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Universal Smart Tool for Assessing and Developing Urban Morphology

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Abstract*: *The city occupies an important place in the country's settlement system. The urban population of the Russian Federation is more than 74% of the total population of the country. The city gives residents many opportunities, but also a large number of problems for city planners. An important component of a smart city is smart planning - urban strategic development of the city, the use of high technologies and smart tools for analysis, drawing and visualization. Smart planning can be divided into stages of urban development: big data analysis and modelling, data collection, strategic planning and forecasting, and promoting smart life. The purpose of the study is a comprehensive review of intelligent design and the creation of a universal tool for urban planning, planning and evaluation of the structure of the city. The morphology of the city is chosen as a tool for visualizing the design and modelling of a smart city, because, in the practice of urban planning, specialists are faced with the rapid growth of cities and people. This leads to uncontrolled land use. As a result, a universal tool for urban planning, modelling and evaluation of the urban morphology "Urban blok" has been developed.

Index Terms*: *Planning, Programming, Smart Tool, Urban Morphology.

I. INTRODUCTION

The city is a complex structure that combines the natural-territorial, socio-demographic, economic-town-planning and engineering-technical systems. The development of these complexes is caused by natural and anthropogenic factors. The city is a complex planning process. Urban spatial organization and morphological features reflect and show interrelations of changes in all environmental characteristics.

The development of technologies and the emergence of new programs enrich the urban planning and design process. Progress offers many new opportunities for social interaction, faster decision-making regarding the planning and management of the city. The gradually emerging technologies of the smart city have played a key role in transforming various areas of human life that have affected sectors such as transport, health, energy, and education.

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Smart design is an important constituent of a smart city. This is urban strategic planning and sustainable development of the city. The concept of a smart city uses high technology and smart analysis tools. Smart planning in urban planning includes big data analysis, modelling, evaluation, strategic planning, data collection, forecasting and popularization of smart life.

The paradigm shifts from the traditional use of computers to increasingly complex calculations. The significant increase in connected devices and sensors makes it possible to conduct life in a smart environment [1]. Several applications of the intellectual environment were introduced relatively recently in everyday life, including smart homes, smart grids, intelligent transportation, and finally, smart cities began to appear.

The main problem is the search for qualities, properties, objects from the chaotically existing information and data, which researchers and urban planners face. This is done to give a more or less current view of the existing urban morphology.

The purpose of the study is to present a comprehensive review of intelligent design and the creation of a universal tool for urban planning, planning and evaluation of the city structure.

The morphology of the city is selected in the study as a tool for visualizing the design and modelling of a smart city because, in urban planning practice, specialists are faced with the rapid growth of cities and population. This leads to uncontrolled land use. Accordingly, this entails the inevitable change in the physical appearance of cities and the increasing complexity of the city morphology. As a result, the created smart tool for assessing and developing the urban structure based on the electronic kit and programming allows to simulate urban morphology, to conduct automated calculations of the building density at the stages of planning, design and evaluation in real time.

II. METHODOLOGY AND MATERIALS

The study is based on the following methodology:

1. Theoretical substantiation. The review and study of researches and examples in the field of town-planning IT technologies.
2. The division of the concept of smart planning into four stages of town-planning activity.
3. Creating a tool for smart-planning, design and assessment.
4. The description of a created tool for smart-planning, design and assessment.

The value of the methodology lies in the prototype that was developed using widely accessible technologies and materials. The model is based on the open-source electronics platform Arduino. This is a tool for designing electronic devices. It interacts more closely with the surrounding physical environment than standard personal computers, which actually do not go beyond the limits of virtually.

The body is made of the physical model of the paperboard thickness 1mm.

The accompanying computer software with control interface and visualization of the received data and calculations was developed using Processing programming language. The circuitry consists of Arduino Nano board, 2 shift registers 74HC595, 8 resistors 220Ω, 8 LEDs, 8 resistors100Ω, 64 diodes N5819, 64 resistors 4.7Ω and 384 pieces of copper plates. It is important to note, that the modular design of the model and circuit allows transformation of the configuration and change in the number of fields.

III. REVIEW OF RESEARCH

In the article, The Role of Big Data in a Smart City, a group of scientists describes modern communication technologies and intelligent applications in the context of smart cities. They characterize the visions of big data analytics with a focus on how big data can drastically change the urban population at different levels [2].

