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HYDRO JET- EFFICIENT ROOFTOP CLEANING SYSTEM WITH EXTERNAL HIGH-PRESSURE WASHER INTEGRATION

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Abstract: *The world is quickly becoming more automated, with robots taking the place of people and mimicking their behaviors. Although this change is changing homes, it also presents environmental issues. Cleaning a roof can be challenging because of its great height and slick surfaces, especially during the wet seasons. Automatic roof cleaning devices were created to remove filth, grime, and algae from roofs that have a consistent slope in order to address this issue. This project uses an NodeMCU ESP8266, motor driver L293D, geared motor, Wiper Motor, and ESP32 Cam module to design and build an autonomous roof cleaning machine. The device will be easy to operate, for those with less technical knowledge, and time-saving without causing damage to the roof structure while also having a more aesthetically pleasing appearance.*

Key Words: Roof Cleaning, Automatic, NodeMCU, User-friendly, Geared motor, technical knowledge.

1. INTRODUCTION

1.1 Overview

Roof cleaning is a method to clean the rooftop such as pressure washing, soft washing, or hand washing to get rid of dirt, debris, mold, and algae from a building's roof. It increases durability, maintains structural integrity, and makes it more aesthetically pleasing. Regular cleaning reduces heat absorption and cooling costs, stops leaks and water damage, and stops the deterioration of roofing materials, all of which contribute to increased energy efficiency.

Initially people designed brush to clean green house roof but manually people are using brush which is a laborious and hazardous procedure that frequently requires unsafe instrument handling and climbing. To avoid climbing the roof they use pipe for hold the brush and clean the roofs [11]. This method is time consuming and labour -intensive. To address this issue a cleaning robot was implemented by using light weight frames with four sponge wiper blades in wet condition [10]. Then the didactic robot system was developed using Rasperry-pi3 for cleaning greenhouse roofs in both wet and dry conditions [9]. To clean the roofs water jet pressure cleaning machine was developed with the help of DC motor and stepper motor [8]. Then cleaning and painting robot was designed using atmega328 ppu along with the web camera which monitors the cleaning and painting [6]. Then people used robot to clean the various surfaces like cement, polished and rusting. The robot was integrated with the wiper mechanisms to clean the floor [3]. With the same mechanism, the automatic floor cleaner machine has been implemented [2].

The purpose of designing and implementing an Automatic Roof Cleaning Machine using Mobile Application Makes cleaning process easier rather than using Manual method. Automatic Floor Cleaner Machine will have several criteria that are user-friendly, safe for the people with less technical knowledge, and Save time without damaging the roof structure. Enabling the machine in accessing hard to reach areas on the roof and at higher altitudes. To make the controlling user friendly BlynkApp is used.

1.2 Literature survey

The glass greenhouse roof cleaning machine is experiencing issues with deflection and inconsistent speed of wheels. To address these, a joint simulation method using Adams and Matlab was used. 3D models were constructed using SolidWorks and Adams software, and constraints and material properties were set. The system was modeled using Fuzzy-Proportion Integration Differentiation (PID) control algorithm [1]. The Automatic Floor Cleaner Machine uses an Arduino UNO, Motor Driver L293D, Geared Motor, Ultrasonic Sensor, and Bluetooth module to clean floors. It simplifies cleaning by vacuuming specific areas, collects dust, detects obstacles, and uses a microcontroller for high current. The machine uses two batteries for power supply, one for cleaning and the other for suction [2]. The floor cleaning robot is designed to clean various surfaces like cement, polished, rustic, and marble. It uses dry or wet mopping to clean the bottom and collect dust. The robot has two wipers attached, one flat and one wet, for effective cleaning and dust collection. The wet wiping system uses a small water tank for complete cleaning. The robot can clean cement and uneven surfaces, which are covered with heavy dust, consuming longer cleaning times [3]. A hardware and

