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Design and Selection of Components for Automated Omnidirectional Marking Vehicle

Akash C. Govalkar[1], Akshay M. Pudke[1], Mr. Dhirajkumar S. Lal[2].

[1]PG Student (Construction Management), Department of Civil Engineering, Pimpri Chinchwad College of Engineering, Pune, India.
[2]Associate Professor, Department of Civil Engineering, Pimpri Chinchwad College of Engineering, Pune, India.

Abstract - *Present construction industry needs some automation to complete the construction task with accuracy and within time. Using robotic vehicle on construction sites is new trend to move towards automation. For the purpose of field marking not any kind of robotic automation is done on site. Therefore, in this research design and suggest a vehicle which will be suitable for any kind of field and it will mark with accuracy. This vehicle comes with the chip swerve drive mechanism which is affordable to any construction site for marking. Swerve drive mechanism provides vehicle an omnidirectional movement and work efficiently on rough ground. In this paper discussed steps for Selection process of components for the vehicle. For any kind of project cost is the major factor which effect on design. So, in this design cost efficient components are selected.*

Key Words: Omnidirectional, layout marking, Automation, swerve drive robots.

1.INTRODUCTION

According to the Midwest Economy Policy Institute (MEPI), up to 2057 2.7 million constructions work positions are going to be replaced. Study finds out 49 % of the jobs will be automated with similar time and cost. Swerve drive robots are specially design robots to spin robots during travelling on the field. With the ability to rotate by each wheel provides a efficient omnidirectional movement. In swerve drive normal wheels will replace by self-rotating wheels which is connected with steering motor. A normal force is translated in the direction of the wheel by the peripheral roller. The resultant force is developed by the individual elements of the roller, which in turn move freely without changing the direction of the wheel. In the present automation world, the demand for industrial robots are increasing. Many processes service industries are using mobile or movable robots for transmitting of raw material of finished product from one place to another place. It is observed that uses of industrial robots are common due to the reason of saving in time and money in transportation. The advantage of the omnidirectional robot is that it can move independently as well as work in three degrees of freedom. An omnidirectional vehicle can increase its movability in an effective manner. Although, it is a challenging task to apply mobile robots in many industrial sectors like cement industry, automobile industry, aerospace industry and defiance organization. These industries required high skills and high movability at the same time. Manufacturing of different parts in such type of industries requires high labour cost as well as complexibility in operation. The LiDAR pulse generator emits rapid light pulses to a surface, some up to 150,000 pulses per second. The sensor on the instrument measures the time it takes for each pulse to return back, flight time (Time of Flight ToF). Light moves with a known constant speed so the LiDAR instrument can calculate with high accuracy the distance between him and his target. Repeating this rapid sequence, as it rotates, the measuring instrument may be planning a complex map of the environment, see. [1,2] Autonomous Mobile Robot(AMR) with the application of fleet tracking, surveillance control robotic car, there two main concepts in this AMR. First one is to analysis the waypoint from starting and destination points, then get the Latitude and Longitude and receive the Latitude(LAT) and Longitude(LON) using GPS receiver (Ublox Neo). Second one is too dependent on the waypoints to run a AMR with help of LAT and LON to reach the destination point in straight line with guidance of MPU6050 sensor, if any obstruction near the AMR they stop automatically with some distance using Ultrasonic sensor(HC-SR04) in front. [2] The task of the controller is to achieve various goals and desired features for the robot motion. It is also designed to execute the planned sequences of motions correctly in the presence of any error. The control strategies in this work are based on controlling the traction forces causing • arc r), (oo yx Y-direction Xdi i • Goal • • Start θ arc •), (mm yx), (22 yx), (11 yx 153 the motion as well as maintaining the tracking of the desired path without any slippage or deviation. Traction motion control has some desired feature such as: 1- Maintaining the fastest possible acceleration and deceleration 2- Maintaining the desired path following accuracy 3- Maintaining the robot stability during the manoeuvres 4- Preventing the robot from slipping or sliding. [3] Mobile robots are generally operated as unmanned ground vehicle (UGV) or by teleoperation. It means that the user or engineer cannot manage when the robot falls into emergency situations such as rollover or stop due to discharge. For this reason, the robot should maintain its stability while operating on various kinds of terrains and the energy efficiency should be good enough. [4] capable of receiving and sending information over the internet with the help of various Arduino shields, which are discussed in this paper. Arduino uses a hardware known as the Arduino development board and software for developing the code known as the Arduino IDE (Integrated Development

