ARTIFICIAL INTELLIGENCE-BASED SMART DRAINAGE CLEANING ROBOT

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Abstract - *The waste and gases produced by drainage are very harmful to humans because of various illnesses that are spreading among people and the environment. Drainage maintenance and monitoring are currently performed manually. Because the presence of harmful gases in the drainage system might influence labor, it is not safe. This project, "Artificial Intelligence-Based Smart Drainage Cleaning Robot," uses automation to simplify the procedure, eliminate the drawbacks, and protect worker lives. The artificial intelligence-based smart drainage cleaning robot is designed with an Arduino, an ESP8266 microcontroller, a DC gear motor, a robotic arm, a camera, and a GPS module. It is used to locate and clear blockages in drainage systems by using a pick-and-place mechanism. It uses hand recognition for picking and placing to clear the blockage. The designed robot is intelligent enough to cover both simple and complex paths as per requirements, which makes it usable in all possible conditions.*

Key Words: **Drainage cleaning, Artificial intelligence, Robotics, Automation, Worker safety, Efficiency, Arduino, ESP8266, Pick-and-place mechanism, Blockage detection.**

1. INTRODUCTION

The "Artificial Intelligence-Based Drainage Cleaning Robot" offers a transformative solution to simplify drainage maintenance while safeguarding workers from hazardous waste and gases. Powered by an Arduino, ESP8266 microcontroller, DC gear motor, robotic arm, camera, and GPS module, this innovative robot employs a pick-and-place mechanism to clear blockages within drainage systems. Its intelligent design ensures maximum cleaning efficiency and is capable of navigating both simple and complex paths with ease. Automating the cleaning process significantly reduces the risks associated with manual labor, thereby minimizing the spread of diseases and protecting worker health. This project represents a vital step forward in enhancing the safety and efficacy of drainage maintenance operations. With its advanced features and adaptability, the "Artificial Intelligence-Based Smart Drainage Cleaning Robot" promises to revolutionize the industry, offering a sustainable and efficient solution to a critical environmental and public health challenge."

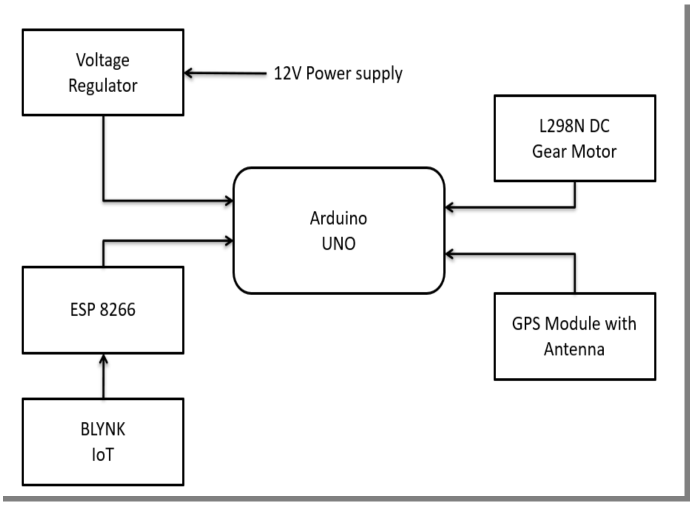

Fig -1: Block Diagram

2. Hardware

2.1 ESP8266

Node MCU is built on the mature ESP8266 technology to take advantage of the abundant resources available on the web. Node MCU has ESP-12-based serial Wi-Fi integrated onboard to provide GPIO, PWM, ADC, I2C, and 1-WIRE resources. It also has a built-in USB-TTL serial with super-reliable industrial-grade CH340 for superior stability on all supported platforms. This module is one of the cheapest available Wi-Fi modules on the market. V3, or Version 3, is the latest version of this module. This tutorial, however, will facilitate connecting all the versions of ESP8266 Node MCU, i.e., V1, V2, or V3.

