Visual Support for Interpretation of Spatial Complexities in Urban Environments

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Abstract. The paper presents the second phase of our research efforts to further develop a model for interpretation of spatial complexities in urban environments (IMUSC – Interpretation Model of Urban Spatial Coherence). The model’s central structure is a result of our former research work being now further upgraded with the visual component and followed by the initial idea to extend it in terms of the pragmatic instrument and educational tool for the general public, participating in the process of urban decision-making. The paper concisely summarizes both theoretical and empirical phase of our research efforts; we explain the methodology used to gain novel knowledge regarding the abilities of the general public to decode professional visual messages. Further proposals are set by embedding the acquired empirical knowledge in the model structure as well as promote it in terms of a digital educational tool.

Keywords. Visual presentation; public participation; urban design; interpretation model.

INTRODUCTION

By challenging novel approaches in communicating spatially related contents to the general public, this paper reflects and continues our research efforts to develop a model for interpretation of urban space (IMUSC – Interpretation Model of Urban Spatial Coherence). The conceptual, methodological and technical establishment of the model stone is a result of our preceding work (Verovsek et al., 2011) being now further upgraded with the visual component.

The initial premise of the model (IMUSC) proposes the mechanism for a traceable linkage between the basic, mostly visible elements and features in the urban space, and the three (operational) qualities concerning its actual use, i.e., (a) access to the space, (b) movement within and through the space and (c) permitted/tolerated and stimulated sojourn of the users in the space. The model aims to assist with decoding professional language in terms of urban design (see e.g. Franz et al., 2005; Ewing and Handy, 2009; Forsyth et al., 2010; Molotch, 2011, etc.), and propose a method for identifying/tracing the contributors that generate the existing situation in a certain urban space on the other hand. It is an instrument for increasing comprehensions of spatial complexities and hence developing common priorities concerning spatial values.
The model consists of two main parts: the first part is based on the generalization of spatial complexity into key spatial elements and simplified but systematic linkage to the operational qualities (which serve at this point as a numerical output). The second part of the model is a visual extension of its numerical outputs, proposing experiential visual presentation of the essentially pre-defined elements embedded in the representation of certain location/site that is at issue.

The visualization extension we tend to further link to the model outputs automatically, generating a 2D and 3D representation of the selected location and its elements, which further presented as a series of experiential vistas in regard to the place and inputs chosen. Second, our efforts aim at developing IMUSC to the stage of the integral educational tool that can be used and managed by the general public involved in the process of urban co-deciding.

The present paper focuses on the second part; this is a development of the visual extension of the IMUSC as an upgrade of the model core by means of both theoretical and empirical approach. Initially a questionnaire-based inquiry was conducted to gain novel knowledge on the abilities of the general public (to decode professional visual messages) and to become better acquainted with its comprehension skills or preferences for the proposed visual material. Second, three digital mockups are proposed to demonstrate the visual extension of the model by applying/embedding the acquired empirical knowledge in the model structure as well as upgrading it in terms of a digital educational tool to support participatory design process.

The paper first provides a brief insight into the backgrounds of the model development. It sheds light upon the theoretical grounds of the research and shortly describes the empirical methods used to develop suitable visualisation techniques for participatory purposes. The second part summarizes the three proposals for the digital upgrade of the model (IMUSC) and discusses their relevance concerning further development.

**BACKGROUNDS**

When it comes to communication between the professional (e.g. planners, urban designers, geographers, engineers, architects, etc.) and the general public, in an attempt to involve the broader general public in the decision-making process, one is quickly encountered with the problem of insufficient understanding between these two groups (Rydin, 2007). We are faced with the Gordian knot of questions deriving from diverse types of skills, different priorities, values, attitudes, educational backgrounds, and motivation for participation etc. Especially the role of education and common priorities concerning spatial values and qualities are a strong factor in bridging the gap between the expert and lay public reasoning (Dietz, 2005). The social and psychological science literature provides us with evidence about the kinds of values and knowledge people actually bring to bear in making decisions and also about the impact of formal/informal education, norms, needs and other external influences on one’s comprehension of spatial reality (Schultz et al, 2005; Dietz et al, 2005). It is recognized (Svetina et al, 2011) that profound acquaintance with spatial complexity can arouse rational reasoning and converge the different priorities concerning spatial development.

