Assignment_4

July 24, 2025

[34]:
```
import warnings
warnings.filterwarnings('ignore')
```

[32]:
```
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns

from sklearn.impute import SimpleImputer
from sklearn.model_selection import train_test_split
from sklearn.preprocessing import StandardScaler
from sklearn.decomposition import PCA
from sklearn.svm import SVC
from sklearn.metrics import accuracy_score, precision_score, recall_score,␣
↪confusion_matrix
```

[35]:
```
# Load the dataset
df = pd.read_csv("/content/cancer.csv")
print("CSV Shape:", df.shape)
df.head()
```

```
CSV Shape: (569, 33)
```

[35]:
```
         id diagnosis  radius_mean  texture_mean  perimeter_mean  area_mean  \
0    842302         M        17.99         10.38          122.80     1001.0
1    842517         M        20.57         17.77          132.90     1326.0
2  84300903         M        19.69         21.25          130.00     1203.0
3  84348301         M        11.42         20.38           77.58      386.1
4  84358402         M        20.29         14.34          135.10     1297.0

   smoothness_mean  compactness_mean  concavity_mean  concave points_mean  \
0          0.11840           0.27760          0.3001              0.14710
1          0.08474           0.07864          0.0869              0.07017
2          0.10960           0.15990          0.1974              0.12790
3          0.14250           0.28390          0.2414              0.10520
4          0.10030           0.13280          0.1980              0.10430

   …  texture_worst  perimeter_worst  area_worst  smoothness_worst  \
```

```
0  …          17.33           184.60      2019.0             0.1622
1  …          23.41           158.80      1956.0             0.1238
2  …          25.53           152.50      1709.0             0.1444
3  …          26.50            98.87       567.7             0.2098
4  …          16.67           152.20      1575.0             0.1374

   compactness_worst  concavity_worst  concave points_worst  symmetry_worst  \
0             0.6656           0.7119                0.2654          0.4601
1             0.1866           0.2416                0.1860          0.2750
2             0.4245           0.4504                0.2430          0.3613
3             0.8663           0.6869                0.2575          0.6638
4             0.2050           0.4000                0.1625          0.2364

   fractal_dimension_worst  Unnamed: 32
0                  0.11890          NaN
1                  0.08902          NaN
2                  0.08758          NaN
3                  0.17300          NaN
4                  0.07678          NaN

[5 rows x 33 columns]
```

[36]:
```python
# Drop 'id' column and extract features
X = df.drop(columns=['id', 'diagnosis'], axis=1)

# Encode 'diagnosis': M = 1, B = 0
Y = df['diagnosis'].map({'M': 1, 'B': 0}).values

# Handle missing values using mean imputation
imputer = SimpleImputer(strategy='mean')
X = imputer.fit_transform(X)

# Check shape
print("X shape:", X.shape)
print("Y shape:", Y.shape)
```

```
X shape: (569, 30)
Y shape: (569,)
```

[37]:
```python
# Confusion Matrix Plot Function
def get_confusion_matrix(cnf_matrix):
    class_names = sorted(Y.unique())
    fig, ax = plt.subplots()
    tick_marks = np.arange(len(class_names))
    plt.xticks(tick_marks, class_names)
    plt.yticks(tick_marks, class_names)
    sns.heatmap(pd.DataFrame(cnf_matrix), annot=True, cmap="YlGnBu", fmt='g')
```

```python
    plt.title('Confusion Matrix')
    plt.ylabel('Actual Label')
    plt.xlabel('Predicted Label')
    plt.show()
```

[38]:

```python
# Evaluation Metrics Function
def get_results(y_test, y_pred):
    acc = accuracy_score(y_test, y_pred)
    prec = precision_score(y_test, y_pred)
    rec = recall_score(y_test, y_pred)
    print("Accuracy:", acc)
    print("Precision:", prec)
    print("Recall:", rec)
    return acc * 100, prec * 100, rec * 100
```