Fig -2 Node MCU

2.1.2 Specifications

Microcontroller	Tensilica 32-bit RISC CPU Xtensa LX106
Operating Voltage	3.3V
Input Voltage	7-12V
Digital I/O Pins (DIO)	16
Analog Input Pins (ADC)	1
Flash Memory	4 MB
SRAM	64 KHZ
Clock Speed	80 MHZ

2.2 L298N Dual H-Bridge Motor Driver

This dual bidirectional motor driver shown in Fig. 3.12 is based on the very popular L298 Dual H-Bridge Motor Driver Integrated Circuit. The circuit will allow one to easily and independently control two motors of up to 2A each in both directions. It is ideal for robotic applications and well-suited for connection to a microcontroller requiring just a couple of control lines per motor. It can also be interfaced with simple manual switches, TTL logic gates, relays, etc. This board is equipped with power LED indicators, an onboard +5V regulator, and protection diodes.

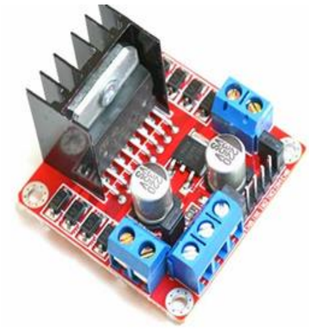

Fig -3: Motor Driver

2.2.1 Specifications

Input Voltage	3.2V~40Vdc
Power Supply	DC 5 V - 35 V
Control signal input voltage range	Low: -0.3V ≤ Vin ≤ 1.5V. High: 2.3V ≤ Vin ≤ Vss.
Maximum power consumption	20W (when the temperature T = 75).
Storage temperature	-25 ~ +130
Peak current	2 Amp
Size	3.4cm x 4.3cm x 2.7cm

2.3 GPS Module with patch Antenna:

This is a third-generation POT (Patch Antenna On Top) GPS module. This POT GPS receiver provides a solution that has high position and speed accuracy performances as well as high sensitivity and tracking capabilities in urban conditions & provides standard NMEA0183 strings in "raw" mode for any microcontroller. The module provides current time, date, latitude, longitude, speed, altitude, and travel direction / heading among other data, and can be used in a host of applications, including navigation, tracking systems, fleet management, mapping, and robotics.

Fig -4: GPS Module with Patch Antenna

3. LITERATURE REVIEW

Ganesh U L, et.al. Showed the usage of mechanical drainage cleaner to replace the manual work required for drainage cleaning system. Drainage pipes are very dirty. Sometimes it is harmful to human life while it is needed for cleaning drainage systems. To overcome this problem, they implemented a mechanical semi-automatic drainage water cleaner, and the water flow is efficient because of the regular filtration of waste with the help of that project. Different kinds of environmental hazards are reduced with the help of a drainage system machine.

Elangovan K., et al. reviewed drainage cleaning to replace manual work with an automated system because manual cleaning systems are harmful for human life and cleaning time. To overcome this problem, they implemented an “automatic drainage water pump monitoring and control system using PLC and SCADA." PLC and SCADA were designed. In this project, we will use an efficient way to control the disposal of waste regularly.

NDUBUISI C. Daniels et al. showed the drainage system cleaner machine used to remove garbage and sewage automatically, which helped to protect the environment from different kinds of environmental hazards. The drainage system cleaner has three major parts, which are the propeller, the cleaner, and the pan, all of which make up for its effective functioning.

Prof. S.D. Anap et al. showed blockage is the major cause of pollution and flooding in metro cities. They have designed the drainage blockage detection system to avoid such problems. The system provides monitoring of drainage conditions and informs authorities of these conditions. This design presets an implementation of a wireless sensor network for the monitoring of drainage systems using a GSM system. To detect blockage and monitor it, Juha Latvala et al. aim to find out whether systematic improvement of drainage can produce significant savings in rail network maintenance.

4. MECHANICAL DESIGN

The mechanical design of the Artificial Intelligence-Based Drainage Cleaning Robot is a critical aspect that ensures the robot's ability to navigate through drainage systems, locate blockages, and effectively clear them. Here's an overview of the key components and considerations in the mechanical design:

1. Chassis: The chassis serves as the structural foundation of the robot, providing support for all other components. It needs to be robust yet lightweight to navigate through the drainage system without causing damage or obstruction.

