

Data Load

```
In [5]: import pandas as pd

# 파일 경로 지정
file_path = r"C:\Users\준서\Desktop\준서\3-2\데과프\A4\seeds_dataset.txt"

# 공백 또는 탭을 구분자로 읽기
df = pd.read_csv(file_path, delim_whitespace=True, header=None)

# 컬럼 수 확인
print(df.shape) # (행 수, 열 수)

# 앞부분 출력
print(df.head())

print(df.info())
```

```
(210, 8)
   0      1      2      3      4      5      6    7
0  15.26  14.84  0.8710  5.763  3.312  2.221  5.220  1
1  14.88  14.57  0.8811  5.554  3.333  1.018  4.956  1
2  14.29  14.09  0.9050  5.291  3.337  2.699  4.825  1
3  13.84  13.94  0.8955  5.324  3.379  2.259  4.805  1
4  16.14  14.99  0.9034  5.658  3.562  1.355  5.175  1
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 210 entries, 0 to 209
Data columns (total 8 columns):
 #   Column  Non-Null Count  Dtype  
---  -- 
 0   0        210 non-null   float64
 1   1        210 non-null   float64
 2   2        210 non-null   float64
 3   3        210 non-null   float64
 4   4        210 non-null   float64
 5   5        210 non-null   float64
 6   6        210 non-null   float64
 7   7        210 non-null   int64  
dtypes: float64(7), int64(1)
memory usage: 13.3 KB
None
```

```
In [9]: df_cluster = df.iloc[:, :-1]
print(df_cluster.info())
```

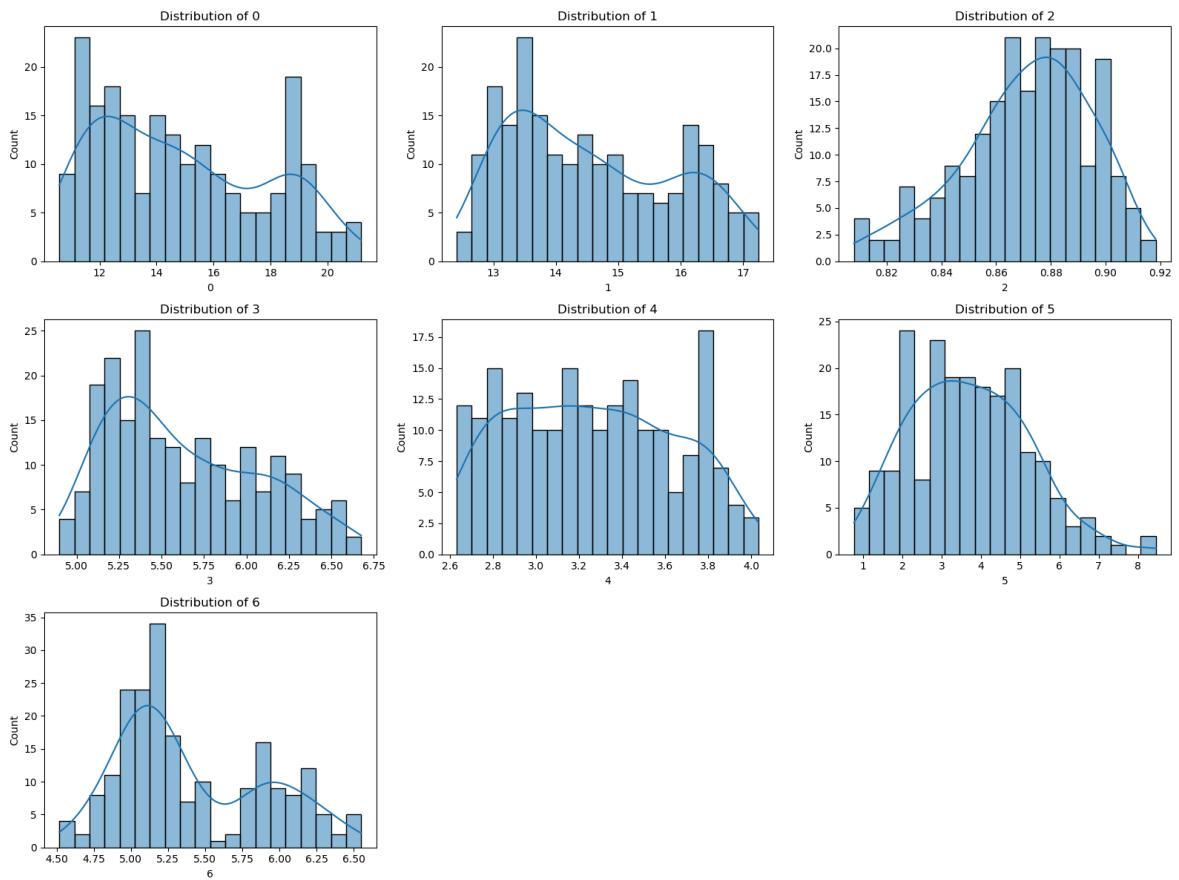
```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 210 entries, 0 to 209
Data columns (total 7 columns):
 #   Column  Non-Null Count  Dtype  
---  -- 
 0   0        210 non-null    float64
 1   1        210 non-null    float64
 2   2        210 non-null    float64
 3   3        210 non-null    float64
 4   4        210 non-null    float64
 5   5        210 non-null    float64
 6   6        210 non-null    float64
dtypes: float64(7)
memory usage: 11.6 KB
None
```

```
In [12]: import matplotlib.pyplot as plt
import seaborn as sns
feature_columns = df_cluster.columns

# 시각화 설정
plt.figure(figsize=(16, 12))
for idx, col in enumerate(feature_columns):
    plt.subplot(3, 3, idx + 1)
    sns.histplot(df[col], kde=True, bins=20)
    plt.title(f"Distribution of {col}")
    plt.xlabel(col)
    plt.ylabel("Count")

plt.tight_layout()
plt.show()
```

```
C:\anacon\Lib\site-packages\seaborn\_oldcore.py:1119: FutureWarning: use_inf_as_n
a option is deprecated and will be removed in a future version. Convert inf value
s to NaN before operating instead.
    with pd.option_context('mode.use_inf_as_na', True):
C:\anacon\Lib\site-packages\seaborn\_oldcore.py:1119: FutureWarning: use_inf_as_n
a option is deprecated and will be removed in a future version. Convert inf value
s to NaN before operating instead.
    with pd.option_context('mode.use_inf_as_na', True):
C:\anacon\Lib\site-packages\seaborn\_oldcore.py:1119: FutureWarning: use_inf_as_n
a option is deprecated and will be removed in a future version. Convert inf value
s to NaN before operating instead.
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C:\anacon\Lib\site-packages\seaborn\_oldcore.py:1119: FutureWarning: use_inf_as_n
a option is deprecated and will be removed in a future version. Convert inf value
s to NaN before operating instead.
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C:\anacon\Lib\site-packages\seaborn\_oldcore.py:1119: FutureWarning: use_inf_as_n
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a option is deprecated and will be removed in a future version. Convert inf value
s to NaN before operating instead.
    with pd.option_context('mode.use_inf_as_na', True):
```



