Development of a Wireless Surveillance-Based Robotic Transportation System with Front-Mounted Robotic Arm for Intelligent Material Handling

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Abstract— SmartCargoBot is a smartphone-controlled robotic arm-based mobile vehicle developed to improve material transportation, remote handling, surveillance, and operational safety in industrial and indoor environments. The proposed system integrates a mobile robotic platform with a rigid frame structure and a robotic arm mounted at the front section for picking, lifting, gripping, and placing lightweight materials. An Arduino Uno acts as the central controller and coordinates vehicle movement, robotic-arm operation, wireless communication, obstacle detection, LCD monitoring, and power management. A Bluetooth module provides wireless communication between the Arduino and smartphone application, enabling the operator to remotely control the vehicle and robotic arm. A wireless camera provides real-time visual surveillance, allowing the operator to observe the surrounding environment and perform accurate navigation and material handling. An ultrasonic sensor installed at the front detects obstacles and helps prevent collisions during movement. DC geared motors and motor drivers provide vehicle mobility, while servo motors operate the robotic arm and gripper. The system is powered by a rechargeable battery with a dedicated charging arrangement. SmartCargoBot provides a compact, economical, and flexible solution for industrial material transportation, warehouse operations, hazardous-area handling, laboratory assistance, and remote inspection, while reducing human effort and improving workplace safety.

Keywords— Smart Cargo Bot, Robotic Arm, Smartphone Control, Wireless Surveillance, Obstacle Detection etc.

I. INTRODUCTION

The rapid advancement of robotics, automation, embedded systems, and wireless communication has created significant opportunities for improving material handling and transportation processes. In many industries, transportation of materials from one location to another is still dependent on manual labor. Workers may need to repeatedly move components, tools, packages, or other lightweight objects, resulting in physical fatigue, increased labor requirements, and reduced productivity. In hazardous or restricted environments, manual material handling can also expose workers to unnecessary safety risks. Mobile robotic systems provide an effective solution by performing transportation tasks with limited human intervention. When a mobile robot is integrated with a robotic arm, it can perform both transportation and object manipulation, making the system more versatile and useful for industrial automation [1][2].

SmartCargoBot is proposed as an intelligent smartphone-controlled robotic arm-based vehicle for automated material transportation. The system consists of a mobile robotic platform constructed using a rigid frame structure. A robotic arm is mounted at the front section of the vehicle to perform basic pick-and-place operations. The front-mounted arrangement allows the arm to approach objects directly and perform gripping, lifting, moving, and placement operations. After collecting an object, the mobile platform can transport it to a required destination. This integrated approach eliminates the need for separate transportation and manipulation systems and provides a compact solution for material-handling applications [3][4][5].

An Arduino Uno microcontroller is used as the central control unit of SmartCargoBot. It receives commands from the smartphone and coordinates the operation of the vehicle, robotic arm, ultrasonic sensor, LCD display, and other connected components. The vehicle movement is achieved using DC geared motors connected to motor driver units. These motors provide sufficient torque for moving the robotic platform and carrying lightweight materials. The direction of the vehicle can be controlled to achieve forward, reverse, left, and right movement. Servo motors are used for controlling the different joints of the robotic arm and gripper, allowing controlled movement during object handling [6][7].

One of the important features of SmartCargoBot is smartphone-based wireless control. A Bluetooth module such as HC-05 establishes communication between the Arduino and smartphone application. Through the application, the operator can issue commands for vehicle movement and robotic-arm operation without requiring a wired control system. Bluetooth provides a low-cost and relatively simple communication method for prototype development. Smartphone control also improves user convenience because the operator can control the robot from a suitable distance and operate it in locations where direct physical access is inconvenient [8].

