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EEE187 - 01
HOMEWORK 02

Robotics Homework Assignment # 2

PROBLEM 1: CALIBRATION OF SHARP IR SENSOR

In this problem we want to determine the calibration curve of the sharp sensor shown in figures 1 and 2. It is clear that the relationship between the input (distance) and output (voltage) is nonlinear. In order to have one to one relationship, we ignore any distance that is less than $3cm$. The data points are shown in table 3. To obtain the calibration curve, we propose to use polynomial regression model as follows

$$d_i = a_0 + a_1 v_i + a_2 v_i^2 + ... + a_k v_i^k \quad (1)$$

$$i = 1, ..., n \quad (2)$$

where

- d_i is the distance in centimeters and v_i is the voltage in volts.
- $a_0, a_1, ..., a_k$ are the coefficients of the polynomial, to be determined.
- k is the degree of the polynomial
- n is the number of data points.

For n measurements, system (1) can be written under matrix form as follows

$$\begin{bmatrix} d_0 \\ d_1 \\ \vdots \\ d_n \end{bmatrix} = \begin{bmatrix} 1 & v_1 & \cdots & v_1^k \\ 1 & v_2 & \cdots & v_2^k \\ \vdots & \vdots & \ddots & \vdots \\ 1 & v_n & \cdots & v_n^k \end{bmatrix} \begin{bmatrix} a_0 \\ a_1 \\ \vdots \\ a_n \end{bmatrix} \quad (3)$$

Using Least Squares Fit methodology and the five data points displayed below in Table 3 calculate the second degree polynomial that best fits the sensor data curve. Plot the two curves (actual data and polynomial curve) together and comment on the similarities and the discrepancies.

