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CONTROL MODELS FOR MOBILE ROBOT PARKING USING DISTANCE SENSOR DATA

Abstract. Relevance. The growing demand for autonomous mobile systems capable of independent navigation and parking is driven by several critical factors. Firstly, the rapid robotization in logistics, security, delivery, and service industries necessitates reliable mechanisms for precise positioning of mobile platforms in spatially constrained environments. Secondly, in the context of autonomous vehicle development, the issue of automatic parking becomes a priority for enhancing safety, reducing energy consumption, and minimizing human involvement in control processes. Currently, a significant number of studies focus on the implementation of automatic parking systems; however, most of them either rely on high-cost sensors (such as LiDARs or deep-learning-based cameras) or fail to ensure the required accuracy under dynamic or unfamiliar environmental conditions. Against this backdrop, the use of ultrasonic sensors represents an effective alternative, enabling a necessary level of adaptability and sensitivity while maintaining low system cost. The relevance of this research is further reinforced by the need to develop a universal control model that is scalable, adaptive, and easily integrable into various types of mobile platforms. This work focuses not only on the theoretical formulation of the control model but also on its experimental validation using data from ultrasonic sensors that reflect the physical environment in real time. Therefore, the development of a mobile robot parking control model based on ultrasonic sensors is a timely and important task that combines scientific novelty with practical significance for the advancement of autonomous systems. **The object of research**. A parking control system for a mobile robot that operates based on data obtained from ultrasonic distance sensors. This system comprises both hardware components, such as ultrasonic sensors, actuators, and controllers, and software that implements algorithms for environmental analysis, decision-making related to parking maneuvers, and motion control. **Purpose of the article.** This article presents a comprehensive review of contemporary models for mobile robot parking control based on distance sensor data. The objective is to identify and critically evaluate effective approaches to sensor integration, control algorithm design, and architectural implementation of such systems. Particular attention is given to analyzing their applicability in real-world environments, with the aim of outlining development prospects that enhance system accuracy, reliability, and adaptability under dynamic and constrained conditions. **Research results.** As a result of the conducted review, it has been established that modern mobile robot parking control systems encompass a wide range of modeling approaches, varying in both mathematical complexity and sensor configurations. The analysis reveals that the choice of control model is directly influenced by the availability of computational resources, the robot's chassis type, and the nature of the operational environment. Particular attention is given to the comparative assessment of sensors, with ultrasonic sensors remaining dominant in short-range positioning systems due to their low cost, ease of integration, and reliability in controlled conditions. Conversely, LiDAR sensors have demonstrated superior accuracy and spatial resolution, although they present higher implementation and maintenance complexity. Cameras and infrared sensors are regarded as supplementary data sources, functioning effectively only within well-defined conditions and with appropriate software support. The findings of the review confirm that an effective parking control system for mobile robots relies on a holistic approach that integrates sensor selection, control model design, algorithmic implementation, and system architecture. Such integration enables high accuracy and operational reliability even in complex, dynamic, or constrained environments. **Conclusions.** Effective mobile robot parking control is based on the integration of reliable sensor systems, particularly ultrasonic sensors and adaptive decision-making algorithms. Ultrasonic sensors remain the most suitable option for low-cost and simple systems, whereas hybrid approaches involving LiDAR or camera-based solutions offer higher precision. Among the control algorithms, finite state machines, fuzzy logic, and machine learning methods have demonstrated the greatest effectiveness. The most optimal system architecture is modular, with a clear separation between sensing, computation, and actuation layers, which ensures adaptability, accuracy, and operational stability under real-world conditions.

Keywords: mobile robot, autonomous parking, ultrasonic sensors, sensor system, decision-making algorithms, finite state machine, fuzzy logic, machine learning, motion control, navigation system.

Introduction

In the context of rapid advancements in autonomous mobility, the issue of efficient parking control for mobile robots has become increasingly relevant. Across multiple industries – from warehouse logistics to autonomous vehicles – robotic platforms must not only navigate through environments but also independently execute precise parking maneuvers in confined spaces. The ability to perform automated parking is a critical component of full autonomy and a key factor for the safe and efficient operation of such systems.

