FINAL PROJECT IF540 MACHINE LEARNING

Klasifikasi & Analisis Perilaku Pengunjung Mall Dengan Hierarchical Clustering & KNN Berdasarkan Karakteristik Kehidupan Untuk Perencanaan Marketing

Semester Genap 2023/2024

Link GitHub : https://github.com/KanekIAN/final_project_ML

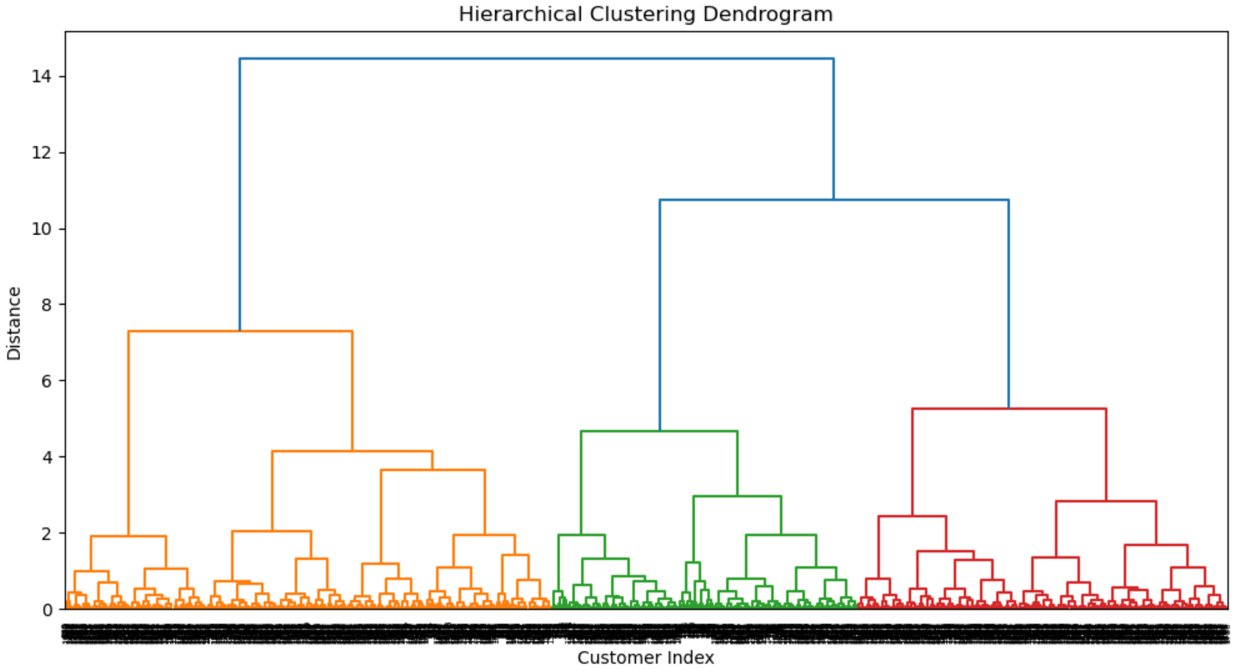
```python
import pandas as pd
import sys
import numpy as np
import matplotlib.pyplot as plt

#Buka Data
customer = pd.read_csv('Customers.csv')
print("Columns of the DataFrame: \n{}".format(customer.columns))
customer
```

```
Columns of the DataFrame:
Index(['CustomerID', 'Gender', 'Age', 'Annual Income ($)',
       'Spending Score (1-100)', 'Profession', 'Work Experience',
       'Family Size'],
      dtype='object')
```

```
      CustomerID  Gender  Age  Annual Income ($)  Spending Score (1-
100)  \
0              1    Male   19              15000
39
1              2    Male   21              35000
81
2              3  Female   20              86000
6
3              4  Female   23              59000
77
4              5  Female   31              38000
40
...          ...     ...  ...                ...                     .
..
1995        1996  Female   71             184387
40
1996        1997  Female   91              73158
32
1997        1998    Male   87              90961
14
1998        1999    Male   77             182109
4
```

```
1999        2000    Male   90             110610
52

         Profession  Work Experience  Family Size
0        Healthcare                1            4
1          Engineer                3            3
2          Engineer                1            1
3            Lawyer                0            2
4     Entertainment                2            6
...             ...              ...          ...
1995         Artist                8            7
1996         Doctor                7            7
1997     Healthcare                9            2
1998      Executive                7            2
1999  Entertainment                5            2

[2000 rows x 8 columns]

# Drop semua kolom kecuali 'Annual Income ($)' & 'Spending Score (1-
100)'
df_selected = customer[['Annual Income ($)', 'Spending Score (1-
100)']]
df_selected

      Annual Income ($)  Spending Score (1-100)
0                 15000                      39
1                 35000                      81
2                 86000                       6
3                 59000                      77
4                 38000                      40
...                 ...                     ...
1995             184387                      40
1996              73158                      32
1997              90961                      14
1998             182109                       4
1999             110610                      52

[2000 rows x 2 columns]

df_selected = customer[['Annual Income ($)', 'Spending Score (1-
100)']]

#Min-Max normalization
