2. Another method involves using two IR sensors mounted on the front sides of the Mouse aimed in a crisscross fashion, as shown in Figure 16.27.[19] This gives us the added bonus to simultaneously monitor the left, right, and front regions of the robot with only two infrared sensors.

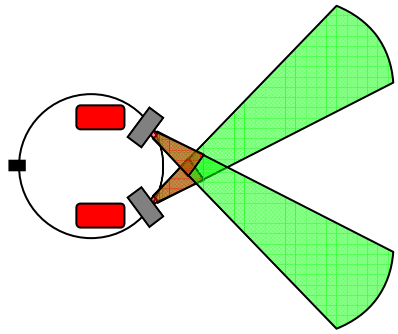

Figure 16.27. Crisscrossing two IR sensors affords us left, right, and forward views.

16.9 Fitting a Curve to the GP2D12 Sensor Data

Look again at Figure 16.22. The data between about 10cm and 100cm forms a smooth and continuous curve – like a child's playground slide. One nice thing about smooth, continuous curves is that we can ask our computers to *fit a mathematical equation to the curve*. We call this "fitting a curve". Plotting the date within this range in Excel, we find that there is a well-defined mathematical relationship between the range of an object and the values returned by the IR sensor.[20]

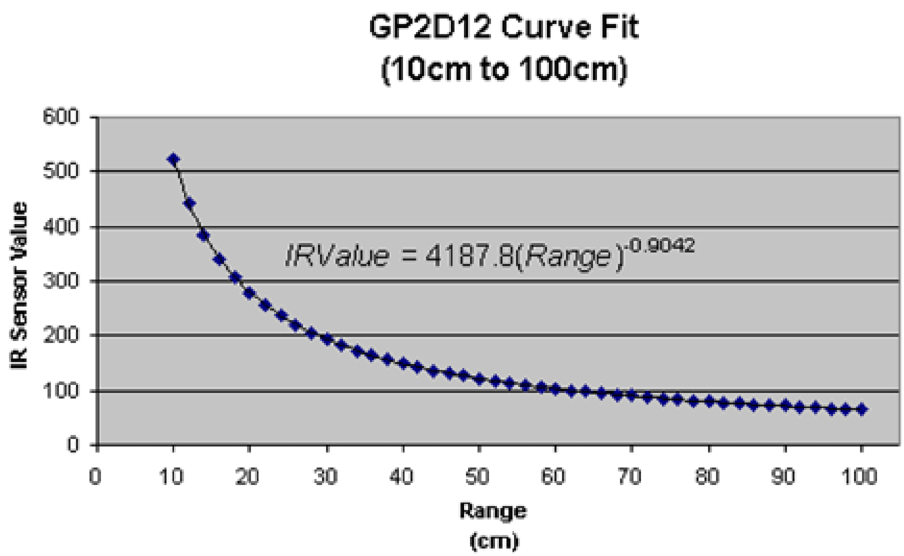

Figure 16.28. The curve-fit for the GP2D12 Sensor. This equation is valid for ranges between 10cm and 100cm.

From the graph's trendline shown in Figure 16.28, we see that the relationship between the object's range and the returned sensor value obeys the formula:

$$IRValue = 4187.8(Range)^{-0.9042}$$ **Equation 1**

where *IRValue* is the value returned by the infrared sensor, and *Range* is the actual distance to the object in units of **centimeters**.

[19] Mounting the IR sensors in this configuration requires using the flat bottom of the Adjustable Sensor Mount.
[20] Need help using Excel? See www.basicxandrobotics.com.

Applying a little algebra to Equation 1, we are able to find an equation that gives the range of any object located between about 10cm and 100cm of the sensor. I leave the derivation to you. (See Challenge Problem 17.)

The Range Equation

$$Range = \left(\frac{4187.8}{IRValue} \right)^{1.1060} \qquad \textbf{Equation 2}$$

The meaning of this equation may confuse some of you reading this, while others may be trembling with delight at its implications. The implication is simple and powerful: ***Any digital (integer) value returned by the Sharp GP2D12 can now be converted to a distance (in centimeters) with the use of the range equation (Equation 2).***

Let's look at a familiar example to illustrate my point. We know from experience that when we place the GP2D12 exactly 15cm away from an object it should return a value of 360. Let's use this bit of information to verify the range equation. Setting *IRValue* = 360, Equation 2 becomes,

$$Range = \left(\frac{4187.8}{360} \right)^{1.1060} = 15.088$$

15.088cm is a good approximation of 15cm, don't you think? How about one more: What is the range of an object if the GP2D12 returns a value of 193? What did you calculate? I hope it was 30.067cm.

In Table 16.1 below, I compare distances calculated using the range equation to actual measured distances. As you can see, the range equation is not perfectly accurate but it is especially well-behaved when the object is between 10cm and 70cm. In this range, the equation is generally accurate to within ±1cm. (Note well that the range values were determined by finding the average of 20 individual readings. You can expect *individual* readings to fluctuate about these averages.) For more information about the behavior of this infrared sensor, see *Appendix F: Limitations of the Sharp GP2D12 Range Finder*.

Table 16.1. Comparison of Range Equation Values With Actual Ranges

Actual Range (cm)	IR Sensor Value[21]	Calculated Range (cm)	% Error
10	505	10.38	3.8%
15	360	15.09	0.6%
20	280	19.92	0.4%
25	230	24.77	0.9%
30	190	30.59	2.0%
35	167	35.29	0.8%
40	150	39.73	0.7%
45	135	44.64	0.8%
50	122	49.93	0.1%
55	111	55.44	0.8%
60	103	60.22	0.4%
65	99	62.91	3.2%
70	91	69.06	1.3%
75	86	73.51	2.0%
80	82	77.49	3.1%
85	78	81.90	3.7%
90	74	86.81	3.5%
95	73	88.12	7.2%
100	71	90.87	9.1%

[21] The values listed here are an average of 20 readings.