M. Mezhar, Retor and others in "Urban Planning and Design of Smart Cities Based on the Internet of Things (IT) using Big Data analysis" propose a combined IT-based system for the intellectual development of the city using Big Data analytics. Scientists propose a system that consists of various types of sensors. It includes intelligent home sensors, network systems, weather and water sensors, intelligent parking sensors and objects of observation [3].

The article "Urban morphology as a tool" states that at present, the urban morphology as a subject is not only a useful tool to recognize urban structures and forms, but also a powerful tool that city planners can use to make decisions the future development .

The article "Smart City: the application of GIS and FM technologies in the implementation of urban planning policy" states that smart city is characterized by the unification of areas of urban planning activity. This application requires IT tools, as well as special technologies, methods, calculations [4].

A decision support project for computing delivery service areas is one example of smart modeling developed by the Media Labs Change Maces (MIT) group and the MIT Transport and Logistics Center.

IV. THEORETICAL SUBSTANTIATION

The concept of the smart city assumes modernization of infrastructure of the city with new opportunities of the centralized management and new level of the provided services. This strategic concept combines the various factors of urban development into a single system. Smart city is characterized by the combination of fields of urban planning, which require the use of IT tools, as well as special technologies, methods, calculations. This concept recognizes the role of artificial intelligence, information and communication technologies, social and environmental potential as a resource for development and competitiveness of the city. Important component of a smart city is smart planning – urban planning strategic development of the city, using high technologies and smart tools for analysis, sketching and visualization.

The concept of smart planning can be divided into four stages of urban development:

Stage 1

Smart analysis, which is mainly, based on big data and geographic information systems (GIS).

The use of big data helps to find a solution to the problems of urban design and ways of development in an indefinite time. GIS is a single technological substrate and one of the technologies for the practical application of the concept of Smart-City. This is a technological platform that allows you to understand spatial relationships and solve complex issues of administrative management.

Stage 2

Receiving and processing information from the Internet of Things.

Maintaining a smart city depends on the work of billions of sensors, Internet of Things devices associated with various applications that generate large amounts of data. Wireless sensor networks are the main sources of information generation. Networks provide intellectual and flexible support for professionals and city residents. The task of urban planners is to collect and process all the information received from the Internet of Things.

Stage 3

Strategic planning and forecasting of development and changes in the urban environment in real-time.

After collecting and processing information collected from different platforms and sources, the work of the town planner does not stop. The stage of strategic planning begins on the basis of the obtained data in real time. This process does not stop; it should be constantly updated depending on the needs of the city. The specialist must quickly respond to emerging threats and opportunities, and make quick decisions based on the results of smart analysis (big data information, GIS technology, Internet of things).

Stage 4

Visualization and popularization of a smart city on the basis of smart tool for urban morphology.

The last and no less important step in smart planning is modeling. With the development of IT technologies in the field of architecture and urban planning, smart tools should appear for analysis, design, visualization and training. The goals of smart modeling using visual communications are to present as much data as possible and to help the designer and other specialists to identify different solutions.

Smart tools, that demonstrate and mimic various models of development and design, up to a thorough assessment and control in real time by urban processes. All this makes it possible to individualize the solution for each city or individual area in it. High technologies in the field of urban planning must continuously develop and be one step ahead of urban development.

Fig.1. Smart Planning

V. DESCRIPTION OF TOOL

Universal tool for urban planning, planning and evaluation of the morphology of the city "Urban Blok" was developed on the basis of a theoretical study. The program consists of three parts, such as a physical interactive layout, visualization of a model on a computer monitor, and a program that performs calculations in real time.

The physical layout of the prototype consists of a field of simulated site. This field consists of an 8x8 square grid (64 cells in total, the size of each cell is 60x60mm), square modules (blocks) that imitate a building unit, a series of LED light bulbs. For example, building units are sections of a residential building or a single-story detached building (the size of each block is 60x60x20mm). Light bulbs visualize the results of calculations on the layout.

First of all, an interactive model with software serves as a tool for sketching the morphology of the projected area, which is designed to predict the results of several planning and development scenarios in a short time. The main functionality of the software is the calculation of the density of the building, the coefficient of the building, the floor-area ratio (FAR), ground coverage, open space ratio (OSR), the average height of buildings on the territory, the area of the building and the area of free territories, and the balance of built-up and free space of the territory. This is the first information that is required when analyzing the territory and designing a new development in the city.

In the program, the main opportunity is to enter the maximum permissible values, for example, the floor-area ratio (FAR). This design function is used on the basis of quantitative indicators and data that take into account regulatory requirements. All calculations are visualized on a computer monitor and on an interactive model using with LEDs.

