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AN APPLICATION FOR ESTIMATING THE DENSITY OF PUBLIC AND BUSINESS ZONES IN THE CITY

Abstract. One of the priority tasks for the development of the modern urban environment is the analysis of the placement densities of public and business spaces that have a significant impact on the social and economic dynamics of cities. Such spaces form the core of daily activity, determine urban planning priorities and influence the comfort of living. In the context of the continuous growth of cities, the increasing complexity of their spatial configuration and the increasing of information flows, the use of digital technologies for the systematic and operational assessment of such zones is becoming especially relevant. This article discusses the process of developing of a software tool designed for automated visualization and quantitative assessment of the object placement densities of public and business purposes. The OpenStreetMap service is used as a cartographic database, and the technical implementation is carried out using the Python programming language and a set of specialized libraries. The result of the work is an application that generates an interactive map, a table of objects, and graphical analytical visualization. The software product has been tested in five cities of the Volgograd region as an example. The presented data demonstrate the potential of using such solutions in the framework of urban analysis, urban planning and spatial management tasks. The work also highlights the importance of digital cartographic tools in expanding the capabilities of local government and analytics at the municipal level. Despite the availability of technological capabilities, many Russian cities are faced with restrictions in access to open and relevant spatial data, which creates additional difficulties in implementing such solutions and scaling projects to certain regions.

Key words: public and business spaces, urban environment, Python, OpenStreetMap, geoinformation systems, infrastructure analysis, building density, spatial planning.

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Introduction

The rapid growth of cities and active urbanization processes are forming a new level of requirements for spatial planning and analysis of the urban environment. Public and business spaces are key elements of urban infrastructure, that have a significant impact on the socio-economic development of the territory, transport accessibility, the level of business activity and the overall quality of life of the population. It's spatial organization is closely related to the daily activities of citizens and the nature of the use of urban territory. The increase in building density, the specialization of districts and the growth of mobility require a systematic approach to the study of the structure and saturation of the urban environment.

In the context of digitalization and the growth of spatial data volumes, there is an increasing need to create automated solutions capable of providing accurate and operational analysis of the location of objects for various purposes. One of the promising directions in this context is the use of geoinformation systems and open cartographic platforms such as OpenStreetMap, which allow integrating and processing spatial data without involving expensive commercial solutions. However, limitations remain in the Russian practice of spatial analysis: the lack of unified tools, fragmented information, and limited access to relevant data for research and management needs (Parygin, 2023).

This article presents an approach to the development of a software tool for visualizing and quantitative assessment of the density of public and business objects with reference to coordinates and urban infrastructure. The application is implemented in the Python programming language using specialized libraries that provide collect, filter, and display spatial information. The software product allows you to create interactive maps, plot density graphs, export tabular reports and provide data in a visual form. The results of the methodology approbation using the example of five cities in the Volgograd region demonstrate the possibilities of this approach for spatial planning, infrastructure analysis and support of management decisions in the field of urban development.

Public and business spaces in urban infrastructure: significance, challenges, and digital approaches

Modern cities are complex spatial structures, where public and business spaces become particularly important. These zones form the infrastructural and socioeconomic framework of an urbanized territory, combining key institutions and objects of daily and business activity. According to the Urban Planning Code of the Russian Federation No. 190-FZ of December 29, 2004 (as amended on December 26, 2024), such zones are intended to accommodate healthcare facilities, culture, trade, catering, social and communal services, business activities and other socially significant functions.

The role of public and business spaces is to ensure public access to basic services: education, medical care, administrative services, as well as to support business activity and economic growth. In accordance with the code of rules of CP 42.13330.2016 "Urban planning. Planning and building of urban and rural settlements" public and business zones are formed as a system of public centers of business, financial and social life, focused on serving the population and creating a comfortable urban environment.

Objects located in such zones include institutions and organizations that ensure the sustainable functioning of urban infrastructure. These facilities include administrative buildings that provide public utilities, banks, insurance companies, state and municipal governments, social assistance institutions, and consumer service companies. Besides, this list also consists educational and scientific institutions, shopping malls, markets, exhibition and fair grounds, as well as enterprises operating in the field of catering can be included in this category of objects.

With the rapid growth of cities and the increasing complexity of spatial structure, it becomes necessary to quickly identify, analyze and visualize public and business spaces. Traditional methods of urban planning analysis do not always allow to perform required speed and scale of information processing, what causes the growth of interest in using digital solutions and geoinformation systems in the researching and planning of urban infrastructure.

