TASHKENT STATE UNIVERSITY OF ECONOMICS

International journal of topics

INNOVATION SCIENCE AND TECHNOLOGY

Scopus || Electronic journal specializing in Scopus

ISSUE 4

Acceptance of papers **April, 2026**

Acceptance of papers

Published monthly

Topics

economics, technology, social sciences

ISSN 3060-5229

Electronic publication, Issue 4. 272 pages.
Approved for publication on April, 2026.

THE SCIENTIFIC-POPULAR ELECTRONIC JOURNAL **"INNOVATION SCIENCE AND TECHNOLOGY"** HAS BEEN REGISTERED UNDER THE NUMBER **C-5669633** BY THE AGENCY FOR INFORMATION AND MASS COMMUNICATIONS (AOKA) OF THE REPUBLIC OF UZBEKISTAN, EFFECTIVE FROM OCTOBER 9, 2024.

CONTACTS

Phone: **+998 50 737 87 88**

Website: https://ist-journal.uz

Email: innovationist2025@gmail.com

The scientific electronic journal “Innovation Science and Technology” has been included in the list of scientific publications recommended for the publication of main scientific results of dissertations for the award of PhD and DSc degrees in economics and technical sciences, in accordance with the Resolution No. 370 of the Presidium of the Higher Attestation Commission of the Republic of Uzbekistan, dated May 8, 2025.

Editorial board:

CONTENTS

CONTENTS

CONTENTS

SMART PARKING MANAGEMENT ALGORITHMS IN SMART CITIES

Begmurodov Begzod Adham o‘g‘li
Master’s Degree Student, Karshi State Technical University

Abstract. Recently, various advanced technologies have been employed to build smart cities. Smart cities aim to improve the quality of life by delivering better services. One of the essential services for any smart city is the availability of sufficient parking spaces to ensure smooth and efficient traffic flow.

This research proposes a new framework for solving the problem of parking lot allocation, emphasizing the equitable distribution of users based on the total number of people in each parking area. The allocation process is carried out while considering the available parking lots in each area.

To achieve this goal, the study develops a set of seven algorithms aimed at reducing the gap in the number of people between parking areas. Numerous experiments were conducted on 2,430 different cases to evaluate aspects such as execution time and gap calculations, in order to assess the performance of the developed algorithms.

The analysis of the obtained results indicates strong performance of the proposed algorithms. It also demonstrates that the algorithms effectively solve the studied problem in terms of both gap reduction and computational time. The MR algorithm achieved excellent performance compared to one of the best algorithms in the literature, with an accuracy of 96.1%, an average gap of 0.02, and an execution time of 0.007 s.

Keywords: Smart cities, parking spaces, parking management, Genetic Algorithm, equitable distribution, required parameters, proposed algorithm.

Аннотация. В последнее время для создания «умных городов» активно используются передовые технологии. Основной целью «умных городов» является повышение качества жизни за счёт предоставления более эффективных услуг. Одной из ключевых услуг является наличие достаточного количества парковочных мест, обеспечивающих бесперебойное и удобное движение транспорта.

В данном исследовании предлагается новая модель решения задачи распределения парковочных мест, основанная на справедливом распределении пользователей с учётом общего количества людей на каждой парковочной зоне. Процесс распределения осуществляется с учётом доступных парковочных мест в каждой зоне.

Для достижения поставленной цели разработан набор из семи алгоритмов, направленных на сокращение разрыва в количестве людей между парковочными зонами. Для оценки эффективности алгоритмов были проведены многочисленные эксперименты на 2430 различных сценариях с учётом времени выполнения и расчётов разрыва.

Анализ полученных результатов показывает высокую эффективность разработанных алгоритмов. Также подтверждается, что предложенные алгоритмы успешно решают поставленную задачу с точки зрения сокращения разрыва и времени вычислений. Алгоритм MR продемонстрировал отличные результаты по сравнению с одним из лучших алгоритмов, представленных в литературе: точность составила 96,1 %, средний разрыв — 0,02, а время выполнения — 0,007 с.

Ключевые слова: умные города, парковочные места, управление парковками, генетический алгоритм, справедливое распределение, необходимые параметры, предлагаемый алгоритм.

