ID 1687 | DIMENSIONING OF MATRIX OF URBAN STRUCTURES COMPLEXITY – FUNCTIONAL PARADIGM

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1 INTRODUCTION

By its content, the article is an integral part of a more comprehensive research on the complexity and sustainability of urban structures and systems. It is focused on identifying the forms of activity and possible procedures of operationalisation and transformation of the urban functions acting in the everyday life of the inhabitants in the observed space.

In studying the complexity, for the purpose of this article, it was necessary to define the basic notions that are applied in the process of analysis and generating the manifest dimensions of this phenomenon. As a starting point, a precondition is set according to which the identity of the notion can be identified identically in social and technical sciences.

Accordingly, the basics are urban fabrics, generically followed by urban structures and constructs, and then finally spatial systems and configurations. In our considerations of complexity phenomenon, we use the following definitions of notions.

Urban fabrics is a set of natural and artificial elements of components in the form of built and unbuilt parts of the observed space. It covers structures with elements of substructure and suprastructure, and all forms and types of ecostructures and infrastructures that connect them functionally and spatially.

Urban structure (city) is a set of urban fabrics of the observed part of area that makes an administrative, functional and spatially connected entity.

When in the consideration of urban structure (city) the people are included, their public and private needs, which are realized in the appropriate types of functions (institutions of public and private sector) and executed by appropriate processes, urban constructs appear. Urban construct is an urban structure connected with people, functions and processes in the observed area.

Spatial system is a set of urban structures connected with the hierarchy of functions and roles in the observed area (conurbation, region).

When in the spatial system the processes are included, which are generated by the people with their public and private needs realized in the appropriate functions (public and private sector institutions), then configurations arise.

Therefore, in our considerations, the urban structure is not only seen as a group of interconnected components of settlements made up of artificial fabrics and natural elements, but as urban constructs created by the complex acting of economic, social, functional and spatial relations. These connections arise as a result of the needs realized inside and outside the components of the observed space by urban fabrics.

The urban system is not only considered as a sum of inhabited spaces of different sizes and characteristics (Vresk, 1984; Grgurević, 1990), but as a spatial configuration. The realisation of these connections, relations and features is observed vertically, hierarchically - according to the rule of the "size order" of the inhabited area, horizontally - towards distance between them, and co-evolutionally towards the functional relations and transformations that urban systems turn into a spatial configuration.

The functions analysis in urban planning and spatial planning refer to their dual role role in space. Once is a facility of the components with features of attractors in the space (relational paradigm), and in next case it is a subject of complexity research within the components of urban structure or systems by the function flow diagram.

As an attractor, the function affects the size, intensity and frequency of relations between spatial entities, and as a paradigm, the function is interpreted by algorithms that simulate activities in the process of realisation of functions in the observed area. The function paradigm has the role to link the parameters obtained at the level of the relational paradigm and the processes being explored at the next level of research.

The purpose of this paper is to clarify the role of urban functions in the observed space and to point out the contribution of the functional paradigm to the possibility of operationalisation of complexity and sustainability of urban constructs and spatial configurations.

For the relational paradigm of complexity, a thesis was set up that in the geographic administrative area, included in the research of urban structure and system, there are not two inhabited spaces of the same characteristics. Therefore, the relation matrix must give a greater number of combinations without repeating than the observed area has functionally and administratively organized independent populated places at regional level.

For the functional paradigm, the axioms were set, that the function paradigm of complexity at a higher level - region depends on:

- sum of the categories of settlements hierarchy located in the observed space,
- the category in which the considered inhabited area belongs according to the concept of nodality and centrality,
- the number of functions that take place in the inhabited area for their own needs and the needs of people in other inhabited environments,
- the number of inhabited places of lower rank in the surroundings of the observed inhabited space that supports functionally and institutionally, defining the gravitational space and the intensity degree,
- distribution of functions in a space that plays a significant role in analysing and generating processes in the observed space.

2 STARTING POINTS FOR THE ANALYSIS OF FUNCTIONAL PARADIGM

The assumption is that the purpose and aim of this work can be achieved by the application of different scientific (logical and mathematical) methods.

From the previous research, the purposefulness of the application of the inductive method in the generative procedure has been confirmed, and for the analytical processes, it is appropriate to use logical deduction. By one component it expresses axioms that can be used to calculate the scalar value of the functional paradigm, and the other component (control) determines the way in which the deduction is applied in the axioms. Because of this, any changes in the axioms are followed by well-defined changes in the algorithm.