def min_max_normalize(column):
    return (column - column.min()) / (column.max() - column.min())

#Apply Min-Max normalization
normalized_df = df_selected.apply(min_max_normalize)

print("Normalized data:")
normalized_df
```

```
Normalized data:

      Annual Income ($)  Spending Score (1-100)
0              0.078958                    0.39
1              0.184236                    0.81
2              0.452694                    0.06
3              0.310569                    0.77
4              0.200027                    0.40
...                 ...                     ...
1995           0.970591                    0.40
1996           0.385095                    0.32
1997           0.478808                    0.14
1998           0.958600                    0.04
1999           0.582238                    0.52

[2000 rows x 2 columns]

#Plot Dendrogram untuk cari number of clusters
from scipy.cluster.hierarchy import dendrogram, linkage

#Distance Metric & Linkage Method dengan euclidean & ward
Z = linkage(normalized_df, method='ward', metric='euclidean')

plt.figure(figsize=(12, 6))
dendrogram(Z)
plt.title('Hierarchical Clustering Dendrogram')
plt.xlabel('Customer Index')
plt.ylabel('Distance')
plt.show()
```



```python
#Hierarchical Clustering
from sklearn.preprocessing import StandardScaler
from sklearn.cluster import AgglomerativeClustering

scaler = StandardScaler()
scaled_data = scaler.fit_transform(normalized_df)

# Pilih n_clusters
n_clusters = 11
clusterer = AgglomerativeClustering(n_clusters=n_clusters,
linkage='complete')
cluster_labels = clusterer.fit_predict(scaled_data)

normalized_df['Cluster'] = cluster_labels
normalized_df
```

```
      Annual Income ($)  Spending Score (1-100)  Cluster
0              0.078958                    0.39        2
1              0.184236                    0.81        1
2              0.452694                    0.06        0
3              0.310569                    0.77        9
4              0.200027                    0.40        2
...                 ...                     ...      ...
1995           0.970591                    0.40        6
1996           0.385095                    0.32        3
1997           0.478808                    0.14        0
1998           0.958600                    0.04        6
1999           0.582238                    0.52        7

[2000 rows x 3 columns]
```

```python
#Training datanya
customer_train= AgglomerativeClustering(n_clusters=11,
metric='euclidean', linkage='ward')
y_pred= customer_train.fit_predict(normalized_df)
customer_train
```

```
AgglomerativeClustering(metric='euclidean', n_clusters=11)
```

```python
#Silhouette score biar bisa lihat gimana penyebaran dan pembagian
kelompok Clusternya
from sklearn.metrics import silhouette_score

silhouette_avg = silhouette_score(normalized_df, y_pred)

print("The average silhouette score is:", silhouette_avg)
```

