



e-ISSN: 2319-8753 | p-ISSN: 2320-6710

IJRSET

International Journal of Innovative Research in
SCIENCE | ENGINEERING | TECHNOLOGY

INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

Volume 9, Issue 12, December 2020

ISSN INTERNATIONAL
STANDARD
SERIAL
NUMBER
INDIA

Impact Factor: 7.512

9940 572 462

6381 907 438

ijirset@gmail.com

www.ijirset.com

Design of Robotic Arm for Ship Surface Cleaning, Painting and Monitoring

Aagash.G¹, Yogesh Kumar.A², Vignesh.K³, Brijesh.C.R⁴, Dr.T.Baldwin Immanuel⁵

Student, IV Year EEE, AMET University, Chennai, India^{1,2,3,4}

Associate Professor, Department of EEE, AMET University, Chennai, India⁵

ABSTRACT: Today's world the technology development in various filed is in wide range. It reduces the human effort. The automatic robotic arm performing ship surface cleaning,painting and protecting ship from dangeris described in this paper. The painting arm robot holds the roller and it scans the vertical surface in front of it. The arm has two joints with link mechanism. Joints movements are made through the stepping motor. It follows a mechanism of ball screw nut. The ultrasonic sensors are placed in four sides, these can helps to maintain distance from the facing surface of the ship and to avoid collision. After these parameters are monitored, the robot starts to paint the surface of the ship. The robot holding the camera which can monitor the ship and the surrounding of the ship at a particular distance.Experiments are made which result a better efficiency.

I INTRODUCTION

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. These factors make painting an ideal candidate process for automation. 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. In the open literature, few systems were reported to serve the task of wall painting.

In this work, a full scale robot is described consisting of a 2 DOF robotic painting arm and a 3 DOF mobile platform. Using the roller instead of spray reduces the cost significantly since spray gun and its accessories are expensive. Light weight is achieved here by using a light weight two link robotic arm with new joint actuation mechanism. This mechanism is inspired from hydraulic cylinder actuation in heavy machinery and has decreased the overall robot weight significantly. It has the advantage of strong and accurate actuation due to the use of ball screw-nut. Also, a four wheeled mobile platform with a new idle wheel attachment have been introduced and claimed to be easier in control.

II.STRUCTURE CONTINGENCY

At first, we have to make explicit statement about the assumptions needed for the robot operation and can be summarized as follows:

1. The robot moves on flat terrain and no inclination.
2. The painting wall is vertical, smooth and flat without any obstructions, such as windows or hangers.
3. The painting fluid is supplied by a human user to a tank in the robot.

4. Roller maintenance and cleaning is also left for user.
5. The walls to be painted are instructed by the user through a suitable interface.

The motion requirements of the robot arm is which shows the basic need to move the roller vertically for painting and the need for horizontal motion to make direct contact with the wall and to depart from the wall.

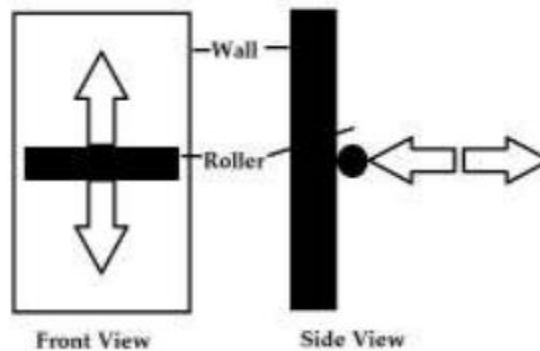


Fig 1.1 Projection between wall and roller

The motion requirements of the robot base for placement of the whole robot and maneuvering. The robot needs to move parallel to the wall to make lateral feed motion and to move normal to the wall to start and depart the painting process. The need to rotate is essential to adjust the robot orientation against the wall. Paint the walls in a once-through fashion vertically from top to bottom. Be stable and not to flip over during painting or maneuvering. Paint the walls and the ceilings. Have painting speed higher than that of human painter (0.15 m²/min). Have light weight, less than 35 kg (excluding painting liquid), so that it can be carried by a single human. Have foldable structure to fit into a single bag for human to carry conveniently. Have simple interface for non technical users. Have affordable price so that painting cost does not exceed 50% of the cost of human painters.

