We begin the design of the robot car with the basic approach. The robot uses **sensors** to learn about its environment. There will be two IR distance sensors. If we are in the middle of the road, then both sensors will report the same distance to their respective walls.

VIDEO 14.6A. IR SENSOR FOR ROBOT CAR

0:00 / 12:49 1.0x

DR. RAMESH YERRABALLI: So we've looked at a transducer which

was a potentiometer that gave us a voltage value

from a corresponding variable resistance.

Jon, can we look at a different device that

has some significance that we can then use to control something?

DR. JONATHAN VALVANO: Yeah, let's look at the sharp sensor.

The goal is to drive a robot car autonomously down a road. Autonomous driving is a difficult problem, and we have greatly simplified it and will use this simple problem to illustrate the components of a control system. Every control system has real-world parameters that it wishes to control. These parameters are called **state variables**. In our system we wish to drive down the middle of the road, so our state variables will be the distance to the left side of the road and the distance to the right side of the road as illustrated in Figure 14.7. When we are in the middle of the road these two distances will be equal. So, let's define *Error* as:

$$Error = D_{left} - D_{right}$$

If *Error* is zero we are in the middle of the road, so the controller will attempt to drive the *Error* parameter to zero.

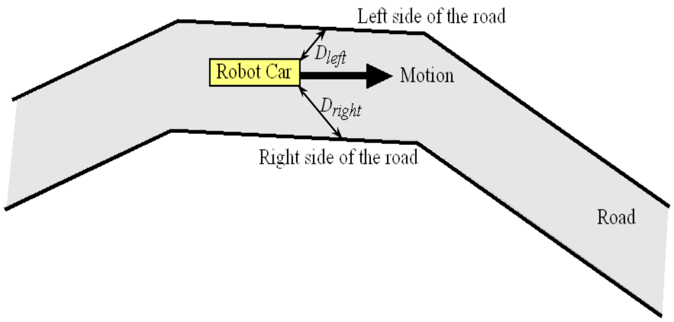

Figure 14.7. Physical layout of the autonomous robot as is drives down the road.

We will need sensors and a data acquisition system to measure D_{left} and D_{right}. In order to simplify the problem we will place pieces of wood to create walls along both sides of the road, and make the road the same width at all places along the track. The Sharp GP2Y0A21YK0F infrared object detector can measure distance (http://www.sharpsma.com (http://www.sharpsma.com/)) from the robot to the wood. This sensor creates a continuous analog voltage between 0 and +3V that depends inversely on distance to object, see Figure 14.6. We will avoid the 0 to 10 cm range where the sensor has the nonmonotonic behavior. We will use two ADC channels (PE4 and PE5) to convert the two analog voltages to digital numbers. Let `Left` and `Right` be the ADC digital samples measured from the two sensors. We can assume distance is linearly related to 1/voltage, we can implement software functions to calculate distance in mm as a function of the ADC sample (0 to 4095). The 241814 constant was found empirically, which means we collected data comparing actual distance to measured ADC values.

`Dleft` = 241814/`Left`

`Dright` = 241814/`Right`

Figure 14.8 shows the accuracy of this data acquisition system, where the estimated distance, using the above equation, is plotted versus the true distance.

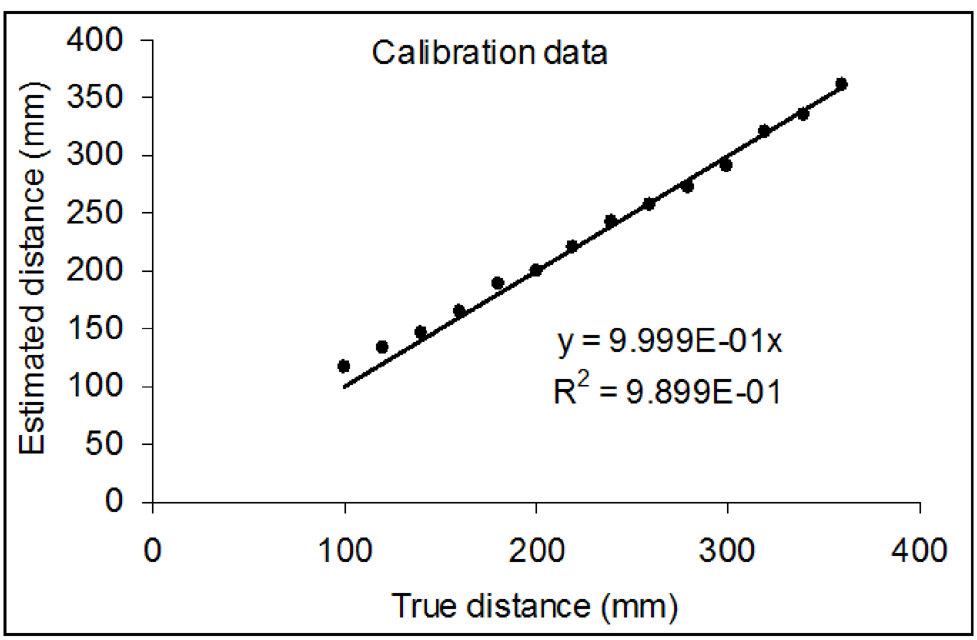

Figure 14.8. Measurement accuracy of the Sharp GP2Y0A21YK0F distance sensor used to measure distance to wall.