Acumen: International Journal of Multidisciplinary Research
ISSN: 3060-4745 IF(Impact Factor)10.41 / 2024
Volume 2, Issue 3

A SMALL-SIZED MOBILE ROBOT DEVELOPMENT

Kateryna Nimets[1], Amer Abu-Jassar[2], Svitlana Maksymova[1], Vladyslav Yevsieiev[1]

[1]Department of Computer-Integrated Technologies, Automation and Robotics, Kharkiv National University of Radio Electronics, Ukraine

[2]Department of Computer Science, College of Information Technology, Amman Arab University, Amman, Jordan

Abstract

The article considers an example of assembling a small-sized mobile robot. The main principles that distinguish a robot from other intelligent devices are considered. The types of parts that must be in each such robot are also given. The main stages of assembling a mobile robot are presented with photographs.

Keywords: Mobile Robot, Small-Sized Mobile Robot, Wheel, ESP32-Cam, Assembly.

Introduction

In the modern world, the principles of the Industry 4.0 concept have become widespread [1]-[12]. The main one of its provisions is the widespread use of robots [13]-[25]. Based on today's realities, the development of small-sized mobile robots is becoming extremely relevant. Modern small-sized mobile robots are one of the most promising branches of robotics. They are used in various areas: from everyday life to scientific research, and their popularity is due to compactness, high maneuverability and accessibility of technologies. These robots are characterized by the use of various technical means and materials that ensure their functionality. Such robots, in addition to conventional use, find their purpose for military purposes. These include the analysis and study of rubble, especially in buildings made of reinforced concrete structures and panels. Small-sized robots can also be used for mining and demining territories. And here various methods and algorithms can be used, both for justifying such robots and for making decisions during their work [26]-[42].

It should be noted that one of the main conditions is the low cost of such a robot and the possibility of remote control. In this case, preference is given to the use of Wi-Fi technology, rather than Bluetooth, due to its greater range.

Related works

Many modern scientists are developing small-sized robots. Research is conducted in various directions: from creating a design to developing various control systems. Let's consider several recent scientific works on this topic.

The scientists in [43] developed a a small-sized quadruped robotic rat (SQuRo), which includes four limbs and one flexible spine. The results obtained through a series of experimental tests reveal that SQuRo achieves a superior motion performance compared with existing state-of-the-art small-sized quadruped robots.

The paper [44] focuses on the features of transport (locomotion) systems of mobile mini-robots (MMR), i.e., small unmanned ground vehicles of a portable type measuring several tens of centimeters and weighing no more than 15 kg.

Quan, X., and co-authors in [45] also consider a SQuRo. They note that small-scale quadruped robots have limited payloads and thus cannot carry sufficient sensing and computational resources, which imposes limitations on their environmental adaptability. They proposed an efficient closed-loop adaptive controller by simplified pose estimation and control strategy that utilizes only inertial measurement unit sensors, which drastically reduces the control computation.

The study [46] focuses on computer vision system for a small-sized mobile humanoid robot development. The decentralization of the servomotor control and the computer vision systems is investigated based on the hardware solution point of view, moreover, the required software level to achieve an efficient matched design is obtained.

Gao, J., & et al. in [47] ntegrated the inertial measurement unit into the small-sized robotic rat SQuRo, and proposed simplified control strategies to enhance its robustness in order to ensure high environmental adaptability and promising applications.

Researchers in [48] use a low-cost small-scale mobile robot for monitoring temperature. It is equipped with a thermal scanning platform. They claim that robotics system has the potential to revolutionize thermal monitoring of buildings and enable energy characterization through thermal models.

So we see a wide variety of research in the field of the development and use of small-scaled robots in various fields. Further in this article we will look at the assembly of such a robot.

A small-sized mobile robot assembling

Modern robots are equipped with complex sensory systems that allow them to analyze the environment, make independent decisions and adapt to changing conditions. Thanks to the use of machine learning algorithms and artificial intelligence, robots are able to build behavioral models that ensure the performance of even non-standard tasks.

