PART 1: Data importing and cleaning

- Downloaded 5 years EOD data for AAPL, MSFT, SPY, and VIX
- Filled missing dates to align time series
- Removed outliers using rolling z-scores
- Scaled with standard scaling

```
import yfinance as yf
import pandas as pd
import numpy as np
from sklearn.preprocessing import StandardScaler, MinMaxScaler
import matplotlib.pyplot as plt
import seaborn as sns
from sklearn.linear_model import LinearRegression, LogisticRegression
from sklearn.ensemble import RandomForestRegressor
from sklearn.tree import DecisionTreeClassifier
from sklearn.metrics import mean_squared_error, r2_score,
accuracy_score, f1_score
import matplotlib.cm as cm
import feedparser
from sklearn.cluster import KMeans, AgglomerativeClustering
from sklearn.metrics import silhouette_score, silhouette_samples
import scipy.cluster.hierarchy as sch
import nltk
from nltk.corpus import stopwords
from nltk.stem import WordNetLemmatizer
import string
from nltk.sentiment.vader import SentimentIntensityAnalyzer

tickers = ['AAPL', 'MSFT', 'SPY', '^VIX']

data = yf.download(tickers, period='5y', interval='1d')['Close']
data.ffill(inplace=True)
data.dropna(inplace=True)

data.head()
```

```
/var/folders/0f/l_wv06ws6k3063l3r6mv6xb80000gn/T/
ipykernel_8265/245659955.py:10: FutureWarning: YF.download() has
changed argument auto_adjust default to True
  data = yf.download(tickers, period='5y', interval='1d')['Close']
[**********************100%**********************]  4 of 4 completed
```

Ticker	AAPL	MSFT	SPY	^VIX
Date				
2020-08-12	109.926849	200.421951	314.196594	22.280001
2020-08-13	111.872284	199.952469	313.628448	22.129999
2020-08-14	111.772568	200.144073	313.637787	22.049999
2020-08-17	111.480751	201.466278	314.634125	21.350000
2020-08-18	112.409714	202.625549	315.313873	21.510000

```python
for ticker in tickers:
    data[ticker] = data[ticker].ffill()

data.dropna()
```

```
Ticker            AAPL        MSFT         SPY       ^VIX
Date
2020-08-12  109.926834  200.421921  314.196472  22.280001
2020-08-13  111.872269  199.952469  313.628479  22.129999
2020-08-14  111.772568  200.144058  313.637878  22.049999
2020-08-17  111.480751  201.466263  314.634125  21.350000
2020-08-18  112.409698  202.625580  315.313843  21.510000
...                ...         ...         ...        ...
2025-08-06  213.008255  524.940002  632.780029  16.770000
2025-08-07  219.780563  520.840027  632.250000  16.570000
2025-08-08  229.090012  522.039978  637.179993  15.150000
2025-08-11  227.179993  521.770020  635.919983  16.250000
2025-08-12  228.899994  525.010010  639.229980  15.600000

[1256 rows x 4 columns]
```

```python
def remove_outliers_rolling_zscore(df, window=30, threshold=10):
    df_clean = df.copy()
    rolling_mean = df.rolling(window).mean()
    rolling_std = df.rolling(window).std()
    z_scores = (df - rolling_mean) / rolling_std
    df_clean = df.where(z_scores.abs() <= threshold)
    df_clean.ffill(inplace=True)
    return df_clean

clean_close = remove_outliers_rolling_zscore(data)

print(clean_close)
```

```
Ticker            AAPL        MSFT         SPY   ^VIX
Date
2020-08-12         NaN         NaN         NaN    NaN
2020-08-13         NaN         NaN         NaN    NaN
2020-08-14         NaN         NaN         NaN    NaN
2020-08-17         NaN         NaN         NaN    NaN
2020-08-18         NaN         NaN         NaN    NaN
...                ...         ...         ...    ...
2025-08-06  213.008255  524.940002  632.780029  16.77
2025-08-07  219.780563  520.840027  632.250000  16.57
2025-08-08  229.090012  522.039978  637.179993  15.15
2025-08-11  227.179993  521.770020  635.919983  16.25
2025-08-12  228.899994  525.010010  639.229980  15.60

[1256 rows x 4 columns]
```

```
scalers = {}
scaled_close = pd.DataFrame(index=clean_close.index)

for ticker in tickers:
    scaler = StandardScaler()
    scaled_col = scaler.fit_transform(clean_close[[ticker]])
    scaled_close[ticker] = scaled_col.flatten()
    scalers[ticker] = scaler

scaled_close
```