Thus our efforts and the model proposed in its widest sense are committed to understanding the cityscape, its societal, economic and environmental dimension, with a great emphasis laid on the conveyance of interdisciplinary professional knowledge to a broader public in a form that can enable deeper comprehension of urban structure and through the optics that reflect the everyday experiences (Tuan, 1975; Gehl, 1987) with the urban spaces.

In terms of the model IMUSC particular consideration is given to the visual representation of the interpreted urban patterns and phenomena. Although the conceptual visual language is rational in terms of professional communication, we deem the experiential approach in visualization a crucial factor for the general public to comprehend the sensitivity, qualities or limitations of urban space. By visual presentations our major attempt is to merge two
principles: first, rousing one’s experiential spatial percepience that would then assist comprehending and decoding the visual message (Zupancic and Juvancic, 2003) and further rule his decisions and attitude concerning urban spaces (Carmona et al., 2010); and second, to pledge a certain level of genercity in a visual design that has a potential for prompt and repeated application in different spatial circumstances.

Although at times nearly diametrically opposite principles, they can, combined successfully, soften the sharp edges between particularly subjective, intuitive, unique representations of urban spaces on one hand, and extremely objective, automated and computerised on the other hand. The tendency towards merging the described aspects is being derived from our continuous research of the tradeoffs between the experiential and conceptual visualization techniques.

Inquiry
In order to use an optimal set of visualization techniques to frame the final visualization extension for the model, a questionnaire-based inquiry (N=365) was conducted. The tasks/questions of the empirical survey have been applied to several actual urban spaces and issues within the city of Ljubljana and were targeted separately to both, lay and professional (1) public in order to identify their responses to the visual messages, expressed by different visual techniques. The image-based questionnaire was implemented in two different versions (basic and control group) that were randomly assigned to the population sample, which ensured the relevance of the results and assisted with revealing the actual efficiency of each particular technique examined.

Sample population was non-random and was represented by 365 internet-users who hold an e-mail address and were selected in regard to their readiness for cooperation. The sample population had not previously been limited to the specific char-

<table>
<thead>
<tr>
<th>G</th>
<th>GRAPHIC MODE</th>
<th>S</th>
<th>SEQUENTIALITY</th>
<th>I</th>
<th>INFORMATION SUPPLEMENTATION</th>
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<tbody>
<tr>
<td>G1</td>
<td>line drawing</td>
<td>S1</td>
<td>concise manner (less than two images)</td>
<td>I1</td>
<td>basis = experiential depiction (pedestrian perspective)</td>
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<tr>
<td>G1a</td>
<td>manual mode</td>
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<td>I2</td>
<td>systematic supplementation of semantic information in the experiential manner</td>
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<td>G1b</td>
<td>app mode</td>
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<td>I3</td>
<td>systematic supplementation of semantic info in the conceptual layout technique</td>
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<tr>
<td>G2</td>
<td>colour-shaded line drawing</td>
<td>S2</td>
<td>sequential manner (series of images, narration)</td>
<td>I4</td>
<td>systematic supplementation of semantic info in the conceptual cross-section technique</td>
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<td>G2a</td>
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<td>photo post-processing</td>
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<td>cross-section technique</td>
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<td>G8</td>
<td>diagram method</td>
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Table 1
The variables/terms examined in the inquiry.
acteristics of the participants; however, additional classification for the purpose of descriptive statistic was made in accordance to age, educational field and degree, place of residence and employment status. In most cases paired t-test was used to compare statistical means and significance between the basic and control group.

Particular concern was dedicated to the structure of the questions to avoid biased responses and the impact of participants’ eventual attitudes and opinions of the actual places, represented in the visual material (if recognised). Here by no means we neglect the subjective nature of any individual spatial perception; however experiment-based approach was applied to test the assumptions (related to effectiveness of visualization techniques) in the absence of other factors that may influence the participants’ responses.

The variables examined can be clustered in three foremost groups designated by the main attributes of the modifying terms, these are, modifying the graphic mode, modifying the sequentiality of the images and revising an approach to add new information to the basic experiential representation (Table 1).

