lab02

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###

Lab Session 2

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Roll Number: BL.EN.U4AIE23213 A1. Please refer to the “Purchase Data” worksheet of Lab Session Data.xlsx. Please load the data and segregate them into 2 matrices A & C (following the nomenclature of AX = C). Do the following activities. - What is the dimensionality of the vector space for this data? - How many vectors exist in this vector space? - What is the rank of Matrix A? - Using Pseudo-Inverse find the cost of each product available for sale.
(Suggestion: If you use Python, you can use numpy.linalg.pinv() function to get a pseudo-inverse.)

[32]:
```
import numpy as np
import pandas as pd
import statistics
import matplotlib.pyplot as plt
import seaborn as sns
from sklearn.preprocessing import LabelEncoder, MinMaxScaler
from sklearn.metrics.pairwise import cosine_similarity
file_path = r"C:\\Users\\Praanesh Nair\Downloads\\python-learning\\Lab Session␣
↪Data.xlsx"
xls = pd.ExcelFile(file_path)
```

[33]:
```
try:
    df = pd.read_excel(xls, sheet_name="Purchase data")
    purchase_matrix = df.iloc[:, 1:4].values
    purchase_amounts = df.iloc[:, 4].values.reshape(-1, 1)
    dimensionality = purchase_matrix.shape[1]
    num_vectors = purchase_matrix.shape[0]
    rank_A = np.linalg.matrix_rank(purchase_matrix)
    purchase_matrix_pinv = np.linalg.pinv(purchase_matrix)
    product_costs = np.dot(purchase_matrix_pinv, purchase_amounts).flatten()
    print("A1 Results:")
    print(f"Dimensionality: {dimensionality}")
    print(f"Number of Vectors: {num_vectors}")
    print(f"Rank of A: {rank_A}")
    print(f"Product Costs: {product_costs}")
```

```python
except FileNotFoundError:
    print(f"Error: File not found at {file_path}")

except ValueError:  # Catches potential Excel sheet issues
    print("Error: Could not read specified sheet from Excel file.")
```

```
A1 Results:
Dimensionality: 3
Number of Vectors: 10
Rank of A: 3
Product Costs: [ 1. 55. 18.]
```

A2. Use the Pseudo-inverse to calculate the model vector X for predicting the cost of the products available with the vendor.

[34]:
```python
print(f"Model Vector X: {product_costs}")
```

```
Model Vector X: [ 1. 55. 18.]
```

A3. Mark all customers (in "Purchase Data" table) with payments above Rs. 200 as RICH and others as POOR. Develop a classifier model to categorize customers into RICH or POOR class based on purchase behavior.

[35]:
```python
df = pd.read_excel(xls, sheet_name="Purchase data")
df["Customer Class"] = np.where(df.iloc[:, 4] > 200, "RICH", "POOR")
print("A3 Result:")
print(df[["Customer Class"]])
```

```
A3 Result:
  Customer Class
0           RICH
1           RICH
2           RICH
3           POOR
4           RICH
5           POOR
6           RICH
7           RICH
8           POOR
9           POOR
```

A4. Please refer to the data present in "IRCTC Stock Price" data sheet of the above excel file. Do the following after loading the data to your programming platform. - Calculate the mean and variance of the Price data present in column D.
(Suggestion: if you use Python, you may use statistics.mean() & statistics.variance() methods). - Select the price data for all Wednesdays and calculate the sample mean. Compare the mean with the population mean and note your observations. - Select the price data for the month of Apr and calculate the sample mean. Compare the mean with the population mean and note your

observations. - From the Chg% (available in column I) find the probability of making a loss over the stock. (Suggestion: use lambda function to find negative values) - Calculate the probability of making a profit on Wednesday. - Calculate the conditional probability of making profit, given that today is Wednesday. - Make a scatter plot of Chg% data against the day of the week