Data Preprocessing

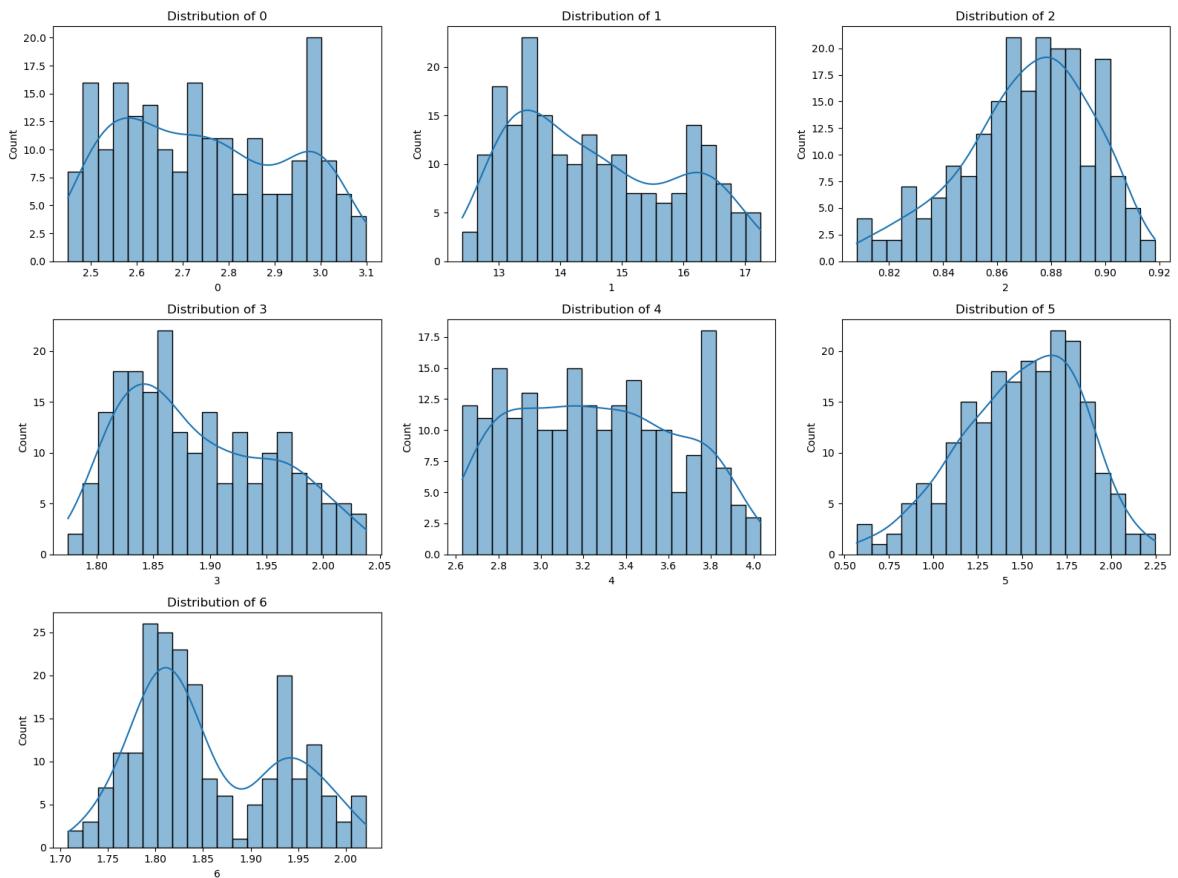
```
In [32]: import warnings
warnings.filterwarnings('ignore')
```

```
In [33]: import numpy as np

# 로그 변환 대상: 0, 3, 5, 6
df_log = df_cluster.copy()
for col in [0, 3, 5, 6]:
    df_log[col] = np.log1p(df_log[col]) # Log(x + 1)

plt.figure(figsize=(16, 12))
for idx, col in enumerate(df_log.columns):
    plt.subplot(3, 3, idx + 1)
    sns.histplot(df_log[col], kde=True, bins=20)
    plt.title(f"Distribution of {col}")
    plt.xlabel(col)
    plt.ylabel("Count")

plt.tight_layout()
plt.show()
```



