition, transportation policies, etc.

The basic unit of the morphological analyses is parcel: the layout of parcels, theirs dimensions, shape, correlations, patterns remain one of the main threads of urban morphology analyses. Descriptions usually concentrate on more general units: urban blocks, districts, etc., although more detailed elements had also been present, like public spaces, streets, built up areas [34]. As it was said, the requirement of description of the character of space needs the engagement of more detailed observations, involving the perception of urban form.

A. Geocomputation as a platform for urban analyses

The analyses of physical patterns of urban development should constitute the basis for other layers, describing the non-physical issues - as physical structure change progress is by definition slower than other processes.

The concept of sustainability and climate resilience assumes the conciseness of urban structures [22]. The need for extended application of geomatics in assessing the current structures seems obvious in this context.

Currently, the most popular theoretical approaches refer to figure background illustrations and land use data. The analyses of urban structure may assume the extended use of remote sensing. The commonly used photogrammetric refers to land use layer only, for example the commonly used thematic classifications, like the one by Anderson et al. at the U.S. Geological Survey [36]. The other most common example of remote sensing use refers to the analyses of growth processes of urban organisms [35]. The research of Yua et al. [43] provides an example of counting urban intensity, using LIDAR data. Another approach addresses the analyses of urban structure including the description of housing units [12].

B. Space Syntax and modelling of social behaviours

Space Syntax is a method of simulating human social behavior based on the analyses of spatial layout [18], [19]. The analyzed patterns include movements, vulnerability, and activity in buildings and urban settings. The simulations are based on a process, that informs human and social usage of an environment. A model of individual decision behavior, based on spatial affordances offered by the morphology of a local visual field, is consistent with the spatial configuration of movement patterns.

C. Development of morphological description of urban structure - suggestions

The commonly applied land-use analyses derived from the LIDAR data are useful in urban planning praxis, but not satisfactory. The production of planning documents by definition must refer to the property layer. The basic analysis of urban morphological structure used for the master plans preparation includes a description of much more features than land-use parameter only, this concerns, e.g., Polish urban planning practice. The list of the most basic descriptors is contained in the table below. The list may be extended to include other features or shortened in case, when some of them are not substantial. The list content differs in different country planning regulations.

TABLE I. QUALITIES OF URBAN STRUCTURE (EXAMPLES)

Feature	**Description**
Land-use	Basic and complimentary uses
Parcellation	Minimum and maximum sizes of parcels and front widths
Urban parameters	Intensity of development, percentage of built up area
Location on plot	Buildings forming line of frontages, of different character: continuous or with breaks, Set back of building from the street
Character of development	Traditional or modernist, contemporary or of historical style, rich in/devoid of details, etc.
Form of development	
Building height	Number of stories, height [m]
Roof shapes	Slopes, kind of roof: flat or sloped, number of slopes, main ridge direction
Materials	Facades and roof materials
Fences	Materials, dimensions, shape
Details	Decoration

The above description refers to urban structures only. Although a similar list of features could be defined for streets and squares, their patterns, etc. [20], [30], [31] or for any other set of features referring to urban-landscapes of different cultures and periods. An example of an analysis of the city physical structure, following some of the principles listed above, is shown in the Figure 6. The analyses assumed elements of both the qualitative description, referring to the types of development, and the quantitative one – describing a level of completeness. GIS generalisation allowed for the semi-automatic production of consecutive maps showing different phenomena in the scale of the whole city.