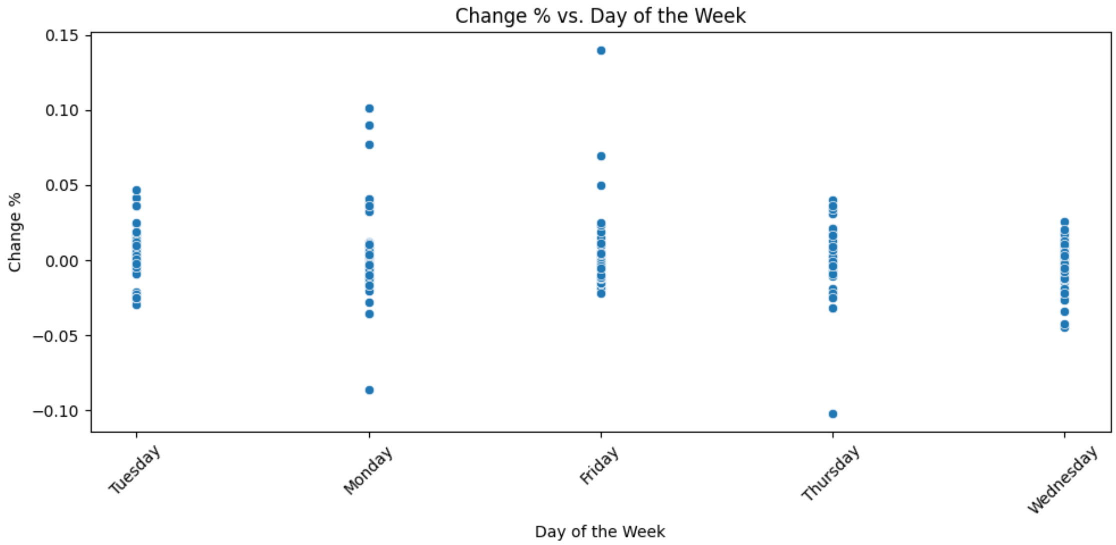
[36]:
```
df = pd.read_excel(xls, sheet_name="IRCTC Stock Price")
df["Date"] = pd.to_datetime(df["Date"])
df["Day"] = df["Date"].dt.day_name()

mean_price = statistics.mean(df["Price"])
variance_price = statistics.variance(df["Price"])
wednesday_mean = df[df["Day"] == "Wednesday"]["Price"].mean()
april_mean = df[df["Date"].dt.month == 4]["Price"].mean()
prob_loss = (df["Chg%"] < 0).mean()
prob_profit_wed = df[(df["Day"] == "Wednesday") & (df["Chg%"] > 0)]["Chg%"].
  ↪count() / df[df["Day"] == "Wednesday"]["Chg%"].count()

print("A4 Results:")
print(f"Mean Price: {mean_price}")
print(f"Variance Price: {variance_price}")
print(f"Wednesday Mean Price: {wednesday_mean}")
print(f"April Mean Price: {april_mean}")
print(f"Probability of Loss: {prob_loss}")
print(f"Probability of Profit on Wednesday: {prob_profit_wed}")

plt.figure(figsize=(10, 5))
sns.scatterplot(x=df["Day"], y=df["Chg%"])
plt.xlabel("Day of the Week")  # axis labels
plt.ylabel("Change %")
plt.xticks(rotation=45)
plt.title("Change % vs. Day of the Week")
plt.tight_layout() #  prevents labels from overlapping
plt.show()
```

```
A4 Results:
Mean Price: 1560.663453815261
Variance Price: 58732.365352539186
Wednesday Mean Price: 1550.7060000000001
April Mean Price: 1698.9526315789474
Probability of Loss: 0.4979919678714859
Probability of Profit on Wednesday: 0.42
```



A5. Data Exploration: Load the data available in "thyroid0387_UCI" worksheet. Perform the following tasks: - Study each attribute and associated values present. Identify the datatype (nominal etc.) for the attribute. - For categorical attributes, identify the encoding scheme to be employed. (Guidance: employ label encoding for ordinal variables while One-Hot encoding may be employed for nominal variables). - Study the data range for numeric variables. - Study the presence of missing values in each attribute. - Study presence of outliers in data.
- For numeric variables, calculate the mean and variance (or standard deviation).

