# 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

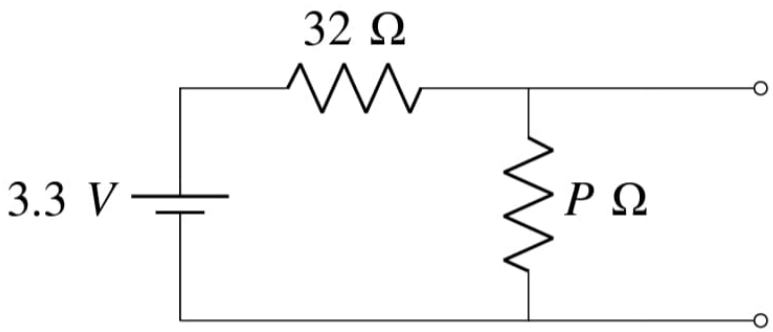



Fig. 1: Schematic Circuit Diagram to Measure the Output of PT-100 ($P$).

# Training data

| Temperature (°C) | Voltage (V) |
|---:|---:|
| 35 | 2.63 |
| 55 | 2.66 |
| 49 | 2.65 |
| 85 | 2.71 |
| 75 | 2.70 |
| 65 | 2.68 |
| 27 | 2.61 |

Table: Training data

# Validation data

| **Temperature (°C)** | **Voltage (V)** |
|---:|---:|
| 34 | 2.64 |
| 60 | 2.67 |
| 16 | 2.59 |
| 93 | 2.72 |
| 70 | 2.69 |
| 32 | 2.62 |