The main characteristics that distinguish robots from other intelligent devices:

1. SENSE. The robot is able to obtain data about the environment through sensors such as microphones, cameras, infrared, electromagnetic or electromechanical sensors.
2. THINK. The robot analyzes the collected information, models the environment and makes decisions to achieve the set goal. This is possible thanks to algorithms that allow you to assess the situation and adjust actions in real time..
3. ACT. A robot influences the external environment using actuators such as manipulators, actuators, or mobile platforms.

Wheeled robots are a type of robot that uses wheels for movement. They are characterized by high maneuverability, speed of movement and simplicity of design. The main components of a wheeled robot:

– Housing. Serves as the basis for all other components. It is made of various materials (plastic, metal) and can have a variety of shapes.

– Wheels. Ensure the movement of the robot. Can be of different diameters, have different tread patterns and be made of different materials.

– Motors. Convert electrical energy into mechanical energy, setting the wheels in motion.

– Microcontroller. A component of the robot that controls all its functions.

– Sensors. Allow the robot to navigate in space, avoid obstacles, and determine the distance to objects. The most common sensors are ultrasonic, infrared, laser, lidar.

– Batteries. Ensure the operation of the robot's electronics.

– Drivers. Control the operation of the motors.

Wheeled robots equipped with cameras are extremely popular due to their effectiveness in performing tasks related to computer vision, autonomous navigation, and interaction with the environment. Such robots are used in scientific research, education, logistics, everyday life, and other fields.

Acumen: International Journal of Multidisciplinary Research
ISSN: 3060-4745 IF(Impact Factor)10.41 / 2024
Volume 2, Issue 3

To implement a small-sized mobile robot, it is important to consider in detail the hardware components used and the process of their assembly. This section presents the key elements of the robot design, as well as step-by-step instructions for its creation, which will ensure the reliability and functionality of the device.

Elegoo Robot Car Kit is a universal kit for assembling a mobile robot, containing the main hardware components that ensure its functionality.

The basis of the robot are two acrylic plates, marked "A" and "B" - Top Plate (top plate) and Bottom Plate (bottom plate), respectively. It is quite easy to distinguish them - the top plate A has an additional hole for the SG90 servo.

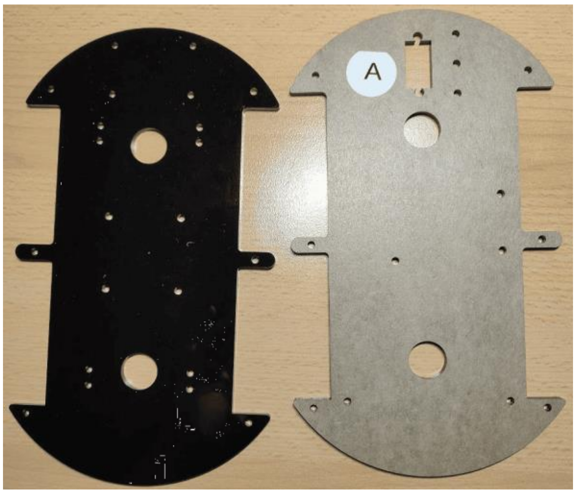

Figure 1: Acrylic robot plates

After removing the protective film, it is necessary to assemble the four motors and install them on the bottom plate (Fig. 2).

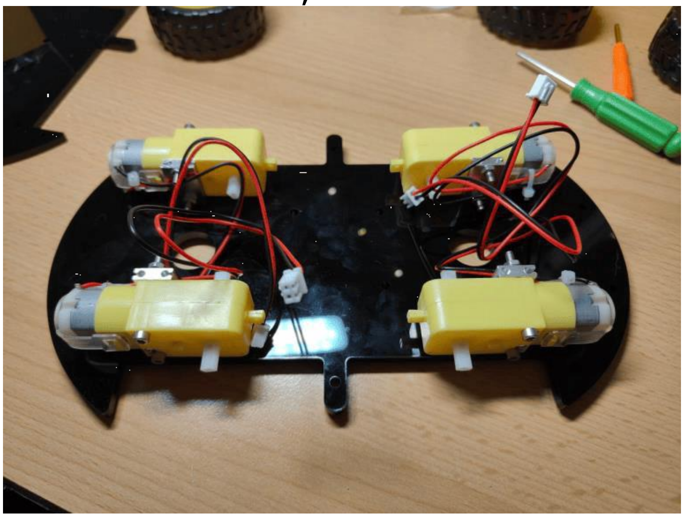

Figure 2: Installing motors on the plate

Next, you need to install the line following module on the bottom plate. The sensor consists of three infrared sensors (Fig. 3), which allow the robot to follow a black line on a light background, providing the line tracking function.

