# T.R.O.N.

**Transportional Regulation Obedient Newbie**

Sensor Report

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## SENSORS

There are several sensors that are need for the robot to accurately mimic a car on the roadway. The following is a list of sensors to be used along with some miscellaneous parts:

- Two IR Sensors
- One Sonar Sensor
- Four Bump Sensors
- CMU Cam
- Miscellaneous: buzzer and various leds

### IR Sensors

There are two IR line tracking sensors to be used on the robot body. Each IR sensors will be placed on either side of the front of the robot about ½" off the ground. They will also be placed so the outer edge of the sensor board is further out than the robot body.

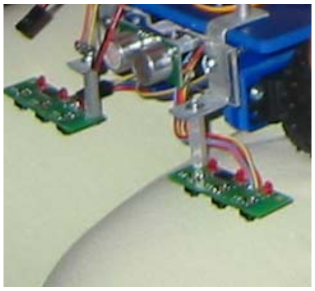

Figure 1: IR Sensor Mounting

The IR sensors will detect the difference between light and dark backgrounds. They go high for white surfaces and low for dark. The surfaces do not have to be black and white. The IR sensors also work in various light conditions. They have been tested in window light (daytime), window light plus intense light fixtures, and at night time with low intensity light bulbs that are not placed in the robots line of sight. The IR sensor has worked in all these situations. They also work for distance of about 2 mm away from the surface to a little more than ½" away from a surface; they will not however work if they are touching the surface. The following are some schematics of the IR sensor being used:

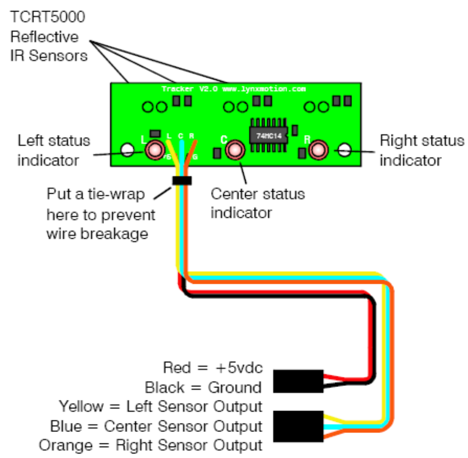


Figure 2: Diagram of IR sensor (Lynxmotion, Inc)

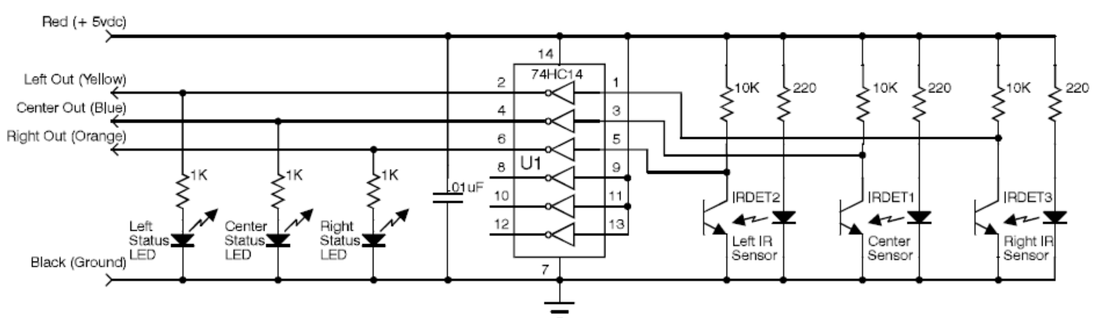


Figure 3: Circuit Schematic Diagram (Lynxmotion, Inc)

The IR sensor on the T.R.O.N. robot is used to avoid white lines on either side of the robot that represent a lane of traffic. When the right sensor detects the white line it causes the robot to turn left and vice versa for the left sensor. Secondly, since there are three IRs on each sensor, the closer the line is to the inner most sensor on one side, the more adjustment to the right or left the robot makes. After the adjustment is done the robot reverts back to a forward motion.

Lessons Learned: The after the first demo until right before the demo day the line following was not to smooth and seemed to over estimate the adjustment of the turn, to fix this problem the reversion back towards forward motion was done at a faster speed than the turn correction which made the line following much smoother in the end.

**Sonar Sensor**

The sonar sensor will be used for proximity detection so the robot does not collide with any other objects on the roadway. The robot only needs one sonar sensor due to the fact that the robot stops before an object and does not swerve into another lane or oncoming traffic. Once the sonar detects an object the robot stops and will not move until the object is removed.

The way the sonar works is it sends out a ping and waits for an echo to return and then measures the distance as the function of the time. The sonar used on the robot is a SRF04, the following list are the specifications of this sensor (Lynxmotion, Inc.):

- Sensor type = Reflective Ultrasonic
- Frequency = 40KHz
- Ultrasonic sender = N1076
- Ultrasonic receiver = N1081
- I/O required = Two digital lines, 1 output, 1 input
- Minimum range = Approximately 3cm
- Maximum range = Approximately 3m
- Sensitivity = Detects a 3cm diameter stick at > 2m
- Input trigger = 10uS Min. TTL level pulse
- Echo Pulse = Positive TTL level signal, width proportional to range
- Input voltage = 5vdc regulated
- Current requirements = 30mA Typ 50mA Max
- PC board size = ~.75" x 1.75"

The sonar sensor on the T.R.O.N. robot is set to determine distance in inches. The minimum range for the sonar during testing was 1” and the maximum range around 9 ft (108”), the max angle with which it detected an object was approximately 25º.