software solution for roof top dust cleaning is utilized, involving a dust sensor, microcontroller, and DC motors. The software uses Matlab's GUIDE tool, connecting the serial port to the PC. The system's state is visualized by clicking "START" and observing the sensor's value and engine state. Artificial dust accumulation triggers the engine to clean the PV panel [4]. Dust particles on greenhouse roofs affect plant growth and photosynthesis, posing risks to both roofs and humans. Manual cleaning can cause severe damage. An automatic robot cleaning system was designed to address this issue. The robot, made of lightweight steel, starts cleaning when a message is received and completes its task, sending the completed message to the owner [5]. The robot's microcontroller, an atmega328 ppu, controls various components like position and braking sensors, Arduino boards, and wireless RF remotes. It also monitors sheet cleaning and painting, and includes components like compressor, end switches, safety sensors, and water pump. An air compressor increases pressure in a storage tank [6]. An automatic solar panel cleaner machine has been designed to improve efficiency by controlling brush movement through a threaded rod system. The machine uses Arduino programming and is flexible, adjustable to different panel sizes. The methodology involves collecting software and hardware details, designing a prototype, choosing an accurate microcontroller, and designing the algorithm for control [7]. The water jet pressure cleaning machine is a frame with two longitudinal and three cross members that directs high pressure water against a cleaned surface. It uses a DC motor and stepper motor for driving wheels and moving over the roof surface. To achieve the required degree of rotation, the motors need to be interfaced with an integrated circuit and run via a coded program [8]. The paper presents a Didactic Robot system using Raspberry-pi3 for greenhouse roof cleaning. It uses sponge wipers for flexible, easy removal, and a brush cleaner attached to a frame. The lightweight, slow, and efficient robot reduces human work and prevents accidents. It is a safer alternative to manual cleaning, as it is less labour-intensive and time-consuming [9]. Hydroponic vegetables grow in greenhouses, causing dust buildup due to plastic sheeting blocking sunlight. A cleaning robot has been developed to address this issue, using lightweight frames and four sponge wiper blades to clean roof sheetings at 1.3 meters per minute, removing 85-95% of dust [10]. The existing method for cleaning greenhouse roofs is time-consuming, heavy, and dangerous, leading to poor cleaning and reduced light and heat. A new method uses a brush and a man-handled device, using a pipe to hold the roof and clean it using a product instead of climbing [11]. The cleaning robotic system consists of a mobile climbing robot, a supporting vehicle, a compressor, and a computer. The robot moves on a glass surface, while the supporting vehicle supplies power and cleaning liquid. The human operator monitors and controls the robot's operation through communication. Vacuum meters measure vacuum degree and send alarm signals to the master computer [12].

1.3 Issues and Challenges

Costs and Affordability: The initial investment required for developing and deploying automatic rooftop cleaning solutions can be high. Property owners may face challenges in justifying these costs, particularly for smaller buildings or in cases where the economic benefits are not immediately apparent.

Maintenance and Durability: Automatic cleaning systems, like any mechanical equipment, require regular maintenance to ensure optimal performance. Designing systems that are durable and can withstand environmental conditions while minimizing maintenance needs is a significant challenge.

1.4 Relevance of the work

It has the power to prolong the life of roofing materials, lower labor costs, increase safety by manual cleaning, support environmental sustainability, and adhere to regulatory requirements. These initiatives address both financial and environmental issues by providing a low-cost, low-impact way to maintain clean, well-maintained rooftops. The ability to prolong the life of the roof is the main advantages of roof cleaning. A roof will endure longer as it is less prone to experience leaks and other issues. A clean rooftop has both financial and environmental benefits since it may reflect more sunshine, which lowers heat absorption and helps save cooling costs.

1.5 Objectives

- To design and develop an Eco-friendly device which cleans the rooftop automatically to maintain the integrity and functionality of the roof structure.
- To integrate motor controlling with Blynk -App.

1.6 Problem statement

- The traditional roof top cleaning methods may lead to excess use of water, also while cleaning the roof top they used chemicals, causing Environment harm.
- Ensuring the safety of workers and the structural integrity of rooftops during the cleaning process is crucial. Climbing the roof tops with the help of DC Motor is not so efficient.

2. HARDWARE DESCRIPTION

2.1 NodeMCU ESP8266

ESP8266 is a 32-bit micro controller. Which is a Wi-Fi enabled system on chip (SoC) module developed by Espressif system. It is mostly used for development of IoT (Internet of Things) embedded applications. The module has

a maximum frequency of 80MHz and runs between 3-3.6V. It has power pins, digital pins, analog pins, UART pins, SPI pins, I2C pins. It has 9 digital pins from D0-D8 and analog pin analog pin A0. It has flash button and reset button used for flashing the wi-fi and reset the chip respectively. Also, it has had TTL converter used convert the program in the IDE to wi-fi SOC. The esp8266 is used to control the movement of wheels through a Motor Driver L293D module and also is used to make the turn ON and OFF of the wheel.

2.2 Johnson Motor

The Johnson Geared Motors are famous for their compact size and massive torque-speed characteristic. It is a simple DC motor featuring metal gearbox for driving the shaft of the motor, so it is a mechanically commutated electric motor which is powered from DC supply. The motor will run smoothly between the 6 to 18 V DC voltage range. And provides a 200 RPM at 12V supply. It gives a massive torque of 13.5Kgcm. These motors are commonly used for climbing up and pulling up a heavy weight. So, we have used Johnson motos which will help the system to climb the inclined surfaces and carry the heavy weights.

