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Practice quiz: Multiclass Classification

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1.

1 / 1 point

Softmax regression (4 possible outputs)

$$\begin{aligned}
 \times z_1 &= \vec{w}_1 \cdot \vec{x} + b_1 & a_1 &= \frac{e^{z_1}}{e^{z_1} + e^{z_2} + e^{z_3} + e^{z_4}} \\
 & & & \quad \times \quad \circ \quad \square \quad \triangle \\
 & & & = P(y = 1|\vec{x}) \quad 0.30 \\
 \circ z_2 &= \vec{w}_2 \cdot \vec{x} + b_2 & a_2 &= \frac{e^{z_2}}{e^{z_1} + e^{z_2} + e^{z_3} + e^{z_4}} \\
 & & & = P(y = 2|\vec{x}) \quad 0.20
 \end{aligned}$$

$$\begin{aligned}
 \square z_3 &= \vec{w}_3 \cdot \vec{x} + b_3 & a_3 &= \frac{e^{z_3}}{e^{z_1} + e^{z_2} + e^{z_3} + e^{z_4}} \\
 & & & = P(y = 3|\vec{x}) \quad 0.15
 \end{aligned}$$

$$\begin{aligned}
 \triangle z_4 &= \vec{w}_4 \cdot \vec{x} + b_4 & a_4 &= \frac{e^{z_4}}{e^{z_1} + e^{z_2} + e^{z_3} + e^{z_4}} \\
 & & & = P(y = 4|\vec{x}) \quad 0.35
 \end{aligned}$$

For a multiclass classification task that has 4 possible outputs, the sum of all the activations adds up to 1. For a multiclass classification task that has 3 possible outputs, the sum of all the activations should add up to

- ☐ More than 1
☒ 1
☐ It will vary, depending on the input x.
☐ Less than 1

The sum of all the softmax activations should add up to 1 whether the number of possible classes is 3, 4, 5 or any other number of classes. One way to see this is that if $e^{z_1} = 10$, $e^{z_2} = 20$, $e^{z_3} = 30$, then the sum of $a_1 + a_2 + a_3$ is equal to $\frac{e^{z_1} + e^{z_2} + e^{z_3}}{e^{z_1} + e^{z_2} + e^{z_3}}$ which is 1.

✓ Correct

Yes! The sum of all the softmax activations should add up to 1. One way to see this is that if $e^{z_1} = 10$, $e^{z_2} = 20$, $e^{z_3} = 30$, then the sum of $a_1 + a_2 + a_3$ is equal to $\frac{e^{z_1} + e^{z_2} + e^{z_3}}{e^{z_1} + e^{z_2} + e^{z_3}}$ which is 1.

2.

1 / 1 point

Cost

Logistic regression

$$z = \bar{w} \cdot \bar{x} + b$$

$$a_1 = g(z) = \frac{1}{1 + e^{-z}} = P(y = 1 | \bar{x})$$

$$a_2 = 1 - a_1 = P(y = 0 | \bar{x})$$

$$\text{loss} = -y \log a_1 - (1 - y) \log(1 - a_1)$$

if $y = 1$ if $y = 0$

$$J(\bar{w}, b) = \text{average loss}$$

Softmax regression

$$a_1 = \frac{e^{z_1}}{e^{z_1} + e^{z_2} + \dots + e^{z_N}} = P(y = 1 | \bar{x})$$

$$\vdots$$

$$a_N = \frac{e^{z_N}}{e^{z_1} + e^{z_2} + \dots + e^{z_N}} = P(y = N | \bar{x})$$

Crossentropy loss

$$\text{loss}(a_1, \dots, a_N, y) = \begin{cases} -\log a_1 & \text{if } y = 1 \\ -\log a_2 & \text{if } y = 2 \\ \vdots & \vdots \\ -\log a_N & \text{if } y = N \end{cases}$$

$\text{loss} = -\log a_j$ if $y = j$

For multiclass classification, the cross entropy loss is used for training the model. If there are 4 possible classes for the output, and for a particular training example, the true class of the example is class 3 ($y=3$), then what does the cross entropy loss simplify to? [Hint: This loss should get smaller when a_3 gets larger.]

- ☐ $\frac{-\log(a_1) - \log(a_2) - \log(a_3) - \log(a_4)}{4}$
- ☐ z_3
- ☒ $-\log(a_3)$
- ☐ $z_3 / (z_1 + z_2 + z_3 + z_4)$

✓ Correct

Correct. When the true label is 3, then the cross entropy loss for that training example is just the negative of the log of the activation for the third neuron of the softmax. All other terms of the cross entropy loss equation ($-\log(a_1)$, $-\log(a_2)$, and $-\log(a_4)$) are ignored

3.

1 / 1 point

MNIST (more numerically accurate)

```
model
import tensorflow as tf
from tensorflow.keras import Sequential
from tensorflow.keras.layers import Dense
model = Sequential([
    Dense(units=25, activation='relu')
    Dense(units=15, activation='relu')
    Dense(units=10, activation='linear') ])

loss
from tensorflow.keras.losses import
SparseCategoricalCrossentropy

model.compile(..., loss=SparseCategoricalCrossentropy(from_logits=True) )

fit
model.fit(X, Y, epochs=100)

predict
logits = model(X)
f_x = tf.nn.softmax(logits)
```

For multiclass classification, the recommended way to implement softmax regression is to set `from_logits=True` in the loss function, and also to define the model's output layer with...

- ☐ a 'softmax' activation
- ☒ a 'linear' activation

✓ **Correct**

Yes! Set the output as linear, because the loss function handles the calculation of the softmax with a more numerically stable method.