

Smart Movable Vehicle Robot Arm

Ajith S¹, Karthikeyan S², Madhavan V³, Shanmuganathan P⁴, Vinothkumar G⁵

^{1, 2, 3, 4}Dept of Mechanical Engineering

⁵Faculty, Dept of Mechanical Engineering

^{1, 2, 3, 4, 5} Salem College Of Engineering And Technology

Abstract- *The "Smart Movable Vehicles with Robotic Arm" aims to design and develop a semi-autonomous mobile robotic system capable of performing remote operations in dynamic environments. This vehicle integrates mobility with a versatile robotic arm, enabling it to carry out tasks such as material handling, object detection, and pick- and-place operations efficiently. The system is designed to operate under both wired and wireless control modes, enhancing its adaptability and user flexibility in various operational scenarios. The core objective of this project is to simulate real-world industrial or rescue applications where human intervention might be difficult or risky. The vehicle's movement and robotic arm actions can be monitored and controlled through a dual-interface system: one through direct wired commands and another through wireless modules such as Bluetooth or Wi-Fi. This dual-control approach ensures consistent operation even in cases where one mode fails or becomes less effective due to environmental limitations. The robotic arm is actuated using servo or DC motors, which are precisely controlled to execute complex tasks like gripping, lifting, and placing objects. The smart vehicle base is equipped with motor drivers and microcontrollers (such as Arduino or Raspberry Pi) that interpret user inputs and manage both navigation and arm coordination. Sensors may be integrated to enhance environmental awareness, such as obstacle detection or camera-based monitoring.*

Keywords- Arduino, Robotic Arm, Smart Vehicle, Wireless control.

I. INTRODUCTION

The smart movable vehicle robot arm is an advanced in today's world, automation and robotics play a vital role in enhancing productivity, safety, and efficiency across various industries. The integration of robotic arms with mobile vehicles has opened new possibilities in intelligent automation systems. This project, titled "smart movable vehicles with robotic arm", focuses on designing a mobile robotic system capable of performing controlled mechanical operations. The vehicle is equipped with a robotic arm that can pick, place, lift, or manipulate objects as per user commands. It combines the principles of robotics, electronics, and wireless communication in a compact, mobile platform. The system

operates under two control methods: wired control using direct connections and wireless control using Bluetooth or Wi-Fi. This dual-mode operation enhances system reliability and offers flexible usage in different environments.

The robotic arm consists of multiple joints and servo motors to provide movement in different directions. Microcontroller is used to coordinate the operations of both the vehicle and the robotic arm. User inputs are translated into actions through motor drivers and control circuits. This system is ideal for applications where human access is difficult or dangerous, such as in hazardous industries or rescue missions. The mobility feature allows the robot to navigate through various terrains and workspaces. Wireless monitoring enables real-time feedback and control even from a remote location. The vehicle can be used in tasks like warehouse automation, bomb disposal, and agricultural automation.

The robotic arm is designed to be lightweight yet strong enough to handle moderate loads. Power supply is managed using rechargeable batteries to allow longer field operations. The entire setup is built on a user-friendly and modular platform for easy maintenance and upgrades. This project serves as a practical demonstration of modern automation technology in motion. It also offers scope for integrating smart features such as camera vision and ai in the future. By combining smart mobility with precise mechanical action, this system bridges the gap between manual labor and intelligent machines.

a) Key components of smart movable vehicle robot arm

- Microcontroller unit Arduino: Acts as the brain of the system, handling input signals, processing data, and controlling motors and communication modules.
- Robotic arm assembly: Composed of servo or DC motors, joints, and a gripper to perform mechanical tasks like lifting, holding, and placing objects.
- Chassis with motorized wheels: Provides mobility to the vehicle, usually driven by geared DC motors controlled via a motor driver module.
- Control system (wired and wireless): Includes wired joystick or switches and wireless modules like

Bluetooth / Wi-Fi for remote operation and real-time control.

- Power supply unit: A rechargeable battery pack or regulated power source to supply consistent energy to the entire system.

Classification of smart movable vehicle robot arm

The smart movable vehicle robot arm (SMVRA) can be classified based on several key characteristics, including mobility, autonomy, and arm configuration, application, and control systems. Below is a structured classification.

