Development of Autonomous Wall Painting Robot using Raspberry Pi and Image Processing

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***Abstract*-This paper describes development of Automatic Wall Painting Robot prototype which helps to achieve low cost painting equipment. 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.The system performs the painting process by the use of image captured by the pi camera. The painting area is calculated and information is transferred to the spray gun. The painting is done using bound box. Raspberry pi module will control the base DC motors and the actuator. The actuator while extending and retracting raises the scissor lift and lowers it, respectively. The spray gun handle is mounted at top of the lift, while the air compressor is set on the lower platform, and is turned ON/OFF at the bidding of the raspberry pi module.**

I. INTRODUCTION

Building and construction is one of the significant industries around the world. In this fast-moving life, the construction industry is also growing rapidly. But the laborers in the construction industry are not sufficient. This insufficient labors in the construction industry is because of the difficulty in the work. There are some other reasons for insufficient labor which maybe because of the improvement in the education level which causes the people to think that these types of work are not as prestigious as the other jobs [1].

The system thus proposed below, is expected to solve the major challenge that a paint robot may face on how to implement a design on a given wall. Also, the techniques employed by the system are expected to provide much better paint finishing when working on walls with varying roughness. The system has two degrees of freedom, along the z-axis and either the x or the y-axis. The system is expected to improve the overall cost factorsof the painting job. On the contrary, the time factor of the paint application when compared to the humans working on the same depends greatly on thetype of paint operation to be performed. Ifthe paint is to applied just as a single paint over the complete wall, the system is expected to perform faster when compared to the human labor, but as far as, implementing complex designs are concerned, the time factor is expected to be higher because of the various curve planning, along which the paint operation is to be performed.

II. PROBLEM STATEMENT

Painting is often tedious, repetitive work, as well as being time-consuming work which in turn costs money. Also, workers risk exposure to harmful toxins. In addition to the fact that manual painting, paint guns depend mostly on human precision, when compared to automated spraying lacks consistency. Manual wall painting is repetitive, time-consuming, physically exhaustive, and dangerous [1] [2].

Spray painting robot is an important advanced paint production equipment, which is widely used in the paint production line of automotive and other products at home and abroad. Due to the diversity and complexity of the sprayed work-pieces, there is not yet a complete set of surface modeling methods suitable for a variety of sprayed work-pieces[3][4][16].

III. SOLUTION STRATEGY

Painting had been automated in the automotive industry but not yet for the construction industry. There is a strong need for a mobile robot that can move to paint the interior walls of residential buildings. The preliminary design of an autonomous wall painting robot is described consisting of an arm that scans the walls vertically and is fitted on a mobile robot base is given to the lateral feed motion to cover the painting area. The design of this prototype is to satisfy the criteria of simplicity, low weight, low cost and fast painting time. The conceptual design of a mobile painting robot to be used for painting the interior walls of the building had been required.

IV. OBJECTIVES

- Design a prototype of a wall painting robot.
- Paints a specified area of the wall with no obstruction using a mounted spray gun.
- To make machine structure simple to enable easy mounting as well as for safety.
- Obstacle avoidance.
- Designing of easily interfacing device

V. LITERARTURE SURVEY

The literature survey provides a complete knowledge about selection of best suitable systems.

VaniMukundan, et al. presented the idea of an autonomous wall painting robot consists of an arm that scans the walls vertically and is fitted on a mobile robot base to give the lateral feed motion to cover the painting area. Ultrasonic sensors are contoured on the arm and the mobile base to adjust the motion limits and maneuver in the room area. The proposed project has higher efficiency and better productivity [1].

P.Keerthanaa, et al. proposed an idea that approaches the use of IR transmitter and IR receiver to detect the presence of a wall. DC motor movements are controlled by microcontroller. They also have a very small weight to power output ratio and predictable performance ie., losses are minimized due to less number of moving parts and so gives expected performance. The peril of the project is that the robot continues painting even after the end of the wall [2].

T S Mohammad Zaid, et al. proposedan idea for an exterior wall painting robot, which has a Crank wheel fixed at the bottom of the frame. The crank wheel has an offset hole from its center. Both the ends of the connecting rod are connected to the crank wheel at the offset hole as well as at bottom of the roller handle. Fixed support is provided for sliding of roller in vertical direction on which the roller will be sliding upward and downward. 3D model is created and motion simulation is carried out using Solid works [3].

