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Automatic Wall Painting Robot

Prof. Ashish P. Borhade[1] , Ankit N. Patil[2], Srushti K. Patil[3]

[1]Assistant Professor, Mechanical, Sandip Institute of engineering and Management, Nashik, India
[2]Student, Mechanical, Sandip Institute of Engineering and Management, Nashik, India
[3]Student, Mechanical, Sandip Institute of Engineering and Management, Nashik, India

ABSTRACT: The primary aim of the project is to design, develop and implement Automatic Wall Painting Robot which helps to achieve low cost painting equipment. Despite the advances in robotics and its wide spreading applications, interior wall painting has shared little in research activities. The painting chemicals can cause hazards to the human painters such as eye and respiratory system problems. Also the nature of painting procedure that requires repeated work and hand rising makes it boring, time and effort consuming. When construction workers and robots are properly integrated in building tasks, the whole construction process can be better managed and savings in human labor and timing are obtained as a consequence. In addition, it would offer the opportunity to reduce or eliminate human exposure to difficult and hazardous environments, which would solve most of the problems connected with safety when many activities occur at the same time. An increasing interest in the development of special climbing robots has been witnessed in last decade. Motivations are typically to increase the operation efficiency in dangerous environments or difficult-to-access places, and to protect human health and safety in hazardous tasks. Climbing robots with the ability to maneuver on vertical surfaces are currently being strongly requested by various industries and military authorities in order to perform dangerous operations such as inspection of high-rise buildings, spray painting and sand blasting of gas tanks, maintenance of nuclear facilities, aircraft inspection, surveillance and reconnaissance, assistance in firefighting and rescue operations, etc. Such capabilities of climbing robots would not only allow them to replace human workers in those dangerous duties but also eliminate costly scaffolding.

***Keywords*: Automatic Wall Painting Robot, Construction Field**

I. INTRODUCTION

Building and construction is one of the major industries around the world. In this fast moving life construction industry is also growing rapidly. But the labors in the construction industry are not sufficient. This insufficient labor in the construction industry is because of the difficulty in the work. In construction industry, during the work in tall buildings or in the sites where there is more risky situation like interior area in the city. There are some other reasons for the insufficient labour which may be because of the improvement the education level which cause the people to think that these types of work is not as prestigious as the other jobs. The construction industry is labour intensive and conducted in dangerous situations; therefore the importance of construction robotics has been realized and is grown rapidly. Applications and activities of robotics and automation in this construction industry started in the early 90‟s aiming to optimize equipment operations, improve safety, enhance perception of workspace and furthermore, ensure quality environment for building occupant. After this, the advances in the robotics and automation in the construction industry has grown rapidly. The development of service robots became popular recently due to the fact that the society needs robots to relax humans from tedious and dangerous jobs. In Egypt, as well as other developing countries, the increasing population stimulates the construction-related activities such as interior finishing and painting. Painting is classically done by humans and generally requires exhaustive physical efforts and involves exposure to dangerous chemicals. Chemicals can seriously impair the vision, respiratory system and general health of the human painter.

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These factors make painting an ideal candidate process for automation. More than 100,000 apartments are built annually in Egypt, with an average painting area of 40 million square meters (based on an average 100 m2 apartment area with 400 m2 painting area). The surface area of painting is more due to the renovation work and expected population increase in the future. This demand imposes challenges that will hardly be met using human painters only in the next decade. Therefore, development of a Painting machine that can perform the painting task with minimum human intervention is needed and will improve the quality of painting. The need for an autonomous painting robot is both clear and strong. Automated painting had been realized successfully in the automotive industry to paint millions of cars in the assembly lines. This industry uses spray painting and the robotic system is fixed in the assembly line. The domestic painting robots should be different in the sense that robots should have mobility so that it can move to paint the fixed walls. Also, the domestic painter robots should use roller instead of spray which is the common practice in the market to attain customer satisfaction.