Annotatsiya. So‘nggi yillarda aqlli shaharlarni yaratishda turli ilg‘or texnologiyalar keng qo‘llanilmoqda. Aqlli shaharlarning asosiy maqsadi — aholining hayot sifatini yaxshilash va xizmatlar sifatini oshirishdir. Bunday shaharlarda muhim xizmatlardan biri — transport harakatining uzluksiz va qulayligini ta’minlash uchun yetarli miqdorda avtoturargoh joylarining mavjudligidir.

Mazkur tadqiqotda avtoturargoh joylarini taqsimlash muammosini hal etishga qaratilgan yangi yondashuv taklif etiladi. Ushbu yondashuv har bir hududdagi foydalanuvchilar soniga asoslangan holda adolatli taqsimotni ta’minlashga qaratilgan. Taqsimlash jarayoni har bir hududdagi mavjud avtoturargoh joylarini inobatga olgan holda amalga oshiriladi.

Belgilangan maqsadga erishish uchun mazkur tadqiqotda yettita algoritmdan iborat tizim ishlab chiqilgan bo‘lib, ular turli hududlar o‘rtasidagi foydalanuvchilar soni farqini kamaytirishga xizmat qiladi. Algoritmlar samaradorligini baholash maqsadida 2430 ta turli holatda tajribalar o‘tkazilib, bajarilish vaqti va farq ko‘rsatkichlari tahlil qilindi.

Olingan natijalar ishlab chiqilgan algoritmlarning yuqori samaradorlikka ega ekanligini ko‘rsatdi. Shuningdek, ular muammoni farqni kamaytirish va hisoblash vaqti nuqtai nazaridan samarali hal eta olishini isbotladi. MR algoritmi adabiyotlarda mavjud eng yaxshi algoritmlardan biri bilan solishtirganda yuqori natija ko‘rsatdi: aniqlik darajasi 96,1 %, o‘rtacha farq 0,02 va bajarilish vaqti 0,007 soniyani tashkil etdi.

Kalit so‘zlar: aqlli shaharlar, avtoturargoh joylari, avtoturargoh boshqaruvi, genetik algoritm, adolatli taqsimot, zarur parametrlar, taklif etilgan algoritm.

INTRODUCTION

Smart cities include public spaces such as parks, zoos, and playgrounds for entertainment, as well as commercial areas for shopping and business activities. To facilitate smooth traffic flow to these locations, technologies such as motion sensors and cameras are employed. In addition, traffic personnel are assigned to regulate the entry and exit of vehicles to and from available parking lots within designated parking areas.

Despite these measures, several challenges remain inevitable when directing vehicles to available parking lots. These challenges often lead to congestion at the entrance points of target locations, largely due to variations in the number of passengers per vehicle. The first major issue is the accumulation of vehicles at entry and exit points, which results in traffic blockage within parking areas. The second issue is the long waiting time experienced by passengers while searching for available parking spaces within designated areas.

For vehicle passengers, waiting time is a critical factor that can significantly influence their overall experience; therefore, its consideration becomes essential. Prolonged waiting times may discourage repeat visits, ultimately reducing the number of visitors to such locations. Consequently, this decline can negatively affect the financial performance of associated businesses. Thus, managing parking spaces using conventional methods may lead to increased congestion at entrance gates, particularly due to the variability in the number of passengers per vehicle.

GOALS AND CONTRIBUTIONS

In this study, the proposed solution begins by dividing each parking area into a set of well-defined and identifiable parking lots. This approach focuses on optimizing the allocation of vehicles within available parking spaces by applying novel techniques (e.g., entity-based rules) that consider the total number of people in each parking area, rather than simply ensuring an equal distribution of vehicles across spaces.

The proposed solution can be applied to various types of parking environments, including airports, shopping centers, public parks, entertainment venues, and other locations that require efficient and optimized parking space management.

RELATED WORK

In several previous studies, researchers have applied various strategies and techniques to address the problem of assigning vehicles to available parking spaces. For example, the allocation of parking spaces based on driver preferences was discussed in [8], where the authors proposed a system that allows users to reserve a parking space closest to their destination. This approach contributes to more efficient utilization of parking resources.