2. Wheels or Tracks: Depending on the terrain and requirements of the drainage system, the robot may be equipped with wheels or tracks for locomotion. These components should provide sufficient traction and maneuverability to navigate through both simple and complex pathways.

3. Robotic Arm: The robotic arm is responsible for the pick-and-place mechanism used to clear blockages. It needs to be articulated and equipped with grippers capable of grasping and manipulating objects of various sizes and shapes.

4. Motors and Actuators: Motors drive the movement of the wheels or tracks as well as the articulation of the robotic arm. Actuators control the movement of specific components, such as opening and closing grippers on the robotic arm.

5. Enclosures and Seals: Since the robot operates in potentially harsh and hazardous environments, it's essential to enclose sensitive components such as electronics and motors to protect them from water, dust, and other contaminants. Seals ensure that no water or debris enters the internal components of the robot.

6. Size and Form Factor: The size and form factor of the robot should be designed to fit through standard drainage openings while still accommodating all necessary components. It should also be compact enough to maneuver through tight spaces within the drainage system.

7. Material Selection: Materials used in the construction of the robot should be durable, corrosion-resistant, and able to withstand environmental conditions commonly found in drainage systems. Overall, the mechanical design of the robot plays a crucial role in its functionality, durability, and ability to effectively perform drainage cleaning tasks autonomously. It should be carefully engineered to meet the specific requirements and challenges of operating drainage systems while prioritizing safety and efficiency.

4. METHODOLOGY

The methodology for developing the Artificial Intelligence-Based Drainage Cleaning Robot involves a systematic approach that encompasses several key phases, including research, design, development, testing, and implementation. Below is a detailed methodology outlining the steps involved:

1. Research and Requirements Gathering: Conduct a thorough literature review to understand existing technologies, methodologies, and best practices related to drainage cleaning robots, artificial intelligence, robotics, and automation. Identify and analyze the specific requirements and challenges associated with drainage maintenance, including safety concerns, environmental factors, and cleaning efficiency metrics. Define clear project objectives and scope based on the research findings and stakeholder input.

2. Design Phase: Develop detailed design specifications for the drainage cleaning robot, including mechanical, electrical, and software components. Design the mechanical structure of the robot, including the chassis, wheels or tracks, robotic arm, and gripper mechanism, ensuring compatibility with sensor integration and mobility requirements. Design the electrical system, specifying components such as motors, actuators, sensors, microcontrollers, and power supply units. Design the software architecture, outlining algorithms and control strategies for autonomous navigation, obstacle detection, blockage clearance, and adaptive decision-making.

3. Development Phase: Construct a physical prototype of the drainage cleaning robot based on the design specifications, integrating mechanical, electrical, and software components. Implement sensor integration, including cameras, GPS modules, and environmental sensors, and develop software interfaces for data acquisition and processing. Implement the robotic arm mechanism and pick-and-place functionality, including hand recognition algorithms for object manipulation. Develop software modules for autonomous navigation, obstacle avoidance, blockage detection, and adaptive decision-making using artificial intelligence techniques.

4. Testing and Validation: Conduct comprehensive functional testing of the drainage cleaning robot to verify its performance and functionality according to the design specifications. Evaluate the performance of the robot in simulated and real-world drainage environments, assessing factors such as navigation accuracy, obstacle detection, blockage clearance, and cleaning efficiency. Perform safety testing to ensure compliance with safety standards and regulations, particularly regarding worker safety and environmental protection. Iterate on the design and software algorithms based on testing feedback to optimize the performance and reliability of the robot. 5. Deployment and Maintenance: Develop plans for deploying the drainage cleaning robot in real-world drainage systems, including deployment logistics, operational procedures, and user training. Establish procedures for ongoing maintenance, troubleshooting, and software updates to ensure the continued functionality and effectiveness of the robot in long-term operation. Monitor and evaluate the performance of the deployed robot, collecting feedback from users and stakeholders to identify areas for improvement and refinement.

5. RESULTS AND DISCUSSION

5.1 Software Requirements:

5.1.1 Blynk IoT Application:

Blynk is a platform for building IoT applications without complex coding. It allows you to create a user interface for your IoT devices and provides a way to remotely monitor and control them Usage in the System: Blynk can be utilized to create a user-friendly mobile application interface for users to set up medication reminders, view tracking data, and receive notifications.