[39]:

```python
# PCA + SVM Training and Evaluation
def svm_model_training_pca(X, Y):
    n = X.shape[1]
    acc_list = []
    recall_list = []
    precision_list = []
    k_list = []

    for i in range(n):
        print("K =", i + 1)
        pca = PCA(n_components=i + 1)
        principalComponents = pca.fit_transform(X)
        X_train, X_test, y_train, y_test =␣
 ↪train_test_split(principalComponents, Y, test_size=0.20, random_state=99)
        classifier = SVC(kernel='linear')
        classifier.fit(X_train, y_train)
        y_pred = classifier.predict(X_test)
        result = get_results(y_test, y_pred)
        acc_list.append(result[0])
        precision_list.append(result[1])
        recall_list.append(result[2])
        k_list.append(i + 1)

    high_acc = max(acc_list)
    high_acc_k = acc_list.index(high_acc) + 1
    print("----------------")
    print("Highest Classification Accuracy Achieved: {:.2f}% for K = {}".
 ↪format(high_acc, high_acc_k))

    return k_list, acc_list, precision_list, recall_list
```

[40]:
```python
# Plotting metrics over principal components
def plot_result_with(k_list, acc_list, precision_list, recall_list):
    plt.plot(k_list, acc_list, label='Accuracy')
    plt.plot(k_list, precision_list, label='Precision')
    plt.plot(k_list, recall_list, label='Recall')
    plt.xlabel("K")
    plt.ylabel("Metric Value")
    plt.title("PCA Dimensionality vs SVM Metrics")
    plt.legend()
    plt.show()
```

Problem 1:

- 1.1

[41]:
```python
# Train and evaluate
k_list, acc_list, precision_list, recall_list = svm_model_training_pca(X, Y)
```