Environment). Built up with the 8-bit Atmel AVR microcontroller's that are manufactured by Atmel or a 32-bit Atmel ARM, these microcontrollers can be programmed easily using the C or C++ language in the Arduino IDE. [5]

2.Design and Selection of Motors

Step 1. Selection of Size of the chassis

Chassis dimensions are not standards, select any dimension for square frame. Ex. 50cm X 50cm

Step 2. Selection of Drive Motor

Initially the bot will accelerate and overcome the static friction. Then move with constant velocity up to certain required distance. At the end, to stop the bot at specific position deceleration is required.

Over all motion is depicted by the v-t graph as shown in Chart - 1.

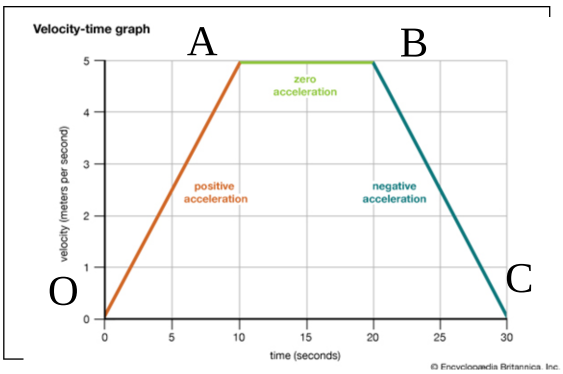

Chart -1: v-t Graph

Calculations:

A-B (Uniform Velocity)

$v = \frac{s}{t}$

O-A Motion

To find acceleration and time

$v^2 = u^2 + 2as$ v = u + a × t

B-C Motion

Similar to OA as Distance is same for deaccelerated, Total time=Required time for (O-A) +(A-B) + (B-C)
From this find out the maximum and minimum acceleration
Select the type of belt according to the suitability on field

Torque Calculation:

At starting point 'O', Static friction needs to be overcome.

Coefficient of Static Friction between rubber and painted surface = 0.5
Mass of robot = m

$F_3 = \mu_s \times m \times g$

Starting torque on each wheel:

$\tau_s = (\frac{F}{4}) \times r$

Force due to acceleration:
F = m × a.

Force due to rolling resistance:

$F_r = \mu r \times m \times g$ where $\mu_r = 0.005$

Torque during O-A Motion:

Due to acceleration and rolling resistance
$\tau_{OA} =$

Torque during A-B Motion:

Bot is moving with constant velocity.
$F_{acceleration} =$
To move with uniform velocity, the bot needs to overcome kinetic as well as rolling friction.
$F_r =$
Coefficient of Kinetic Friction between wheel material and material for testing μ_k=?
$F_k = \mu mg$

$\tau_{AB} = (\frac{Fk + F_r}{4}) \times 0.007.$
$\tau_{AB} =$

Torque during B-C motion:

Same as O-A
$\tau_{OA} =$

As the speed depends on the voltage supplied to motor. Therefore, considering the transmission efficiency from motors, gears and couplings, kept FOS 1.7.

Step 3. Selection of Steering Motor

Selection of Timing Belt:

Timing belt drives employ the positive engagement of two sets of meshing teeth. Hence, there is no relative motion between the two elements in mesh. Due to this feature, different parts of the drive will maintain a constant speed ratio or even a permanent relative position. This is extremely important in applications such as automatic machinery in which a definite motion sequence and/or indexing is involved.

Timing Belt Calculations:

Initially find out the coefficient of friction between material which use for wheel and surface where it's going for testing. Select timing pulley according to the specification of timing belt.

$$L = 4c + \pi D$$

Slider Velocity(v)= $\frac{\pi D N}{60}$ = [where N=100rpm]

S = $\frac{D}{2} \times \theta$ $[\theta = 90]$

$v^2 - u^2 = 2 \times a \times s$

a =?