The implementation of the research in this paper should contribute to the illumination of the complexity of the different origins of causes and consequences resulted from the activities in the observed space for the purpose of defining the condition in this area. Operationalisation of functions can be accomplished by linking and deducing to a common denominator of the influence of economic and social connections and relations that realize in the space through the artificial and natural structures of the observed space.

For the purpose of this research, the following axioms were set:

- all components of particular urban structures and systems do not have the same capacities to meet the living and other functions in their immediate environment;
- all components of structures and systems do not have the same functional facilities for everyday and occasional needs of their inhabitants;
- The diversity of social, cultural, sports, administrative and other functions of inhabited areas depend on their size / population and the structure disposition of inhabited places in the observed space.

In the elaboration of the relational paradigm, there is a common statement for the relational, functional and structural (organisational) paradigm, but it should be repeated here: Criteria, indicators and benchmarks of complexity and sustainability in urban planning and spatial planning are determinable. For their determination, in the analysis it is necessary to include a larger number of variables and relations depending on the size and components of complex urban structures and systems (Petrović et al., 2014).

3 ANALYSIS OF ELEMENTS OF FUNCTIONAL PARADIGM

Functional paradigm elements are the parameters obtained by parameterisation of component relations and algorithms compiled of flow diagram of components functions of urban structures and systems. The relational paradigm shows the size of the interaction between components of urban structures and systems for a particular observed function.

In order to carry out the operationalisation of functions of urban structures and systems, their algorithmisation is carried out by using the results of relations parametrisation of urban structures and systems. By this process, conditions for quantitative and qualitative operationalisation of functions are achieved.

In order to carry out algorithmisation of urban functions, their features are considered to establish an analogy between the occurrence, by which some function or phenomenon is manifested in the space, and the flow diagram of the observed function in the algorithmisation process.

3.1 CHARACTERISTICS OF URBAN STRUCTURES AND SYSTEMS FUNCTIONS

The functional paradigm expresses the forms in which the parameters of each observed functions are manifested, as well as their effects in the observed space. In simple urban systems, the functions can be manifested autonomously, and can also act interactively in the space. In both cases, the effects of functions are summative.

In interactive functions, interaction mechanisms can be conductional and correlational. In the first case, a co-occurrence event causes linear changes in execution of the function. In the second case, the change (covariance) that is the result of joint action should be observed with more attention because it produces additional effects that are a consequence of joint action, but are not interactive actions. Relating to time the functions from the aspect of duration can be discrete and continuous, and from the aspect of metric, they can be deterministic and unpredictable (random).

Functional paradigm shows the operator actions and effects on changes in the input sizes of some functions processed by operand of the observed component of the urban structure or system.

3.2 FLOW DIAGRAM OF THE URBAN FUNCTIONS SIMULATION

The flow diagram of the simulation of urban functions should encompass as many information as possible about the way of realisation of the function or process. But at the same time for the purpose of operationalisation, it is necessary to reduce it to a limited number of parameters by the "reduction of information".

Through the abstraction, diagram should visualize the manifest dimension of the observed phenomenon, and by graphic interpretation, it should, as much is possible, simulate the dynamism of function relations in the space. Although the function flow diagrams are interpreted in reduced form, they can in its essence simulate complex relations. The most important is to set up correctly and exploit the operational nature of a diagram that simulates the material reality of possible events expressed by scalars.

3.3 ALGORITHM CHARACTERISTICS OF THE URBAN FUNCTION SIMULATION

In the process of functions algorithmisation, urban fabrics are treated as function operands in the observed component of structure or systems. Operands are manageable values and they have inert characteristics. In the functions processing, users and service providers are treated as operators of functions. Function operators perform the transmission or transformation of input value, and may have stochastic characteristics and have changeable characteristics. These transformations, as a consequence of functions processing, may have linear or complex characteristics.

In this kind of research, the diagram has two roles: one is to edit, record, transmit and process information and another is a creative role by which model of actions and processes is abstractly generated, that are manifested in space in real physical dimensions and scales.

To make an algorithm, as a means of recording procedures for solving problems of functions operationalisation, appropriate for computer processing and simulation of urban functions, with the generally accepted algorithm characteristics (discreteness, finality, determination, and massiveness), it should also have the characteristics of sequencing, graphical interpretation and compatibility with computer software languages.

3.4 METHODS USED IN URBAN FUNCTIONS SIMULATION

Since in the research, starting from the ideation, through the definition and interpretation comes the operationalisation of the state of space - as the ultimate aim of the study of the complexity of urban constructs and spatial configurations, it is necessary to apply various methods appropriate for the multidimensionality of this phenomenon.

