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E se la forma seguisse la funzione? L'esplorazione della desiderabilità nella città di Skopje

What if form follows function? The exploration of suitability in the city of Skopje

L'integrazione della visualizzazione interattiva con le tecnologie GIS rappresenta oggigiorno un consistente supporto per i processi di pianificazione e progettazione urbana. I sistemi informatici di modellazione tridimensionale offrono nuove opportunità per comunicare i dati territoriali e far comprendere le relazioni che li interconnettono. Esiti rilevanti di questa unione provengono dall'analisi della compatibilità delle funzioni urbane con le aree residenziali. Questo tema, studiato per l'area "Taftalidze" di Skopje (Macedonia), genera una relazione tra i servizi pubblici e la qualità percepita della vita, fornendo una nuova morfologia urbana. L'esplorazione interattiva di questo nuovo paesaggio offre elementi progettuali da indagare, consentendo ai progettisti di creare una propria conoscenza e consapevolezza sulle questioni urbane in esame.

The integration of interactive visualization with GIS technologies is nowadays a new frontier in supporting the processes of urban design and planning. Informed three-dimensional modelling systems can provide new insights in understanding both the elements which constitute the city and the relationships among these elements. One key outcome of this combination is the analysis of suitability of residential areas with urban functions. This topic, studied for the Taftalidze residential area in Skopje (Macedonia), generates a relationships between public facilities and perceived quality of life, providing a new urban morphology. The interactive exploration of this new landscape offers a large amount of project elements to investigate, allowing planners and designers to create an own knowledge and awareness on urban questions to be solved.

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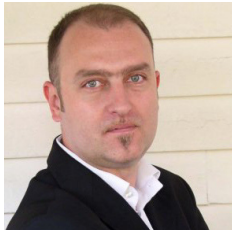

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Parole chiave: forma e funzione urbana; geovisualizzazione; mappe dinamiche; PSS; GIS; grasshopper

***Keywords**: urban form and function; geovisualization; dynamic maps; PSS; GIS; grasshopper*

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FORM AND FUNCTION IN THE CITY OF SKOPJE

Historically, urban design derives from the search for balance between form and function. Nevertheless, in some cases the two weights were not the same. If during times of richness and strong power, cities grow up on well-designed plans that show their inner beauty, in emergency situations, urban areas have to face functional priorities to address the basic needs, provoking fast changes and discontinuity in the construction of the city.

This fragmented development, due to continuous newer questions to solve, is the same as that occurring in the history of Skopje. The city has a past of discontinuity, quick transformations followed by questioning on its previous urban configuration and new starts with tabula rasa (Marina and Pencic, 2009). Until 1990 Skopje grew up on state controlled processes, in which the public domain and collective interest had a crucial role. Afterwards, the transition from socialism to capitalism had as consequence several changes in the political and social system. Among these, the new regulations on properties transfer, which are now determined by market principles, generated further strong discontinuity in both urban and social aspects so that the city has become more fragmented than ever (Marina and Armando, 2012). As a consequence, the city results as a collection of architectural events rather than the outcome of a designed urban image.

In this context, the development of Taftalidze residential area in Skopje is the result of an urgent process of reconstruction and renewal which followed the devastating earthquake in 1963. The city of Skopje remained with more than 85% of building stock ruined or with high level of devastation (UNDP, 1970). For these reasons, in order to manage the dire situation, new residential areas have been developed on the metropolitan areas beyond the existing city limits. This is the case of Taftalidze residential area, which, in contrast with the historical city, grew up on an orthogonal network of road with a well defined zoning of functions in the middle of the area. This planning approach, based on functionalist and modernist dogma, has led to an emergence of constant pressure to the physical configuration of the city, which now appears conceptually and morphologically fragmented as a random collection of complex urban portions that produce a multifaceted image of the city.

