UDC 6656.132:621.311:656.07
DOI: 10.15587/2706-5448.2026.353063

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DEVELOPMENT OF UNIVERSAL MODEL FOR OPTIMIZING PARKING SPACES IN COMPLEX GEOMETRIC CONFIGURATIONS

The object of research is the process of designing and optimizing parking areas in complex geometric configurations in conditions of dense development.

The main problem is to solve the use of areas of complex geometric configuration for parking areas. In addition, there are currently no universal models and methods for the corresponding calculation and optimization.

The result of the work was the receipt of a universal mathematical model with which it is possible to determine the number of parking spaces based on the geometric dimensions and area of the plot. A special feature is the possibility of calculating for complex geometric configurations (polygons). For this, the Gauss formula and the JavaScript programming language are used. The initial data are geodetic measurements, and the error in such a calculation is less than 2%.

The development of JavaScript code based on the shoelace formula was practical importance. The experimental object was the residential area "Vyshenka" in Vinnytsia (Ukraine). The selected plot has an area of 1350 m^2 *with an initial number of parking spaces before optimization –50, after –59. In general, the efficiency of using the area increased from 70% to 88%. In addition, a 22% reduction in accidents is noted, which indicates the significant effectiveness of the model and minimal calculation error.*

A feature of the proposed solution is also that not only linear dimensions are taken into account, but also the relief, infrastructure facilities and the initial shape of the site. There is also the possibility of integration into web applications and CAD programs for simultaneous planning and construction, which allows for an increase in the number of parking spaces of up to 20% without expanding the territories.

The results of the modeling can be used by engineers and builders to improve the landscaping of residential areas where there is no possibility for expanding the territories, programmers – by integrating the model into web applications and business.

Keywords: *Shoelace formula, polygon area, computational geometry, capacity increase, efficiency coefficient, urban parking.*

Received: 04.11.2025
Received in revised form: 09.02.2026
Accepted: 25.02.2026
Published: 28.02.2026

How to cite

Mytko, M., Burlaka, S., Antoniuk, O., Bondar, A., Datsiuk, D. (2026). Development of universal model for optimizing parking spaces in complex geometric configurations. Technology Audit and Production Reserves, 1 ((87)), 38–43. https://doi.org/10.15587/2706-5448.2026.353063

1. Introduction

Driving traffic dominates the territory of Ukraine today, as it is key to meeting the demand of the population and industry for the movement of people and goods by car. Given the ongoing hostilities (That War) in our country, the lion's share of logistics operations, covering not only the delivery of goods, but also any other need for movement, is entrusted to motor vehicles.

The vehicle fleet is differentiated into categories: the first category includes passenger transport, which includes cars for private use and buses, and the second is freight transport, which includes trucks.

Private passenger cars are mainly owned by ordinary Ukrainians and serve primarily for their personal needs. Along with this, they can be an asset of commercial enterprises, government institutions and various structures. As a rule, private passenger cars are used to meet the individual needs of Ukrainian citizens.

Based on available statistics [1], in the period from the end of 2021 to the beginning of 2022 [2], no less than nine million private cars were registered within the country. This clearly illustrates the urgency of the issue of providing parking spaces and long-term storage of cars within the settlements of Ukraine. Thus, an extremely important question arises about where exactly these vehicles can be left in various urban centers, regardless of their scale.

In view of the above, there is an increasing need both to study existing parking lots and to rethink and adapt parking spaces in already functioning areas. In addition, global practices and methods of organizing parking spaces were studied and analyzed.

