AUTOMATIC WALL PAINTING ROBOT

A PROJECT REPORT

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SRM UNIVERSITY
(Under section 3 of UGC Act 1956)

SRM Nagar, Kattakulathur-603 203, Kancheepuram District, Tamil Nadu

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DECLARATION

This project titled —**AUTOMATIC WALL PAINTING ROBOT** is a research work Done by BALAJI N (Reg.No:1171310043), RISHIKIRAN S (Reg.No:1171310022), VIGNESH R (Reg.No:1171310053) for our B.Tech (ELECTRONICS AND INSTRUMENTATION ENGINEERING) Project work and we are solely responsible for all the contents, information and observations/results mentioned in this report.

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BONAFIDE CERTIFICATE

Certified that this report of project titled **—AUTOMATIC WALL PAINTING ROBOT** is the bonafide work of BALAJI N (Reg.No:1171310043) , RISHIKIRAN S (Reg.No:1171310022), VIGNESH R (Reg.No:1171310053) **B.Tech (ELECTRONICS AND INSTRUMENTATION ENGINEERING)** who carried out the project work under my supervision.

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Submitted for the Project Work Viva-Voice Examination held on ________________ in the Department of Electronics And Instrumentation Engineering, Faculty of Engineering and Technology, SRM University, Kattankulathur.

Date:

Internal Examiner **External Examiner**

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EXECUTIVE SUMMARY

Painting is automatic in many automobile industries and factories, but yet to reach for commercial purpose like painting the house wall. So in this paper we introduce a robot to paint the wall automatically with minimum human interface. The machine which we make are more efficient and precise than humans. In this paper we have used a basic components to design this machine. A lever arm to move the sprayer vertically and a pixy camera for image processing. Pixy Camera board is used for image processing. Here image processing is used to detect any error on the wall.Sensors are used to detect the wall distance and detect any obstacles if present. Thousands of building are built every day in overcrowded countries like India, so to paint those building requires a large human work force to do it. So to reduce the human effort we are proposing this system which could paint faster and better than humans.

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CHAPTER 1
INTRODUCTION

1.1 Overview

Fast globalization and interconnectivity create the major driving force in creating and enhancing chance. Therefore, the society has to acquire new trends of innovation to prosper in their ways of life. The community has revolutionized due to the interconnectivity greatly compared to some years back when usage of technology did not exist. Saving human labor numbers and timing are only the two main advantages; besides them we must consider the opportunity to reduce or eliminate human exposure to difficult and hazardous environments, and to improve the quality of such works which would solve most of the problems connected with safety when many activities occur at the same time. 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. These factors motivate the development of an automated robotic painting system. Valuable experiments were led to verify how convenient is carrying on painting works through robots. The task of painting is a time consuming one. Automation in this field would at least substitute humans in applying the paint, thus saving the valuable labor hours of working. Also, the fact that long exposure to paint and varnishes damages the human health has been proving. So the advent of automation will help to get rid of this hazard. The automated painting robot was to be designed with the vision to facilitate easy wall painting. Results of comparisons at full scale between labor and robotized execution showed that there are significant savings in labor, depending on the labor rate, when auxiliary work is considerably lessened. Through the performance of full scale experiments, it was possible to show that robots are always more profitable than human work when highly autonomous robots are adopted. The feasibility of highly autonomous robots is shown by a number of papers which pictured the reduction of auxiliary work from labor.

Automation is the use of machines, control systems and information technologies to improve productivity in the production of goods and delivery of services. The appropriate reason for applying automation is to boost up productivity and quality beyond that possible with current human labor levels so as to realize economies of scale, and realize predictable quality levels. The inappropriate application of automation, which arises most often, is a tendency to eliminate or replace human labor. Simply because, correct application of automation can net as much as 3 to 4 times original output with no increase in current human labor costs whereas incorrect application of automation can only save a fraction of current labor level costs. In the room of industrialization, automation is a phase beyond mechanization as the latter provides human operators with machinery to help them with the muscular requirements of work whereas automation greatly reduces the need for human sensory and mental requirements and on the same time rising load capacity, speed, and repeatability. Automation is becoming an increasingly important aspect in the world economy and in daily experience.

Automation has had a remarkable impact in a wide range of industries beyond manufacturing. Automated telephone switchboards and answering machines have nowadays substituted once-ubiquitous telephone operators. Medical practices, for instance, primary screening in electrocardiography or radiography and laboratory analysis of human genes, sera, cells, and tissues are processed at much higher speed and accuracy by automated systems. Automated teller machines have decreased the need for people to queue up in banks to obtain cash or carry out transactions. In general, automation has been responsible for the shift in the world economy from industrial jobs to service jobs in the 20th and 21st centuries.

In recent years, the construction industry has experienced the effects of an aging work force, including a chronic shortage of skilled construction workers. This has resulted in a tendency for work efficiency and quality to deteriorate. One method of overcoming this problem that has been urged forcefully upon us has been automation and robotization of construction operation. One of the areas where this has been attempted is in painting work.

Despite the advances in the robotics and its wide spreading applications, painting is also considered to be the difficult process as it also has to paint the whole building. To make this work easier and safer and also to reduce the number of labors automation in painting was introduced. Above all these the interior wall painting has shared little in research activities. The painting chemicals can cause hazards to the 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. These factors motivate the development of an automated robotic painting system. This project aims to develop the interior wall painting robot. This automatic wall painting robot is not designed using complicated components. This robot is simple and portable. The robot is designed using few steels, conveyor shaft, spray gun and a controller unit to control the entire operation of the robot. This robot is compact because of high speed and pressure capabilities they have. They also have a very small weight to power output ratio and predictable performance i.e. losses are minimum due to less number of moving parts and so gives expected performance. Due to elegant and simple control systems it can control noise vibration and does silent operation and no vibration is produced. It has longer life, flexibility and it is efficient and dependable, and the installation is simple and the maintenance is also easy. Some of the conditions that have to be considered while using this robot is that the system is operates in pneumatics, so it needs air tank or compressor and the electric shock is always there, which makes the machines ugly and dust and dirt are adhering to them. The life of the parts like seals, packing and gaskets etc., are very short but, they are essential to prevent leakage so that the system becomes costlier. 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.