MODELLING SKOPJE: A WAY TO EXPLORE THE CITY STRUCTURE

In order to investigate the future development of urban residential areas in the city of Skopje, it is essential to explore, but also to understand, the relationship that ties the city morphology with its function. Different methodologies can be used to investigate the form-function association. Despite most of these techniques are experience based just on the professionals' knowledge, although several computer tools are nowadays available to support the analysis, simulation and evaluation of urban design.

It is now more than half a century that urban models are used to study cities and their

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complexity (Batty, 2011). Despite the continuous debate which animates the literature on the opportunity of complex models versus simple ones, on their transparency, usability and their effectiveness in reproducing reality (Hopkins, 2011), the use of spatial models to describe urban dynamics is worldwide recognized as a way to support the knowledge building on spatial issues (Andrienko et al., 2007; Van den Brink et al., 2007; MacEachren et al., 2004).
To study the Taftalidze residential area in Skopje, a new approach to urban modelling has been used, which employs parametrical features to visualize in real time the effects of specific choices on urban design. This methodology for using urban data is the basis of Interactive Visualization Tool (InViTo), a research project based on Grasshopper, a free plug-in for McNeel's Rhinoceros, which allows managing databases in a parametric and interactive environment (Lami, Masala and Pensa, 2011).
InViTo can work on different scales, from the urban to the trans-national one, and can be used to achieve several purposes in which visualization can support the analysis of information as well as decision-making and planning processes. These purposes include spatial analysis, spatial simulation, scenario assessment and the presentation and communication of results. It can use as input data a large amount of typologies of information. It works with GIS data as well as CAD drawings, spreadsheets and raster files.
This variety enhances the possibility to work with different people at the same time, thus to allow high chance for multi-disciplinary collaboration. Furthermore, these incomes can be arranged to provide different meanings to the model. In particular, they are very useful when elaborated to provide information about the relationships among different components so to reveal unseen elements. The outputs of InViTo are interactive visualizations, which can be set to best fit the specific goal of case study. It can provide dynamic bi-dimensional maps, three-dimensional models as well as geo-referenced charts which can assume the values of desired parameters on the basis of user's preferences. These outputs can be displayed also by means of Google Earth virtual globe, thus allowing users to interact with an already known interface.
Throughout the use of InViTo, a three-dimensional model has been realized to explore the Taftalidze residential area of Skopje. To understand the urban dynamics by which the city changes its morphology, the study has been structured to perform two main tasks. The former represents an effort to analyse and understand the local dynamics, which determine the localization of activities on the area, by relating the suitability of places with their shape and their distances from the other functions, infrastructures and facilities. On the basis of several urban indicators, the model expresses the suitability for the residential function and visualizes, by the use of both 2D maps and 3D models, its intensity as calculated all over the area. InViTo allows users to change the value of the parameters used as indicators and visualizes in real time the effect on suitability values as

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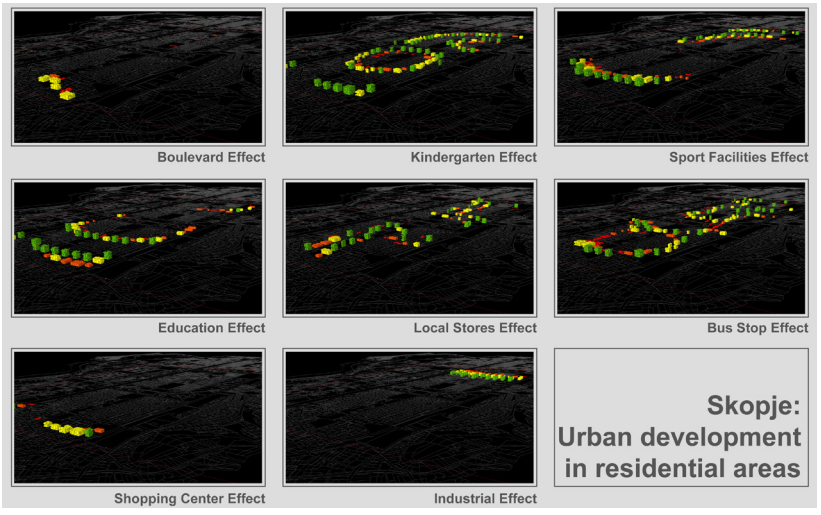

Figure 1. Localization of suitability on the basis of each specific indicator.