Date	AAPL	MSFT	SPY	^VIX
2020-08-12	NaN	NaN	NaN	NaN
2020-08-13	NaN	NaN	NaN	NaN
2020-08-14	NaN	NaN	NaN	NaN
2020-08-17	NaN	NaN	NaN	NaN
2020-08-18	NaN	NaN	NaN	NaN
...	...	...	...	...
2025-08-06	1.212293	2.448113	2.219073	-0.564059
2025-08-07	1.402573	2.398359	2.212682	-0.600115
2025-08-08	1.664138	2.412921	2.272129	-0.856109
2025-08-11	1.610472	2.409644	2.256936	-0.657804
2025-08-12	1.658799	2.448963	2.296849	-0.774984

[1256 rows x 4 columns]

Part 2: Feature engineering

- Created technical indicators and got features
- Labeled data on 5-day future returns direction
- Explored feature relationships with PCA
- Selected top 10 features

```
def SMA(series, window):
    return series.rolling(window).mean()

def EMA(series, window):
    return series.ewm(span=window, adjust=False).mean()

def RSI(series, window=14):
    delta = series.diff()
    gain = delta.clip(lower=0)
    loss = -delta.clip(upper=0)
    avg_gain = gain.rolling(window).mean()
    avg_loss = loss.rolling(window).mean()
    rs = avg_gain / avg_loss
    rsi = 100 - (100 / (1 + rs))
    return rsi
```

```python
def Bollinger_Bands(series, window=20, num_std=2):
    sma = series.rolling(window).mean()
    std = series.rolling(window).std()
    upper = sma + (num_std * std)
    lower = sma - (num_std * std)
    return upper, lower

def MACD(series, fast=12, slow=26, signal=9):
    ema_fast = EMA(series, fast)
    ema_slow = EMA(series, slow)
    macd = ema_fast - ema_slow
    signal_line = EMA(macd, signal)
    hist = macd - signal_line
    return macd, signal_line, hist


df = clean_close[['AAPL']].copy()

df['SMA_20'] = SMA(df['AAPL'], 20)
df['EMA_20'] = EMA(df['AAPL'], 20)
df['RSI_14'] = RSI(df['AAPL'])
df['BB_upper'], df['BB_lower'] = Bollinger_Bands(df['AAPL'])
df['MACD'], df['MACD_signal'], df['MACD_hist'] = MACD(df['AAPL'])

df['Return_1d'] = df['AAPL'].pct_change(1)
df['Return_5d'] = df['AAPL'].pct_change(5)
df['Return_10d'] = df['AAPL'].pct_change(10)

df['Momentum_1d'] = df['AAPL'] - df['AAPL'].shift(1)
df['Momentum_5d'] = df['AAPL'] - df['AAPL'].shift(5)
df['Momentum_10d'] = df['AAPL'] - df['AAPL'].shift(10)

df.dropna(inplace=True)

display(df.head())

# to save:
#df.to_csv('output.csv', index=False)
```

