Experiment-3
Root Finding
Bisection Method

(Duration: 120 mins)

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Purpose: The aim of this lab is to apply bisection method to find the root of the function that is used in engineering problem.

Introduction

The method is also called the interval halving method and it is used to find root of an equation in a given interval that is value of 'x' for which f(x) = 0 .The method is based on The Intermediate Value Theorem which states that if f(x) is a continuous function and there are two real numbers a and b such that $f(a) * f(b) < 0$ and $f(a) < 0$ or $f(b) < 0$), then it is guaranteed that it has at least one root between them. Assumptions: f(x) is a continuous function in interval [a, b] $f(a) * f(b) < 0$ Advantage of the bisection method is that it is guaranteed to be converged. Disadvantage of bisection method is that it cannot detect multiple roots.

The input for the method is a continuous function f, an interval [a, b], and the function values f(a) and f(b). The function values are of opposite sign (there is at least one zero crossing within the interval). Each iteration performs these steps:

- Calculate the midpoint $c = (a + b)/2$
- Calculate the function value at the midpoint, f(c)
- If convergence is satisfactory; (a-c) is sufficiently small, or f(c) is sufficiently small, return c and stop iterating
- Examine the sign of f(c) and replace either $(a, f(a))$ or $(b, f(b))$ with $(c, f(c))$ so that there is a zero crossing within the new interval.

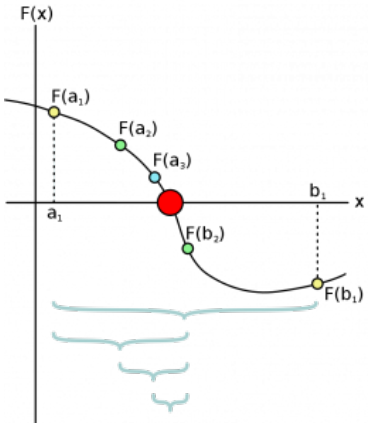

Figure 1

Problem Statement

Thermistors are temperature-measuring devices based on the principle that the thermistor material exhibits a change in electrical resistance with a change in temperature.

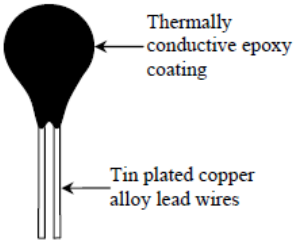

Figure 2: A Typical Thermistor

For one of the typical commercial thermistor, the relationship between the resistance R of the thermistor and the temperature T is given by

$$\frac{1}{T} = 1.1292 \times 10^{-3} + 2.3410 \times 10^{-4} \ln(R) + 8.7754 \times 10^{-8} [\ln(R)]^3 \quad (1)$$

where T is in **Kelvin** and R is **ohm**.

A Resistor error of no more than $\pm 0.01 ohm$ is acceptable. Do not forget:

$$T(Kelvin) = 273.15 + T(^\circ C) \quad (2)$$

Problem: You are asked to find resistance values of this thermistor in order to design sensor circuit that gives warning at $-20^\circ C$, $0^\circ C$, $20^\circ C$ and $100^\circ C$.

Lab Procedure

Implement a bisection root finding method in order to find the resistor value which satisfy the Equation-1 for different temperature values, under these conditions;

→ Program must take the values of 4 different temperature in Celsius in order to calculate the resistances values in single run ***(**10pt**)***.

⋆ Temperature values: $-20^\circ C$, $0^\circ C$, $20^\circ C$ and $100^\circ C$

→ Write the function that gives temperature in $^\circ C$ for the any resistance value. Test the function and print the temperature value for 2 test resistance value which are $R_{test1} = 500 ohm$ and $R_{test2} = 25000 ohm$ ***(**20pt**)***

⋆ **Results**: $T(for R_{test1}) = 41.5831^\circ C$ and $T(for R_{test2}) = 5.3259^\circ C$

→ Write the Bisection Function to find the root of the function for 4 different temperature values given above. ***(**35pt**)***.

⋆ Use the **100ohm** and **100Kohm** for minimum and maximum, respectively, as initial values for Bisection Method

→ Finally, program must print the resistance values and the total iteration number for 4 different temperatures in single run. ***(**20pt**)***

⋆ Program must print the each resistance value and the total iteration number in main function. Do not use print in bisection function which should return the root of equation and the iteration number only. ***(**15pt**)***

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- Finally, the running program in the bash shell should display these:

```
Enter the Temperature values in Celcius

-20
0
20
100
-------------------------

For R_test_1: Temperature is calculated =41.583176
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For R_test_2: Temperature is calculated= 5.325944
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start point?
100
end point?
100000
start point= 100000.000000
end point= 100.000000
Enter the temperature tolerance?
0.01

For Temperature= -20.000000, Accurate Root calculated is = 97046.357602
with 23  iteration

For Temperature= 0.000000, Accurate Root calculated is = 32665.069312
with 23  iteration

For Temperature= 20.000000, Accurate Root calculated is = 12498.819572
with 23  iteration

For Temperature= 100.000000, Accurate Root calculated is = 678.664654
with 23  iteration

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Process exited after 25.43 seconds with return value 0
Press any key to continue . . .
```

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