The proposed system also incorporates a wireless surveillance camera for real-time monitoring. The camera is mounted on the robotic platform and provides visual information about the surrounding environment. The operator can use the live camera view to identify obstacles, observe the transportation path, locate materials, and monitor robotic-arm operations. This feature is particularly useful when the robot is operating in areas where the operator cannot maintain direct visual contact with the vehicle. Wireless surveillance therefore improves remote operation, navigation, and inspection capabilities [9].

Safety is further improved through the use of an ultrasonic obstacle detection sensor. The sensor is positioned at the front of the vehicle and continuously measures the distance between the robot and nearby objects. When an obstacle enters the predefined detection range, the Arduino can generate an alert or stop the vehicle to reduce the possibility of collision. This feature is important for indoor industrial environments, warehouses, laboratories, workshops, and other locations where people, equipment, and materials may be present along the robot's path [9][10].

A rechargeable battery and charging system provide portable power to the robotic platform. The battery supplies energy to the Arduino, DC motors, servo motors, Bluetooth module, camera, ultrasonic sensor, LCD, and other electronic components. The LCD display can provide useful information such as system status, Bluetooth connection, obstacle detection, and operating mode. The complete system is designed using easily available and economical components, making it suitable for educational and prototype-level industrial automation [5][8][10].

Overall, SmartCargoBot combines mobile transportation, robotic manipulation, smartphone control, wireless surveillance, and obstacle detection into a single integrated system. The project aims to reduce manual effort, improve safety, provide remote monitoring, and increase the efficiency of lightweight material transportation. The developed platform can be applied in warehouses, manufacturing facilities, laboratories, hospitals, hazardous environments, and educational robotics. In the future, SmartCargoBot can be further enhanced through IoT connectivity, autonomous navigation, GPS tracking, artificial intelligence, computer vision, voice control, and advanced obstacle avoidance to develop a more intelligent and autonomous material-handling robot.

II. PROBLEM IDENTIFICATION

- Manual Material Transportation: Industrial material movement often requires continuous human effort, causing fatigue, repetitive work, increased labor requirements, and reduced productivity.
- Limited Material Handling: Conventional transportation robots mainly move materials but cannot independently pick, lift, grip, or place objects, limiting their functionality.
- Restricted Remote Monitoring: Operators may not have direct visibility of the robot during operation, creating difficulties in navigation, inspection, and accurate material handling.
- Collision Risk: Mobile robots without obstacle detection can collide with people, equipment, or objects, creating safety concerns and possible equipment damage.
- Complex Control: A simple integrated smartphone-based control system is required to operate transportation, robotic-arm movement, surveillance, and safety functions conveniently from a remote location.

A. Existing System

Existing material transportation systems mainly use manual handling, conveyor belts, automated guided vehicles (AGVs), and basic mobile robots. These systems are commonly employed to move materials between predefined locations in industrial and warehouse environments. Some robotic platforms provide remote control through Bluetooth or Wi-Fi, while others incorporate robotic arms for pick-and-place operations. Surveillance cameras and ultrasonic sensors are also available separately in robotic applications. However, these technologies are generally designed to perform specific functions rather than providing an integrated platform combining transportation, manipulation, wireless surveillance, smartphone control, and obstacle detection.

B. Drawbacks

Conventional systems may require significant human supervision and can involve high installation and maintenance costs. Basic transportation robots generally cannot pick, lift, and place objects without additional equipment. Systems without cameras provide limited visibility during remote operation, while robots without obstacle sensors have higher collision risks. Wired control systems restrict operator mobility and convenience. Separate transportation and manipulation mechanisms also increase system complexity and space requirements. Therefore, there is a need for a compact, economical, and integrated robotic platform capable of material transportation, robotic-arm operation, wireless surveillance, smartphone control, and obstacle detection.

III. LITERATURE REVIEWS

A) Literature Survey:

1. Chaitanya, Sri, and Prakash (2023), The authors developed a robotic vehicle capable of wireless pick-and-place operation using an Android smartphone and Bluetooth communication. Arduino UNO was used as the main controller for DC motors, robotic-arm movement, and gripper operation. The study demonstrated that smartphone-based Bluetooth control can provide simple and economical remote operation. The work is directly relevant to SmartCargoBot because it combines vehicle movement and robotic-arm manipulation through a mobile interface.