1. Based on control method
 - Wired controlled vehicle operated using physical connections like switches or joysticks via direct wiring.
 - Wireless controlled vehicle operated remotely using Bluetooth, Wi-Fi, or RF modules.
2. Based on mobility system
 - Wheeled vehicle uses wheels for movement suitable for smooth surfaces.
 - Tracked vehicle uses crawler tracks better suited for rough or uneven terrain.
3. Based on power source
 - Battery powered vehicle operates using rechargeable battery packs for mobile, cordless functionality.
 - DC powered vehicle operates using direct ac supply (mostly for lab or indoor setups).
4. Based on type of robotic arm:
 - 2-DOF or 3-DOF arm simple arms with limited degrees of freedom (DOF) for basic operations.
 - Multi-DOF arm advanced arms with more joints allowing complex, human-like movements.
5. Based on application area:
 - Industrial automation robots used in manufacturing and assembly lines.
 - Rescue and surveillance robots used in disaster zones or military for object manipulation and monitoring.
 - Agricultural robots used in fields for tasks like picking fruits or planting.
 - Educational/prototype models used in learning and research environments for robotics training

Construction of smart movable vehicle robotic arm

The construction of the smart movable vehicle with robotic arm involves the integration of mechanical, electrical, and electronic components into a compact and functional robotic system. The system is built in modular sections to ensure ease of assembly, maintenance, and scalability.

1. Chassis frame
 - The base of the vehicle is constructed using lightweight materials such as aluminum, acrylic, and metal sheets.
 - It is designed to support all the electronic components, motors, and the robotic arm securely.
2. Mobility system
 - The vehicle is mounted on two or four wheels driven by DC geared motors.
 - A motor driver (MG995) controls the speed and direction of the wheels based on user inputs.
 - For stability and better traction, rubber wheels or tracks can be used depending on terrain.
3. Robotic arm assembly
 - The arm is mounted on the chassis and built using servo motors for controlled joint movement.
 - It typically consists of 3 to 5 joints to enable motions such as up/down, left/right, and gripping.
 - A gripper or claw is attached at the end for object handling, often 3d printed or metal-built.
4. Control system
 - The core control unit is a microcontroller like Arduino Uno, mega, or raspberry pi.
 - Inputs from the wired controls (switches or joystick) and wireless modules (Bluetooth/Wi-Fi) are processed to control movement and arm actions.
5. Power supply
 - A rechargeable battery pack (li-ion or lead-acid) is mounted on the chassis to power the motors and electronics.
 - A voltage regulator is used to ensure stable power delivery to sensitive components.
6. Wired and wireless interfaces
 - Wired control, toggle switches or a joystick are connected via wires to the controller.
 - Wireless control, a module like hc- 05 (Bluetooth) or ESP32 (Wi-Fi) is interfaced with the microcontroller for remote commands.

7. PCB or breadboard wiring
 - All circuit connections for sensors, motors, and control inputs are either soldered on a PCB or arranged on a breadboard for testing.
 - Wires are secured neatly to avoid interference with moving parts.
 8. Enclosure and safety
 - The electronics are enclosed in a protective casing to avoid damage from mechanical shocks or environmental exposure.
 - Proper insulation and heat management (ventilation or heat sinks) are applied where necessary.
- Each motion is executed precisely using PWM signals from the microcontroller to each servo.
4. Dual mode control advantage
 - If the wireless system fails or is unavailable, the wired system can serve as a backup, making the robot reliable.
 - Wireless control allows remote operation in unsafe or inaccessible zones, such as hazardous environments.

Working of smart movable vehicle robotic arm

The smart movable vehicle with robotic arm functions through a coordinated interaction between mechanical movements, electronic control systems, and user command both wired and wireless. The overall working can be divided into two main parts vehicle movement and robotic arm operation.

