Homework 02

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CSCI-347

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Show your work. Include any code snippets you used to generate an answer, using comments in the code to clearly indicate which problem corresponds to which code

```
import numpy as np
import matplotlib.pyplot as plt
import math

data    = np.chararray((7, 3), itemsize=6)

data[0] = np.array(['red',    'yes',  'north'])
data[1] = np.array(['blue',   'no',   'south'])
data[2] = np.array(['yellow', 'no',   'east'])
data[3] = np.array(['yellow', 'no',   'west'])
data[4] = np.array(['red',    'yes',  'north'])
data[5] = np.array(['yellow', 'yes',  'north'])
data[6] = np.array(['blue',   'no',   'west'])

data
```

```
    chararray([[b'red', b'yes', b'north'],
               [b'blue', b'no', b'south'],
               [b'yellow', b'no', b'east'],
               [b'yellow', b'no', b'west'],
               [b'red', b'yes', b'north'],
               [b'yellow', b'yes', b'north'],
               [b'blue', b'no', b'west']], dtype='|S6')
```

Question 1

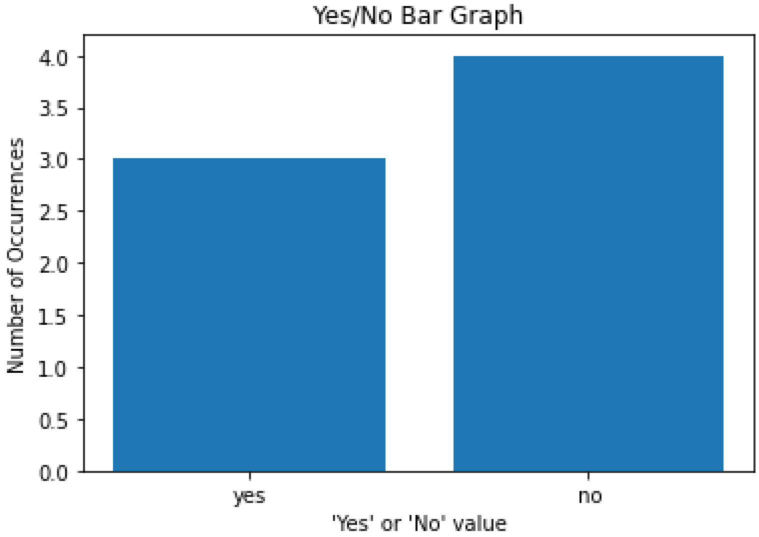
Use matplotlib to create a bar plot for the counts of the variable X2 . Make sure to label the axis.

```
target = data
np.unique(target)
target_x2 = target[:,1]
```

```
counts = [sum(target_x2==b'yes'), sum(target_x2==b'no')]
target_names = ['yes' ,' no']

plt.bar(target_names, counts)
plt.ylabel('Number of Occurrences')
plt.xlabel("'Yes' or 'No' value")
plt.title('Yes/No Bar Graph')
```

```
Text(0.5, 1.0, 'Yes/No Bar Graph')
```



2. (2 points)

Use one-hot encoding to transform all the categorical attributes to numerical values.

Write down the transformed data matrix. (In what follows, we will referred to the transformed data matrix as Y).

```
oneHotData = np.ndarray((7, 9))

for row in range(data.shape[0]):
    row_array = data[row,:]
    color       = row_array[0]
    yes_no      = row_array[1]
    direction   = row_array[2]
    # empty row for encoded data
    hot_data_row = np.array([0] * 9)
    # encode color
    if color == b'red': hot_data_row[0] = 1
    elif color == b'blue': hot_data_row[1] = 1
    elif color == b'yellow': hot_data_row[2] = 1
    # encode yes/no
    if yes_no == b'yes': hot_data_row[3] = 1
    else: hot_data_row[4] = 1
    # encode direction (north, south, east, and west)
    # encode direction (north, south, east, and west)
    if   direction == b'north': hot_data_row[5] = 1
    elif direction == b'south': hot_data_row[6] = 1
    elif direction == b'east': hot_data_row[7] = 1
    elif direction == b'west': hot_data_row[8] = 1
    # set row values on encoded matrix
    oneHotData[row] = hot_data_row

# print one-hot encoded matrix
oneHotData
```

```
array([[1., 0., 0., 1., 0., 1., 0., 0., 0.],
       [0., 1., 0., 0., 1., 0., 1., 0., 0.],
       [0., 0., 1., 0., 1., 0., 0., 1., 0.],
       [0., 0., 1., 0., 1., 0., 0., 0., 1.],
       [1., 0., 0., 1., 0., 1., 0., 0., 0.],
       [0., 0., 1., 1., 0., 1., 0., 0., 0.],
       [0., 1., 0., 0., 1., 0., 0., 0., 1.]])
```

Question 3

What is the Euclidean distance between instance x 2 (second row) and x 7 (seventh row) after applying one-hot encoding.

```
def euclideanDistance(m, row1Num, row2Num):
    x1 = m[row1Num,:]
    x2 = m[row2Num,:]
    answer = 0
    for i in range(m.shape[1]):
        answer += (x1[i] - x2[i]) ** 2
    return math.sqrt(answer)

print("Euclidean Distance (x2 and x7): ", euclideanDistance(oneHotData, 1, 6))
```

```
Euclidean Distance (x2 and x7):  1.4142135623730951
```