A similar concept was introduced in [9], where software agent negotiation was employed to develop a reservation mechanism that considers both user preferences and the interests of parking space owners. In an effort to address parking allocation challenges in urban areas, the authors in [10] proposed the use of private parking lots that are available during the day by enabling the sharing of indoor parking spaces between residents and external users. This framework is suitable for urban environments and provides a potential solution to parking shortages. However, it is not directly applicable to the context of this study due to differences in parking types considered.

In [11], the authors developed several parking policies within a framework that utilizes vehicle GPS data to solve the dynamic parking allocation problem using 0–1 programming models. Power consumption is a critical concern for hybrid and electric vehicles, which motivated the authors in [12] to address parking allocation in the context of charging port distribution. Their objective was to minimize the total system power cost.

In another study [13], an online parking reservation system was introduced, allowing users to reserve parking spaces in advance. While this approach guarantees parking availability, it does not effectively reduce traffic congestion, which may lead to increased energy consumption and longer travel times to reach reserved spaces.

The management of parking in central commercial areas was examined in [14], where the authors proposed a Genetic Algorithm combined with Dynamic Shared Parking to generate near-optimal solutions.

In this approach, drivers can rent idle parking spaces near their destinations based on cost, distance, and time constraints. However, this method is limited to certain vehicle types and does not consider the number of passengers in each vehicle.

Using patterns of driver arrival and departure times, the authors in [15] proposed a chance-constrained optimization model to address shared parking allocation. Their objective was to improve parking utilization rates and reduce service failure probability.

Furthermore, in [16], an online resource allocation framework for urban parking management was developed using a multi-agent system. This system considers dynamic geographic positions and the stochastic arrival of both drivers and parking spaces. It relies on shared information from groups of drivers to reduce the time required to locate available parking spaces.

This approach is primarily designed for static parking allocation and is unable to handle real-time changes in parking availability, i.e., the dynamic parking allocation problem. Consequently, it does not effectively prevent vehicle overcrowding in parking spaces.

To mitigate traffic congestion during parking search and to assist drivers in locating available parking spots efficiently, the authors in [17] proposed a dynamic parking system based on driver preferences, utilizing an online multi-agent approach. This system incorporates a shortest-route guidance module to help drivers reach their reserved parking spaces.

Similarly, the authors in [18] introduced a Reservation-Based Smart Parking System (RSPS) that employs a cluster-based algorithm to address the dynamic parking allocation problem. The system uses a network of wireless sensors to continuously update the availability of parking spaces, enabling drivers to identify and reserve nearby parking spots via their smartphones. This approach simplifies the parking process and reduces congestion caused by searching for parking.

Another study [19] proposed a prediction-based parking allocation framework that integrates occupancy prediction with allocation mechanisms to provide efficient parking services. In addition, the authors in [20] examined parking assignment for both connected and non-connected vehicles by developing a multi-agent deep reinforcement learning framework. This approach addresses uncertainties in parking availability caused by reservations made by non-connected vehicles.

Parking space allocation in hospital environments was addressed in [21], where a cumulative model based on prospect theory was developed to manage shared parking challenges. The objective was to maximize the utilization and financial returns of available parking spaces while considering user preferences and time window constraints, particularly for patients and visitors.

Furthermore, the authors in [22] applied an agile algorithm to enhance the performance of an existing cloud-based parking system, incorporating IoT technology to design an efficient network architecture. This system allocates parking spaces based on vehicle size while ensuring low cost and minimal waiting time. It also incorporates load balancing and congestion avoidance mechanisms based on parking space dimensions and availability. Additionally, the system can recommend alternative parking options if the selected parking space is full, redirecting drivers to nearby available locations.

Although the approach presented in [22] addresses load balancing, waiting time reduction, and congestion avoidance—making it a near-optimal solution—it does not consider the variation in the number of passengers per vehicle or the total number of people within each parking space. Moreover, the load balancing strategy is based on the number of vehicles rather than the number of passengers. In contrast, the proposed work focuses on load balancing based on the total number of people in each parking space.