In recent years, digital tools have been actively developing and platforms intended to collect, analyze and visualize spatial data related to public and business areas. Among the Russian developments, modern geoanalytical services attract special attention: 2GIS Analytics, solutions developed in the Sber ecosystem, including location portrait, analytical modules for small businesses, and interactive assistants for choosing territories. Also, platforms developed by Tinkoff Business, Geointelligence and GeoCursor are actively used. These solutions allow to assess the potential of territories, identify the features of spatial structure, analyze building density and transport accessibility, as well as obtain other information necessary for a comprehensive analysis of the urban environment.

Among the foreign developments used for spatial analysis of the urban environment, Strava Global Heatmap, a platform for visualizing routes of daily activity of the population, deserves special attention. It allows you to assess the level of passability of territories, identify the intensity of use of individual sites and form an idea of the dynamics of movement in the urban environment.

The international initiative Earth Observation Toolkit for Sustainable Cities and Communities, which aims to promote the sustainable development of the urban environment, is of additional interest. The program focuses on monitoring the processes of urban expansion and seals, assessing the accessibility of public transport, as well as a comprehensive analysis of the distribution of public spaces within the city.

Despite the fact that these solutions are widespread, their usage for research purposes is subject to a number of limitations. Commercial orientation, lack of open access to data processing algorithms, limited customization flexibility and inability to integrate with local information sources often make it impossible to adapt them to specific territorial and analytical tasks, which determines the need to develop our own specialized software product, that capable of considering research goals, using open geodata and implementing original spatial analysis methods (Zelensky, Parygin, Savina, 2024).

Methodology and software implementation of spatial analysis

Analyzing the need for system control of the location of public and business areas and the need to improve the accuracy of urban infrastructure assessment, it becomes obvious, that there is the need to develop a specialized software product focused on the automated execution of spatial analysis. The modern urbanized environment is characterized by a high degree of spatial complexity, a multiplicity of objects with different functional purposes and pronounced territorial heterogeneity. Under these conditions, the use of traditional analysis methods is insufficient, since they do not provide the required information processing speed, adaptability to local features, and visual clarity. The starting point for developing our own software platform was the lack of flexibility and limited functionality of existing geoanalytical solutions, which do not allow to fully take into account the unique parameters of the studied territory.

The software implementation is based on an application created in Python. The choice of this platform is caused by its extensive capabilities for processing spatial and tabular data, a well-developed ecosystem of specialized libraries, and a high degree of customization. To download spatial data from open sources, the OSMnx library is used, which provides connection to the OpenStreetMap database and filtering of objects by specified coordinates and tags. The processing and presentation of the received data is implemented using GeoPandas, which allows spatial operations, filtering, aggregation and transformation of data within the framework of urban area analysis (Boeing, 2025). Visualization of the results is performed using Matplotlib and Folium, which allows the construction of both static density graphs and interactive maps with the ability to scale and interact.

The application structure is organized according to the modular principle, where each component is responsible for performing a certain stage of processing of user request. At the initial point of interaction, the user enters the parameters of the territory of interest to him — the city and the category of objects, that belongs to public and business zones. The main window has a graphical interface based on the PyQt5 library, which provides step-by-step data submission: first, enter the name of the locality, then select a category from the suggested list (Fig. 1). Next, the application accesses the CityLocator module, which performs geocoding of the entered city and returns its coordinates.

The system initiates accessing the TagManager module, which is functionally designed to determine a set of tags corresponding to a given category of objects after obtaining the coordinates of the central part of the city under study. At this stage, an intelligent selection of identifiers is being carried out, providing accurate identification of spatial entities based on OpenStreetMap data. An updated tag database is used as an information base, reflecting the most frequently used designations of institutions and elements of urban infrastructure. For example, when analyzing a healthcare area, the sample includes objects with hospital, clinic, and pharmacy attributes, and when examining the retail sector, items labeled as shop, supermarket, and convenience. This step is conceptually significant, since the completeness of the sample, the accuracy of spatial coverage and the reduction in the probability of including irrelevant data depend on the correctness of the generated set of tags (Tuvaleva, Samsonov, 2020).