[37]:
```
df = pd.read_excel(xls, sheet_name="thyroid0387_UCI")
df.replace('?', np.nan, inplace=True)
df = df.infer_objects()  # Ensures proper type conversion
missing_values = df.isnull().sum()

# Converts categorical columns to string for Label Encoding
categorical_cols = df.select_dtypes(include=['object']).columns
for col in categorical_cols:
    df[col] = df[col].astype(str)  # Converts to string
    df[col] = LabelEncoder().fit_transform(df[col])

print("A5 Results:")
print(df.describe())
print("Missing Values:\n", missing_values)
```

```
A5 Results:
          Record ID          age          sex  on thyroxine  \
count  9.172000e+03  9172.000000  9172.000000   9172.000000
mean   8.529473e+08    73.555822     0.371348      0.135194
std    7.581969e+06  1183.976718     0.548110      0.341949
min    8.408010e+08     1.000000     0.000000      0.000000
```

```
25%    8.504090e+08     37.000000     0.000000      0.000000
50%    8.510040e+08     55.000000     0.000000      0.000000
75%    8.607110e+08     68.000000     1.000000      0.000000
max    8.701190e+08  65526.000000     2.000000      1.000000

       query on thyroxine  on antithyroid medication         sick  \
count         9172.000000                9172.000000  9172.000000
mean             0.016681                   0.012647     0.037505
std              0.128081                   0.111752     0.190007
min              0.000000                   0.000000     0.000000
25%              0.000000                   0.000000     0.000000
50%              0.000000                   0.000000     0.000000
75%              0.000000                   0.000000     0.000000
max              1.000000                   1.000000     1.000000

          pregnant  thyroid surgery  I131 treatment  …  TT4 measured  \
count  9172.000000      9172.000000     9172.000000  …   9172.000000
mean      0.011666         0.014610        0.018426  …      0.951810
std       0.107383         0.119991        0.134492  …      0.214179
min       0.000000         0.000000        0.000000  …      0.000000
25%       0.000000         0.000000        0.000000  …      1.000000
50%       0.000000         0.000000        0.000000  …      1.000000
75%       0.000000         0.000000        0.000000  …      1.000000
max       1.000000         1.000000        1.000000  …      1.000000

               TT4  T4U measured          T4U  FTI measured          FTI  \
count  8730.000000   9172.000000  8363.000000   9172.000000  8370.000000
mean    108.700305      0.911797     0.976056      0.912560   113.640746
std      37.522670      0.283606     0.200360      0.282494    41.551650
min       2.000000      0.000000     0.170000      0.000000     1.400000
25%      87.000000      1.000000     0.860000      1.000000    93.000000
50%     104.000000      1.000000     0.960000      1.000000   109.000000
75%     126.000000      1.000000     1.065000      1.000000   128.000000
max     600.000000      1.000000     2.330000      1.000000   881.000000

       TBG measured         TBG  referral source    Condition
count   9172.000000  349.000000      9172.000000  9172.000000
mean       0.038051   29.870057         3.898495    22.474160
std        0.191329   21.080504         1.504564     5.942872
min        0.000000    0.100000         0.000000     0.000000
25%        0.000000   21.000000         3.000000    25.000000
50%        0.000000   26.000000         5.000000    25.000000
75%        0.000000   31.000000         5.000000    25.000000
max        1.000000  200.000000         5.000000    31.000000

[8 rows x 31 columns]
Missing Values:
 Record ID                      0
```

```
age                            0
sex                          307
on thyroxine                   0
query on thyroxine             0
on antithyroid medication      0
sick                           0
pregnant                       0
thyroid surgery                0
I131 treatment                 0
query hypothyroid              0
query hyperthyroid             0
lithium                        0
goitre                         0
tumor                          0
hypopituitary                  0
psych                          0
TSH measured                   0
TSH                          842
T3 measured                    0
T3                          2604
TT4 measured                   0
TT4                          442
T4U measured                   0
T4U                          809
FTI measured                   0
FTI                          802
TBG measured                   0
TBG                         8823
referral source                0
Condition                      0
dtype: int64
```

```
C:\Users\Praanesh Nair\AppData\Local\Temp\ipykernel_2876\4224358239.py:2:
FutureWarning: Downcasting behavior in `replace` is deprecated and will be
removed in a future version. To retain the old behavior, explicitly call
`result.infer_objects(copy=False)`. To opt-in to the future behavior, set
`pd.set_option('future.no_silent_downcasting', True)`
  df.replace('?', np.nan, inplace=True)
```

A6. Data Imputation: employ appropriate central tendencies to fill the missing values in the data variables. Employ following guidance. - Mean may be used when the attribute is numeric with no outliers - Median may be employed for attributes which are numeric and contain outliers - Mode may be employed for categorical attributes

