Advanced operations

Puteaux, Fall/Winter 2020-2021

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

```
§2 Introduction to TensorFlow in Python
```

```
§2.1 Introduction to TensorFlow
```

1 Advanced operations

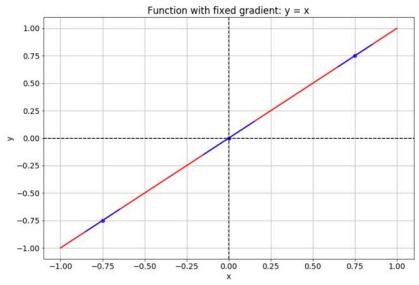
1.1 What are the advanced operations?

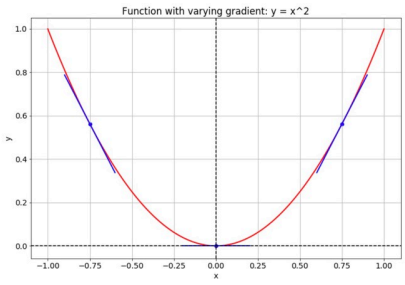
Operation	Use
`gradient()`	Computes the slope of a function at a point
`reshape()`	Reshapes a tensor (e.g. 10x10 to 100x1)
`random()`	Populates tensor with entries drawn from a probability distribution

1.2 How to find the optimum?

- In many problems, it is in need to find the optimum of a function:
  - **Minimum**: the lowest value of a loss function
  - **Maximum**: the highest value of the objective function
- It is possible to do this by using the `gradient()` operation:
  - **Optimum**: find a point where $gradient = 0$
  - **Minimum**: change in $gradient > 0$
  - **Maximum**: change in $gradient < 0$

1.3 How to calculate the gradient?





1.4 Code of gradients in TensorFlow:

[1]:
```
# Import tensorflow under the alias tf
import tensorflow as tf

# Define x
x = tf.Variable(-1.0)

x
```

[1]:
```
<tf.Variable 'Variable:0' shape=() dtype=float32, numpy=-1.0>
```

[2]:
```
# Define y within instance of GradientTape
with tf.GradientTape() as tape:
    tape.watch(x)
    y = tf.multiply(x, x)

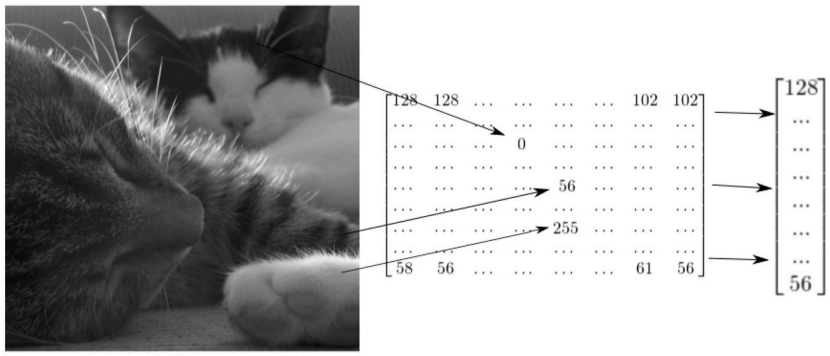
y
```

[2]:
```
<tf.Tensor: shape=(), dtype=float32, numpy=1.0>
```

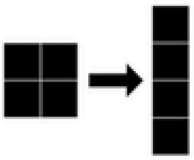
[3]:
```
# Evaluate the gradient of y at x = -1
g = tape.gradient(y, x)
print(g.numpy())
```

```
-2.0
```

1.5 How to deal with images as tensors?



1.6 How to reshape a grayscale image?



1.7 Code of reshaping a grayscale image:

[4]:
```
# Import tensorflow as alias tf
import tensorflow as tf

# Generate grayscale image
gray = tf.random.uniform([2, 2], maxval=255, dtype='int32')

gray
```

