1 Multiple Choice 1 point

Which of the following is an example of linear regression where y is the scalar output, **x** is the input vector, and **w** is a weight vector?

- $y = (\mathbf{w}^T x+1)^2 + (\mathbf{w}^T x)^2$
- $y = (\mathbf{w}^T x)^2$
- $y = (\mathbf{w}^T x+1)^2 - (\mathbf{w}^T x)^2$
- $y = (\mathbf{w}^T x)^2 + \mathbf{w}^T x$

$(w^Tx)^2 + 2w^Tx + 1 - (w^Tx)^2$

$= 2w^Tx + 1$ linear

其他都是含$(w^Tx)^2$，不linear

2 Multiple Choice 1 point

Suppose in a linear regression setting with squared loss, the design matrix is such that $\mathbf{X}^T\mathbf{X}$ is invertible. Suppose $\mathbf{w}^*$ is the minimizer of $\|\mathbf{y} - \mathbf{X}\mathbf{w}\|^2$. What will be the minimizer of $\|2\mathbf{y} - \mathbf{X}\mathbf{w}\|^2$?

有analytic sol

- $\mathbf{w}^*$
- $2\mathbf{w}^*$
- $\mathbf{w}^*/2$
- Cannot be written just in terms of $\mathbf{w}^*$

$w^* = (X^TX)^{-1}X^Ty$

$w^{*\prime} = \dots 2y = 2w^*$

3 Multiple Choice 1 point

Suppose in a linear regression setting with squared loss, the design matrix is such that $\mathbf{X}^T\mathbf{X}$ is invertible. Suppose $\mathbf{w}^*$ is the minimizer of $\|\mathbf{y} - \mathbf{X}\mathbf{w}\|^2$. What will be the minimizer of $\|\mathbf{y} - 2\mathbf{X}\mathbf{w}\|^2$?

- $\mathbf{w}^*$
- $2\mathbf{w}^*$
- $\mathbf{w}^*/2$
- Cannot be written just in terms of $\mathbf{w}^*$

$w^* = (X^TX)^{-1}X^Ty$

$w^{*\prime} = (2X^T 2X)^{-1}\cdot 2X^Ty$

$= \frac{1}{4}(X^TX)^{-1}\cdot 2X^Ty = \frac{1}{2}(X^TX)^{-1}X^Ty$

$= \frac{1}{2}w^*$

4 Multiple Choice 1 point

Recall that the norm $||\mathbf{w}||$ of a vector $\mathbf{w}$ is defined as $(\mathbf{w}^T\mathbf{w})^{1/2}$. What is the gradient of $||\mathbf{w}||^4$ with respect to $\mathbf{w}$?

- ○ $2\,\mathbf{w}$
- ○ $4\,||\,\mathbf{w}\,||^3$
- ◉ $4\,\mathbf{w}\,\mathbf{w}^T\mathbf{w}$
- ○ $2\,\mathbf{w}^T\mathbf{w}$

$$\nabla_w ||x||^4 = \nabla_w (w^T w)^2 = (2w)(2w^T w) = 4ww^T w$$

(注意: chain rule 里层乘在前)

5 Multiple Choice 1 point

What does "minibatch" in "minibatch stochastic gradient descent" refer to?

- ○ The fact that only a small number of entries of the weight vector are updated at each step
- ◉ The fact that a randomly drawn small subsample of the entire training set is used at each step
- ○ The fact that it uses a very small learning rate
- ○ The fact that it attempts to make the loss function very small at each step

6 Multiple Choice 1 point

What does "stochastic" in "minibatch stochastic gradient descent" refer to?

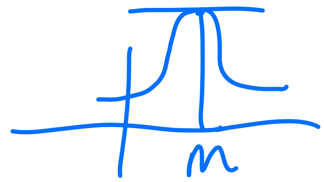
- ◉ The fact that randomness is involved in selecting the minibatch
- ○ The fact that the learning rate is randomly selected
- ○ The fact that the training set is a random draw from some underlying probability distribution
- ○ The fact that the loss function is randomly selected

7 Multiple Choice 1 point

Suppose that we draw a single observation Y from a Gaussian distribution with mean m and variance 1. What is the maximum likelihood estimate of the parameter m in terms of the observation Y?

无关

- [x] Y
- [ ] m
- [ ] 1
- [ ] 0



一次：Y

多次：$\frac{1}{n}\sum_{i=1}^{n} Y_i$

8 Multiple Choice 1 point

When is it a good idea to use minibatch stochastic gradient descent?