The simulation of the functions is performed by the methods of abstraction, analogy and reduction, and is interpreted by the function flow diagrams that show the operationalisation of the appearance (manifest dimensions) of the function using the method of algorithmisation.

Complexity, as an occurrence, is composed of latent and manifest dimensions. These characteristics of phenomenon determines on the mental level - the ontological status of the constituent elements, on the level of definition - the epistemological aspects, on the level of interpretation - the hermeneutical aspects, and on the level of operationalisation of physical - mathematical aspects in the form of quantitative and qualitative indicators (Greco & Sosa, 1999; Portugali et al., 2012; Batty, 2005, 2009;)

The abstraction method, that meets the necessary and sufficient conditions for studying the complexity of phenomena in space, is appropriate to these criteria. According to I. Kant, abstraction is preceded by reflection, and for G. W. Hegel abstraction is "placing a formal identity in which actual differences are abolished in manifolds" i.e. between latent and manifest dimensions. Traditional philosophy distinguishes three degrees of abstraction. In the first stage, the notion, as result of abstraction, is abstracted from individual sensory characteristics. In the second stage, it is abstracted from substance (mathematical terms), and in the third stage notions (result of abstraction) are abstracted from the quantity (Kutleša, 2012, p. 46). At these three levels, knowledge from metaphysics, mathematics and physics is also appropriate as a supplement to urban planning and spatial planning.

By the axiomatisation of the above statements, in the relational paradigm the method of parameterisation of relations was applied, and at this level of research of the functional paradigm of complexity, the method of analogy and algorithmisation of functions was applied. The method of analogy has consistently been applied in the process of interpretation of the flow diagram of the function of urban structures and systems according to the aforementioned their characteristics and the characteristics of the algorithm in the simulation of urban functions[1].

[1] In order to interpret different function flow diagrams by analogy method, for the purpose of this research, works of Howard (2007) and Erdi (2008) were used as a model for analogy.

4 REVIEW OF STUDY RESULTS

Realisation of urban functions in a given area may have different effects on the occurrence of events that characterize the condition in the observed area. They are represented by various types of flow diagrams of function realisation as a tool for application of functions algorithmisation in urban structures and systems.

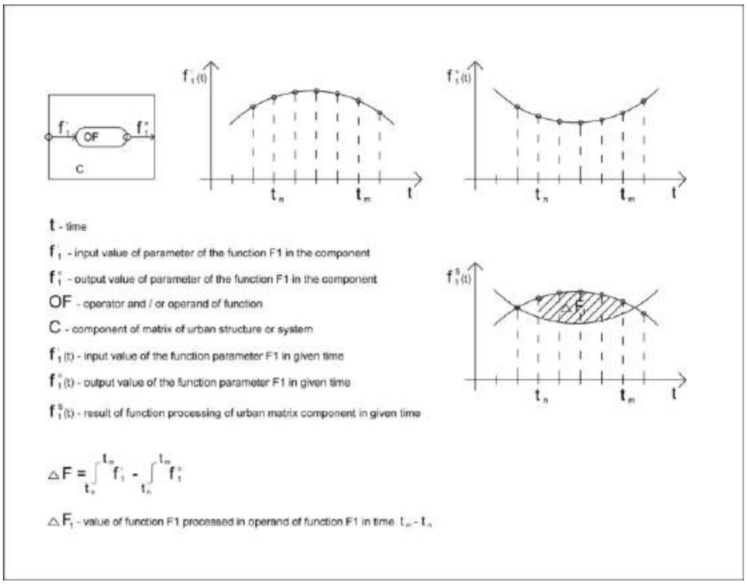

Figure 1 - Scheme of a monofunctional flow diagram of urban functions

Figure 1 shows a scheme of a monofunctional flow diagram of urban functions with arbitrary inputs and outputs, expressed in numbers that can have a positive and / or negative value on the positive part of the abscissa. These function values at this level are viewed as scalar value functions, which can happen discreetly and/or continuously.

Linear multifunctional algorithm is characterized by superposition property. The superposition of the input value of the function (cause) results in upgrading the output value of the function (consequence). This rule is valid for the input values of all components functions of urban structures and systems. From there follows a bifunctional or polyfunctional algorithm with parallel processing characteristics of two or more functions that are processed simultaneously according to the co-existence law.