Whereas the detailed analysis is beyond the scope of this paper, we extend this chapter by several examples of the visual material used (Figure 1 – Figure 4). Nevertheless, our initial objective, which was met by the survey results, brings novel knowledge about the abilities and skills of the general public (to decode visual messages) – e.g., of how successfully lay person interpret the conveyed message when given in a single image (with aggregated information) or a series of images (sequential information); how successfully a traffic issue in the visual material is interpreted when being conveyed in a pedestrian perspective or when supplementary conceptual information are available; what are the expressed preferences of the respondents over the photo-realistic depiction as opposed to different levels of photo post-processing; etc. In some cases, our assumptions proved to be consistent with our expectations, however in others we have encountered a significant intricacy of the outcomes and the deviations from the expected results. Such case is for instance a comparison of the benefits gained by supplementation of the two different conceptual types of information (a bar chart or a cross-section). Although in most of the examined tasks the cross-section demonstrated more accessible information for the respondents, there have been some unexpected errors made by the participants when interpreting it in the particular spatial circumstances; especially it proved to be delicate in estimating the dynamics of the activities in space, where not explicitly depicted.
Suchlike and similar patterns not only brought better acquaintance with participants’ comprehension skills or preferences for the particular visual techniques, but the inquiry besides enabled us to identify possible methodological constraints and difficulties in applying particular visualisation techniques to different types of narratives and a digitalized form.

The greatest challenge – addressing each of the above mentioned structures – is to establish such software support that can be navigated and managed by the general public (as an application user), that facilitates quick and intuitive entry of the spatial data, as well as follows the sufficient accuracy in reconstructing the geo-unit, its elements and phenomena, while maintaining adequately generalized algorithmic structure to pledge a certain level of uniformity that enable comparison and recurrent relevance in different spatial circumstances.

In the current state of research three separate solutions are proposed (Flip, Vili and Balthazar) due to the limited means and ICT feasibilities; however, closer collaboration with the experts in the field of computing and information science is intended in our further work to implement both the idea of visual extension and educational application in rational and integrated digital form.

**Flip**

Our first attempt, we name it Flip, demonstrates the relationship between the input and the output variables of the model and link their values to the corresponding visual form. It is an attempt to transpose the model structure from the existing mathematical form (adjusted to Excel software environments) to such programming environments that enable assignment and projection of experiential visual forms.

For pragmatic reasons, (i.e. availability of software, prior familiarity with the program and its basic principles, the possibility of a relatively straightforward visual-based programming, etc.) software package GrasshopperRhino was applied for this phase.

Grasshopper is a software tool that utilizes Rhino 3-D as a modelling platform to develop parametrically controlled models with real time geometric manipulation. The main idea of this platform proposes the use of modules (e.g. parameters, components, specials) that can be further interconnected into a complex network of relations defining the design geometry, which usually represented by geometry in Rhino. While parameters can be defined in a different way, i.e. as curves, surfaces, points,
numbers, text or vectors, this enabled us to adjust and express the parameters in a numerical way and to additionally link them to the external visual forms. As a parametric tool, grasshopper is numerically driven and as a result, not only is it possible to modify the form with the numbers, but also to distil numerical data out from the form that have previously been created [1].

Although the described basic structure of this software environment is intended for the manipulation of geometric structures in terms of architectural design, it seemed flexible enough to adopt it for our purpose. It has been tested as a simulator of the model, on the basis of a limited number of input variables and a single output parameter (accessibility in regard to 4 different travel modes). Initially a complete set of input variables was intended to be passed on to the visual programming language, however, the final script technically proved to be too complex in terms of clear/concise structure and rational managing. The latter had partly been expected since this software primarily is not aimed at executing such tasks. Despite the limitations and due to the other tradeoffs we decided to test the best opportunities offered to demonstrate the integration of input and output variables, associated with the predetermined visual silhouettes and its qualitative and quantitative attributes. The number sliders were used to define the value (numerical or descriptive) of each input variable within a certain range and type and its numerical contribution to the output value of accessibility (aggregated output parameter) was defined by simple mathematical functions. The output value was then further linked to the set of pre-defined visual silhouettes by which the abstract measure of accessibility can capture visual expressions on the experiential level. Since the parametric design enables to selectively track and recall the value of any parameter [2] it was possible to link the aggregated measure of accessibility by input contributors and their share.

