Unmanned Ground Vehicle With Robotic Arm

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ABSTRACT

Unmanned ground vehicle(UGV) is a smart autonomous vehicle that capable to do tasks without the need of human operator. The automated vehicle works during off road navigation and mainly used in military operations. The goal of producing robotic ground vehicle systems capable of executing surveillance, reconnaissance, obstacle-clearing, and infantry tasks in the absence of, or with minimal, human interaction. The purpose of the project is to build a robotic arm on movable platform, which can be controlled remotely over the internet, and to perform operations exhibiting higher accuracy with 6 degrees of freedom. The robotic arm vehicle uses receiver to receive data/commands from the user, over the internet which are interpreted into proper instructions and relayed to the controller. It reduces the human effort when used for applications such as nuclear waste disposal and bomb disposal when compared to present methods.

Keyword : - Unmanned ground vehicle (UGV),Robotic Arm, Servo Motors, Accelerometer *,permanent magnet DC Motor(PMDC Motor),Radio-Control(R/C)*

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1. INTRODUCTION

In the recent years, UGV has been used in different applications like armed and national operations i.e. border patrol, surveillance, law enforcement, hostage situation, police for some specific mission i.e. detecting and diffusing bombs etc. The capability to detect problem by yourself is very critical to the safety of mobile robots and robot routing. UGV is a smart autonomous vehicles that are capable to do tasks in structured or unstructured environment without the help of human machinist. [4] Protection is a major intension of a coal for proper functioning. It will be helpful not only for employees and workers but also for the environment and nation. Coal mines are the most critical challenge for safety, health and environment compared to other industry due to the complication in its operation with wide range of hazardous. Due to vast technological progress, the safety culture and safety at work still serious issues. That's why maintaining of high standards of health, environment and safety in coal mines is of immense value. To save the fatalities life of coal mines workers, due to unfortunate natural accident or unknowingly human made failure, demands sophisticated and organized rescue planning.[3]

Robotic arm provides same functions like a human arm which is depending upon the degree of freedom it can offer. Motion control system plays a important role in the control of different types of industrial automation devices such as robotic arm manipulator.[2] A robotic arm designed using motors is a mechanical arm, which can be remotely controlled having multipurpose manipulator programmable in three or more axes and it can be used to perform a variety of tasks with high accuracy and speed. The ROBOTIC ARM with 6 DOF Of Freedom similar to a human arm can perform all tasks with ease and comparatively faster, simpler with fewer movements.[7]

2. RELATED WORK

Designing and fabricating of a 4-DOF manipulator has been successfully completed. A practical design for the manipulator has been perceived and computer aided designing tools like Creo 1.0 and AutoCAD are used to model the desired manipulator. The mechanical construction in this project is to build and assemble the robotic arm body. After giving a thorough consideration of all the preceding work in this field, a 4 DOF manipulator having variable programmed motions to carry out variety of tasks in diverse environments is chosen. This is a four axis articulate arm designed to move material like tool, machine parts, specialized devices, etc. It is driven by four servomotors and has a gripper as end-effectors. The gripper has fingers manipulation of objects as big as a 150 ml cylindrical bottle. **[1]**

With the help of simulation for all the angles, the input width of 32 bits of coordinates, precision of 32 bits is achieved. Speed control of the robotic arm can be achieved by changing the frequency of PWM signal for every motor on every joint. **[2]**

With this UGVs we can reduce the accident percentage and occupational safety. Whenever any accident occurs, the UGVs detect the accident, reched to location well before the arrival of rescuers. It find the accident location, searches for survivors and informs the rescue team about environmental conditions.These are mainly four types of rescue robots according to that can be categorized like this:

- Unmanned Ground Vehicles-These robots works on the ground(surface) and can help rescuers to find and interact with trapped hostages, in areas were human cannot enter.
- Unmanned Aerial Vehicles-These robots can easily work above the ground and transport medical treatments to victims and can give the signal of the situation to the rescue team.
- Unmanned Underwater Vehicles-These robots can works in water and serched fatalities, hazardous subject. **[3]**

Image segmentation is widely used in many fields such as object recognition, image compression, medical, satellite. Thus, A method of image segmentation i.e. region based is proposed that will help to detect and identification of objects (i.e. cars, human, trees etc.) that come in the path of unmanned ground vehicle during on road navigation. **[4]**