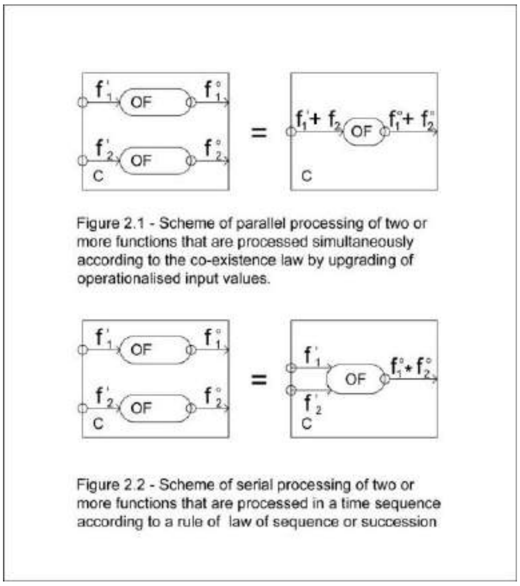

Figure 2.1 - Scheme of parallel processing of two or more functions that are processed simultaneously according to the co-existence law by upgrading of operationalised input values.

Figure 2.2 - Scheme of serial processing of two or more functions that are processed in a time sequence according to a rule of law of sequence or succession

Figure 2 - Scheme of the bifunctional flow diagram of urban functions

Figure 2 shows the scheme of the bifunctional flow diagram of the urban functions in which output values are of different values depending on the subject of the recipient and the service provider of the function - function operator and the urban fabrics as the object of the function operand. They can be constant, but also variable values in space and time of activity of some urban function. A special form of multifunctional flow diagrams of functions in space is an example of serial processing of functions. It takes place in a time sequence according to the rules of law of sequence or succession.

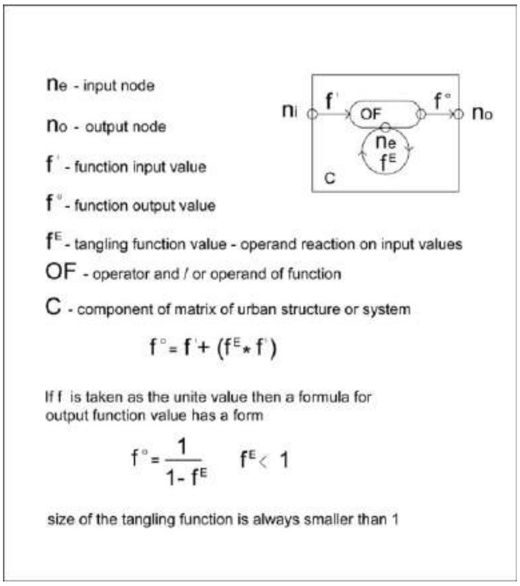

Figure 3 - Scheme of flow diagram of circular causality of urban functions

Figure 3 shows the scheme of flow diagram of circular causality or tangling of urban functions. The third form of functions processing in the components of urban structures and systems results in consequence of acting of the input value of the observed function and the addition resulting from the tangling (Howard, 2007, p 100) of the input value in the observed component. Causes of tangling can be autocorrelative characteristics of the identity of the fabrics component of urban structure or system.

Figure 4 shows the scheme of flow diagram of the reverse effect of urban function. In the flow diagram of reverse effect of the function processing there is not a clear border of the cause and effect because output influences the input. This reverse mechanism[1] affects the dynamics of functions operationalisation, because it can have a positive and negative sign. The negative reverse effect reduces the difference between input and output values and thus stabilizes the effects of function processing.

A positive reverse effect increases the difference from the initial state and thus destabilizes the effects of function processing. (Erdi, 2008, p. 8)

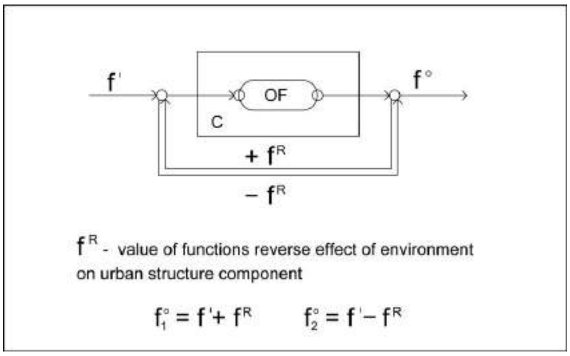

Figure 4 - Scheme of flow diagram of the reverse effect of urban functions

[1] Natural and social systems abound with reverse mechanisms, so there are inevitable in complexity studying.

The output vector from the linear system is obtained by tangling the input vector with the response vector of component to the effects of the input vector. These effects can be precisely determined in linear systems, and in complex systems, they are determined by the probability account, based on the previous state of the system.