One of the most promising approaches to solving this problem involves the use of real-time sensory data, particularly from ultrasonic distance sensors. These sensors offer a simple, low-cost, and reliable means of detecting obstacles and measuring distances to them, enabling the implementation of adaptive maneuvering algorithms. The primary challenge lies in developing an appropriate mathematical model and a software-hardware implementation that can effectively interpret sensor signals and use them to execute precise motion control commands.

This paper presents an approach to developing a parking control model for a mobile robot based on ultrasonic sensors, along with results from experimental evaluations of the system's performance in both simulated and real-world conditions.

Review of recent studies and publications. Contemporary research in mobile robot control demonstrates a growing interest in low-cost and reliable sensor solutions, such as ultrasonic sensors, to support accurate positioning, obstacle detection, and autonomous parking functionality. The reviewed academic sources cover a range of approaches to sensor integration, algorithmic control, and the evaluation of autonomous navigation system accuracy. The first two references are particularly foundational, as they systematize key methods and examine the potential of ultrasonic systems in real-world applications, especially in environments with spatial or resource constraints.

In [1], the authors analyze modern sensor systems used for obstacle detection in mobile robotics. The study focuses on comparing ultrasonic sensors, LiDAR, infrared sensors, and cameras. Ultrasonic sensors are identified as the most effective for short-range navigation, especially when computational resources or budget are limited. The authors conclude that ultrasonic sensors offer the lowest energy consumption and cost, and high indoor reliability, but can be affected by surfaces that strongly absorb sound. The review in [2] explores a broad range of applications for ultrasonic sensors, including robotics, automotive ADAS systems, security systems, and smart cities. In the context of robotics and autonomous parking, ultrasonic sensors are highlighted as the best solution for short-distance measurement and object detection. The study also notes that combining them with other sensors (infrared, magnetic, cameras) significantly improves system stability and adaptability in complex environments. Studies [3] and [4] focus on emerging technologies that enhance traditional applications of ultrasonic sensors in mobile robotics, particularly in the domain of autonomous parking. These works highlight the transition from simple two-dimensional systems to volumetric sensing approaches, which open new possibilities for achieving full autonomy in real-world-like environments. Study [3] addresses a new generation of ultrasonic sensors designed to provide three-dimensional coverage of the space surrounding a mobile robot. Specifically, it explores Acoustic Detection and Ranging (ADAR) systems, which enable 360-degree spatial perception without the need for rotating mechanisms or complex optical setups. One of the key advantages of these sensors lies in their significantly lower cost compared to traditional LiDAR solutions: a single ADAR module is priced at approximately $1,000, whereas a conventional 2D LiDAR system may cost $4,000 or more. In addition to affordability, the authors emphasize safety advancements – ADAR sensors are certified under IEC 61508 (SIL2), making them suitable for use in industrial and commercial autonomous platforms. The experimental section presents results of implementing ADAR sensors in an autonomous mobile device with a fully integrated obstacle-avoidance system during parking maneuvers. Even in conditions involving irregularly reflective surfaces, the sensor demonstrated stable performance, whereas conventional ultrasonic modules with single-plane detection suffered from accuracy loss or false positives. This publication, therefore, underlines the relevance of transitioning toward multi-angle ultrasonic arrays or volumetric solutions for autonomous parking applications in mobile platforms.

Study [4] has a practical focus and provides technical insights into ADAR system design for mobile robot developers. It presents the advantages of a new acoustic radar architecture that relies not on the classic conical emission diagram, but on analytical reconstruction of the acoustic wave in space. By minimizing mechanical components and increasing the data refresh rate (up to 100 Hz in scanning mode), the system significantly improves obstacle detection stability during rapid maneuvers. The authors also emphasize the economic impact: a configuration using four ADAR modules effectively replaces two full-scale LiDAR units, resulting in an overall cost reduction of 60–80%. Practical examples include configurations for logistics-class robots, where the parking system operates based on a 3D ultrasonic map of the environment. Unlike traditional systems that require prior map alignment, the new system performs local spatial reconstruction and does not rely on external references. Consequently, this publication not only confirms the potential of 3D ultrasonic sensors but also serves as a technical foundation for their integration into next-generation mobile robot parking control solutions.