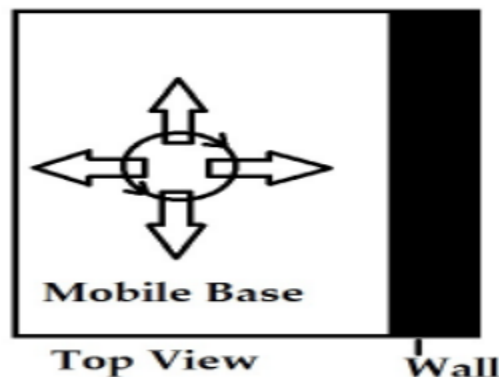


Fig 1.2 Distance between wall and arm robot

III SYSTEMATIC DESIGN

The long reach of 2.7 m imposes the need of the serial link arm. But serial link robot arm with such long reach will require large actuating torques and will exhibit end effector vibrations. And here comes the new joint actuation mechanism. Using roller as the painting method will require continuous contact with the wall, which will induce complexity to the control system if not solved mechanically. This is done by using spring compensation. In the following subsections further analysis is provided. A. Robotic Arm Kinematics and Dynamics First we should determine the motion profile of the roller on the

wall. For the purpose of decreasing vibration in the structure, a fifth order motion profile has been utilized. The equation is given by

$$P_y = 148.828125 \times 10^{-9}t^5 - 14882.8125 \times 10^{-9}t^4 + 396875 \times 10^{-9}t^3 - 0.14$$

where, P_y , V_y , A_y are the position, velocity and acceleration in Y-axis respectively. A paint strip should be finished in 40 seconds for a single stroke on the wall, either up or down. The general equations describing the kinematics and dynamics of two link manipulators are provided. Specifications of the designed robotic arm are presented. Corresponding joint's angular position and velocity profiles of the two joints constituting the arm together with the torque requirements are presented.

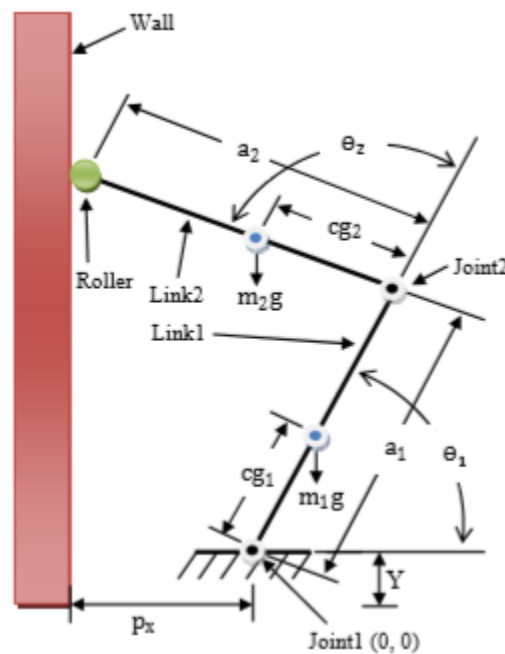


Fig 1.3 Kinematics and dynamics of robotic arm

B. New Joint Actuation Mechanism: A very common problem in robotic arm implementation is the problem of drives. Using direct drive has the advantage of accurate control but low output torques can be obtained and so the arm is not powerful. On the other hand introducing gear trains enhances the powerfulness of the arm, but have the disadvantage of gear backlash and its nonlinearity. In the mechanism we use ball screw give us both advantages. Firstly the arm is powerful due to the mechanical advantage of the screw, where little amount of torque can generate large value of axial force. Secondly it is accurate, since the use of ball screw whose accuracy is selectable. End effector vibrations have been significantly decreased by the use of this mechanism due to decrease arm length between the end-effector and the joint. Mechanism is inspired by hydraulic cylinder actuator machinery. It is also important to point out that this mechanism have the drawback of being relatively slow, but usually low angular speeds are required in driving robotic arms.