Ticker	AAPL	SMA_20	EMA_20	RSI_14	BB_upper
Date					
2020-10-20	114.304062	112.780793	112.848918	52.563308	120.957995
2020-10-21	113.681519	113.254991	112.928213	50.121869	120.367004
2020-10-22	112.592102	113.621220	112.896202	54.524383	119.677372
2020-10-23	111.901466	113.755457	112.801466	47.335779	119.512162

```
2020-10-26  111.911201  113.759835  112.716679  53.926079  119.510484


Ticker        BB_lower      MACD  MACD_signal  MACD_hist  Return_1d  \
Date
2020-10-20  104.603591  2.526094     2.664306  -0.138212   0.013192
2020-10-21  106.142978  2.283982     2.588241  -0.304259  -0.005446
2020-10-22  107.565068  1.981360     2.466865  -0.485505  -0.009583
2020-10-23  107.998751  1.666590     2.306810  -0.640220  -0.006134
2020-10-26  108.009186  1.401760     2.125800  -0.724040   0.000087

Ticker      Return_5d  Return_10d  Momentum_1d  Momentum_5d
Momentum_10d
Date

2020-10-20  -0.029645    0.038441     1.488243    -3.492050
4.231308
2020-10-21  -0.035647    0.015554    -0.622543    -4.202148
1.741150
2020-10-22  -0.041090    0.006784    -1.089417    -4.824661
0.758728
2020-10-23  -0.033440   -0.016500    -0.690636    -3.871407    -
1.877319
2020-10-26  -0.008019   -0.075161     0.009735    -0.904617    -
9.094887

df['Future_Close_5d'] = df['AAPL'].shift(-5)
df['Target'] = (df['Future_Close_5d'] > df['AAPL']).astype(int)
df.dropna(subset=['Target'], inplace=True)

df[['AAPL', 'Future_Close_5d', 'Target']]

Ticker            AAPL  Future_Close_5d  Target
Date
2020-10-20  114.304062       113.418892       0
2020-10-21  113.681519       108.166214       0
2020-10-22  112.592102       112.173820       0
2020-10-23  111.901466       105.890060       0
2020-10-26  111.911201       105.802513       0
...                ...              ...     ...
2025-08-06  213.008255              NaN       0
2025-08-07  219.780563              NaN       0
2025-08-08  229.090012              NaN       0
2025-08-11  227.179993              NaN       0
2025-08-12  228.899994              NaN       0

[1208 rows x 3 columns]

features = ['SMA_20', 'EMA_20', 'RSI_14', 'BB_upper', 'BB_lower',
            'MACD', 'MACD_signal', 'MACD_hist',
            'Return_1d', 'Return_5d', 'Return_10d',
```

```
            'Momentum_1d', 'Momentum_5d', 'Momentum_10d']

X = df[features]
y = df['Target']

X.head(), y.head()
```

```
(Ticker          SMA_20      EMA_20     RSI_14    BB_upper    BB_lower
\
 Date

 2020-10-20  112.780793  112.848918  52.563308  120.957995  104.603591

 2020-10-21  113.254991  112.928213  50.121869  120.367004  106.142978

 2020-10-22  113.621220  112.896202  54.524383  119.677372  107.565068

 2020-10-23  113.755457  112.801466  47.335779  119.512162  107.998751

 2020-10-26  113.759835  112.716679  53.926079  119.510484  108.009186


 Ticker           MACD  MACD_signal  MACD_hist  Return_1d  Return_5d  \
 Date
 2020-10-20  2.526094     2.664306  -0.138212   0.013192  -0.029645
 2020-10-21  2.283982     2.588241  -0.304259  -0.005446  -0.035647
 2020-10-22  1.981360     2.466865  -0.485505  -0.009583  -0.041090
 2020-10-23  1.666590     2.306810  -0.640220  -0.006134  -0.033440
 2020-10-26  1.401760     2.125800  -0.724040   0.000087  -0.008019

 Ticker      Return_10d  Momentum_1d  Momentum_5d  Momentum_10d
 Date
 2020-10-20    0.038441     1.488243    -3.492050      4.231308
 2020-10-21    0.015554    -0.622543    -4.202148      1.741150
 2020-10-22    0.006784    -1.089417    -4.824661      0.758728
 2020-10-23   -0.016500    -0.690636    -3.871407     -1.877319
 2020-10-26   -0.075161     0.009735    -0.904617     -9.094887  ,
 Date
 2020-10-20    0
 2020-10-21    0
 2020-10-22    0
 2020-10-23    0
 2020-10-26    0
 Name: Target, dtype: int64)
```

PART 3: Training ML model

- Training metrics being significantly better than test metrics would suggest overfitting.
- Walk-forward validation avoids look-ahead bias and simulates real-time performance.
- Feature lagging ensures no future info leaks into predictions.