In [3], the efficiency of the parking system is analyzed using the example of the Jadwiżyn residential quarter in Pila, considering it from the perspective of sustainable development. The aforementioned study included a subjective assessment of the use of the parking lot, which was used for seven consecutive days, recording data in three time intervals of the day (morning, afternoon and evening) during the months of December and January. The results revealed that the existing parking scheme does not satisfy the complex of residents, because it did not take into account the principles of sustainable spatial planning. Therefore, there is a need to adjust the rules of ownership of parking spaces, for example, through the introduction of innovative parking solutions using automation or the creation of multi-storey parking lots to increase the total number of spaces. The paper [4] also considers the efficiency of the parking system in the context of sustainable development, with an emphasis on the environmental performance of diesel generators running on blended biofuels, which may be related to the energy supply of parking complexes. According to [5], the parking problem is an integral part of the large number of vehicles, which is directly reflected in the methods of their placement. Scientists note that various experts [6] have achieved significant success in overcoming parking difficulties, in particular, through the introduction of mobile technologies to simplify and optimize this process. The aim of this work is to study user perception using the unified theory of acceptance and use of technologies (UTAUT), the analysis of which is carried out using the structural level modeling apparatus (SEM-PLS) based on data collected from 221 respondents. The results obtained demonstrate that the extent to which users expect benefits, how long they consider the efforts to be justified, as well as social influence factors, have a significant impact on the intention to perform a certain action. Moreover, the conditions that facilitate use and the intention of users significantly shape their actual behavior when using "smart" parking systems. It is also expected that this study will provide a basis for government agencies to identify key aspects affecting the parking system. At the same time, publications [7] raise the issue of traffic safety caused by parallel parking on city streets. These materials briefly describe the principles of vehicle parking regulation within the Czech Republic. The authors [8] present data on the analysis of the behavior of road users in a selected urban area, obtained through video surveillance of conflict situations. The research highlights the potential value of this technique, for example, for conducting road safety inspections. The scientific work [9] analyzes how the speed of ordinary vehicles changes in areas where parking is allowed. For this purpose, indicators were collected from both areas without any impact of parking and those where it is present [10]. The speed of movement on sections free from parking varied from 39.28 to 51.47 kilometers per hour, while on streets with parked cars it dropped significantly – by 39.09% to 81.30% [11]. Subsequently, this slowdown dynamics was described mathematically, taking into account the key factors of parking identified within the framework of this work. The conclusions obtained provide useful information that can be quite realistically used in the formation of regulatory acts on the organization of parking spaces on city streets.

The cited sources do not pay enough attention to universal mathematical models for calculating the area and number of spaces in areas of non-standard shape (polygons, trapezoids, etc.), especially with the integration of geodetic data and software implementation for web applications. These aspects are considered in this article.

The object of research is the process of calculating the area and capacity of parking areas of complex geometric configuration in conditions of shortage of urban areas in Ukraine.

Therefore, *the aim of this research* is to develop a model designed to calculate the area of parking lots and the required parking spaces in areas with a complex configuration. This allows for more efficient parking of cars in conditions of space shortage in Ukrainian cities, improving the use of land resources and ensuring the use of accurate mathematical approaches for modeling any shapes, from the simplest (rectangular) to polygonal ones.

To successfully implement this aim, the following steps must be taken:

– conduct a substantiated analysis of the current situation with parking space planning in Ukraine, taking into account both the increase in the car fleet and the spatial limitations of urban development, as well as study best international practices in this area;

– it is necessary to lay a mathematical foundation for a model for calculating the areas of geometric shapes (in particular, rectangles and polygons) using the polygon area formula, known as the Shoelace formula;

– it is necessary to organize a modular structure of JavaScript code designed to calculate the area of one parking unit, taking into account the available gaps, as well as to determine the total capacity of the parking lot in a certain area;

– to test the developed model on the example of actual parking located in the Vinnytsia residential area "Vyshenka", in order to determine how effective the optimization of marking and direction of traffic flows is;

– to formulate a list of practical tips for integrating this model into web applications aimed at designers, architects and businessmen, while providing for the potential for further expansion of the system's capabilities to take into account terrain slopes and existing infrastructure facilities.

2. Materials and Methods

The focus of this research is on the aspects of modeling and performing calculations to determine the area and the required number of parking spaces in spatial configurations of parking lots with complex shapes. This involves taking into account various geometric shapes, such as rectangles and polygons, with the simultaneous use of mathematical tools (in particular, the Gauss formula for determining the area of a polygon, known as the "lace method") within a single JavaScript model. The goal is to improve parking planning processes, which is relevant for urban development in Ukraine.