In [34]: `df_log`

Out[34]:

	0	1	2	3	4	5	6
0	2.788708	14.84	0.8710	1.911467	3.312	1.169692	1.827770
1	2.765060	14.57	0.8811	1.880076	3.333	0.702107	1.784399
2	2.727199	14.09	0.9050	1.839120	3.337	1.308063	1.762159
3	2.697326	13.94	0.8955	1.844352	3.379	1.181420	1.758720
4	2.841415	14.99	0.9034	1.895819	3.562	0.856541	1.820509
...
205	2.579459	13.20	0.8783	1.814336	2.981	1.532773	1.769855
206	2.503892	12.88	0.8511	1.814825	2.795	1.672413	1.792259
207	2.653242	13.66	0.8883	1.830339	3.232	2.231626	1.801050
208	2.552565	13.21	0.8521	1.820509	2.836	1.525621	1.799066
209	2.587764	13.34	0.8684	1.831461	2.974	1.892660	1.802205

210 rows × 7 columns

In [35]: `from sklearn.preprocessing import StandardScaler`

```
scaler = StandardScaler()
X_scaled = scaler.fit_transform(df_log.iloc[:])
```

```
In [44]: from sklearn.preprocessing import PolynomialFeatures
poly = PolynomialFeatures(degree=2, include_bias=False)
X_poly = poly.fit_transform(X_scaled)
```

```
In [47]: from sklearn.decomposition import PCA
pca = PCA(n_components=0.95) # 전체 분산의 95%를 설명하는 주성분만
X_pca = pca.fit_transform(X_scaled)
```

Training

Case1: without Data Preprocessing

```
In [23]: import warnings
warnings.filterwarnings('ignore', category=UserWarning)
```

```
In [50]: from sklearn.cluster import KMeans
from sklearn.metrics import adjusted_rand_score

X_raw = df_cluster.iloc[:,:]
y_true = df.iloc[:, -1]
k_values = range(2, 8)
ari_scores = []

for k in k_values:
    kmeans = KMeans(n_clusters=k, random_state=42, n_init='auto')
    y_pred = kmeans.fit_predict(X_raw)
    ari = adjusted_rand_score(y_true, y_pred)
    ari_scores.append({'K': k, 'ARI(raw data)': round(ari, 4)})

results_df1 = pd.DataFrame(ari_scores)
print(results_df1)
```

K	ARI(raw data)
0 2	0.4648
1 3	0.7166
2 4	0.5467
3 5	0.5600
4 6	0.4699
5 7	0.4658

Case2: with Data Preprocessing (log transform for col 0,3,5,6)