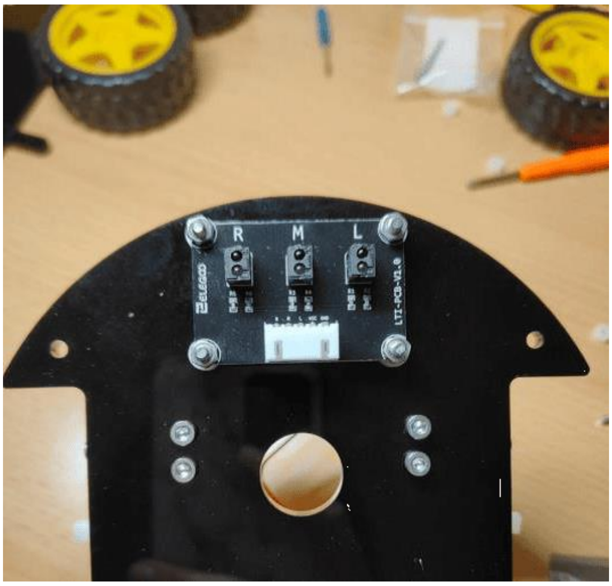

Figure 3: Line following module

We install the GY-521 module on the expansion board. The GY-521 is an accelerometer and gyroscope module based on the MPU-6050, which allows you to measure acceleration and angular velocity, providing data on the inclination and movement of the robot. The OI expansion board (V5.0 Expansion Board) is used to conveniently connect various modules and sensors to the UNO R3 board, simplifying the assembly process and preventing errors during connection.

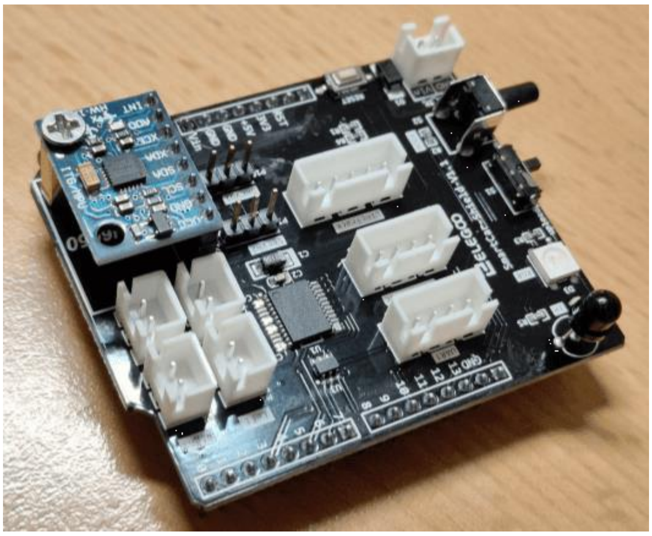

Figure 4: GY-521 module and expansion board

We install the UNO R3 board (Fig. 5) on the top plate and connect the expansion board with the GY-521 module to it (Fig. 6). UNO R3 is an ATmega328P-based microcontroller board compatible with Arduino. It provides control of all robot modules and is programmed via the Arduino IDE.