2. Ang Jia He and Min Thu Soe (2024), The researchers reviewed different sensor technologies and control methods for mobile robots with obstacle detection. Ultrasonic, LiDAR, radar, infrared, computer vision, and sensor-fusion approaches were compared. The study highlighted ultrasonic sensing as a practical solution for detecting obstacles and preventing collisions. Android Bluetooth, Wi-Fi, voice, and gesture control methods were also examined. The findings support SmartCargoBot's use of an ultrasonic sensor and

Bluetooth smartphone control for economical and safer robotic transportation.

3. Dilip S. Choudhari, G. D. Gosavi, Mangesh D. Shende, and S. P. Joshi (2025), The researchers designed a Bluetooth-controlled robotic arm using Arduino Uno and four servo motors. A smartphone application was used for wireless control, enabling remote pick-and-place operations. The system was intended to reduce human fatigue and improve safety when handling inaccessible or hazardous objects. CAD and 3D-printing techniques were used for development. The study demonstrates the feasibility of low-cost smartphone-controlled robotic arms and provides a strong foundation for integrating similar robotic-arm control into SmartCargoBot.

4. Sarah Al Aiz and Md Ibnul Hasan Abir (2024), The researchers developed a smartphone-controlled robotic arm using Arduino UNO and an HC-05 Bluetooth module. The mobile robot could move forward, reverse, turn left, and turn right while performing pick-and-place operations. Performance was evaluated according to speed, distance, and load-handling capability. The study demonstrated that smartphone-based robotic control can simplify remote material handling and reduce the need for direct human access. These findings strongly support SmartCargoBot's Bluetooth-based smartphone control and mobile robotic-arm configuration.

5. Michael Sillang and Susie Patricia (2024), developed a robot arm controlled through a smartphone using an Arduino Uno platform. The system was designed for pick-and-place operations in manufacturing environments and used Bluetooth communication to transmit commands. The research demonstrated how smartphone interfaces can provide convenient wireless control of robotic mechanisms. Their work emphasized the increasing role of robotics in Industry 4.0 and manufacturing automation. The proposed approach is relevant to SmartCargoBot because it provides a proven foundation for smartphone-controlled robotic-arm operation.

6. Afsana Rubyat et al. (2025), The authors developed an Android-controlled robotic arm using Arduino UNO, Bluetooth, and five servo motors. Testing showed that the arm could lift lightweight objects and respond to wireless commands. The study reported approximately 1.2-second response time with wireless connectivity and identified servo strength as a limitation. The research demonstrates practical advantages and limitations of Bluetooth robotic-arm systems. Its findings are useful for SmartCargoBot when selecting servo motors and designing the front-mounted manipulator.

7. Ashish Singh, Bhupendra Singh, Vibhu Tomar, Aniket Singh, and Lavi (2025), The study presented a smartphone-controlled programmable robotic arm using Arduino, HC-05 Bluetooth communication, and servo motors. The smartphone application transmitted real-time commands that were converted into PWM signals for controlling the arm joints. The system demonstrated remote operation and programmable movement sequences. The research concluded that Arduino and Bluetooth provide a low-cost approach for robotics education, prototyping, and automation. This architecture is directly applicable to SmartCargoBot's smartphone-controlled robotic arm.

8. S. Thirumalairajan et al. (2025), The researchers developed an autonomous mobile robot for warehouse material handling and inventory management. RFID technology was used for product identification, while RPLIDAR and SLAM provided mapping and navigation. A Raspberry Pi 4 and ROS formed the main control architecture. The system aimed to reduce human intervention and improve warehouse efficiency. Although SmartCargoBot uses Arduino and ultrasonic sensing instead of advanced autonomous navigation, this research demonstrates the future potential of integrating intelligent navigation and inventory functions.

