Application of Machine Learning to model the behaviour of PT-100 sensor

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Outline

1. Introduction

2. Experient Setup

3. Regression

4. Conclusion

Aim

- In this experiment we will see how to use regression techniques to identify the temperature based on the voltage across the PT-100 sensor.
- We will also see how the PT-100 resistance changes with changes in temperature, and an appropriate circuit to detect the changes in resistance

PT-100 Sensors

- PT-100 is a temperature dependent resistor with a positive temperature coefficient(it resistance increases with temperature).
- It is called PT-100 because the resistance is made of platinum and at 0° C it resistance is 100Ω.
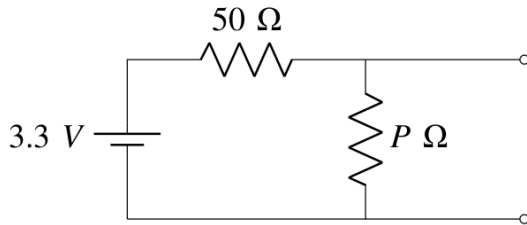
Circuit Diagram

Figure: Circuit Diagram

Data Acquisition

- Platinum Resistance Temperature Detectors(RTDs) follow Callendar Van Dussen equation,

$$V(T) = V(0)\left(1 + BT + AT^2\right) \tag{1}$$

- As the temperature increases, resistance of the PT-100 sensor increases and hence the voltage across PT-100 sensor V_P increases.
- We use an arduino board to read the voltage V_P and a thermomenter to measure the corresponding temperature.

Regression Model

We model the relation between Voltage V_P and the temperature T as,

$$V_P(T) = C + BT + AT^2 \tag{2}$$

Say we collect N data points $(V_{P_1}, T_1), (V_{P_2}, T_2), \ldots (V_{P_N}, T_N)$. Then we can write these N equations as,

$$v = Xn \tag{3}$$

$$\begin{pmatrix} V_{P_1} \\ V_{P_2} \\ \vdots \\ V_{P_N} \end{pmatrix} = \begin{pmatrix} 1 & T_1 & T_1^2 \\ 1 & T_2 & T_2^2 \\ \vdots & \vdots & \vdots \\ 1 & T_N & T_N^2 \end{pmatrix} \begin{pmatrix} C \\ B \\ A \end{pmatrix} \tag{4}$$

Training Data

The following table shows the data that is used to train the regression model

Temperature(in Celcius)	Voltage(in Volts)
24	2.40
38	2.44
45	2.45
52	2.48
63	2.49
93	2.55
100	2.57

Table: Training data

Regression Model

In regression we find the n that minimizes the euclidean norm of the error between actual voltage and predicted voltage.

$$n_{LS} = \arg\min_n \|v - Xn\|^2 \tag{5}$$

The Least Squares estimate of n is given by

$$n_{LS} = (X^\top X)^{-1} X^\top v \tag{6}$$

For the above training data, the least squares estimate that we get is,

$$n = \begin{pmatrix} 2.33483 \\ 2.93939 \times 10^{-3} \\ -6.24626 \times 10^{-6} \end{pmatrix} \tag{7}$$

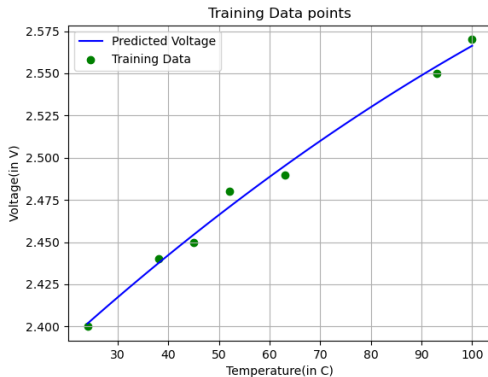# Plot of Predicted voltage and Training Data

Figure: Training Data

Validation Data

Temperature(in Celcius)	Voltage(in Volts)
29	2.41
32	2.43
74	2.52
85	2.54

Table: Validation data

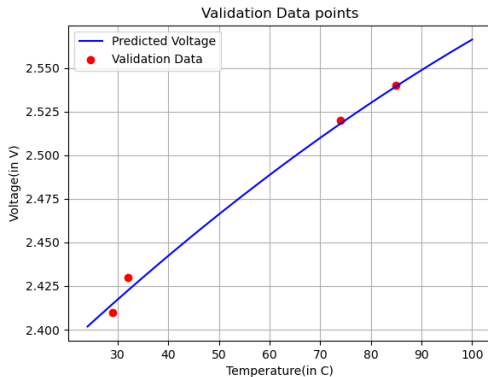# Plot of Predicted voltage and Validation Data

Figure: Validation Data

Conclusion

- From above plots we can see that the plot of voltage vs temperature does not vary a lot from the training and validation.
- Hence, Regression is effective in mapping the relation between the voltage across the PT-100 sensor and it's temperature.