Accelerating Force of Slider

F=ma

Friction due to mass of Robot

$$F_w = \mu_s \times m \times g$$

Initial Forces Due to Accelerating effect of Belt

$F_{ab} = \frac{W_b \times L \times b}{g} \times a$

Where $W_b \rightarrow$ Specific weight of belt

F_{ai} =

Forces due to idler pulley

$F_{ai} = \frac{4 \times J_i \times \alpha \times 3}{d}$

$= \frac{m_i}{2} \times \left(1 + \frac{d_b^2}{d_i^2}\right) \times a \times 3$

$d_o \rightarrow$ diameter of bore of idler

$m_i \rightarrow$ inertia of idler pulley

$\alpha \rightarrow$ angular momentum

Since no of idler pulley is 3 hence the force is multiplied by F_{ai}

Thus Tension of belt can be obtained by

$T_e = F_a + F_w + F_{ab} + F_{ai}$ [T_e = tension in belt]

Based on Tension and Chassis dimension we have selected HTD 5 Belt for our application, from manufacturer catalogue of Gates Mectrol.

Torque = Radius of pulley × 2 × T_e

Power required = $\frac{2\pi \times N \times T}{60}$

After the selecting the suitable timing belt and timing pulley consider factor of safety on power required which is up to 2 and then select suitable steering motor.

3. SELECTION OF OTHER COMPONENTS REQUIRED FOR ROBOT

Arduino UNO: Arduino is the main controller of this system. It receives indications from the sensors which are used for the collection of data and from the User. Then on the basis of data ALMV will perform accordingly

Sensors: In this vehicle mainly three sensors are required LIDAR sensor, Bluetooth Sensor, Rotary Encoder. LIDAR for accurate distance measuring and follow the path, Bluetooth for receiving task from user and Encoder to give input for the wrong direction of wheel.

Relay: It is a one type of driver to control and switch the load of current. For ALMV it is help to provide an isolation between power device and Microcontroller which Arduino in this vehicle. It switches for 5 ampere devices.

Power Supply: To give power to the ALMV it provides acid lead battery which is available in low cost.

Servo Motors: to rotate the Lidar sensor it need one low torque motor. So, for this purpose Tower Pro SG90 is selected. Which having capacity to give rotation in 360 degrees and also it is very helpful in forward and backward rotation.

DC motor: These are used mainly for the UGV movement.

Motor Driver: To program the motion of DC Motor and Rotation of Stepper required some suitable drivers according to their current supply. For the DC motor VNH2SP30 is selected because it is very suitable for the high torque motor with 14A current. For Stepper motor selected TB6600 Driver which is having intelligent current control with PWM Modulation.

Fig - 1 shows assembled vehicle

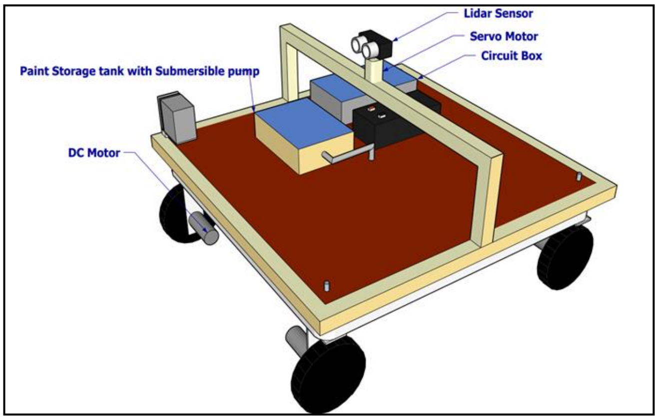

Fig - 1: Components of Marking Vehicle

3. CONCLUSION

The present work describes the design and manufacturing process of Automated omnidirectional vehicle. The basic application of vehicle is to done marking on the field. In the present paper cost-effective design and manufacturing process is described. Design of vehicle will be used in robot application which further use in many applications like monitoring, field marking etc. It is found that the present method for designing is quite easy.

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