In [51]: #Log변환 한 경우 training

```
X_log = df_log.iloc[:, :]
k_values = range(2, 8)
ari_scores = []

for k in k_values:
    kmeans = KMeans(n_clusters=k, random_state=42, n_init='auto')
    y_pred = kmeans.fit_predict(X_log)
    ari = adjusted_rand_score(y_true, y_pred)
    ari_scores.append({'K': k, 'ARI(log transform)': round(ari, 4)})

results_df2 = pd.DataFrame(ari_scores)
print(results_df2)
```

K	ARI(log transform)	
0	2	0.4815
1	3	0.6699
2	4	0.6197
3	5	0.4745
4	6	0.4389
5	7	0.4268

Case3: with Data Preprocessing (log transform for col 0,3,5,6 & Standard Scaling)

In [52]: # scaling 한 경우 traing

```
k_values = range(2, 8)
ari_scores = []

for k in k_values:
    kmeans = KMeans(n_clusters=k, random_state=42, n_init='auto')
    y_pred = kmeans.fit_predict(X_scaled)
    ari = adjusted_rand_score(y_true, y_pred)
    ari_scores.append({'K': k, 'ARI(Scaled)': round(ari, 4)})

results_df3 = pd.DataFrame(ari_scores)
print(results_df3)
```

K	ARI(Scaled)	
0	2	0.4805
1	3	0.7860
2	4	0.6545
3	5	0.5227
4	6	0.4717
5	7	0.3874

Case4: with Data Preprocessing (log transform for col 0,3,5,6 & Standard Scaling & Polynomial features)

In [53]: # Polynomial features

```
k_values = range(2, 8)
ari_scores = []

for k in k_values:
    kmeans = KMeans(n_clusters=k, random_state=42, n_init='auto')
    y_pred = kmeans.fit_predict(X_poly)
    ari = adjusted_rand_score(y_true, y_pred)
```

```

    ari_scores.append({'K': k, 'ARI(Poly)': round(ari, 4)})

results_df4 = pd.DataFrame(ari_scores)
print(results_df4)

   K   ARI(Poly)
0  2    0.2351
1  3    0.3490
2  4    0.3290
3  5    0.3494
4  6    0.2816
5  7    0.2401

```

Case5: with Data Preprocessing (log transform for col 0,3,5,6 & Standard Scaling & feature extraction)

In [79]: # PCA 이용하여 feature extraction

```

k_values = range(2, 8)
ari_scores = []

for k in k_values:
    kmeans = KMeans(n_clusters=k, random_state=42, n_init='auto')
    y_pred = kmeans.fit_predict(X_pca)
    ari = adjusted_rand_score(y_true, y_pred)
    ari_scores.append({'K': k, 'ARI(PCA)': round(ari, 4)})

results_df = pd.DataFrame(ari_scores)
print(results_df5)

```

K	ARI(PCA)
0	0.4805
1	0.7631
2	0.6191
3	0.5999
4	0.4745
5	0.4443

Case6: with Data Preprocessing (log transform for col 0,3,5,6 & Standard Scaling & Filter Method feature selection)

In [96]: from sklearn.feature_selection import SelectKBest, mutual_info_classif
from itertools import product

```

k_range = range(2, 8)          # 클러스터 수: 2~7
feature_range = range(2, 7)    # 선택 피처 수: 2~6

results = []
for k, n_features in product(k_range, feature_range):
    # 피처 선택
    selector = SelectKBest(mutual_info_classif, k=n_features)
    X_selected = selector.fit_transform(X_scaled, y_true)

    kmeans = KMeans(n_clusters=k, random_state=42, n_init='auto')
    y_pred = kmeans.fit_predict(X_selected)

    # ARI 평가
    ari = adjusted_rand_score(y_true, y_pred)
    results.append({

```

```

        'Clusters_K': k,
        'Selected_Features': n_features,
        'ARI(Filter1)': round(ari, 4)
    })

# 5. 결과 정렬 및 상위 5개 출력
results_df6 = pd.DataFrame(results).sort_values(by='ARI(Filter1)', ascending=False)

# 6. 출력
print("KMeans Results with Feature Selection(mutual_info_classif):")
print(results_df6)

```

KMeans Results with Feature Selection(mutual_info_classif):

	Clusters_K	Selected_Features	ARI(Filter1)
9	3	6	0.7039
5	3	2	0.6595
7	3	4	0.6562
8	3	5	0.6532
6	3	3	0.6364
13	4	5	0.5709
12	4	4	0.5504
18	5	5	0.5455
14	4	6	0.5180
3	2	5	0.4912
4	2	6	0.4858
11	4	3	0.4850
1	2	3	0.4797
10	4	2	0.4765
0	2	2	0.4720
17	5	4	0.4708
2	2	4	0.4683
16	5	3	0.4544
23	6	5	0.4527
15	5	2	0.4523
24	6	6	0.4358
19	5	6	0.4347
21	6	3	0.4161
20	6	2	0.4096
28	7	5	0.3994
22	6	4	0.3855
26	7	3	0.3800
25	7	2	0.3773
29	7	6	0.3479
27	7	4	0.3470