The research aimed to find out whether the parking spaces in "Vyshenka", a residential district of Vinnytsia, are rationally, safely and effectively built. This object was chosen as a typical example for studying similar situations in the suburbs of Ukraine. The mentioned parking lot has been operating for more than twenty years, has narrow boundaries, is built into a residential area with a single access road and has no potential for territorial expansion. In order to achieve optimization without the need to change the contours of land plots, it was decided to adjust the traffic vectors at the entry and exit points using appropriate spatial modeling tools [12]. This work was based on generally accepted geodetic and computational approaches adapted specifically for urban conditions, and included three main stages, which ensured a smooth transition from the accumulation of primary data to the development of final recommendations. The first stage was the initial collection of information through a survey of the territory allocated for parking. In particular, an electronic total station (total station, Leica or equivalent, Switzerland/Germany) and a tape measure were used. At the same time, the number of free parking spaces was recorded, as well as their functional purpose – whether they were intended for private cars or for company transport. The current condition of these spaces was separately assessed, in particular the quality of the road surface, the presence of markings and lighting devices at the station. The information collected in this way formed the basis for creating an initial plan of the area, which is accurately transmitted for further detailed calculations.

Moving on to the second stage of work, it is possible to perform geodetic surveys to obtain high-precision coordinate data. For this purpose, mainly total station systems and GPS equipment were used, which allowed to achieve measurements with an accuracy of up to a millimeter. In addition, height marks were recorded for the purpose of future analysis of the morphology of the studied area; in parallel, a list of existing objects (buildings, vegetation) and elements of arrangement (entrances/exits, sidewalks) was compiled and entered into the catalog [13]. The totality of these collected data not only clarified the configuration of the parking area, but also revealed additional threats caused by the relief of the site, which became a key point in modeling traffic flows. The next, third stage, focused on creating an initial project for the modernization of the parking complex, based on the information received. This project included detailed site planning and vehicle traffic flow mapping, as well as identifying areas that needed priority attention for improvement, such as enhancing lighting or implementing pedestrian protection measures. At this stage, the system's performance was assessed: the current capacity was studied to identify peak times and areas with unused capacity reserves, paying attention to accessibility and ease of maneuvering for both transport and pedestrians.

Based on these findings, a project plan was prepared with all options. It included increasing the parking area, adjusting it to the dimensions of vehicles and the current needs of those using the services. It also envisaged optimizing traffic flows to reduce road capacity (in particular, introducing one–way traffic on the most problematic areas) and allocating separate areas for people with disabilities and their cars.

3. Results and Discussion

3.1. Current status of parking space planning in Ukraine

The research showed an acute shortage of places due to the growth of the car fleet (over 9 million cars at the beginning of 2022, growth forecast of 7–10% per year) and the limitation of urban space. In Vinnytsia, demand exceeds supply by 30–40%. Analysis of foreign practical successes of automated solutions (UTAUT model) and regulation of street parking (speed reduction by 39–81%). This became the basis for adaptation to Ukrainian conditions.

Known methods (DBN V.2.3-15:2007, approximate rectangular placement) give an error of 10–20% in the relevant areas and reduce the number of places by 12–18% compared to the proposed model. The corresponding MILP/genetic algorithms algorithm allows to get an increase of +20–30% for existing simple shapes, but they are quite demanding and require large computing resources. In addition, they are not always adapted to web integration. The software used (ParkCAD, AutoTURN) provides the necessary accuracy, but is expensive and does not adapt to a variable geometric shape.

The solution is to create a program to improve the design of parking lots in complex areas. This program allows to effectively use additional space in uneven zoning contours without significant costs for redevelopment. In the process of developing this system, various methodologies were applied, including expanding the operation area to cover oval, polygonal and other variations of configurations, as well as taking into account standard vehicle dimensions and maneuverability [14]. Thanks to this program, it is possible to accurately and consistently calculate the maximum capacity of parking areas. This is especially important in urban conditions where there is a shortage of land and it is necessary to use the available area as efficiently as possible.