1. Control system activation
 - A microcontroller Arduino acts as the central control unit.
 - It receives user commands via two modes, Wired through joystick, push buttons, or direct switches connected to the controller, Wireless via Bluetooth (HC-05), Wi-Fi (ESP32), or RF module using a smartphone or remote controller.
2. Vehicle movement
 - Upon receiving directional commands, the microcontroller sends signals to the motor driver MG995.
 - The motor driver powers the DC geared motors to move the vehicle forward, backward, left, or right.
 - Speed and direction are controlled based on input duration and intensity.
3. Robotic arm operation
 - The robotic arm is composed of servo motors/joints and a gripper.
 - The microcontroller controls the servos based on input commands to perform desired motions.
 - Base rotation (left/right)
 - Arm lift (up/down)
 - Elbow movement (extend/retract)
 - Gripper open/close for picking or placing objects

Objectives

- To design and develop a mobile robotic vehicle equipped with a functional robotic arm for multi- purpose operations.
- To implement dual control methods wired for flexible operation.
- To enable the robotic arm to perform basic mechanical tasks.
- To integrate a microcontroller-based system for coordinated control of vehicle movement and arm functions.
- To create a compact, lightweight, and modular design suitable for educational, industrial, and field applications.
- To allow future scalability by keeping the design open for enhancements like camera vision.
- To promote hands-on learning in robotics, electronics, and wireless communication systems.
- To ensure real-time response and smooth operation through effective programming and control logic.
- To demonstrate the prototype's potential use in remote handling, automation, and hazardous environment tasks.

II. METHODOLOGY

The development of the smart movable vehicle with robotic arm follows a structured, step-by-step approach to ensure systematic design, integration, testing, and implementation of both mechanical and electronic systems.

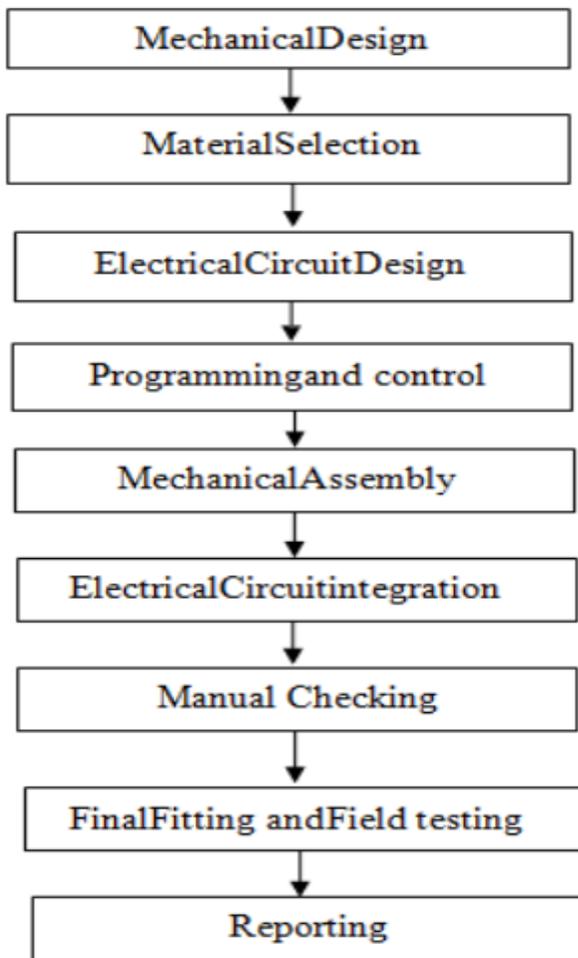


Fig. 2.1 The Process of SMVRA

Mechanical Design

The design of the smart movable vehicle with robotic arm is divided into several key components, each carefully selected and structured to ensure functionality, durability, and ease of assembly. The overall design emphasizes modularity and low-cost implementation without compromising operational efficiency.

a) Chassis

The vehicle chassis is designed using lightweight materials such as mild steel. It includes cutouts and mounting holes for motors, battery pack, Arduino board, and robotic arm base.

b) Wheel and Drive System

The vehicle uses two or four rubber wheels connected to DC geared motors.

The design includes precise placement of the motor mounts to balance torque and support directional control.