It give a easy way to control a robotic arm using radio control which is more intuitive and easy to work, besides offering the possibility to control a robot by other wireless means. This system Experience robotic arm controller can easily control robotic arm quickly and in a natural way. Also, many applications which require precise control and work like human beings can be easily implemented using this approach the model consists of the transmitting and receiving units. The unit contains an accelerometer, a microcontroller for processing the signals from RF transmitter to transmit signal against different ADC values from micro controller unit. **[5]**

Using Matlab code, able to design and analyze the geometry of the entire articulated robotic arm.Then performed torque calculations and used these calculations to select motors for the robotic joint. **[6]**

Building high torque-servos to reduce the size of arm and to increase the Pay load capacity up to 10Kgs or higher ,build multiple ROBOT Arm’s. The entire ARM is constructed on a ROBOT which can be moved via positioning control through GUI. The focus of this work is effective use of arm control through computer networks, based on IP protocol. **[7]**

2.1.PMDC Motor

DC motors run on of direct current, which is supplied by batteries, which is one of the main reasons that these type of motors are used in robots. Small DC motors quite in quality but most have the same essential features. DC motor works on using a basic law of physics which states that a force is exerted on an electrical current traveling through a magnetic field. Current passes through the motors armature wires, which are surrounded by permanent magnet, generates a force which is communicated to the motor shaft around which the wires are wound. Reversing the direction of the current changes the rotation direction of the motor shaft from clock-wise to counter clock-wise.

The speed is altered by varying the voltage applied to the motor. DC motors runs at high speed of RPMs with low torque. This is not suitable for driving a robot. The motor output torque is too low to move the robot. In order to use the motor ,gearbox is used. Many DC motors come with a gearbox already jointed and these are simply called DC gear head motor .The benefit of using gear head motor is that it is readily available in many sizes, provide a lot of torque, are available with a wide variety of output speeds, come with various voltage ratings, The disadvantage is that gear head motors are not precise.

list some of the important gear head motor parameters:

Availability – Gear head motor come in very small to fractional horse power size. They are plentiful on the market, which makes them inexpensive.

Voltage -The motor operating voltage for modest sized is in the range of six to 24 volts.

Torque - motor torques vary from 20 oz-in, useable for small platforms, to 80 oz-in, which is suitable for eight to ten inch robots.

Motor Speed (ω) – The shaft RPM combined with the size of the wheels determines the maximum speed of the robot.[8]

2.2.Servo Motor

Servo Motor is a DC motor attached with a servo mechanism for precise control of angular position. The servo motors usually have a rotation limit from 90° to 180°.but after following modifications servo motors are run continuously

1. Replace the position sensing potentiometer with an equivalent resistor network
2. Remove the mechanical stop from the output shaft

Here are the steps. You will need a few supplies

- small screwdriver for opening the case
- a soldering iron
- a desoldering pump or solder wick for removing the potentiometer
- wire cutters for removing the mechanical stop
- Two 2.2k resistors

The following steps will help you make the modifications.

- Open the case by removing the screws which is at the bottom of the servo. The bottom plate should remove easily. Remove the top of the case. You will find a set of gears under the top case.

Fig -1: Gears located in servo

- Note how the gears are arranged and remove them from the top of the servo place them as they are supposed to sit. The large tooth gear in the middle does not need to be removed. See the picture below.