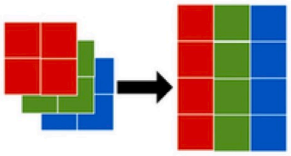
[4]:
```
<tf.Tensor: shape=(2, 2), dtype=int32, numpy=
array([[196, 216],
       [248, 250]], dtype=int32)>
```

[5]:
```
# Reshape grayscale image
gray = tf.reshape(gray, [2 * 2, 1])

gray
```

[5]:
```
<tf.Tensor: shape=(4, 1), dtype=int32, numpy=
array([[196],
       [216],
       [248],
       [250]], dtype=int32)>
```

1.8 How to reshape a color image?



1.9 Code of reshaping a color image:

[6]:
```
# Import tensorflow as alias tf
import tensorflow as tf

# Generate color image
color = tf.random.uniform([2, 2, 3], maxval=255, dtype='int32')

color
```

[6]:
```
<tf.Tensor: shape=(2, 2, 3), dtype=int32, numpy=
array([[[100,   9,  78],
        [ 74, 227, 203]],

       [[229,  18, 178],
        [182, 210, 221]]], dtype=int32)>
```

[7]:
```
# Reshape color image
color = tf.reshape(color, [2 * 2, 3])

color
```

[7]:
```
<tf.Tensor: shape=(4, 3), dtype=int32, numpy=
array([[100,   9,  78],
       [ 74, 227, 203],
       [229,  18, 178],
       [182, 210, 221]], dtype=int32)>
```

1.10 Practice exercises for advanced operations:

► **Diagram of images for reshaping:**

► **Package pre-loading:**

[8]:
```
import numpy as np
from tensorflow import reshape
```

▶ **Data pre-loading:**

[9]:
```
gray_tensor = np.loadtxt("ref11. Gray tensor.csv", delimiter=',')

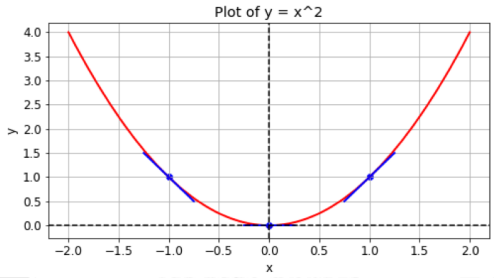
color_tensor = np.loadtxt("ref12. Color tensor.csv", delimiter=',')
color_tensor = color_tensor.reshape(color_tensor.shape[0],
                                    color_tensor.shape[1] // 3, 3)
```

▶ **Tensor reshaping practice:**

[10]:
```
# Reshape the grayscale image tensor into a vector
gray_vector = reshape(gray_tensor, (-1, 1))

# Reshape the color image tensor into a vector
color_vector = reshape(color_tensor, (-1, 1))
```

▶ **Diagram of gradient descent:**



▶ **Package re-pre-loading:**

[11]:
```
from tensorflow import Variable, GradientTape, multiply
```

▶ **Gradients optimization practice:**

[12]:
```
def compute_gradient(x0):
    # Define x as a variable with an initial value of x0
    x = Variable(x0)
    with GradientTape() as tape:
        tape.watch(x)
        # Define y using the multiply operation
        y = multiply(x, x)
    # Return the gradient of y with respect to x
    return tape.gradient(y, x).numpy()


# Compute and print gradients at x = -1, 1, and 0
```

```
print(compute_gradient(-1.0))
print(compute_gradient(1.0))
print(compute_gradient(0.0))
```

```
-2.0
2.0
0.0
```

▶ Package re-pre-loading:

[13]:
```
from tensorflow import matmul, reduce_sum
```

▶ Data re-pre-loading:

[14]:
```
letter = np.array([[1., 0., 1.], [1., 1., 0.], [1., 0., 1.]])

model = np.array([[1., 0., -1.]])
```

▶ Image data working practice:

[15]:
```
# Reshape model from a 1x3 to a 3x1 tensor
model = reshape(model, (3, 1))

# Multiply letter by model
output = matmul(letter, model)

# Sum over output and print prediction using the numpy method
prediction = reduce_sum(output)
print(prediction.numpy())
```

```
1.0
```