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

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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.

Circuit Diagram

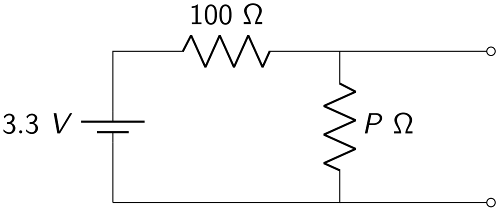
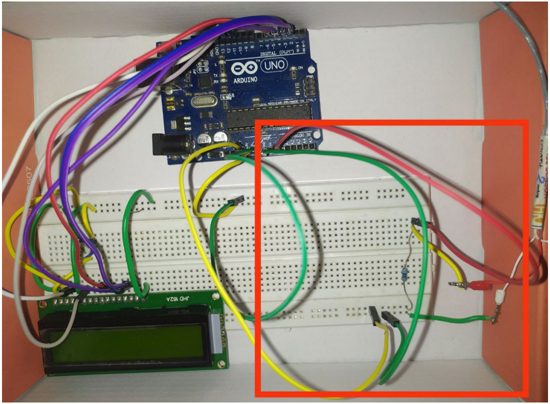


Figure: Schematic Circuit Diagram to Measure the Output of PT-100 (P).

Why R $= 100\ \Omega$?

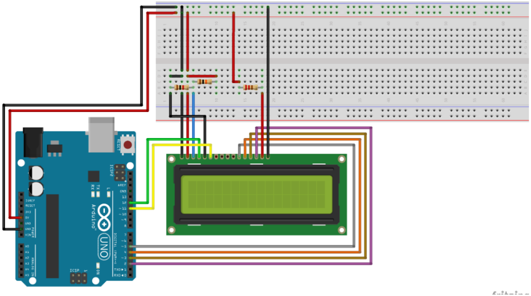
1. Source voltage V $= 3.3$Volt
2. The most common type (PT100) has a resistance (P) of $100\ \Omega$ at 0° C and $138.4\ \Omega$ at $100\ ^\circ$ C.
3. So for any R we use voltage drop accross R will be, $\frac{VP}{P+R}$
4. In terms of sensorvalue, $\frac{Sensorvalue \times P}{P+R} \times \frac{3.3}{1023}$
5. So it we use very large R compared to P, the voltage drop will be very small even for signficant change in sensorvalue/Temperature.
6. That's why we use R $= 100\ \Omega$, a comparable value to P.

Experiment



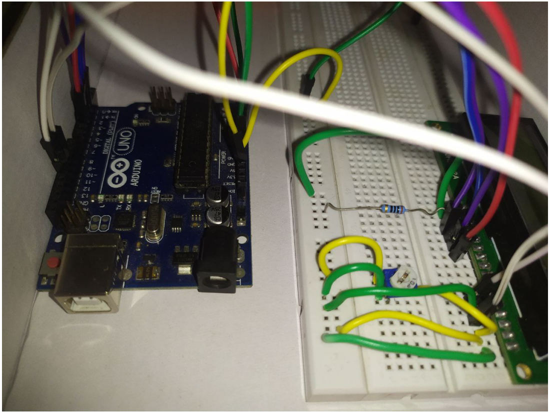
PT-100 circuit is connected to arduino 3.3V and ground pins. The 200Ω resistor is being used in circuit. The voltage/sensorvalue is read from A0 pin of arduino.

Experiment



This is the LCD circuit which is used to display the temperature readings.

Experiment



This is the LCD circuit which is used to display the temperature readings.

Training data

Temperature (°C)	Voltage (V)
16	1.52
21	1.54
25	1.56
33	1.57
41	1.60
48	1.62
53	1.63
61	1.65
70	1.69
78	1.70
81	1.72
90	1.74

Validation data

Temperature (°C)	Voltage (V)
18	1.53
36	1.58
45	1.61
65	1.66
85	1.73

Model

The voltage reding for arduino varies as per temperature. The voltage reading can be modelled as

$$V(T) = A + BT \tag{1}$$

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

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

Model

For multiple points,eqn (3) becomes

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

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

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

$$\mathbf{n} = \begin{pmatrix} A \\ B \end{pmatrix} \tag{7}$$

Here $\mathbf{n}$ is the unknown, $\mathbf{X}$ and $\mathbf{Y}$ are readings.

Model

We approximate $\mathbf{n}$ by using the least sqaures method. The Python code `codes/lsq.py` solves for $\mathbf{n}$. The calculated value of $\mathbf{n}$ is

$$\mathbf{n} = \begin{pmatrix} 1.48 \\ 0.0029 \end{pmatrix} \tag{8}$$

The linear model between temperature and voltage is given by

$$V(T) = 1.48 + 0.0029T \tag{9}$$

Data visulization

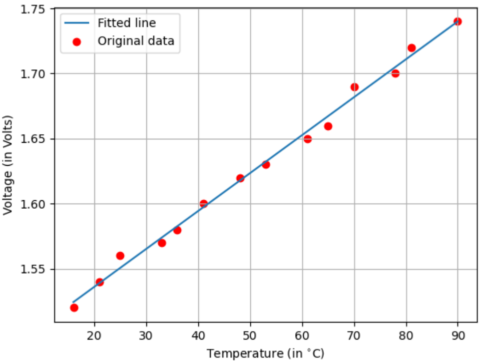


Figure: Training data

Data visulization

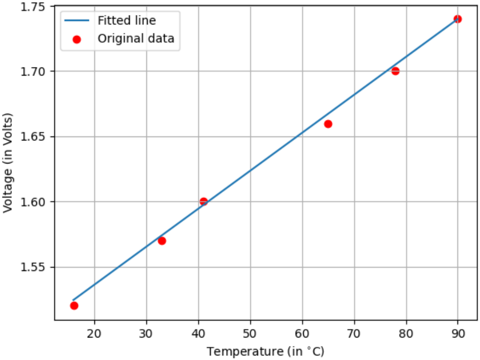


Figure: Validation data