APMA 2070 Deep Learning for Scientists and Engineers
Homework 04
Due Date: 03-24-2025, 11:59 pm (E.T.)

Lecture 1.4

1. Using the autodifferentiation routine provided by TensorFlow or PyTorch or JAX, write codes for computing the derivative of the following Gaussian function in both frameworks:

$$f(x) = \frac{1}{\sigma\sqrt{(2\pi)}} \exp\left(-\frac{1}{2}\frac{(x-\mu)^2}{\sigma^2}\right), \tag{1}$$

where $\sigma^2 = 0.2,\ \mu = 0$, and $x \in [-5, 5]$.

Using the *time* module provided by Python measure the run-times for the code at least 10 times to obtain a measure of unbiased performance. Try it for both CPU and GPU, and report the CPU and GPU you used (For example- CPU: Intel Core i9-10900X / GPU: GeForce RTX 3090 Ti). Plot the run-time against the number of runs and compute the mean and standard deviation of the measured run-times. (Note: Use the same hardware for all the following problems.)

2. Write a TensorFlow or PyTorch or JAX function to compute the 2nd-order derivatives $f''(x)$. Use your function to predict $f''(x)$ for 10000 uniform points in $[-5, 5]$, and measure the runtime. Validate the code by comparing the results with the exact formula.

3. Write a TensorFlow or PyTorch or JAX function to compute the 3rd-order derivatives $f'''(x)$. Use your function to predict $f'''(x)$ for 10000 uniform points in $[-5, 5]$, and measure the runtime. Validate the code by comparing the results with the analytical solution.

4. Plot the runtime against the derivative order, including 0-order (the original function $f(x)$), 1st-order ($f'(x)$), 2nd-order ($f''(x)$) and 3rd-order ($f'''(x)$). Discuss your findings.

5. Repeat Problems 1–4 with GPU. Compare your results on CPU and GPU, and discuss. Also report what GPU you used (such as NVIDIA GeForce RTX 3080).