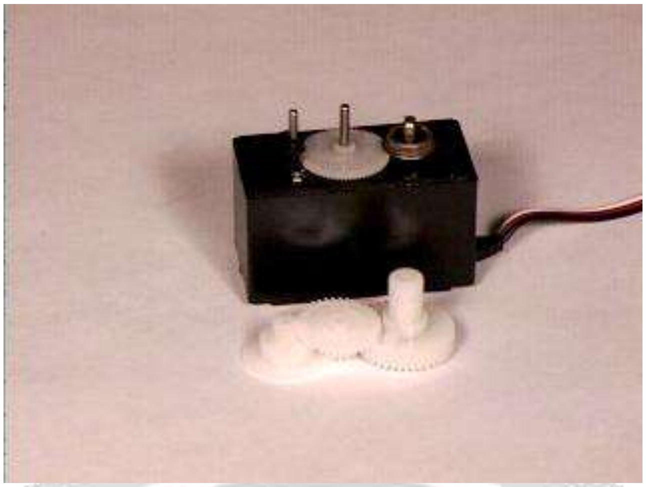

Fig -2: Servo with top and gears removed

- Locate and remove the two small screws on the left shaft in the picture above. These screws go through the top case and into the drive motor.
- There is a need to remove the circuit board from the case. You will probably need to press down hard on the brass shaft on the right side. This is the top of the position potentiometer . Pressing that brass shaft against the workbench helps push it through.
- From the bottom, pry up on opposing corners of the circuit board. The board should move out with the motor and potentiometer attached.

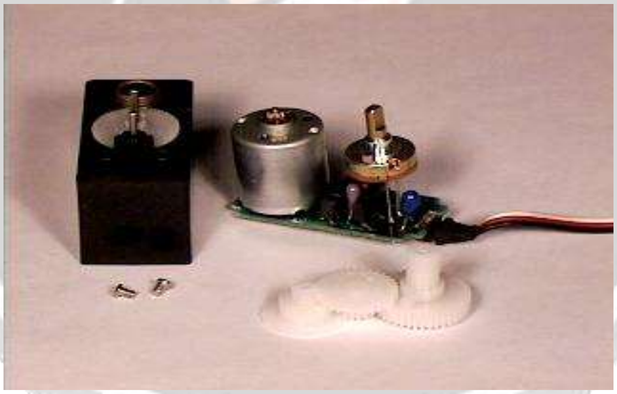

Fig -3: Disassembled servo motor

- Now for the actual modifications. There is a need to desolder the potentiometer from the board. cut the long leads off a quarter inch or so from the bottom. then use solder wick on the back side of the board.
- Once the pot has been removed, joint resistor network in its place, place the resistors side by side and make one pair of leads. Solder them together.The pot has been replaced by the resistor network.

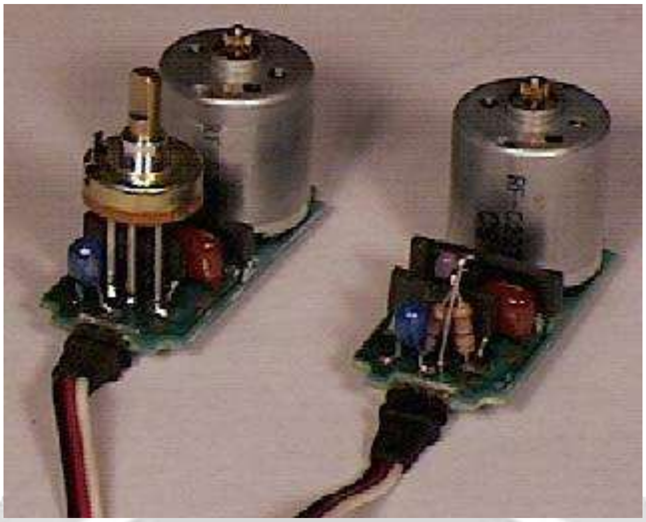

Fig -4: An unmodified (left) and modified circuit board.

- Reassemble the circuit board into the case. Note that the pot is now missing, so only the motor will protrude through the top.
- Before reinstalling the gears, it is essential to modify the gear with the output shaft so the mechanical stop is removed.

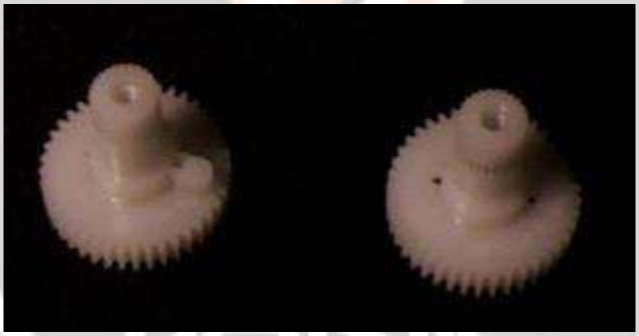

Fig -5: An unmodified (left) and modified output shaft gear

The motor should now be able to rotate in all the way around. Connect a horn, and carefully apply enough pressure to make the horn turn around.