Load balancing and equitable distribution have been widely applied by researchers across various domains.

The authors in [23] developed upper and lower bounds for the distribution of projects across regions, with the objective of reducing disparities between allocated budgets. In addition, they introduced an exact solution using the branch-and-bound method.

Within the same context of project distribution, the authors in [24] proposed a mathematical model to address the problem. To obtain solutions within acceptable execution times, several approximate methods were developed. For instance, the authors in [25] introduced three heuristics based on probabilistic and iterative approaches. More recently, the authors in [26] proposed five heuristics to further improve solution quality.

Load balancing techniques have also been applied in memory systems. The authors in [27] addressed the problem of storage space utilization by developing several approximate solutions aimed at generating efficient scheduling strategies. Their objective was to ensure fair distribution of storage across media, thereby minimizing the gap in utilized space.

Equitable distribution has also been explored in networking. For example, the author in [28] studied the fair distribution of data across routers and proposed solutions based on a multi-fit algorithm and a subset-sum approach.

In the aviation domain, several algorithms have been proposed to maximize the utilization of gas turbine engines and extend aircraft operating time. The authors developed lower bounds based on iterative methods and reformulated the problem as a knapsack optimization problem. In this context, various heuristics were also proposed, such as in [29], where approximate solutions based on randomization techniques were developed.

More recently, the authors in [30] addressed the problem of allocating parking lots to different vehicle types based on the equitable distribution of the total number of people in each vaccination center. This work focused on traffic management at COVID-19 vaccination centers and introduced nine heuristics to solve the problem. The results demonstrated that the C3S algorithm outperformed other methods, achieving a performance rate of 94%.

A comparative analysis was conducted between the C3S algorithm and the algorithms presented in this study to highlight performance differences and demonstrate the superiority of the proposed methods over existing approaches. It is important to note that the work presented in this article generalizes the approach in [30], introducing algorithms that consider multiple parking types based on a novel architecture and allocation process.

Furthermore, service-oriented computing approaches, as discussed in [31], can be extended and adapted to the studied problem. In addition, deep learning techniques presented in [32] can be utilized to enhance heuristic solutions. Other optimization techniques and scheduling algorithms may also be applied to improve equitable distribution in parking management systems.

omains.

Despite the numerous studies addressing the problem of allocating available parking spaces, many of these works exhibit significant limitations when applied to real-world scenarios. Based on the analysis of the existing literature, the following research gaps have been identified:

Insufficient consideration of different types of parking lots suitable for various vehicle types.

Limited effectiveness in alleviating traffic congestion, which results in increased energy consumption and

longer waiting times to reach reserved parking spaces.

A predominant focus on static parking allocation models, which fail to handle real-time changes in parking availability, i.e., dynamic parking allocation. Consequently, these approaches do not effectively prevent vehicle overcrowding.

Lack of consideration for the varying number of passengers in each vehicle and the total number of people within each parking space when fully utilized. Moreover, existing load-balancing approaches are typically based on the number of vehicles, whereas the proposed work focuses on balancing based on the total number of people in each parking space.

The studies discussed in the literature have addressed parking allocation by developing algorithms and various approaches that aim to assign parking spaces efficiently while considering user and system constraints. However, none of these approaches explicitly accounts for the number of passengers in vehicles. This limitation may lead to the accumulation of people within parking areas or at exit points, potentially causing crowding and operational inefficiencies.

The work presented in this study addresses this gap by allocating parking spaces to vehicles while ensuring equitable distribution based on the number of people in each parking area, thereby reducing congestion and improving overall system performance.

Problem Formulation

This section presents the parking allocation problem in the context of smart cities (Figure 1).

