Project Title : Autonomous Robotic System for Manhole Cap Removal and Internal Cleaning with Live Monitoring

Aim:

To design and build an autonomous robotic system capable of removing manhole covers, performing internal cleaning operations, and providing live video monitoring to ensure safety, hygiene, and efficiency in underground maintenance tasks.

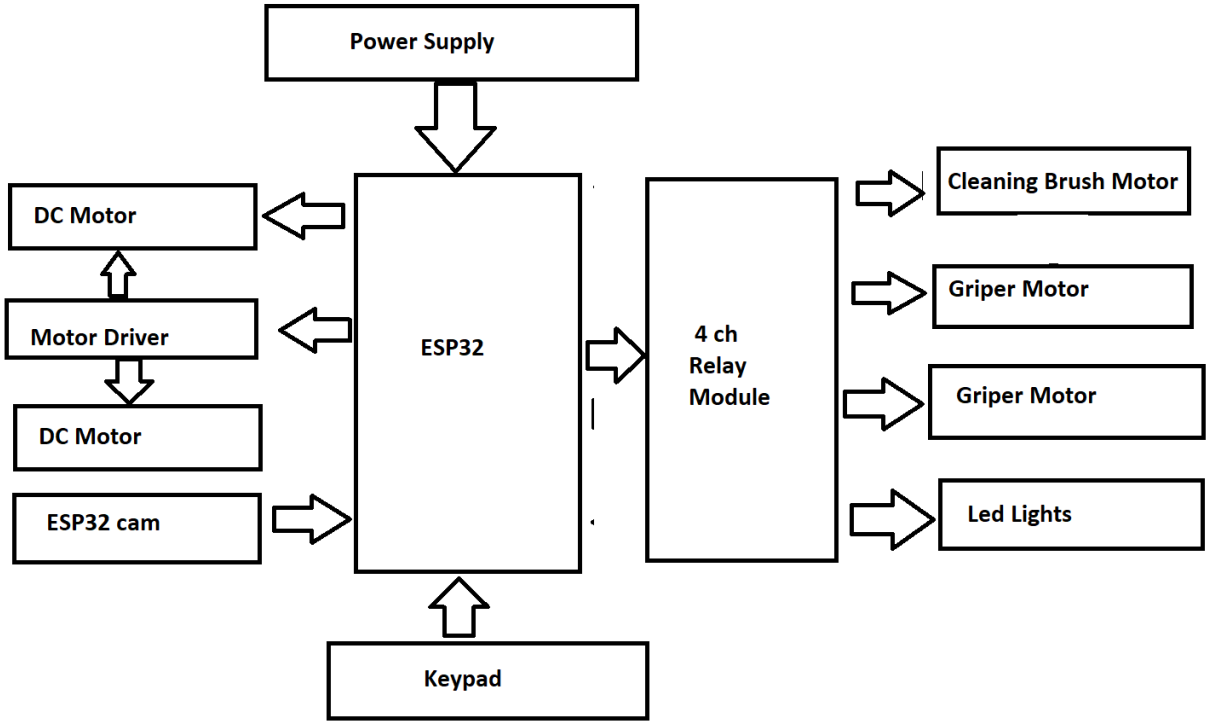
Objectives:

- To remove heavy manhole covers without human effort.
- To inspect the manhole interior using a camera.
- To detect and clean waste, blockages, or harmful substances inside.
- To reduce the need for manual labor in dangerous environments.
- To monitor the entire operation in real-time via a wireless video feed.

Working Principle:

The system includes a robotic arm with a mechanical gripper to lift and remove the manhole cap. After removal, a camera-equipped robot is lowered into the manhole to inspect and clean the interior using a rotating brush or water jet. Sensors help detect the depth and obstacles inside. The entire operation is controlled autonomously or manually via a remote, and the live video feed is streamed to a mobile or PC using Wi-Fi or RF technology.

Block Diagram



Hardware Components:

Component

- ESP32
- High Torque DC Motor
- Robotic Arm with Gripper
- ESP32-CAM
- Rotating Cleaning Brush
- DC Motors with Tracks or Wheels
- Battery Pack (12V/24V Li-ion)
- LED Lights

Software Used:

- Arduino IDE
- Web/App Interface
- Embedded C

Advantages:

- Reduces human exposure to toxic gases and pathogens in manholes.
- Minimizes accidents and injuries during manual manhole cleaning.
- Automates a high-risk and labor-intensive task.
- Provides clear video data for analysis and reporting.
- Can operate in low-light and dangerous environments.

Disadvantages:

- Mechanical complexity due to lifting and cleaning components.
- Requires waterproofing and protection from sewage elements.
- Limited battery life for extended operations.
- May require recalibration for different manhole sizes or conditions.

Applications:

- Municipal sewer and drainage system maintenance
- Industrial underground inspection and cleaning
- Infrastructure maintenance in smart cities
- Emergency response in blocked or flooded manholes
- Environmental safety and monitoring tasks

Future Scope:

- Add gas sensors to detect hazardous gases before entering the manhole

- Use AI for automated blockage detection and path planning
- Add auto-docking and charging for continuous operation
- Expand to a fully autonomous fleet for city-wide sewer inspection
- Connect to a cloud platform for logging and reporting data

Conclusion:

This autonomous robotic system provides a safe, effective, and modern solution for manhole maintenance. By automating tasks like cap removal, internal inspection, and cleaning, it significantly reduces human risk and increases efficiency. With further upgrades, this system can play a vital role in smart city sanitation and maintenance management.