9. Panta et al. (2025), The authors developed and tested an autonomous mobile robot for material handling using SLAM, Nav2, and computer vision. The system incorporated real-time obstacle detection, obstacle avoidance, path planning, localization, and ArUco-based object identification. The research demonstrated how mobile robots can perform material-handling tasks in complex environments with reduced human intervention. This work provides a higher-level reference for SmartCargoBot's future development, particularly for upgrading its manually controlled platform toward autonomous navigation and intelligent object handling.

10. Yumin Choi and Hyunbum Kim (2025), investigated obstacle-aware surveillance using mobile robots in environments containing moving and stationary objects. Their work emphasizes the need for reliable obstacle detection and avoidance during surveillance operations. The research demonstrates that mobile robots can combine monitoring functions with intelligent navigation to operate safely in dynamic environments. These findings support SmartCargoBot's integration of a wireless surveillance camera and front-mounted ultrasonic sensor. Combining visual monitoring with obstacle detection can improve remote operation, navigation safety, and inspection performance.

11. S. Thirumalairajan et al. – Warehouse AMR Development (2025), This research demonstrated the application of autonomous mobile robots for material transportation and warehouse inventory operations. The integration of RFID, RPLIDAR, SLAM, Raspberry Pi, and ROS enabled product tracking, mapping, and autonomous navigation. The system reduced dependence on manual transportation and improved operational efficiency. The study shows that mobile robots can become effective industrial logistics platforms when sensing, navigation, and material-handling capabilities are integrated. SmartCargoBot can adopt similar concepts in future versions while maintaining a simpler Arduino-based architecture.

B) Literature Summary

- Robotic Manipulation: Previous studies demonstrate that Arduino and smartphone/Bluetooth control can effectively operate robotic arms for pick-and-place applications.
- Mobile Transportation: Research shows that mobile robots can combine transportation, grasping, tracing, and obstacle avoidance for industrial material handling.

- Obstacle Detection: Ultrasonic sensors are widely used as economical solutions for detecting obstacles and preventing collisions in mobile robots.
- Surveillance: Recent Bluetooth-controlled robots combine ultrasonic sensing with live camera feedback to improve remote monitoring and operator awareness.
- Proposed Contribution: SmartCargoBot integrates these functions into a single smartphone-controlled platform with a front-mounted robotic arm, wireless surveillance, and ultrasonic obstacle detection.

C) *Research Gap*

- Limited Integration: Existing studies generally address robotic arms, mobile transportation, surveillance, or obstacle detection separately. Few low-cost systems integrate all these functions into one compact platform.
- Basic Wireless Control: Bluetooth and smartphone-controlled robots provide convenient operation, but many systems lack coordinated control of transportation, front-mounted robotic-arm manipulation, live surveillance, and safety functions.
- Safety and Intelligence: Ultrasonic sensors provide economical obstacle detection, but their limitations indicate the need for improved integration with camera surveillance and future sensor-fusion or autonomous navigation techniques.

IV. RESEARCH METHODOLOGY

A) *Proposed System*

- Power Supply: The rechargeable battery supplies power to the Arduino, motor drivers, DC motors, servo motors, Bluetooth module, ultrasonic sensor, LCD, and wireless camera.
- System Initialization: When the robot is switched ON, the Arduino initializes all connected components and checks the Bluetooth communication, ultrasonic sensor, motor drivers, and robotic-arm system.