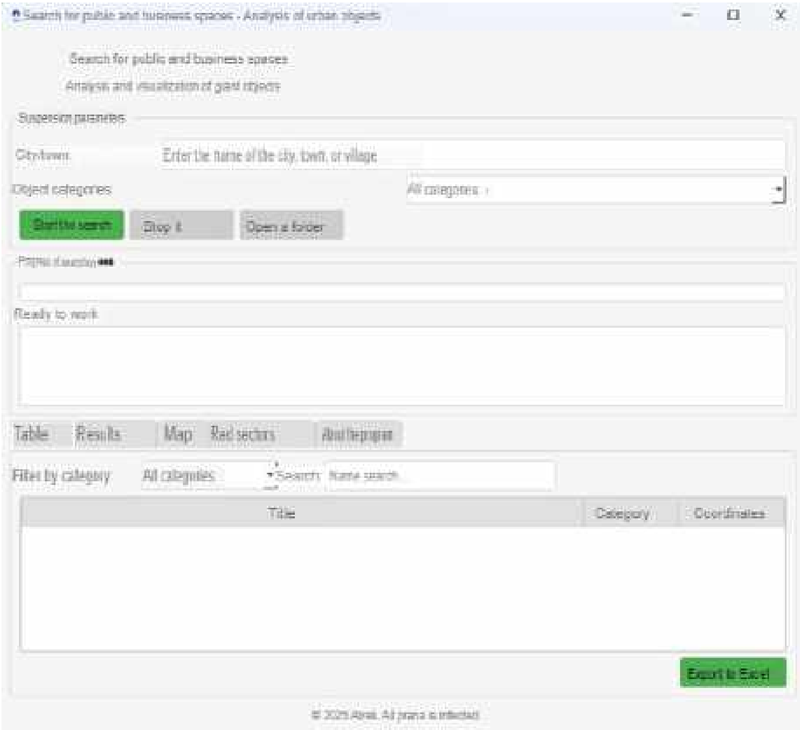

Fig. 1. The main application window

The OSMFetcher component is activated next, which generates a request to the OpenStreetMap database based on coordinates and prepared tags. The returned data is received in the GeoDataFrame format, which contains information about the object type, its spatial position, identifiers, and additional attributes. The information received is sent to the main analysis module, where the construction of a spatial grid and aggregation of the results begin. For a more accurate density estimation, a hexagonal grid is used (Burdziej, 2019). Each hexagon in this structure has a radius of 100 meters, which corresponds to a diameter of 200 meters. This configuration ensures optimal coverage of the territory, avoiding overlaps and maintaining a balance between detail and readability. The grid is formed using the library H3.py, which allows you to flexibly adapt the scale of the research to the characteristics of a particular city.

The results of the spatial analysis are transformed into a graphical representation. Using Matplotlib, heat density maps, distribution diagrams, and histograms are generated that reflect the degree of saturation of objects in individual areas. In addition, an interactive Folium-based map is being created, including all the found objects, their characteristics and coordinates. The user gets the opportunity to view the data in real time, navigate the map, examine the attributes of each object and visually assess the density and spatial structure of the identified zones (Fig. 2).