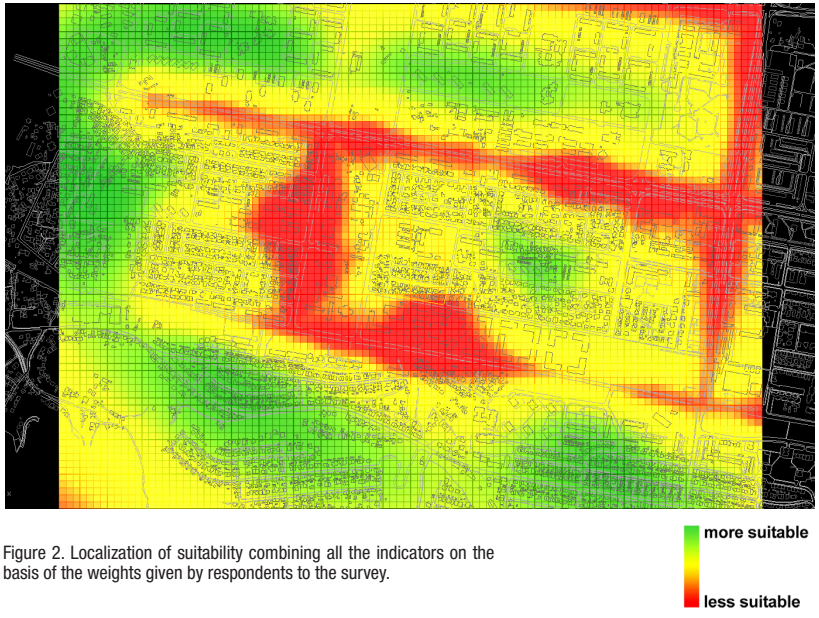

Figure 2. Localization of suitability combining all the indicators on the basis of the weights given by respondents to the survey.

geo-referenced three-dimensional charts.
The latter simulates the changes in urban form on the basis of the most suitable localization for the different urban functions. This three-dimensional model intends to investigate different urban indicators and their priorities to find the most appropriate for planning the new development in Skopje. The form of building, their volumes as well as their localization depend on the localization of preferences. Therefore, the changes in parameters imply the direct transformation of location, dimension and shape of residential buildings, but also of residential units.

THE DEFINITION OF SPATIAL DYNAMICS

Cities are par excellence complex systems (Portugali, 1999) and far from being chaotic, disorganised forms, have rather well-defined spatial structures. Order of the cities appears on all scales, with urban form and activities forming clusters of different sizes (Penn et al., 1997). These clusters are supported by networks of interdependent relations and links among the elements of urban form which distribute different aspects of the system of urban form such as urban morphology, spatial arrangements, property value, energy consumption and others. In order to create a more realistic model of an urban form development, in process of creating and implementing a set of local rules of the system's elements transformations, we traced and mapped the types and tendencies of transformations observed in the residential area in Skopje. To the each of the elements (spatial cells) ranking from single residential unit to whole city block (or part of the city) of the model a list of attributes (physical and non-physical), data has been attached that will affect the configuration of elements through the locally based rules of interaction among elements. The structure of the model is organized in "clusters" of elements exercising functional, economical or spatial coherence within the system. This allows us to use the same system regardless of the size and level of complexity of the basic entity.
The model for the residential area in Skopje is a simple model which relates with linear connections the function of urban elements with a spatial effect on form. It has been built starting from geographic data related to different attributes as the land use or the height of buildings. Each data are related to the others on the basis of a utility function which defines its level of influence on the choice of a residential unit or building. This influence can be attractive or repulsive, or even both, depending on the distance, measured in meters or walking time from the singular element and the residential unit.
To establish the indicators of suitability and their relative weights, a research survey has been distributed among approximately two hundred citizens of Skopje, aged between 35 and 44