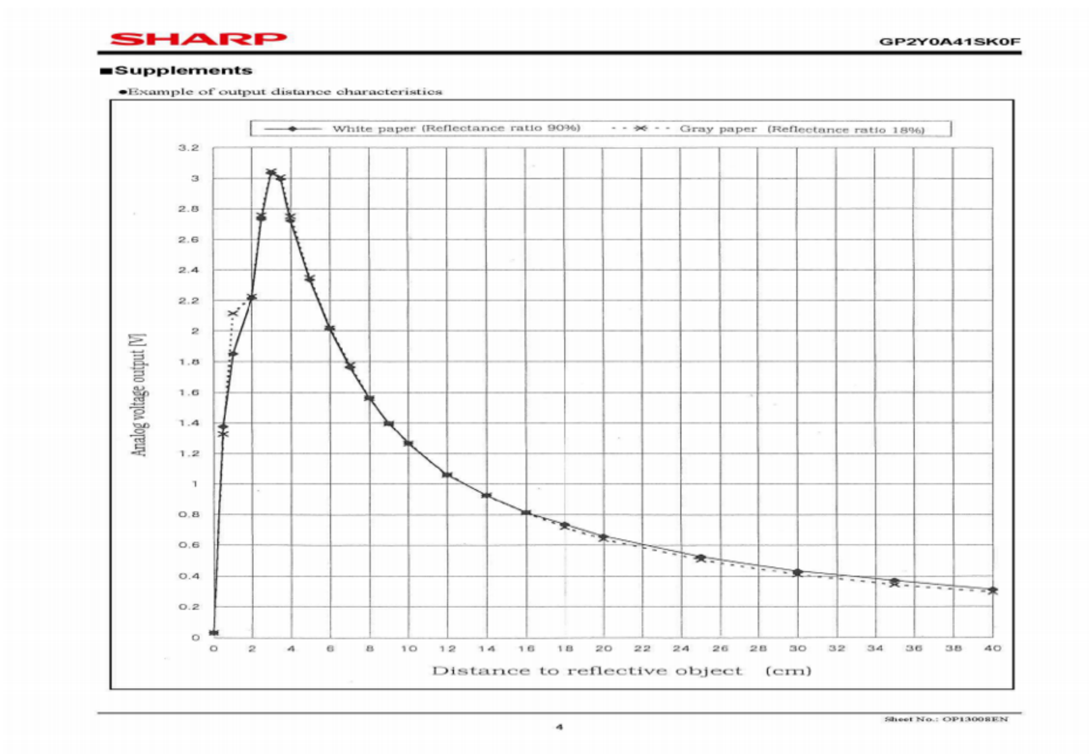

Figure 1: Sensor input/output data from datasheet

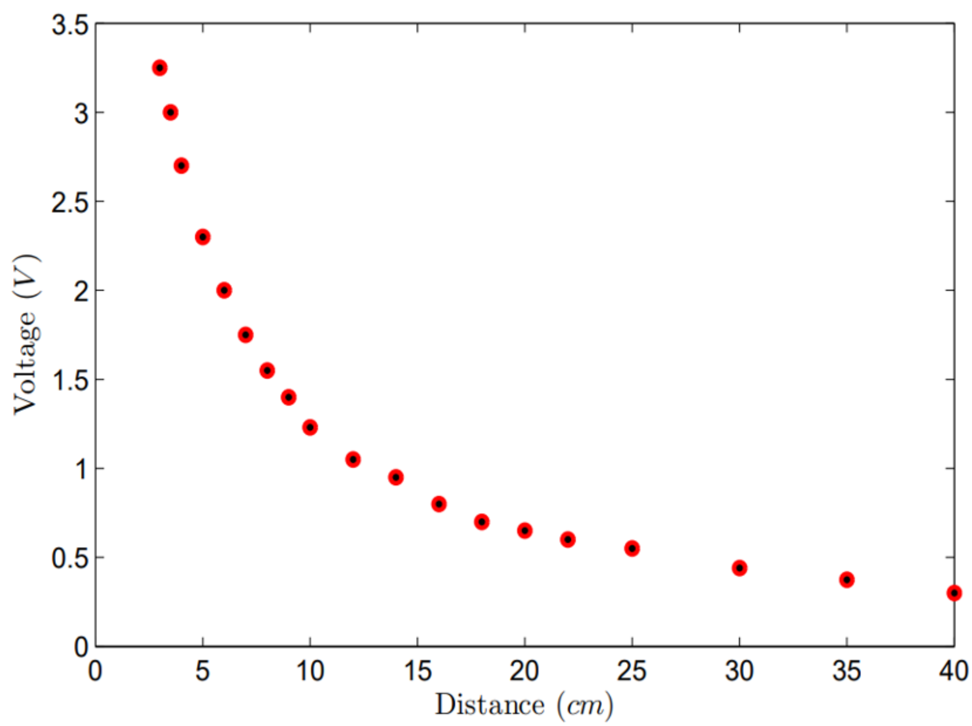

Figure 2: Sensor input/output data in the interval [3, 40]cm

SENSOR DATA

TABLE-3

(Taken from graph)

X = Distance in Centimeters	Y = Voltage in Volts
3.50	3.00
6.00	2.00
10.0	1.23
22.0	0.60
40.0	0.30

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$$\begin{bmatrix} 5 & 81.5 & 2232.25 \\ 81.5 & 2232.25 & 75\,906.875 \\ 2232.25 & 75\,906.875 & 2\,805\,702.063 \end{bmatrix} \begin{bmatrix} a_0 \\ a_1 \\ a_2 \end{bmatrix} = \begin{bmatrix} 7.13 \\ 60 \\ 1002.15 \end{bmatrix}$$

$$M_0 = \begin{bmatrix} 7.13 & 81.5 & 2232.25 \\ 60 & 2232.25 & 75\,906.875 \\ 1002.15 & 75\,906.875 & 2\,805\,702.063 \end{bmatrix}$$

$$M_1 = \begin{bmatrix} 5 & 7.13 & 2232.25 \\ 81.5 & 60 & 75\,906.875 \\ 2232.25 & 1002.15 & 2\,805\,702.063 \end{bmatrix}$$

$$M_2 = \begin{bmatrix} 5 & 81.5 & 7.13 \\ 81.5 & 2232.25 & 60 \\ 2232.25 & 75\,906.875 & 1002.15 \end{bmatrix}$$

$$M = \begin{bmatrix} 5 & 81.5 & 2232.25 \\ 81.5 & 2232.25 & 75\,906.875 \\ 2232.25 & 75\,906.875 & 2\,805\,702.063 \end{bmatrix}$$

$$a_0 = \frac{\det(M_0)}{\det(M)} = \frac{1.226 \times 10^9}{3.658 \times 10^8} = 3.351$$

$$a_1 = \frac{\det(M_1)}{\det(M)} = \frac{-7.755 \times 10^7}{3.658 \times 10^8} = -0.212$$

$$a_2 = \frac{\det(M_2)}{\det(M)} = \frac{1.253 \times 10^6}{3.658 \times 10^8} = 0.00342$$

$$\boxed{y = 0.00342x^2 - 0.212x + 3.351}$$