ILLINOIS

IE534/CS547: Deep Learning **(Due: Mar-4-2021)**

Homework #4

Instructor: Richard B. Sowers

Read all the instructions below carefully before you start working on the assignment, and before you make a submission.

- **This is a group homework, every group only submit ONE solution on Compass .** Please include the names of all the group members.
- **Due time is at 11:59pm** at the due date. **No late submission!**
- All students are expected to abide by the Honor Code
- All date-times will be in Champaign-Urbana
- Please put your typed solution in a PDF format. For code, you should submit a google colab notebook link with viewers permission to instructors and TAs in your solution PDF file.

Problem 1: Backpropsimple (10 points)

Define

$$\phi(x) \stackrel{\text{def}}{=} \cos(2x). \qquad x \in \mathbb{R}$$

Define

$$f(m) \stackrel{\text{def}}{=} \exp\left[\pi\phi(mx)\right]$$

for $m \in \mathbb{R}$. Set $x = 5$, and compute $f'(10)$.

Problem 2: Backprop (10 points)

Define

$$\phi_n(x) \stackrel{\text{def}}{=} \cos(2^n x) \qquad x \in \mathbb{R}$$

for $n \in \{1, 2, 3\}$. Set $x = 5$ and define

$$f_5(m_1, m_2, m_3) \stackrel{\text{def}}{=} \exp\left[\pi\phi_3(m_3\phi_2(m_2\phi_1(m_1 x)))\right]$$

for $(m_1, m_2, m_3) \in \mathbb{R}^3$.

(a) Compute $\frac{\partial f_5}{\partial m_3}(10, 9, 8)$

(b) Compute $\frac{\partial f_5}{\partial m_2}(10, 9, 8)$

(c) Compute $\frac{\partial f_5}{\partial m_1}(10, 9, 8)$

Problem 3: BackpropConstants (10 points)

Define

$$\phi_n(x) \stackrel{\text{def}}{=} \cos(2^n x) \qquad x \in \mathbb{R}$$

for $n \in \{1, 2, 3\}$. Set $x = 5$ and define

$$f_5(m_1, b_1, m_2, b_2, m_3, b_3) \stackrel{\text{def}}{=} \exp\left[\pi\phi_3(m_3\phi_2(m_2\phi_1(m_1 x + b_1) + b_2) + b_3)\right]$$

for $(m_1, b_1.m_2, b_2.m_3, b_3) \in \mathbb{R}^6$.

(a) Compute $\frac{\partial f_5}{\partial m_3}(10, 11, 9, 19, 8, 18)$

(b) Compute $\frac{\partial f_5}{\partial m_2}(10, 11, 9, 19, 8, 18)$

(c) Compute $\frac{\partial f_5}{\partial m_1}(10, 11, 9, 19, 8, 18)$

Problem 4: Coding Question (10 points)

Define $\Phi_n(x) = \cos(2^n x)$ for $x \in \mathbb{R}$ and $n \in \{1, 2, 3\}$. Set $x = 5$ and define

$$f_5(m_1, m_2, m_3) \stackrel{\text{def}}{=} \exp\left[\pi\phi_3(m_3\phi_2(m_2\phi_1(m_1 x)))\right]$$

for $(m_1, m_2, m_3) \in \mathbb{R}^3$.

- Numerically compute $\lim_{\epsilon\to 0}\{f_5(10, 9, 8+\epsilon) - f_5(10, 9, 8)\}/\epsilon$.
- Numerically compute $\lim_{\epsilon\to 0}\{f_5(10, 9+\epsilon, 8) - f_5(10, 9, 8)\}/\epsilon$.
- Numerically compute $\lim_{\epsilon\to 0}\{f_5(10+\epsilon, 9, 8) - f_5(10, 9, 8)\}/\epsilon$.