1.1.1 Problem Definition

Wall painting, conventionally, has been carried out by human hands on scaffolds or ladders provisionally built around a subject wall. This, however, not only is a kind of work performed on dangerous elevated spots and in unclean environment but also requires extra work to take down the scaffolds, thus often making it difficult to shorten a construction term or to reduce cost. Moreover, painting of wall involves other manual tasks such as carrying, pushing, pulling and lifting of painting equipment. Carrying a spray gun, roller or even paint brush a long time can lead to repetitive stress injuries due to strenuous use of the same part of the body.

Paint rollers and paint brushes are used by putting a cover on a handle and rolling it up and down a wall. The painter has to fill a paint tray with paint and roll the roller or put the brush end into it to get it wet with paint before using it on the wall. The painter has then to lift the roller which is loaded with paint and roll it on the wall or perform to and fro with the paint brush on the wall. These repetitive actions of pushing, pulling or lifting of heavy loads such as rollers, ladders or even paint tray may lead to back ache.

Moreover, when loading the roller or paint brush with paint, the amount of paint absorbed is often difficult to control and thus, the brush or roller is often overloaded. This causes paint to be wasted by either dripping or splattering. Further to that, if much force is not applied on the brush or roller, paint is wasted due to the absorption of paint in the paint brush or roller nap. Most paint contains chemicals and compounds that are harmful to the environment and potentially harmful to painters. During painting process, painters may inhale those hazardous substances which can cause severe complications if exposed too much.

Automation and robotics have entered various fields of the construction industry, and paint work is no exception. Generally, conventional painting of the walls of buildings which is carried out using scaffolding or ladders has proved to be costly and labour-intensive. It is also unsafe as it involves working at considerable heights. Due to these problems, people are discouraged to opt for painters as job and as a result of that there have been problems involving quality due to the lack of skilled painters, and there is clearly an urgent need to improve the working environment and quality of the work being carried out.

In this project we are going to design an autonomous as well as manually working wall painting robot which is consisting 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.

1.2 Robot Development Concepts

This robot was developed to meet the following requirements:

- It must have a capacity equivalent to or greater than a skilled worker (both in o work efficiency and painting quality).
- It should save energy.
- It should be able to paint walls with indentations and protrusions.
- Operation of the robot body and its moving equipment must be possible one man control from a control room on the ground. .
- The robot main body must use moving equipment that enables it to move precisely to its proper work position and maintain that position.
- It must have safe operation and must not have an adverse effect on the surrounding environment.

1.3 Description of the Painting Robot System

The automatic painting system using this painting robot consists of the robot main body which sprays paint, robot moving equipment to carry the robot main body to the proper work position, paint supply equipment and a controller to control the system.

Features of Painting Robot

The principle features of this painting robot are as follows.

- It maintains painting quality which cannot be distinguished from the quality of skilled painting personnel.
- Painting by manual labor on high scaffolding, as done previously, is eliminated, the work efficiency is high and there is little danger.
- Uneven walls with indentations and protrusions can also be painted automatically.
- Through automatic painting, the dirty work required with human workers is reduced and the work environment is improved.

1.4 Project Objectives

This project was done to fulfill these objectives:

- To design a wheeled robot using Arduino board to carry the lever arm and the sprayer a top on it.
- We have designed the lever arm using AUTOCAD software and we have to implement it in machine workshop.
- We are designing a gripper which would be attached with sprayer. Gripper are used here to push and pull the sprayer.
- We intend to use camera along with digital image processing to detect the error and rectify them using MATLAB software.

1.5 Scope of Work

A few guidelines are proposed so that this project is narrowed to a certain boundaries. This is to ensure that this project achieves its objectives.

Firstly, the basic model of robot is designed using software SOLID WORKS which only includes the design of lever arm. Then, the base stand is designed and wheeled robot using Arduino board to carry the lever arm and the sprayer a top on it is designed.

This project model which also detects the error using camera while painting and corrects those error using Digital image processing techniques.

The control mechanism of robot is implemented by using Arduino Programming and it synchronize the mechanism of robot using relay circuits.

CHAPTER 2
LITERATURE SURVEY

[1] B.Kayalvizhi , V.Seetha, B.Lavanya, P.ParuthiIlam vazhuthi,□Development of robot for automatic wall painting, writing, drawing and crack detection□, International Journal of Advanced Research in Electronics, Communication & Instrumentation Engineering and Development, Volume: 2 Issue: 1 Apr,2016,ISSN_NO: 2347 -7210.

We had discussed the new prototype that aims to design, develop and implement Automatic Wall Painting Robot which helps to achieve less human interaction and low cost painting equipment. Despite the advances in robotics and its wide spreading applications, interior wall painting has shared little in research activities. Despite the fact that the utilization of spreading robotized frameworks for inside painting was at that point indicated to be attainable and helpful, a ton of tests must be completed later on to convey an exceedingly self-governing robot for inner part painting. A new approach is proposed using raspberry pi, the robot which can be operated by both manual and autonomous. The autonomous robot can be controlled using an android mobile where the application was installed. The existing approach gives feasible analysis for time and labor. It is not easy to correlate the work and people because painting an elevated building is very risk and time consuming. In this paper, the robot is mounted on equipment which permits it to move up and down, left and right along the exterior walls of a building. It is also equipped with sensors which measure indentations and protrusions in the wall surface and making it possible for painting.

IR is used to enhance the current approach to detect cracks on the wall and gives indication such that we can rectify in prior from elongation of damage. In addition, it is very effective on time management and completes it without an error and would offer the opportunity to reduce or eliminate human exposure to difficult and hazardous environments. Finally, it is expected that the conceptual model of the wall painting robot would be efficiently used in various applications in wall finishing and maintenance of other architectural and civil structures such as commercial buildings, tower sand high-rise storage tanks.

[2] Mohamed T. Sorour, Mohamed A. Abdellatif, Ahmed A. Ramadan, and Ahmed A. Abo-Ismail, Development of Roller-Based Interior Wall Painting Robot, International Journal of Mechanical, Aerospace, Industrial, Mechatronic and Manufacturing Engineering Vol:5, No:11, 2011.

The development of an autonomous robot for painting the interior walls of buildings. The robot consists of a painting arm with an end effector roller that scans the walls vertically and a mobile platform to give horizontal feed to paint the whole area of the wall. The painting arm has a planar two link mechanism with two joints. Joints are driven from a stepping motor through a ball screw-nut mechanism. Four ultrasonic sensors are attached to the mobile platform and used to maintain a certain distance from the facing wall and to avoid collision with side walls. When settled on adjusted distance from the wall, the controller starts the painting process autonomously. Simplicity, relatively low weight and short painting time were considered in our design. Different modules constituting the robot have been separately tested then integrated. Experiments have shown successfulness of the robot in its intended tasks.