2.3. Sabertooth Dual Motor Driver

Sabertooth allows to control two motor using parameters like analog voltage, radio control, serial and packetized serial. Sabertooth has speed+direction and independent operating modes, making it the ideal driver for differential drive (tank style) robots and more. Many different robots of increasing complexity for years can build to come with a Sabertooth.The operating mode is set with the onboard DIP switches so that there are no jumpers to lose. Sabertooth features screw terminal connectors - making it possible for you to build a robot without even soldering. The first synchronous regenerative motor driver in its class is sabertooth. The regenerative topology means that batteries get recharged whenever you command robot to slow down or reverse.It also allows you to make very fast stops and reverses - giving your robot a quick and nimble edge. Sabertooth has a built in 5V 1A Switch-mode BEC that can provide power to a microcontroller or radio control receiver, as well as 3-4 standard analog servos. The lithium cutoff mode allows Sabertooth to operate safely with lithium ion and lithium polymer battery packs - the highest energy density batteries available.

2.4.Radio Control

Radio control is use of radio signals to remotely control a device. Radio control is used for control of model vehicles from a hand-held radio transmitter. Industrial, military, and scientific research organizations make use of radio-controlled vehicles as well.Today radio control is used in industry for such devices as overhead cranes and switchyard locomotives. Radio-controlled teleoperator is used for such purposes as inspections and special vehicles for disarming of bombs. Some remotely controlled devices are loosely called robots only under control of a human operator. When the receiver receives the radio signal which is sent by the transmitter , it checks it so that it is the correct frequency and that any security codes match,

3.PROPOSED SYSTEM

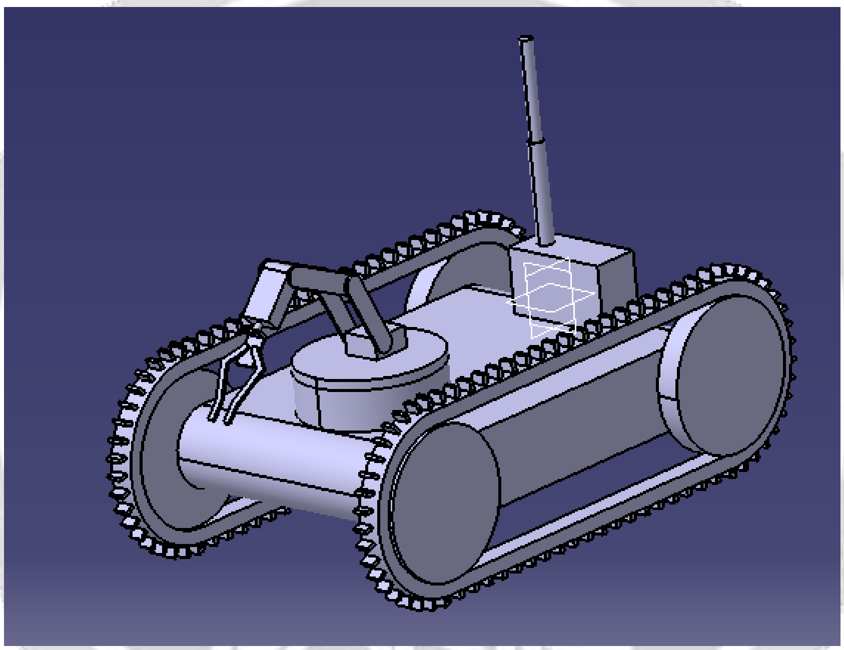

Fig -6: Unmanned Ground Vehicle With Robotic Arm

A remote-operated UGV is a vehicle that is controlled by a human operator via interface. All actions are determined by the operator based upon either direct visual observation or remote use of sensors such as digital video cameras. A basic example of the principles of remote-operation would be a remote controlled toy car.