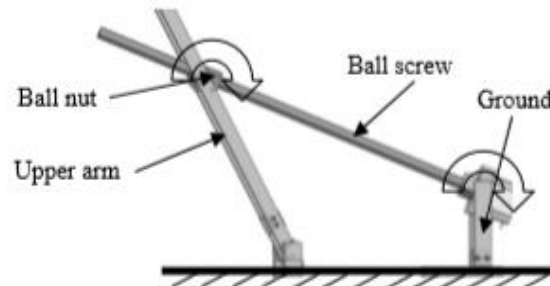


Fig 1.4 Joint actuation mechanism

IV CONTROL AND FLOW ALGORITHM

Two of the joint driving mechanisms are installed at each joint of the two link arm mechanism. The algorithm assumes the platform is initially positioned somewhere in the middle of the room and facing the wall to be painted. The ultrasonic sensors shown in Fig.8, is used to measure the robot distance from the surrounding walls. The control algorithm indicated by the flowchart shown in Fig.9 starts by scanning the front side of the platform using two front ultrasonic sensors, then according to the indicated distances it will move forward or backward till one of the sensors indicate the required value of, at this point we have reached our position in x and y directions and still have to adjust the platform's orientation. After that it scans both sides of the platform in search for the nearest beginning of the facing wall. Then the platform moves toward it until the corresponding side range sensor indicates a clearance value of 5cm, then adjusts its orientation again. At this point the robot is ready to start painting the first strip of the wall with a width of 21 cm.

By finishing this strip the platform moves laterally a distance of 20cm (software adjustable), readjust its orientation and start painting the next strip and so on. An overlap of 1cm between every two successive paint segments is required to maintain paint continuity, and this overlap is adjustable based on experiments. The rear sensors are used to ensure that the robot does not hit any obstacle while it is maneuvering backwards. It should be noted that the interface of human user to select the wall is not yet implemented and will be done in future work. The experiments ensured that the robot arm can do the vertical scan successfully and can adjust its location and feed through the width of the walls.

By finishing this strip the platform moves laterally a distance of 20cm (software adjustable), readjust its orientation and start painting the next strip and so on. An overlap of 1cm between every two successive paint segments is required to maintain paint continuity, and this overlap is adjustable based on experiments.