B Kayalvizhi, et al .designed the robot which is mounted on equipment that permits it to move up and down, left and right along the exterior walls of a building and paint it. It is very effective in time management and completes without an error [4].

DebarghaRoy, proposed the idea of interior wall painting and designing the robot, that is capable of identifying the roughness of the surface, which is to be painted, to reduce the wastage of paint. Implementing complex designs are concerned, the time factor is expected to be higher. The colors are to be painted only in rectangular shapes [5].

Dipakshelar, et al. has presented a robot system that aims the automatic wall painting. The Arduino in it is used to control the DC motor and the moment of spray gun fitted on the slider. This machine reduces human efforts as well as time-consuming.It prevents the hazardous to human painter. The painting work is accurate and reliable [6].

Jayanth R Swarkar, et al. proposed a painting machine used for the construction of paint paths is apart into the following steps: outlining of the painting process, planning to encounter free spray gun motions. Specifies a path of the spray gun, which satisfies the crave paint quality. In this module only spray gun motions are considered as concerning process quality. The painting robot saves the time required for painting. The painting robot saves thelabour [7].

Dr. S. M. Mowade , et al.[4] proposed an idea, of the conditions that must be considered with the robot that the mechanism is run by the electric motor and these components. Air is available everywhere. It can be stored easily. It is Clean and no – pollutant. Transportable over long distances. It is a high-speed operation. Compressed air needs good preparation. Dirt, humidity may not be present. It is unlikely to reach in constant piston speed and uniform employing compressed air.

VI. EXISTING SYSTEM VS PROPOSED SYSTEM

Few systems were reported to serve the task of wall painting. However, these robots are bulky and has small work space and designed to paint the ceiling only. 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. Slow painting rate is observed in the existing wall painting systems.

In our Automatic Wall Painting Machine guided by wall dimensions and paint colour being sent from user through a camera embedded Raspberry Pi module. The Raspberry Pi Module will capture the wall image and calculates the dimensions using Image Processing tools and remotely forwards the dimensions to the base painter system using bluetooth transmission. The Mechanical structure consists of a 2-D plotter with the painting joint attached to a DC operated DCV (Directional Control Valve) spray paint that moves from a point to another line by line. The robot uses a roller fed with painting liquid and keeps contact with the walls. The robot enables the roller to scan both vertically and horizontally the painted walls. The robot can maneuver to adjust itself in front of the wall. Therefore a spray paint based automatic wall painter with remote input from the user is proposed.

VII. DETAILED DESIGN

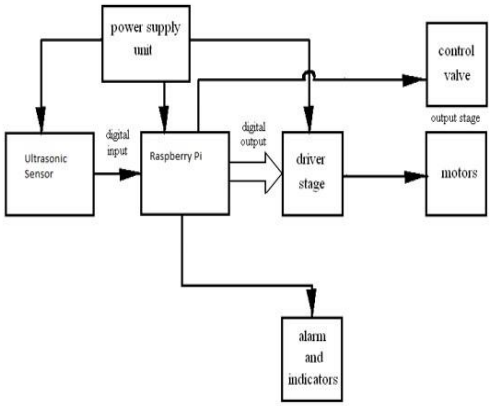

Fig 1 : Block diagram of the proposed system

The overall system consists of Raspberry as a heart of the system is interfaced with two Ultrasonic Sensor, L293D – Motor driver and DC motor. If we set the condition the ultrasonic value is within the limit of some present value means it automatically follows the wall without any human intervention. If it is greater means it automatically changes its path. It is a prototype to build more application based on object follower based on distance with the help of image processing technique.

The power supply unit is used to supply the power to the system which is 5 volt dc, the pi camera checks for the readings of the ultrasonic sensor to find the range between the wall and the robot. If the wall is away from the robot as

the pi camera detects it and sends the signal to the motor driver, which controls the motor speed and direction. The software within the pi determines the path towards the wall and sends the signal to the spray paint assembly which in turns starts spraying the paint to the wall. The alarm and indicators give the feedback indicating that the wall is too far away from the robot and need physical attention to guide the robot towards the wall.

A. Hardware and software requirements

- Raspberry Pi 3 Model B+
- Ultrasonic Sensors
- DC Motor
- Raspberry Pi Camera
- Servo Motor
- Spray can
- Robot wheels

These are the hardware components which are used to build our prototype.

Coming to software requirement we have used 3 types software.

