Steinhart-Hart Equation

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Overview

The Equation

- The Steinhart−Hart equation is a model of the resistence of a thermistor at different temperatures.
- It is defined as:

$$\frac{1}{\tau} = w_1 + w_2 ln(R) + w_3 (ln(R))^3$$

where
w_1, w_2, w_3 are the Steinhart-Hart coefficients,
τ is the temperature in Kelvin and,
R is the resistence in Ω

Matrix Transformation

- The equation can be transformed into matrices in the following way

$$\mathbf{x_1} = \begin{bmatrix} 1 \\ ln(R) \\ (ln(R))^3 \end{bmatrix}, \mathbf{w} = \begin{bmatrix} w_1 \\ w_2 \\ w_3 \end{bmatrix}, \; y_1 = \frac{1}{\tau_1}$$

- From this, we get:

$$y_1 = \mathbf{x_1}^T \mathbf{w}$$

..contd.

- For n>3:

$$\mathbf{y} = \begin{bmatrix} y_1 \\ y_2 \\ . \\ . \\ . \\ y_n \end{bmatrix}, \mathbf{X}^T = \begin{bmatrix} \mathbf{x_1} & \mathbf{x_2} & . & . & . & \mathbf{x_n} \end{bmatrix}$$

Hence, we have

$$\mathbf{y} = \mathbf{Xw}$$

Least Squares approach

- The Steinhart-Hart coefficients can be derived using measurements of Resistence and Temperature
- To get the best possible values of the coefficients, we adopted the ordinary least squares(OLS) approach.

  $$f(x, \beta) = \sum_{j=1}^{m} \beta_j \phi_j(x)$$

  where the function ϕ_j is a function of x
- Take $X_{ij} = \phi_j(x_i)$

Least Squares approach (contd.)

- The matrix X is known as the design matrix and encodes all known information about the independent variables.
- It is possible to find optimal coefficients through the method of least squares using simple matrix operations. In particular, the optimal coefficients $\hat{\boldsymbol{\beta}}$ as estimated by least squares can be written as follows:

$$\hat{\boldsymbol{\beta}} = (\mathbf{X}^T\mathbf{X})^{-1}\mathbf{X}^T\mathbf{y}$$

- This is the Optimum value of $\boldsymbol{\beta}$ which can be used to estimate $y = f(x, \beta)$ with the least possible error.

Figures

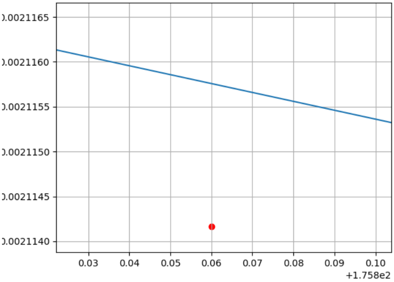

Figure: Difference

Figures

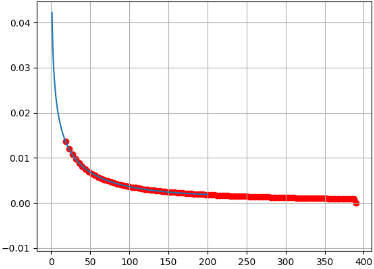

Figure: Model Vs Data Points

Figures

80	130.9
90	134.71
100	138.51
110	142.29
120	146.07
130	149.83
140	153.58
150	157.33
160	161.05
170	164.77
180	168.48
190	172.17
200	175.86
210	179.53
220	183.19
230	186.84
240	190.47
250	194.1
260	197.71

Figure: Data

Figures

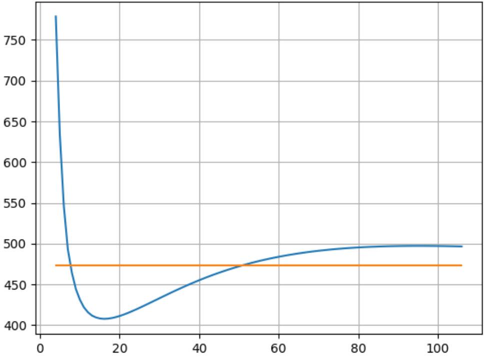

Figure: Data