- [x] When the training set size is too large
- [ ] When the loss of the model weights is too large
- [ ] When the number of weights in your model is too large
- [ ] When the learning rate is too large

详细推导：

$$p(y_i|m,\sigma^2)=\frac{1}{\sqrt{2\pi\sigma^2}}e^{-\frac{(y_i-m)^2}{2\sigma^2}}$$

$$\ln\left(\prod_{i=1}^{n} p(y_i|m,\sigma^2)\right)$$

const

$$=\cdots=\underbrace{-\frac{n}{2}\ln(2\pi\sigma^2)}_{}-\frac{1}{2\sigma^2}\sum_{i=1}^{n}(y_i-m)^2$$

9 Multiple Choice 1 point

Suppose weight vector **w** is of size d x 1. What is the gradient of F(**w**) = **w** with respect to **w**?

- [ ] **w**
- [ ] 1
- [x] Identity matrix of size d x d
- [ ] d x 1 vector consisting of all 1s

$$\nabla_w w = I_d$$

$\Updownarrow$

$\equiv$ minimize $\sum_i (y_i-m)^2$

set derivative $=0$

$$\Rightarrow 0=\sum_{i=1}^{n}(y_i-m)$$

因而 $\hat{m}=\frac{1}{n}\sum_{i=1}^{n} y_i$

10 Multiple Choice 1 point

Which of the following is NOT a reasonable way to select model parameters given data?

- Choose a loss function and minimize the total loss over the dataset
- Setup a statistical model using the parameters and maximize the likelihood of the data given parameters
- Setup a statistical model using the parameters and minimize the negative log likelihood of the data given parameters
- Choose a loss function and make sure that the losses for every training example are roughly equal

11 Multiple Choice 1 point

Why is "deep learning" called by that name?

- Because it uses very deep mathematics
- Because it has deep connections with neuroscience
- Because it uses neural networks that have many layers
- Because the loss function landscape in the space of model parameters has deep valleys

12 Multiple Choice 1 point

Suppose a Gaussian distribution has the density p(x) proportional to exp(- x^2/8). What are the mean and standard deviation of this distribution?

- Can't be determined. Need to know the constant of proportionality.
- Mean 0, Standard Deviation 2
- Mean 0, Standard Deviation 4
- Mean 0, Standard Deviation 8

$\mu = 0, \quad \frac{1}{2\sigma^2} = \frac{1}{8}$

$\Rightarrow \sigma^2 = 4, \sigma = 2$

13 Multiple Choice 1 point

Suppose f(**x**) = A **x** and g(**u**) = B **u** where A is m x n and B is k x m. Which of the following correctly describes the function g(f(**x**))?

- ○ It's not well defined since the output dimension of f does not match the input dimension of g
- ● It's a linear function given by B A **x**
- ○ It's a linear function given by A B **x**
- ○ It's a non linear function of **x**

$g(f(x))$
$= B(Ax)$

14 Multiple Choice 1 point

When applying the principle of maximum likelihood, we can instead look at the negative log likelihood. In the context, which of the following statement is NOT correct?

- ○ Under independence, taking logs gives a sum of terms to work with instead of a product of terms ✓
- ○ The negative sign allows us to express a maximization problem as a minimization problem and thus establish a link to loss minimization ✓ ✓
- ● Taking the negative log likelihood allows us to solve the optimization problem in closed form ✓ X
- ○ The solution of the problem of maximization of the likelihood is the same as that of minimization of the negative log likelihood ✓

15 Multiple Choice 1 point

Suppose we view linear regression as a simple neural network. What happens to the number of layers of this network if we double the dimension of the input features?

- ● Stays the same
- ○ Number of layers gets doubled
- ○ Number of layers gets halved
- ○ Number of layers increases by 1

layer 不变,因为算法不变
(num(layer)
=1)

16 Multiple Choice 1 point

Which of the following is a point of similarity between artificial and biological neurons?

- They both have inputs and generate outputs
- In both cases, their weights are trained using gradient descent
- Both can only compute linear functions
- They are both incapable of aggregating their inputs

17 Multiple Choice 1 point

Which of the following is a classification problem?

- Predicting whether or not a student will pass STATS 315
- Predicting a student's GPA at graduation
- Predicting the time a student will take to solve the midterm exam
- Predicting the salary of a student in their first job after college

18 Multiple Choice 1 point

Which is of the following is a correct statement about the cross entropy loss function?

- It is incapable of handling the situation when true labels are soft
- It is not differentiable with respect to model predictions
- It is not bounded from above by a finite constant
- It is not bounded from below by a finite constant

$l_j = -y_j \underbrace{\ln \hat{y}_j}$

可以 $\to -\infty$

因而 l_j 可以 $\to +\infty$

19 Multiple Choice 1 point

Let R be the set of all real numbers and let S = { softmax(**x**) : **x** = (x_1, x_2) , x_1, x_2 ε R }. That is, S is the set obtained by applying the softmax function to all points in the two dimensional plane. Which of the following statements correctly describes S?

