PT100 Experiment using Gradient Descent

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***Abstract*—The volatge readings from Voltage divider having PT100 sensor one of the arms is mapped to corresponding temperatue. `numpy.linalg.lstsq` was initially used to fit a linear curve over data. Refer PT100 experiment.**
Now, Gradient Descent method is used to obtain the parameters of linear relation.

1 Cost Function

Here, cost function or error function is defined as mean of squared errors.i.e.

$$Cost(\mathbf{n}) = \frac{1}{m}\sum_{i=1}^{m}(y_i - \hat{y}_i)^2 \tag{1.0.1}$$

$$= \frac{1}{m}(\mathbf{X}\mathbf{n} - \mathbf{y})^T(\mathbf{X}\mathbf{n} - \mathbf{y}) \tag{1.0.2}$$

where y_i is the actual value and $\hat{y}_i$ is the predicted value and m is the number of data points.
$\mathbf{n}$ is the vector of parameters of linear relation.

$$\mathbf{n} = \begin{pmatrix} A \\ B \end{pmatrix} \tag{1.0.3}$$

The plot of cost function with respect to A and B is shown in figure 0.

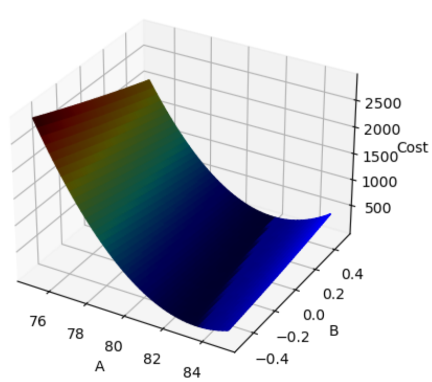

Fig. 0: Cost

`codes/cost.py` contains the code for plotting the cost function.

2 Method

For minimizing the cost function, gradient descent method is used.
The gradient of cost function is given by:

$$\frac{\partial Cost}{\partial n} = \frac{1}{m}\sum_{i=1}^{m} 2(y_i - \hat{y}_i)\frac{\partial \hat{y}_i}{\partial n} \tag{2.0.1}$$

$$= \frac{2}{m}(\mathbf{X}\mathbf{n} - \mathbf{y})^T\mathbf{X} \tag{2.0.2}$$

The parameters are updated as,

$$\mathbf{n} = \mathbf{n} - \alpha\frac{\partial Cost}{\partial n} \tag{2.0.3}$$

where α is the learning rate.
Above equation is run on loop until the cost function is lesser than a certain tolerance.

3 Results

Above method is implemented in `codes/Grad_Des.py` with tolerance of 1 and Learning rate of 4.72×10^{-5}

Temperature	Reading
30	86
34	88
40	91
46	92
56	95
60	97
70	99
80	100
94	104
98	105

TABLE 0: Data used for training

The data used for training the model is given in Table 0. Resulting parameters:

$$n = \begin{pmatrix} 78.37174146 \\ 0.28238033 \end{pmatrix} \quad (3.0.1)$$

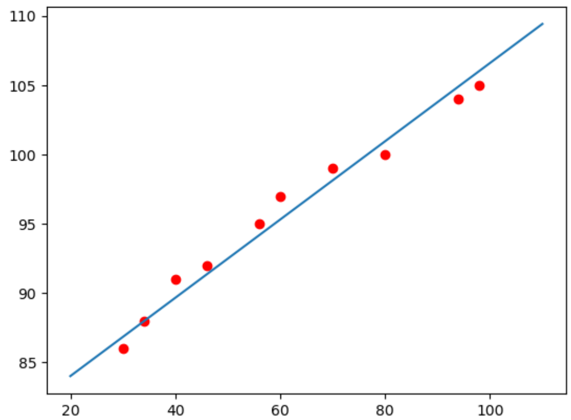

Fig. 0: Training

The plot of training data and predicted line is shown in figure 0.

4 Testing

The model is used to predict the results for the test data.

Temperature	Reading
31	87
52	94
66	98
90	103

TABLE 0: Data used for testing

The data used for testing in given in Table 0

The plot of test data and predicted line is shown in figure 0.

Mean Squared Error in Testing = 0.62699

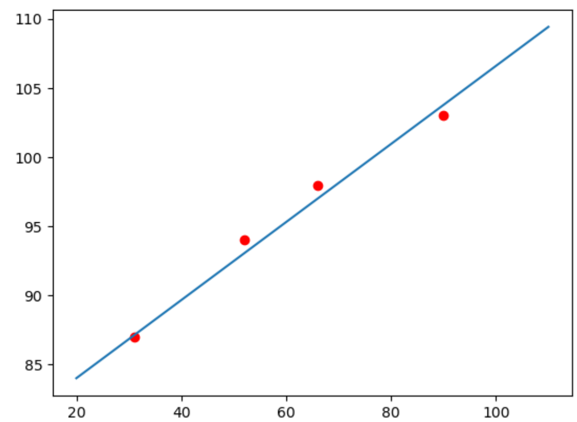

Fig. 0: Testing