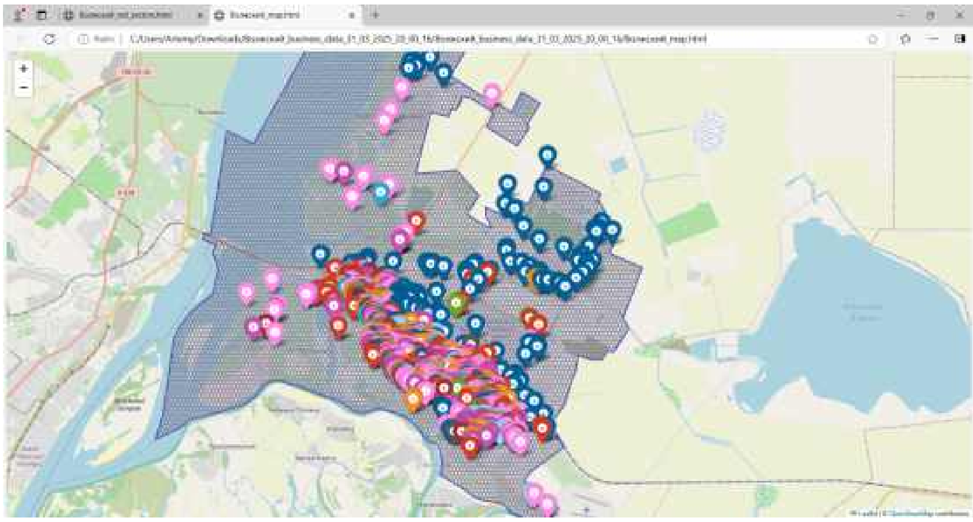

Fig. 2. Display of the created interactive map of zones and objects

Density visualization is implemented through a heat map using a color scale (Hu, Ghorbany, Yao, Wang, 2024). Cells where no objects of interest are found are displayed in white. Yellow indicates from one to seven objects, orange — from eight to fourteen, and red — fifteen or more (Fig. 3). Such color coding makes it possible to quickly identify areas with a high functional load and use the data obtained when making urban planning decisions.

In addition to the heat map, a histogram of the density distribution is formed. Using Matplotlib, a graph is created where the X-axis shows the number of objects in a cell, and the Y-axis shows the number of such cells. This graph makes it possible to assess the uniformity of the distribution of public and business facilities, to identify deviations and overload areas or, conversely, a lack of infrastructure.

An important part of the architecture is the DensityAnalyzer module, which is responsible for algorithms of estimating density, analyzing boundaries, and identifying local activity centers (Moradi, Roche, Mostafavi, 2025). Its implementation allows you to conduct not only a quantitative assessment, but also a qualitative analysis of spatial distribution, which is critical when planning urban infrastructure. The data received from this module then is sent to the MapGenerator block, where visual layers, legends, and symbols are formed. At the same time, the map is exported to HTML format, suitable for web publication and replication of research results (Parygin, Feklistov, Smirnova et al., 2025).

To ensure compatibility with other analytical systems, the function of exporting of received data to a tabular format has been implemented. The ExcelExporter module has built-in the ability to convert a GeoDataFrame into an Excel file that includes attributes of all detected objects, which facilitates the preparation of reporting materials, reanalysis, and integration with other platforms.

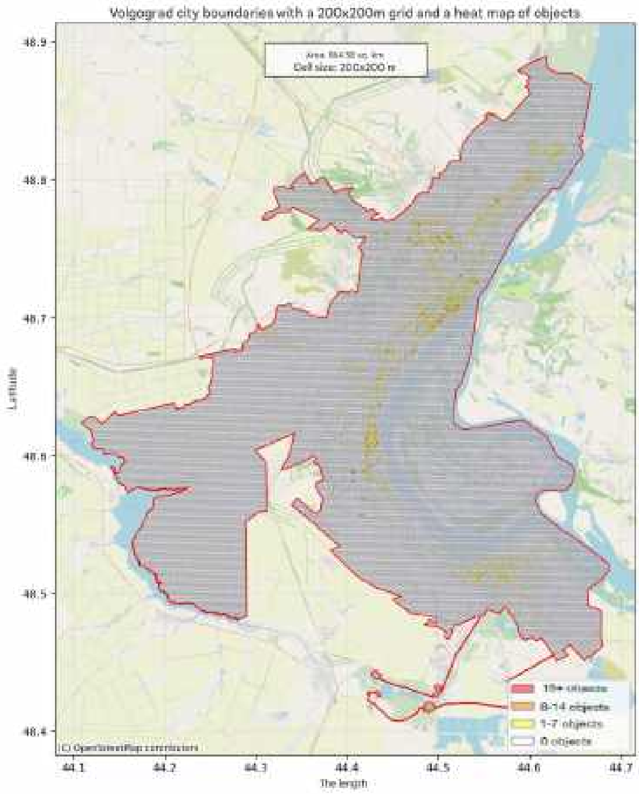

Fig. 3. Heat map

The architecture also provides the ErrorHandler module, which is responsible for catching and processing possible errors. It tracks the instability of the connection to the OSM database, the lack of coordinates for the entered city, incorrect data entry, or exceeding the time limit during processing. The user receives a notification about all failures with an explanation and a suggestion to repeat the operation. This approach makes the application resistant to external factors and increases its reliability when working in the field or with an unstable Internet connection.

The dialog interaction between the user and the program is fully implemented through the graphical interface. The program is designed in such a way as to minimize the number of actions on the part of the user. All queries are generated automatically, and the results are presented in a convenient way. For the convenience of work, a single-page structure is provided, in which all the functionality is available within a single window, which provides intuitive navigation, increases accessibility and reduces the entry threshold when using the application for the first time.