In [5], the authors propose a fundamentally novel approach to sensor integration: instead of mounting ultrasonic sensors on the robot body or masts, the sensing elements are embedded directly into the wheels of the mobile platform. This configuration creates an acoustic canalization system that combines contact-based and contactless sensitivity. The paper presents a technical description of the sensor architecture: a piezoelectric element embedded in the wheel rim generates acoustic waves that propagate through the tire and reflect from the surface with which the wheel makes contact. By analyzing the acoustic response, the system can determine the type of surface, detect micro-obstacles, and even localize the initial point of contact with a wall or other object. Experimental results demonstrate that the robot was able to accurately detect changes in ground material without the assistance of cameras or conventional sensors. This opens new prospects for parking systems operating under low-light, dusty, or confined conditions, where ultrasonic reflection from walls offers advantages over optical systems. The authors emphasize that such tactile ultrasonic sensing could serve as a backup system for registering real contact with obstacles during parking maneuvers, significantly reducing the risk of mechanical damage to the platform.

In [6], the authors investigate the deployment of multiple ultrasonic localization systems in a single environment without prior calibration. A common challenge for autonomous robots relying on ultrasonic beacons is the need for precise manual placement and calibration of those beacons. In response, the authors propose the SCAN algorithm, which enables a robot to simultaneously build an environmental map and automatically calibrate beacon positions based solely on signals received from the ultrasonic sources. To process signals and estimate position, the study employs Extended Kalman Filters (EKF), Weighted Least Squares Error filters, and Unscented Kalman Filters (UKF). A series of indoor experiments using a TurtleBot platform demonstrated that the SCAN approach reduces localization error by half compared to traditional ULPS without self-calibration. In the context of parking, this system enables the mobile robot to adaptively orient itself even in environments with dynamic spatial configurations – such as temporarily relocated or occluded beacons – which is especially valuable in settings like warehouses, parking areas, or logistics hubs. In [7], the authors present an IoT-based parking system that integrates various sensors (IR, ultrasonic, DHT22, MQ-2), an OLED display, and a mobile application connected via MQTT. The system provides real-time monitoring of parking slot availability and supports automation features.

The reviewed publications illustrate current trends in the development of sensor systems and control algorithms for mobile robots in the context of autonomous parking. The combination of traditional ultrasonic sensing principles with novel architectural and algorithmic approaches significantly extends the capabilities of autonomous parking, enhances system adaptability, and brings mobile robots closer to fully independent operation in complex and dynamic environments.

The purpose of this work is to generalize, systematically analyze, and critically evaluate contemporary approaches to the design of mobile robot parking control systems based on distance sensor data. Special attention is given to the comparison of sensor configurations, control model types, decision-making algorithms, and system architectures, with the aim of identifying their advantages, limitations, and potential for practical implementation in real-world environments.

Main part

In contemporary scientific and technical literature, several principal approaches have emerged for developing models of parking control for mobile robots. These approaches differ in terms of the level of mathematical formalization, the type of input data used, algorithmic structures, and adaptation to specific technical conditions such as chassis configuration, environmental characteristics, and sensor types. Despite their differences, all methods share a common objective: to ensure stable, accurate, and safe insertion of the robot into a predefined parking position within a constrained and obstacle-filled environment.

One of the most prominent categories includes kinematic models with feedback control. These models describe the motion of the mobile robot using differential equations that account for orientation and velocity. Based on a typical model (e.g., $x = \cos(x)$, $y = \sin(x)$, $\theta = w$) a controller (proportional, fuzzy, model predictive control, or neural network-based) adjusts the robot's trajectory by computing the deviation from the desired parking pose. This method offers mathematical precision but is sensitive to sensor noise and irregular parking area geometry.

