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

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Outline

Aim

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

Circuit Diagram

Training data

Table: Training data

Validation data

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

$$\mathbf{n} = \begin{pmatrix} 2.5577569 \\ 2.0663864 \times 10^{-3} \\ -2.9546268 \times 10^{-6} \end{pmatrix} \tag{7}$$

The approximation is shown in Figures further.

Model

Thus, the approximate model is given by

$$V(T) = 2.5577569 + \left(2.0663864 \times 10^{-3}\right) T - \left(2.9546268 \times 10^{-6}\right) T^2 \tag{8}$$

Equation 8 can be written in the form of,

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

$$\implies 2.9546268 \times 10^{-6} T^2 + 2.0663864 \times 10^{-3} T - (2.5577569 - V(T)) = 0 \tag{10}$$

Now, we can use the quadratic formula to find the value of the temperature.(which has been done in Arduino)

Data Visualization

Figure: TRAINING DATA

Data Visualization

figs/valid.png

Figure: VALIDATION DATA

Experiment

figs/arduino.png

Conclusions

1. The modelling of the sensor has been done using Python and has been executed using a microcontroller.
2. This project demonstrates how machine learning methods can be used to model the behaviour of an unknown component, and find the right parameters that fit the model.