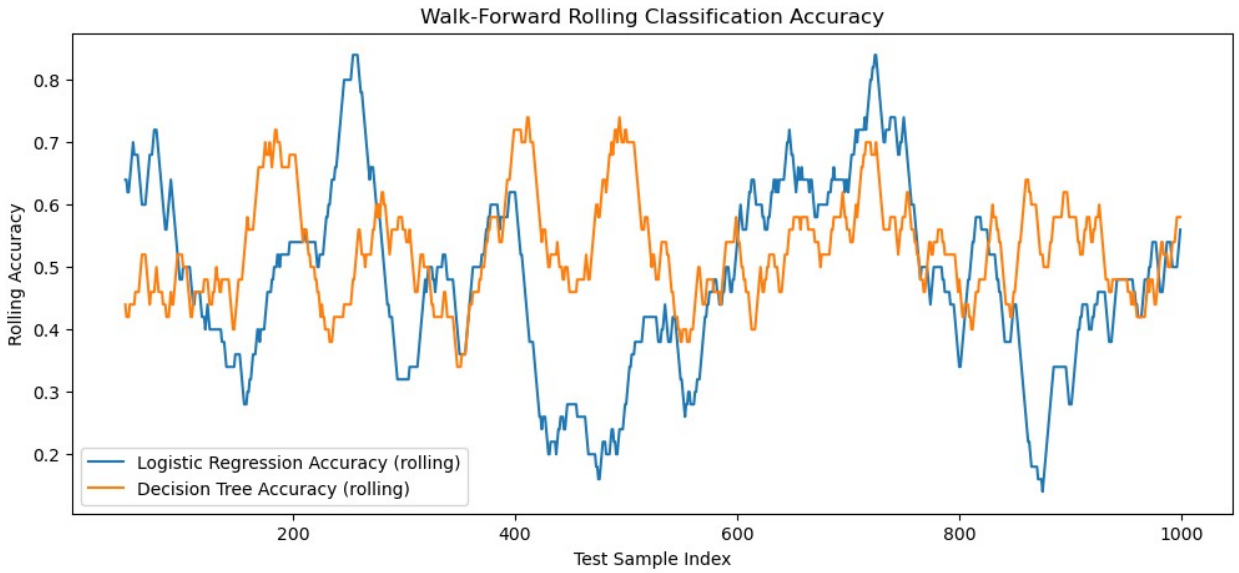
- Consider hyperparameter tuning to reduce overfitting.

```
window_size = 200
test_size = 50
X_lagged = X.shift(1).dropna()
y_aligned = y.loc[X_lagged.index]

predictions = {
    'LinearRegression': [],
    'RandomForestRegressor': [],
    'LogisticRegression': [],
    'DecisionTreeClassifier': []
}
true_vals = []

start = 0
end = window_size

dates = X_lagged.index

while end + test_size <= len(X_lagged):
    train_X = X_lagged.iloc[start:end]
    train_y = y_aligned.iloc[start:end]
    test_X = X_lagged.iloc[end:end+test_size]
    test_y = y_aligned.iloc[end:end+test_size]
    true_vals.extend(test_y)

    # LR
    lr = LinearRegression()
    lr.fit(train_X, train_y)
    pred_lr = lr.predict(test_X)
    predictions['LinearRegression'].extend(pred_lr)

    # RF
    rf = RandomForestRegressor(n_estimators=100, random_state=42)
    rf.fit(train_X, train_y)
    pred_rf = rf.predict(test_X)
    predictions['RandomForestRegressor'].extend(pred_rf)

    # LogR
    logr = LogisticRegression(max_iter=1000)
    logr.fit(train_X, train_y)
    pred_logr = logr.predict(test_X)
    predictions['LogisticRegression'].extend(pred_logr)

    # DT
    dt = DecisionTreeClassifier(random_state=42)
    dt.fit(train_X, train_y)
    pred_dt = dt.predict(test_X)
    predictions['DecisionTreeClassifier'].extend(pred_dt)
```

```
    start += test_size
    end += test_size
```

```
/opt/anaconda3/lib/python3.11/site-packages/sklearn/linear_model/
_logistic.py:458: ConvergenceWarning: lbfgs failed to converge
(status=1):
STOP: TOTAL NO. of ITERATIONS REACHED LIMIT.

Increase the number of iterations (max_iter) or scale the data as
shown in:
    https://scikit-learn.org/stable/modules/preprocessing.html
Please also refer to the documentation for alternative solver options:

https://scikit-learn.org/stable/modules/linear_model.html#logistic-
regression
  n_iter_i = _check_optimize_result(
```

```
window_plot = 50  # rolling window for metric

acc_logr = pd.Series(pred_logr ==
true_vals).rolling(window_plot).mean()
acc_dt = pd.Series(pred_dt == true_vals).rolling(window_plot).mean()

plt.figure(figsize=(12,5))
plt.plot(acc_logr, label='Logistic Regression Accuracy (rolling)')
plt.plot(acc_dt, label='Decision Tree Accuracy (rolling)')
plt.xlabel('Test Sample Index')
plt.ylabel('Rolling Accuracy')
plt.title('Walk-Forward Rolling Classification Accuracy')
plt.legend()
plt.show()
```