The following charts are of the timing and beam pattern of the SRF04.

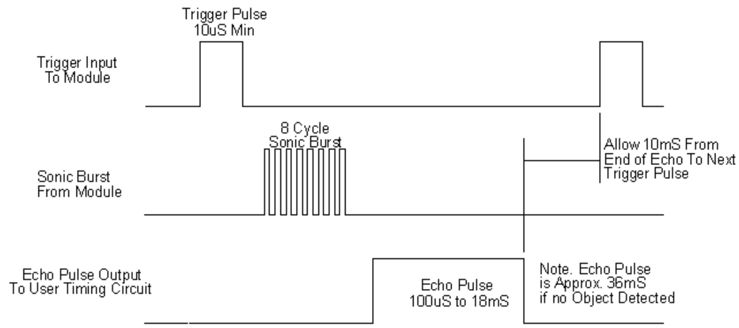


Figure 4: Timing Chart for Sonar SRF04

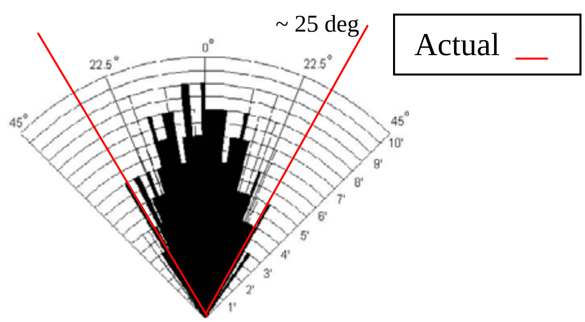


Figure 5: Beam Pattern for Sonar Sensor

Another collision avoidance tool will be the bump sensor which is used in the case an object collides with T.R.O.N from the back. If this occurs T.R.O.N will stop and scream at the object/vehicle “Whiplash!, Whiplash!” and then continue on its path after 2.5 seconds. The way that the bump switch works is that the circuit is open when the button is not pushed in and then when it is it reads out high.

**CMU Camera**

The CMU cam will be used for vision, so the robot can see the traffic light as well as which phase it is in (i.e. red, yellow, or green). Once the image is processed it will react accordingly, which would be stop for red, go for green, and double current speed for yellow. Below is a picture of the CMU cam from Seattle Robotics:

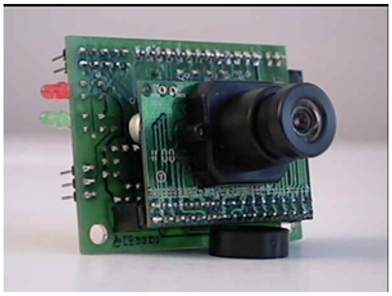

Figure 6: CMU Cam Board (Seattle Robotics)

The way the camera works: (Rowe, et al., 2002)

> Upon completion of the frame, it divides these accumulated values by the total number of pixels returning the mean color. It also returns an approximation of the absolute deviation from the mean of each color. This can be used like a variance measure to quantify the spread of the colors about the mean. When used in conjunction with other features such as windowing, described below, the color statistics can be used as a building block for a motion detection algorithm or for determining the color of an object at a specific location in the field of view.

Since the robot is only going to be using the CMU cam to detect three colors the "GM\R" command (or get mean color value) will be used. The mean values produced by the camera are between the range of 16 to 240.

In testing the CMU cam lighting was the most difficult variable to account for. To minimize the effect of the lighting conditions the camera's auto white balance and gain are on for the calibrating phase and then are turned off to better notice the shifts in color. The camera does calibrate to the traffic light in front of it to a set window of coordinates (1, 60) to (60, 83) for six seconds. After that the camera is triggered by the an intersection line on the roadway, in which it takes a snapshot of the traffic light and gives back a packet of R G B colors. While testing on the traffic light several times it was noticed that the camera detected the red light with the average packet numbers at R 215 G 190 and the yellow light at R 176 G 140. The Blue color never changed significantly and the default was the green light detected.

## Miscellaneous

The miscellaneous section includes the buzzer that is used as a horn on the robot vehicle. This buzzer has a range of 3 to 12 volts and .7 amps.


Lynxmotion, Inc. Users Manual TRA-01 Version 5.0. &
http://www.lynxmotion.com/Product.aspx?productID=57&CategoryID=8 &
http://www.lynxmotion.com/Product.aspx?productID=59&CategoryID=8

Rowe, et al. A Low Cost Embedded Color Vision System. Jan. 19, 2002.
http://www-2.cs.cmu.edu/~cmucam/Publications/iros-2002.pdf

Seattle Robotic. CMUcam Users Manual.
http://www.seattlerobotics.com/New%20CMUcam%20manual%20.doc