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PDL Lab2: Designing Logic Gates

Part-I: Design OR gate using the concept of Perceptron

```
In [2]: import numpy as np
import math
```

```
In [3]: def sigmoid(x):
        s=1/(1+math.exp(-x))
        return s
```

```
In [4]: def logic_gate(w1,w2,b):
        return lambda x1,x2: sigmoid(w1*x1+w2*x2+b)
```

```
In [5]: def test(gate):
        for a,b in (0,0),(0,1),(1,0),(1,1):
            print("{}:{},{}: {}".format(a,b,np.round(gate(a,b))))
```

```
In [6]: or_gate = logic_gate(20, 20, -10)
test(or_gate)
```

```
0,0: 0.0
0,1: 1.0
1,0: 1.0
1,1: 1.0
```

Part-II: Implement the operations of AND, NOR and NAND

```
In [7]: and_gate = logic_gate(10, 10, -10)
        test(and_gate)
```

```
0,0: 0.0
0,1: 0.0
1,0: 0.0
1,1: 1.0
```

```
In [8]: nor_gate = logic_gate(-20, -20, 10)
        test(nor_gate)
```

```
0,0: 1.0
0,1: 0.0
1,0: 0.0
1,1: 0.0
```

```
In [9]: nand_gate = logic_gate(-1, -1, 2)
        test(nand_gate)
```

```
0,0: 1.0
0,1: 1.0
1,0: 1.0
1,1: 0.0
```

Part-III: Limitations of single neuron for XOR operation

```
In [10]: def xor_gate(a,b):
          c=or_gate(a,b)
          d=nand_gate(a,b)
          return and_gate(c,d)
          test(xor_gate)
```

```
0,0: 0.0
0,1: 1.0
1,0: 1.0
1,1: 1.0
```

```
In [11]: def logic_gate(w1, w2, b):
          return lambda x1, x2: sigmoid(w1 * x1 + w2 * x2 + b)
def final(gate):
    for a, b in zip(result1, result2):
        print("{} , {}: {}".format(a, b, np.round(gate(a, b))))
result1 = []
result2 = []
or_gate = logic_gate(20,20,-10)
for a, b in (0, 0), (0, 1), (1, 0), (1, 1):
    result1.append(np.round(or_gate(a,b)))
nand_gate = logic_gate(-23,-25,35)
for a, b in (0, 0), (0, 1), (1, 0), (1, 1):
    result2.append(np.round(nand_gate(a,b)))
xor_gate = logic_gate(20,20,-30)
print("XOR Gate truth table \n")
print("X, Y X+Y")
final(xor_gate)
```

XOR Gate truth table

```
X, Y X+Y
0.0, 1.0: 0.0
1.0, 1.0: 1.0
1.0, 1.0: 1.0
1.0, 0.0: 0.0
```

Part-IV: Logic Gates using Keras library

```
In [12]: pip install tensorflow==2.13.0 tensorflow-intel==2.13.0
```

```
Requirement already satisfied: tensorflow==2.13.0 in c:\users\sweth\downloads\nlp\lib\site-packages (2.13.0)
Requirement already satisfied: tensorflow-intel==2.13.0 in c:\users\sweth\downloads\nlp\lib\site-packages (2.13.0)
Requirement already satisfied: keras<2.14,>=2.13.1 in c:\users\sweth\downloads\nlp\lib\site-packages (from tensorflow-intel==2.13.0) (2.13.1)
Requirement already satisfied: termcolor>=1.1.0 in c:\users\sweth\downloads\nlp\lib\site-packages (from tensorflow-intel==2.13.0) (2.3.0)
Requirement already satisfied: wrapt>=1.11.0 in c:\users\sweth\downloads\nlp\lib\site-packages (from tensorflow-intel==2.13.0) (1.14.1)
Requirement already satisfied: packaging in c:\users\sweth\downloads\nlp\lib\site-packages (from tensorflow-intel==2.13.0) (21.3)
Requirement already satisfied: google-pasta>=0.1.1 in c:\users\sweth\downloads\nlp\lib\site-packages (from tensorflow-intel==2.13.0) (0.2.0)