4.DESIGN CALCULATION

We begin with the relationship between robot speed, motor speed, and wheel size. The basic equation relating robot speed to motor angular speed is:

$$\mathbf{V} = \omega \times \mathbf{R}$$

Where

V = is the robot speed

Ω = is the motor angular speed (how fast the shaft turns) in radians/sec

R = is the wheel radius

If the wheel is not directly mounted to the motor shaft, then ω is the wheel angular speed, the rotation rate of the motor modified by any gearing interposed between the motor and the wheel . Choosing practical units, the relationship between wheel size, motor speed, and robot speed is:

$$V = \omega \times D / 19.1$$

Where,

V = robot speed in inches/sec

ω = motor speed in revolutions/minute (RPM)

D = wheel diameter

19.1= is a conversion factor to make the units consistent

We can turn this equation around to calculate a required motor speed given a desired robot speed and wheel diameter, or we can calculate a wheel diameter to provide a desired robot speed from a given motor speed. These relationships, using the same units of rev/minute and inches, are:

$$\omega = 19.1 \times V / D$$

$$D = 19.1 \times V / \omega$$

4.1 Speed Requirement

Let's say the average speed of a suitable competitor is Vold and we want to go faster by some factor **f**. Then our average speed requirement is simply

$$V_{avg} = f \times Vold$$

And our motor speed requirement is:

$$\omega = 19.1 \times f \times Vold/D$$

Let's examine picking an average speed for a contest in more detail. Average speed is just the distance traveled, **X**, divided by the time taken, **T**.

Choose a distance appropriate to the contest. The distance between objectives, or the whole field if the rules permit. The motor will accelerate over part of the range, **S**, during which the robot goes from **zero** to some cruising speed, **VC**. For loads that are not too great, a motor will achieve a steady speed and torque over a short distance. The time **T** is divided into two parts, T_1, time of the acceleration over distance **S**, and T_2, the time spend cruising at speed **VC**. Then the average speed is:

$$V_{avg} = X / T = X / (T_1 + T_2)$$

Where,
X = is the total distance traveled
T_1 = is the acceleration time
T_2 = is the cruising time

4.2 Motor Torque

$$\mathbf{C = F_f / F_N}$$

where
C = is the coefficient of friction
F_f = is the frictional force to begin motion
F_N = is the normal force

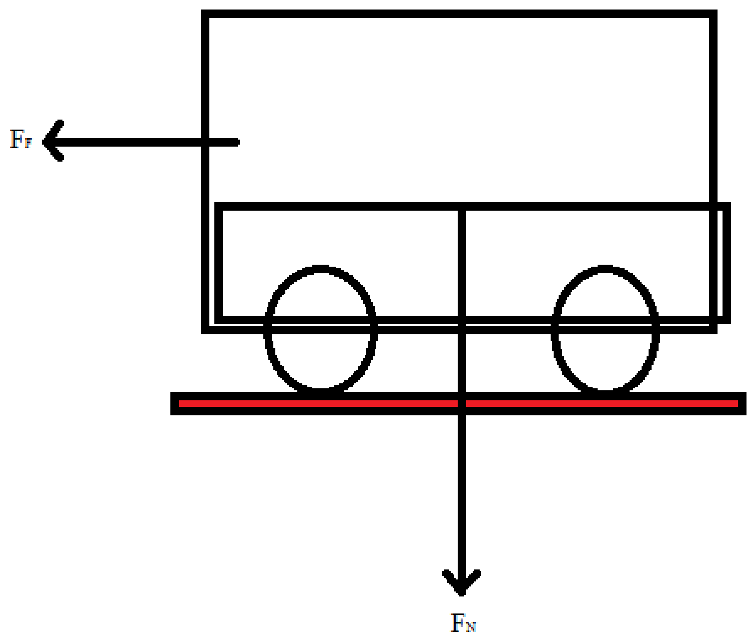

Fig -7: Forces acts on body

On a level playing surface, the normal force is just the robot weight, W.
Thus the minimum required motor torque is:

$$\mathbf{T = F_f \times R = C \times F_N \times R = C \times W \times R}$$

Converting units,

$$\mathbf{T = 8 \times C \times W \times D}$$

Where,
T = is the torque in oz-in
C = is the coefficient of friction
W = is the weight in lbs
D = is the wheel diameter in inches.

The robot acceleration is given by Newton's second law of motion:

$$\mathbf{F = m \times a}$$

Where,
F = is the net accelerating force.
M = is the mass of the object that the force acts on
A = is the resulting acceleration.