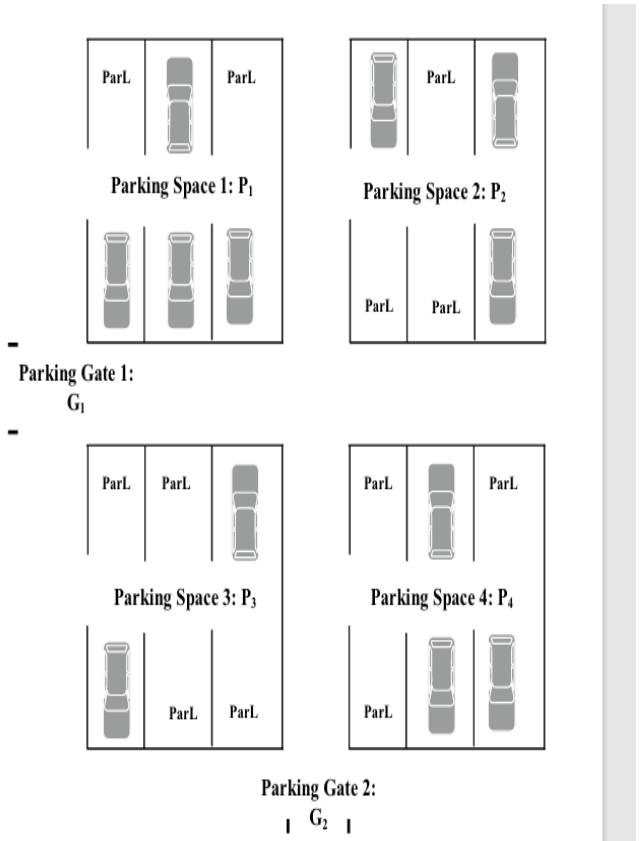

FIGURE 1. PARKING SPACES REPRESENTATION EXAMPLE

Notations and Problem Representation

The primary objective of this study is to develop a set of algorithms for allocating vehicles to available parking lots within given parking spaces based on the number of people in each vehicle. This approach ensures an equitable distribution of people across parking spaces, minimizes the time required for vehicles to reach their assigned parking lots, and prevents overcrowding.

In this study, it is assumed that a parking area consists of a set of parking spaces, where each parking space contains a specified number of parking lots, as illustrated in Fig. 1.

Each parking lot is denoted by **ParL**. The parking area also includes a set of parking gates, denoted by

$G = \{G_1, \ldots, G_n g\}$, where G_k represents the k-th parking gate, and n_9 denotes the total number of parking gates.

The set of parking spaces is denoted by $P = \{P_1, P_2, \ldots, P_n p\}$, where P_i represents the i-th parking space, and n_p is the total number of parking spaces. As shown in Fig. 1, the example consists of four parking spaces and two parking gates (G_1 and G_2), where each parking space contains six parking lots.

The main entrance to the parking area serves as the access point to the parking system and is denoted by E_k. The area between E_k and G_k is defined as the queuing area, denoted by Q_{ak}, where incoming vehicles wait before being allocated by the scheduler. As illustrated in Fig. 1, the system may include multiple main entrances (e.g., four entrances in the given example).

A set of sensing devices is employed to collect data on the number of people inside each vehicle entering the queuing area Q_{ak} through the main entrance E_k. This data is transmitted to a data control unit, which processes it to determine the number of passengers in each vehicle. The processed data is then forwarded to the scheduler to update the allocation process dynamically and reassign vehicles based on real-time information.

To ensure the equity distribution constraint, the scheduler considers the updated total number of people within each parking space before allocating any vehicle. Let M_v denote the maximum number of vehicles that can be allocated to a given parking space. If M_v is reached, the scheduler reallocates the incoming vehicle to the first available parking lot in any other parking space (Figure 2).

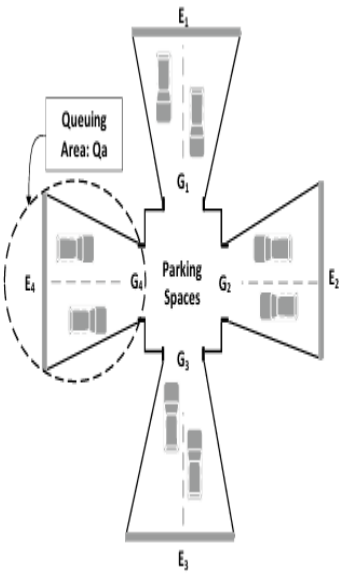

Figure 2. Entrance and Queuing Area Representation

This implies that the scheduler considers the remaining $n_p - 1$ parking spaces while ensuring that the equity distribution constraint is not violated. Furthermore, when the total number of vehicles exceeds M_{v1} for all $i \in \{1 \leq i \leq n_{vk}\}$, the control unit displays a notification at the entrance of each queuing area indicating that a specific parking space is full.