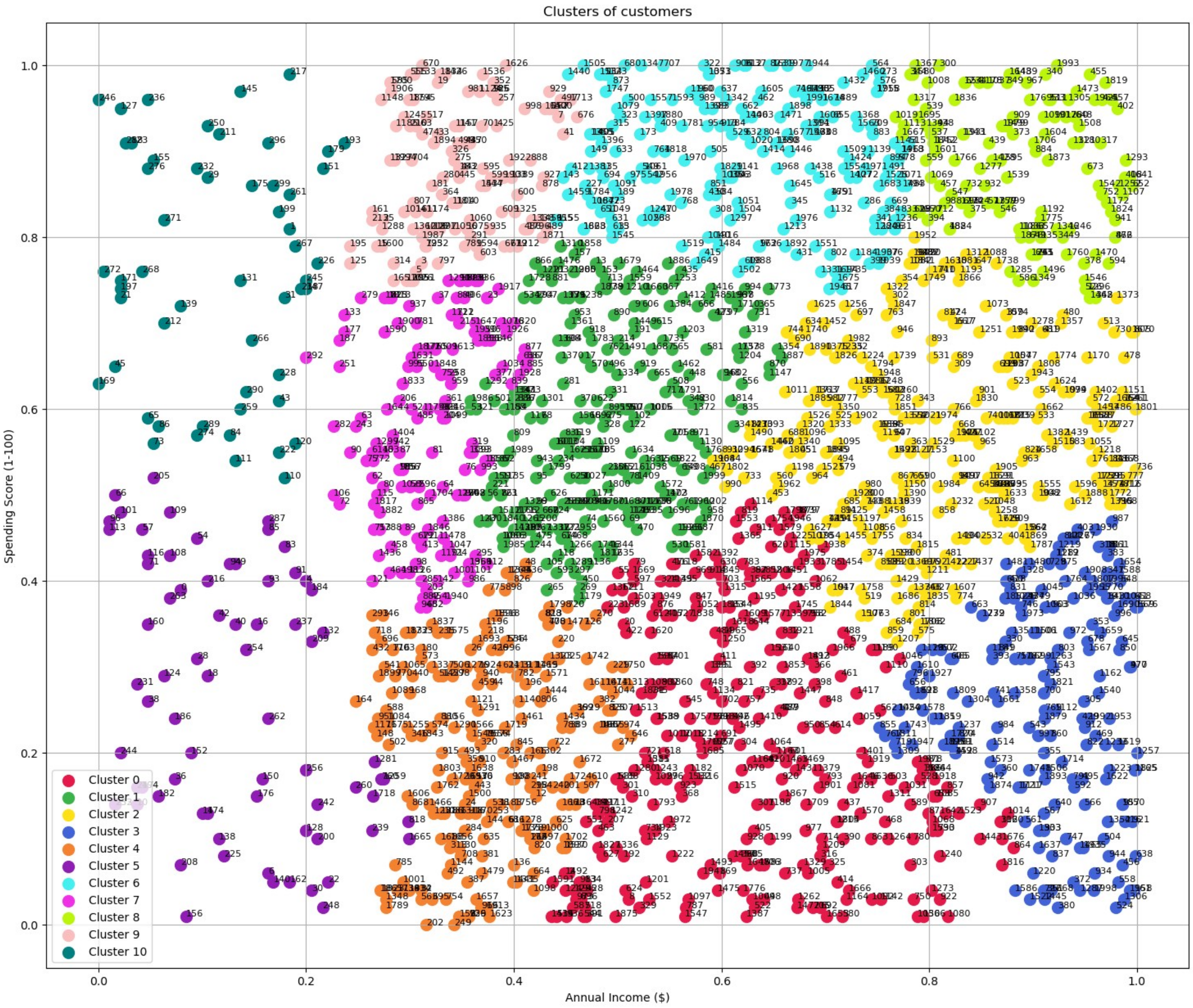
```
The average silhouette score is: 0.8465650884565473
```

```python
def categorize_cluster(row):
    if row['Cluster'] == 0:
        return 'Low income & Low spending scores'
    elif row['Cluster'] == 1:
        return 'Moderate to high income & High spending scores'
    elif row['Cluster'] == 2:
        return 'High income & Moderate to high spending scores'
    elif row['Cluster'] == 3:
        return 'Moderate income & High spending scores'
    elif row['Cluster'] == 4:
        return 'Low to moderate income & Low to moderate spending
scores'
    elif row['Cluster'] == 5:
        return 'Low to moderate income & Very low spending scores'
    elif row['Cluster'] == 6:
        return 'High income & Low spending scores'
    elif row['Cluster'] == 7:
        return 'Low income & High spending scores'
    elif row['Cluster'] == 8:
        return 'Moderate to high income & Moderate to high spending
scores'
    elif row['Cluster'] == 9:
        return 'Moderate income & Moderate to high spending scores'
    elif row['Cluster'] == 10:
        return 'Low income & Low spending scores'
    else:
        return 'Unknown'

normalized_df['Customer Category'] =
normalized_df.apply(categorize_cluster, axis=1)

normalized_df
```

```
      Annual Income ($)  Spending Score (1-100)  Cluster  \
0              0.078958                    0.39        2
1              0.184236                    0.81        1
2              0.452694                    0.06        0
3              0.310569                    0.77        9
4              0.200027                    0.40        2
...                 ...                     ...      ...
1995           0.970591                    0.40        6
1996           0.385095                    0.32        3
1997           0.478808                    0.14        0
1998           0.958600                    0.04        6
1999           0.582238                    0.52        7

                                      Customer Category
0        High income & Moderate to high spending scores
1        Moderate to high income & High spending scores
2                      Low income & Low spending scores
3     Moderate income & Moderate to high spending sc...
4        High income & Moderate to high spending scores
```