Applying equation to the force of gravity:

$$\mathbf{W = m \times g}$$

Where,
W = is an objects weight
M = is the object mass
G = is the acceleration caused by gravity

4.3 Playing Fields with Inclines

Figure 8 illustrates the situation for a robot on an inclined plane. Part of the weight of the robot presses it against the surface, called the normal force F_N, and part is directed down hill, called the tangential force F_T.

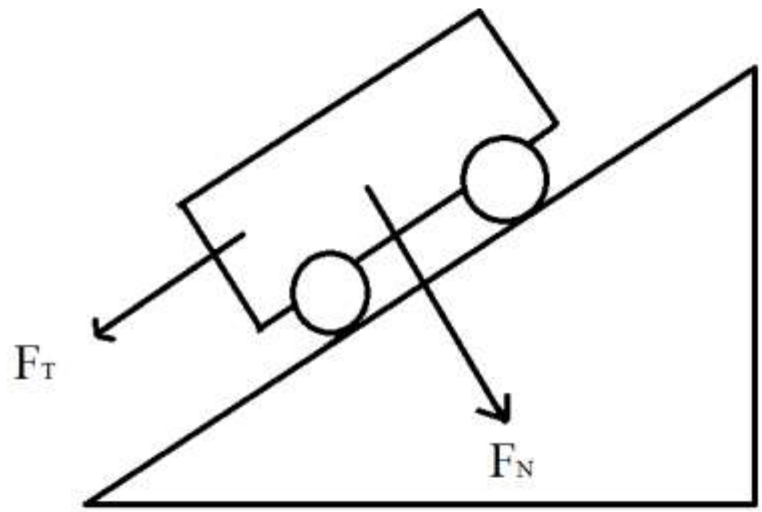

Fig -8: Forces acts on body at inclines

$$\mathbf{F_T = 16 \times W \times \sin(\theta)}$$

where,
F_T = is the force in oz
W = is the robot weight in pounds
θ = (theta) is the inclination angle (tilt) of the surface
Sin θ = is a trigonometric function

The force pressing on the incline is equal to the portion of the robot's weight against the plane, the normal force,

$$\mathbf{F_N = 16 \times W x \cos(\theta)}$$

where,
F_N = is the force in oz
W = is the robot weight in pounds
θ = (theta) is the inclination angle
Cos θ = is a trigonometric function

When the gravitational tangential force pulling the robot down the incline exceeds the static friction force, **FS**, sliding will occur. As the steepness of the incline increases from zero, a point will be reached when the forces are in balance. That is when,

fS = FT

As the slope increases further, the robot will begin to slide. Since the coefficient of sliding friction is less than the coefficient of static friction, the robot continues to slide. Using equation 11, we can calculate the coefficient of static friction, CS, from the slope when the robot begins to slide.

$$CS = 16 \times W \times \sin(\theta) / 16 \times W \times \cos(\theta)$$

$$CS = \tan(\theta)$$

Where,
CS = is the coefficient of static friction
θ = is the inclination angle
Tanθ = is a trigonometric function

To find the torque needed to overcome the pull of gravity down the incline, we simply multiply the tangential force, equation 22, by the wheel radius.

$$T = 8 \times W \times D \times \sin(\theta)$$

Where,
T = is the motor torque in oz-in
W = is the robot weight in pounds
D = is the wheel diameter in inches
θ = is the inclination angle.

A motor with no external load (zero torque), operating at its nominal rated voltage, will spin at its maximum rate, the no load speed **ωo.**

$$T = Ts \times (1 - \omega/\omega_o)$$

Where,
ω = is the angular speed
ω_o = is the no load speed
Ts = is the stall torque
T = is the torque at ω