II. SYSTEM ARCHITECHTURE

A. Expected Working of Robot

The objective of this paper is designing a "Smart Wall Painting System". The system consists of microcontroller, DC stepper motor, RGB sensor and power source. Using the RGB sensor, we can detect the intensity of the color sprayed onto the wall. When the rate of spraying is stored on the microcontroller, it can be transferred to the motor spray pump that controls the intensity of spray. All these components are interfaced to the microcontroller Arduino Uno.

1. Block Diagram:

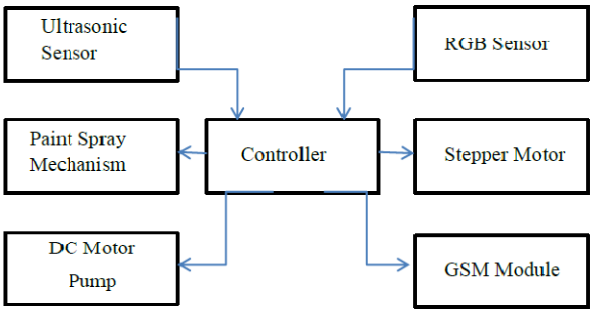

Fig. 2.1 Block Diagram of Robot

Using the above order of the block diagram we were able to design the wall painting system as shown. The first part is the insides of the systems railing which holds the nozzle, the motor pump, the sliding mechanism and the Arduino connected to the RGB sensor. The second part shows how this arrangement is placed beside a wall. The dc motor on the left is used to maneuver the system up and down over the wall by using a screw thread on the shown spoke.

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When the mechanism is initiated at the first position, the pump starts spraying the paint and the RGB sensor guides the nozzle such that the paint is even throughout. The Arduino senses this from information from the RGB and rotates the dc motor to move the nozzle on a horizontal plain and the stepper motor connected to the screw thread to move the nozzle and the arrangement up and down depending on where the painting needs to be done.

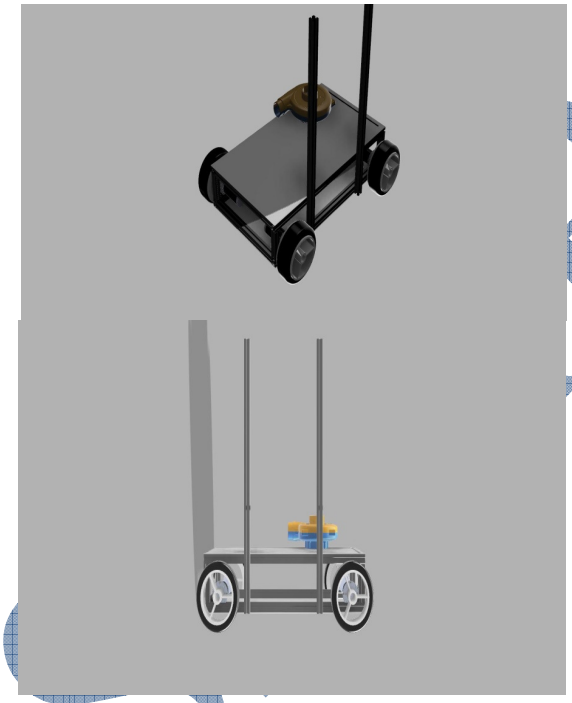

Fig.2.2. Frame of Robot

At first, the robot is placed at the extreme left of wall to be painted. The carried moves up and down with the sprayer and paint the wall vertically. The end stop gives signal to controller to stop the upward motion when it reaches at the end of wall. The end stopper is adjustable manually. After one cycle the base moves towards right with a set unit value and the process is repeated until the whole wall is painted.

2. Material Selection

Steel is the most common and least expensive metal, and also one of the strongest. Unhardened mild steel yields at 30,000-50,000 psi. For structural purposes, it can be hardened easily to 100,000 psi, and for tooling, can be strengthened to nearly 300,000 psi. It has a density of approximately 8 times the density of water (7.9gm/cc), and a melting point around 1400 degrees C (pure iron 1530 C), which looks white hot. Hence we are selecting mild steel for the fabrication of frame.