[3] Shin Terauchi , Toshikazu Miyajima, Takezo Miyamoto, Kazuhiko Arai and Seiichiro Takizawa,□ Development of an Exterior Wall Painting Robot Capable of Painting Walls with Indentations and Protrusions□, Automation and Konotics in Loflstrucuun, 1993 Elsevier Science Publishers 13. V.

We had discussed the development of an exterior wall painting robot for the purpose of automating this painting operation. The robot is mounted on equipment which permits it to move up and down, left and right along the exterior walls of a building. It is computer controlled and is activated simply by the operator pressing a switch on the control panel located on the ground. The robot is capable of painting a four square meter wall surface (4 m long X 1 m high) at one time. It is also equipped with sensors which measure indentations and protrusions in the wall surface, making it possible for it to paint exterior walls with windows, pillars or other indentations or protrusions.

[4] Kundan Jawale, Ramesh Kumar, Vishal Kale,□ Design and Development of a Wall Painting Robot for the Houses Wall□, International Journal of Multidisciplinary Research and Development.

We had studied the application of robot is still not widely implemented in construction industry. In construction industry, robots are designed to increase speed and improve the accuracy of construction field operations. It can also be used to do hazardous and dangerous jobs in construction. For example, currently house painting is done manually. This process can be simplified using a special dedicated robot. It is very difficult and troublesome for human being to work in an upright position, especially for painting, cleaning and screwing in the ceiling for a long time. Painting in an upright position is also very dangerous for the eyes. To overcome this difficulty, a wall painting robot system is proposed, designed and developed. The testing results indicate that the performance of the painter robot is better compared with that of using manual painting technique.

[5] Mohamed T. Sorour, Mohamed A. Abdellatif, Ahmed A. Ramadan, and Ahmed A. Abo-Ismail,□ Development of Roller-Based Interior Wall Painting Robot□,

International Journal of Mechanical, Aerospace, Industrial, Mechatronic and Manufacturing Engineering Vol:5, No:11, 2011.

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CHAPTER-3
SYSTEM DESCRIPTION

3.1 Proposed system Block diagram

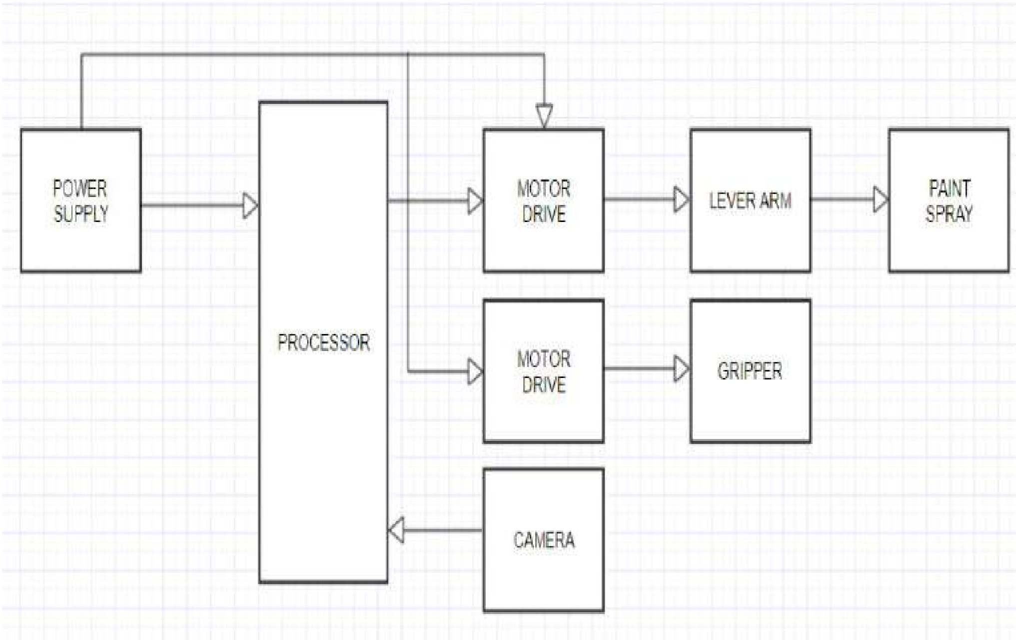

Fig.3.1 Block diagram of Proposed system

3.2 Base stand and Wheel

The base stand is the attached in such a way that it can carry the whole equipment. Four wheels are attached to the base stand in order to move the robot in the forward and reverse direction specified. The movement of these wheels are controlled by the DC motor rotation which is controlled by the microcontroller. Since it is obvious that if either the movement of front or back wheels are controlled automatically the movement of the other one will be controlled. Therefore, in this robot the movement of the back wheels are controlled using the DC motor such that the movement of entire robot is controlled. The arrangement of the frame and wheel.

3.3 Power Supply

3.3.1 Arduino power Supply

The Arduino/Genuino Uno board can be powered via the USB connection or with an external power supply. The power source is selected automatically. External (non-USB) power can come either from an AC-to-DC adapter (wall-wart) or battery. The adapter can be connected by plugging a 2.1mm center-positive plug into the board's power jack. Leads from a battery can be inserted in the GND and Vin pin headers of the POWER connector. The board can operate on an external supply from 6 to 20 volts. If supplied with less than 7V, however, the 5V pin may supply less than five volts and the board may become unstable. If using more than 12V, the voltage regulator may overheat and damage the board. The recommended range is 7 to 12 volts

The power pins are as follows:

- Vin. The input voltage to the Arduino/Genuino board when it's using an external power source (as opposed to 5 volts from the USB connection or other regulated power source). You can supply voltage through this pin, or, if supplying voltage via the power jack, access it through this pin.
- 5V.This pin outputs a regulated 5V from the regulator on the board. The board can be supplied with power either from the DC power jack (7 - 12V), the USB connector (5V), or the VIN pin of the board (7-12V). Supplying voltage via the 5V or 3.3V pins bypasses the regulator, and can damage your board. We don't advise it.
- 3V3. A 3.3 volt supply generated by the on-board regulator. Maximum current draw is 50 mA.
- GND. Ground pins.
- IOREF. This pin on the Arduino/Genuino board provides the voltage reference with which the microcontroller operates. A properly configured shield can read the IOREF pin voltage and select the appropriate power source or enable voltage translators on the outputs to work with the 5V or 3.3V.