The Developed Algorithms

Seven algorithms are presented in this section. These algorithms are based on four main techniques.

The first technique is an iterative method, which selects a predefined number of iterations to repeat a procedure in order to identify the best solution. The second technique is a randomization approach, in which a probability value is used to select between a vehicle and a parking space; this probability varies depending on the specific algorithm. The third technique combines the previous two approaches, where each combination produces a new algorithm with distinct performance characteristics.

The fourth technique addresses the two-parking-space problem using the subset-sum problem. This approach is inspired by the parallel machine scheduling problem, where the subset-sum method is applied. In this context, the subset-sum procedure is used to balance the load between two parking spaces, specifically the most loaded and the least loaded ones.

In the following subsection, a non-increasing order-based procedure, denoted by **NI**, is employed. This procedure follows a structured strategy: first, all vehicles are sorted in non-increasing order based on the number of passengers. Then, the vehicle with the highest number of passengers is assigned to the parking

space with the lowest total number of people. This process continues iteratively until all vehicles are allocated.

To address the problem, this research begins by collecting the required data, which is subsequently analyzed to derive the necessary parameters. These parameters are used to define the constraints, determine the variables, and formulate the objective functions aimed at maximizing the minimum load balance to obtain approximate solutions. The resulting solutions are then evaluated using performance metrics, including efficiency and execution time. These evaluations form the foundation for designing the proposed algorithms, which constitute the framework of the presented approach.

LITERATURE REVIEW

Smart parking management has become an important research direction within the broader concept of smart cities. As urban areas continue to expand, the efficient use of parking infrastructure plays a significant role in reducing traffic congestion, minimizing waiting time, and improving the overall mobility experience. Previous studies have shown that smart cities rely on advanced technologies such as sensors, cameras, GPS systems, wireless networks, Internet of Things (IoT), cloud platforms, and intelligent algorithms to manage transportation and public services more effectively.

Several researchers have investigated parking allocation problems from different perspectives. Some studies have focused on driver preferences, where parking systems allow users to reserve spaces close to their destination. Such approaches improve user convenience and support more efficient parking space utilization. Other studies have proposed reservation-based smart parking systems that use wireless sensor networks and mobile applications to detect available spaces and guide drivers to the nearest free parking lot.

Dynamic parking allocation has also been widely discussed in the literature. In this approach, real-time data are used to update parking availability and support drivers in locating suitable parking spaces. Multi-agent systems, GPS-based guidance, and online allocation models have been applied to reduce search time and improve decision-making. However, many of these systems mainly focus on vehicle allocation and do not sufficiently consider the number of passengers inside each vehicle.

Genetic algorithms and other optimization techniques have also been used in parking management. These methods are effective in finding near-optimal solutions under constraints such as cost, distance, time, and availability. Some studies have introduced dynamic shared parking models, while others have applied chance-constrained optimization, deep reinforcement learning, and prediction-based allocation methods. These approaches contribute to better parking utilization, but they often remain limited in terms of equity distribution among parking spaces.

Load balancing and equitable distribution have been applied in different domains, including project allocation, memory storage, networks, aviation, and transportation systems. In parking management, load balancing is usually based on the number of vehicles allocated to each parking area. However, this approach does not always prevent crowding, because vehicles may contain different numbers of passengers. Therefore, balancing parking spaces according to the total number of people, rather than only the number of vehicles, provides a more accurate and socially effective solution.

Based on the reviewed studies, it can be concluded that existing smart parking systems have made important contributions to parking reservation, congestion reduction, real-time allocation, and efficient use of parking resources. Nevertheless, most previous approaches do not fully address the equitable distribution of people across parking spaces. This research fills this gap by proposing smart parking management algorithms that allocate vehicles according to the number of passengers in each vehicle, thereby reducing overcrowding, improving traffic flow, and enhancing parking efficiency in smart cities.