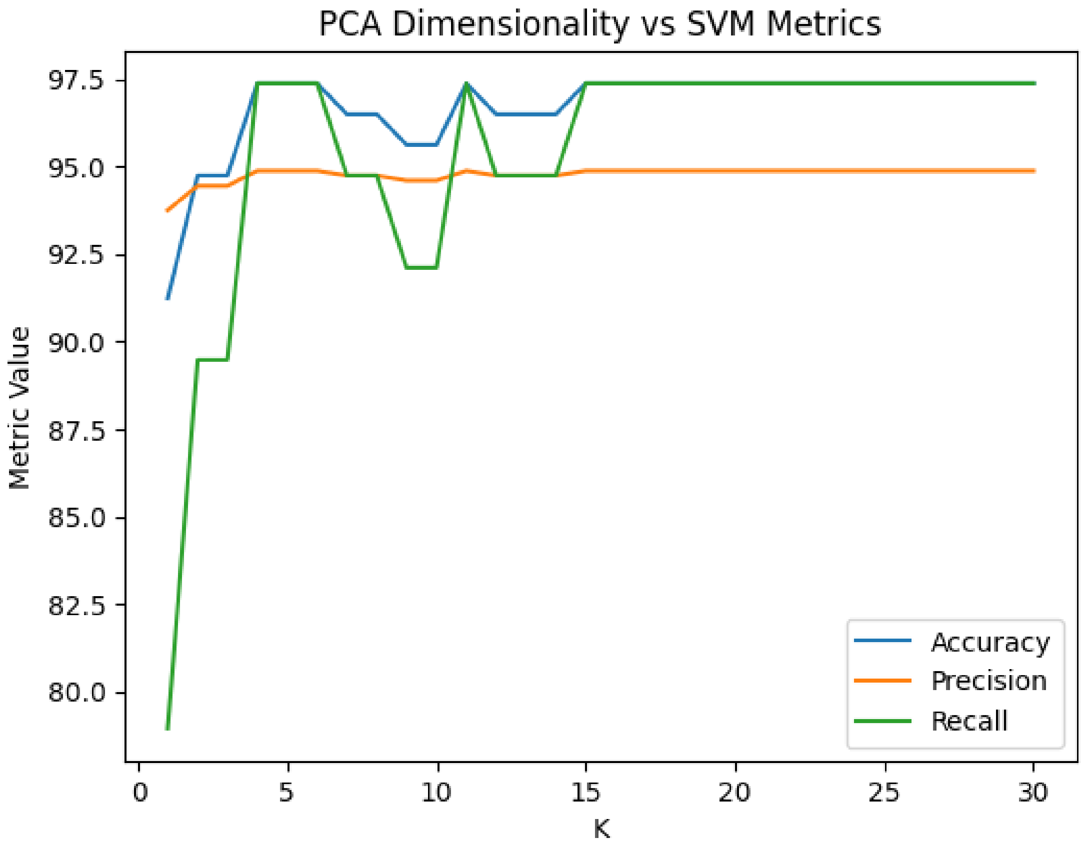
```
K = 1
Accuracy: 0.9122807017543859
Precision: 0.9375
Recall: 0.7894736842105263
K = 2
Accuracy: 0.9473684210526315
Precision: 0.9444444444444444
Recall: 0.8947368421052632
K = 3
Accuracy: 0.9473684210526315
Precision: 0.9444444444444444
Recall: 0.8947368421052632
K = 4
Accuracy: 0.9736842105263158
Precision: 0.9487179487179487
Recall: 0.9736842105263158
K = 5
Accuracy: 0.9736842105263158
Precision: 0.9487179487179487
Recall: 0.9736842105263158
K = 6
Accuracy: 0.9736842105263158
Precision: 0.9487179487179487
Recall: 0.9736842105263158
K = 7
Accuracy: 0.9649122807017544
Precision: 0.9473684210526315
Recall: 0.9473684210526315
K = 8
Accuracy: 0.9649122807017544
```

```
Precision: 0.9473684210526315
Recall: 0.9473684210526315
K = 9
Accuracy: 0.956140350877193
Precision: 0.9459459459459459
Recall: 0.9210526315789473
K = 10
Accuracy: 0.956140350877193
Precision: 0.9459459459459459
Recall: 0.9210526315789473
K = 11
Accuracy: 0.9736842105263158
Precision: 0.9487179487179487
Recall: 0.9736842105263158
K = 12
Accuracy: 0.9649122807017544
Precision: 0.9473684210526315
Recall: 0.9473684210526315
K = 13
Accuracy: 0.9649122807017544
Precision: 0.9473684210526315
Recall: 0.9473684210526315
K = 14
Accuracy: 0.9649122807017544
Precision: 0.9473684210526315
Recall: 0.9473684210526315
K = 15
Accuracy: 0.9736842105263158
Precision: 0.9487179487179487
Recall: 0.9736842105263158
K = 16
Accuracy: 0.9736842105263158
Precision: 0.9487179487179487
Recall: 0.9736842105263158
K = 17
Accuracy: 0.9736842105263158
Precision: 0.9487179487179487
Recall: 0.9736842105263158
K = 18
Accuracy: 0.9736842105263158
Precision: 0.9487179487179487
Recall: 0.9736842105263158
K = 19
Accuracy: 0.9736842105263158
Precision: 0.9487179487179487
Recall: 0.9736842105263158
K = 20
Accuracy: 0.9736842105263158
```

```
Precision: 0.9487179487179487
Recall: 0.9736842105263158
K = 21
Accuracy: 0.9736842105263158
Precision: 0.9487179487179487
Recall: 0.9736842105263158
K = 22
Accuracy: 0.9736842105263158
Precision: 0.9487179487179487
Recall: 0.9736842105263158
K = 23
Accuracy: 0.9736842105263158
Precision: 0.9487179487179487
Recall: 0.9736842105263158
K = 24
Accuracy: 0.9736842105263158
Precision: 0.9487179487179487
Recall: 0.9736842105263158
K = 25
Accuracy: 0.9736842105263158
Precision: 0.9487179487179487
Recall: 0.9736842105263158
K = 26
Accuracy: 0.9736842105263158
Precision: 0.9487179487179487
Recall: 0.9736842105263158
K = 27
Accuracy: 0.9736842105263158
Precision: 0.9487179487179487
Recall: 0.9736842105263158
K = 28
Accuracy: 0.9736842105263158
Precision: 0.9487179487179487
Recall: 0.9736842105263158
K = 29
Accuracy: 0.9736842105263158
Precision: 0.9487179487179487
Recall: 0.9736842105263158
K = 30
Accuracy: 0.9736842105263158
Precision: 0.9487179487179487
Recall: 0.9736842105263158
----------------
Highest Classification Accuracy Achieved: 97.37% for K = 4
```

1.2

[56]:
```python
# Plot the results
plot_result_with(k_list, acc_list, precision_list, recall_list)
```