3.3.2 **External Power Supply**

In order to provide supply to the controller unit battery is used. Lead acid battery is used in this project. The lead-acid battery is a rechargeable battery. Despite having a very low energy-to-weight ratio and a low energy-to volume ratio, their ability to supply high surge currents means that the cells maintain a relatively large power-to-weight ratio. These features, along with their low cost, make them attractive for use in motor vehicles to provide the high current required by automobile starter motors.

Fig.3.2 Battery[16]

Nominal Voltage	12.0 v
Nominal Capacity	1.2 Ah, 1200 mAh
Max.Charging current	0.36 A
Max.Discharging current	18 A max
Dimension(LxWxH)	97mm (3.82") x 43mm (1.69") x 52mm (2.05")
Weight	1.3 lb (590g)
Terminal	T1

Table.3.1 Battery Specifications[24]

3.4 Processor Module

Arduino is an open source, computer hardware and software company, project, and user community that designs and manufactures microcontroller kits for building digital devices and interactive objects that can sense and control objects in the physical world. The project's products are distributed as open-source hardware and software, which are licensed under the GNU Lesser General Public License (LGPL) or the GNU General Public License (GPL),[1] permitting the manufacture of Arduino boards and software distribution by anyone. Arduino boards are available commercially in preassembled form, or as do-it-yourself kits.

Arduino board designs use a variety of microprocessors and controllers. The boards are equipped with sets of digital and analog input/output (I/O) pins that may be interfaced to various expansion boards (shields) and other circuits. The boards feature serial communications interfaces, including Universal Serial Bus (USB) on some models, which are also used for loading programs from personal computers. The microcontrollers are typically programmed using a dialect of features from the programming languages C and C++. In addition to using traditional compiler tool chains, the Arduino project provides an integrated development environment (IDE) based on the Processing language project.

3.4.1 Arduino UNO

Arduino/Genuino Uno is a microcontroller board based on the ATmega328P.It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz quartz crystal, a USB connection, a power jack, an ICSP header and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started.. You can tinker with your UNO without worring too much about doing something wrong, worst case scenario you can replace the chip for a few dollars and start over again.

"Uno" means one in Italian and was chosen to mark the release of Arduino Software (IDE) 1.0. The Uno board and version 1.0 of Arduino Software (IDE) were the reference versions of Arduino, now evolved to newer releases. The Uno board is the first in a series of USB Arduino boards, and the reference model for the Arduino platform; for an extensive list of current, past or outdated boards see the Arduino index of boards.

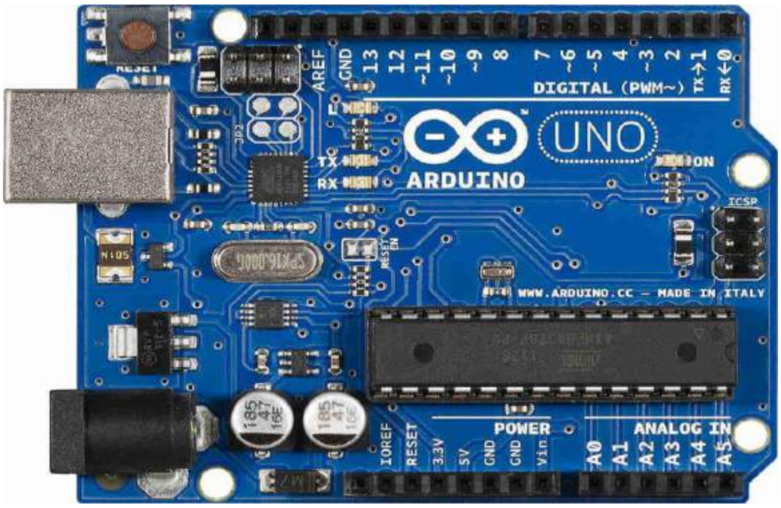

Fig.3.3 Arduino Controller[18]

Microcontroller	ATmega328P
Operating Voltage	5V
Input Voltage (recommended)	7-12V
Input Voltage (limit)	6-20V
Digital I/O Pins	14 (of which 6 provide PWM output)

PWM Digital I/O Pins	6
Analog Input Pins	6
DC Current per I/O Pin	20 mA
DC Current for 3.3V Pin	50 mA
Flash Memory	32 KB (ATmega328P) of which 0.5 KB used by boot loader
SRAM	2 KB (ATmega328P)
EEPROM	1 KB (ATmega328P)
Clock Speed	16 MHz
LED_BUILTIN	13
Length	68.6 mm
Width	53.4 mm
Weight	25 g

Table.3.2 Technical Specifications[25]

3.4.2 Automatic (Software) Reset

Rather than requiring a physical press of the reset button before an upload, the Arduino/Genuino Uno board is designed in a way that allows it to be reset by software running on a connected computer. One of the hardware flow control lines (DTR) of the ATmega8U2/16U2 is connected to the reset line of the ATmega328 via a 100 nanofarad capacitor. When this line is asserted (taken low), the reset line drops long enough to reset the chip. The Arduino Software (IDE) uses this capability to allow you to upload code by simply pressing the upload button in the interface toolbar. This means that the bootloader can have a shorter timeout, as the lowering of DTR can be well-coordinated with the start of the upload. This setup has other implications. When the Uno is connected to either a computer running Mac OS X or Linux, it resets each time a connection is made to it from software (via USB). For the following half-second or so, the boot loader is running on the Uno. While it is programmed to ignore malformed data (i.e. anything besides an upload of new code), it will intercept the first few bytes of data sent to the board after a connection is opened. If a sketch running on the board receives one-time configuration or other data when it first starts, make sure that the software with which it communicates waits a second after opening the connection and before sending this data.

The Uno board contains a trace that can be cut to disable the auto-reset. The pads on either side of the trace can be soldered together to re-enable it. It's labeled "RESET-EN". You may also be able to disable the auto-reset by connecting a 110 ohm resistor from 5V to the reset line; see this forum thread for details.

3.5 DC Motors

3.5.1 DC Gear motors

DC motors are part of the electric motors using DC power as energy source. These devices transform electrical energy into mechanical energy. The basic principle of DC motors is same as electric motors in general, the magnetic interaction between the rotor and the stator that will generate spin. DC motors are widely used in speed and direction control because control of these motors are easier than other motors. The motion of a DC motor is controlled using a DC drive. DC drive changes the speed and direction of motion of the motor. Some of the DC drives are just a rectifier with a series resistor that converts standard AC supply into DC and gives it to the motor through a switch and a series resistor to change the speed and direction of rotation of the motor. But many of the DC drives have an inbuilt microcontroller that provides programmable facilities, message display on LCD, precise control and also protection for motors.

