Robotic Vision in Game Theme
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Abstract

Today, the autonomous robots are widely used to perform task in a wide variety of application. A number of research works has been carried out to examine and remove problems faced by the current robotic world. The theme of this paper is to discuss different design consideration along with their limitations and solutions for an autonomous robot which will be able to climb and cross the ramp and place boxes on to stands placed at different points of arena using line following principle. The implementation of this robot was the theme of “NERC 2010”. The robot has also the limitation of weight, size and power.

Keywords: Keywords: Autonomous robot; Design Strategies; NERC; Sensors arrangement

1. Introduction

The design features and failures has now become the challenge for the current robotic world. Line following robot is the basic and simple way to learn about the motion of robot according to its sense of vision. In this paper we will be focusing on an autonomous robot design which can perform pre-defined task. A set of rules has to be declared for autonomous robots to perform its action without any human interaction. This paper will focus on different design aspects of robot which can climb and cross the ramp and place pegs on to different stand place within arena using line following principle. Since simplicity in mechanical design is the key task of any robotic system. So, this paper will discuss simple and efficient mechanical design for the above described task. In [1, 7, 8], the authors focussed on three wheeler design with IR sensors for line detection while in this paper two different mechanical designs has been discussed capable to climb on to ramp along with their pros and cons. Also, the contrast of IR and coloured sensors has been made.

2. Design consideration

A set of rules has been pre-decided to define the action performed by the autonomous robot without any human interaction. The robot is designed so that it can complete the task of peg placement into specific stand after crossing ramp present in two different positions of arena. There were also weight, size and power limitation for the robot [2].

3. Mechanical design

The mechanical design has a number of aspects to be considered. The dimensional consideration was the first challenge; the robot size should not exceed 60cm in length, 60cm in width and 60cm in height at zero position of arena. The weight of whole structure should be within 12kg.

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3.1. Driving wheels and motor arrangement

The wheels and motor is the most sophisticated part of robot. Its importance is similar as that of legs and joints in body. Wheels describe the stability and strength of robot against the hurdles, while motor is selected on the bases of torque required. In arena there is a ramp with an angle of inclination equal to 30° as shown in fig. 1, so wheels should be selected so that robot can easily climb and cross the ramp, likewise the motors should be of enough toque so that wheel should not get free while descending from ramp. In order to achieve the task two most common design approaches can be adopted.

3.2. Three wheeler design

The simplest design technique to climb on to ramp and achieve the task is three wheeleras shown in Fig. 1. In this design the back two wheels are of rubber with cuts on their faces to have a good grip with arena. These wheels are directly coupled with geared motors having good torque and speed to achieve the task on time. The diameter of the wheel is on your choice, we have used the wheels of 20cm diameter so that the robot steps must be within controllable limits. The third and central wheel is ball caster; this is because it’s a free wheel with rolling ability on floor i.e. having 3D movement ability. Although this is the simplest implementation of line follower [10], but since our task is not only to follow the line but it also requires to cross the ramp in order to reach the other peg stands so this design creates certain unbalance situations during test drives so we have to move to the next design approach which is four wheeler.
3.3. Four wheeler design

The problem with three wheeler design is the stability, while crossing the ramp because of weight distribution. So the next design technique with some complexity but have greater stability than three wheels is the four wheels chain drive.

In such design, as shown in Fig. 2a; we are using four wheels with two motors driving the back wheels. The diameter of back wheels is twice times greater than that of front wheels because of increasing the speed as shown in Fig. 2b. The front and back wheels of respective sides are connected to each other through chain and sprockets mechanism so that both left wheels and both right wheels move synchronously. Only two motors were used to drive the wheels instead of using four separate motors for individual wheels to reduce the chances of RPM mismatch which causes turning effect in your robot.

3.4. Drive mechanism

The robot differential DC drives consists of two individual DC motors of same RPM’s attached to the left and right back wheel respectively. The same rpm of driving motors allow the robot to have linear motion else it will show turning behavior.

Normally, the mechanism of PWM is adopted in order to control the rpm or speed of motor as described in [7, 9], however if you are using used motor then PWM is not suitable because such motors already have variable magnetic flux due to problem in their permanent magnet or in winding, so any attempt to control their flux will lead to uncertain behavior of motor. The robot drive follows the Table 1 for robots movement. The wheels are made differentially controlled so that the turns of the robot could be made smooth.

| Left motor | Right motor | Motion   |
|------------|-------------|----------|
| 0          | 0           | Stop     |
| 1          | -1          | Right    |
| -1         | 1           | Left     |
| 1          | 1           | Forward  |
| -1         | -1          | Reverse  |
3.5. Peg placement mechanism

Pegs are wooden blocks which are to be placed in four stands (marked as a, b, c and d) present at four corners of arena. The boxes of each stand are marked as shown in Fig 3a. The robot cannot place more than one peg in the similar numbered pigeon-hole even on a different stand. Only two outlets were allowed for peg placement.

