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

Lokesh Surana (ES20BTECH11017)

April 26, 2023

Outline

Aim

1. The modeling of the voltage-temperature characteristics of the PT-100 RTD (Resistance Temperature Detector) using least squares method.
2. In next slide we have training and validation data. This data have been recorded using voltage readings from serial monitor of arduino and temperature readings from a thermometer.

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

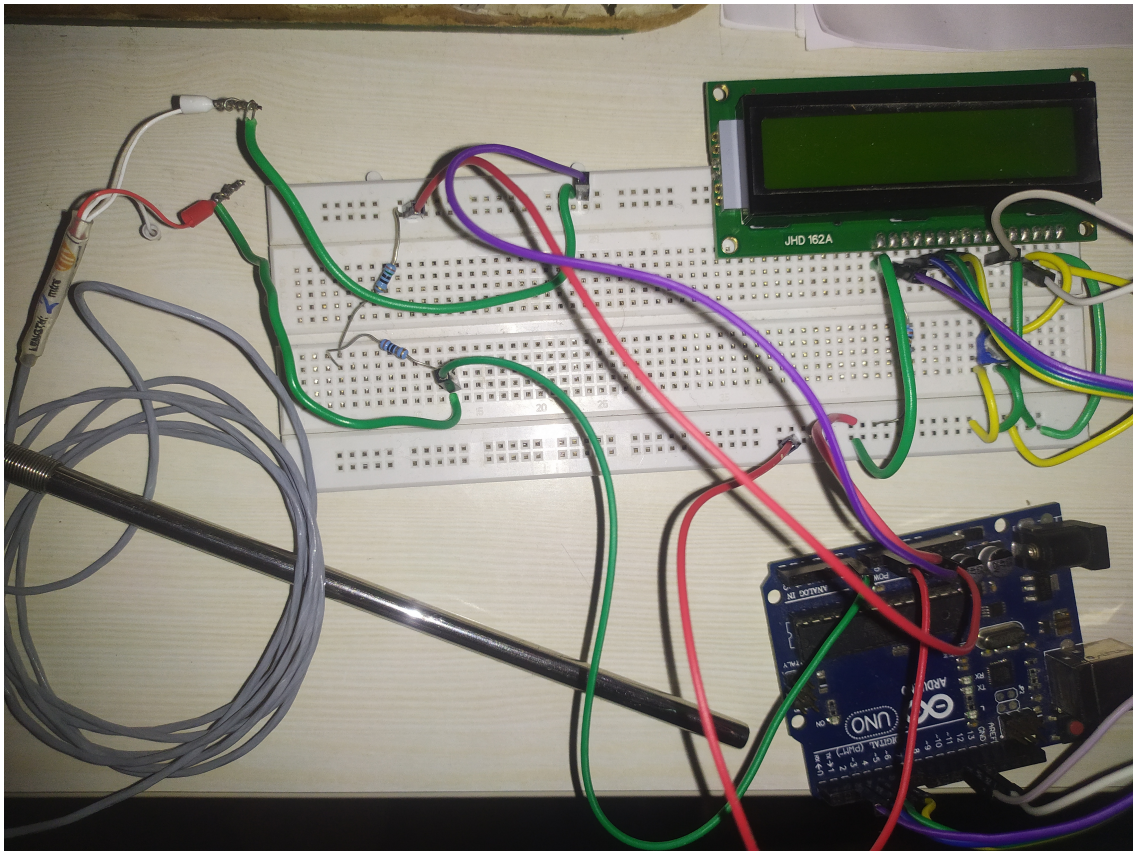
Table: Training data

Validation data

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

Table: Validation data

Experiment



PT-100 circuit is connected to arduino 3.3V and ground pins. The 200Ω resistor is being used in circuit. The voltage/sensorvalue is read from A0 pin of arduino.

Model

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

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

$$\text{this can be written in the form of } c = \mathbf{n}^\top \mathbf{x} \tag{2}$$

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

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

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

Model

Thus, the approximate model is given by

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

Equation 8 is in the form of,

$$ax^2 + bx + c = 0 \quad (9)$$

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