Another widely used approach is the motion-pattern-based model. In this case, predefined maneuver templates – such as arcs, reverse curves, or pivot turns – are selected based on the geometric layout derived from sensor input. This method is especially suitable for low-computation environments or systems with limited degrees of freedom.

Trajectory-planning algorithms represent a third class of models, where the robot's path is generated using search-based techniques such as A*, D*, RRT, Hybrid A*, or their heuristic-enhanced variants. These methods operate in either coordinate space or configuration space, accounting for kinematic constraints, and enable the construction of smooth, optimal, or safe paths in complex environments. However, they often require considerable computational resources.

Decision-making in uncertain or noisy environments is frequently addressed through fuzzy logic, where behavior is governed by a set of “if-then” rules. While highly adaptive and robust to incomplete data, such systems are less amenable to formal optimization.

An increasingly popular direction involves deep learning-based methods, where the robot’s behavior is trained on large datasets. These include neural networks for situation classification, regression models for coordinate estimation, and reinforcement learning for acquiring parking maneuvers through trial and error. Hybrid models aim to combine the strengths of the above techniques – for example, initiating entry with motion templates and refining the final trajectory using A* planning or fuzzy controllers. The choice of a suitable parking control model for a mobile robot largely depends on the platform type, environmental complexity, required precision, reaction time constraints, and available sensor data. Ultrasonic sensors, although limited in spatial resolution, enable effective implementation of adaptive or fuzzy control strategies under constrained computational budgets. Next, we turn to the comparative analysis of sensors used for autonomous parking of mobile robots. Sensor selection plays a critical role in obstacle detection, spatial awareness, and accurate environmental mapping. The most common types in such systems are ultrasonic sensors, infrared sensors, LiDAR, and cameras – each with distinct advantages, limitations, and performance characteristics that directly impact overall system accuracy and reliability.

Ultrasonic sensors operate by measuring the time-of-flight of acoustic waves reflected from surrounding objects. They perform well for short-range obstacle detection, offering low cost, ease of integration, and stable performance in indoor environments. Ultrasonic systems are less affected by lighting conditions, making them reliable for shaded or enclosed spaces. However, their accuracy is limited, particularly when detecting soft or angled surfaces that absorb or scatter the sound waves. They also have a wide field of view, which complicates precise localization and may cause false positives due to multipath reflections in cluttered environments.

Infrared sensors, which detect reflected or absorbed thermal radiation, offer high accuracy at very short ranges. They are suitable for detecting nearby objects or edges, but their performance degrades under variable lighting or when interacting with materials that poorly reflect IR radiation (e.g., glass, dark, or shiny surfaces). As a result, IR sensors are rarely used as primary components in complex parking systems but may serve as auxiliary sources of localized information.

LiDAR systems provide significantly higher distance-measurement precision using laser beams to construct point clouds of the environment. They can capture detailed 2D or 3D models, making them indispensable in autonomous vehicles and robots operating in dynamic or unstructured environments. However, LiDAR is expensive, energy-intensive, and requires advanced data processing. Moreover, performance may be affected by adverse weather, dust, moisture, or glass surfaces, which scatter or attenuate the laser signal.

Camera systems, including RGB, stereo, or depth cameras, offer the most versatile means of environmental perception. They capture object contours and colors while enabling scene interpretation, marker recognition, spatial estimation, and object classification. When combined with computer vision or deep learning algorithms, cameras become powerful tools for navigation. Nevertheless, their range estimation is limited without specialized processing (e.g., stereo vision), and they are highly sensitive to lighting conditions. Poor illumination, glare, backlighting, or shadows can degrade image quality and compromise algorithmic performance.