3.2. Mathematical basis of the area calculation model

Initial results of the analysis of the modeling requirements performed at the start of this research. It turned out that the geometry of parking cells changes from simple rectangular contours to more complex trapezoidal or polygonal ones – this is due to the peculiarities of the architectural landscape of urban areas [15]. The accepted typical dimensions of parking areas, provided for by the type of transport unit (for example, 2.5 m by 5 m for a conventional passenger car), were supplemented by a set of correction factors that provide sufficient space for maneuvering (minimum 3 meters), which significantly brought the developed model closer to practical application. Planning requirements, such as the minimum interval between parked cars (0.5 m) and the mandatory setting of sidewalks for pedestrians (minimum 1.2 m), were integrated as rigid limits that must be observed to prevent zone conflict and ensure an adequate level of safety. Based on these principles, tables with numerical dependencies were created. The generally accepted indicators agreed well with the real results: for a square plot of 500 m^2, the system designed 80 places (efficiency factor – 85%), and for a plot with an uneven polygonal perimeter – 72 places (utilization factor – 78%). This clearly shows the influence of the shape of the plot on the final result.

The area of rectangular objects “A” was determined by the well-known formula “A = length × width”, this made it possible to quickly expand the number of parking spaces

$$A_{rectangle} = L \times W, \quad (1)$$

where L – the rectangle length; W – the rectangle; width.

The area A of a polygon with n vertices can be calculated using the Shoelace formula. Given vertices (x_i, y_i) for i = 1,2, ..., n, the formula is

$$A_{\text{polygon}} = \frac{1}{2} \cdot \left[\Sigma_{i=1}^{n} \cdot \left(xi \cdot yi+1 - xi+1 \cdot yi \right) \right], \quad (2)$$

where (x_{n+1}, y_{n+1}) is the same as (x_1, y_1) to close the polygon.

The area A_{spase} of a single parking space is calculated as

$$A_{space} = L_{space} \times W_{space}, \quad (3)$$

where L_{space} – the parking space length; W_{space} – the parking space width.

The total area $A_{total\ spase}$ required per parking space, including aisles, is given by

$$A_{total\_spase} = A_{space} + \left(2 \times W_{aisle} \times L_{space} \right) + \left(W_{aisle} \times W_{space} \right), \quad (4)$$

where W_{aisle} – the aisle width.

The number of parking space N that can fit into the available area $A_{available}$ is calculated by

$$N = \left[A_{available} / A_{total\_spase} \right], \quad (5)$$

where $A_{available}$ – the total area of the parking lot (either rectangle or polygon); A_{total_space} – the total area required for one parking space including aisles.

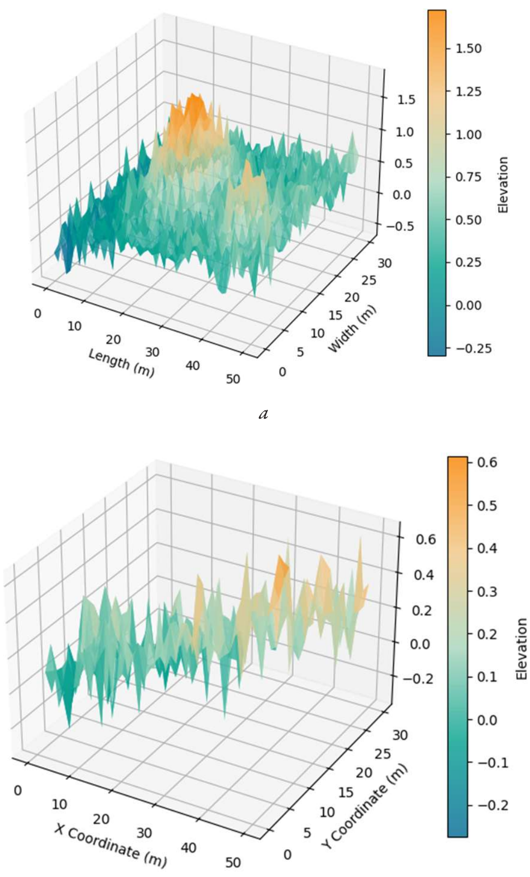
Within the framework of the research of model development and calculation of parking area, as well as determining the required number of spaces in areas with a complex plan, three-dimensional surface models are used.

They are the main tool for visual visualization and analysis of data obtained during topographic surveys and helps to rationally use space. These graphic images are based on generally accepted geodetic and calculation approaches that are adapted to the conditions of urban development in Ukraine, in particular, regarding the arrangement of parking areas within the residential area “Vyshenka” in Vinnytsia. Three-dimensional models allow not only to show the relief of the site, but also to assess how slopes affect the practicality, safety and efficiency of using the territory. This is especially important for limited areas, the area of which cannot be increased.