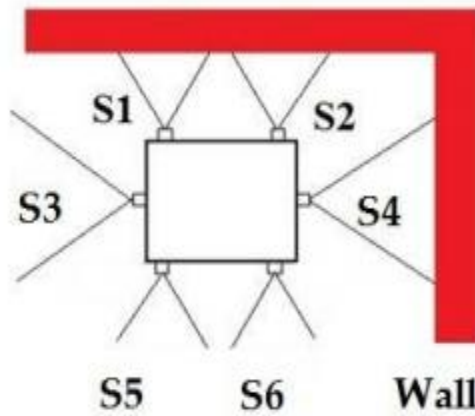


Fig 1.5 Position of ultrasonic sensor and its feedback

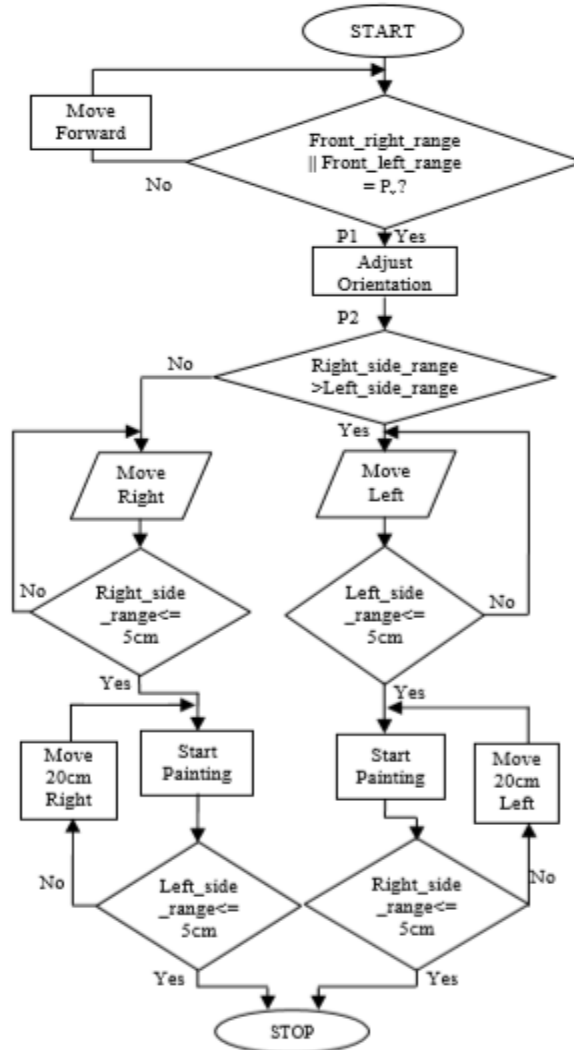


Fig 1.6 Flow chart of control algorithm

V. RESULT AND DISCUSSION

For the purpose of lowering the overall cost of the robot two stepping motors have been used for driving the joints, controlled by micro-stepping drivers. Since open loop control is utilized, stepper motors have to be over designed during the selection process. From the previous torque curve we realize the maximum torque requirements as actuation and about 0.1 N.m for second joint. The workspace of compensation using the previously mentioned pre-compressed spring together with the measured values of spring compression. It is obvious that there is a large error in compression that is beyond allowable.theoretical values. Two reasons resulting in such error are the shifting between axis of roller and that of link2 and at the beginning of operation the change in thetas is very small, so as the manipulator elevates, the spring extends without any movement in the roller till the balance between the roller weight and the tension force in spring happens. Experimental observations confirm contact presence between roller and wall due to roller weight despite the measured error in permissible compression. If we move above the line of initial compression, the spring extends but decreasing the value of compression till we reach the curve of free length at which the compression in spring equals zero. While moving downwards means that the spring is further compressed.

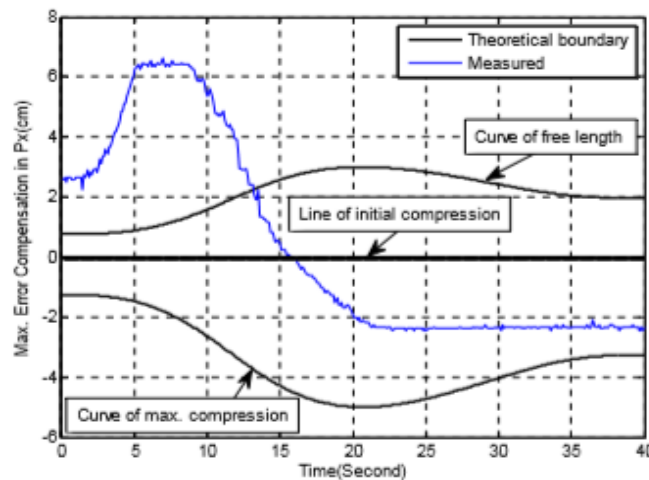


Fig 1.7 Compensation of Px error and its spring compression

The normal force acting upon the wall by the roller due to the addition of the spring. Both the theoretical and measured values are provided. Theoretical curve assumes perfect control is applied and that no deviation in is encountered so that the initial compression of 3cm is constant throughout the whole trajectory. As shown there is some variation in the contact force range of both curves due to error presence in trajectory; 1.9 to 8 Newton in theoretical and 1.5 to 11.5 in measured. This range of variation is assumed to have little effect on the quality of paint.

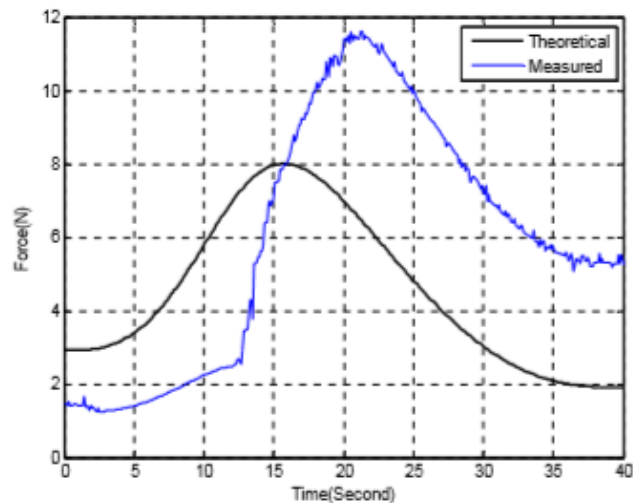


Fig 1.8 Measured value when force applied to wall at the time of painting

VI. CONCLUSION

The robotic arm with link mechanism is designed and implemented. An algorithm for automating the process of painting a single ship surface was developed. The implemented mobile platform was tested and succeeded in carrying the intended load while enabling the plane degrees of freedom. The two link manipulator was tested and fulfilling the intended reach ability, while maintaining low levels of vibration and noise. Overall system have been successfully integrated and tested. The robotic arm has succeeded in moving along the trajectory intended while keeping roller-wall contact at all times. The limited distance monitoring is get enlarged in future methods.

