COMPUTER SCIENCE AND ENGINEERING

Indian Institute of Technology, Palakkad

CS5016: Computational Methods and Applications

Coding Assignment 4

Numerical Differentiation and Integration

8 Feb, 2024

1. Write a program to visualize actual derivative ($f'(x)$) and forward finite difference approximation ($\delta^+_{0.01}(x)$) of the function $\sin(x^2)$ in the internal $[0, 1]$. [10]

2. Write a program to visualize the absolute errors of approximation $\delta^+_{0.01}(x)$, $\delta^-_{0.01}(x)$ and $\delta^c_{0.01}(x)$ of function $\sin(x^2)$ in the internal $[0, 1]$. [10]

3. Write a program to visualize, as a function of h, the maximum absolute error of approximations $\delta^+_h(x)$ and $\delta^c_h(x)$ of function $\sin(x^2)$ in the internal $[0, 1]$. In the same figure, also plot the theoretical maximum absolute error of approximations $\delta^+_h(x)$ and $\delta^c_h(x)$. [20]

4. Write a program to visualize, as a function of M (number of intervals), area under the curve $y(x) = 2x \cdot e^{x^2}$ in the interval $[1, 3]$ computed using the trapezoidal formula. In the figure, also indicate the exact area. [20]

5. Write a program to visualize, as a function of u, area under the curve $y(x) = 2x \cdot e^{x^2}$ in the interval $[0, u]$ computed using various integration functions available in Python's `scipy.integrate` module. In the figure, also indicate the actual area under the curve. [20]

6. Enhance the class `Polynomial`, developed in the last coding assignment, as follows [10]

   - Add a method `derivative` that will return the polynomial's derivative.

   ```
   p = Polynomal([1, 2, 3])
   pd = d.derivative()
   print(pd)
   ```

   Expected output:

   ```
   Coefficients of the polynomial are:
   2 6
   ```

   - Add a method `area` that takes two arguments a and b, and returns the exact area under the polynomial in the interval $[a, b]$

   ```
   p = Polynomal([1, 2, 3])
   print(p.area(1,2))
   ```

   Expected output:

   ```
   Area in the interval [1, 2] is: 11
   ```

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7. Write a program that uses the enhanced `Polynomial` class to approximate area under the curve $y(x) = e^x \cdot \sin x$ in the interval $[0, 1/2]$ within a guaranteed error of 10^{-6}. [10]

   NOTE: Your code should not use any numerical integration techniques, and should not compute the actual area under the curve.