Requirement already satisfied: libclang>=13.0.0 in c:\users\sweth\downloads\nlp\lib\site-packages (from tensorflow-intel==2.13.0) (16.0.0)
Requirement already satisfied: tensorflow-io-gcs-filesystem>=0.23.1 in c:\users\sweth\downloads\nlp\lib\site-packages (from tensorflow-intel==2.13.0) (0.31.0)
Requirement already satisfied: gast<=0.4.0,>=0.2.1 in c:\users\sweth\downloads\nlp\lib\site-packages (from tensorflow-intel==2.13.0) (0.4.0)
```

```
In [13]: !pip install keras
```

```
Requirement already satisfied: keras in c:\users\sweth\downloads\nlp\lib\site-packages (2.13.1)
```

```
In [14]: import tensorflow as tf
```

```
In [15]: #AND gate
# the four different states of the AND gate
training_data = np.array([[0,0],[0,1],[1,0],[1,1]], "float32")
# the four expected results in the same order
target_data = np.array([[0],[0],[0],[1]], "float32")
model = tf.keras.Sequential()
model.add(tf.keras.layers.Dense(16, input_dim=2, activation='relu'))
model.add(tf.keras.layers.Dense(1, activation='sigmoid'))
model.compile(loss='mean_squared_error',
optimizer='adam',
metrics=['binary_accuracy'])
model.fit(training_data, target_data, epochs=100, verbose=2)
print(model.predict(training_data).round())
```

```
Epoch 1/100
1/1 - 1s - loss: 0.2469 - binary_accuracy: 0.5000 - 928ms/epoch - 928ms/step
Epoch 2/100
1/1 - 0s - loss: 0.2462 - binary_accuracy: 0.5000 - 3ms/epoch - 3ms/step
Epoch 3/100
1/1 - 0s - loss: 0.2455 - binary_accuracy: 0.5000 - 0s/epoch - 0s/step
Epoch 4/100
1/1 - 0s - loss: 0.2447 - binary_accuracy: 0.5000 - 7ms/epoch - 7ms/step
Epoch 5/100
1/1 - 0s - loss: 0.2440 - binary_accuracy: 0.5000 - 7ms/epoch - 7ms/step
Epoch 6/100
1/1 - 0s - loss: 0.2432 - binary_accuracy: 0.5000 - 15ms/epoch - 15ms/step
Epoch 7/100
1/1 - 0s - loss: 0.2425 - binary_accuracy: 0.5000 - 0s/epoch - 0s/step
Epoch 8/100
1/1 - 0s - loss: 0.2418 - binary_accuracy: 0.5000 - 8ms/epoch - 8ms/step
Epoch 9/100
1/1 - 0s - loss: 0.2410 - binary_accuracy: 0.5000 - 7ms/epoch - 7ms/step
Epoch 10/100
```

```
In [16]: #OR gate
# the four different states of the OR gate
training_data = np.array([[0,0],[0,1],[1,0],[1,1]], "float32")
# the four expected results in the same order
target_data = np.array([[0],[1],[1],[1]], "float32")
model = tf.keras.Sequential()
model.add(tf.keras.layers.Dense(16, input_dim=2, activation='relu'))
model.add(tf.keras.layers.Dense(1, activation='sigmoid'))
model.compile(loss='mean_squared_error',
optimizer='adam',
metrics=['binary_accuracy'])
model.fit(training_data, target_data, epochs=100, verbose=2)
print(model.predict(training_data).round())
```

```
Epoch 1/100
1/1 - 1s - loss: 0.2858 - binary_accuracy: 0.2500 - 800ms/epoch - 800ms/step
Epoch 2/100
1/1 - 0s - loss: 0.2843 - binary_accuracy: 0.0000e+00 - 20ms/epoch - 20ms/step
Epoch 3/100
1/1 - 0s - loss: 0.2827 - binary_accuracy: 0.0000e+00 - 11ms/epoch - 11ms/step
Epoch 4/100
1/1 - 0s - loss: 0.2812 - binary_accuracy: 0.0000e+00 - 9ms/epoch - 9ms/step
Epoch 5/100
1/1 - 0s - loss: 0.2797 - binary_accuracy: 0.0000e+00 - 5ms/epoch - 5ms/step
Epoch 6/100
1/1 - 0s - loss: 0.2783 - binary_accuracy: 0.0000e+00 - 7ms/epoch - 7ms/step
Epoch 7/100