Sensor Type	Ultrasonic	Infrared	LiDAR	Camera
Operating Principle	Sound wave reflection	Infrared light reflection	Laser scanning	Image processing
Range (m)	0.02 – 3	0.01 – 0.8	0.1 – 100+	0.5 – 10+
Accuracy	Low–Medium	High (short range)	High	Medium–High
Resistance to Interference	High (indoors)	Low	Medium	Low–Medium
Cost	Low	Very low	High	Medium
Suitability for Parking	Good	Limited	Excellent	Excellent (hybrid use)

Fig. 1. Comparative analysis of sensors

Fig. 1 presents a comparative table of four types of sensors commonly employed in mobile robot parking systems. It summarizes the key technical characteristics of ultrasonic, infrared, LiDAR sensors, and visual cameras, focusing on parameters that influence system accuracy, stability, and operational efficiency.

Each sensor type demonstrates specific strengths and is most effective under operating conditions. Ultrasonic sensors are optimal for basic parking tasks in enclosed or structured environments. Infrared sensors are well-suited for short-range object detection and can serve as auxiliary detectors. LiDAR offers the highest spatial resolution, but its use is justified primarily in resource-intensive systems capable of advanced data processing. Cameras provide the most comprehensive scene understanding but are highly sensitive to environmental factors and computational demands. In practice, hybrid sensor configurations – combining multiple modalities – prove to be the most effective, as they allow compensation for individual sensor limitations and enable system adaptability in dynamic or complex environments.

The classification of decision-making algorithms used in mobile robot parking systems constitutes an important analytical task. It allows researchers to evaluate how sensor input, particularly distance measurements, is transformed into specific actuator commands and to assess the adaptability of each approach to different environmental conditions. Based on complexity, adaptability, and logical structure, decision-making algorithms can be categorized into several conceptual types.

One of the simplest yet most widely adopted approaches is the rule-based system. In this case, the robot's behavior is described through predefined conditional statements, such as: "if the front distance is < 30 cm, then stop; if the right sensor detects free space, then initiate a right turn." These systems are easy to implement and computationally inexpensive, but they offer limited flexibility and perform poorly in unpredictable scenarios.

A more structured approach is the finite state machine (FSM), in which the parking process is divided into discrete states, each associated with specific transition conditions based on sensor data. FSM-based systems enable the development of logically structured, stable, and predictable algorithms. However, their scalability is limited, as the number of states and transitions increases exponentially with scenario complexity.

Fuzzy logic systems offer a more adaptive approach by formulating rules with linguistic variables and fuzzy sets, rather than strict numerical thresholds. For instance: "if the distance ahead is short and the left distance is moderate, then gently steer right." Such systems provide flexible responses to sensor input and perform well under conditions with high measurement noise. However, they require manual tuning of membership functions and rule validation, which can be complex and time-consuming.

A contemporary trend in decision-making for robotic systems is the use of machine learning methods [8], including deep neural networks and reinforcement learning algorithms. These models learn decision-making strategies from extensive datasets or through environmental interaction. They can recognize spatial patterns, evaluate the suitability of parking spots, and predict optimal maneuvers based on historical experience. Their advantages lie in generalization capabilities and adaptability to novel situations. Nevertheless, they demand large training datasets, significant computational power, and often lack interpretability compared to traditional logic-based systems.

Hybrid approaches are increasingly adopted to combine the advantages of different paradigms. For example, rule-based logic may be used to govern safety-critical behaviors, while machine learning components handle adaptive planning. Alternatively, FSMs may incorporate fuzzy control modules within individual states. Such integration ensures both stability and predictability while enhancing flexibility and the capacity for autonomous learning.

Fig. 2 presents a table of effectiveness criteria for mobile robot parking control systems. It summarizes four key parameters used to evaluate the performance quality of such systems. Positioning accuracy is measured as the deviation from the target parking location, with deviations under 5 cm considered indicative of high-precision platforms. Energy consumption refers to the power used per parking maneuver, where values below 10 W are acceptable for battery-powered robots. Adaptability reflects the system's ability to respond to changing environmental conditions – an especially critical requirement in hybrid systems operating in dynamic or unpredictable spaces. Response time denotes how quickly the system initiates action following a command trigger, with values under 2 seconds deemed suitable for real-time operation.