Fig.3.4 DC Motor[20]

Specifications

- Motor Configuration: **Motor** Only, Gearmotor
- 1000RPM 12V DC motors with Gearbox

- 6mm shaft diameter with internal hole
- 125gm weight
- Stall Torque = 0.5kgcm torque
- No-load current = 60 mA(Max), Load current = 300 mA(Max)

3.5.2 Heavy Duty Motor

Fig.3.5 Heavy Duty Motor[17]

Specifications

Operating voltage: 12VDC

No load speed: 206 RPM

Motor Size: 57.5mm (L) * 36.8mm(D)

Shaft Diameter: 6mm

Shaft Length: 15.5mm

3.6 Spray Gun

Fig.3.6 Spray Gun[19]

Spray painting is a painting technique where a device sprays a coating (paint, ink, varnish, etc.) through the air onto a surface. The most common types employ compressed

Gas—usually air—to atomize and direct the paint particles. Spray guns evolved from airbrushes, and the two are usually distinguished by their size and the size of the spray pattern they produce. Airbrushes are hand-held and used instead of a brush for detailed work such as photo retouching, painting nails or fine art. Air gun spraying uses equipment that is generally larger. It is typically used for covering large surfaces with an even coating of liquid. Spray guns can be either automated or hand-held and have interchangeable heads to allow for different spray patterns. Single color aerosol paint cans are portable and easy to store.

This process occurs when paint is applied to an object through the use of an air-pressurized spray gun. The air gun has a nozzle, paint basin, and air compressor. When the trigger is pressed the paint mixes with the compressed air stream and is released in a fine spray.

Due to a wide range of nozzle shapes and sizes, the consistency of the paint can be varied. The shape of the work piece and the desired paint consistency and pattern are important factors when choosing a nozzle. The three most common nozzles are the full cone, hollow cone, and flat stream. There are two types of air-gun spraying processes. In a manual operation method the air-gun sprayer is held by a skilled operator, about 6 to 10 inches (15–25 cm) from the object, and moved back and forth over the surface, each stroke overlapping the previous to ensure a continuous coat. In an automatic process the gun head is attached to a mounting block and delivers the stream of paint from that position. The object being painted is usually placed on rollers or a turntable to ensure overall equal coverage of all sides.

3.7 Relay Module

The basic design of an optocoupler consists of an LED that produces infra-red light and a semiconductor photo-sensitive device that is used to detect the emitted infra-red beam. Both the LED and photo-sensitive device are enclosed in a light-tight body or package with metal legs for the electrical connections as shown.

An optocoupler or opto-isolator consists of a light emitter, the LED and a light sensitive receiver which can be a single photo-diode, photo-transistor, photo-resistor, photo-SCR, or a photo-TRIAC with the basic operation of an optocoupler being very simple to understand.

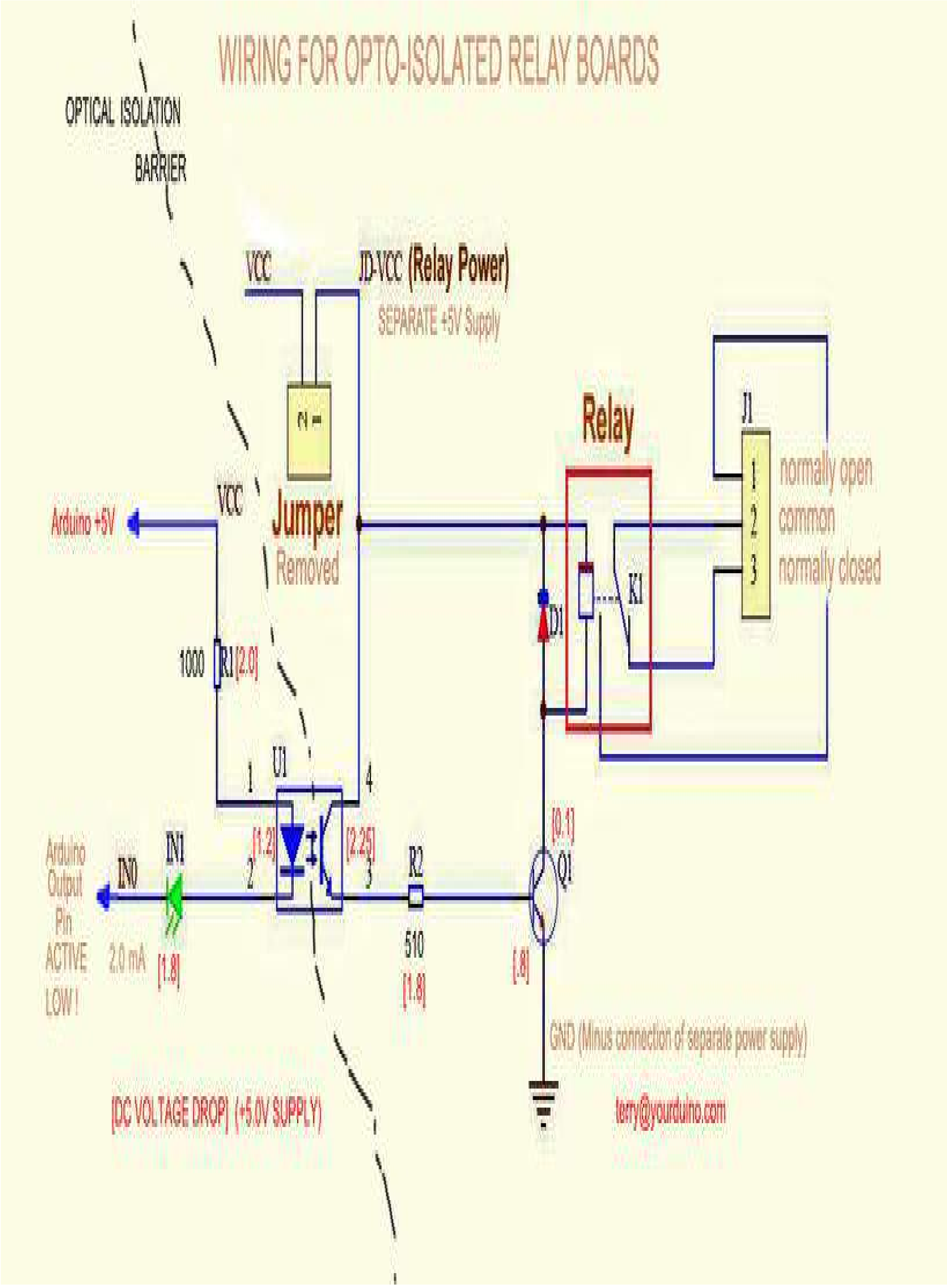

Fig 3.7.1 Optocoupler Circuit Diagram[14]

