UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN

CS440/ECE448 Artificial Intelligence

Exam 1

Spring 2023

February 20, 2023

Your Name: _____

Your NetID: _____

Instructions

- Please write your name on the top of every page.
- Have your ID ready; you will need to show it when you turn in your exam.
- This will be a CLOSED BOOK, CLOSED NOTES exam. You are permitted to bring and use only one 8.5x11 page of notes, front and back, handwritten or typed in a font size comparable to handwriting.
- No electronic devices (phones, tablets, calculators, computers etc.) are allowed.
- Make sure that your answer includes only the variables that it should include, but DO NOT simplify explicit numerical expressions. For example, the answer $x = \frac{1}{1+\exp(-0.1)}$ is MUCH preferred (much easier for us to grade) than the answer $x = 0.524979$.

Possibly Useful Formulas

$$P(X=x|Y=y)P(Y=y) = P(Y=y|X=x)P(X=x)$$
$$P(X=x) = \sum_y P(X=x,Y=y)$$
$$E\left[f(X,Y)\right] = \sum_{x,y} f(x,y)P(X=x,Y=y)$$

$$\textbf{Precision,Recall} = \frac{TP}{TP+FP}, \frac{TP}{TP+FN}$$
$$\textbf{MPE=MAP:} \quad f(x) = \arg\max\left(\log P(Y=y) + \log P(X=x|Y=y)\right)$$
$$\textbf{Naive Bayes:} \quad P(X=x|Y=y) \approx \prod_{i=1}^{n} P(W=w_i|Y=y)$$

$$\textbf{Laplace Smoothing:} \quad P(W=w_i) = \frac{k+\text{Count}(W=w_i)}{k+\sum_v (k+\text{Count}(W=v))}$$
$$\textbf{Fairness:} \quad P(Y|A) = \frac{P(Y|\hat{Y},A)P(\hat{Y}|A)}{P(\hat{Y}|Y,A)}$$

$$\textbf{Linear Regression:} \quad \varepsilon_i = f(x_i) - y_i = b + w@x_i - y_i$$
$$\textbf{Mean Squared Error:} \quad \text{MSE} = \frac{1}{n}\sum_{i=1}^{n} \varepsilon_i^2$$
$$\textbf{Linear Classifier:} \quad f(x) = \arg\max_k w_k@x + b$$

$$\textbf{Cross-Entropy:} \quad \mathscr{L} = -\frac{1}{n}\sum_{i=1}^{n} \log f_{y_i}(x_i)$$
$$\textbf{Softmax:} \quad \operatorname{softmax}_c(w@x+b) = \frac{\exp(w_c@x+b_c)}{\sum_{k=0}^{V-1}\exp(w_k@x+b_k)}$$
$$\textbf{Softmax Error:} \quad \varepsilon_{i,c} = \begin{cases} f_c(x_i) - 1 & c = y_i \\ f_c(x_i) - 0 & \text{otherwise} \end{cases}$$
$$\textbf{Gradient Descent:} \quad w \leftarrow w - \eta\nabla_w\mathscr{L}$$

$$\textbf{Neural Net:} \quad h = \text{ReLU}\left(b_0 + w_0@x\right), \quad f = \text{softmax}\left(b_1 + w_1@h\right)$$
$$\textbf{Back-Propagation:} \quad \frac{\partial\mathscr{L}}{\partial h_j} = \sum_k \frac{\partial\mathscr{L}}{\partial f_k}\times\frac{\partial f_k}{\partial h_j}, \quad \frac{\partial\mathscr{L}}{\partial w_{0,k,j}} = \frac{\partial\mathscr{L}}{\partial h_k}\times\frac{\partial h_k}{\partial w_{0,k,j}}$$