3. Components Used In Robot

There are various types of components that need to be used in order to make the whole system function, a few of these components include:

a) Microcontroller

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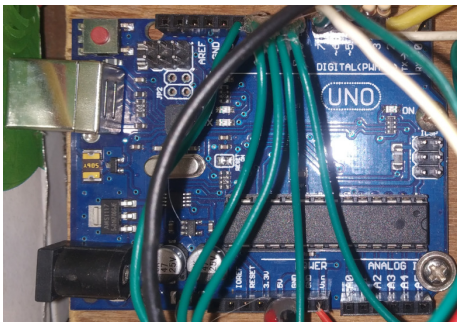

Fig 2.3 Arduino

A Microcontroller is an IC chip that executes programs for controlling other devices or machines. It is a micro device which is used for control of other devices and machines that is why it is called 'Microcontroller'. It is a Microprocessor having RAM, ROM and I/O ports.

b) Driven Mechanism

Mechanisms generally consist of moving components that can include: Gears and gear trains, Belt and chain drives, Cam and followers, Linkage, Friction devices, such as brakes and clutches, Structural components such as a frame, fasteners, bearings, springs, lubricants, etc.
Belts are the cheapest utility for power transmission between shafts that may not be axially aligned. They run smoothly and with little noise, and cushion motor and bearings against load changes, albeit with less strength than gears or chains. Power transmitted between a belt and a pulley is expressed as the product of difference of tension and belt velocity:

$$P = (T_1 - T_2)\, v$$

Where, T1 and T2 are tensions in the tight side and slack side of the belt respectively. They are related as

$$T_1/T_2 = e^{\mu\alpha}$$

Where, μ is the coefficient of friction, and α is the angle (in radians) subtended by contact surface at the center of the pulley.
The belt drive mechanism is being utilized here because of the fact that it's a fairly basic and less expensive contrasting option to the rack and pinion on some other sliding systems in the present market. We would utilize 2 simple and similar gears on either end on the drive and control the one end fixed to a motor that is guided by an arduino.
Belt drives are simple, inexpensive, and do not require axially aligned shafts. They help protect machinery from overload and jam, and damp and isolate noise and vibration. Load fluctuations are shock-absorbed (cushioned). They need no lubrication and minimal maintenance. They have high efficiency (90–98%, usually 95%), high tolerance for misalignment, and are of relatively low cost if the shafts are far apart.

c) Motor

From robotics to automobiles, small and medium sized motoring applications often feature DC motors for their wide range of functionality. The DC Motors speed can be controlled by varying the supply voltage and are available in a wide range of voltages, however the most popular type are 12 & 24V. In today's

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industrial sector, direct current (DC) motors are everywhere. From robotics to automobiles, small and medium sized motoring applications often feature DC motors for their wide range of functionality.

d) Spray Nozzle

A nozzle is an instrument intended to control the direction or characteristics of a liquid stream (particularly to build speed) as it exits (or enters) an encased chamber or pipe. A nozzle is regularly a pipe or container of change in cross sectional zone, and it can be utilized to change the stream of a liquid (fluid or gas). Nozzles are as often as possible used to control the rate of stream, speed, course, mass, shape, as well as the weight of the stream that rises up out of them. In a nozzle, the speed of liquid increments to the detriment of its pressure energy.

Fig. 2.4 Spraying Paint Nozzle

The nozzle performs four basic functions:
1. Atomizes liquid into droplets.
2. Disperses the droplets in a specific pattern.
3. Meters liquid at a certain flow rate.
4. Provides hydraulic momentum.