Let's look at how to visualize on the layout, for example, the calculation of the coefficient of the building. The LED range consists of 8 lamps of different colors, where color is indicative of values from optimal to limiting (blue, green, yellow, red). If the coefficient of the building exceeds the maximum allowed values, a red light comes on.

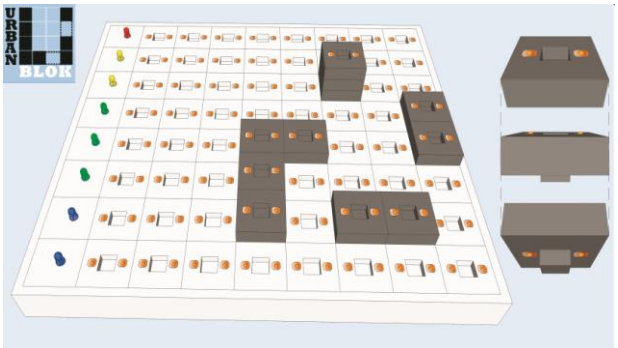

Fig.2. Model sketch

The developed tool is aimed at supporting decision-making on the basis of augmented reality, which facilitates cooperation between designers, the city administration and non-expert stakeholders. Decision making in urban design and planning is outdated. Currently, the process is carried out from top to bottom. The participation of citizens takes place only in the later stages and consists of public hearings. The peculiarity of «Urban Blok» is the ease of understanding its work and ease of use. This tool is an example of technology that adapts to the actions and needs of people, and not vice versa. This model will allow citizens to interact with the planners already in the early stages of conceptual design. Users can add and transfer modules, adjust the height and area of each element.

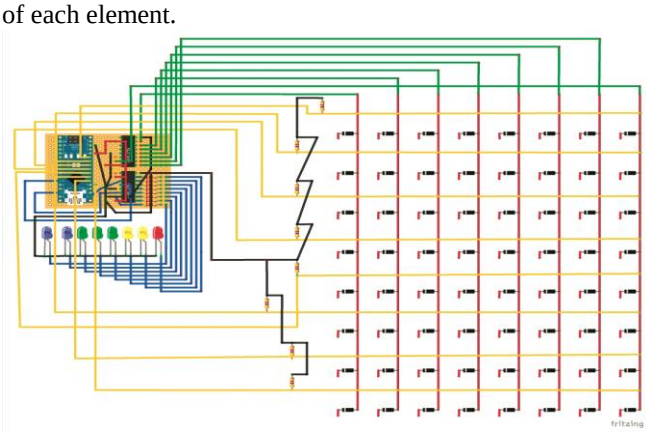

Fig.3. Circuit (fritzing)

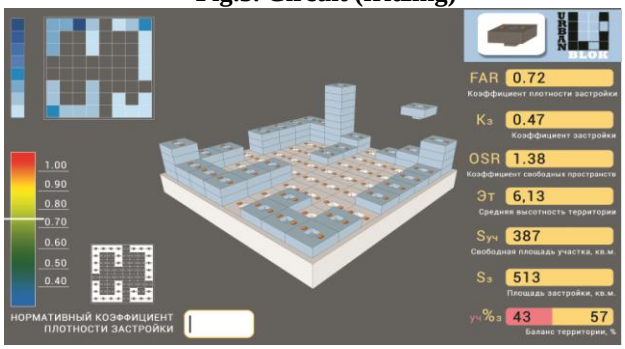

Fig.4. Control and Visualization Interface

Each user can easily create a sketch, regardless of the specialized education. This process allows planners and urban planners to easily communicate with citizens in a more understandable language.

In other words, an understanding of urban problems, opportunities and needs become more accessible to all. This provides a level of transparency; therefore,

The responsibility of planners to the citizens is much more than at the moment. In addition, the model can serve as a visualization tool of the finished project at the decision-making stage with the ability to make changes in real time. This feature distinguishes created tool from standard primitive layouts. The model will accelerate the process of finding compromises and decision making. Such visualization allows achieving the satisfaction of the needs of the city and using the potential of the designed territory.

Furthermore, the layout can be interpreted as a three-dimensional model, which clearly demonstrates the work of the smart city, where each object of urban morphology is connected to the general “Internet of things” system. In the system, all devices can connect and exchange information with each other via the Internet, as well as visualize immediate changes online. Devices collect and analyze big data, and if necessary, report and predict city services about possible threats. This process helps to shape the thinking of the population, which is ready to understand that there is a smart city, what processes it takes. This generates a willingness to participate and start a smart life in the city. We are interested in the fact that both children and adults can perceive the city as a habitat depending on them. «Urban Blok» is able to teach not only citizens but also to become a tool for teaching students in construction, urban planning and architectural universities.

