

CSC487: Data Mining - Midterm

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1. Suppose you have these data points: 29, 75, 13, 20, 168, 163, 140, 52, 4, 37, 36, 123, 120, 31, 111. (35 points total)

Let us first load in the data...

```
nums = [29, 75, 13, 20, 168, 163, 140, 52, 4, 37, 36, 123, 120, 31, 111]
nums = sorted(nums)
df1 = pd.DataFrame()
df1['nums'] = nums
df1['nums']
```

```
## 0      4
## 1     13
## 2     20
## 3     29
## 4     31
## 5     36
## 6     37
## 7     52
## 8     75
## 9    111
## 10   120
## 11   123
## 12   140
## 13   163
## 14   168
## Name: nums, dtype: int64
```

a.) If you draw a histogram with a bin size of 25, how many bars will you have in your chart? Please justify your answer. (7 points)

```
# find range.
r = (df1['nums'].max() - df1['nums'].min())
r
```

```
## 164
```

```
# min bin lower bound.
min_bins = r / 25
min_bins
```

```
## 6.56
```

As 6.56 bins are needed to span the whole range of the data, we need 7 bins in total.

b. What's the value at the 60th percentile. (7 points)

```
# 60th percentile.
df1.quantile(0.6)
```

```
## nums      89.4
## Name: 0.6, dtype: float64
```

We can see that the 60th percentile cutoff is 89.4 .

c. Use z-score normalization to transform the value 36. (7 points)

```
# Create z score scaling function.
def z_score_scaler(val):
    return (val - df1['nums'].mean()) / df1['nums'].std()

# Scale 36.
z_score_scaler(36)
```

```
## -0.6791180070064667
```

We can see that z-score normalization transforms the value 36 -0.679 .

d. Use min-max normalization to transform the value 13 onto the range [1, 10]. (7 points)

```
# Create min max scaling function.
def min_max_scaler(val):
    r = df1['nums'].max() - df1['nums'].min()
    return (val - df1['nums'].min()) / r

# Scale 36.
min_max_scaler(36)
```

```
## 0.1951219512195122
```

We can see that min-max normalization transforms the value 36 [0.1959](#) .

e. Suppose you have a bin depth 3 and use smoothing by bin median to smooth the first bin. (7 points)

```
# length of data.
l = df1.size
l

## 15

# cut idx.
q = int(l/3)
q

## 5

# binning & averaging.
df1['3bin_median'] = 0
df1['3bin_median'].iloc[0:q] = df1['nums'].iloc[0:q].median()
df1['3bin_median'].iloc[q:2*q] = df1['nums'].iloc[q:2*q].median()
df1['3bin_median'].iloc[2*q:l] = df1['nums'].iloc[2*q:l].median()

df1
```

```
##      nums  3bin_median
## 0      4           20
## 1     13           20
## 2     20           20
## 3     29           20
## 4     31           20
```

```
## 5      36      52
## 6      37      52
## 7      52      52
## 8      75      52
## 9     111      52
## 10     120     140
## 11     123     140
## 12     140     140
## 13     163     140
## 14     168     140
```

```
df1.iloc[0:q]
```

```
##      nums  3bin_median
## 0       4           20
## 1      13           20
## 2      20           20
## 3      29           20
## 4      31           20
```

We can see that with depth 3 the first bin's median is [20](#) .

2. Compute the distance between objects 3 and 4 in the table below. (15 points)

```
# Build the dataframe.
table1 = {
    "Object": [1,2,3,4],
    "test-1 (nominal)" : ["A","B","A","A"],
    "test-2 (ordinal)" : ["excellent","fair","good","excellent"],
}

df2 = pd.DataFrame(table1)

# Set the index.
df2.set_index("Object",inplace=True)
df2

##          test-1 (nominal) test-2 (ordinal)
## Object
## 1                A          excellent
## 2                B              fair
## 3                A              good
## 4                A          excellent

# Replace nominal values.
df2["test-1 (nominal)"].replace("A",3,inplace=True)
df2["test-1 (nominal)"].replace("B",2,inplace=True)

t1_range = (df2["test-1 (nominal)"].max()-df2["test-1 (nominal)"].min())
df2["test-1 (nominal)"] = (df2["test-1 (nominal)"]-1)/t1_range
df2

##          test-1 (nominal) test-2 (ordinal)
## Object
## 1                2.0          excellent
## 2                1.0              fair
## 3                2.0              good
## 4                2.0          excellent

# Replace ordinal values.
df2["test-2 (ordinal)"].replace("excellent",3,inplace=True)
df2["test-2 (ordinal)"].replace("good",2,inplace=True)
df2["test-2 (ordinal)"].replace("fair",1,inplace=True)

t2_range = (df2["test-2 (ordinal)"].max()-df2["test-2 (ordinal)"].min())
df2["test-2 (ordinal)"] = (df2["test-2 (ordinal)"]-1)/t2_range
df2
```

```
##          test-1 (nominal)  test-2 (ordinal)
## Object
## 1          2.0          1.0
## 2          1.0          0.0
## 3          2.0          0.5
## 4          2.0          1.0
```