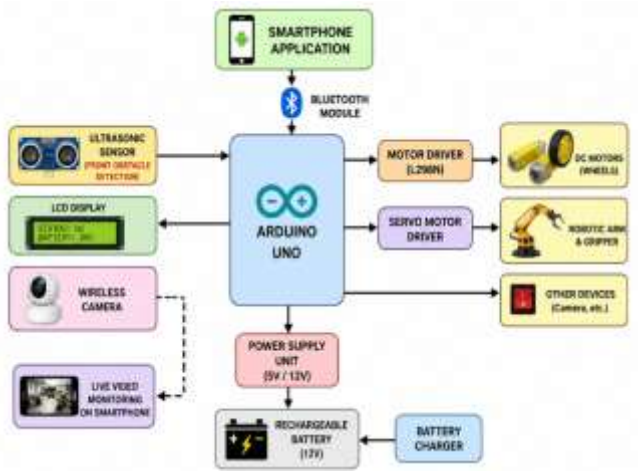


Figure 2. Proposed System

- Smartphone Connection: The operator connects the smartphone application to the HC-05 Bluetooth module. Movement and robotic-arm commands are transmitted wirelessly to the Arduino.
- Vehicle Movement: The Arduino processes the received commands and controls the DC geared motors through the motor driver. The robot moves forward, backward, left, and right according to the selected command.
- Obstacle Detection: The front-mounted HC-SR04 ultrasonic sensor continuously measures the distance to obstacles. If an obstacle is detected within the preset safety range, the Arduino stops the motors or provides an alert.
- Robotic Arm Operation: Servo motors control the front-mounted robotic arm, enabling base rotation, lifting, lowering, wrist movement, and gripper operation for picking and placing lightweight materials.
- Wireless Surveillance: The camera continuously captures the surrounding area and provides live video to the operator for remote navigation and monitoring.
- LCD Monitoring: The LCD displays important information such as operating status, Bluetooth connection, obstacle warnings, and system conditions.
- Material Transportation: After gripping the required object, the robot transports it to the desired location and releases it safely using the robotic gripper.

B) *Hardware Used*

- Arduino Uno: Acts as the main controller and processes smartphone commands, ultrasonic sensor data, motor control, robotic-arm operation, and LCD information.
- Bluetooth HC-05: Provides wireless communication between the Arduino and smartphone application for remote vehicle and robotic-arm control.
- DC Geared Motors: Four motors provide sufficient torque for moving the robotic vehicle in forward, reverse, left, and right directions.
- L298N Motor Driver: Controls the speed and direction of the DC motors according to commands received from the Arduino.
- Robotic Arm: Front-mounted on the vehicle frame for gripping, lifting, moving, and placing lightweight industrial materials.
- Servo Motors: Operate the robotic-arm joints and gripper with controlled angular movement.
- HC-SR04 Ultrasonic Sensor: Detects obstacles in front of the vehicle by measuring the distance between the robot and nearby objects.
- Wireless Camera: Provides real-time video surveillance for remote navigation, inspection, and material-handling operations.
- 16×2 LCD Display: Displays system status, Bluetooth connection, obstacle alerts, and operating information.
- Rechargeable Battery: Supplies electrical power to the complete robotic system.
- Metal Frame and Wheels: Provide structural support, stability, and mobility.
- Battery Charger: Recharges the battery after operation for repeated use.

V. CALCULATION

1. DC Motor Power

Assume each DC geared motor is rated at:

- Voltage, $V = 12V$
- Current, $I = 1A$
- Number of motors = 4

Power of one motor:

$$P = V \times I$$
$$P = 12 \times 1 = 12W$$

Total motor power:
$$P_{motor} = 4 \times 12 = 48W$$

Total motor power = 48 W

2. Robotic Arm Power
Assume 4 servo motors are used:

- Servo voltage = 5 V
- Average current per servo = 0.8 A

Power of one servo:
$$P = 5 \times 0.8 = 4W$$

For four servos:
$$P_{servo} = 4 \times 4 = 16W$$

Robotic-arm power ≈ 16 W

3. Total System Power.

Component	Power
DC Motors	48 W
Servo Motors	16 W
Arduino + Bluetooth	2 W
Camera	3 W
Ultrasonic Sensor	0.5 W
LCD	0.5 W
Total	70 W