Fig 3.7.2 Relay Circuit Board[15]

CHAPTER 4
SYSTEM DESIGN

4.1 Mobile Platform Design

The robot's CG (Center of Gravity) point varies as the manipulator moves between the three extreme points of its stroke as shown in Fig.9. It is obvious that the most critical extreme position is the starting point in the stroke, at which the CG point approaches most the end line of the platform. So we should enhance stability in the front side. Another source of instability is the torque generated due to wall roller contact force that will provide quite large reaction torque due to the long span of the manipulator that will reach 2.7 meters at end point of stroke. This tends to turn over the whole robot from backward, where we should enhance the stability. Self-stable platform should constitute of three or more wheels. Three wheeled platform can provide stability for three faces at 120 degrees, since at each face there are two wheels carrying the load, but not for opposite faces at 180 degrees. The need for stable front and back will lead us to the choice of four wheeled platform.

Robot's platform needs to have three degrees of freedom. It has to move in both the x and y directions in order to approach the wall and move between successive strips of paint. Also it needs to rotate about z axis in order to have the ability to adjust its orientation facing the wall so as to assure parallelism before starting the actual painting.

From this data we can think of two main approaches to enable such degrees of freedom which are:

1. attaching a motor to each single wheel.
2. Attaching one motor to each pair of wheels and using one idle motor for the idle wheel attachment.

Considering the first solution we should have four motors with four velocity controllers. Advantages of this method include precise control of platform velocity, fast reach of the desired position and orientation and having all three DOF enabled without the need of extra attachments. On the other hand we have four motors to control which introduces extra cost of sophisticated controllers and motors. But even when applying velocity control on motors we can't overcome using ultrasonic sensor signals as a feedback element form the operational space. The other alternative is to attach every two wheels to a single shaft and by doing so we have one motor dedicated to each pair of wheels. This will enable only two degrees of freedom that are moving in x and y directions. And here comes the need for an extra attachment that enables the third degree of freedom, this is simply an idle castor wheel., that

Is being raised and lowered by a third motor. On lowering this idle wheel, it replaces both back Omni wheels in touch with the ground, so the robot can rotate by making the motors spin in similar directions without the fear of hindering form the on-axis wheels which are now floating.

4.2 Lever arm Design

The lever arm is defined as the perpendicular distance from the axis of rotation to the line of action of the force. The robot arm has the capability to paint the wall by holding the brush or sprayer. Without fixing a sprayer or brush it can perform pick and drop operations which is used as general purpose robot.

Slider-crank mechanism

The Slider-crank mechanism is used to transform rotational motion into translational motion by means of a rotating driving beam, a connection rod and a sliding body. In the present example, a flexible body is used for the connection rod. The sliding mass is not allowed to rotate and three revolute joints are used to connect the bodies. While each body has six degrees of freedom in space, the kinematical conditions lead to one degree of freedom for the whole system.

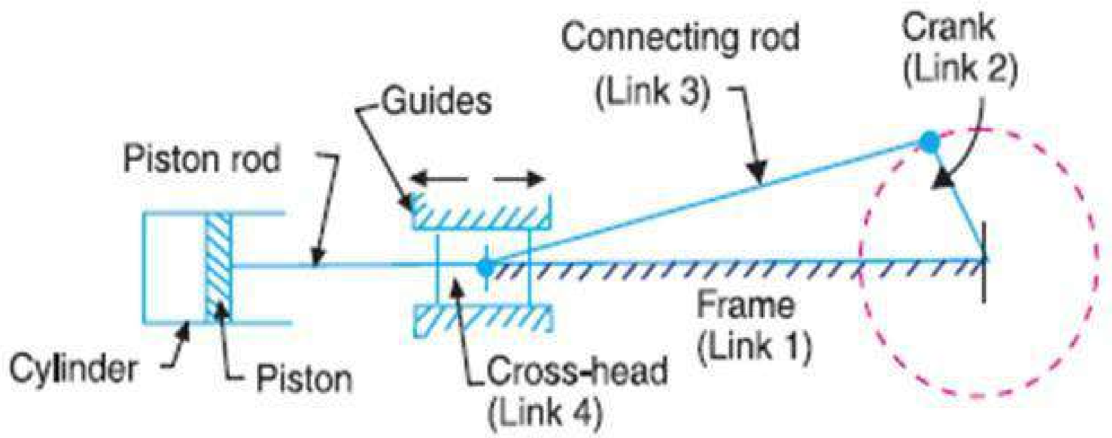

Fig.4.1 Slider Crank Mechanism[22]

A slider crank mechanism converts circular motion of the crank into linear motion of the slider. In order for the crank to rotate fully the condition L> R+E must be satisfied where R is the crank length, L is the length of the link connecting crank and slider and E is the offset of slider . A slider crank is a RRRP type of mechanism i.e. It has three revolute joints and 1 prismatic joint. The total distance covered by the slider between its two extreme positions is called the path length. Kinematic inversion of slier crank mechanisms produce ordinary an white work quick return mechanism.