Define our distance function.

```
def dist(i,j, df):
    neum = 0
    denom = 0
    for col in df.columns:
        print(col)
        if 'nominal' in col:
            if df[col].iloc[j-1] != df[col].iloc[i-1]:
                dist = 1
            else:
                dist = 0
        else:
            dist = np.abs(df[col].iloc[j-1] - df[col].iloc[i-1])
        print('feature distance:',dist)
        neum += dist
        denom += 1
    print()
    print('numerator:',neum)
    print('denominator:',denom)
    print('\ntotal distance:',neum/denom)
    return neum/denom
```

```
# Compute the distance between object 1 & 3  
d_1_3 = dist(3,4, df2)
```

```
## test-1 (nominal)  
## feature distance: 0  
##  
## test-2 (ordinal)  
## feature distance: 0.5  
##  
## numerator: 0.5  
## denominator: 2  
##  
## total distance: 0.25
```

We can see that the distance between objects 3 and 4 is [0.25](#) .

3. Use chi-square for the data below to find out whether there's a relation between playing basketball and eating cereal. Based on your result describe the relation (15 points)

```
# Build the dataframe.
```

```
table2 = {
  "idx": ["Cereal", "Not cereal", "Sum(col.)"],
  "Basketball" : [213, 138, 351],
  "Not basketball" : [203, 110, 313],
  "Sum (row)" : [416, 248, 664],
}
```

```
df3 = pd.DataFrame(table2)
```

```
# Set the index.
```

```
df3.set_index("idx", inplace=True)
df3
```

```
##           Basketball  Not basketball  Sum (row)
## idx
## Cereal             213             203         416
## Not cereal         138             110         248
## Sum(col.)          351             313         664
```

```
# Create an expectation dataframe as a copy of the original.
```

```
expectation_df3 = df3.copy()
expectation_df3
```

```
##           Basketball  Not basketball  Sum (row)
## idx
## Cereal             213             203         416
## Not cereal         138             110         248
## Sum(col.)          351             313         664
```

```
# Compute probabilities on basketball status
```

```
expectation_df3["Sum (row)"] = expectation_df3["Sum (row)"].apply(
  lambda x: x / expectation_df3["Sum (row)"].max()
)
expectation_df3
```

```
##           Basketball  Not basketball  Sum (row)
## idx
## Cereal             213             203    0.626506
## Not cereal         138             110    0.373494
## Sum(col.)          351             313    1.000000
```

```
# Compute basketball expectations.
```

```
expectation_df3["Basketball"] = (  
    expectation_df3["Basketball"].max()*expectation_df3["Sum (row)"]  
expectation_df3
```

```
##           Basketball  Not basketball  Sum (row)  
## idx  
## Cereal      219.903614           203    0.626506  
## Not cereal  131.096386           110    0.373494  
## Sum(col.)   351.000000           313    1.000000
```

```
# Compute not basketball expectations
```

```
expectation_df3["Not basketball"] = (  
    expectation_df3["Not basketball"].max()*expectation_df3["Sum (row)"]  
expectation_df3
```

```
##           Basketball  Not basketball  Sum (row)  
## idx  
## Cereal      219.903614      196.096386    0.626506  
## Not cereal  131.096386      116.903614    0.373494  
## Sum(col.)   351.000000      313.000000    1.000000
```

```
# Trim our original dataframe.
```

```
df3 = df3.iloc[:-1,:-1]  
df3
```

```
##           Basketball  Not basketball  
## idx  
## Cereal           213           203  
## Not cereal       138           110
```

```
# Trim our expectation dataframe
```

```
expectation_df3 = expectation_df3.iloc[:-1,:-1]  
expectation_df3
```

```
##           Basketball  Not basketball  
## idx  
## Cereal      219.903614      196.096386  
## Not cereal  131.096386      116.903614
```

```
# Compute passing portion of chi squared.
```

```
basketball_ = np.sum(  
    np.square(  
        (df3["Basketball"] - expectation_df3["Basketball"])  
    )/expectation_df3["Basketball"]  
    )  
basketball_
```

```
## 0.5802793153909802
```

```
# Compute failing portion of chi square.
```

```
not_basketball_ = np.sum(  
    np.square(  
        (df3["Not basketball"] - expectation_df3["Not basketball"])  
    )/expectation_df3["Not basketball"]  
    )  
not_basketball_
```

```
## 0.6507285613489868
```

```
# Sum for our chi squared value.
```

```
chi_squared_ = basketball_ + not_basketball_  
chi_squared_
```

```
## 1.231007876739967
```