RESEARCH METHODOLOGY

This study adopts an algorithmic and simulation-based methodology to address the parking allocation problem in smart cities by ensuring equitable distribution of people across parking spaces. The system is modeled as a structured environment consisting of multiple parking areas divided into parking spaces and parking lots, where vehicles enter through designated gates and are temporarily stored in queuing areas. Real-time data on vehicle flow, parking availability, and the number of passengers per vehicle are collected using sensing devices and processed by a control unit, which forwards the information to a scheduler for dynamic allocation. Based on this framework, seven algorithms were developed using four main techniques: iterative methods, randomization approaches, hybrid combinations of both, and subset-sum optimization inspired by parallel machine scheduling problems. Additionally, a non-increasing (NI) procedure is applied, where vehicles are sorted by the number of passengers and assigned to parking spaces with the lowest total occupancy to maintain load balance. The model incorporates constraints such as parking capacity limits, availability of

parking lots, and equity distribution based on the total number of people rather than the number of vehicles. To evaluate performance, simulation experiments were conducted on 2,430 different scenarios, using metrics such as execution time, gap minimization, and allocation efficiency. The results were analyzed to validate the effectiveness of the proposed algorithms in reducing congestion, balancing occupancy, and improving overall parking management efficiency.

ANALYSIS AND RESULTS

The performance of the proposed parking allocation algorithms was evaluated through simulation experiments conducted on 2,430 different scenarios, considering key performance metrics such as execution time, gap minimization, and allocation efficiency. The analysis shows that the developed algorithms effectively ensure equitable distribution of people across parking spaces by dynamically assigning vehicles based on the number of passengers rather than merely the number of vehicles. Among the proposed methods, the MR algorithm demonstrated the best performance, achieving an accuracy rate of 96.1%, an average gap value of 0.02, and a fast execution time of 0.007 seconds, outperforming the benchmark C3S algorithm. The NRβ algorithm ranked second with a performance rate of 88.1%, indicating strong but comparatively lower efficiency. The results further confirm that the proposed algorithms significantly reduce congestion by balancing occupancy levels across parking spaces, thereby minimizing the accumulation of vehicles and people at entrances and exits. Additionally, the incorporation of real-time data and dynamic scheduling enhances the adaptability of the system under varying traffic conditions. Overall, the analysis indicates that the proposed approach not only improves allocation fairness but also optimizes traffic flow and reduces waiting time, making it a robust solution for smart parking management in smart cities.

CONCLUSIONS AND RECOMMENDATIONS

This study presents a solution to the problem of equitable distribution of parking spaces within smart city parking areas for different types of vehicles. Each parking area is divided into parking spaces, and each parking space consists of a set of well-defined parking lots.

The primary objective of this work is to ensure an equitable distribution of people across all parking spaces. This objective is achieved through a set of developed algorithms that allocate parking lots to vehicles of different types. Vehicles are directed to specific parking spaces based on the total number of people already present in each space. The total number of people within a parking space determines the availability of parking lots.

In this study, seven algorithms were developed to address the problem. Experimental results demonstrate that the **MR algorithm** achieved a high performance rate of **96.1%**, with an average gap value of **0.02** and an execution time of **0.007 s**, outperforming the C3S algorithm. The **NRβ algorithm**, with a performance rate of **88.1%**, was identified as the second-best method.

The obtained results indicate that the proposed algorithms effectively minimize the gap in the total number of people across parking spaces, regulate occupancy levels, reduce congestion, and decrease the time required for users to reach their destinations.

Prospects

Future research may focus on integrating real-time data analytics, advanced machine learning techniques, and adaptive optimization methods to further enhance the efficiency and scalability of parking management systems in smart cities.

In future work, four main aspects will be addressed.

First, the range of considered classes will be expanded, and a more detailed comparative analysis of the proposed algorithms against existing methods in the literature will be conducted. This will provide academics and researchers with clearer directions for addressing parking management challenges in smart cities.

Second, the efficiency and robustness of the developed algorithms will be further validated through comprehensive experimental evaluation.