Therefore,
$$P_{total} = 48 + 16 + 2 + 3 + 0.5 + 0.5$$
= 70w

4. Battery Energy Calculation
12 V, 7 Ah rechargeable battery.
$$E = V \times Ah$$
$$E = 12 \times 7$$
= 84 *wh*

The battery theoretically stores 84 Wh of energy.
Considering approximately 80% usable energy:
$$E_{usable} = 84 \times 0.8 = 67.2Wh$$

5. Estimated Operating Time
$$T = \frac{E_{usable}}{P_{total}}$$
$$T = \frac{67.2}{70}$$
= 0.96 hrs

Therefore, the estimated continuous operating time is approximately 58 minutes at the assumed full system load.
In practical operation, the motors and robotic arm do not operate continuously at maximum load, so the actual operating duration may be higher.

6. Obstacle Detection Calculation
For an HC-SR04 ultrasonic sensor:

$$Distance = \frac{Time \times Speed\ of\ Sound}{2}$$

The division by 2 is required because the ultrasonic wave travels to the obstacle and returns.
At approximately $20°C$:
$$Speed\ of\ Sound \approx 343m/s$$

If the measured echo time is $1.75ms$:
$$D = \frac{0.00175 \times 343}{2}$$
$$D = 0.300m$$
= 30 cm

Thus, if the measured distance becomes less than 30 cm, the Arduino can command the motor driver to stop the vehicle.

7. Battery Charging Time
For a 12 V, 7 Ah battery and a 12 V charger supplying approximately 1 A:
$$T = \frac{Battery\ Capacity}{Charging\ Current}$$

$$T = \frac{7Ah}{1A}$$

= 7 hrs

Considering charging losses, the practical charging time may be approximately 8–9 hours.

8. Payload Calculation
Assume:

- Robot mass = 5 kg
- Maximum material load = 2 kg

Total moving mass:
$$M = 5 + 2 = 7kg$$

Weight:
$$W = M \times g$$
$$W = 7 \times 9.81$$
= 68.67 N

Therefore, the frame, wheels, and drive system should safely support approximately 69 N of total weight.

VI. ADVANTAGES AND APPLICATIONS

A) Advantages

- Remote Control: Smartphone-based Bluetooth operation provides convenient wireless control of robot movement and robotic-arm functions.
- Improved Safety: Ultrasonic obstacle detection reduces collision risks during transportation.
- Live Monitoring: Wireless camera enables real-time surveillance and remote navigation.
- Multifunctional: Combines transportation, manipulation, surveillance, and obstacle detection in one compact system.
- Cost-Effective: Arduino-based components provide an economical and easily maintainable solution.

B) Applications

- Industries: Automated transportation and handling of lightweight components.
- Warehouses: Movement, loading, and unloading of packages.
- Hazardous Areas: Remote inspection and material handling.
- Hospitals: Transportation of medicines and lightweight equipment.
- Laboratories: Remote handling of samples and instruments.
- Disaster Management: Surveillance and transportation in unsafe environments.
- Education: Robotics, automation, and embedded-system training.

VII. CONCLUSION

SmartCargoBot successfully proposes an integrated smartphone-controlled robotic arm-based mobile transportation system designed for automated material handling, remote surveillance, and safer operation. The system combines an Arduino controller, Bluetooth communication, DC geared motors, motor drivers, servo motors, robotic arm, ultrasonic sensor, wireless camera, LCD display, rechargeable battery, and charging unit into a single robotic platform. The front-mounted robotic arm enables the robot to grip, lift, transport, and place lightweight materials, while the mobile platform provides controlled movement in different directions. Smartphone-based Bluetooth communication allows the operator to control the robot remotely, reducing direct human involvement.