ISSN: 3060-4745 IF(Impact Factor)10.41 / 2024
Volume 2, Issue 3

Figure 5: UNO R3 board installed

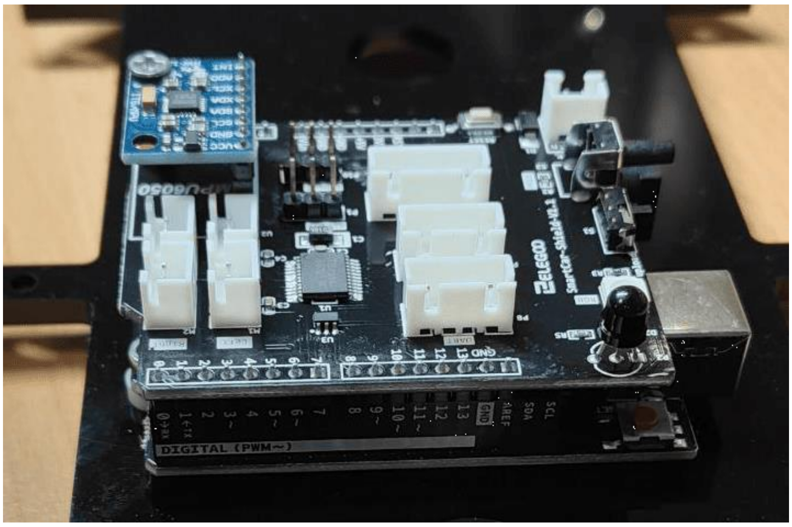

Figure 6: Connecting modules to the board

To create a computer vision system and for the robot to perceive information from the outside, it is necessary to install the following modules on a fixed platform: the ESP-32 Cam camera module, the ultrasonic sensor module and the Servo SG90 microservo.

ESP32-CAM is a module with an OV2640 camera, built on the basis of the ESP32 microcontroller. It has Wi-Fi and Bluetooth capabilities, which makes it the right choice for video surveillance, face recognition and IoT projects.

HC-SR04 is an ultrasonic distance sensor used to detect obstacles in the path of the robot. It measures the distance to objects and helps to avoid collisions.

The SG90 microservo is used to rotate the ultrasonic sensor, providing the robot with the ability to scan the space in front of it and detect obstacles at different angles.

After assembly, we install the elements on the top plate, having previously attached to it a battery compartment with a lithium battery, which provides power and operation of the robot for approximately 2 hours in line tracking mode.

ISSN: 3060-4745 IF(Impact Factor)10.41 / 2024
Volume 2, Issue 3

Figure 7: Modules installed on the top plate

Next, we assemble the entire robot body, connect the motors and all elements to the UNO R3 board, and attach the wheels to the motors.

