PT-100 Lab Assignment

Nithish

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***Abstract*—This document contains a lab report on the modeling of the voltage-temperature characteristics of the PT-100 RTD (Resistance Temperature Detector) using least squares method.**

1 Training Data

The training data gathered by the PT-100 to train the Arduino is shown in the following table.

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 1: Training data

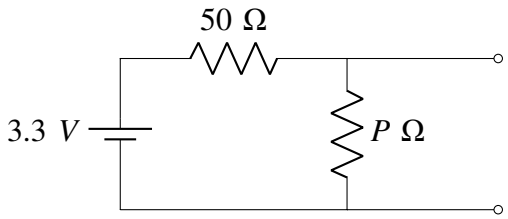

Fig. 1: Circuit Diagram

2 Model

For the PT-100, we use the Callendar-Van Dusen equation

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

$$\implies c = \mathbf{x}^\top \mathbf{n} \tag{2}$$

where

$$c = V(T),\ \mathbf{n} = \begin{pmatrix} C \\ B \\ A \end{pmatrix},\ \mathbf{x} = \begin{pmatrix} 1 \\ T \\ T^2 \end{pmatrix} \tag{3}$$

For multiple points, the above equation becomes

$$\mathbf{X}^\top \mathbf{n} = \mathbf{c} \tag{4}$$

where

$$\mathbf{X} = \begin{pmatrix} 1 & 1 & \dots & 1 \\ T_1 & T_2 & \dots & T_n \\ T_1^2 & T_2^2 & \dots & T_n^2 \end{pmatrix} \tag{5}$$

$$\mathbf{C} = \begin{pmatrix} V(T_1) \\ V(T_2) \\ \vdots \\ V(T_n) \end{pmatrix} \tag{6}$$

and $\mathbf{n}$ is the unknown.

3 Solution

We approximate $\mathbf{n}$ by finding the least squares estimate of it. The least square estimate of $\mathbf{n}$ for the above training data is

$$\mathbf{n} = \begin{pmatrix} 2.3348 \\ 2.9394 \times 10^{-3} \\ -6.2462 \times 10^{-6} \end{pmatrix} \tag{7}$$

The approximation is shown in Fig. 2, we can see that our model fits the training data very well. Thus, the approximate model is given by

$$V(T) = 2.3348 + \left(2.9394 \times 10^{-3}\right) T - \left(6.2462 \times 10^{-6}\right) T^2 \tag{8}$$

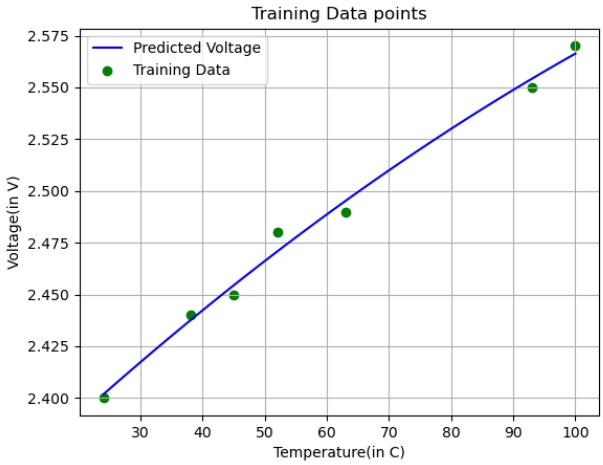

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Fig. 2: Training the model.

4 Validation

The validation dataset is shown in Table 2. The results of the validation are shown in Fig. 3. We can see that our model perform well in validation data.

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

TABLE 2: Validation data.

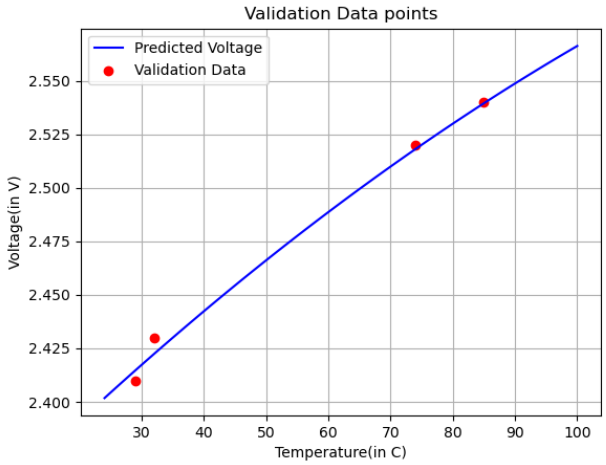

Fig. 3: Validating the model.

5 Conclusion

In this project we saw how we can use simple machine learning techniques to map the characteristics of an unknown sensor. We also learned how we can idetinfy the temperature using a temperature dependent resistor like PT-100.