The functionality of the program was formed with a focus on maximum compliance with the tasks of spatial analysis of public and business zones. Based on preliminary tests, the categories of facilities were identified, which include administrative infrastructure, retail facilities, medical and educational institutions, banks, office centers and service organizations. A set of tags was compiled for each category, taking into account semantic differences and regional specifics, to ensure the accuracy and completeness of the sample. The list of supported tags can be expanded as needed, which makes the system flexible and extensible.

The modular organization of the application facilitates its development and maintenance. Each functional unit operates independently and can be updated or redesigned without interfering with the overall architecture. This structure allows you to connect additional modules, including machine learning algorithms for predictive analytics, time series aggregation modules, or seasonal dynamics assessment. This approach opens up prospects for scaling the project and its application in other areas of urban environment analysis (Barbierato, Curzel, Gatti, Gribaudo, 2025).

Approbation of the method on the example of the cities of the Volgograd region

The developed spatial analysis algorithm was tested using the example of five settlements in the Volgograd region, which differ in scale, structure, and level of functional saturation. Volgograd, Volzhsky, Kamyshin, Uryupinsk and Ilovlya were selected as testing sites. The population of the studied territories varies from ten thousand to more than one million people, which made it possible to evaluate the versatility of the method in conditions of different building densities and spatial configurations of the urban environment (Anokhin, Parygin, Rashevsky, 2024).

Volgograd, as the largest center of the region with a population of over one million people, demonstrated clearly defined areas of concentration of public and business facilities in the central part of the city, as well as near transport hubs. In Volzhsky, which has about three hundred and twenty thousand inhabitants, there was a distribution of business activity in several local centers, reflecting the polycentric structure of urban planning. In Kamyshin, where more than one hundred thousand people live, business facilities are concentrated along the main highways, forming linear zones of activity. In Uryupinsk and Ilovlya, with populations of approximately thirty-six thousand and ten and a half thousand people, respectively, compact and isolated zones with a predominance of trade facilities and basic administrative functions have been identified.

In each of the cities, the system performed an automated selection of objects by category, distributed them on a hexagonal grid and generated a heat map of the density. Additionally, distribution histograms were constructed, visualizing the prevailing types of social and business activity. The results of the testing confirmed the stable operation of the algorithm, its ability to adapt to various spatial scenarios and effectively identify the localization of functional centers within the urban area.

Prospects for further development and integration of modeling tools

The presented application has the potential for further scaling and functional expansion. In the near future, it is possible to integrate machine learning tools, which will allow not only analyzing the density of objects, but also predicting changes in the spatial structure of the urban environment, taking into account socio-economic trends, migration flows and building scenarios. The development of appropriate modules based on learning models will create the conditions for the formation of an intelligent support system for urban planning solutions (Shcherbakov, Sadovnikova, Parygin et al., 2025).

Special attention is planned to be paid to integration with municipal geoinformation platforms, which will help to automate real-time analysis and integrate the developed tool into urban planning practice. In the future, the application may be supplemented with modules for assessing transport accessibility, analyzing walking routes, taking into account the time dynamics of activity, as well as scenario modeling tools for comparative assessment of various options for the development of the territory (Savina, Larin, Zelensky et al., 2024). This approach will ensure the transition from static analysis to flexible and adaptive modeling of urban infrastructure (Zelensky, Parygin, Savina et al., 2020).

Research results and discussion

The conducted testing of the software product using the example of five cities in the Volgograd region allowed us to obtain meaningful results confirming the efficiency and applicability of the developed tool for analyzing urban infrastructure. Each of the selected localities has a unique spatial configuration, urban planning characteristics, and saturation level with public and business facilities, which made it possible to evaluate the sustainability and versatility of algorithms for various input parameters and allowed us to identify a number of patterns in the distribution of infrastructure elements.

The generated heat maps revealed significant differences in the density and spatial localization of objects, which is especially important for understanding the structure of urban space. In large cities such as Volgograd and Volzhsky, there is a steady concentration of facilities in historical and business centers with a gradual decrease in density as they move away from the core. This concentration may indicate the need to develop secondary activity centers on the periphery in order to evenly distribute functional loads (Shcherbina, Kuznetsov, 2024). In more compact municipalities such as Kamyshin, Uryupinsk, and Ilovlya, visualization showed a point-based placement structure where individual clusters of public and business facilities are concentrated near administrative buildings or central streets.

