ALGONQUIN COLLEGE

Computer Engineering Technology – Computing Science

Course: Numerical Computing – CST8233
Term: Fall 2021

Lab #10

• Objectives

The main objective of this lab is to use R program to perform numerical differentiation.

• Earning

This lab worth 1.5 % of your final course mark. Each student should complete this lab and demo the codes of the exercises to the lab professor during the lab session.

• Steps

Step 1. Numerical Differentiation

Differentiation is widely used in many applications to find rates of change. It allows us to find the rate of change of a dependent variable y with respect to an independent variable x, which on a graph of y against x is the gradient of the curve. For example, we can find the rate of change of velocity with respect to time to obtain the acceleration.

Numerically, there are three different ways to approximately calculate the first derivative at point x_i: 1) Forward Divided Difference (FDD), 2) Backward Divided Difference (BDD), and 3) Central Divided Difference (CDD). The formulas are as follows:

$$f`(x_i) \approx \frac{y_{i+1}-y_i}{x_{i+i}-x_i} \text{ (FDD)}$$

$$f`(x_i) \approx \frac{y_i-y_{i-1}}{x_i-x_{i-1}} \text{ (BDD)}$$

$$f`(x_i) \approx \frac{y_{i+1}-y_{i-1}}{x_{i+i}-x_{i-1}} \text{ (CDD)}$$

The second derivative at point x_i can be approximately calculated using the following formula:

$$f``(x_i) \approx \frac{y_{i+1} - 2\,y_i + y_{i-1}}{(x_{i+i} - x_i)^2}$$

Step 2. Exercise

A. Download the file **`data.xlsx`**. This data represents the altitude (*km*) of a rocket as a function of time (*sec*.) Examine the data and plot the distance travelled by the rocket as a function of time.

B. Write R program that takes two vectors (`xVec, yVec`) representing a set of data pairs (x, y) and finds the first derivative using CDD method. The function returns a vector of first derivative at each point of `xVec`. Call this vector **`firstDev`**. Use this function to find the velocity of the rocket at each time.

C. Plot the velocity (*m/sec*) of the rocket as function of time.

D. Write R program that takes two vectors (`xVec, yVec`) representing a set of data pairs (x, y) and finds the second derivative. The function returns a vector of the second derivative at each point of `xVec`. Call this vector **`secondDev.`** Use this function to find the acceleration of the rocket at each time.

E. Plot the acceleration (*m/sec*^{2}) of the rocket as a function of time.

<u>You need to demo this to your lab professor.</u>