1.3

[44]:
```python
from sklearn.svm import SVC
from sklearn.decomposition import PCA
from sklearn.model_selection import train_test_split

# Define function to test multiple SVM kernels with fixed number of principal␣
↪components
def svm_model_training_with_kernel(X, Y, n_pc):
    kernel_list = ["linear", "poly", "rbf", "sigmoid"]
    acc_list = []
    precision_list = []
    recall_list = []

    for i in range(len(kernel_list)):
        print("Kernel =", kernel_list[i])
```

```
        # Apply PCA
        pca = PCA(n_components=n_pc)
        principalComponents = pca.fit_transform(X)

        # Train/Test split
        X_train, X_test, y_train, y_test = train_test_split(
            principalComponents, Y, test_size=0.20, random_state=99
        )

        # Train SVM with specified kernel
        classifier = SVC(kernel=kernel_list[i])
        classifier.fit(X_train, y_train)
        y_pred = classifier.predict(X_test)

        # Evaluate
        r = get_results(y_test, y_pred)  # From previous function
        acc_list.append(r[0])
        precision_list.append(r[1])
        recall_list.append(r[2])

        print("----------------")

    # Find best kernel by accuracy
    high_acc = max(acc_list)
    n = acc_list.index(high_acc)
    high_acc_kernel = kernel_list[n]
    print("Highest Classification Accuracy Achieved: {:.6f}% for Kernel = {}".
 ↪format(high_acc, high_acc_kernel))

    return kernel_list, acc_list, precision_list, recall_list
```

[57]:
```
# Plot the results and compare the accuracies for different kernels
kernel_list, acc_list, precision_list, recall_list =␣
 ↪svm_model_training_with_kernel(X, Y, 4)
```

```
Kernel = linear
Accuracy: 0.9736842105263158
Precision: 0.9487179487179487
Recall: 0.9736842105263158
----------------
Kernel = poly
Accuracy: 0.868421052631579
Precision: 1.0
Recall: 0.6052631578947368
----------------
Kernel = rbf
Accuracy: 0.9385964912280702
```

```
Precision: 0.9428571428571428
Recall: 0.868421052631579
-----------------
Kernel = sigmoid
Accuracy: 0.9035087719298246
Precision: 0.8648648648648649
Recall: 0.8421052631578947
-----------------
Highest Classification Accuracy Achieved: 97.368421% for Kernel = linear
```

Problem 2

- 2.1

[59]:
```
import pandas as pd
import numpy as np
from sklearn.model_selection import train_test_split
from sklearn.svm import SVR
from sklearn.decomposition import PCA
import warnings
from sklearn.exceptions import DataConversionWarning

# Suppress the y-shape warning from sklearn
warnings.filterwarnings(action='ignore', category=DataConversionWarning)

# Load dataset
df = pd.read_csv("/content/Housing.csv")
print("CSV File Shape:")
print(df.shape)
df.head()
```

```
CSV File Shape:
(545, 13)
```

[59]:
```
      price  area  bedrooms  bathrooms  stories mainroad guestroom basement  \
0  13300000  7420         4          2        3      yes        no       no
1  12250000  8960         4          4        4      yes        no       no
2  12250000  9960         3          2        2      yes        no      yes
3  12215000  7500         4          2        2      yes        no      yes
4  11410000  7420         4          1        2      yes       yes      yes

  hotwaterheating airconditioning  parking prefarea furnishingstatus
0              no             yes        2      yes        furnished
1              no             yes        3       no        furnished
2              no              no        2      yes   semi-furnished
3              no             yes        3      yes        furnished
4              no             yes        2       no        furnished
```

[60]:
```python
# Convert binary categorical columns
svar_list = ['mainroad', 'guestroom', 'basement', 'hotwaterheating',␣
 ↪'airconditioning', 'prefarea']

def binary_mapping(x):
    return x.map({'yes': 1, 'no': 0})

df[svar_list] = df[svar_list].apply(binary_mapping)
df.head()
```

[60]:
```
      price  area  bedrooms  bathrooms  stories  mainroad  guestroom  \
0  13300000  7420         4          2        3         1          0
1  12250000  8960         4          4        4         1          0
2  12250000  9960         3          2        2         1          0
3  12215000  7500         4          2        2         1          0
4  11410000  7420         4          1        2         1          1

   basement  hotwaterheating  airconditioning  parking  prefarea  \
0         0                0                1        2         1
1         0                0                1        3         0
2         1                0                0        2         1
3         1                0                1        3         1
4         1                0                1        2         0

  furnishingstatus
0        furnished
1        furnished
2   semi-furnished
3        furnished
4        furnished
```

[61]:
```python
# Extract Features and Target
num_vars = ['area', 'bedrooms', 'bathrooms', 'stories', 'mainroad',
            'guestroom', 'basement', 'hotwaterheating',
            'airconditioning', 'parking', 'prefarea']

target_column = 'price'
data = df[num_vars]

X = data.to_numpy()
Y = df[[target_column]].to_numpy()

# Impute missing values
from sklearn.impute import SimpleImputer
imputer = SimpleImputer(strategy='mean')
X = imputer.fit_transform(X)
```

```
print("Input shape:", X.shape)
print("Target shape:", Y.shape)
```

```
Input shape: (545, 11)
Target shape: (545, 1)
```