Criterion	Evaluation Method	Typical Values	Relevant System Types
Positioning Accuracy	Distance to parking target	< 5 cm deviation	High-precision robots
Energy Consumption	Power usage per maneuver	< 10 W per task	Battery-powered platforms
Adaptability	Ability to handle environment changes	High in hybrid systems	Dynamic environments
Response Time	Time from trigger to action	< 2 s transition	Real-time systems

Fig. 2. A table of effectiveness criteria for mobile robot parking control systems

The classification of decision-making algorithms illustrates the evolution from simple logical constructs to intelligent, adaptive systems. Each approach occupies its own niche of effectiveness, and the selection of an appropriate algorithm depends on the complexity of the operating environment, the types of available sensors, computational capabilities, and the reliability requirements of the parking control system.

Another critical aspect is the choice of system architecture and the criteria by which its effectiveness is evaluated. In mobile robot parking control systems, architecture defines how sensors, computational modules, and actuators are integrated to implement the full perception-to-action cycle. The most common design follows a three-layer structure: the sensing layer (data acquisition), the decision-making layer (processing and planning), and the actuation layer (command execution). The effectiveness of such systems is assessed based on several criteria, including positioning accuracy within the parking space, maneuver execution speed, adaptability to environmental changes, energy efficiency, and fault tolerance. The closer the integration between sensory and computational components and the more responsive the system is to dynamic changes, the more effective the architecture is considered.

Conclusions

During this study, a comprehensive analysis was conducted on current approaches to modeling mobile robot parking control systems based on distance sensor data, with particular emphasis on ultrasonic sensors. The review synthesizes system architectures, algorithmic strategies, types of sensor configurations, and key criteria for evaluating the effectiveness of autonomous parking. It has been shown that ultrasonic sensors, due to their simplicity, affordability, and reliability in short-range detection, remain a core component of many parking systems, especially in constrained environments and platforms with limited computational resources. At the same time, other sensors, such as infrared detectors and visual cameras, offer significant advantages in terms of accuracy, sensing range, and adaptability, making them essential for integration into hybrid or high-precision systems.

The review has examined key decision-making methodologies, including rule-based logic, finite state machines, fuzzy logic, and machine learning techniques. Each of these has proven effective in specific applications, ranging from simple reactive behaviors to self-learning strategies suitable for complex, dynamic environments. Hybrid models that combine classical logic with adaptive elements are particularly promising for achieving autonomous parking in real-world settings.

Furthermore, system architectures were analyzed with a focus on how effectively sensory input, processing logic, and actuation are integrated. Key performance indicators include parking precision, robustness to external disturbances, response speed, energy consumption, and adaptability. The most effective architectures are those that support real-time responsiveness, tolerate uncertainty, and ensure operational robustness.

In conclusion, the development of an intelligent, flexible, and reliable mobile robot parking control model constitutes a multi-layered engineering challenge. It encompasses both hardware and algorithmic components and requires an interdisciplinary approach to achieve a robust and deployable solution.

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Моделі управління паркуванням мобільного роботу на основі даних від датчика відстані