2.3 Motor Driver L293D

L293D is a basic motor driver integrated chip (IC) that enables us to drive a motor in either direction and also control the motor speed. The L293D is a 16-pin IC, with 8 pins on each side, allowing us to control the motor. The Maximum continuous motor currents 600mA and Supply Voltage is about 4.5V to 7V. The Motor driver L293D is a link between the nodeMCU ESP8266 and the Johnson motor. It helps us to give a smooth and controlled operation of the motors based on the commands received from the microcontroller.

2.4 ESP32 Cam

The ESP32-CAM is basically a camera module based on ESP32 from this we can observe a high-quality image and videos. It has low power and small in size. It comes with an OV2640 camera and it provides onboard TF card slot. It has 4MB PSRAM for buffering images for video streaming and other tasks, allowing higher image quality without crashing the ESP32. It also features an LED for flash and multiple GPIOs for peripheral connection. ESP32 Cam act like an eye of our system, it allows us to monitor the objects.

2.5 Servo Motor

A servo motor is a rotary actuator that controls angular position with a feedback system and controller. The feedback system monitors the motor's actual position and adjusts it to match the desired position, while the controller interprets the difference and sends signals to correct any variations. It is used to control the steering mechanisms. It will receive commands from micro controller commands. Based on the commands the servo motor will turn left or right such that wheels will change its direction.

2.6 Water Spary Nozzle

A 15-degree water spray nozzle is a type of nozzle used in pressure washers or other equipment to spray water at a specific angle, indicating the width of the spray pattern. These are used for concentrated cleaning tasks, such as removing stubborn dirt or grime.

2.7 Wiper Motor

A wiper motor is an electric motor that moves windscreen wipers across the windshield. It operates on a 12-volt electrical system and is typically located behind the dashboard, under the hood, or in the trunk of a car. The motor transforms electrical energy into mechanical energy driving the wiper arms across the windscreen managed by the driver through the wiper switch. So here it is used to move the nozzle from right to left or vice-versa.

2.8 Wheels

A wheel is a circular piece of equipment that revolves around an axle bearing. It is an essential component of the wheel and axle system that makes movement smooth and helps with transportation and industrial operation. Wheels provide simple mobility by rolling away friction. Wheels have been essential for a variety of jobs, from transportation to ceramics, since they rotate.

3. SOFTWARE DESCRIPTION

3.1 Arduino IDE

The Arduino IDE, it has a code editor, menus, a text terminal, a toolbar, and a message area. It supports C and C++ and makes authoring, building, and uploading code to Arduino devices easier. The open-source, user-friendly IDE makes it easier to generate and debug code for a variety of Arduino modules.

3.2 IOT Blynk App

Blynk Apps, an iOS and mobile application that uses the Blynk platform to enable remote control, monitoring, and automation of connected devices. It makes configuring mobile interfaces easier in the manufacturing and prototype phases. Blynk enables users to easily design smartphone applications for microcontrollers and computers, which makes the process of developing mobile applications incredibly simple.

3.3 Solid Edge

Solid Edge OEM software enables original equipment manufacturers (OEMs) to extend the capabilities of their products with industry-leading product design technology. Siemens Digital Industries Software's Solid Edge is a powerful CAD software used for creating 3D models, assemblies, and 2D drawings in various sectors such as aerospace, automotive, and machinery and consumer products, facilitating mechanical design, simulation, rendering, and manufacturing.