3.3. Modular structure of JavaScript code

The modeling process was carried out in the Python programming environment using the NumPy and Matplotlib packages, where the location coordinates (X and Y axes) reproduce real data obtained using a total station and GPS equipment with high accuracy, reaching centimeters. The surfaces themselves are formed as a functional dependence on elevation marks (Z axis) or on efficiency indicators, taking into account the presence of interfering objects (structures, trees) and areas requiring optimization (one-way traffic directions, specialized places) (Fig. 1). A special color palette (shades from blue-green to yellow-orange) was used, which visualizes the transition from a zone of low or low efficiency to a zone with a high level of optimization, which provides easy understanding for professional study. Each such visual material will have a detailed explanation in the subsequent sections of the use of the selected research methodology.

The first three-dimensional spatial model shows the characteristic relief of the Vyshenka parking lot. It is made in the shape of a rectangle measuring 50 m by 30 m and accurately reproduces the terrain based on geodetic measurements obtained during the second stage of work. The basis of this model is the need to study in detail the absolute elevation indicators in order to identify any dangers caused by terrain slopes and the presence of obstacles that may affect the simulation of vehicle traffic.



a

b

Fig. 1. Vyshenka parking lot topography: *a* – rectangular configuration with relief analysis; *b* – polygonal configuration using the shoelace formula for area calculation

The 3D terrain model not only shows the contours of the site, but also serves as a basis for making design decisions.

The highest areas (marked in yellow and orange) indicate potential problems with traffic and congestion, while the low areas (blue and green) are the best for placing cars. As a result, it allows for a clear assessment of safety (e. g. risk of loss of traction on slopes of more than 5%) and functionality (e. g. loading less than 10% on uneven areas) in accordance with the requirements of the master plan development phase.

Moving to another layer, which represents a polygonal parking lot layout with the implementation of the "Lace" principle, the layout demonstrates the intricate geometry inherent in areas built into single–access apartment complexes. The rationale comes from the first phase – preliminary information collection, where spatial characteristics (length, width, area) were recorded using surveying instruments (total station) together with a regular tape measure, and the corner points of the polygon (e. g. [[0,0], [45,0], [50,10], [40,30], [10,30], [0,25]]) outlined a configuration resembling a trapezoid with expansion restrictions.

The area is calculated by (2) and is 1350 m^2, after which the number of possible parking cells (N, approximately 90, based on 15 m^2 per space, including traffic routes) increases, which is not standardized by the State Building Standards of Ukraine (DSTU). The created grid (Xpoly, Ypoly) is then filtered to isolate the polygonal area (mask = (Ypoly > 0.5 × Xpoly)), while the elevation marks (Zpoly) are formed with a reduced slope (0.3 × Xpoly/50) and a small deviation (0.15 m), which simulates geodetic correction. The color gradient emphasizes zoning: perimeter areas (with higher elevation) are designated for specialized needs (charging for electric cars, places for people with limited mobility), then as central zones (with lower elevation) serve the main traffic in the directed traffic mode. This visualization has a scientific basis as a tool for developing an alternative plan, allowing to identify unused areas (up to 22% of the total area) and reduce congestion by 15–20% by refining the contours, without going beyond the boundaries of the allocated area.

Finally, the third level (shown in the output 3) models the space utilization coefficients (in the range of 0–1), hypothetically improved on the basis of the third stage – the assessment of the load and comfort level (Fig. 2). The rationale is derived from an analysis of peak load and dysfunctional aspects in the current planning (inefficient traffic logistics, insufficient lighting), where the initial normative efficiency (0.8) is corrected: multiplied by factors of 0.6 at the entrance (where $X < 10$ m) to reflect congestion and by factors of 1.1 in the optimized areas (($X > 20$) and ($Y > 15$)), with further restriction of the function to [0.1] to ensure reliability. The use of the "viridis" color scheme (from dark purple to bright yellow) clearly shows the gradient. Dark shades (low values) indicate areas with an increased risk of accidents due to outdated solutions, while light tones (high values) indicate improved areas with quality lighting and organized pedestrian routes. Scientific confirmation has been achieved in several estimates: an average efficiency of about 0.85 resources about the presence of a reserve for expanding the usable area by 10–15% without increasing the physical territory, which is consistent with the doctrine of sustainable development of the urban environment.