[38]:
```
df = pd.read_excel(xls, sheet_name="thyroid0387_UCI")
df.replace('?', np.nan, inplace=True)
df = df.infer_objects()
```

```python
for col in df.columns:
    if df[col].dtype in ['float64', 'int64']:
        df[col] = df[col].fillna(df[col].median())
    else:
        df[col] = df[col].fillna(df[col].mode()[0])

print("A6 Results:")
print(df)
```

```
A6 Results:
      Record ID  age sex on thyroxine query on thyroxine  \
0     840801013   29   F            f                  f
1     840801014   29   F            f                  f
2     840801042   41   F            f                  f
3     840803046   36   F            f                  f
4     840803047   32   F            f                  f
…           …   …  ..           …                …
9167  870119022   56   M            f                  f
9168  870119023   22   M            f                  f
9169  870119025   69   M            f                  f
9170  870119027   47   F            f                  f
9171  870119035   31   M            f                  f

     on antithyroid medication sick pregnant thyroid surgery I131 treatment  \
0                           f    f        f               f              f
1                           f    f        f               f              f
2                           f    f        f               f              f
3                           f    f        f               f              f
4                           f    f        f               f              f
…                         …   …      …             …             …
9167                        f    f        f               f              f
9168                        f    f        f               f              f
9169                        f    f        f               f              f
9170                        f    f        f               f              f
9171                        f    f        f               f              f

      … TT4 measured    TT4 T4U measured   T4U FTI measured    FTI  \
0     …            f  104.0            f  0.96            f  109.0
1     …            t  128.0            f  0.96            f  109.0
2     …            f  104.0            f  0.96            f  109.0
3     …            f  104.0            f  0.96            f  109.0
4     …            f  104.0            f  0.96            f  109.0
…   …          …    …          …    …          …     …
9167  …            t   64.0            t  0.83            t   77.0
9168  …            t   91.0            t  0.92            t   99.0
9169  …            t  113.0            t  1.27            t   89.0
9170  …            t   75.0            t  0.85            t   88.0
9171  …            t   66.0            t  1.02            t   65.0
```

```
     TBG measured   TBG  referral source     Condition
0               f  26.0            other  NO CONDITION
1               f  26.0            other  NO CONDITION
2               t  11.0            other  NO CONDITION
3               t  26.0            other  NO CONDITION
4               t  36.0            other             S
…             …     …               …              …
9167            f  26.0              SVI  NO CONDITION
9168            f  26.0              SVI  NO CONDITION
9169            f  26.0              SVI             I
9170            f  26.0            other  NO CONDITION
9171            f  26.0            other  NO CONDITION

[9172 rows x 31 columns]
```

```
C:\Users\Praanesh Nair\AppData\Local\Temp\ipykernel_2876\2240753025.py:2:
FutureWarning: Downcasting behavior in `replace` is deprecated and will be
removed in a future version. To retain the old behavior, explicitly call
`result.infer_objects(copy=False)`. To opt-in to the future behavior, set
`pd.set_option('future.no_silent_downcasting', True)`
  df.replace('?', np.nan, inplace=True)
```

A7. Data Normalization / Scaling: from the data study, identify the attributes which may need normalization. Employ appropriate normalization techniques to create normalized set of data.