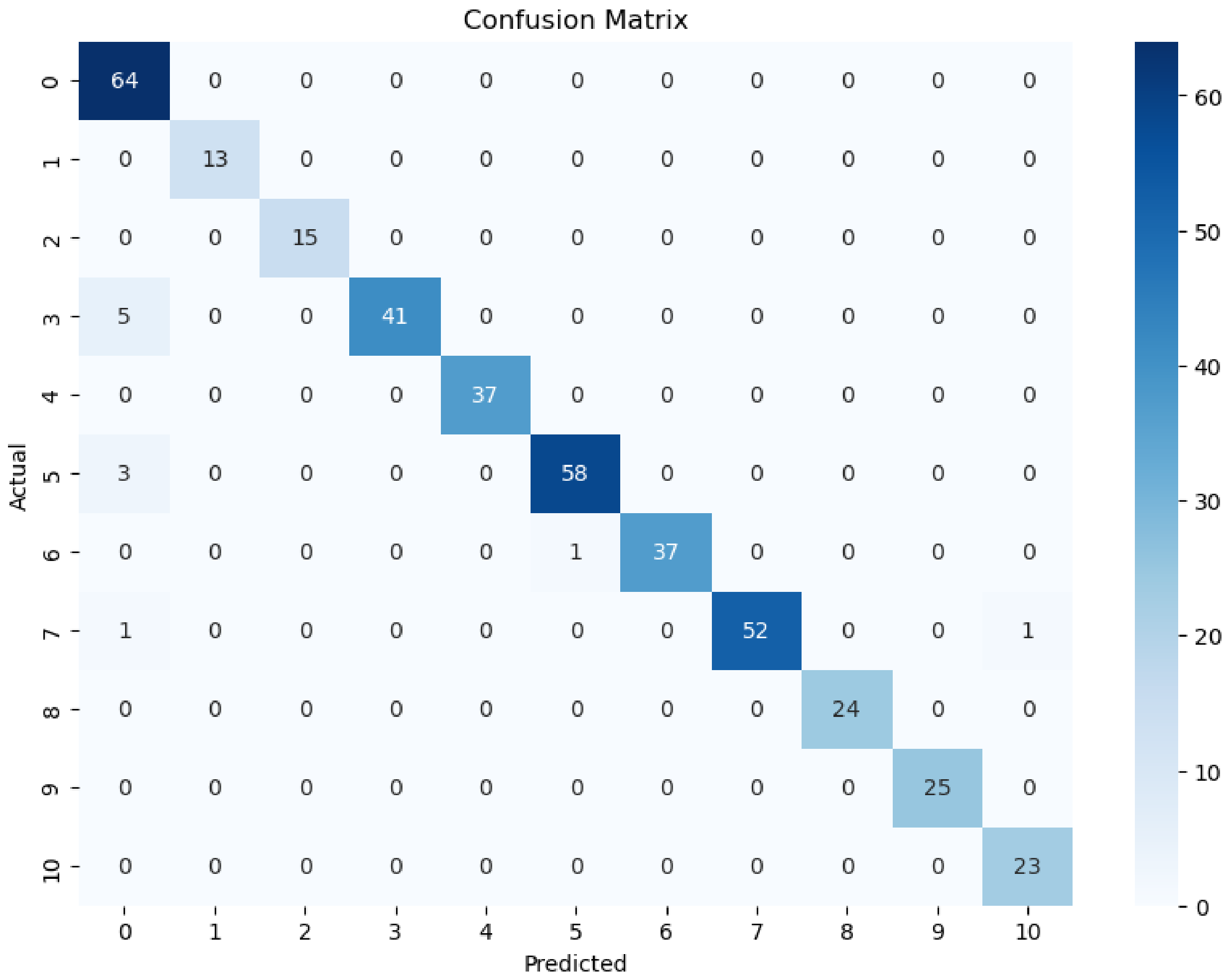
```
...                                                 ...
1995                      High income & Low spending scores
1996                 Moderate income & High spending scores
1997                       Low income & Low spending scores
1998                      High income & Low spending scores
1999                      Low income & High spending scores

[2000 rows x 4 columns]
```