Mechanisms derived from the slider-crank chain

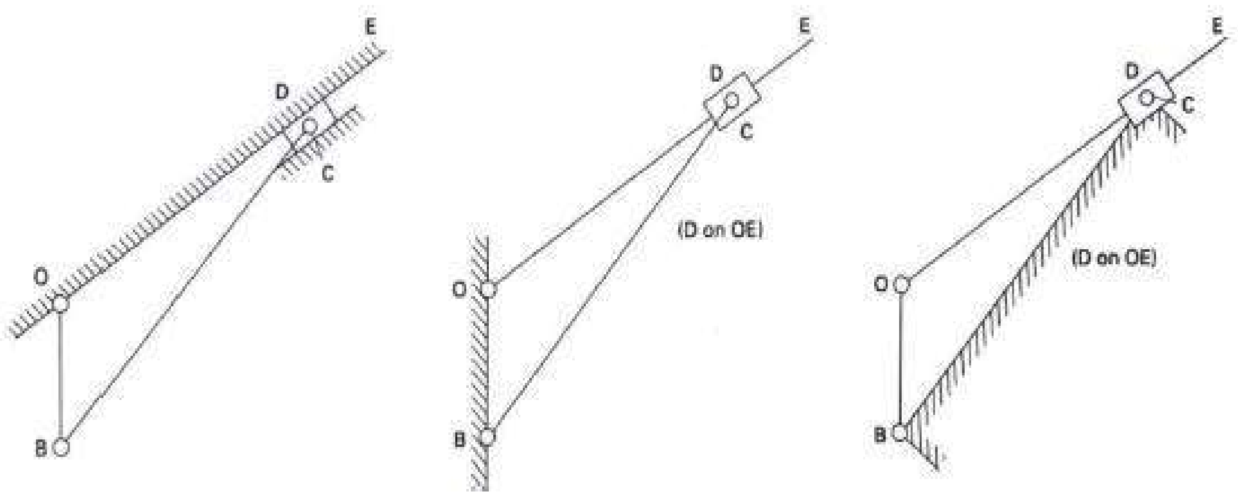

Fig 4.2 Slider Crank Mechanism with different angles[23]

Figures 4.2 show three mechanisms which are obtained by changing the link which is shed. You may recognize Figure as the slider-crank which was examined in Section 4.1. In Figure the link OB is fixed instead of OD. This forms the basis of the Whitworth quick-return mechanism, which you studied in Unit 2. The third variant is obtained by fixing link BC this mechanism is used in oscillating-cylinder steam engines. This process of obtaining different mechanisms from a given assembly of links is known as inversion. You will notice that in invasion. Figure the slider moves along a rotating body, and in Figure the slider itself can now only rotate, but ODE moves through it. Figure shows the slider moving inside the link OE. Although this is physically different from Figure, it is kinematically identical.

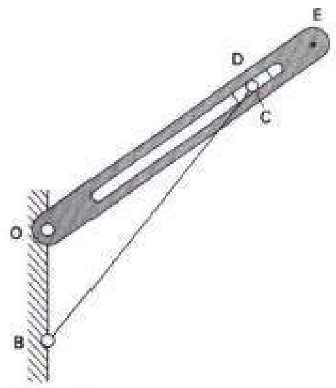

Fig.4.3 Slotted bar[23]

4.3 Gripper Design

Mechanical gripper mechanisms

Robot mechanical grippers and its actuating mechanisms can be classified into several methods. The first method is based on the type of finger movement. During this arrangement, the opening and closing of the fingers can be actuated by either pivoting, or linear or translational movement.

Pivoting movement:

In this motion, the rotation of fingers is concerned with the fixed pivot points of the gripper for providing open and close actions. It uses the linkage mechanism for achieving this movement.

Linear or translational movement:

During linear motion, the guide rails are used to move the fingers parallel to each other for accomplishing closing and opening. In translational movement, the fingers are maintained in a parallel orientation to each other. As like pivoting movement, it also uses the linkage mechanism for actuation.

The second method of classifying the mechanical grippers is based on the type of kinematic device used for the actuation of finger motions. It can be accomplished by anyone of these types: linkage, screw, gear and rack, rope and pulley, or cam actuation.

Linkage actuation:

The design of linkage actuation helps in finding out the conversion of gripper's input force into the gripping force, the time taken to actuate the gripper, and the maximum capability to open the finger. It has plenty of designs for opening and closing the finger, and some of its types are shown below.

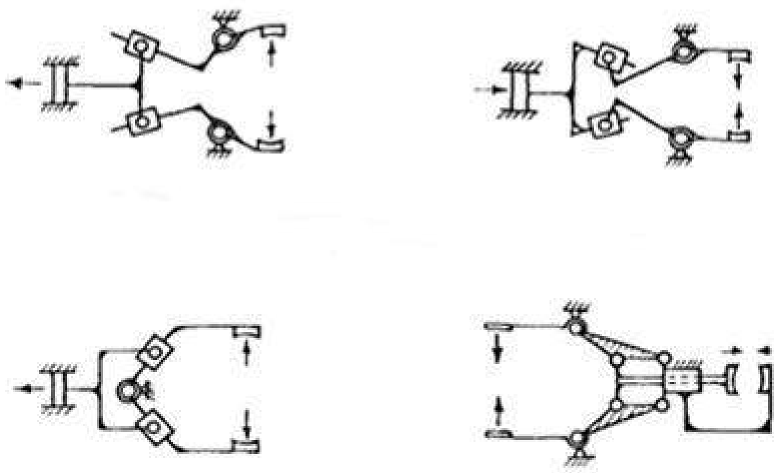

Fig.4.4 Gripper design structures[21]

Our idea for rotating parts requires two ―hard finger contacts, which are defined as contacts that can apply forces pointing into the friction cone but cannot resist torques about the contact point. Clearly, a grasp with two hard finger contacts cannot achieve form closure as the part is free to rotate about the contact axis. Indeed, showed that 4 hard finger contacts are both necessary and sufficient to achieve form closure on a polyhedron. However for feeding parts we do not require form closure; we want to insure that the part will not translate when lifted, and in contrast to most work on grasping, we want to insure that the part will rotate about the grasp axis. One way to achieve hard finger contacts is to use sharpened points. Such point contacts are sensitive to small variations in part orientation and do not have the ―self-aligning benefits of flat contacts. Furthermore, point contacts may damage the part. To implement true hard finger contacts, the biggest problem is eliminating frictional resistance to torques about the pivot axis. An important consideration is that the bearing mechanisms has a small footprint and also permit the pivoting axis to reach as close as possible to the work surface to grasp small parts. Machining such a mechanism poses practical difficulties. We machined our own bearing races and used custom needle bearings to build a prototype with footprint 13_22mm permitting the pivot axis to be lowered to within 6mm of the worktable. We used flat-topped pencil erasers to provide high frictional resistance to translational forces. We mounted a pair of these bearings on a commercial pneumatic parallel-jaw gripper. When the jaws are closed under air pressure, compressive forces tax our thrust bearings and introduce frictional resistance to rotation. Fortunately, we have found that it is a simple matter to achieve compliant rotation by brushing parts against a fixed ―lip in the environment. The brushing movement can be achieved with a combination of vertical and horizontal movements of the arm, thus requiring no actuation at the pivot.

Here we are using a 12v DC motor for triggering the sprayer gun, when the motor rotates in reverse direction the spray gun triggered and starts spraying, if the motor rotates in forward direction it stops spraying. The pressure is to maintained about 30 – 50 psi for the sprayer gun, the compressor or pressure valve is being used for it.