The wireless camera provides real-time visual monitoring, supporting navigation and accurate material-handling operations. The ultrasonic sensor improves safety by detecting obstacles in the robot's forward path and enabling an appropriate stopping or warning response. The LCD provides useful system-status information to the operator. Overall, SmartCargoBot offers a compact, economical, flexible, and user-friendly solution for industrial material transportation and remote handling. The project demonstrates the practical integration of robotics, embedded control, wireless communication, surveillance, and sensing technologies. It can reduce repetitive human effort, improve operational safety, and provide a foundation for developing more advanced intelligent and autonomous material-handling systems.

VIII. FUTURE SCOPE

- IoT Integration: Enable internet-based remote monitoring and control from anywhere.
- Autonomous Navigation: Add GPS, LiDAR, or advanced sensors for autonomous movement.
- AI Vision: Implement object recognition and automatic object handling.
- Advanced Safety: Introduce sensor fusion for improved obstacle avoidance.
- Voice Control: Add voice commands for easier robotic operation.

REFERENCES

[1] C. K. Chaitanya, P. Likhitha Sri, and E. B. Prakash, "Pick and place robotic arms movement controlled by Android wirelessly," *International Journal for Research in Applied Science & Engineering Technology (IJRASET)*, vol. 11, no. 10, pp. 2049–2054, Oct. 2023, doi: 10.22214/ijraset.2023.56375.

[2] M. Z. H. Bhuiyan and S. A. Sabina, "Multipurpose surveillance robot using Arduino Mega 2560 and Bluetooth module HC-05," *MATEC Web of Conferences*, vol. 393, Art. no. 04001, 2024, doi: 10.1051/matecconf/202439304001.

[3] C. Sarkar, A. Das, and R. K. Jain, "Development of CoAP protocol for communication in mobile robotic systems using IoT technique," *Scientific Reports*, vol. 15, Art. no. 9269, 2025, doi: 10.1038/s41598-024-76713-2.

[4] S. Thirumalairajan, M. Dhyanesh, V. Aswaddhaman, M. J. V. Pudeen, and M. Yaswanth, "Design and development of autonomous mobile robot for material handling application," *International Journal for Research in Applied Science & Engineering Technology (IJRASET)*, vol. 13, no. 5, pp. 5566–5594, 2025, doi: 10.22214/ijraset.2025.71204.

[5] D. S. Choudhari, G. D. Gosavi, M. D. Shende, and S. P. Joshi, "Design and implementation of a Bluetooth-controlled robotic arm for efficient pick-and-place operations," 2024/2025.

[6] S. Al Aiz and M. I. H. Abir, "Smartphone-controlled robotic arm for material handling applications," 2024.

[7] M. Sillang and S. Patricia, "Smartphone-controlled robot arm using Arduino for manufacturing applications," 2024.

[8] A. Rubyat, S. M. T. Tuhin, S. Al Razi, S. Banik, M. R. Uddin, and M. Hasan, "Bluetooth controlled Arduino-based robotic arm for object pick and place," 2025.

[9] A. Singh, B. Singh, V. Tomar, A. Singh, and Lavi, "Robotic arm," *International Journal for Research in Applied Science & Engineering Technology (IJRASET)*, 2025.

[10] Y. Choi and H. Kim, "Obstacle-aware surveillance system using mobile robots," *Sensors*, 2025.

[11] A. J. He and M. T. Soe, "Review of sensors and control methods for obstacle detection in mobile robots," 2024.

[12] P. Panta, N. Panta, P. Shrestha, S. Basnet, and S. P. Adhikari, "Autonomous mobile robot for material handling application," 2025.

[13] P. Patil, G. Rajender, P. Reddy, Poojitha, and Suchindhar, "Multi-tasking robotic arm with locomotives," 2025.

[14] D. Venkat, "Embedded-based design of a wireless explosive disposal robot with real-time surveillance," 2025.

[15] A. A. Abd Eltwab, H. M. Amer, and H. B. Nafea, "An intelligent multi-purpose service robot for cleaning and object handling in versatile environments," 2025. .