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

# Define 11 warna cluster
color_list = ['#e6194B', '#3cb44b', '#ffe119', '#4363d8', '#f58231',
              '#911eb4', '#46f0f0', '#f032e6', '#bcf60c', '#fabebe',
'#008080']

plt.figure(figsize=(18, 15))

for cluster_label in set(y_pred):
    plt.scatter(normalized_df.loc[y_pred == cluster_label, 'Annual
Income ($)'],
                normalized_df.loc[y_pred == cluster_label, 'Spending
Score (1-100)'],
                s=100, label=f'Cluster {cluster_label}',
color=color_list[cluster_label])

    # Add labels
    for index, row in normalized_df.loc[y_pred ==
cluster_label].iterrows():
        plt.text(row['Annual Income ($)'], row['Spending Score (1-
100)'], str(index), fontsize=8)

plt.title('Clusters of customers')
plt.xlabel('Annual Income ($)')
plt.ylabel('Spending Score (1-100)')
plt.legend()
plt.grid(True)
plt.show()
```



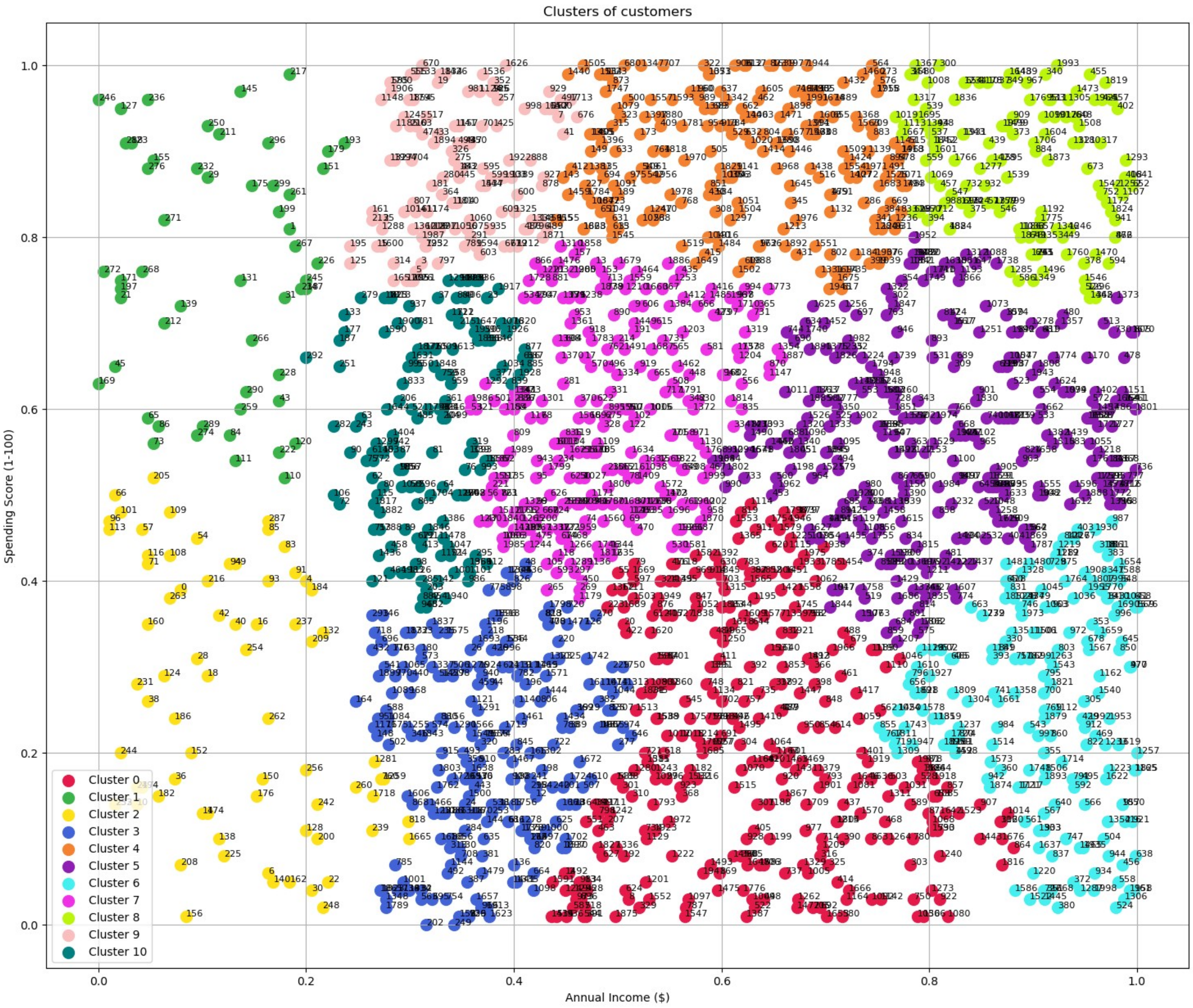
```
import seaborn as sns
from sklearn.preprocessing import StandardScaler
from sklearn.cluster import AgglomerativeClustering
from sklearn.model_selection import train_test_split, cross_val_score,
GridSearchCV
from sklearn.neighbors import KNeighborsClassifier
from sklearn.metrics import accuracy_score, classification_report,
confusion_matrix

# 11 warna cluster
color_list = ['#e6194B', '#3cb44b', '#ffe119', '#4363d8', '#f58231',
              '#911eb4', '#46f0f0', '#f032e6', '#bcf60c', '#fabebe',
'#008080']

# Splitting data menjadi training & testing
X = normalized_df[['Annual Income ($)', 'Spending Score (1-100)']]
y = normalized_df['Cluster']
X_train, X_test, y_train, y_test = train_test_split(X, y,
test_size=0.2, random_state=42)

# KNN Classification
knn = KNeighborsClassifier(n_neighbors=4, metric='manhattan')
knn.fit(X_train, y_train)
y_pred = knn.predict(X_test)