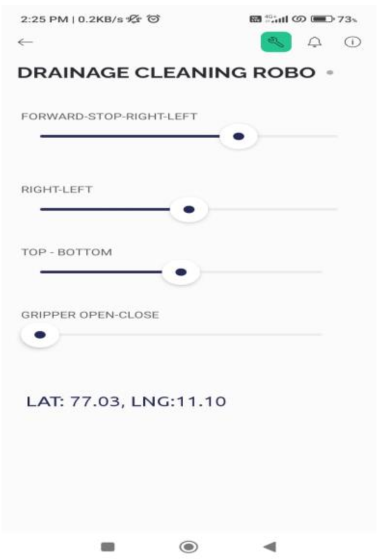

Fig -5: Blynk IoT

5.1.2 Arduino IDE

Arduino IDE is a software platform used for writing, compiling, and uploading code to Arduino microcontrollers.

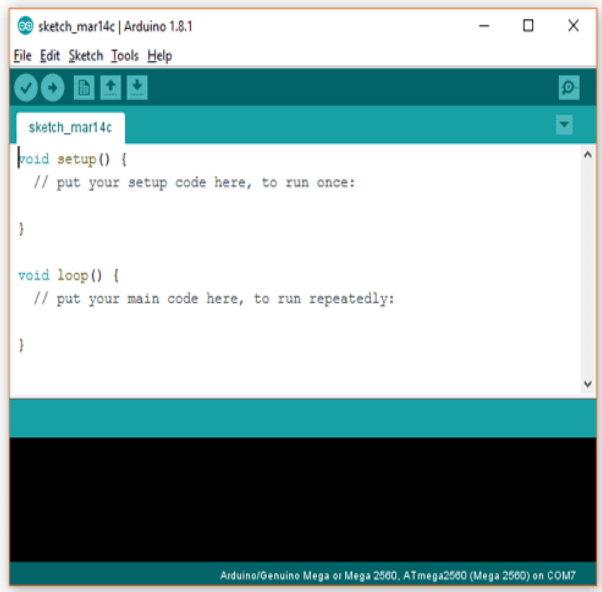

Fig -6: Arduino IDE

5.1.3. Open CV

Open CV (Open-Source Computer Vision) is a library of programming functions mainly aimed at real-time computer vision originally developed by Intel. The library is cross-platform and free for use under the open-source BSD license OpenCV supports deep learning frameworks TensorFlow, Torch/PyTorch, and Cafe.

Fig -7: Open CV

5.2 FINAL OUTPUT

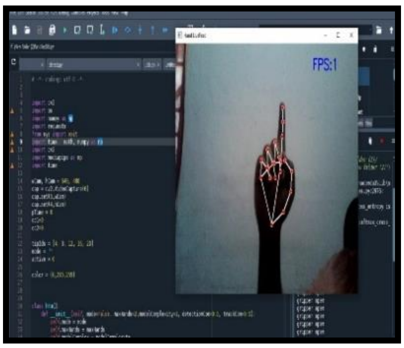

Fig -8: Hand Recognized

Fig -9: **Drainage Cleaning Robot**

6. CONCLUSION

In conclusion, the development of the Artificial Intelligence-Based Smart Drainage Cleaning Robot marks a significant milestone in drainage maintenance. Combining AI, robotics, and sensor technologies, the robot autonomously locates and clears blockages while prioritizing safety and efficiency. Equipped with sensors like cameras and GPS modules, it navigates through drainage networks, identifying blockages and determining optimal paths for intervention. Controlled by microcontrollers, its robotic arm utilizes a pick-and-place mechanism with hand recognition for precise manipulation of obstructions. This approach minimizes manual labor and exposure to hazardous conditions, enhancing worker safety and cleaning efficiency. With its adaptability to diverse pathways, the robot offers a promising solution to improve drainage maintenance practices, contributing to safer and more sustainable urban environments. Ongoing research and development hold potential for further advancements in this field, ensuring continued progress in drainage infrastructure management.

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