Third, a study will be conducted to explore the potential of hybridizing different proposed algorithms in order to achieve improved performance in terms of execution time and gap minimization.

Fourth, the proposed algorithms may be further enhanced by applying meta-heuristic techniques as initial solution strategies, as well as by integrating exact methods to obtain optimal solutions.

REFERENCES

1. Chen, C., Yuan, Z., & Zhu, H. (2020). Playing, parenting, and family leisure in parks: Exploring emotional geographies of families in Guangzhou Children's Park, China. Children's Geographies, 18, 463–476. https://doi.org/10.1080/14733285.2019.1676879
2. Reuben, A., Rutherford, G. W., James, J., & Razani, N. (2020). Association of neighborhood parks with child health in the United States. Preventive Medicine. https://doi.org/10.1016/j.ypmed.2020.106265
3. Hanifi, M., & Heidarzadeh, K. (2020). Developing a scale to measure "comfortable shopping experience" in shopping malls. Journal of Business Management, 12, 227–242. https://doi.org/10.22059/JIBM.2018.261571.3130
4. Jaeger, E. C., & Smith, A. C. (2020). Introduction to the Natural History of Southern California. University of California Press.
5. Burris, A. (2021). Measuring intrinsic traits of children at zoos. Interdisciplinary Journal of Environmental Science Education, 17, e2246. https://doi.org/10.21601/ijese/10939
6. Lejdel, B. A. (2020). A conceptual framework for modeling smart parking. In Application of Expert Systems: Theoretical and Practical Aspects. IntechOpen. https://doi.org/10.5772/intechopen.85202
7. Winter, K., Cats, O., Martens, K., & van Arem, B. (2021). Parking space for shared automated vehicles: How less can be more. Transportation Research Part A: Policy and Practice, 143, 61–77. https://doi.org/10.1016/j.tra.2020.11.008
8. Суяров, А. Б. (2025-01). Технологии организации дистанционного обучения. Phonex Publikation, II-son.
9. Geng, Y., & Cassandras, C. G. (2012). A new "smart parking" system infrastructure and implementation. Procedia - Social and Behavioral Sciences, 54, 1278–1287. https://doi.org/10.1016/j.sbspro.2012.09.842
10. Mladenović, M., Delot, T., Laporte, G., & Wilbaut, C. (2020). The parking allocation problem for connected vehicles. Journal of Heuristics, 26, 377–399. https://doi.org/10.1007/s10732-017-9364-7
11. Karimov, A. (2023). Parameters justification of the improved potato digger. Innovative Development in Educational Activities, 2(18), 256–263.
12. Karimov, A. A. (2024-06). Organizing management in the transport logistics system. American Journal of Engineering, Mechanics and Architecture, 2(6), 66–68.

Proofreader: Zokir ALIBEKOV

Layout and Designer: Oloviddin Sobir ugli

2026. № 4

To publish articles in this journal, you may submit articles, advertisements, stories, and other creative materials through the following links. Materials and advertisements are published on a paid basis.

You may subscribe to the journal at any time using the following details. Once subscribed, please send a screenshot or photo of your payment confirmation to our Telegram page @iqtisodiyot_77. Based on this, we will send the latest issue of the journal to your address each month.

“The journal “INNOVATION SCIENCE AND TECHNOLOGY” has been registered by the Agency for Information and Mass Communications under the Administration of the President of the Republic of Uzbekistan from 09.10.2024 under the registration number №390637. License number: C-5669633. PNFL: 30407832680027

Our address: Tashkent city, Yunusobod district, 19th block, House 17.

TASHKENT STATE UNIVERSITY OF ECONOMICS

Acceptance of articles

Published every monthly

Directions

Social, economic, political, technological, scientific

Scopus || Scientific electronic journal specializing in Scopus

CERTIFICATE NUMBER: №390637

ORDER NUMBER ACCORDING TO THE LICENSE REGISTER: C-5669633

CONTACT:

Contact us
+998 50 737 87 88

Telegram channel
t.me/scopus_IST2100

Journal official website
https://ist-journal.uz/index.php/IST