CHAPTER 5
IMPLEMENTATION AND EXPERIMENTAL RESULTS

5.1 The Painting Arm

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. The robotic arm design presented in past sections has been implemented in full scale as shown in fig.5.1

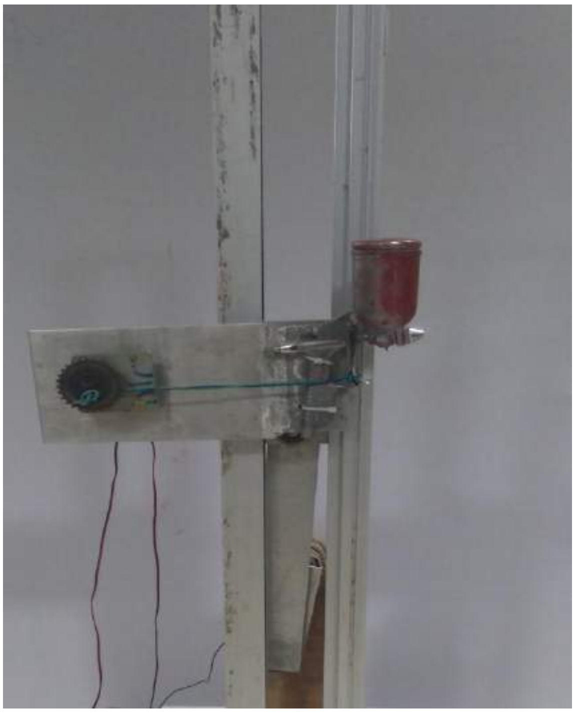

Fig.5.1 Lever arm

5.1.1 Painting Process

The paint robots were introduced for the human in which it can help people from the untrusted painters. Normally a strange painter is suspected to be untrusted in the absence of the owner, so the mobile painting robot can vanish that fear and make the owner to get comfortable with their work. So a person can paint their need by using the paint robots even from any place just by providing commands to their robot in such a secured way. Presently automation is mostly spread in the field of industrial engineering, where there are a lot of patented prototypes, like robots for painting cars, buildings, aircrafts and so on. The major parts used in this project are drivers, DC motors. The process is carried out using the robot arm. The motor parts in the arm enable the robot to rotate in the desired directions, microcontroller programming is done to drive the motor.

5.2 Base Stand

Fig.5.2 Base stand

Four DC geared motors have been used in providing motion to the platform two of them are attached to the two main axes responsible for X-Y positioning, using relay driver circuits, whereas the full scale implementation is shown in Fig.5.2. For moving equipment, a movable work base which uses a mast was adopted. It is composed of a transporter which propels the moving equipment along the outside of the building being painted, a work stage on which the robot main body is mounted and which moves up and down automatically, and a mast which serves as a guide for raising and lowering the work stage. The top of the mast is attached to a travel fitting via a support. This fitting moves along a guide rail mounted on the top of the building.

5.3 Full Robot Structure

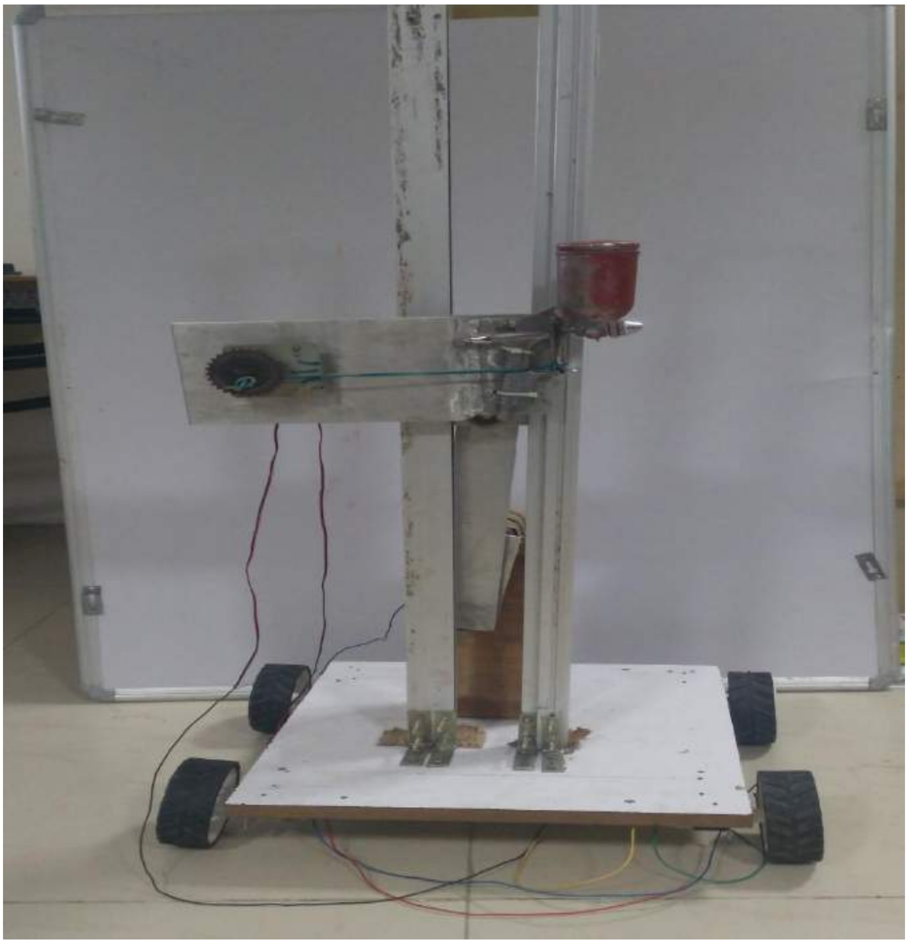

Fig.5.3 Full robotic structure

5.3.1 The Painting Arm

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.

5.3.2 The Mobile Platform

Three DC geared motors have been used in providing motion to the platform two of them are attached to the two main axes responsible for X-Y positioning, while the third is used by the idle castor wheel attachment and responsible for

orientation. Transmission between motors and shaft axes is done via gear-pinion while using rack-pinion in case of idle wheel.

CHAPTER 6
CONCLUSION

A two link planar robotic arm with new actuating mechanism and a mobile platform were designed and implemented. An algorithm for automating the process of painting a single wall 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 succeeded in fulfilling the intended reachability, 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 mobile platform has fulfilled its lateral feeding task in the desirable manner. It is expected that further enhancement of the trajectory can divide this number by two and introduce ceil painting as well.

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