The program effectively adapted to the conditions of each city and demonstrated stable operation regardless of the number of objects found. The interactive map, built on the basis of OpenStreetMap data, provided a high level of visualization, allowing the user to explore each object, its location and connections with neighboring zones. The ability to zoom in, navigate the map, and display attributes has made the analysis process clear and accessible even to users without specialized training. The flexibility of the application highlights the versatility and practical importance of the developed tool in spatial planning tasks.

The obtained histograms of the distribution made it possible to identify the prevailing density ranges and identify areas with abnormal values. In some cases, excessive concentration was observed in narrow areas, which may indicate an overloaded infrastructure and the need to adjust urban planning policies. In other cases, on the contrary, areas with low density of accommodation with a high population were found, which indicates a shortage of infrastructure facilities and the need for their strategic location. Thus, the program not only captures the current state of affairs, but also allows you to identify potential stress points in the urban environment.

An important result of the approbation was the verification of the scalability of the system and its ability to process various amounts of input data. The program has shown high stability when working with several dozen objects, as well as when analyzing dense urbanized territories with hundreds of spatial units. The accuracy of the filtering and tagging modules deserves special attention. The results obtained indicate that the selected semantic groups correctly reflect the belonging of objects to the specified categories, and the set of tags covers the main types of institutions that are part of public and business zones.

General testing of the entire program was carried out on the "Software and hardware complex for artificial intelligence" deployed at the Department of Digital Technologies in Urban Studies, Architecture and Civil Engineering at Volgograd State Technical University as part of the implementation of the state scientific grant of the Volgograd Region for the project "Development of intelligent network technologies for surveying the urban environment quality in the context of meeting the social needs of the urban population of the Volgograd Region" (Agreement No. 10 dated December 14, 2022).

Conclusion

The conducted research has demonstrated the importance of digital tools in solving the problems of spatial analysis of public and business zones. In the context of increasing urbanization and the complexity of the urban structure, the need for rapid identification, visualization and interpretation of spatial characteristics affecting the quality of the urban environment is becoming especially relevant. The developed software product has proven its efficiency both in terms of collecting and processing spatial data, as well as in providing visual clarity and ease of analysis.

The modular architecture of the application, the use of open geodata sources, and a focus on flexible parameter settings make the system versatile and scalable. The program was successfully tested using the example of five cities in the Volgograd region, where heterogeneity in the distribution of public and business facilities was identified and meaningful visual models were obtained to justify urban planning decisions. The use of geoinformation methods in combination with a visually interactive analysis environment opens up prospects for integrating such solutions into the practice of spatial planning.

The developed tool can be used both in scientific research and in tasks related to monitoring urban infrastructure, assessing territorial development and developing strategies for the spatial distribution of services. The results obtained confirm the expediency of further improving digital approaches and expanding the functionality of software platforms that provide a comprehensive analysis of the urban environment at different levels of government.

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REFERENCES

Anokhin A. O., Parygin D. S., Rashevsky N. M. (2024) Application of intelligent analysis in the problems of assessing the distribution of residents in the city. *Sbornik nauchnykh trudov XIV Vserossiyskogo soveshchaniya po problemam upravleniya (VSPU-2024), Moskva, 17—20 iyunya 2024 g.* [Collection of scientific papers of the XIV All-Russian Conference on Management Problems (VSPU-2024), Moscow, June 17—20, 2024], pp. 1213—1217 (in Russian).

Barbierato E., Curzel S., Gatti A., Gribaudo M. (2025) Urban Science Meets Cyber Risk: Quantifying Smart City Downtime with CTMC and H3 Geospatial Data. *Urban Science*, vol. 9, no. 9, art. no. 380.

Boeing G. (2025) Modeling and Analyzing Urban Networks and Amenities with OSMnx. *Geographical Analysis*, vol. 57, no. 4, pp. 567—577.

Burdziej J. (2019) Using Hexagonal Grids and Network Analysis for Spatial Accessibility Assessment in Urban Environments — A Case Study of Public Amenities in Toruń. *Miscellanea Geographica: Regional Studies on Development*, vol. 23, no. 2, pp. 99—110.