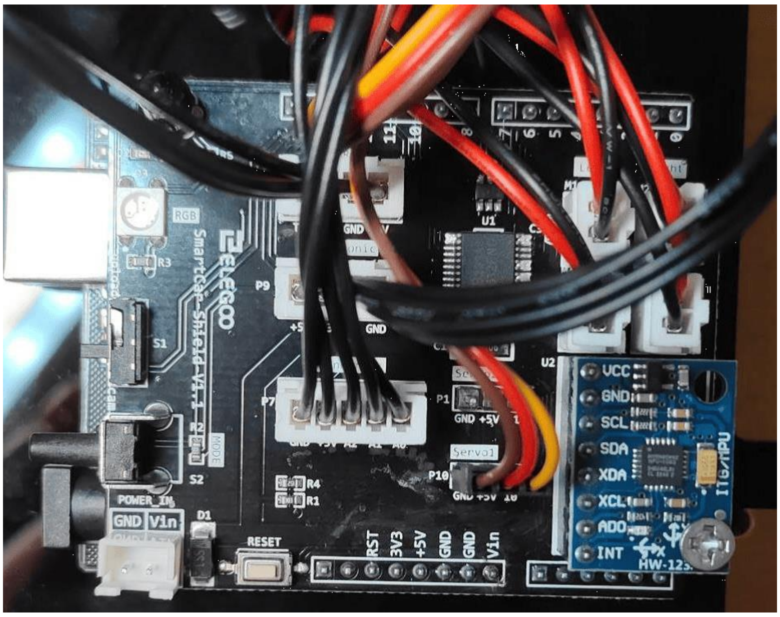

Figure 8: Connecting modules to the UNO R3 board

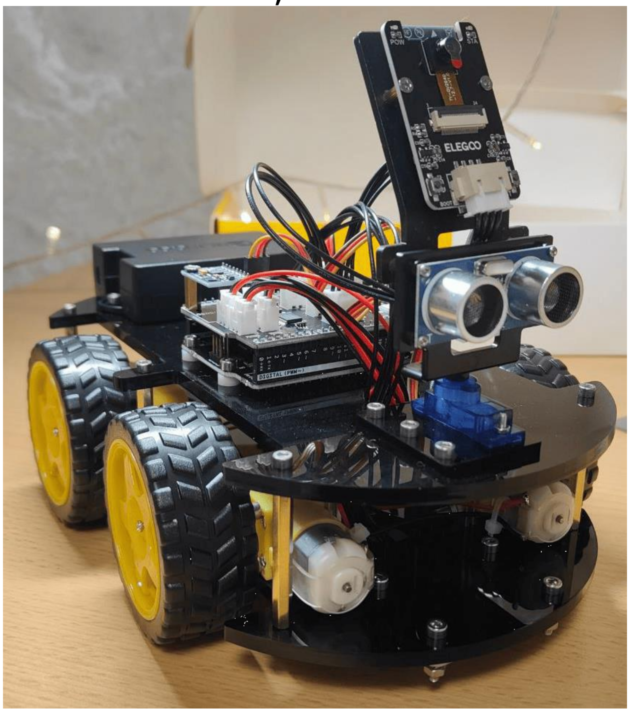

Figure 9: General view of a small mobile robot

Conclusion

In accordance with the principles of the Industry 4.0 concept, robots are increasingly penetrating all spheres of human life. It should be noted that for different areas of application, different criteria for selecting both hardware and software for robots are used. In particular, small-sized mobile robots are used in active combat situations. They can be used both for examining rubble, including searching for victims, fires, etc., and for mining/demining and similar tasks. It should be taken into account that one of the key requirements for such robots is low cost.

A selection of hardware components was made to create a robot prototype, in particular, the use of an ESP32-CAM camera and an Elegoo Uno R3 controller, which provided an optimal ratio of performance and cost.

A wheeled mobile robot design was selected with the possibility of additional integration of sensors and modules to expand functionality.

References

1. Yevsieiev, V. V., & et al. (2023). A Small-Scale Manipulation Robot a Laboratory Layout Development. International independent scientific journal, 47, 18-28.

2. Nevliudov, I., & et al. (2023). A Small-Sized Robot Prototype Development Using 3D Printing. Faculty of mechanical engineering bialystok university of technology. CAD In Machinery Design Implementation and Educational Issues (CADMD'2023), Suprasl, 12.
3. Kuzmenko, O., & et al. (2024). Robot Model For Mines Searching Development. Multidisciplinary Journal of Science and Technology, 4(6), 347-355.
4. Maksymova, S., & et al. (2024). Balancing System For A Zoomorphic Spot Type Mobile Robot Development Using An Accelerometer MPU 6050 (GY-521). In 2024 IEEE 19th International Conference on the Perspective Technologies and Methods in MEMS Design (MEMSTECH), IEEE, 39-42.
5. Yevsieiev, V., & et al. (2024). The Canny Algorithm Implementation for Obtaining the Object Contour in a Mobile Robot's Workspace in Real Time. Journal of Universal Science Research, 2(3), 7–19.
6. Gurin, D., & et al. (2024). Using Convolutional Neural Networks to Analyze and Detect Key Points of Objects in Image. Multidisciplinary Journal of Science and Technology, 4(9), 5-15.
7. Samoilenko, H., & et al. (2024). Review for Collective Problem-Solving by a Group of Robots. Journal of Universal Science Research, 2(6), 7-16.
8. Chala, O., & et al. (2024). Analysis of Systems for Coordination of Enterprise Subsystems Control. Journal of universal science research, 2(10), 127-137.
9. Maksymova, S., & et al. (2024). The Bipedal Robot a Kinematic Diagram Development. Journal of Universal Science Research, 2(1), P. 6–17.
10. Yevsieiev, V., & et al. (2024). Building a traffic route taking into account obstacles based on the A-star algorithm using the python language. Technical Science Research In Uzbekistan, 2(3), 103-112.
11. Gurin, D., & et al. (2024). Using the Kalman Filter to Represent Probabilistic Models for Determining the Location of a Person in Collaborative Robot Working Area. Multidisciplinary Journal of Science and Technology, 4(8), 66-75.
12. Mustafa, S. K., Yevsieiev, V., Nevliudov, I., & Lyashenko, V. (2022). HMI Development Automation with GUI Elements for Object-Oriented Programming Languages Implementation. SSRG International Journal of Engineering Trends and Technology, 70(1), 139-145.
13. Attar, H., Abu-Jassar, A. T., Amer, A., Lyashenko, V., Yevsieiev, V., & Khosravi, M. R. (2022). Control system development and implementation of

