An Application of Machine Learning to model a Temperature Sensor(PT100)

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April 26, 2023

Outline

Aim

The modeling of the voltage-temperature characteristics of the PT-100 RTD (Resistance Temperature Detector) using least squares method.

Training data

Temperature (°C)	Voltage (V)
20	1.46
33	1.48
44	1.50
50	1.52
56	1.54
61	1.55
67	1.57
71	1.58
79	1.60
84	1.61

Table: Training data

Validation data

Temperature (°C)	**Voltage (V)**
30	1.47
36	1.49
51	1.52
56	1.54
68	1.57

Table: Validation data

Model

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

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

$$\implies c = \mathbf{n}^\top \mathbf{x} \quad (2)$$

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

Model

For multiple points,eqn (3) becomes

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

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

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

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

Model

We approximate **n** by using the least sqaures method. The Python code `codes/pt100.py` solves for **n**. The calculated value of **n** is

$$\mathbf{n} = \begin{pmatrix} 1.423 \\ 1.472 \times 10^{-3} \\ 9.8158 \times 10^{-6} \end{pmatrix} \tag{7}$$

The approximation is shown in Figures further.

Model

Thus, the approximate model is given by

$$V(T) = 1.423 + \left(1.472 \times 10^{-3}\right) T + \left(9.8158 \times 10^{-6}\right) T^2 \tag{8}$$

Equation 8 can be written in the form of,

$$ax^2 + bx + c = 0 \tag{9}$$

Now, we can use the quadratic formula to find the value of the temperature. That has been implemented in arduino.