Question 4

What is the cosine similarity (cosine of the angle) between data instance x 2 and data instance x 7 after applying one-hot encoding?

```
def cosineOfRows(m, row1Num, row2Num):
    x1 = m[row1Num,:]
    x2 = m[row2Num,:]
    top = 0
    bottom_left = 0
    bottom_right = 0
    bottom_right = 0
    for i in range(m.shape[1]):
        top += x1[i] * x2[i]
        bottom_left += x1[i] ** 2
        bottom_right += x2[i] ** 2
    return top / (math.sqrt(bottom_left) * math.sqrt(bottom_right))

print("Cosine x2 and x7: ", cosineOfRows(oneHotData, 1, 6))
```

```
Cosine x2 and x7:  0.6666666666666667
```

Question 5

What is the Hamming distance between data instance x2 and data instance x7 after applying one-hot encoding?

```
def hammingDistance(m, row1Num, row2Num):
    x1 = m[row1Num,:]
    x2 = m[row2Num,:]
    sum = 0
    for i in range(m.shape[1]):
        if (x1[i] == 1 and x2[i] == 0) or (x1[i] == 0 and x2[i] == 1):
            sum += 1
    return sum

print("Hamming Distance (XOR) of x2 and x7: ", hammingDistance(oneHotData, 1, 6))
```

```
Hamming Distance (XOR) of x2 and x7:  2
```

Question 6

What is the Jaccard similarity between data instance x 2 and x 7 after applying one-hot encoding?

```
def jaccardSimilarity(m, row1Num, row2Num):
    x1 = m[row1Num,:]
    x2 = m[row2Num,:]
    top = 0
    bottom = 0
    for i in range(m.shape[1]):
        # top
        if (x1[i] == x2[i]): top += 1
        # bottom
        if (x1[i] != x2[i]): bottom += 1
    return (top / bottom)

jaccardSimilarity(oneHotData, 1, 6)
jaccardSimilarity(oneHotData, 1, 6)
```

```
3.5
```

Question 7

What is the multi-dimensional mean of `Y`?

```
def multiDimensionalMean(m):
    mean_data = [0] * m.shape[1]
    for row in range(m.shape[0]):
        for col in range(m.shape[1]):
            mean_data[col] += m[row, col]
    for col in range(len(mean_data)):
        mean_data[col] = mean_data[col] / m.shape[0]
    return mean_data

multiDimensionalMean(oneHotData)
```

```
[0.2857142857142857,
 0.2857142857142857,
 0.42857142857142855,
 0.42857142857142855,
 0.5714285714285714,
 0.42857142857142855,
 0.14285714285714285,
 0.14285714285714285,
 0.2857142857142857]
```

Question 8

What is the estimated variance of the first column of Y ?

```
def coVariance(m, col1Num, col2Num):
    col1 = m[:,col1Num]
    col2 = m[:,col2Num]
    answer = 0
    for i in range(m.shape[0]):
        answer += (col1[i] - col1.mean()) * (col2[i] - col2.mean())
    return answer / (m.shape[0] - 1)

print("Estimated variance of the first column of Y: {!s}".format(coVariance(oneHotDat
```

```
Estimated variance of the first column of Y: 0.23809523809523814
```

```
# We can double check this by:
print('Double check with np built in function: {!s}'.format(np.var(oneHotData[:,0], d
Double check with np built in function: 0.23809523809523814
```

Question 9

What is the resulting matrix after applying standard (z-score) normalization to the matrix `Y`. In the following, we will call this matrix `Z`.

```
def zScore(m):
    z_score = np.ndarray(m.shape)
    for row in range(z_score.shape[0]):
        for col in range(z_score.shape[1]):
            z_score[row, col] = 0
            x_ij = m[row, col]
            mean = m[:,col].mean()
            div = math.sqrt(coVariance(m, col, col))
            z_score[row, col] = (x_ij - mean) / div
    return z_score

zScore(oneHotData)
```

```
array([[ 1.46385011, -0.58554004, -0.80178373,  1.06904497, -1.06904497,
         1.06904497, -0.37796447, -0.37796447, -0.58554004],
       [-0.58554004,  1.46385011, -0.80178373, -0.80178373,  0.80178373,
        -0.80178373,  2.26778684, -0.37796447, -0.58554004],
       [-0.58554004, -0.58554004,  1.06904497, -0.80178373,  0.80178373,
        -0.80178373, -0.37796447,  2.26778684, -0.58554004],
       [-0.58554004, -0.58554004,  1.06904497, -0.80178373,  0.80178373,
        -0.80178373, -0.37796447, -0.37796447,  1.46385011],
       [ 1.46385011, -0.58554004, -0.80178373,  1.06904497, -1.06904497,
         1.06904497, -0.37796447, -0.37796447, -0.58554004],
       [-0.58554004, -0.58554004,  1.06904497,  1.06904497, -1.06904497,
         1.06904497, -0.37796447, -0.37796447, -0.58554004],
       [-0.58554004,  1.46385011, -0.80178373, -0.80178373,  0.80178373,
        -0.80178373, -0.37796447, -0.37796447,  1.46385011]])
```

Question 10

What is the multi-dimensional mean of `Z`?

```
multiDimensionalMean(zScore(oneHotData))
```

```
[0.0,
 6.344131569286608e-17,
 0.0,
 1.586032892321652e-17,
 1.1102230246251565e-16.
```

```
      1.586032892321652e-17,
      4.7580986769649563e-17,
      4.7580986769649563e-17,
      3.172065784643304e-17]
```

Question 11

Let z i be the i-th row of Z. What is Euclidean distance between `z2` and `z7`?

```
euclideanDistance(zScore(oneHotData), 1, 6)
```

```
    3.3466401061363023
```