Case6-(2): with Data Preprocessing (log transform for col 0,3,5,6 & Standard Scaling & Filter Method feature selection)

```

In [97]: from sklearn.feature_selection import SelectKBest, f_classif
from itertools import product

k_range = range(2, 8)          # 클러스터 수: 2~7
feature_range = range(2, 7)    # 선택 피처 수: 2~6

results = []
for k, n_features in product(k_range, feature_range):
    # 피처 선택
    selector = SelectKBest(f_classif, k=n_features)
    X_selected = selector.fit_transform(X_scaled, y_true)

```

```

# KMeans
kmeans = KMeans(n_clusters=k, random_state=42, n_init='auto')
y_pred = kmeans.fit_predict(X_selected)

# ARI 평가
ari = adjusted_rand_score(y_true, y_pred)
results.append({
    'Clusters_K': k,
    'Selected_Features': n_features,
    'ARI(Filter2)': round(ari, 4)
})

# 5. 결과 정렬 및 상위 5개 출력
results_df62 = pd.DataFrame(results).sort_values(by='ARI(Filter2)', ascending=False)

# 6. 출력
print("KMeans Results with Feature Selection(f_classif):")
print(results_df62)

```

KMeans Results with Feature Selection(f_classif):

	Clusters_K	Selected_Features	ARI(Filter2)
9	3	6	0.7039
5	3	2	0.6595
8	3	5	0.6532
7	3	4	0.6527
6	3	3	0.6364
12	4	4	0.6178
13	4	5	0.5709
18	5	5	0.5455
2	2	4	0.5183
14	4	6	0.5180
17	5	4	0.5127
3	2	5	0.4912
4	2	6	0.4858
11	4	3	0.4850
1	2	3	0.4797
10	4	2	0.4765
0	2	2	0.4720
22	6	4	0.4650
16	5	3	0.4544
23	6	5	0.4527
15	5	2	0.4523
24	6	6	0.4358
19	5	6	0.4347
21	6	3	0.4161
27	7	4	0.4158
20	6	2	0.4096
28	7	5	0.3994
26	7	3	0.3800
25	7	2	0.3773
29	7	6	0.3479

Case7: with Data Preprocessing (log transform for col 0,3,5,6 & Standard Scaling & Wrapper Method feature selection)

In [98]:

```

from sklearn.linear_model import LogisticRegression
from sklearn.feature_selection import SequentialFeatureSelector
from itertools import product

```

```
k_range = range(2, 8)      # 클러스터 수: 2~7
feature_range = range(2, 7)  # 선택 피처 수: 2~6

results = []
for k, n_features in product(k_range, feature_range):
    estimator = LogisticRegression()
    sfs = SequentialFeatureSelector(estimator, n_features_to_select=n_features,
    sfs.fit(X_scaled, y_true)

    X_wrapper = sfs.transform(X_scaled)

    kmeans = KMeans(n_clusters=k, random_state=42, n_init='auto')
    y_pred = kmeans.fit_predict(X_wrapper)

    # ARI 평가
    ari = adjusted_rand_score(y_true, y_pred)
    results.append({
        'Clusters_K': k,
        'Selected_Features': n_features,
        'ARI(Wrapper)': round(ari, 4)
    })

# 5. 결과 정렬 및 출력
results_df7 = pd.DataFrame(results).sort_values(by='ARI(Wrapper)', ascending=False)

# 6. 출력
print("KMeans Results with Feature Selection(Wrapper):")
print(results_df7)
```

KMeans Results with Feature Selection(Wrapper):			
	Clusters_K	Selected_Features	ARI(Wrapper)
9	3	6	0.7871
8	3	5	0.7109
13	4	5	0.6723
7	3	4	0.6723
14	4	6	0.6619
6	3	3	0.6085
18	5	5	0.5689
5	3	2	0.5522
17	5	4	0.5288
15	5	2	0.5283
12	4	4	0.5280
16	5	3	0.5116
19	5	6	0.5115
0	2	2	0.5087
1	2	3	0.5027
2	2	4	0.5027
3	2	5	0.4912
4	2	6	0.4858
23	6	5	0.4759
24	6	6	0.4694
11	4	3	0.4630
21	6	3	0.4615
22	6	4	0.4408
29	7	6	0.4405
26	7	3	0.4304
20	6	2	0.4294
10	4	2	0.4232
27	7	4	0.4151
25	7	2	0.4099
28	7	5	0.3893

Case8: with Data Preprocessing (log transform for col 0,3,5,6 & Standard Scaling & Embedded Method feature selection)