- ◉ $\{ (x_1, x_2) : 0 < x_1 < 1, 0 < x_2 < 1, x_1 + x_2 = 1 \}$
- ○ $\{ (x_1, x_2) : 0 <= x_1 <= 1, 0 <= x_2 <= 1, x_1 + x_2 = 1 \}$
- ○ $\{ (x_1, x_2) : -\infty < x_1 < +\infty, -\infty < x_2 < +\infty \}$
- ○ $\{ (x_1, x_2) : -\infty <= x_1 <= +\infty, -\infty <= x_2 <= +\infty \}$

20 Multiple Choice 1 point

Suppose X has Gaussian distribution with mean 0 and standard deviation 1. Which of the following correctly describes X+1 ? μ++, σ不变

- ◉ It has a Gaussian distribution with mean 1 and standard deviation 1
- ○ It has a Gaussian distribution with mean 0 and standard deviation 2
- ○ Its distribution is no longer Gaussian
- ○ It also has a Gaussian distribution with mean 0 and standard deviation 1

21 Multiple Choice 1 point

Consider softmax regression with cross-entropy loss. Suppose I am running minibatch stochastic gradient descent with a batch size of one and learning rate 0.1. I choose a random labeled example with a non-zero feature vector from the dataset. But the update does NOT change the weight vector. What can be correctly concluded from this?

- ○ The training process has finished and we can stop training ✗ 还有其他labels $\Rightarrow \nabla = x(\hat{y}_j - y_j) = 0$
- ◉ The label predicted by the current weight vector matches the true label of the chosen example ✓
  (已经正确, $y_j = \hat{y}_j$)
- ○ Batch size is too small. We should increase it.
- ○ The learning rate is not right. We should modify it.

22 Multiple Choice 1 point

We noted that cross-entropy loss can also be used when true labels in the labeled dataset are soft. Suppose you have a true label which is soft and whose entropy is H. What is the minimum value of the cross-entropy loss for such a true label?

$\sum_j -y_j \ln \hat{y}_j \qquad \hat{y}_j \le 1 \Rightarrow \ln \hat{y}_j \le 0$

$\Rightarrow -y_j \ln \hat{y}_j \ge 0$

$\Rightarrow \sum_j -y_j \ln y_j \ge H$

- ( ) 0
- (•) H
- ( ) Insufficient information: we need to know the number of classes to compute the minimum value
- ( ) -∞

23 Multiple Choice 1 point

$KL = H(P,Q) - \underbrace{H(P)}_{\ge 0}$

Which of the following is a correct observation about cross-entropy and relative-entropy between two probability distributions?

$\le H(P,Q)$

- (•) Cross-entropy is at least as large as relative-entropy
- ( ) Relative-entropy is at least as large as cross-entropy
- ( ) Relative-entropy is always the same as cross-entropy
- ( ) Relative-entropy can be smaller than, larger than, or equal to, cross-entropy

24 Multiple Choice 1 point

Which technology company is primarily responsible for the development of Tensorflow?

- ( ) Facebook
- (•) Google
- ( ) Microsoft
- ( ) Amazon

25 Multiple Choice 1 point

The following code creates a neural network with how many layers?

```
from tensorflow import keras
from tensorflow.keras import layers
model = keras.Sequential([
    layers.Dense(512, activation="relu"),
    layers.Dense(10, activation="softmax")
])
```

2

- (selected) 2
- 512
- 10
- 522

26 Multiple Choice 1 point

What is the closest analogue of a numpy ndarray in tensorflow?

- (selected) tensor
- variable
- gradient tape
- layer

27 Multiple Choice 1 point

Having access to tensorflow/keras saves a programmer from which of the following activities?

- (selected) Implementing minibatch stochastic gradient descent
- Creating a neural network architecture
- Specifying a loss function
- Choosing a training dataset

28 Multiple Choice 1 point

What does the filetype extension ".ipynb" indicate?

- (●) jupyter notebook
- ( ) python notebook
- ( ) tensorflow notebook
- ( ) keras notebook

29 Multiple Choice 1 point

How do we deal with the restriction that tensorflow tensors are not assignable?

- ( ) By coding everything in numpy
- (●) By using tensorflow variables
- ( ) By using keras
- ( ) By using the gradient tape API

30 Multiple Choice 1 point

Which of the following branches of mathematics have we NOT used in this course?

- ( ) linear algebra
- ( ) probability theory
- ( ) multivariable calculus
- (●) differential equations