Hu M., Ghorbany S., Yao S., Wang C. (2024) Micro-Urban Heatmapping: A Multi-Modal and Multi-Temporal Data Collection Framework. *Buildings*, vol. 14, no. 9, art. no. 2751.

Moradi M., Roche S., Mostafavi M. A. (2025) A Novel GIS-based Polygon Shape Similarity Measure Applied to OSM Building Footprints. *Advances in Cartography and GIScience of the International Cartographic Association (ICA)*, vol. 5, art. no. 22.

Parygin D. S. (2023) Decision support based on spatially referenced data in urban development management problems. *Matematicheskiye metody v tekhnologiyakh i tekhnike* [Mathematical methods in technology and engineering], no. 10, pp. 109—116 (in Russian).

Parygin D. S., Feklistov V. A., Smirnova T. V. et al. (2025) Interactive digital exhibition of territory objects in virtual reality. *Sotsiologiya Goroda* [Urban Sociology], no. 2, pp. 84—97 (in Russian). DOI: 10.35211/19943520_2025_2_84

Savina O. V., Larin V. V., Zelenskiy I. S. et al. (2024) Scenario forecasting in planning the restoration of urban environment objects. *Sotsiologiya Goroda* [Urban Sociology], no. 4, pp. 81—89 (in Russian). DOI: 10.35211/19943520_2024_4_81.

Shcherbakov A. G., Sadovnikova N. P., Parygin D. S. rt al. (2025) Intelligent support for the analysis of urban planning projects based on ontology. *Ontologiya proyektirovaniya* [Ontology of design], vol. 15, no. 3, pp. 436—448 (in Russian).

Shcherbina E. V., Kuznetsov I. V. (2024) Analysis of building density in the territories of large cities of the Volga region using GIS. *Gradostroitel'stvo i arkhitektura* [Urban development and architecture], vol. 14, no. 2, pp. 143—150 (in Russian).

Tuvaleva Y. V., Samsonov T. E. (2020) Development of an interactive geographic information system for analyzing the location of urban service facilities using OpenStreetMap data. *Nauchnyye issledovaniya molodykh uchenykh-kartografov, vypolnennyye pod rukovodstvom sotrudnikov kafedry kartografii i geoinformatiki geograficheskogo fakul'teta MGU imeni M.V. Lomonosova* [Scientific research by young cartographers, carried out under the supervision of staff from the Department of Cartography and Geoinformatics of the Faculty of Geography of Lomonosov Moscow State University]. Moscow. Pp. 80—89 (in Russian).

Zelensky I. S., Parygin D. S., Savina O. V. (2024) Features of designing recommender systems for integrated development of urban areas. *Sbornik nauchnykh trudov XIV Vserossiyskogo soveshchaniya po problemam upravleniya (VSPU-2024), Moskva, 17—20 iyunya 2024 g.* [Collection of scientific papers of the XIV All-Russian Conference on Management Problems (VSPU-2024), Moscow, June 17—20, 2024], pp. 2641—2645 (in Russian).

Zelensky I. S., Parygin D. S., Savina O. V. et al. (2020) Intelligent support for decisions on the use of real estate for the management of urbanized areas. *International Journal of Open Information Technologies*, vol. 8, no. 11, pp. 13—29 (in Russian).

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ПРИЛОЖЕНИЕ ДЛЯ ОЦЕНКИ ПЛОТНОСТИ РАЗМЕЩЕНИЯ ОБЩЕСТВЕННО-ДЕЛОВЫХ ЗОН НА ТЕРРИТОРИИ ГОРОДА

Одной из приоритетных задач развития современной городской среды является анализ плотности размещения общественно-деловых пространств, оказывающих существенное влияние на социальную и экономическую динамику городов. Такие пространства формируют ядро повседневной активности, определяют градостроительные приоритеты и влияют на комфорт проживания. В условиях непрерывного роста городов, усложнения их пространственной конфигурации и увеличения информационных потоков особенно актуальным становится использование цифровых технологий для системной и оперативной оценки подобных зон. В данной статье рассматривается процесс разработки программного инструмента, предназначенного для автоматизированной визуализации и количественной оценки плотности размещения объектов общественно-делового назначения. В качестве картографической базы используется сервис OpenStreetMap, а техническая реализация осуществлена с применением языка программирования Python и набора специализированных библиотек. Результатом работы является приложение, генерирующее интерактивную карту, таблицу объектов и графическую аналитическую визуализацию. Разработка протестирована на примере пяти городов Волгоградской области. Представленные данные демонстрируют потенциал использования таких решений в рамках задач городского анализа, градостроительного планирования и пространственного управления. Работа также подчеркивает значимость цифровых картографических инструментов в расширении возможностей локального самоуправления и аналитики на уровне муниципалитетов. Несмотря на наличие технологических возможностей, многие города России сталкиваются с ограничениями в доступе к открытым и актуальным пространственным данным, что создает дополнительные трудности при внедрении подобных решений и масштабировании проектов на некоторые регионы.