So, the peg placement mechanism is designed on the principle of car lifter. We use chain and sprocket mechanism for lifting the outlets up and down while peg pushing is done using antenna motor. Single antenna motor is used to push both the openings.

4. Electronic design

The role of electronics in robots is similar to that of soul in your body. Without electronics robot is unable to know what to do and how to do? Microcontroller family acts like a brain of robot. [3]. There are certain precautions that should be considered like current spike caused by the motor starting behavior for which you need to place a 1000μF capacitor at the supply line of micro-controller so that the unnecessary spike will be grounded directly and will not effect the performance of controller. Such spikes may cause you controller to perform mall functions.

4.1. Sensor

The importance of sensors in automation is similar to that of eyes in human. So it should be designed carefully, since the provided arena is of blue mat with lines on it is of white tape. So the sensor must be designed in order to distinguish clearly the lines on the blue mat.

The basic principle behind the line following sensors is reflection of light that is the angle of incident is equal to the angle of reflection. As in [7, 8] IR sensors are discussed. So, in the beginning we start working with infrared sensors but since it is quite difficult to detect the point where the reflected rays fall because an ideal sensor have minimum resistance
when light falls on it [8] and the biggest issue with IR light is that it is invisible for necked eyes and can be visualized by camera. So we switch to colour led and on observing their reflection from white line we place receiver at the point where we get maximum intensity.

The selection of sensor is very critical in autonomous systems as they are the only way for robots to detect its path and perform other task on time. In short the role of sensors for autonomous line following robot is same as that of senses in human body, if our senses start making false decisions then our body fall in to severe condition. The sensors were made using led and photo transistor. There are two main consideration regarding line following sensors.

- Color selection of transmitter
- Surrounding effects

The colour selection of LED is very important; we first started working on Infrared but as we are unable to detect the reflected beam direction we switched to use red LED because of its high spectral intensity as compared to other colours [1]. The beam of transmitter should be pointed after reflection without losing the intensity, so, convex lenses are placed in front of each led in order to achieve pointed light on fixed point. Hence, In order to achieve successful navigation, the amount of sensors used and the location of these sensors play an important role [5]. So an array of sensors is being used at suitable places with six sensors in front middle, 2, 2 sensors on each left and right side and 2 sensors on back middle side. The six sensors on the middle are such that two sensors are in parallel so that if any sensor fails to work properly than the next sensor will play the role and hence insures the proper working of robot. The same is the case with the left, right and back middle sensors.

As the vehicle travels through the designed arena in the GAME field, the high intensity light from top, as well as travelling in and out of the shadows of nearby chairs and others, causing large brightness changes [6]. The sensors were placed 2cm above the floor and are surrounded with packing so that any sensor will not influence the other nor affected by surrounding.
4.2. Circuit design

For driving the dc motors of robot, H-Bridge circuit is designed using TIP122 and TIP 124 transistors. The selection of transistor depends on the current drawn by the motors. Since in both the described robotic design the torque of all motors is limited and the motor torque \( T \) is proportional to the armature current, \( I \), by a torque constant \( K_t \); [4]

\[
T=K_t*I \tag{1}
\]

So we require transistors of maximum 1A rating for our required task. We avoid using high powered motors because of two reasons. The first is the power limitation for the contest and the second is that as you increase the power of motor it will start difficult for you to design the electronic circuit because the current produce heating effect in the devices and your battery will drain out more quickly than that of low powered motors which will not be suitable as we need to do a lot of testing before moving to final designing.

When the motor start there occur a current spike because of inertia, so we need to place protection circuitry with the controller power supply such that it will remain unaffected from the sudden spikes of current and voltages. Normally a capacitor will be connected so that any spike of current will directly be grounded and will not affect the controller power pins.

The problem with motors driving circuits is that there are chances of sudden back current due to motors internal generated flux. This back current leads your Peripheral Interface Controller (PIC) in to an abnormal condition, so in order to minimize this effect freewheel diodes are used to drain the back current to ground. The overall figure of designed H-Bridge is shown below:

![Fig. 4 H-bridge design](image)

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