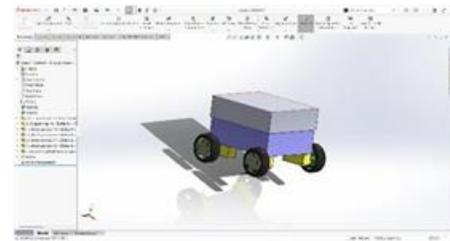


Fig. 2.2 Wheel and Drive System

c) Robotic Arm

The robotic arm consists of 6 Degrees of Freedom (DOF): base rotation, shoulder, elbow, wrist pitch, wrist roll, and gripper. Each joint is driven by a servo motor, selected based on required torque and angular precision.

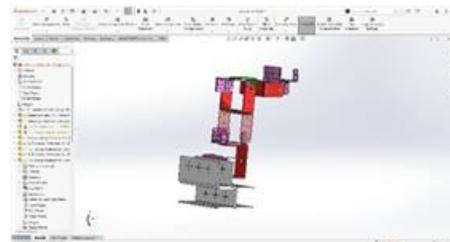


Fig. 2.3 Robotic arm

d) Gripper Mechanism

The gripper is designed to open and close using a micro servo. It has adjustable jaws and can handle small to medium-sized objects. The design includes spring or rubber padding for improved grip and reduced slippage.



Fig. 2.4 Gripper

Material Selection

The Lightweight and durable materials such as Mild steel and acrylic sheets were selected for the vehicle chassis and robotic arm structure to ensure mobility and load efficiency.

Servo-compatible plastic joints were used for smoother motion and reduced stress on motors. Rubber wheels provided better traction and vibration absorption during movement. Electrical components were mounted on insulated boards to ensure safety and proper heat dissipation. All materials were chosen considering cost-effectiveness, availability, and ease of prototyping for academic and industrial use.

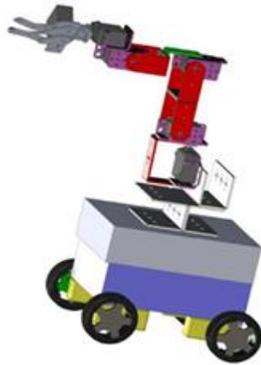


Fig. 2.5 The material selection

Electrical Circuit Design

The electrical system is powered by a 12V Li-ion battery, regulated to 5V for Arduino and servo motors using a MG995 voltage regulator. An L298N motor driver controls the DC motors for vehicle movement, receiving PWM signals from the Arduino. Each joint of the 6-DOF robotic arm is connected to a separate PWM pin on the Arduino for independent servo control. A Bluetooth module (HC-05) enables wireless communication, while a USB camera connects to a PC for video feed. Common ground and power rails ensure stable operation, with careful routing to prevent voltage drops or interference.

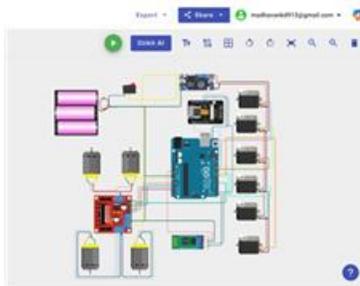


Fig. 2.6 Electrical Circuit

Programming & control

Smart movable vehicle robotic arm function

To Arm Function Code for a 6-DOF (Degrees of Freedom) Robotic Arm using an Arduino microcontroller and

Servo Motors. This code assumes that the robotic arm has 6 joints, with each joint controlled by a separate servo motor.

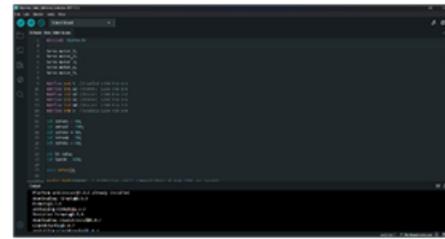


Fig. 2.7 Programming of SMVRA

Each joint allows for a specific range of movement, enabling the arm to move in 3D space and perform tasks like picking and placing objects.

Remote Control Function

The system supports remote operation through both Bluetooth and wired serial communication for flexibility in various environments. Using a Bluetooth module (HC-05), the vehicle and robotic arm can be controlled via an Android app or PC terminal. Directional commands like 'F', 'B', 'L', 'R', and 'S' manage vehicle motion, while 'U', 'D', 'G', and 'C' control the robotic arm and gripper.