REFERENCES

- [1] I. Aris, A. K. Parvez Iqbal, A. R. Ramli and S. Shamsuddin. "Design and development of a programmable painting robot for houses and buildings.," *Jurnal Teknologi, Universiti Teknologi Malaysia*, vol. 42(A), pp. 27-48, 2005.
- [2] B. Kahane, Y. Rosenfeld: "Balancing human-and-robot integration in building task," *Computer-Aided Civil and Infrastructure Engineering*, vol.19, pp. 393-410, 2004.
- [3] Warszawsky, Y. Rosenfeld: "Robot for interior finishing works in building: feasibility analysis," *ASCE Journal of Construction Engineering and Management*, vol.120 (1), pp. 132-151, 1994.
- [4] Naticchia, A. Giretti, A. Carbonari. "Set up of an automated multi-color system for interior wall painting," *International Journal of Advanced Robotic systems*, vol. 4, No. 4 , pp. 407-416, 2007.
- [5] Naticchia, A. Giretti, A. Carbonari, "Set up of a robotized system for interior wall painting," In the 23rd International Symposium on Automation and Robotics in Construction, Tokyo, Japan, pp.194-199, 2006.
- [6] M. De Grassi, B. Naticchia, A. Giretti & A. Carbonari, "Development of an automatic four color spraying device carried by a robot," In the 24th International Symposium on Automation and Robotics in Construction, Sendai, Japan, pp.235-240, 2007.
- [7] M. Sorour, M. Abdellatif, A. Ramadan and A. AboIsmael, "Development of Roller-Based Interior Wall Painting Robot", *Proceeding of the ICAM, Venice, Italy*, pp:1785-1792, 2011.
- [8] Kyung-Seok Byun, Sung-Jae Kim ; Jae-Bok Song, Design of a four-wheeled omni-directional mobile robot with variable wheel arrangement mechanism, *ICRA* pp: 720-725, 2002.
- [9] B. E. Teoh and S. V. Ragavan, "PAINTbot-FPGA Based Wall Painting Service Robot Prototype," in the Recent Advances in Intelligent Computational Systems, Trivandrum, India, pp:777-782, 2011.
- [10] M. Udengaard and K. Iagnemma, Analysis, Design and Control of an Omni-directional Mobile Robot on Rough Terrain, *Journal of Mechanical Design*, Vol. 131, ASME Transactions, 2009.



- [11] T.Baldwin Immanuel, P.Muthukumar, M.Rajavelan, C.Gnanavel, N.Veeramuthulingam, “An Evaluation of Bidirectional Converter Topologies for UPS Applications” International Journal of Engineering and Technology, Vol. 7, no. 33, pp. 1305-1309, 2018.
- [12] T.Baldwin Immanuel, P.Muthukumar, C.Gnanavel, M.Rajavelan, M.Marimuthu, “Transformer less single phase Inverter for Grid Connected PV System with an Optimized Control” International Journal of Engineering and Technology, Vol. 7, no. 34, pp. 217-220, 2018.
- [13] T.Baldwin Immanuel, A.Suresh, M.R.Radhami “Resonant Filter for Photovoltaic Applications” International Journal of Pure and Applied Mathematics, Vol. 119, no. 7, pp. 393-405, 2018.
- [14] C.Gnanavel, M.Rajavelan, P.Muthukumar, T.Baldwin Immanuel, “A Performance Investigation of a Single Phase Multilevel Inverter Fed Nonlinear Loads for Solar PV Applications” International Journal of Engineering and Technology, Vol. 7, no. 24, pp. 388-391, 2018.



INNO  **SPACE**
SJIF Scientific Journal Impact Factor

**Impact Factor:
7.512**

ISSN INTERNATIONAL
STANDARD
SERIAL
NUMBER
INDIA



INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

 **9940 572 462**  **6381 907 438**  **ijirset@gmail.com**



www.ijirset.com

Scan to save the contact details