The Nozzle Tip is one of the most important and least expensive parts of a spraying system.

a. Adjustable nozzle: Most suitable for spraying targets which are not within the reach of a man. Gives a wide angle hollow cone to a straight solid stream that is, it gives a jet to a cone type of spray pattern. Difficult to calibrate as the flow and droplet sizes vary widely with the nozzle angle.
b. Double swirl spray nozzle: Used for spraying in two different directions simultaneously. Nozzles can be fitted with different types of tips like hollow cone, solid cone or flat fan. Suitable for high volume applications. The shape and size of Nozzle Tip orifice controls the spray angel, discharge rate and spray pattern. Spray angle influences the swath of a spray.

Selecting a spray nozzle

The proper selection and use of spray nozzle is the most important part of pesticide application. The nozzle determines the amount of spray that is generated over a given area, the uniformity of the spray produced, the coverage obtained and the amount of drift that occurs. The nozzle selected must optimize coverage application rate and pressure and minimize loss through drift. For each kind of application, dependent upto the physical conditions prevailing, a different nozzle design is available.

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Nozzle tips are usually available in brass, stainless steel, and engineering plastic. Steel tips are most resistant to corrosion and abrasion.
Brass tips are very commonly used, but ear out more easily and can be corroded by some chemicals. Engineering plastic is likely to become the most serviceable material for spray nozzles, being highly resistant to wear-and-tear and corrosion. These are used primarily where plant foliage penetration is essential for effective insect and disease control, and where drift is not a major consideration.
At pressures of 40 – 8- psi hollow cone nozzles give excellent spray coverage to the undersides of reduces penetration correspondingly.
Types of nozzles:

1. Flat fan nozzles: These are used largely for broadcast spraying, where foliar penetration and coverage are not essential. The best operating pressure for flat fan nozzles is 15 – 30 psi, which produce coarser droplets that are not susceptible to drift.

2. Flood jet nozzles: These are ideal for high application rates and speeds, because they produce a wide-angle, flat fan pattern. Operating flood-jet nozzles at 5-25 psi minimizes drift, but pressure changes critically affect the width of the spray pattern. Generally, the spray generated by the flood jet is not as uniform as the flat-fan type.

3. Adjustable nozzles: This model is capable of producing a cone spray in various angles, and also a solid or broken jet spray.

4. Single swivel nozzles: Here the joint of the nozzle and extension rod is capable of swiveling without leakage, it can be locked for use at any angle between 0 – 180 degrees.

5. Double swivel nozzles: This has two swivel nozzles instead of one, capable of independent movement.

6. Double fixed nozzles: Double fixed nozzles are fixed on the 'U' bend, which is, in turn, coupled with the end of a straight extension rod.

e) Sensor

Fig. 2.5Ultrasonic Sensor

It is a device that converts signals from one energy domain to electrical domain. The definition of the Sensor can be understood if we take an example in to consideration.
Types of Sensors used:

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1. IR Sensor

IR Sensors or Infrared Sensor are light based sensor that are used in various applications like Proximity and Object Detection. IR Sensors are used as proximity sensors in almost all mobile phones. There are two types of Infrared or IR Sensors: Transmissive type and Reflective type. In transmissive type IR sensor, the IR transmitter (usually an IR LED) and the IR detector (usually a Photo Diode) are positioned facing each other so that when an object passes between them, the sensor detects the object.

The other type of IR Sensor is a Reflective Type IR Sensor. In this, the transmitter and the detector are positioned adjacent to each other facing the object. When an object comes in front of the sensor, the sensor detects the object.

Different applications where IR Sensor is implemented are Mobile Phones, Robots, Industrial assembly, automobiles etc.

2. RGB Sensor

The sensor comprises of a network of color-sensitive filters and a sensor cluster underneath, as appeared on the photo below:

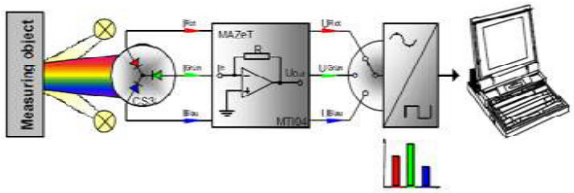

Fig. 2.6 RGB Sensor Principle

Each filter passes light of just a single color to the sensor beneath. A solitary pixel is built out of 4 filters: blue, red, and 2 green. There is twice the same number of green filters to mirror the physiology of the human eye which is more delicate to the green light. The signs from the sensors enable us to compute the RGB estimations of every pixel depicting its color as far as the green, blue and red segments.

