Assignment 5: Neural Network and Numerical Solution

**PART A**: Wildfires are a major environmental concern for forest-rich provinces of Canada such as British Columbia. Such incidents are responsible for significant economical and ecological damages along with endangering human lives. A key factor to reduce the ignition and spread of such fires is its fast detection and improved prediction. Given that regional meteorological conditions greatly influence forest fires, such datasets can be used to predict the burned area of forest fires. BC Wildfire Service makes use of several meteorological conditions i.e. precipitation, relative humidity, wind speed, and temperature to determine fuel moisture and fire behavior indices through the Fire Weather Index System (FWI) which is the key component of the Canadian Forest Fire Danger Rating System (CFFDRS). FWI system is the Canadian system for rating fire danger and depends solely on weather readings that are collected from several weather stations throughout the province.

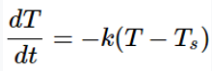
Build a nonlinear Neural Network Model to predict the burnt area of the forest in hectares using the sample data file sample\_FWI\_wildfires\_burnt\_area.csv. The sample dataset is a modified version of the forest fires dataset available through this web link.

The sample\_FWI\_wildfires\_burnt\_area.csv file contains the following meteorological data and FWI fuel codes as following.

1. X - x-axis spatial coordinate: 1 to 9
2. Y - y-axis spatial coordinate: 2 to 9
3. Month - month of the year: "Jan" to "Dec"
4. Day - day of the week: "Mon" to "Sun"
5. FFMC - FFMC index from the FWI system: 18.7 to 96.20
6. Temp - temperature in Celsius degrees: 2.2 to 33.30
7. RH - relative humidity in %: 15.0 to 100
8. Wind - wind speed in km/h: 0.40 to 9.40
9. Rain - outside rain in mm/m2 : 0.0 to 6.4
10. Area - the burned area of the forest (in ha): 0.00 to 1090.84
11. DMC - DMC index from the FWI system: 1.1 to 291.3
12. DC - DC index from the FWI system: 7.9 to 860.6

Fine Fuel Moisture Code (FFMC), Duff Moisture Code (DMC), and Drought Code (DC) are indices values where FFMC denotes the moisture content surface litter and influences ignition and fire spread, DMC and DC represent the moisture content which affects fire intensity. Higher values of these codes suggest more severe burning conditions.

**PART B**: Newton's Cooling Law states that the rate of change of temperature of an object is proportional to the difference in temperature between the object and its surroundings. Mathematically, we can write this as:



where T is the temperature of the body, Ts is the temperature of the surroundings, t is time, and k is a positive heat transfer coefficient. The analytical solution of this equation is:

Diagram

Description automatically generated with low confidence

Make a numerical model using Euler's method to solve Newton's Cooling Law for two different step sizes of t = 2 s and t =10 s. Integrate the model from t = 0 to t = 100s by considering the following initial values

Initial temperature To = 95°C

Room temperature Ts = 22 °C

Heat transfer constant k = 0.079