ISSN: 3060-4745 IF(Impact Factor)10.41 / 2024
Volume 2, Issue 3
a CNC laser engraver for environmental use with remote imaging. Computational intelligence and neuroscience, 2022(1), 9140156.
14. Abu-Jassar, A. T., Al-Sharo, Y. M., Lyashenko, V., & Sotnik, S. (2021). Some Features of Classifiers Implementation for Object Recognition in Specialized Computer systems. TEM Journal: Technology, Education, Management, Informatics, 10(4), 1645-1654.
15. Al-Sharo, Y. M., Abu-Jassar, A. T., Sotnik, S., & Lyashenko, V. (2021). Neural networks as a tool for pattern recognition of fasteners. International Journal of Engineering Trends and Technology, 69(10), 151-160.
16. Abu-Jassar, A. T., Attar, H., Yevsieiev, V., Amer, A., Demska, N., Luhach, A. K., & Lyashenko, V. (2022). Electronic user authentication key for access to HMI/SCADA via unsecured internet networks. Computational intelligence and neuroscience, 2022(1), 5866922.
17. Sotnik, S., Mustafa, S. K., Ahmad, M. A., Lyashenko, V., & Zeleniy, O. (2020). Some features of route planning as the basis in a mobile robot. International Journal of Emerging Trends in Engineering Research, 8(5), 2074-2079.
18. Nevliudov, I., Yevsieiev, V., Baker, J. H., Ahmad, M. A., & Lyashenko, V. (2020). Development of a cyber design modeling declarative Language for cyber physical production systems. J. Math. Comput. Sci., 11(1), 520-542.
19. Baker, J. H., Laariedh, F., Ahmad, M. A., Lyashenko, V., Sotnik, S., & Mustafa, S. K. (2021). Some interesting features of semantic model in Robotic Science. SSRG International Journal of Engineering Trends and Technology, 69(7), 38-44.
20. Lyashenko, V., Abu-Jassar, A. T., Yevsieiev, V., & Maksymova, S. (2023). Automated Monitoring and Visualization System in Production. International Research Journal of Multidisciplinary Technovation, 5(6), 9-18.
21. Matarneh, R., Maksymova, S., Deineko, Z., & Lyashenko, V. (2017). Building robot voice control training methodology using artificial neural net. International Journal of Civil Engineering and Technology, 8(10), 523-532.
22. Nevliudov, I., Yevsieiev, V., Lyashenko, V., & Ahmad, M. A. (2021). GUI Elements and Windows Form Formalization Parameters and Events Method to Automate the Process of Additive Cyber-Design CPPS Development. Advances in Dynamical Systems and Applications, 16(2), 441-455.
23. Maksymova, S., Matarneh, R., Lyashenko, V. V., & Belova, N. V. (2017). Voice Control for an Industrial Robot as a Combination of Various Robotic

Assembly Process Models. Journal of Computer and Communications, 5, 1-15.