- Raspbian JESSIE
- Python 3.5
- VNC viewer

VIII. IMPLEMENTATION

In this section we have described how our idea is converted into prototype. Our prototype has been implemented into two parts i.e. Hardware implementation and Software implementation in Hardware implementation we described how circuit connection is made based on the block diagram and we have explained each component working in the prototype. In Software implementation part we have explained the code which is essential for working.

A 12V DC motor is fixed to the mainframe and connected to the driver IC where deriver IC helps in the movements of the DC motor. The motor is connected to the slider assembly for up-down movements.

When slider motor moves in clockwise direction slider move in up when the slider moves in anti-clockwise direction slider move in the down direction. We have connected the twin between the motor as well as slider movement because they have to work simultaneously and both depend to each other i.e., whenever we need slider assembly to move up and down we make the motor to run. We have placed a small clamp in the mainframe which connects the lead rod to the mainframe. Lead rod is vertically mounted such that we can connect the slider assembly. The X-Y movement of the lead rod is maintained by the mainframe movement itself.The actuator of the system is triggered by a servo motor. Sparing the paint to the wall is done with the help of actuators with the raspberry pi assembly.

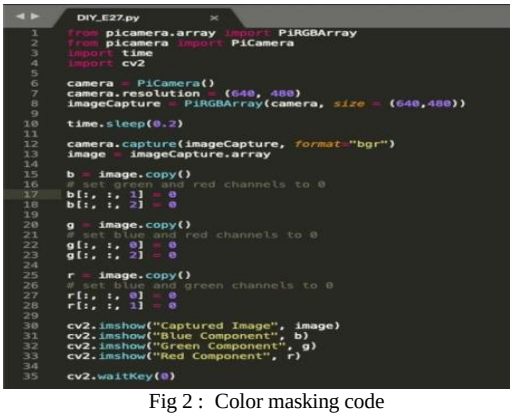

Fig 2 : Color masking code

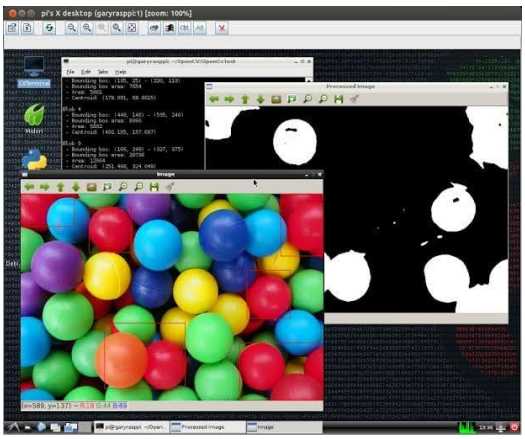
Fig 3 : Color masking in the simple picture

The pi camera is connected to the pin 22 of the Raspberry pi module, with the help of this camera we capture the image of the object and we check whether it is a wall or obstacle. If the captured image is an obstacle we take 90-degree turn and make a path to avoid the obstacle. If the captured object is a wall then the program moves to the next step. The next step of the code is to check the wall is painted with the specified color or not. For color identification, we have used masking techniques. In this technique, we mask another color check for specified color is on the wall, if it is already present it will show that area as white and all other areas as black vice-versa. If all parts of the wall is white then the painting is already done on that particular wall and it will move to the next position. If the area is not painted it will start to paint the wall with the help of hardware working explained in the above paragraph [10].

IX. RESULT

The prototype can cover up to 16 Sq.ft of a wall at a time. The power consumption is 60 watt. The power supply to the prototype can be given in two ways one is we can directly give power through the switchboard, if the switchboard facility is not provided in the area we can use the battery system for supplying the power. We have used a Lithium-ion battery.

The efficiency factor of our project is high compared to the previous models which we have gone through in the survey. It is fast enough to cover the large area in a little time. The height covered by our prototype is 2 feet but we can extend it up to 8 feet.

X. CONCLUSION

Development of an Autonomous wall painting robot uses simple components like a sensor, a driver circuit, and a DC motor. We can design a robot that performs a wall painting operation. The proposed prototype will be designed to automate the interior walls painting process, making it easier and more efficient. This design is simple and relatively easy to implement in comparison with the remainder of interior wall painting robots. Adding to that, the stability of its structure, and the fact that it can be built using any other material, judging by its availability, affordability, and following the needed specifications.

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