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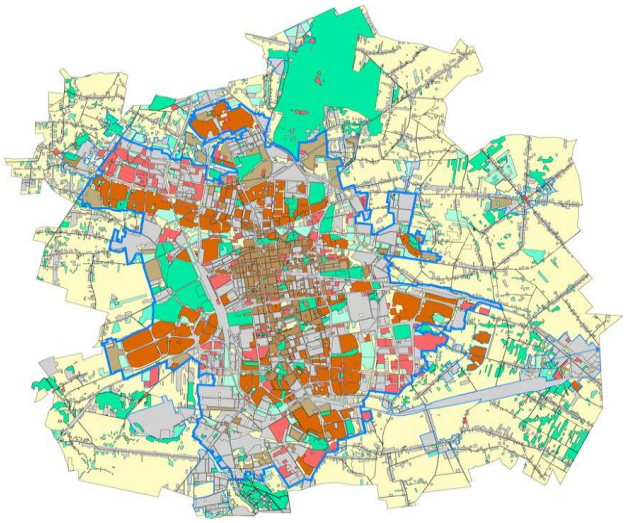

Figure 6. An example of the analyses following the principles mentioned in the paper - Study... Lodz [42]. Level of completion of urbanisation processes. The presentation assumed the generalisation of basic classes with the objective to get the map of most important structures types.

A GIS analysis may also show non-physical phenomena, which influences both the physical aspects and the perception of cityscape by inhabitants and visitors. The juxtaposition of different layers allows for the comparison of the physical appearance and, e.g., public transportation flows and nodes, like in Figure 7. Visual methods of analysis enhance the understanding of phenomena and helps in finding appropriate solutions.

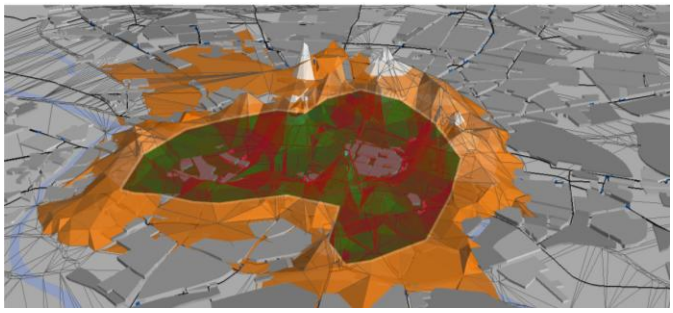

Figure 7. Wrocław center border drawn by capacity and location of tram transport nodes proceeded for 7-9 a.m. on workdays. Course: Architecture for Society of Knowledge, Warsaw University of Technology, seminarium GIS, student: Tomasz Kujawski, tutor: M. Hanzl. Further visualisations are available: http://system.asknow.eu/users/s_tomaszkujawski/ , retrieved: 09.2011

IV. CONCLUSIONS

Planning practice in the postmodern era requires references to urban form rather than to other aspects of urban development. The modernist definition of functions is not adequate and not sufficient, both in the process of analysis and decision making. The rehabilitation of brown-field development, as well as the down-town mixed uses areas, require more flexible treatment of land-use concept and concentration on urban form. The perception of urban landscapes, the concept of legibility and the semiotics of the environment requires conscious treatment of the formal issues in the processes of urban planning [28], [29], [39]. Similarly, concentration on urban form has become result of the desire to redevelop the cities as more concise, which is perceived as required from the point of view of ecology and sustainable development [22]. City morphological structure is also one of elements responsible for the possibility of social adaptation of members of different cultures [16].

The observed changes in urban planning theory and practice should influence alterations of the geomatics approach towards the environmental data, gathered for the purpose of urban planning, including the legal regulations and normative procedures concerning these issues. The current emphasis on land-use analyses should be replaced with form based approaches, which is enabled by the contemporary GIS and remote sensing technology. Currently, the tools encompassing 3D modeling are used mainly for presentation purposes. The requirements of progressing shift in urban planning towards more formal approaches should follow with their usage for analytical purposes. The basic element, and thus level of analysis required, should be the one of parcels. The technology allows for the integration of the two approaches – the main limitation seems to be lack of sufficient communication between urban planners and urban designers and geoinformatics professionals and researchers. The integration of approaches should result in increased easiness to fulfill the requirements of the analysis of urban environment and consequently urban policy preparation, which should also be reflected in the legal requirements.

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