24. Abu-Jassar, A. T., Attar, H., Lyashenko, V., Amer, A., Sotnik, S., & Solyman, A. (2023). Access control to robotic systems based on biometric: the generalized model and its practical implementation. International Journal of Intelligent Engineering and Systems, 16(5), 313-328.
25. Al-Sharo, Y. M., Abu-Jassar, A. T., Sotnik, S., & Lyashenko, V. (2023). Generalized procedure for determining the collision-free trajectory for a robotic arm. Tikrit Journal of Engineering Sciences, 30(2), 142-151.
26. Matarneh, R., Tvoroshenko, I., & Lyashenko, V. (2019). Improving Fuzzy Network Models For the Analysis of Dynamic Interacting Processes in the State Space. International Journal of Recent Technology and Engineering, 8(4), 1687-1693.
27. Khan, A., Joshi, S., Ahmad, M. A., & Lyashenko, V. (2015). Some effect of Chemical treatment by Ferric Nitrate salts on the structure and morphology of Coir Fibre Composites. Advances in Materials Physics and Chemistry, 5(1), 39-45.
28. Lyashenko, V. V., Deineko, Z. V., & Ahmad, M. A. Properties of wavelet coefficients of self-similar time series. In other words, 9, 16.
29. Kuzemin, A., Lyashenko, V., Bulavina, E., & Torojev, A. (2005). Analysis of movement of financial flows of economical agents as the basis for designing the system of economical security (general conception). In Third international conference «Information research, applications, and education (pp. 27-30).
30. Lyashenko, V. V., Matarneh, R., Baranova, V., & Deineko, Z. V. (2016). Hurst Exponent as a Part of Wavelet Decomposition Coefficients to Measure Long-term Memory Time Series Based on Multiresolution Analysis. American Journal of Systems and Software, 4(2), 51-56.
31. Sotnik, S. Overview: PHP and MySQL Features for Creating Modern Web Projects/ S Sotnik, V. Manakov, V. Lyashenko //International Journal of Academic Information Systems Research (IJAISR). – 2023. – Vol. 7, Issue 1. – P. 11-17.
32. Deineko, Zh., & et al.. (2021). Features of Database Types. International Journal of Engineering and Information Systems (IJEAIS), 5(10), 73-80.
33. Matarneh, R., Sotnik, S., Belova, N., & Lyashenko, V. (2018). Automated modeling of shaft leading elements in the rear axle gear. International Journal of Engineering and Technology (UAE), 7(3), 1468-1473.

34. Lyashenko, V., Laariedh, F., Sotnik, S., & Ahmad, M. A. (2021). Recognition of Voice Commands Based on Neural Network. TEM Journal, 10(2), 583.
35. Ahmad, M. A., Baker, J. H., Tvoroshenko, I., & Lyashenko, V. (2019). Computational complexity of the accessory function setting mechanism in fuzzy intellectual systems. International Journal of Advanced Trends in Computer Science and Engineering, 8(5), 2370-2377.
36. Tahseen A. J. A., & et al.. (2023). Binarization Methods in Multimedia Systems when Recognizing License Plates of Cars. International Journal of Academic Engineering Research (IJAER), 7(2), 1-9.
37. Sotnik S., & et al.. (2022). Key Directions for Development of Modern Expert Systems. International Journal of Engineering and Information Systems (IJEAIS), 6(5), 4-10.
38. Sotnik S., & Lyashenko V. (2022). Prospects for Introduction of Robotics in Service. International Journal of Academic Engineering Research (IJAER), 6(5), 4-9.
39. Lyashenko, V., & Sotnik, S. (2022). Overview of Innovative Walking Robots. International Journal of Academic Engineering Research (IJAER), 6(4), 3-7.
40. Sotnik, S., & et al.. (2022). Analysis of Existing Infliences in Formation of Mobile Robots Trajectory. International Journal of Academic Information Systems Research, 6(1), 13-20.
41. Sotnik, S., & et al.. (2022). Modern Industrial Robotics Industry. International Journal of Academic Engineering Research, 6(1),. 37-46.
42. Lyashenko, V., & et al.. (2021). Modern Walking Robots: A Brief Overview. International Journal of Recent Technology and Applied Science, 3(2), 32-39.
43. Shi, Q., & et al. (2022). Development of a small-sized quadruped robotic rat capable of multimodal motions. IEEE Transactions on Robotics, 38(5), 3027-3043.
44. Vasiliev, A., & Dalyaev, I. (2021). Simulation method for the transport system of a small-sized reconfigurable mobile robot. Machines, 9(1), 8.
45. Quan, X., & et al. (2024). An efficient closed-loop adaptive controller for a small-sized quadruped robotic rat. Cyborg and Bionic Systems.
46. Abu-Jassar, A. T., & et al. (2025). Development and Investigation of Vision System for a Small-Sized Mobile Humanoid Robot in a Smart Environment. International Journal of Crowd Science, 9(1), 29-43.

47. Gao, J., & et al. (2023). Posture Estimation and Trajectory Tracking for SQuRo: a Small-sized Quadruped Robotic Rat. In 2022 IEEE International Conference on Cyborg and Bionic Systems (CBS), IEEE, 97-103.
48. Adan, A., & et al. (2023). Robot for thermal monitoring of buildings. Automation in Construction, 154, 105009.