Ключевые слова: общественно-деловые пространства, городская среда, Python, OpenStreetMap, геоинформационные системы, инфраструктурный анализ, плотность застройки, пространственное планирование.

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БИБЛИОГРАФИЧЕСКИЙ СПИСОК

Анохин А. О., Парыгин Д. С., Рашевский Н. М. Применение интеллектуального анализа в задачах оценки распределения жителей в городе // Сборник научных трудов XIV Всероссийского совещания по проблемам управления (ВСПУ-2024), Москва, 17—20 июня 2024 г. 2024. С. 1213—1217.

Зеленский И. С., Парыгин Д. С., Савина О. В. Особенности проектирования рекомендательных систем комплексного развития городских территорий // Сборник научных трудов XIV Всероссийского совещания по проблемам управления (ВСПУ-2024), Москва, 17—20 июня 2024 г. 2024. С. 2641—2645.

Зеленский И. С., Парыгин Д. С., Савина О. В. и др. Интеллектуальная поддержка решений по использованию объектов недвижимости для управления урбанизированными территориями // International Journal of Open Information Technologies. 2020. Т. 8. № 11. С. 13—29.

Парыгин Д. С. Поддержка принятия решений на основе данных с пространственной привязкой в задачах управления развитием урбанизированных территорий // Математические методы в технологиях и технике. 2023. № 10. С. 109—116.

Парыгин Д. С., Феклистов В. А., Смирнова Т. В. и др. Интерактивная цифровая экспозиция объектов территории в виртуальной реальности // Социология города. 2025. № 2. С. 84—97.

Савина О. В., Ларин В. В., Зеленский И. С. и др. Сценарное прогнозирование в планировании реставрации объектов городской среды // Социология города. 2024. № 4. С. 81—89.

Тувалева Ю. В., Самсонов Т. Е. Разработка интерактивной геоинформационной системы для анализа размещения объектов городской сферы услуг по данным OpenStreetMap // Научные исследования молодых ученых-картографов, выполненные под руководством сотрудников кафедры картографии и геоинформатики географического факультета МГУ имени М.В. Ломоносова. М., 2020. С. 80—89.

Щербаков А. Г., Садовникова Н. П., Парыгин Д. С. и др. Интеллектуальная поддержка анализа градостроительных проектов на основе онтологии // Онтология проектирования. 2025. Т. 15. № 3 (57). С. 436—448.

Щербина Е. В., Кузнецов И. В. Анализ плотности застройки на территориях крупных городов Поволжья с применением ГИС // Градостроительство и архитектура. 2024. Т. 14. № 2. С. 143—150.

Barbierato E., Curzel S., Gatti A., Gribaudo M. Urban Science Meets Cyber Risk: Quantifying Smart City Downtime with CTMC and H3 Geospatial Data // Urban Science. 2025. Vol. 9. No. 9. Art. no. 380.

Boeing G. Modeling and Analyzing Urban Networks and Amenities with OSMnx // Geographical Analysis. 2025. Vol. 57. No. 4. Pp. 567—577.

Burdziej J. Using Hexagonal Grids and Network Analysis for Spatial Accessibility Assessment in Urban Environments — A Case Study of Public Amenities in Toruń // Miscellanea Geographica: Regional Studies on Development. 2019. Vol. 23. No. 2. Pp. 99—110.

Hu M., Ghorbany S., Yao S., Wang C. Micro-Urban Heatmapping: A Multi-Modal and Multi-Temporal Data Collection Framework // Buildings. 2024. Vol. 14. No. 9. Art. no. 2751.

Moradi M., Roche S., Mostafavi M. A. A Novel GIS-based Polygon Shape Similarity Measure Applied to OSM Building Footprints // Advances in Cartography and GIScience of the International Cartographic Association (ICA). 2025. Vol. 5. Art. no. 22.

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