4. METHODOLOGY

4.1 Block Diagram

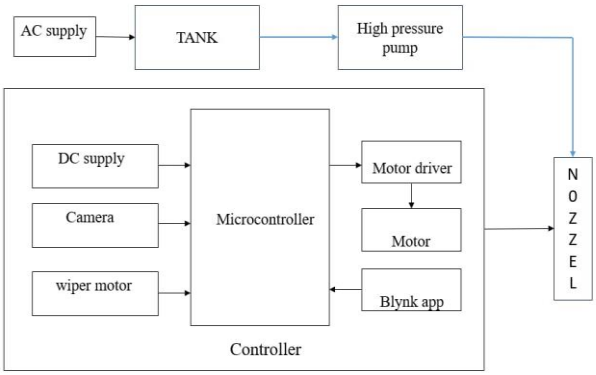

Fig 4.1 Block Diagram of the Proposed System

Our system is a mixture of software and Hardware components Which works together. The NodeMCU is the heart of our system. It is used for controlling the motors through a Motor-driver and also for the movement of wiper. A 15-degree angled nozzle is attached at the end of the wiper. Which moves left to right and visa-versa with the help of the wiper motor. A blynk app is integrated with the nodeMCU for the motor control and to turn ON-OFF of the wiper motor. We also integrate an esp32cam module to navigate the device movements. To all this an external high-pressure pump is used for the supply of the high-pressure water. Via a system of pipes, water is delivered from a tank to a high-pressure pump. Water is forced into the nozzle by the high-pressure pump, making it possible to clean both soft and hard rooftops effectively. Notably, the water spray's angle may be changed, giving the cleaning procedure more flexibility.

4.2 Flow Chart

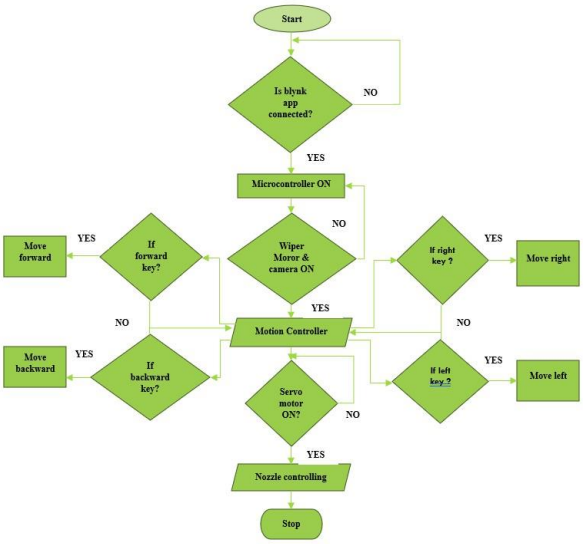

Fig 4.2 Flowchart of the Proposed System

1. Start
2. Verify that the Blynk app is linked.
3. Activate the microcontroller if so.
4. If no, connect the blynk app.
5. Check if ESP32 CAM and wiper motor are turned on.
6. If both are on, control the wiper motor using Blynk app keys (forward, reverse, right, left).
7. If any key is pressed, execute the corresponding action (move forward for “forward" key, etc.).
8. Check if servo motor is turned on.
9. If yes, control the nozzle.
10. If not, proceed to motion control.
11. Stop the process.

4. 3 Conceptual Design

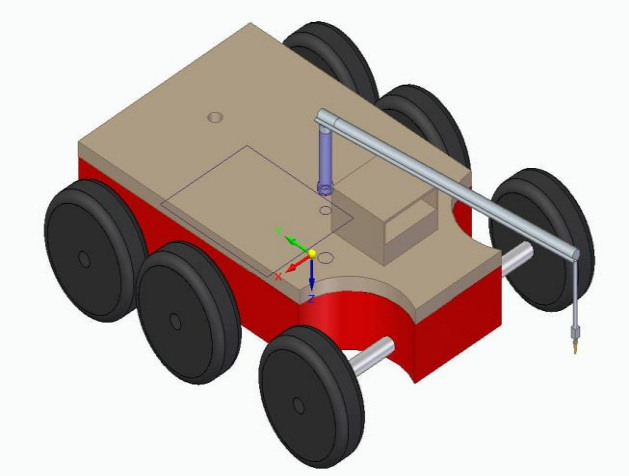

Fig 4.3 Conceptual Design

5. RESULT ANALYSIS

We have designed a rooftop cleaning device Known as Hydro Jet. Which is used to clean the rooftop with the help of nozzle connected to an external high-pressure pump. After testing the system, it cleans the rooftop very effectively. Which will reduce the time and energy compared to manual work. Overall, the project achieves its goals, the concept is highly beneficial.

Fig 5. Implemented model

6. FUTURE SCOPE

- To release the finished product into the market.
- To make the system as compact as possible.
- To design all the circuit in the PCB.

7. CONCLUSIONS

In the present-day scenario, the roof cleaning is not a common practice that is carried out in a country like India, and even if it is being carried out somewhere it is done with the help of labors. These labors are forced to climb on the roofs sometimes located at much higher heights without taking any safety measure. The ideology of bringing ahead the idea of "Hydro jet" a Semi-Automatic roof cleaning machine, is with due respect to the concern of safety of these workers. =This machine will enable a person to carryout roof cleaning operation with minimum physical efforts and mainly without any labor dependency. Not only is this useful for cleaning rooftops, but it can also be handy for cleaning hard floors.

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