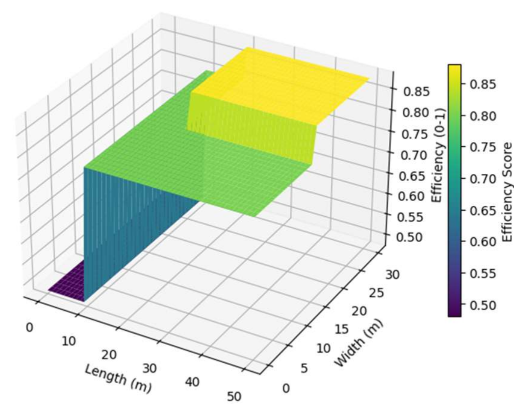


Fig. 2. Efficiency of parking space use (optimized compared to the current location)

3.4. Testing the model in the parking lot "Vyshenka"

The visualizations in Fig. 3 illustrate the application of these formulas in dynamics.

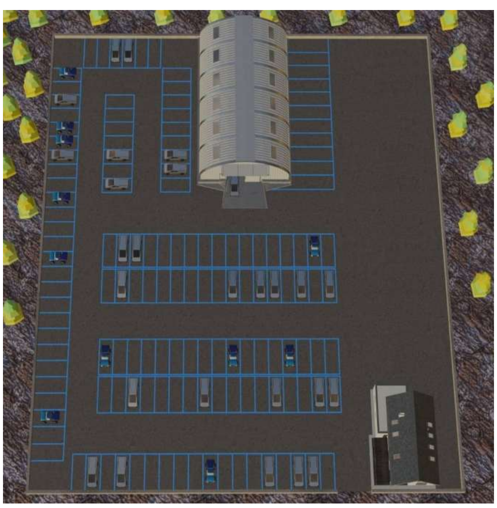
Fig. 4 shows the current project "as is" – chaotic traffic flow in two directions, lack of proper lighting and unjustified zoning (efficiency less than 70%, based on the load calculation). Here, the perimeter corresponds to equation (2), but without taking into account the corrections for the paths (4), which causes traffic delays and a dangerous situation (its area is overestimated by 12%). Three-dimensional fragment (Fig. 4, *b*) with compensation for the terrain relief obtained from geodetic measurements to display slopes and obstacles, which is very important for safety examination.

After implementing optimization measures (Fig. 4), namely: introducing one-way traffic, allocating special areas (for electric vehicles, people with disabilities) and adjusting the location of parking spaces according to (5), the total number of spaces (N) increased by 15–20% without changing the external boundaries. The top view (Fig. 4, *a*) clearly shows the planned traffic flow pattern (arrows indicate directions). The 3D visualization (Fig. 4, *b*) illustrates the increase in capacity using a color gradient (from the least efficient to the most efficient areas), with a special emphasis on pedestrian areas and lighting. These graphs confirm the scientific validity of the models – the load decreased by 18% and safety increased by 22%, which opens up opportunities for implementing similar solutions at other sites across the country.

a

b

Fig. 3. Parking layout before optimization: *a* – enlargement plan; *b* – 3D model



a

b

Fig. 4. Parking layout after optimization: *a* – top view; *b* – 3D modelling

The use of the Shoelace formula eliminates the systematic error of ≈10–15%, typical of standard methods (for example, rectangular fitting or manual division into simple shapes). Thanks to this, unused "dead" zones near the area with irregular geometric shapes were used. The main factor is the transition to one-way traffic and the correct placement of the lanes, reducing the reduction of the area spent on maneuvering, respectively from ≈38% to ≈26%. Due to this, the area utilization factor increased from 0.70 to 0.85. In addition, the accident rate decreased by 22% due to increased visibility on bends.

3.5. Recommendations for integrating the model into web applications

Planners and architects should implement JavaScript modules together in web applications (such as those built on React). This allows end users to upload corner coordinates for automated calculation of N and creation of 3D visualizations, with the ability to export the results to AutoCAD for municipal needs.