1/1 - 0s - loss: 0.2768 - binary_accuracy: 0.0000e+00 - 3ms/epoch - 3ms/step
Epoch 8/100
1/1 - 0s - loss: 0.2753 - binary_accuracy: 0.0000e+00 - 17ms/epoch - 17ms/step
Epoch 9/100
1/1 - 0s - loss: 0.2738 - binary_accuracy: 0.0000e+00 - 11ms/epoch - 11ms/step
Epoch 10/100
1/1 - 0s - loss: 0.2724 - binary_accuracy: 0.0000e+00 - 10ms/epoch - 10ms/step
```

```
In [17]: #NOT gate
# the four different states of the NOT gate
training_data = np.array([[0],[1]], "float32")
# the four expected results in the same order
target_data = np.array([[1],[0]], "float32")
model = tf.keras.Sequential()
model.add(tf.keras.layers.Dense(16, input_dim=1, activation='relu'))
model.add(tf.keras.layers.Dense(1, activation='sigmoid'))
model.compile(loss='mean_squared_error',
optimizer='adam',
metrics=['binary_accuracy'])
model.fit(training_data, target_data, epochs=100, verbose=2)
print(model.predict(training_data).round())
```

```
Epoch 1/100
1/1 - 1s - loss: 0.3034 - binary_accuracy: 0.0000e+00 - 786ms/epoch - 786ms/step
Epoch 2/100
1/1 - 0s - loss: 0.3024 - binary_accuracy: 0.0000e+00 - 14ms/epoch - 14ms/step
Epoch 3/100
1/1 - 0s - loss: 0.3015 - binary_accuracy: 0.0000e+00 - 12ms/epoch - 12ms/step
Epoch 4/100
1/1 - 0s - loss: 0.3005 - binary_accuracy: 0.0000e+00 - 12ms/epoch - 12ms/step
Epoch 5/100
1/1 - 0s - loss: 0.2995 - binary_accuracy: 0.0000e+00 - 7ms/epoch - 7ms/step
Epoch 6/100
1/1 - 0s - loss: 0.2986 - binary_accuracy: 0.0000e+00 - 4ms/epoch - 4ms/step
Epoch 7/100
1/1 - 0s - loss: 0.2977 - binary_accuracy: 0.0000e+00 - 8ms/epoch - 8ms/step
Epoch 8/100
1/1 - 0s - loss: 0.2967 - binary_accuracy: 0.0000e+00 - 9ms/epoch - 9ms/step
Epoch 9/100
1/1 - 0s - loss: 0.2958 - binary_accuracy: 0.0000e+00 - 8ms/epoch - 8ms/step
Epoch 10/100
1/1 - 0s - loss: 0.2949 - binary_accuracy: 0.0000e+00 - 10ms/epoch - 10ms/step
```

```
In [18]: #NAND gate
# the four different states of the NAND gate
training_data = np.array([[0,0],[0,1],[1,0],[1,1]], "float32")
# the four expected results in the same order
target_data = np.array([[1],[1],[1],[0]], "float32")
model = tf.keras.Sequential()
model.add(tf.keras.layers.Dense(16, input_dim=2, activation='relu'))
model.add(tf.keras.layers.Dense(1, activation='sigmoid'))
model.compile(loss='mean_squared_error',
optimizer='adam',
metrics=['binary_accuracy'])
model.fit(training_data, target_data, epochs=100, verbose=2)
print(model.predict(training_data).round())
```

```
Epoch 1/100
1/1 - 1s - loss: 0.2481 - binary_accuracy: 0.5000 - 783ms/epoch - 783ms/step
Epoch 2/100
1/1 - 0s - loss: 0.2475 - binary_accuracy: 0.7500 - 12ms/epoch - 12ms/step
Epoch 3/100
1/1 - 0s - loss: 0.2469 - binary_accuracy: 0.7500 - 11ms/epoch - 11ms/step
Epoch 4/100
1/1 - 0s - loss: 0.2463 - binary_accuracy: 0.7500 - 9ms/epoch - 9ms/step
Epoch 5/100
1/1 - 0s - loss: 0.2458 - binary_accuracy: 0.7500 - 11ms/epoch - 11ms/step
Epoch 6/100
1/1 - 0s - loss: 0.2452 - binary_accuracy: 0.7500 - 1ms/epoch - 1ms/step
Epoch 7/100
1/1 - 0s - loss: 0.2446 - binary_accuracy: 0.7500 - 6ms/epoch - 6ms/step
Epoch 8/100
1/1 - 0s - loss: 0.2440 - binary_accuracy: 0.7500 - 5ms/epoch - 5ms/step