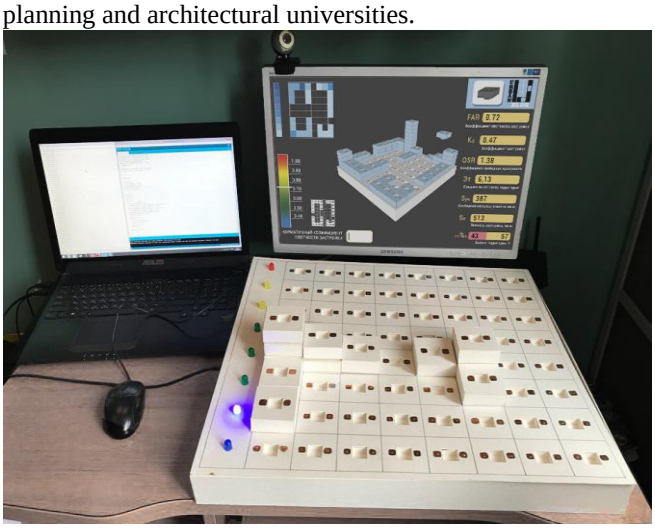

Fig.5. Model «Urban Blok»

The tool makes it easy to explain and show, what are the urban morphology and the relationship between the calculated indicators. A student learns to design in volume and perform calculations based on a software model.

VI. RESULTS

The universal smart tool for sketching and designing the morphological structure of the city "Urban Blok" was developed. With its help the designer can sketch on the site, with the ability to quickly introduce changes and immediately receive feedback with numbers and visualization of the project. The main functionality of the software is the calculation of such coefficients as a floor-area ratio, ground coverage, open space ratio, the average building height, balance of the territory.

The adapted interactive model allows citizens and planners to interact both at the early stage of the concept search and at the final decision-making stage. However, the Urban Blok tool allows interested parties, experts and simple users to quickly design a number of possible scenarios in real time. The model can be used not only as a tool for intelligent design but also as a tool for teaching students and citizens. This is an affordable way to explain the analysis, design, and evaluation of a city’s structure.

VII. CONCLUSION

The article presents a prototype model for design and calculation. In the future plans to refine the program based on GIS technologies and open data, using the projector to make the tool as versatile as possible to perform the necessary calculations on any complexity of the territory by configuration.

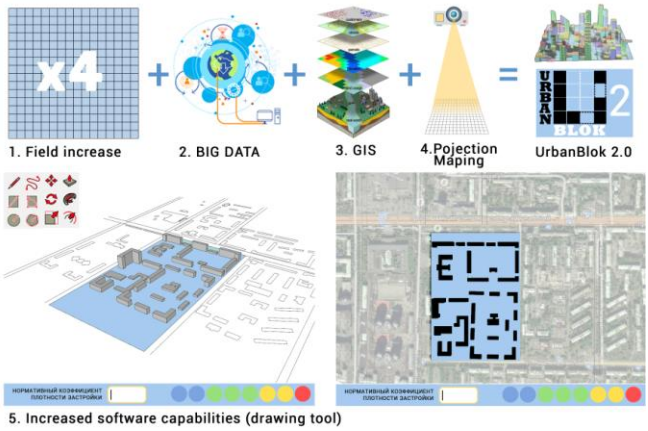

Fig.6. It is planned to Enhance Model

It is planned to enhance model with increased number of fields, adding GIS-technologies, using open data, utilizing projection mapping to make it as universal as possible to perform the necessary calculations for the territory configuration of any complexity.

To improve the model, there are 5 steps:

1. Increasing the number of cells, while reducing the size of the model itself. For this is necessary to search for new materials available.

2. Application of the possibility of using big data in the program.

3. Possibilities of big data visualization through GIS-technology. To implement the second and third steps, it is necessary to involve interdisciplinary specialists.

4. Adding to the tool an additional way to visualize data on a physical layout using projections mapping. This will allow:

- Bring a realistic look to the buildings, as well as the possibility of texturing

- Visualize various kinds of information on the layout, such as zoning, altitude, transport data, etc.

5. Adding to the tool the possibility of conceptual design inside the software (drawing tools). This feature will speed up the process of outline design, which takes into account the specified parameters. This also requires specialists in the field of IT-technologies

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