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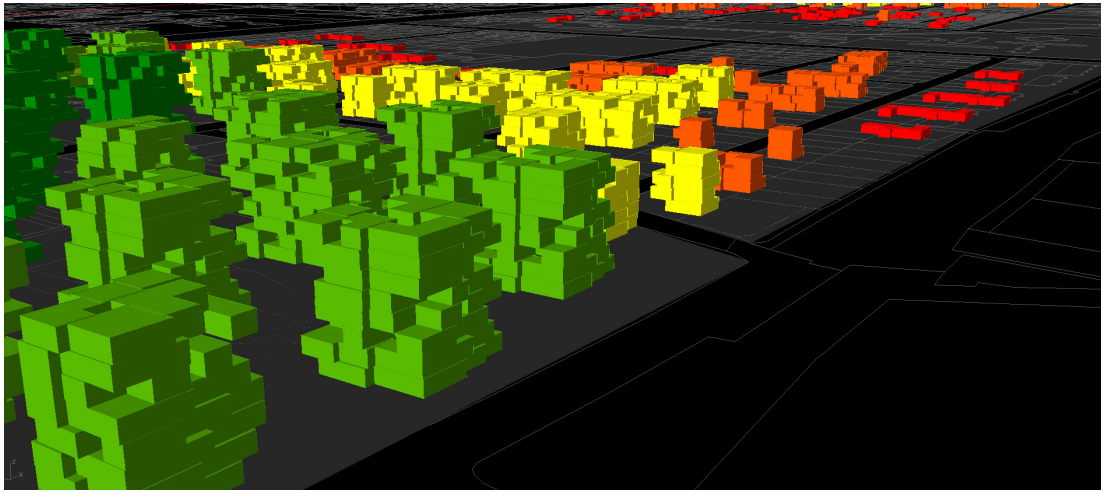

Figure 3. Example of visualizations in which specific spatial attributes determine the number and size of residential units according to the volume, function and buildings suitability to the residential function.

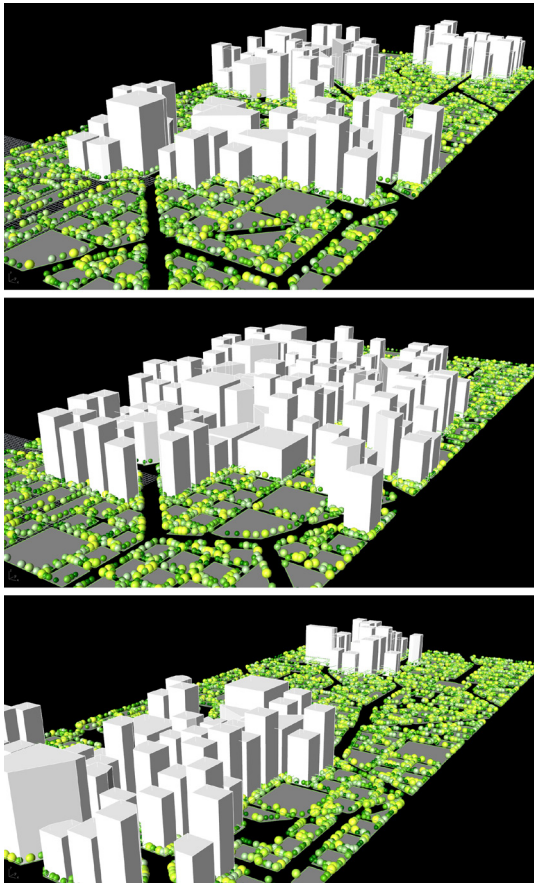

Figure 4. The model modifies the urban morphology in real time according to the changes in the values of parameters used as indicators.

years, who had to respond to and evaluate questions about:
- the level of attractiveness of specific residential areas;
- the importance of the different criteria for the evaluation of residential areas;
- the level of perceived comfort related to the distance of residences from urban infrastructures (boulevards, bus stops, parks, industrial facilities and city centre); commercial infrastructures (grocery shops, shopping centres, green markets); social/civic infrastructures (kindergartens, elementary schools, medical facilities, pharmacies and sport centres).