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Анотація. Актуальність. Зростаюча потреба в автономних мобільних системах, здатних до самостійного орієнтування і паркування, обумовлена кількома вагомими факторами. По-перше, активна роботизація у сферах логістики, охорони, доставки та обслуговування потребує надійних механізмів для точного позиціонування мобільних платформ у просторово обмежених середовищах. По-друге, у контексті розвитку безпілотного транспорту проблема автоматичного паркування набуває пріоритетного значення для підвищення рівня безпеки, зниження енергоспоживання та мінімізації участі людини в управлінні. Нині існує велика кількість досліджень, спрямованих на реалізацію систем автоматичного паркування, однак більшість з них або базуються на високовартісних сенсорах (лідарах, камерах з глибоким навчанням), або не забезпечують необхідної точності в умовах динамічних або незнайомих середовищ. На цьому тлі використання ультразвукових датчиків становить ефективну альтернативу, що дозволяє забезпечити необхідний рівень адаптивності та чутливості при збереженні низької вартості системи. Актуальність дослідження підкріплюється необхідністю створення універсальної моделі управління, яка могла б бути масштабованою, адаптивною та легко інтегруватися в різні типи мобільних платформ. У роботі приділяється особлива увага не лише теоретичному опису управлінської моделі, але й експериментальній перевірці її ефективності на основі даних від ультразвукових сенсорів, що відображають фі-зичне середовище у режимі реального часу. Таким чином, розробка моделі управління паркуванням мобільного ро-бота на основі ультразвукових датчиків є актуальним завданням, яке поєднує в собі як наукову новизну, так і практичну значущість для подальшого розвитку автономних систем. **Об'єкт дослідження**: система управління паркуванням мобільного робота, що функціонує на основі даних, отриманих від ультразвукових датчиків відстані. Ця система включає в себе як апаратні компоненти (ультразвукові сенсори, виконавчі механізми, контролери), так і програмне забезпечення, що реалізує алгоритми аналізу навколишнього середовища, прийняття рішень щодо паркувального маневру та керування рухом. **Мета статті** дослідження сучасних моделей управління паркуванням мобільного робота, що функціонують на основі даних від сенсорів відстані, з метою виявлення ефективних підходів до сенсорного забезпечення, алгоритмічного керування та архітектурної реалізації таких систем, а також визначення перспектив їх розвитку для забезпечення точності, надійності та адаптивності в умовах реального середовища. **Результати дослідження**. У результаті проведеного оглядового дослідження було встановлено, що в сучасних системах управління паркуванням мобільних роботів існує широкий спектр підходів до моделювання, які відрізняються як за рівнем математичної складності, так і за типом сенсорного забезпечення. Виявлено, що вибір моделі безпосередньо пов’язаний із рівнем доступу до обчислювальних ресурсів, типом шасі робота та природою середовища, в якому він функціонує. Окрему увагу приділено порівнянню сенсорів, з яких саме ультразвукові сенсори продовжують домінувати у системах короткодистанційного позиціонування завдяки своїй низькій вартості, простоті інтеграції та надійності в контрольованих умовах. Водночас сенсори LiDAR продемонстрували найвищу точність і просторову інформативність, хоча й залишаються складнішими у реалізації та обслуговуванні. Камери та інфрачервоні сенсори розглянуто як додаткові джерела інформації, які ефективно працюють лише в межах чітко визначених умов і при належному програмному забезпеченні. Результати огляду підтвердили, що ефективна система управління паркуванням мобільного робота базується на комплексному підході до вибору сенсорів, моделі керування, алгоритмічного забезпечення та архітектурної реалізації. Це дає змогу досягти високої точності та надійності функціонування навіть у складних, нестабільних або обмежених середовищах. **Висновки**. Ефективне управління паркуванням мобільного робота ґрунтується на поєднанні надійного сенсорного забезпечення, зокрема ультразвукових датчиків, і адаптивних алгоритмів прийняття рішень. Ультразвукові сенсори залишаються оптимальними для недорогих і простих систем, тоді як гібридні підходи з використанням LiDAR або камер забезпечують вищу точність. Серед алгоритмів найбільш ефективними виявились FSM, нечітка логіка та методи машинного навчання. Оптимальною є модульна архітектура з чітким поділом сенсорного, обчислювального та виконавчого рівнів, що забезпечує адаптивність, точність і стабільність роботи системи в реальних умовах.

Ключові слова: мобільний робот, автономне паркування, ультразвукові датчики, сенсорне забезпечення, алгоритми прийняття рішень, скінченний автомат, нечітка логіка, машинне навчання, керування рухом, система навігації.