PT-100 Hardware Assignment

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Contents

***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.**

Training Data The training data gathered by the PT-100 to train the Arduino is shown in Table **??**.

Temperature (°C)	Voltage (V)
31.9	4.617
43.5	4.628
54.1	4.637
62.7	4.647
74.6	4.657
81.6	4.665
86.6	4.670
91.6	4.673
93.8	4.674

TABLE 1: Training data.

The C++ source `codes/data.cpp` was used along with *platformio* to drive the Arduino.

1 Model

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

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

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

where

$$c = V(T),\ \mathbf{n} = V(0)\begin{pmatrix}1\\A\\B\end{pmatrix},\ \mathbf{x} = \begin{pmatrix}1\\T\\T^2\end{pmatrix} \tag{3}$$

For multiple points, (**??**) 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.

2 Solution

We approximate $\mathbf{n}$ by using the least sqaures method. Using the pseudo-inverse method, the solution to (**??**) is

$$\mathbf{n} = \left(\mathbf{X}\mathbf{X}^\top\right)^{-1}\mathbf{X}\mathbf{C} \tag{7}$$

The Python code `codes/lsq.py` solves for $\mathbf{n}$.

The calculated value of $\mathbf{n}$ is

$$\mathbf{n} = \begin{pmatrix}4.5855\\ 9.954729\times10^{-4}\\ -4.5250\times10^{-7}\end{pmatrix} \tag{8}$$

The approximation is shown in Fig. **??**.

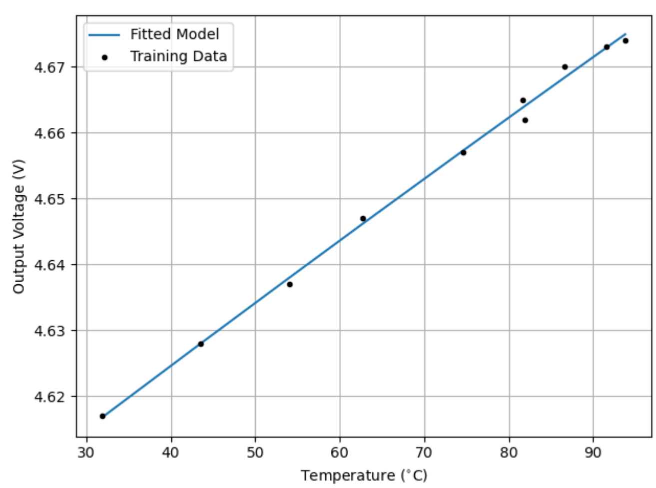

Fig. 1: Training the model.

3 Validation

The validation dataset is shown in Table **??**. The results of the validation are shown in Fig. **??**.

Temperature (°C)	**Voltage (V)**
58.6	4.643
65.3	4.649
71.3	4.652
78.7	4.661
83.6	4.665

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TABLE 2: Validation data.

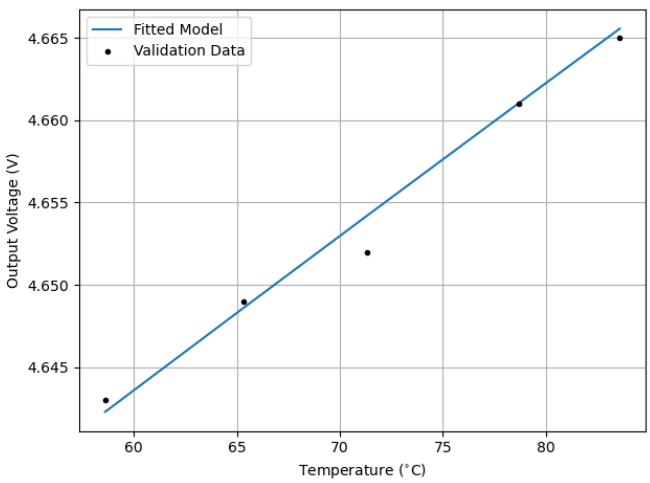

Fig. 2: Validating the model.

4 Conclusion

This lab experiment demonstrates how machine learning methods can be used to model the behaviour of an unknown device, and find the right parameters that fit the model. It also shows how to use Python libraries and frameworks to collect data and perform optimization.