  Another group of questions was related to explore the preferences regarding the following:
- Typology of the residential buildings (houses, buildings with less than 8 apartments, buildings with more than 8 apartments and residential high rises)
- The size of desired backyard/garden as a part of the parcel where the residence is located.
- Typology of use of buildings with residences.

The survey analysis provided the curves by which the model has been set up. Questions about the level of perceived comfort due to the distance of the residential unit from urban, commercial and social infrastructure defined the level of suitability. Therefore, these parameters have been associated with their relative geo-referenced data and used to connect each element on the map with each others.
Since not all indicators present the same importance, a system of weights is assigned to each of them, based on the preferences given by the respondents to the survey. In this way, the model is set to define the most significant spatial elements which affect the choice for residential location.

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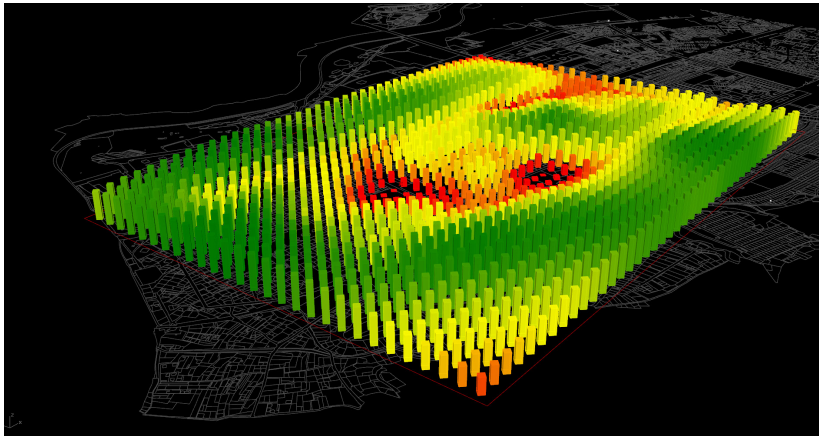

Figure 5. Geo-referenced charts with changes in colour and heights.

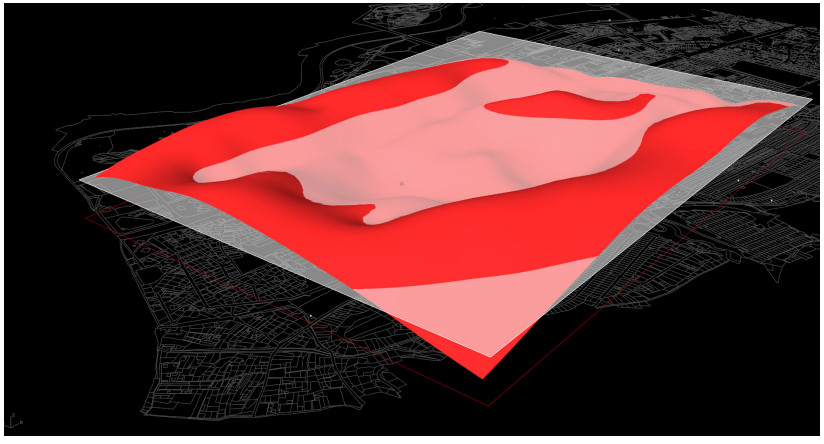

Figure 6. 3D mesh with changes on the height of “peaks and valleys”.