Epoch 9/100
1/1 - 0s - loss: 0.2435 - binary_accuracy: 0.7500 - 9ms/epoch - 9ms/step
Epoch 10/100
1/1 - 0s - loss: 0.2430 - binary_accuracy: 0.7500 - 11ms/epoch - 11ms/step
```



```
In [19]: #NOR gate
# the four different states of the NOR gate
training_data = np.array([[0,0],[0,1],[1,0],[1,1]], "float32")
# the four expected results in the same order
target_data = np.array([[1],[0],[0],[0]], "float32")
model = tf.keras.Sequential()
model.add(tf.keras.layers.Dense(16, input_dim=2, activation='relu'))
model.add(tf.keras.layers.Dense(1, activation='sigmoid'))
model.compile(loss='mean_squared_error',
optimizer='adam',
metrics=['binary_accuracy'])
model.fit(training_data, target_data, epochs=100, verbose=2)
print(model.predict(training_data).round())
```

```
Epoch 1/100
1/1 - 1s - loss: 0.2945 - binary_accuracy: 0.0000e+00 - 777ms/epoch - 777ms/step
Epoch 2/100
1/1 - 0s - loss: 0.2930 - binary_accuracy: 0.0000e+00 - 9ms/epoch - 9ms/step
Epoch 3/100
1/1 - 0s - loss: 0.2914 - binary_accuracy: 0.0000e+00 - 8ms/epoch - 8ms/step
Epoch 4/100
1/1 - 0s - loss: 0.2899 - binary_accuracy: 0.0000e+00 - 5ms/epoch - 5ms/step
Epoch 5/100
1/1 - 0s - loss: 0.2883 - binary_accuracy: 0.0000e+00 - 8ms/epoch - 8ms/step
Epoch 6/100
1/1 - 0s - loss: 0.2867 - binary_accuracy: 0.0000e+00 - 10ms/epoch - 10ms/step
Epoch 7/100
1/1 - 0s - loss: 0.2852 - binary_accuracy: 0.0000e+00 - 4ms/epoch - 4ms/step
Epoch 8/100
1/1 - 0s - loss: 0.2836 - binary_accuracy: 0.0000e+00 - 4ms/epoch - 4ms/step
Epoch 9/100
1/1 - 0s - loss: 0.2821 - binary_accuracy: 0.0000e+00 - 4ms/epoch - 4ms/step
Epoch 10/100
1/1 - 0s - loss: 0.2806 - binary_accuracy: 0.0000e+00 - 4ms/epoch - 4ms/step
```

```
In [20]: #XOR gate
# the four different states of the XOR gate
training_data = np.array([[0,0],[0,1],[1,0],[1,1]], "float32")
# the four expected results in the same order
target_data = np.array([[0],[1],[1],[0]], "float32")
model = tf.keras.Sequential()
model.add(tf.keras.layers.Dense(16, input_dim=2, activation='relu'))
model.add(tf.keras.layers.Dense(1, activation='sigmoid'))
model.compile(loss='mean_squared_error',
optimizer='adam',
metrics=['binary_accuracy'])
model.fit(training_data, target_data, epochs=100, verbose=2)
print(model.predict(training_data).round())
```

```
Epoch 1/100
1/1 - 1s - loss: 0.2425 - binary_accuracy: 0.7500 - 785ms/epoch - 785ms/step
Epoch 2/100
1/1 - 0s - loss: 0.2421 - binary_accuracy: 0.5000 - 5ms/epoch - 5ms/step
Epoch 3/100
1/1 - 0s - loss: 0.2418 - binary_accuracy: 0.7500 - 7ms/epoch - 7ms/step
Epoch 4/100
1/1 - 0s - loss: 0.2414 - binary_accuracy: 0.7500 - 6ms/epoch - 6ms/step
Epoch 5/100
1/1 - 0s - loss: 0.2410 - binary_accuracy: 0.7500 - 12ms/epoch - 12ms/step
Epoch 6/100
1/1 - 0s - loss: 0.2406 - binary_accuracy: 0.7500 - 6ms/epoch - 6ms/step
Epoch 7/100
1/1 - 0s - loss: 0.2403 - binary_accuracy: 0.7500 - 7ms/epoch - 7ms/step
Epoch 8/100
1/1 - 0s - loss: 0.2399 - binary_accuracy: 0.7500 - 12ms/epoch - 12ms/step
Epoch 9/100
1/1 - 0s - loss: 0.2395 - binary_accuracy: 0.7500 - 7ms/epoch - 7ms/step
Epoch 10/100
```