Understanding model optimization

Puteaux, Fall/Winter 2020-2021

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##                            ##
##  Deep Learning in Python   ##
##                            ##
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```

§1 Introduction to Deep Learning in Python

§1.4 Fine-tuning keras models

§1.4.1 Understanding model optimization

1. Why is optimization hard?

- Simultaneously optimize 1000's of parameters with complex relationships.
- Updates may not improve the model meaningfully.
- Updates will be too small (if the learning rate is low) or too large (if the learning rate is high).

2. Code of stochastic gradient descent:

[1]:
```
import pandas as pd
from keras.layers import Dense
from keras.models import Sequential
from keras.utils.np_utils import to_categorical
from keras.optimizers import SGD


def data_preparation(df):
    df = df.reindex(columns=[
        'SHOT_CLOCK', 'DRIBBLES', 'TOUCH_TIME', 'SHOT_DIST', 'CLOSE_DEF_DIST',
        'SHOT_RESULT'
    ])
    df['SHOT_CLOCK'] = df['SHOT_CLOCK'].fillna(0)
    df['SHOT_RESULT'].replace('missed', 0, inplace=True)
    df['SHOT_RESULT'].replace('made', 1, inplace=True)
    df.columns = df.columns.str.lower()
    return df
```

```
data = pd.read_csv('ref1. Basketball shot log.csv')
data = data_preparation(data)

predictors = data.drop(['shot_result'], axis=1).to_numpy()
n_cols = predictors.shape[1]
target = to_categorical(data.shot_result)
input_shape = (n_cols, )
```

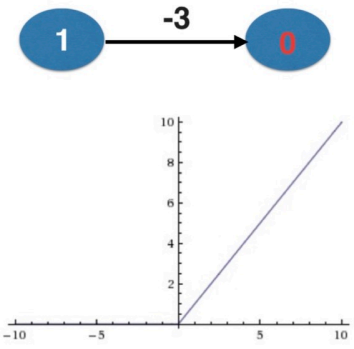
[2]:
```
def get_new_model(input_shape=input_shape):
    model = Sequential()
    model.add(Dense(100, activation='relu', input_shape=input_shape))
    model.add(Dense(100, activation='relu'))
    model.add(Dense(2, activation='softmax'))
    return (model)


lr_to_test = [.000001, 0.01, 1]

# loop over learning rates
for lr in lr_to_test:
    model = get_new_model()
    my_optimizer = SGD(lr=lr)
    model.compile(optimizer=my_optimizer, loss='categorical_crossentropy')
    model.fit(predictors, target)
```

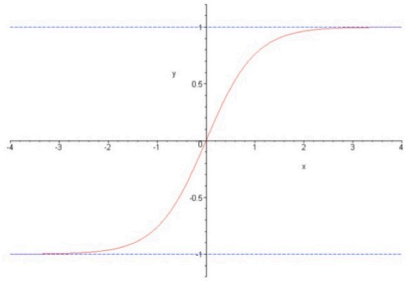
```
4003/4003 [==============================] - 7s 2ms/step - loss: 2.5267
4003/4003 [==============================] - 7s 2ms/step - loss: 0.6762A: 0s -
4003/4003 [==============================] - 7s 2ms/step - loss: 100.1059
```

3. What is the dying neuron problem?



4. What is the vanishing gradient problem?

- This occurs when many layers have very small slopes.
  - e.g., due to being on at part of the hyperbolic tangent (`tanh`) curve
- In deep networks, updates to backpropagation were close to 0.



tanh function

5. Practice question for diagnosing optimization problems:

- Which of the following could prevent a model from showing an improved loss in its first few epochs?

  ☐ Learning rate too low.

  ☐ Learning rate too high.

  ☐ Poor choice of the activation function.

  ☒ All of the above.

6. Practice exercises for understanding model optimization:

▶ Package pre-loading:

[3]:
```
import pandas as pd
from keras.layers import Dense
from keras.models import Sequential
from keras.utils import to_categorical
```

▶ Data pre-loading:

[4]:
```
df = pd.read_csv('ref4. Titanic.csv')

df.replace(False, 0, inplace=True)
df.replace(True, 1, inplace=True)

predictors = df.drop(['survived'], axis=1).to_numpy()
n_cols = predictors.shape[1]
target = to_categorical(df.survived)
input_shape = (n_cols, )
```

▶ Code pre-loading:

[5]:
```
def get_new_model(input_shape=input_shape):
    model = Sequential()
    model.add(Dense(100, activation='relu', input_shape=input_shape))
    model.add(Dense(100, activation='relu'))
```

```
    model.add(Dense(2, activation='softmax'))
    return (model)
```

▶ **Changing optimization parameters practice:**

[6]:
```
# Import the SGD optimizer
from keras.optimizers import SGD

# Create list of learning rates: lr_to_test
lr_to_test = [.000001, 0.01, 1]

# Loop over learning rates
for lr in lr_to_test:
    print('\n\nTesting model with learning rate: %f\n' % lr)

    # Build new model to test, unaffected by previous models
    model = get_new_model()

    # Create SGD optimizer with specified learning rate: my_optimizer
    my_optimizer = SGD(lr=lr)

    # Compile the model
    model.compile(optimizer=my_optimizer, loss='categorical_crossentropy')

    # Fit the model
    model.fit(predictors, target)
```

```
Testing model with learning rate: 0.000001

28/28 [==============================] - 1s 25ms/step - loss: 1.1409


Testing model with learning rate: 0.010000

28/28 [==============================] - 1s 19ms/step - loss: 2.6640


Testing model with learning rate: 1.000000

28/28 [==============================] - 1s 18ms/step - loss: 996183684.8581
```