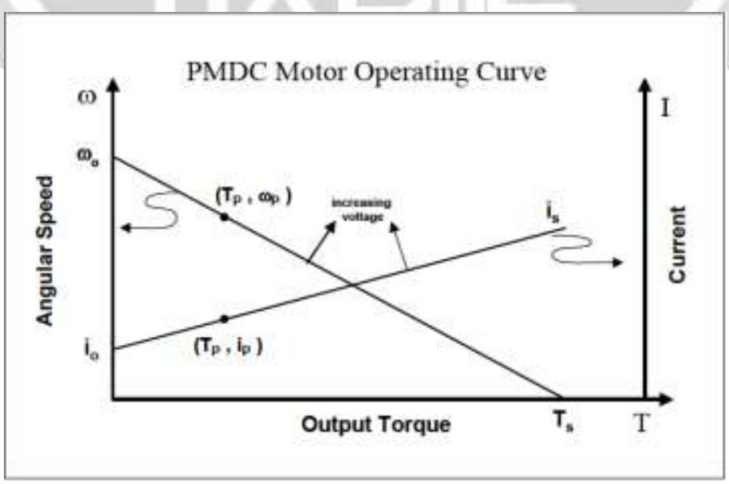

Fig -9: PMDC Motor Characteristics

Using a multimeter we can measure the motor coil resistance. For the Globe motor it's 13.7 ohms. Ohm's law gives:

I = V / R [8]

4.4 Robot Arm Torque

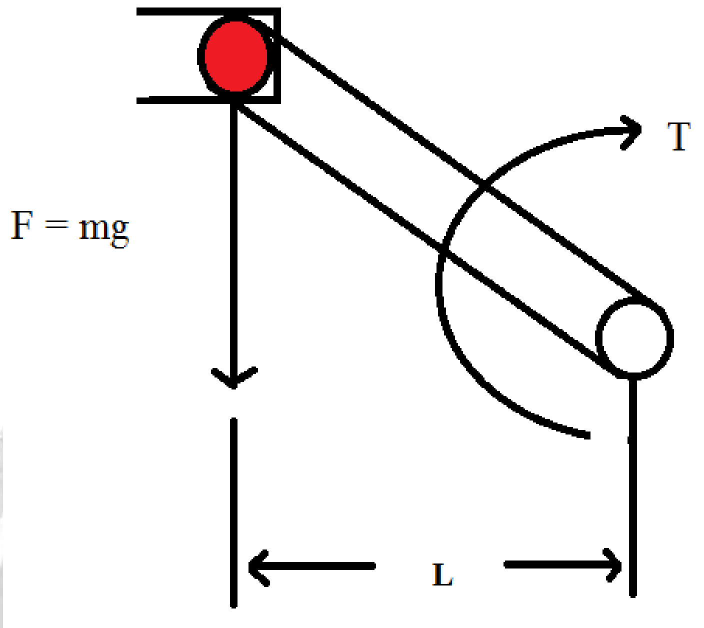

Fig -10: Determination of arm torque

Determine the torque required at any given lifting joint (raising the arm vertically) in a robotic arm

$\tau = F \times L$

$\tau = mg \times L$

where,

τ = torque needed to hold a mass a given distance from a pivot

mg = weight of load

L = is the perpendicular length from pivot to force

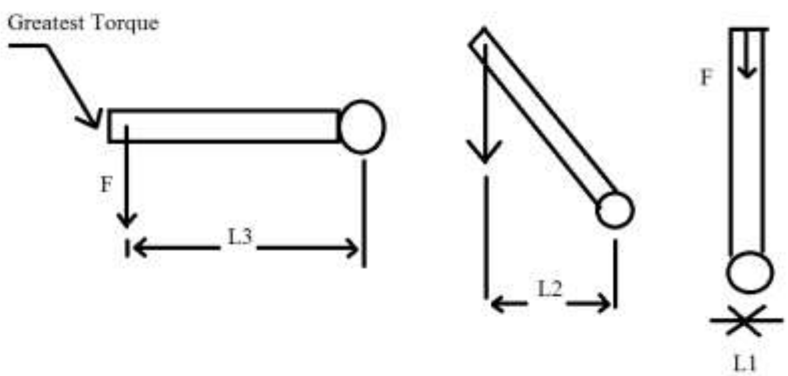

Fig -11: Determination greatest torque

To estimate the torque required to each joint , we must choose the worst case scenario As the arm is rotated in clockwise, L the perpendicular distance decreases from L_3 to L_1 (L_1=0). Therefore the greatest torque is at L_3 (F does not change) & Torque is zero at L_1.Motors are subjected to the highest torque when the arms is stretched out horizontally.