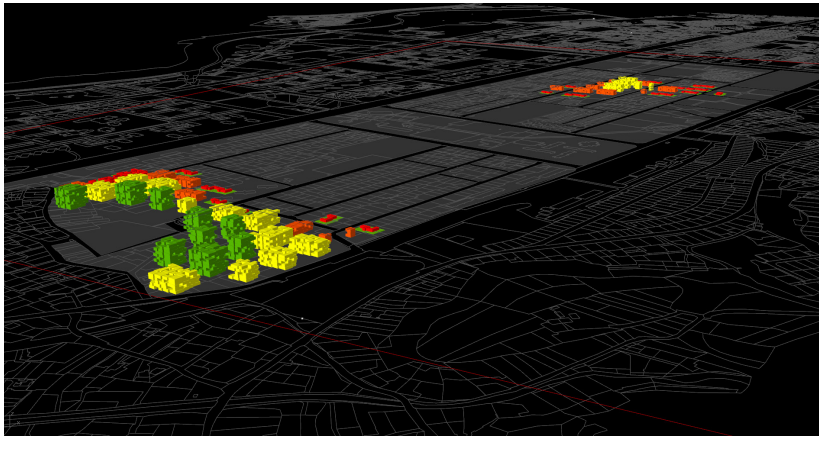

Figure 7. Quantitative 3D representations of suitability, to not be misunderstood with a project design.

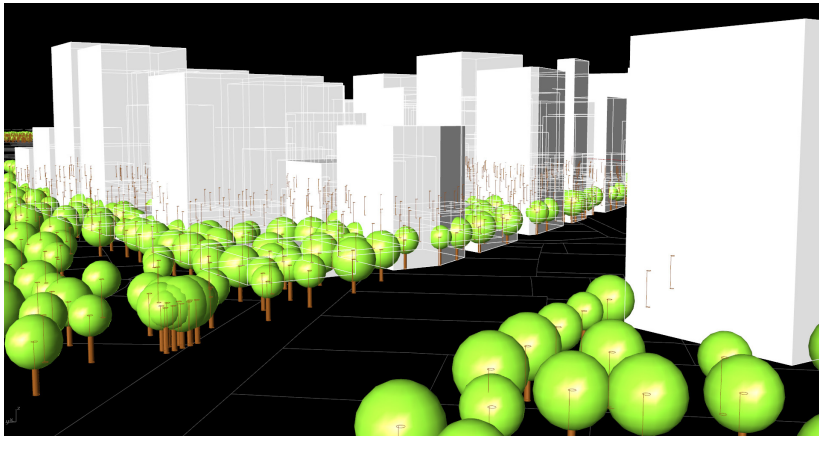

Figure 8. Symbolic visualization with details on urban morphology.

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OUTCOMES ON URBAN DESIGN

As said before, in this specific case InViTo has been set to provide two different outcomes. The first concerns an analysis of suitability of urban facilities with respect to the residential function, while the second uses the values of suitability to generate an urban form that could best meet the preferences of citizens of Skopje, as well as results from assuming the answers to the survey as a valid and shared evaluation.

The first typology of model outcomes represents the localization of suitability on the area. This visualization can be realized showing the values of suitability with respect to each indicator (fig. 1), but also combining all the indicators in a single map (fig. 2), or by selecting only some specific aspects.

This first result visually shows unexpected information which could provide an important guideline for the generation of new plans and projects. First overview on maps shows that, in choosing localization for residence, mono-functional areas are preferred to mixed-up ones. Furthermore, these residential areas should have a relative but substantial distance from the position of urban services as facilities and infrastructures. This is well shown in figure 2, in which the central area that mostly contains services as sport centres, schools, shopping centres and public transport facilities is coloured in red, which means areas with less suitability for the residential activities. These services are then perceived as disturbing the residential function, and their location should be re-thought on the basis of these outcomes.

Another important outcome is that all the indicators have converging results on defining the areas with less and more suitability. This means that the areas with more suitability have a robust attitude with respect to the residential function. Looking at the map related to the boulevards, it is clear that their presence negatively affects the residential desirability, thus requiring new reasoning by designers and planners on increasing their level of attractiveness. The same happens for bus stops, perceived as a trouble rather than a facility, because of a low effectiveness of public transport and a general preference for private transport mode.