The total effect of tangling can be defined either by integral tangling or summative tangling. In this process, the tangling may occur during function processing so that two (or more) output values of functions processing produce a third (or new) value under the influence of the function operator within the component of the urban structure or system. The feedback effect affects the properties of the system so that in the operationalisation of n components of the system, the system generates n + m output components. (M> 0). (Erdi, 2008)

Both reverse connections (the negative - dumping and the positive – amplifying) are always found in complex systems. The effect of the behaviour of an element of a structure or system is such that it always changes itself under the influence of the environment. Unlike the linear system where the superposition principle is applicable, complex systems cannot be expressed as the sum of the behaviour of its parts, because even the components of complex systems can be complex systems.

In linear systems, the effect is always directly proportional to the cause, and in complex systems it can be significantly larger, proportional or none. If the growth of the effect manifests exponentially, and with a small increase of the exponent in the finite time, an infinite increase in appearance may occur.

From above mentioned, it can be concluded about the possibilities of operationalisation of the parallel, serial and feedback connections of the component functions of a structure or system, and thus it is feasible for the complex multifunctional system through the reduction process of flow diagram of the function. Reduction is feasible in many ways, and the same methods of operationalisation can be applied at the level of operationalisation of the functional matrix of complexity.

5 CONCLUSIONS

The article identifies the basic notions used in the process of analysing and generating the manifest dimensions of the complexity of urban structures and systems. The dual role of function and the axioms was determined; the possibility of operationalizing the functions of urban structures and systems by their algorithmisation using relation parametrisation is pointed out; the basic starting points of the functional paradigm of urban structures and systems, their components and their interconnectedness, the dynamics of realisation and the possibility of operationalizing the functions of the urban matrix components are presented.

The analysis and generation of components functions of urban structures and systems, their algorithmisation and conducted analogy as well as the simulation of the movement of urban functions in the flow diagram pointed out the role of urban functions in the observed space and the contribution of the functional paradigm to the possibility of operationalisation of complexity and sustainability of urban constructions and spatial configurations.

Urban fabrics as functions operands in the component of structure or system are manageable in size and have inert characteristics. Functions operators (users and service providers, natural conditions and data) perform transmission or transformation of input value and may have stochastic and variable characteristics. These transformations can be linear or complex, which can be concluded from the presented schemes of functions flow diagrams.

If all components of urban structures and systems would be processed just by parallel and serial algorithmisation processes (regardless of their number) all these algorithms could be reduce to one algorithm by sequential addition for parallel and consecutive tangling of output values for serial algorithms of function.

In the process of algorithmisation of functions, beside the parallel connection of the functions operationalisation it is possible to connect them in series. In this case, the output value of the first function is the input value of the second function in the function flow diagram, and the result of the operationalisation of these two functions is not the sum but the product of multiplication of the two outputs of the function tangling in the observed space.

The basic characteristic of time-invariant linear construct is the transparency of the function process operator and its influence on the output value of a particular function from the observed component of the urban structure or system.

It is important to emphasize that the operator of the tangling of components function of urban structures or systems is commutative, associative and distributive, and the operand is changeable by transforming and intervening into the components constituent elements of the urban structure or system. Since urban fabrics at the observed moment are fixed and invariable in size, limited capacity, linearity manifests itself to a certain load of fabrics by processing all functions at the observed moment.

The phase of their linear characteristics finishes by optimal load of the functional capacity of the components constituent elements of the urban structure and system in the processing of functions. Increasing the functional load of the constituent elements of the urban structures and system components causes the appearance of tangling in the functions processing.

Therewith starts the phase of transformation of urban structures and systems into complex constructs and configurations. Although constructs and configurations have complexity characteristics, their features have not yet ceased to be deterministic. After that limit, by further increasing the function load, the results of the functions processing assume the characteristics of complexity. This firstly results in the variability of the effects of functions processing, and then also in the variability of time needed for function processing. Therewith a possible border between the linearity and complexity of the characteristics of the components of the urban structures and systems caused by the activities of the function operator and the capacity of the operand at the observed moment and time flow, is determined.

Finally, it can be concluded that based on conducted mathematical induction and synthesis, the features of function flow diagram shown in Figures 1 to 4, and the axioms as well as the above conclusions the characteristics of a complex functional paradigm can be defined. The complex functional paradigm has characteristics of parallel, serial, circular and backward processing of functions in discrete and continuous form. This paradigm fully reflects the algorithmisation of the functions of complex urban constructs and configurations.

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