f) Battery

Fig. 2.7 Lithium Battery Pack

A lithium-ion battery or Li-ion battery (known as LIB) is a kind of rechargeable battery in which lithium ions move from the negative cathode to the positive anode during discharge and back while charging. Li-ion batteries utilize an intercalated lithium compound as one cathode material, contrasted with the metallic

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lithium utilized as a part of a non-rechargeable lithium battery. The electrolyte, which considers ionic development, and the two terminals are the constituent components of a lithium-ion battery cell.
Lithium-ion batteries are normal in home gadgets. They are a standout amongst the most mainstream sorts of rechargeable batteries for compact gadgets, with a high energy thickness, minor memory impact and low self-discharge. Beyond consumer electronics, LIBs are additionally developing in fame for military, battery electric vehicle and aviation applications. For instance, lithium-ion batteries are turning into a typical swap for the lead– corrosive batteries that have been utilized verifiably for golf trucks and utility vehicles. Rather than overwhelming lead plates and corrosive electrolyte, the pattern is to utilize lightweight lithium-particle battery packs that can give an indistinguishable voltage from lead-corrosive batteries, so no adjustment to the vehicle's drive system is required.

Table 1
Product Specifications

Lithium Battery type:	12V – 100Ah Lithium Ion Battery	24V – 100Ah Lithium Ion Battery
Model no.	012-00002GF	012-00004GF
Nominal capacity	100Ah	100Ah
Nominal battery voltage	12 VDC	24 VDC
Operation voltage discharge	9.2 VDC	18.4 VDC

B. Working Process

1. The project is designed to create a system that can provide hands free wall painting at a cheaper price
2. Initially the systems first check the distance from the wall and the nozzle using the IR sensor.
3. Once the distance is accurate the pump starts sending the paint through the nozzle.
4. As the paint is sprayed onto the wall the RGB sensor senses the thickness and density of the paint that was sprayed.
5. Based on the output of the RGB the dc motor and the stepper motor move the painting platform accordingly on the wall.
6. The upper and lower limits of the wall and sensed by the stepper motor and the signal is sent to the Arduino which stops any further motion of the platform.

By utilizing the above given technique, the system is planned utilizing the parts. Once the system is produced the working begins once the power is provided. At the point when the instrument is started at the principal position the pump begins splashing the paint and the RGB sensor directs the nozzle to such an

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extent that the paint is even all through. The arduino senses this from data from the RGB and rotates the dc engine to move the nozzle on an even plain and the stepper engine associated with the screw string to move the nozzle and the arrangement up and down relying upon where the sketch should be finished. Along these lines the divider is painted as equitably as conceivable utilizing the above parts

Table 2
Bill of Materials

Component	Cost
Aluminum T-slots	5000
Wheels	2000
Bearings	2000
MDF Based	1500
Holders & Fasteners	1500
Blower	1500
Pump	1500
Spray	1200
HT DC Motor x4	1500
Stepper Motor x1	1500
T2 Timing Belt	200
Pulleys	1000
Mechanism	1200
Controller Unit	550
Arduino	550
Stepper Drivers	500
Dc Control Circuit	500
End Stops	300
Sliders	500

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CONCLUSION

Fig. 3.1 Automatic Wall Painting Robot

1. It eliminates the hazards caused due to the painting chemicals to the human painters such as eye and respiratory system problems and also the nature of painting procedure that requires repeated work and handrushing makes it boring, time and effort consuming. The machine is cost effective, eliminates works on scaffolds, reduces work force for human workers and reduces time consumption.
2. With this fixture it will be possible to avoid the risk of painting tall building at elevated height. The machine is specially designed for painting the outside or exterior Flat wall of the structure.

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