Fig. 2.8 Remote control

Data is processed by the Arduino Uno, which translates incoming characters into specific PWM or logic signals. This setup allows real-time, wireless control of the robot from a safe distance, enhancing usability in hazardous or restricted areas.

Mechanical Assembly

The mechanical structure consists of a two wheel drive chassis assembled using a Mild steel for lightweight durability.

A 6-DOF robotic arm is mounted on the chassis, with each joint driven by a servo motor for flexible articulation.

All components, including motors, battery, Arduino, and drivers, are securely fixed using brackets, Bolts and nuts for vibration-free operation.

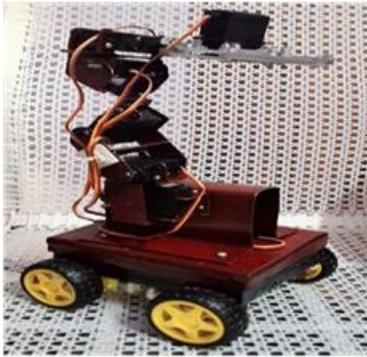


Fig. 2.9 Mechanical Assembly

Electrical Circuit integration (ECI)

The electrical circuit integrates all components Arduino Uno, L298N motor driver, servo motors, Bluetooth module, and power supply into a unified control system.



Fig. 2.10 ECI

DC motors for vehicle movement are wired through the L298N, controlled by digital and PWM signals from the Arduino. Each servo motor of the robotic arm is connected to individual PWM-capable pins for precise joint movement.

A common ground is shared across all components to ensure stable signal referencing and prevent erratic behavior. The entire setup is powered by a regulated 12V to 5V supply, with all connections organized on a breadboard or PCB for reliability and ease of maintenance.

Manual Checking

The powering a system, all mechanical and electrical connections were manually verified for proper alignment, secure mounting, and correct wiring. Servo motor angles were tested without load to ensure smooth motion, and all voltage levels were checked with a multimeter to prevent short circuits or component damage.

Final assembly & Field testing

A successful subsystem integration, the robotic arm and vehicle were assembled into the final chassis. The system was tested in various indoor environments to evaluate mobility, grip strength, response time, and wireless control range. The robot performed pick-and-place tasks reliably and responded accurately to both wired and wireless commands during field testing

Reporting

A detailed report was prepared documenting the design process, component selection, hardware integration, software development, testing results, and conclusions. All diagrams, codes, and references were compiled according to academic formatting guidelines to support further development or research in robotic automation.

III. RESULTS AND COMPARISON

The Smart Movable Vehicle with Robotic Arm system was successfully designed and implemented, with a focus on providing seamless control and monitoring. This project aimed to develop a versatile robotic platform with a movable vehicle and an attached robotic arm, which can be remotely controlled through both wired and wireless methods. The key results and observations from this project are discussed below. The vehicle control system was successfully implemented using an Arduino board interfacing with motor drivers to control DC motors. Through serial communication, the vehicle responded efficiently to directional commands moving forward, backward, left, right, and stopping when necessary. The system exhibited precise movement control, with the vehicle being able to move and accurately in various directions. The vehicle control system also proved to be reliable over both short and extended periods of operation.

IV. CONCLUSION

The development of the Smart Movable Vehicle with Robotic Arm system has successfully met the objectives set out in the initial phases of the project. This system integrates a fully functional movable vehicle, a robotic arm with six degrees of freedom (6- DOF), and a real-time monitoring camera, all controlled via wired and wireless communication methods. The combination of these elements demonstrates the potential of robotic systems in various fields such as industrial automation, surveillance, remote handling, and service robotics. Overall, the Smart Movable Vehicle with Robotic Arm system represents a successful integration of mobility, manipulation, and visual feedback, with potential applications

across multiple industries. The system's flexibility, reliability, and ease of use offer a solid foundation for future development, paving the way for more complex and autonomous robotic systems. As the field of robotics continues to evolve, this system demonstrates a strong starting point for research and development into more advanced, intelligent, and adaptive robotic solutions. The advancements in power, precision, and autonomy envisioned for the future will only serve to make such systems even more invaluable in real-world applications.

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