In [92]: #Lasso 기반 피처 선택

```
from sklearn.linear_model import Lasso
from sklearn.feature_selection import SelectFromModel

k_range = range(2, 8)                      # 클러스터 수: 2 ~ 7
alpha_values = [0.001, 0.005, 0.01, 0.05, 0.1] # Lasso alpha 값

results = []
for k, alpha in product(k_range, alpha_values):
    lasso = Lasso(alpha=alpha)
    model = lasso.fit(X_scaled, y_true)

    selector = SelectFromModel(model, prefit=True)
    X_embedded = selector.transform(X_scaled)

    if X_embedded.shape[1] == 0:
        continue

    kmeans = KMeans(n_clusters=k, random_state=42, n_init='auto')
    y_pred = kmeans.fit_predict(X_embedded)

    # ARI 평가
```

```

    ari = adjusted_rand_score(y_true, y_pred)
    results.append({
        'Clusters_K': k,
        'Lasso_Alpha': alpha,
        'Selected_Features': X_embedded.shape[1],
        'ARI(Embedded1)': round(ari, 4)
    })

# 5. 결과 정렬 및 출력
results_df8 = pd.DataFrame(results).sort_values(by='ARI(Embedded1)', ascending=False)

# 6. 출력
print("KMeans Results with Feature Selection(Embedded,Lasso):")
print(results_df8)

```

KMeans Results with Feature Selection(Embedded,Lasso):

	Clusters_K	Lasso_Alpha	Selected_Features	ARI(Embedded1)
5	3	0.001	7	0.7860
6	3	0.005	6	0.7521
8	3	0.050	5	0.7412
7	3	0.010	5	0.7412
13	4	0.050	5	0.6699
12	4	0.010	5	0.6699
10	4	0.001	7	0.6545
11	4	0.005	6	0.6261
9	3	0.100	3	0.5712
18	5	0.050	5	0.5705
17	5	0.010	5	0.5705
16	5	0.005	6	0.5662
14	4	0.100	3	0.5353
15	5	0.001	7	0.5227
3	2	0.050	5	0.4858
2	2	0.010	5	0.4858
1	2	0.005	6	0.4838
0	2	0.001	7	0.4805
20	6	0.001	7	0.4717
21	6	0.005	6	0.4671
22	6	0.010	5	0.4611
23	6	0.050	5	0.4611
19	5	0.100	3	0.4501
4	2	0.100	3	0.4399
26	7	0.005	6	0.4199
27	7	0.010	5	0.4068
28	7	0.050	5	0.4068
25	7	0.001	7	0.3874
29	7	0.100	3	0.3534
24	6	0.100	3	0.3505

Case8-2: with Data Preprocessing (log transform for col 0,3,5,6 & Standard Scaling & Embedded Method feature selection)

In [93]: #Random Forest 기반 피처 선택

```

from sklearn.ensemble import RandomForestClassifier
from sklearn.feature_selection import SelectFromModel

k_range = range(2, 8)                      # 클러스터 수: 2 ~ 7

results = []

```

```

for k in k_range:
    rf = RandomForestClassifier(random_state=42)
    rf.fit(X_scaled, y_true)

    selector = SelectFromModel(rf, threshold="median")
    X_selected = selector.transform(X_scaled)

    if X_selected.shape[1] == 0:
        continue
    kmeans = KMeans(n_clusters=k, random_state=42, n_init='auto')
    y_pred = kmeans.fit_predict(X_selected)

    ari = adjusted_rand_score(y_true, y_pred)
    results.append({
        "Clusters_K": k,
        "Selected_Features": X_selected.shape[1],
        "ARI(Embedded2)": round(ari, 4)
    })

# 결과 정렬 및 출력
results_df82 = pd.DataFrame(results).sort_values(by='ARI(Embedded2)', ascending=False)

# 6. 출력
print("KMeans Results with Feature Selection(Embedded,RF):")
print(results_df82)

```

KMeans Results with Feature Selection(Embedded,RF):

	Clusters_K	Selected_Features	ARI(Embedded2)
1	3	4	0.6527
2	4	4	0.6178
0	2	4	0.5183
3	5	4	0.5127
4	6	4	0.4650
5	7	4	0.4158

Evaluation & 2D visualization

```

In [81]: df_merged = results_df1.merge(results_df2, on='K') \
            .merge(results_df3, on='K') \
            .merge(results_df4, on='K') \
            .merge(results_df5, on='K')

# 보기 좋게 출력
print("Merged ARI Scores by K:")
display(df_merged)

```

Merged ARI Scores by K:

K	ARI(raw data)	ARI(log transform)	ARI(Scaled)	ARI(Poly)	ARI(PCA)
0 2	0.4648	0.4815	0.4805	0.2351	0.4805
1 3	0.7166	0.6699	0.7860	0.3490	0.7631
2 4	0.5467	0.6197	0.6545	0.3290	0.6191
3 5	0.5600	0.4745	0.5227	0.3494	0.5999
4 6	0.4699	0.4389	0.4717	0.2816	0.4745
5 7	0.4658	0.4268	0.3874	0.2401	0.4443

In [100...]

```
# 각 결과에서 상위 5개 행 추출 및 인덱스 통일
top5_filter1 = results_df6[['Clusters_K', 'Selected_Features', 'ARI(Filter1)']]
top5_filter2 = results_df62[['Clusters_K', 'Selected_Features', 'ARI(Filter2)']]
top5_wrapper = results_df7[['Clusters_K', 'Selected_Features', 'ARI(Wrapper)']]
top5_EMBEDDED1 = results_df8[['Clusters_K', 'Selected_Features', 'ARI(Embedded1)']]
top5_EMBEDDED2 = results_df82[['Clusters_K', 'Selected_Features', 'ARI(Embedded2)']]

# 가로로 병합
summary_top6 = pd.concat([top5_filter1, top5_filter2, top5_wrapper, top5_EMBEDDED1, top5_EMBEDDED2])

# 결과 출력
print("Top 6 Results per Feature Selection Method")
display(summary_top6)
```

Top 6 Results per Feature Selection Method

	Clusters_K	Selected_Features	ARI(Filter1)	Clusters_K	Selected_Features	ARI(Filter2)
0	3	6	0.7039	3	6	0.7039
1	3	2	0.6595	3	2	0.6595
2	3	4	0.6562	3	5	0.6532
3	3	5	0.6532	3	4	0.6527
4	3	3	0.6364	3	3	0.6364
5	4	5	0.5709	4	4	0.6178



In [72]:

```
from sklearn.manifold import TSNE

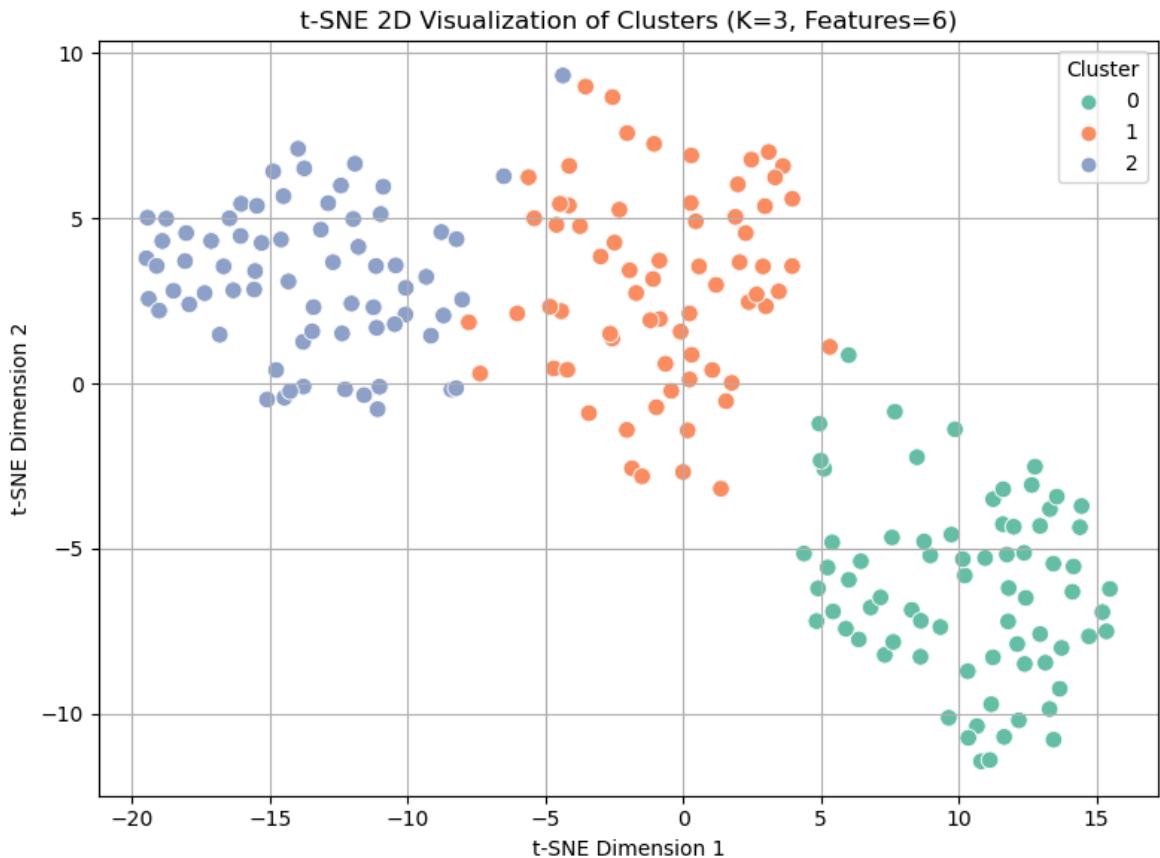
best_k = 3
best_n_features = 6

estimator = LogisticRegression()
sfs = SequentialFeatureSelector(estimator, n_features_to_select=best_n_features,
sfs.fit(X_scaled, y_true)
X_selected = sfs.transform(X_scaled)

kmeans = KMeans(n_clusters=best_k, random_state=42, n_init='auto')
clusters = kmeans.fit_predict(X_selected)

# t-SNE로 2D 시각화
tsne = TSNE(n_components=2, random_state=42, perplexity=30)
X_tsne = tsne.fit_transform(X_selected)
```

```
# 결과 시각화
plt.figure(figsize=(8, 6))
sns.scatterplot(x=X_tsne[:, 0], y=X_tsne[:, 1], hue=clusters, palette='Set2', s=70)
plt.title(f"t-SNE 2D Visualization of Clusters (K={best_k}, Features={best_n_features})")
plt.xlabel("t-SNE Dimension 1")
plt.ylabel("t-SNE Dimension 2")
plt.legend(title="Cluster")
plt.grid(True)
plt.tight_layout()
plt.show()
```