Table: Validation data

# Model

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

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

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

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

# Model

For multiple points,eqn (3) becomes

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

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

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

and 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

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

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

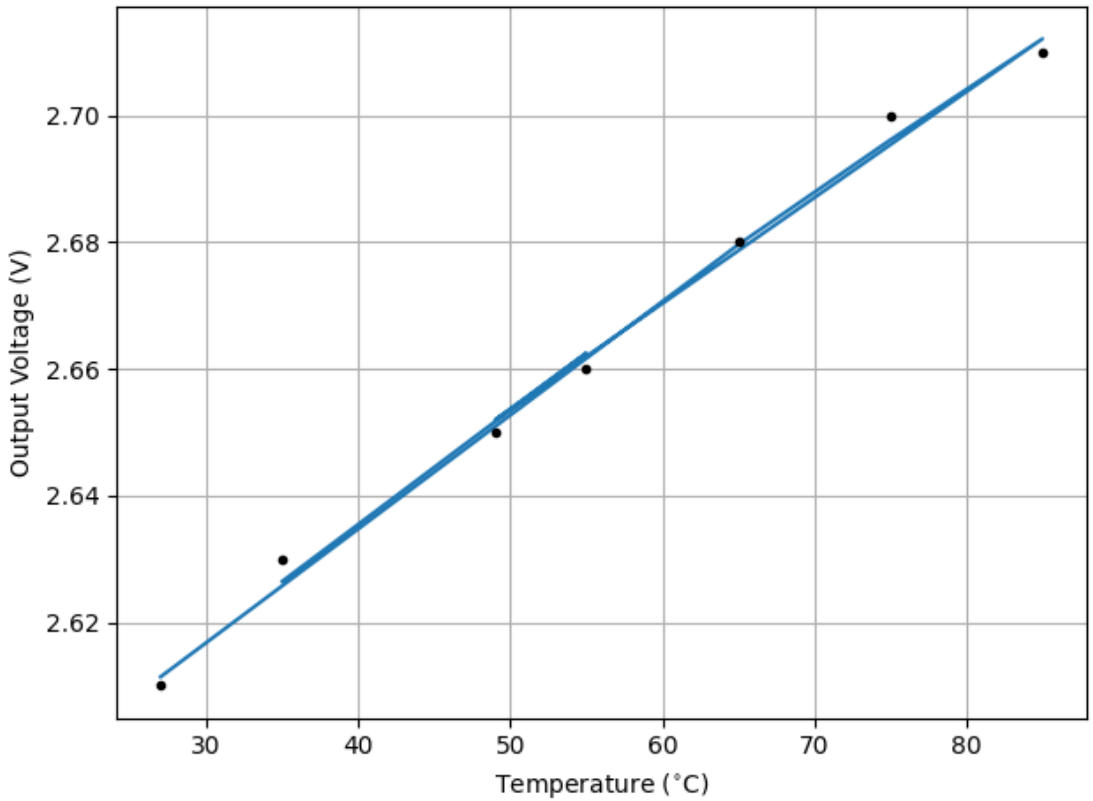



Figure: TRAINING DATA

# Data Visualization

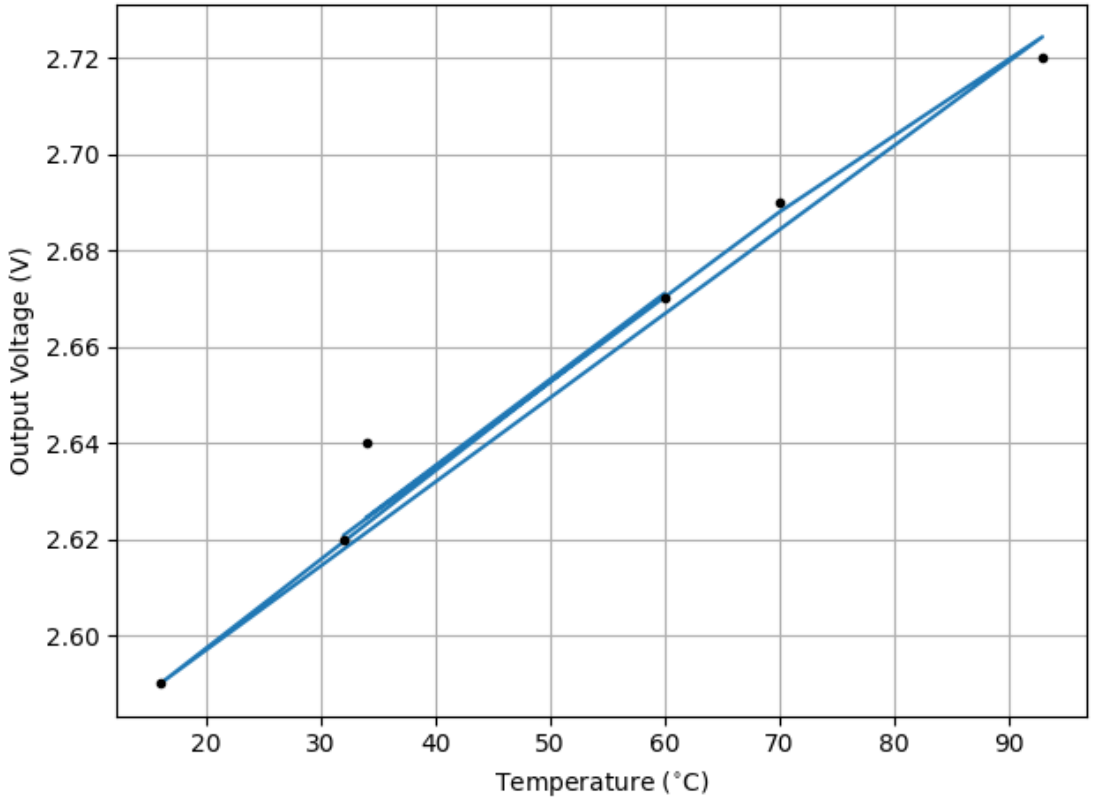
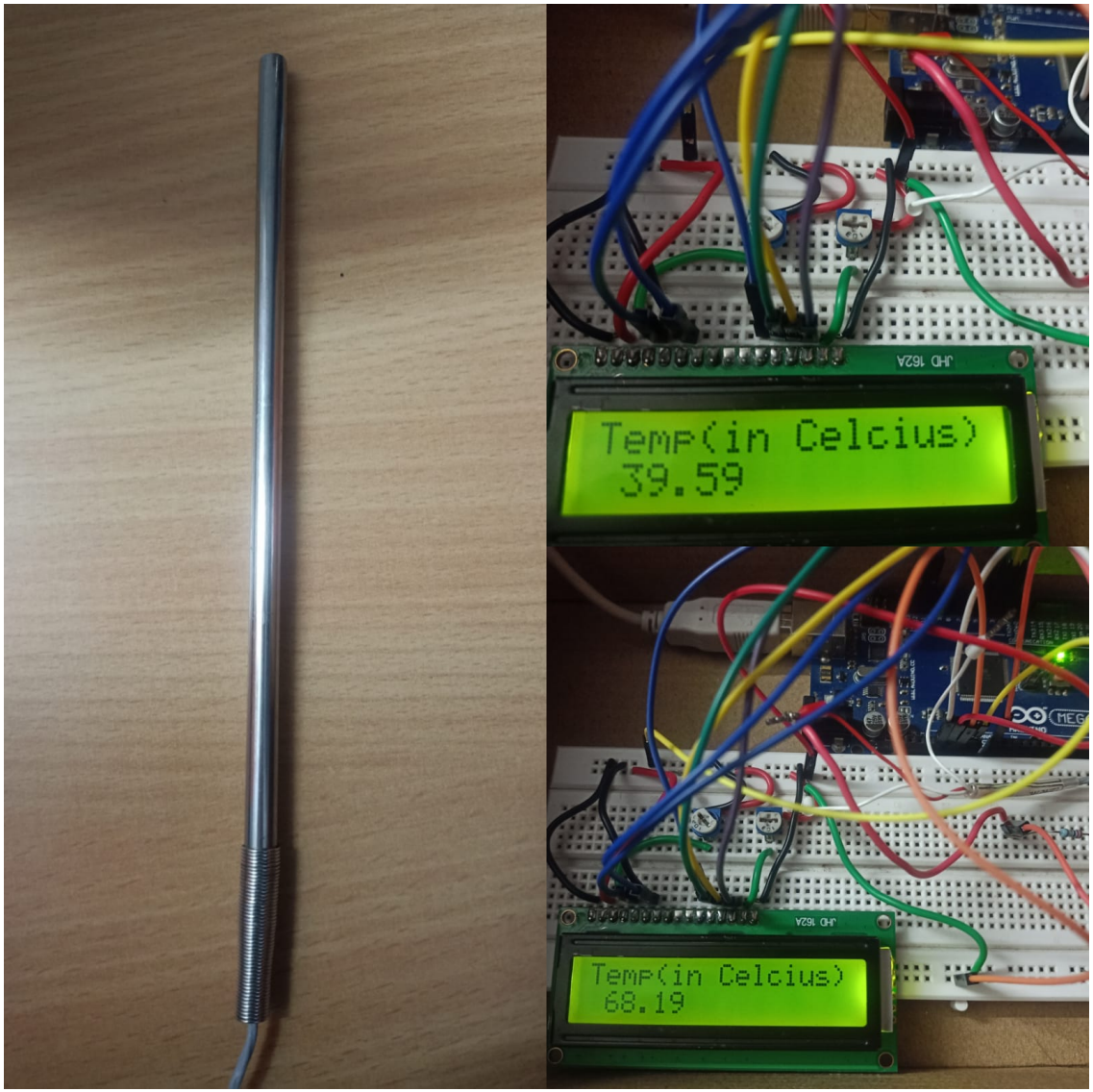



Figure: VALIDATION DATA .

# Experiment



# 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.