[62]:
```
# Cost Function for SVR
def compute_cost(y, y_pred):
    m = len(y)
    errors = np.subtract(y, y_pred)
    sqrErrors = np.square(errors)
    J = 1 / (2 * m) * np.sum(sqrErrors)
    return J
```

[63]:
```
#  Train SVR Model (No PCA)
from sklearn.svm import SVR
from sklearn.model_selection import train_test_split

def svr_model_training(X, Y):
    X_train, X_test, y_train, y_test = train_test_split(X, Y, test_size=0.20,␣
 ↪random_state=99)
    classifier = SVR()
    classifier.fit(X_train, y_train)
    Y_pred = classifier.predict(X_test)
    loss = compute_cost(y_test, Y_pred)
    print("Loss:", loss)
```

[64]:
```
#Run
svr_model_training(X, Y)
```

```
Loss: 238290456164115.3
```

[65]:
```
# PCA + SVR Training Across K
from sklearn.decomposition import PCA

def svr_model_training_pca(X, Y):
    n = X.shape[1]
    loss_list = []
    k_list = []

    for i in range(n):
        print("K =", i+1)
        pca = PCA(n_components=i+1)
        principalComponents = pca.fit_transform(X)
        X_train, X_test, y_train, y_test =␣
 ↪train_test_split(principalComponents, Y, test_size=0.20, random_state=9)
```

```python
        classifier = SVR(kernel='linear')
        classifier.fit(X_train, y_train)
        Y_pred = classifier.predict(X_test)

        loss = compute_cost(y_test, Y_pred)
        print("Loss:", loss)

        loss_list.append(loss)
        k_list.append(i+1)

    low_loss = min(loss_list)
    low_loss_k = loss_list.index(low_loss) + 1
    print("-------------------------")
    print("Lowest Loss Achieved:", low_loss, "for K number =", low_loss_k)

    return k_list, loss_list
```

[66]:
```python
# Run
k_list, loss_list = svr_model_training_pca(X, Y)
```

```
K = 1
Loss: 250088245443913.44
K = 2
Loss: 250064272993220.78
K = 3
Loss: 250063469523478.62
K = 4
Loss: 250063984078365.66
K = 5
Loss: 250065669922950.5
K = 6
Loss: 250065169858786.6
K = 7
Loss: 250065604004005.22
K = 8
Loss: 250067194202934.53
K = 9
Loss: 250067274612974.3
K = 10
Loss: 250067050044776.47
K = 11
Loss: 250067033255061.38
-------------------------
Lowest Loss Achieved: 250063469523478.62 for K number = 3
```

[67]:
```python
# Compare Kernels (with PCA)
def svr_model_training_with_kernel(X, Y, n_pc):
```

```python
    kernel_list = ["linear", "poly", "rbf"]
    loss_list = []
    y_pred_list = []

    pca = PCA(n_components=n_pc)
    principalComponents = pca.fit_transform(X)

    for i in kernel_list:
        print("Kernel =", i)
        X_train, X_test, y_train, y_test = 
 ↪train_test_split(principalComponents, Y, test_size=0.20, random_state=99)
        classifier = SVR(kernel=i)
        classifier.fit(X_train, y_train)
        Y_pred = classifier.predict(X_test)

        y_pred_list.append(Y_pred)
        loss = compute_cost(y_test, Y_pred)
        loss_list.append(loss)
        print("Loss:", loss)
        print("-------------------------")

    low_loss = min(loss_list)
    n = loss_list.index(low_loss)
    low_loss_kernel = kernel_list[n]
    print("Lowest Loss Achieved:", low_loss, "for Kernel =", low_loss_kernel)

    return kernel_list, y_pred_list, loss_list
```

[68]:

```python
# Run
kernel_list, y_pred_list, y_test = svr_model_training_with_kernel(X, Y, n_pc=3)
```

```
Kernel = linear
Loss: 306023058583913.25
-------------------------
Kernel = poly
Loss: 238440221378996.94
-------------------------
Kernel = rbf
Loss: 238289370339162.38
-------------------------
Lowest Loss Achieved: 238289370339162.38 for Kernel = rbf
```