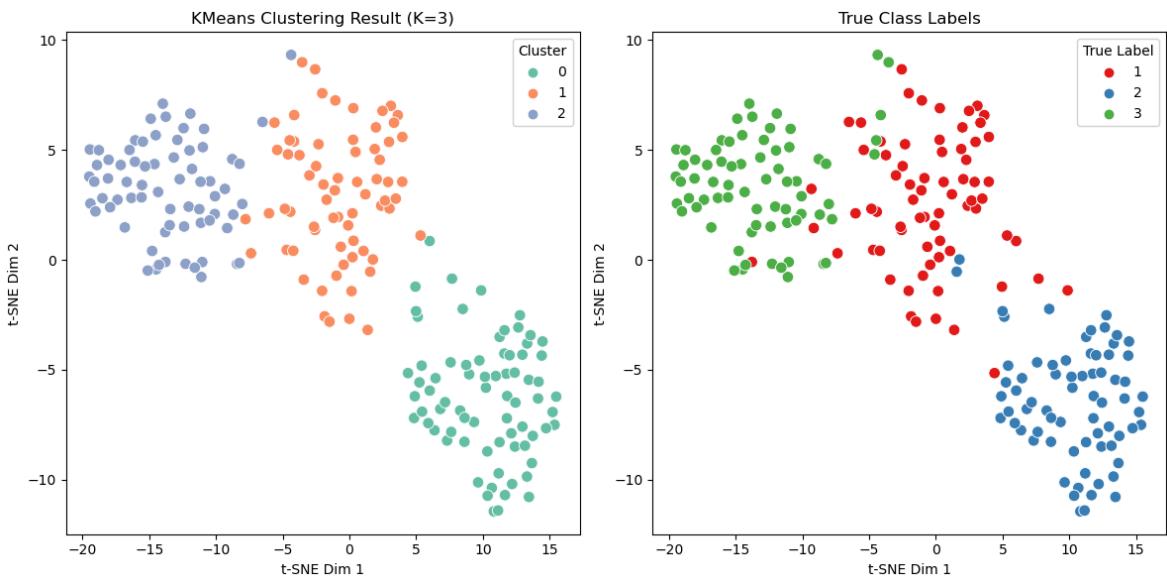


```
In [77]: plt.figure(figsize=(12, 6))

# (1) KMeans 클러스터링 결과
plt.subplot(1, 2, 1)
sns.scatterplot(x=X_tsne[:, 0], y=X_tsne[:, 1], hue=clusters, palette='Set2', s=70)
plt.title(f"KMeans Clustering Result (K={best_k})")
plt.xlabel("t-SNE Dim 1")
plt.ylabel("t-SNE Dim 2")
plt.legend(title="Cluster")

# (2) 실제 클래스 라벨
plt.subplot(1, 2, 2)
sns.scatterplot(x=X_tsne[:, 0], y=X_tsne[:, 1], hue=y_true, palette='Set1', s=70)
plt.title("True Class Labels")
plt.xlabel("t-SNE Dim 1")
plt.ylabel("t-SNE Dim 2")
plt.legend(title="True Label")

plt.tight_layout()
plt.show()
```



In []:

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