The second typology of outcome provided by the model built with InViTo concerns the transformation of suitability in plausible urban morphology. By the use of a generative platform, the system produces new three-dimensional urban forms which depend on the chosen values for indicators, on the level of suitability as previously calculated and on other parameters that identify the size and typology of the residential buildings. The whole area is divided in urban blocks by the use of a grid based on a road network. At the moment, no particular constraints, such as zoning or regulatory plans, have been applied to the development of the area. The model has been set to explore the suitability for the residential function according to citizens preferences. The only limitation has been the size of buildings. In fact, the areas with more suitability have been covered with buildings of seven floors that correspond to the maximum current height in the Taftalidze area. Each of these buildings has a maximum footprint of 20m x 20m and, by the use of an add-on of Grassopper, is divided in residential units of variable size, from 40 to 150m^2. The volume of building decreases depending on the level of suitability, maintaining, as minimum size, a footprint area of at least 10m by side. The height of buildings is kept on discrete values that must be multiple of the conventional 3m per floor (fig. 3).

Since InViTo is an ongoing research, new implementations are expected. In particular, further developments may occur in a more detailed definition of the typology of residential units, which are at the moment reduced to smaller or larger urban blocks. The present setting of InViTo contemplates a variation on building footprint size but there is still a lack on representing different typologies, which are essential to represent the urban structure of the residential area in Skopje. The splitting of residential units in different types should implement the level of information that the model can communicate, thus increasing their usability in pre-figuring the urban form.

Nevertheless, such a visualization of urban morphology allows new insights on the analysis of urban dynamics because of two main characteristics of InViTo. First of all, the model is interactive and allows at any time to change the value chosen to weight the indicators, providing in real-time new configurations based on the latest input data (fig.4).

This consents to the model to be fully transparent and avoid black boxes approaches which causes a general mistrust on the use of spatial models, especially during the processes of urban design and planning. This possibility for users to interact with data is essential to inform the actors involved in spatial decision processes, whose can explore the model and evaluate the effect of their own choices on the resulting urban form.

Second, the visualization of the model can be set in different ways in order to best fit the target of audience. The suitability for the residential function as well as its effect on urban form can be communicated through different languages and with a variety of purposes. The representation of data can vary on a range of more or less symbolism providing information on urban form with different levels of detail. Visualizations can be built using different techniques and vary depending on modeler's choices; some examples are be bi-dimensional maps with changes in colour gradient (fig. 2), or three-dimensional views such as geo-referenced charts (fig. 5), 3D meshes (fig. 6), symbolic buildings (fig. 7) and detailed urban morphology (fig. 8).

These different typologies of visualization could provide several ways to approach the spatial decision process, allowing a full customization of the outputs on the basis of the expertise of involved actors. Planners and designers can use the results of this model to draw the guidelines for project, as well as for comparing scenarios or different design options. In fact, the dynamism of parametric modelling system of InViTo overcomes traditional decision systems, generally based on fixed scenarios, and promotes dynamic alternative options which can grow up together with the evaluations of experts during the work sessions. In particular, they can use

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these interactive visualizations to relate specific choices with a spatial effect, thus introducing not a forecast but a pre-figuration of consequences of spatial decision process. Therefore, urban elements appear not as predetermined and unchangeable conditions but as the object of a knowledge that should be built through a strong collaboration among actors coming from varied disciplines and with a large assortment of expertise.

CONCLUSIONS AND FUTURE WORK

InViTo showed to be particularly suitable for exploring the spatial dynamics that defines the configuration of an urban area. By means of continuous queries between model and user, it provides effective explanations of the cause-effect relationships that occur in urban dynamics. This offer to the actors involved in process of spatial planning and designs a valid support to make grow up their knowledge and awareness on the spatial effect that their choices produce on urban area.

This modelling system becomes the framework for organizing the urban knowledge and exploring it by means of interaction with the complex network of spatial relationships. Users can build their knowledge and improve their awareness in a common and shared environment, which stimulates the communication and exchange of information. For these peculiarities, InViTo is well suited for supporting collaborative processes, in which transparency and usability are essential to the achievement of planning tasks.

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