**Vili**

While in the case of *Flip* the visual outputs are defined and associated by the basic qualitative and quantitative attributes our second attempt *Vili* promotes their placement within the selected visual outline (background layer) of the place. To demonstrate this idea a prototype application has been programmed with the support of Adobe Director (see *Figure 5*). The basic idea of the application proposed represents the principle of recording the input spatial elements and their attributes by means of the digital library of pre-selected photographs of urban units and a digital library of optional spatial elements. Each element selected and placed within the frame of the background layer (performed by the application user) then affects the three output values (defined by the model IMUSC) and generates visual representation in terms of the qualitative and quantitative trait.

Due to the prior division of the background image layer into a set of geometrical plains, central projection (pedestrian view) is applied for the elements to distribute within the frames of photography layer. The horizontal line and the height of the reference object have to be defined by the application user. Therefore, the cause-effect variation and modification of the elements within urban unit in a pedestrian perspective is obtained on one hand and the intuitive and user friendly approach on the basis of visual appearance is kept by the entry of elements on the other hand.

**Balthazar**

While formerly described *Flip* and *Vili* represent the two complementary but separate digital phases of the model visualization upgrade, *Balthazar* puts forward their integration into a form with characteristics of integral educational tool for interpreting the urban spaces. Since the actual design of such digital application even in a prototype version exceeds our knowledge in the field of digital programming, the idea is outlined at the conceptual level. The figure below (*Figure 6*) outlines the main phases as they follow the preparation and manipulation of the visual materials by the app user.
In the first phase identification of the basic spatial structure of the selected urban unit is addressed. It allows the positioning of the built objects within the layout of selected spatial unit, defining approximate height (e.g. by defining the floors) of the objects and marking off the rough outline of the area on the grid with the corresponding coordinates. The second phase addresses the identification of functional or other areas (traffic road, bus lane, cycling path, sidewalk, lawn, restaurant terrace, etc.) and the input of additional elements (urban furniture, greenery, monuments, etc.) from predetermined set of available elements/features, located in the corresponding library file. In a similar way as in the case of Vili a set of rules and conflicts among the elements should previously be defined to avoid placing them in a way unfeasible to real-world circumstances. Only a limited set of possible combinations between the elements can be accomplished. In regard to the features defined, the third digital phase provides an estimation of the output values and the corresponding visual forms. This action follows the algorithms.
underlying the model IMUSC and therefore represents the essential part of the application, being followed by a visual representation in the last phase. Finally, the last digital phase promotes the experiential visualisation of the site. User is allowed to arbitrarily determine one or more standpoints within the reconstructed plot (conceptual level). The selected points are the basis for a visual presentation in a pedestrian perspective by means of 2D or 3D computer graphic. In addition, the final visual presentation comprises both the arrangements of the input elements and the arrangements which generated consequently to the first; this is by means of generated outputs. Later on the modifications of the input attributes are enabled and accompanied concurrently by emerging changes in the experiential view (pedestrian perspective). In this way any adjustment made in respect to the attributes of the input variables is expressed in the final presentation at the experiential level, which ultimately demonstrates the cause-effect narrative and therefore provides an interpretation of the relations.

CONCLUSION
The three attempts highlighted in previous chapter signify the three feasible ideas of how to visually and digitally advance the model IMUSC to capture though basic but firm structure and applicability concerning the interpretation of urban space and its complexity. It is beyond any doubt that Flip, Vili or Balthazar represents yet the initial stage in these tendencies, exemplifying essential structures and tradeoffs made by their establishment. It is also apparent that demonstrated upgrades have not been developed in optimal programming environments, nor can be considered as most rational in terms of their digital configuration. Nevertheless, we consider them relatively adequate approximations and outlines of what the model for the interpretation of spatial reality can combine or correspond to while capturing the form of a digital educational app.

Ultimately, the interpretation of the urban spaces by means of experience-based visual approach, suggested by our on-going research, goes beyond the mere development of digital applications. The idea is to expand this research scope not only in regard to the applicative aspect, but also in the aspects of the underlying empirical, theoretical and methodological contribution; and this has been to some extent demonstrated also by the present paper, while combining the empirical and applicative working phase to meet our initial goals.

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