# Performa model
accuracy = accuracy_score(y_test, y_pred)
print("Accuracy:", accuracy)
print("Classification Report:\n", classification_report(y_test,
y_pred))

# Confusion Matrix
cm = confusion_matrix(y_test, y_pred)
plt.figure(figsize=(10, 7))
sns.heatmap(cm, annot=True, fmt='d', cmap='Blues')
plt.xlabel('Predicted')
plt.ylabel('Actual')
plt.title('Confusion Matrix')
plt.show()

# Cross-Validation
cv_scores = cross_val_score(knn, X, y, cv=8, scoring='accuracy')
print("Cross-validation scores:", cv_scores)
print("Mean cross-validation score:", cv_scores.mean())

# Hyperparameter Tuning with Grid Search
param_grid = {'n_neighbors': np.arange(1, 10), 'metric': ['euclidean',
'manhattan']}
grid = GridSearchCV(KNeighborsClassifier(), param_grid, cv=8)
grid.fit(X_train, y_train)

print("Best parameters:", grid.best_params_)
print("Best cross-validation score:", grid.best_score_)

# Visualisasi Setelah KNN
plt.figure(figsize=(18, 15))

for cluster_label in set(y):
    plt.scatter(normalized_df.loc[y == cluster_label, 'Annual Income
($)'],
                normalized_df.loc[y == cluster_label, 'Spending Score
(1-100)'],
                s=100, label=f'Cluster {cluster_label}',
color=color_list[cluster_label])

    for index, row in normalized_df.loc[y ==
cluster_label].iterrows():
        plt.text(row['Annual Income ($)'], row['Spending Score (1-
100)'], str(index), fontsize=8)

plt.title('Clusters of customers')
plt.xlabel('Annual Income ($)')
plt.ylabel('Spending Score (1-100)')
plt.legend()
plt.grid(True)
plt.show()
```

```
Accuracy: 0.9725
Classification Report:
              precision    recall  f1-score   support

           0       0.88      1.00      0.93        64
           1       1.00      1.00      1.00        13
           2       1.00      1.00      1.00        15
           3       1.00      0.89      0.94        46
           4       1.00      1.00      1.00        37
           5       0.98      0.95      0.97        61
           6       1.00      0.97      0.99        38
           7       1.00      0.96      0.98        54
           8       1.00      1.00      1.00        24
           9       1.00      1.00      1.00        25
          10       0.96      1.00      0.98        23

    accuracy                           0.97       400
   macro avg       0.98      0.98      0.98       400
weighted avg       0.98      0.97      0.97       400
```


Confusion Matrix

Actual \ Predicted	0	1	2	3	4	5	6	7	8	9	10
0	64	0	0	0	0	0	0	0	0	0	0
1	0	13	0	0	0	0	0	0	0	0	0
2	0	0	15	0	0	0	0	0	0	0	0
3	5	0	0	41	0	0	0	0	0	0	0
4	0	0	0	0	37	0	0	0	0	0	0
5	3	0	0	0	0	58	0	0	0	0	0
6	0	0	0	0	0	1	37	0	0	0	0
7	1	0	0	0	0	0	0	52	0	0	1
8	0	0	0	0	0	0	0	0	24	0	0
9	0	0	0	0	0	0	0	0	0	25	0
10	0	0	0	0	0	0	0	0	0	0	23

```
Cross-validation scores: [0.992 0.968 0.984 0.964 0.972 0.976 0.984
0.964]
Mean cross-validation score: 0.9755
Best parameters: {'metric': 'euclidean', 'n_neighbors': 1}
Best cross-validation score: 0.98875
```


Clusters of customers
Spending Score (1-100)
Annual Income ($)
0.0
0.2
0.4
0.6
0.8
1.0
0.0
0.2
0.4
0.6
0.8
1.0
● Cluster 0
● Cluster 1
● Cluster 2
● Cluster 3
● Cluster 4
● Cluster 5
● Cluster 6
● Cluster 7
● Cluster 8
● Cluster 9
● Cluster 10