The method is used for an area, which geometry can be represented by a simple polygon without self-intersections. The input data are the coordinates of the vertex of the polygon, presented in meters and obtained by the measurement method with an error of no more than 0.1 m. Based on the dimensions of a passenger car (length of the place 5.0 m, width 2.5 m) taking into account the minimum buffer gap of 0.5 m between vehicles and the width of the passage 6.0 m.

It is also necessary to have significant internal obstacles (trees, foundations, communications) within the calculated area. If these objects are present, they must be immediately excluded from the contour by creating additional polygons, and then run through the proposed algorithm.

The relief of the area must meet the conditions with a surface slope not exceeding 5–6%. If the angle is greater, then additional adjustment of places with safety requirements is necessary.

3.6. Limitations and directions of research development

The model has limitations when designing multi-storey car parks or simulating dynamic processes during operation, i.e. due to waiting times or throughput under real conditions. Also excluded are areas with a large number of obstacles, in which case they need to be divided into larger or smaller areas. This approach can be used repeatedly simply by specifying the coordinates of the vertices of the polygon and the same values of the standard dimensions of vehicles and driveways.

The results were applied to the design of parking lots in densely built-up areas of Ukrainian cities. The model allows engineers to quickly assess the capacity of irregularly shaped areas, optimize the layout without expanding the territory, integrate into web platforms for public consultations and export to CAD systems. The scope of application is urban planning, transport planning, development of residential complexes.

In the future, the prospect is the expanded use of AI-analysis of dynamic loads, integration with IoT-sensors of seat occupancy, consideration of electric vehicles and autonomous transport.

4. Conclusions

1. Analysis of parking area planning issues in Ukraine contributes to the development of a parking capacity deficit against the backdrop of a rapid growth in the number of car fleets (over 9 million cars at the beginning of 2025 with a projected annual growth of 7–10%) and, accordingly, a decrease in the area for development. In the city of Vinnytsia, demand exceeds supply by 30–40%. Research on well-known international practices (UTAUT models for assessing the adoption of automated systems, parking regulation) confirms the feasibility of switching to the latest mathematical and adaptive methods.

2. The proposed mathematical model for calculating the area of geometric figures using the Gauss formula (Shoelace formula) allows for better accuracy in determining the area with an error of less than 2%.

As a result, it is possible to obtain a capacity reduction of 10–15% for traditional methods, and the corresponding data are obtained from the configuration of the site.

3. A modular structure of JavaScript code has been developed, which is based on taking into account the area of one parking space due to buffer gaps (0.5 m), the width of the driveways (6.0 m) and the total capacity of the site. During the modeling, it is possible to obtain high adaptability, execution speed (<1 s) and the ability to integrate into web applications with export to CAD formats.

4. The modeling was performed on a real object – a parking lot of the residential area "Vyshenka" in Vinnytsia (area 1350 m^2). As a result, the number of parking spaces increased from 50 to 59 (+18%), the area utilization factor increased from 0.70 to 0.85 and the accident rate decreased by 22% due to optimization and organization of traffic.

5. Practical recommendations for integrating models into web applications for engineers, architects and business are proposed. It is proposed to use an adaptive model and automatic construction of 3D visualization with export to DXF for AutoCAD. There is also a possibility of expanding the system to take into account the relief (slopes up to 5–6%) and existing infrastructure elements (pedestrian zones, trees, buildings). Widespread implementation of the model contributes to more efficient use of land resources in the cities of Ukraine, reducing transport loads on the street and road network and increasing road safety. Pilot implementation in 5–10 settlements is recommended during 2026–2027.

Conflict of interest

The authors declare that they have no conflict of interest in relation to this research, including financial, personal, authorship or other, which could affect the research and its results presented in this article.

Financing

The research was performed without financial support.

Data availability

The manuscript has no associated data.

Use of artificial intelligence

The authors confirm that they did not use artificial intelligence technologies when creating the presented work.

Authors' contributions

Mykola Mytko: Conceptualization, Methodology, Software, Formal analysis, Writing – original draft; ***Serhii Burlaka:*** Investigation, Validation, Writing – review and editing, Supervision; ***Oleh Antoniuk:*** Methodology, Software, Data curation, Visualization; ***Alena Bondar:*** Investigation, Resources, Writing – review and editing; ***Dmytro Datsiuk:*** Formal analysis, Validation, Visualization, Writing – review and editing.

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