A χ^2 chart will clearly show that a test statistic of 1.231 given 1 degree of freedom is not a statistically significant. Thus we settle on the null hypothesis that playing basketball and eating cereal are not correlated.

4. Using the data table below, calculate the information gain for gender and age.

```
# Build the dataframe.
```

```
table3 = {
    "gender": ["male","male","female","female",
               "male","female","female","male","female"],
    "age" : ["young","young","young","teenager",
             "young","young","elder","middle age","elder"],
    "income" : ["medium","low","low","medium",
                "high","medium","high","medium","medium"],
    "play golf?" : ["yes","no","no","no",
                    "yes","no","yes","yes","yes"],
    "count" : [30,20,30,20,15,30,13,10,4],
}
```

```
df4 = pd.DataFrame(table3)
```

```
df4
```

```
##   gender      age  income play golf?  count
## 0   male    young  medium         yes    30
## 1   male    young   low          no    20
## 2  female    young   low          no    30
## 3  female  teenager  medium         no    20
## 4   male    young   high         yes    15
## 5  female    young  medium         no    30
## 6  female    elder   high         yes    13
## 7   male  middle age  medium         yes    10
## 8  female    elder   medium         yes     4
```

```
def gainer(df, label, counts):
```

```
    # Create DataFrame for storing gain.
```

```
    gainz = pd.DataFrame(index=['entropy', 'gain'])
```

```
    # Find total observations.
```

```
    total = df[counts].sum()
```

```
    # Find total observations per label.
```

```
    sum0 = pd.DataFrame(df.groupby(by=label)[counts].apply(lambda x: x.sum()))
```

```
    # Find label probabilities.
```

```
    p_label = sum0 / total
```

```
    # Find total entropy.
```

```
    total_entrop = float((-p_label * np.log2(p_label)).sum())
```

```

# Find attribute columns.
cols = df.columns.drop(label)
cols = cols.drop(counts)

for col in cols:
    # Find total observations per bin.
    sum1 = pd.DataFrame(df.groupby(
        by=col)[counts].apply(lambda x: x.sum()))

    # Find label totals per bin.
    sum2 = pd.DataFrame(df.groupby(
        by=[col, label])[counts].apply(lambda x: x.sum()))

    # Solve for entropy per class
    p_label_class = sum2 / sum1
    H = -p_label_class * np.log2(p_label_class)

    # Solve for expected entropy per class
    entrop = pd.DataFrame(H.unstack().apply('sum', axis=1), columns=['H'])
    entrop['P[class]'] = sum1 / total
    entrop['E[H]'] = entrop['H'] * entrop['P[class]']
    entropy = entrop['E[H]'].sum()

    gain = total_entropy - entropy
    gainz[col] = [entropy, gain]

return gainz

g1 = gainer(df4, 'gender', 'count')
g1.T

```

```

##          entropy      gain
## age      0.725905  0.262261
## income   0.982178  0.005988
## play golf? 0.749801  0.238365

```

We can now see that the information gain for age when using gender as labels is [0.262](#) .