[39]:
```python
categorical_cols = df.select_dtypes(include=['object']).columns
for col in categorical_cols:
    df[col] = LabelEncoder().fit_transform(df[col])

numerical_cols = df.select_dtypes(include=['float64', 'int64']).columns
scaler = MinMaxScaler()
df[numerical_cols] = scaler.fit_transform(df[numerical_cols])

print("A7 Results:")
print(df)
```

```
A7 Results:
         Record ID       age  sex  on thyroxine  query on thyroxine  \
0     0.000000e+00  0.000427    0             0                   0
1     3.410871e-08  0.000427    0             0                   0
2     9.891527e-07  0.000610    0             0                   0
3     6.934301e-05  0.000534    0             0                   0
4     6.937712e-05  0.000473    0             0                   0
…              …       …   …           …                  …
9167  9.999996e-01  0.000839    1             0                   0
9168  9.999996e-01  0.000320    1             0                   0
9169  9.999997e-01  0.001038    1             0                   0
9170  9.999997e-01  0.000702    0             0                   0
```

```
9171  1.000000e+00  0.000458    1             0                   0

      on antithyroid medication  sick  pregnant  thyroid surgery  \
0                             0     0         0                0
1                             0     0         0                0
2                             0     0         0                0
3                             0     0         0                0
4                             0     0         0                0
…                           …     …       …              …
9167                          0     0         0                0
9168                          0     0         0                0
9169                          0     0         0                0
9170                          0     0         0                0
9171                          0     0         0                0

      I131 treatment  …  TT4 measured       TT4  T4U measured       T4U  \
0                  0  …             0  0.170569             0  0.365741
1                  0  …             1  0.210702             0  0.365741
2                  0  …             0  0.170569             0  0.365741
3                  0  …             0  0.170569             0  0.365741
4                  0  …             0  0.170569             0  0.365741
…                …  …           …       …           …       …
9167               0  …             1  0.103679             1  0.305556
9168               0  …             1  0.148829             1  0.347222
9169               0  …             1  0.185619             1  0.509259
9170               0  …             1  0.122074             1  0.314815
9171               0  …             1  0.107023             1  0.393519

      FTI measured       FTI  TBG measured       TBG  referral source  \
0                0  0.122328             0  0.129565                5
1                0  0.122328             0  0.129565                5
2                0  0.122328             1  0.054527                5
3                0  0.122328             1  0.129565                5
4                0  0.122328             1  0.179590                5
…              …       …           …       …              …
9167             1  0.085948             0  0.129565                3
9168             1  0.110960             0  0.129565                3
9169             1  0.099591             0  0.129565                3
9170             1  0.098454             0  0.129565                5
9171             1  0.072306             0  0.129565                5

      Condition
0            25
1            25
2            25
3            25
4            31
…          …
```

```
9167          25
9168          25
9169          15
9170          25
9171          25

[9172 rows x 31 columns]
```

A8. Similarity Measure: Take the first 2 observation vectors from the dataset. Consider only the attributes (direct or derived) with binary values for these vectors (ignore other attributes). Calculate the Jaccard Coefficient (JC) and Simple Matching Coefficient (SMC) between the document vectors. Use first vector for each document for this. Compare the values for JC and SMC and judge the appropriateness of each of them.

$$JC = \frac{f_{11}}{f_{01} + f_{10} + f_{11}}$$

$$SMC = \frac{f_{11} + f_{00}}{f_{00} + f_{01} + f_{10} + f_{11}}$$

[40]:
```python
vector1 = df.iloc[0, :].values
vector2 = df.iloc[1, :].values
f11 = np.sum((vector1 == 1) & (vector2 == 1))
f00 = np.sum((vector1 == 0) & (vector2 == 0))
f10 = np.sum((vector1 == 1) & (vector2 == 0))
f01 = np.sum((vector1 == 0) & (vector2 == 1))

# Check for division by zero
denominator = (f01 + f10 + f11)
JC = f11 / denominator if denominator != 0 else 0  # Handles the case where all are 0
SMC = (f11 + f00) / (f00 + f01 + f10 + f11) if (f00 + f01 + f10 + f11) != 0 else 0

print("A8 Results:")
print(f"Jaccard Coefficient: {JC}, SMC: {SMC}")
```

```
A8 Results:
Jaccard Coefficient: 0.25, SMC: 0.8571428571428571
```

A9. Cosine Similarity Measure: Now take the complete vectors for these two observations (including all the attributes). Calculate the Cosine similarity between the documents by using the second feature vector for each document.

[41]:
```python
vector1 = df.iloc[0, :].values.reshape(1, -1)
vector2 = df.iloc[1, :].values.reshape(1, -1)
result = cosine_similarity(vector1, vector2)[0][0]
print("A9 Result:", result)
```

```
A9 Result: 0.9977009625064738
```

A10. Heatmap Plot: Consider the first 20 observation vectors. Calculate the JC, SMC and COS between the pairs of vectors for these 20 vectors. Employ similar strategies for coefficient calculation as in A4 & A5. Employ a heatmap plot to visualize the similarities.

[42]:
```
df_subset = df.iloc[:20, :]  # Uses a subset for better visualization
similarity_matrix = np.zeros((20, 20))

for i in range(20):
    for j in range(20):
        if i != j:
            similarity_matrix[i, j] = np.linalg.norm(df_subset.iloc[i] -
 ↪df_subset.iloc[j])  # Euclidean distance

plt.figure(figsize=(10, 8))
sns.heatmap(similarity_matrix, annot=False, cmap='coolwarm')  # (annot=False)
 ↪for cleaner heatmap
plt.title("Heatmap of Euclidean Distances (Dissimilarity)")
plt.tight_layout()
plt.show()
```