Self-Assessment for BerkeleyX CS190.1x

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Databricks

1 Linear Algebra

1. *Matrix-Matrix Multiply.* Solve the equation below.

$$\begin{bmatrix} 5 & 2 \\ -2 & 4 \end{bmatrix} \begin{bmatrix} 5 \\ 2 \end{bmatrix} = ?$$

2. *Vector-Vector Multiply.* Which of the following statements about the two mathemetical expressions below are true (more than one may be correct)?

$$\begin{bmatrix} 5 \\ -2 \end{bmatrix}^\top \begin{bmatrix} 5 \\ -2 \end{bmatrix} \qquad \begin{bmatrix} 5 \\ -2 \end{bmatrix} \begin{bmatrix} 5 \\ -2 \end{bmatrix}^\top$$

(a) (b)

- (a) is an inner product, and (b) is an outer product.
- (a) is an outer product, and (b) is an inner product.
- The output of (a) is a 2×2 matrix.
- The output of (b) is scalar.

3. *Matrix Properties*. Consider the $n \times m$ matrix $\mathbf{A}$. Which of the following statements are true (more than one may be correct)?
   - $\mathbf{A}$ is symmetric iff $\mathbf{A}^\top = \mathbf{A}$.
   - $\mathbf{A} + \mathbf{A} = 2\mathbf{A}$.
   - If $n \neq m$ then $\mathbf{A}^{-1}$ does not exist.
   - Assuming $\mathbf{A}^{-1}$ exists, $\mathbf{A}\mathbf{A}^{-1} = \mathbf{I}$ where $\mathbf{I}$ is the identity matrix.

4. *Norms.* Consider the n-dimensional vector $\mathbf{x}$. Which of the following statements are true (more than one may be correct)?
   - $\|\mathbf{x}\|_2^2 = \sum_{i=1}^n x_i^2$.
   - $\|\mathbf{x}\|_2^2 = \mathbf{x}^\top \mathbf{x}$.
   - $\|\mathbf{x}\|_2^2 = \|\mathbf{x}\mathbf{x}^\top\|_F$.
   - $\|\mathbf{x}\|_2 \geq \|\mathbf{x}\|_1$.

2 Algorithms

1. *Big-O notation.* Consider the $n \times m$ matrix $\mathbf{A}$ and the n-dimensional vector $\mathbf{x}$. What is the time complexity in Big-O notation of computing $\mathbf{A}^\top \mathbf{x}$? What is the space complexity in Big-O notation?

2. *Higher-order Functions.* Evaluate the Python expression below.

```
myList = [-2, 4, 3, -1]
map(lambda x: x*3 + 2, myList)
```

3 Machine Learning

1. *Overfitting*. Which of the following statements are true (more than one may be correct)?
   - Assessing a coin's bias from a single observed coin flip is an example of overfitting.
   - Overfitting is primarily a concern when training statistical models with large datasets.
   - Regularization is used to protect against overfitting.
   - Overfitting to the training data leads to poor generalization on new data points.
2. *Learning Settings*. Match each problem description with the type of learning setting.

Problem	Learning Setting
Differentiating between spam and non-spam emails	Regression
Predicting SAT scores from high-school GPA	Binary classification
Categorizing images as one of 100 image classes	Multiclass Classification

4 Calculus and Probability

1. *Derivatives*. Compute the derivative of

$$f(w) = l(w) + \lambda w^2$$

   with respect to w, given some differentiable function $l(\cdot)$ and some constant λ.
2. *Expected Value*. Let S_n be the number of successes in n independent and identically distributed Bernoulli trials with probability p for success. Compute the expected number of successes.
3. *Conditional Probability*. Which of the following statements are true (more than one may be correct)?
   - $\mathbf{P}[X|Y]\mathbf{P}[Y] = \mathbf{P}[Y|X]\mathbf{P}[X]$.
   - $\mathbf{P}[X] = \mathbf{P}[X|Y]\mathbf{P}[Y]$.
   - $\mathbf{P}[X, Y] = \mathbf{P}[X|Y]\mathbf{P}[Y]$.
   - $\mathbf{P}[X|Y] = \mathbf{P}[X]$ if X and Y are independent.
4. *Probability Distributions*. Match each distribution to its probability density function.

Distribution	Probability Density Function
Normal	$\binom{n}{k} p^k (1-p)^{n-k}$
Binomial	$\frac{1}{b-a}$ when $a \leq x \leq b$; 0 otherwise
Uniform	$\frac{1}{\sqrt{2\pi\sigma}} \exp\left(\frac{(x-\mu)^2}{-2\sigma^2}\right)$
Bernoulli	$p^x (1-p)^{1-x}$

5 Python

1. *Online Quiz*. Take the following online quiz: `http://www.mypythonquiz.com`.

6 Additional Resources

Listed below are a few resources that cover the topics discussed above. All of these resources are freely available on the web.

- Machine Learning: Pedros Domingos' review paper [3] and the introduction to Mohri, Rostamizadeh and Talwalkar's texbook [6].[1]
- Linear Algebra: Zico Kolter and Chuong Do's tutorial [5].
- Calculus: Wikipedia's calculus book [2].
- Probability: Paola Sebastiani's tutorial [7].
- Algorithms: Wikipedia's algorithms book [1], in particular Chapter 2: Mathematical Background.
- Python: The Python tutorial as part of the UC Berkeley CS188 course [4].

References

[1] Algorithms {fundamental techniques}. http://en.wikibooks.org/wiki/Algorithms.

[2] Calculus. http://en.wikibooks.org/wiki/Calculus.

[3] Pedro Domingos. A Few Useful Things to Know About Machine Learning. *Communications of the ACM*, 55(10):78–87, 2012. http://homes.cs.washington.edu/~pedrod/papers/cacm12.pdf.

[4] Dan Klein and Pieter Abbeel. Python Basics. http://ai.berkeley.edu/tutorial.html#PythonBasics.

[5] Zico Kolter and Chuong Do. Linear Algebra Review and Reference. http://www.cs.cmu.edu/~zkolter/course/15-884/linalg-review.pdf.

[6] Mehryar Mohri, Afshin Rostamizadeh, and Ameet Talwalkar. *Foundations of Machine Learning*. The MIT Press, 2012. https://mitpress.mit.edu/books/foundations-machine-learning.

[7] Paola Sebastiani. A Tutorial on Probability Theory. http://www.sci.utah.edu/~gerig/CS6640-F2010/prob-tut.pdf.

[1] The introduction to this book is available as a 'Sample Chapter' on the MIT Press website.