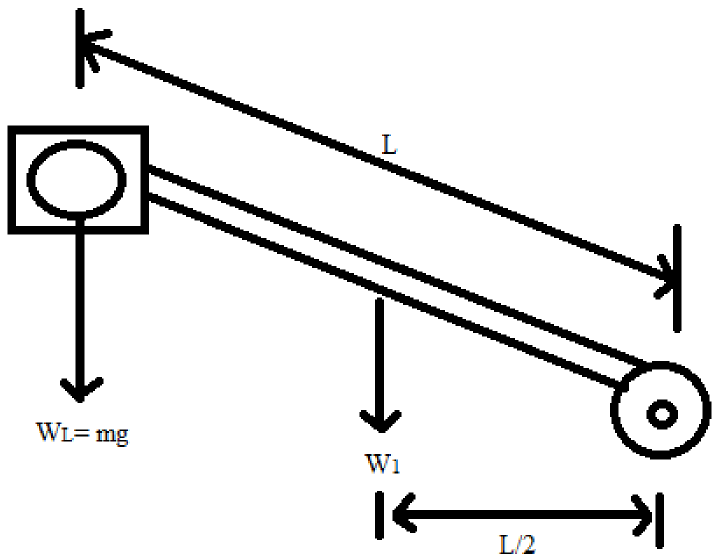

Fig -12 Force acting on end point and midpoint of link

Also adding the torque imposed by the arm itself

$\tau = (mg \times L) + (W_1 \times L/2)$

$= L\,(mg + W_1/2)$

RMF (motor specs) Robot arm torque

$\tau \times rps = L(mg + W_1/2)\,(rps)\,(1/efficiency)$

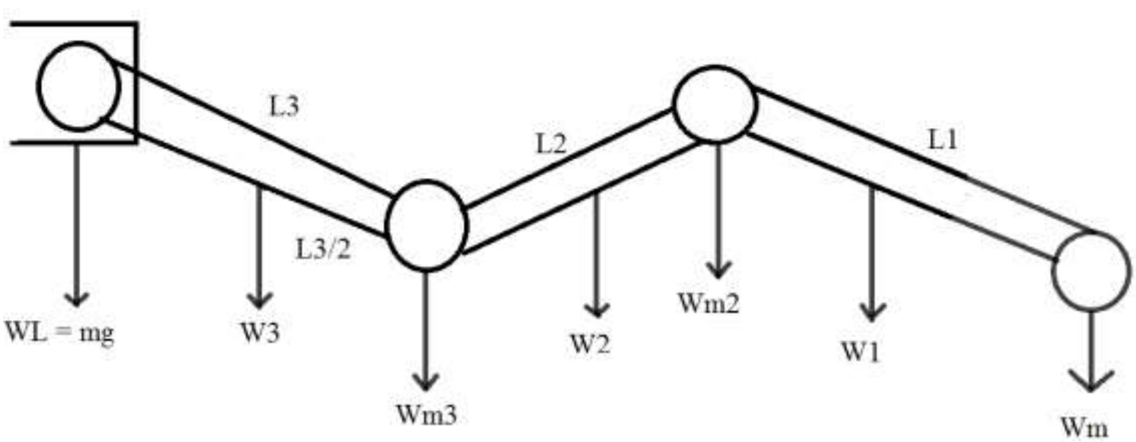

Fig -13: Arm with multiple point and forces

If arm has multiple points, you must determine the torque around each joint to select the appropriate motor

$\tau_3 = (mg \times L_3) + (W_3 \times L_3/2)$

$\tau_2 = [mg \times (L_3+L_2)] + [W_3 \times (L_2+L_3/2)] + (W_{m3} \times L_2) + (W_2 \times L_2/2)$

$\tau_1 = [mg \times (L_3+L_2+L_1)] + [W_3 \times (L_1+L_2+L_3/2)] + [W_{m3} \times (L_1+L_2)] + [W_2 \times (L_1+L_2/2)] + (W_{m2} \times L_2) (W_1 \times L_1/2)$

5. CONCLUSIONS

The unmanned ground vehicles can spot the explosives or the human opposition before the soldiers can be harmed in the combat. They can save the human soldier from the harms.With this UGVs we can reduce the coal mines accident and occupational safety. Whenever any accident occurs, the UGV automatically detect the accident, find the location and enter the coal mine tunnel well before the reaching of rescuers. It finds the accident location, searches for trapped survivors to give them first aid treatment at right time and informs the rescue team about environmental conditions and about the survivors inside the coal mine.

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