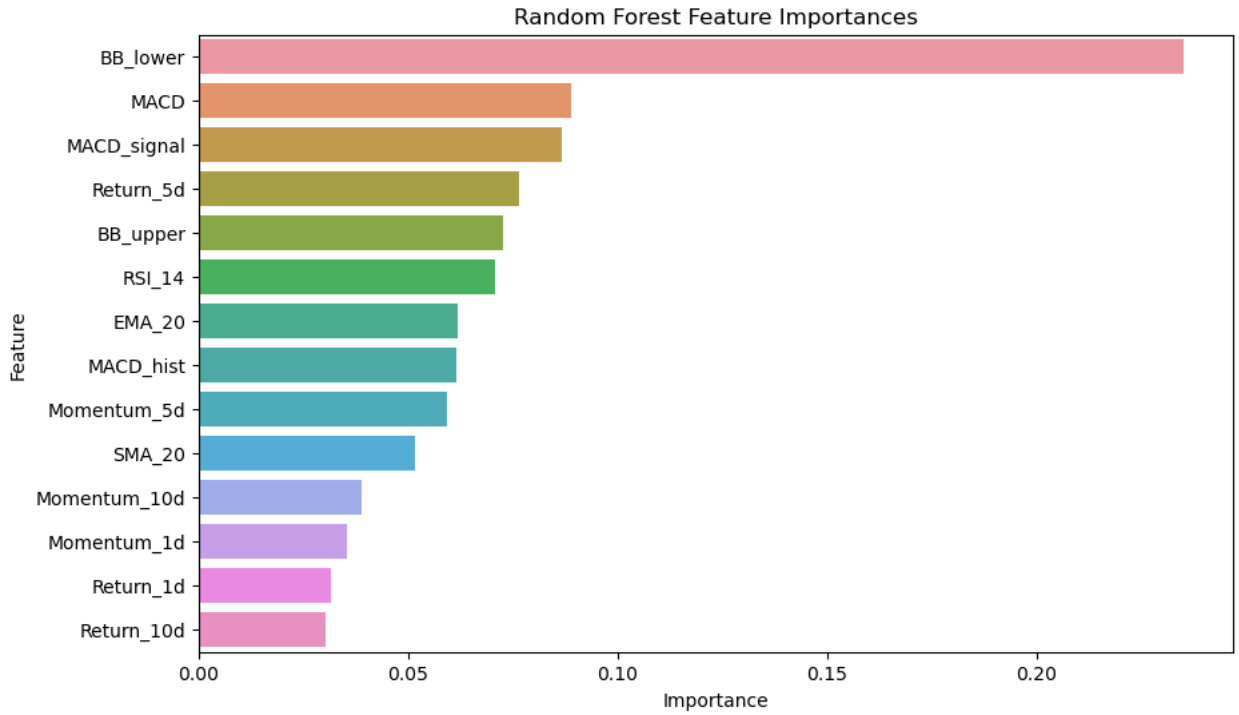


PART 4: Model Evaluation

```
true_vals = np.array(true_vals)
pred_lr = np.array(predictions['LinearRegression'])
pred_rf = np.array(predictions['RandomForestRegressor'])
pred_logr = np.array(predictions['LogisticRegression'])
pred_dt = np.array(predictions['DecisionTreeClassifier'])

print("LR R^2:", r2_score(true_vals, pred_lr))
print("LR RMSE:", np.sqrt(mean_squared_error(true_vals, pred_lr)))

print("RF R^2:", r2_score(true_vals, pred_rf))
print("RF RMSE:", np.sqrt(mean_squared_error(true_vals, pred_rf)))

print("LogR Accuracy:", accuracy_score(true_vals, pred_logr))
print("LogR F1:", f1_score(true_vals, pred_logr))

print("DT Accuracy:", accuracy_score(true_vals, pred_dt))
print("DT F1:", f1_score(true_vals, pred_dt))
```

```
Linear Regression R^2: -1.0095792785779905
Linear Regression RMSE: 0.7066386980358353
Random Forest Regression R^2: -0.18715022195034625
Random Forest Regression RMSE: 0.5431223619038347
Logistic Regression Accuracy: 0.485
Logistic Regression F1: 0.5478489903424056
Decision Tree Accuracy: 0.527
Decision Tree F1: 0.5525070955534532
```

```
importances = rf.feature_importances_
feature_names = X_lagged.columns

fi_df = pd.DataFrame({'Feature': feature_names, 'Importance':
importances})
fi_df = fi_df.sort_values(by='Importance', ascending=False)

plt.figure(figsize=(10,6))
sns.barplot(x='Importance', y='Feature', data=fi_df)
plt.title('Random Forest Feature Importances')
plt.show()
```



PART 5: Clustering

Source for markdown: Internet search for clustering techniques, I was not particularly familiar with them.

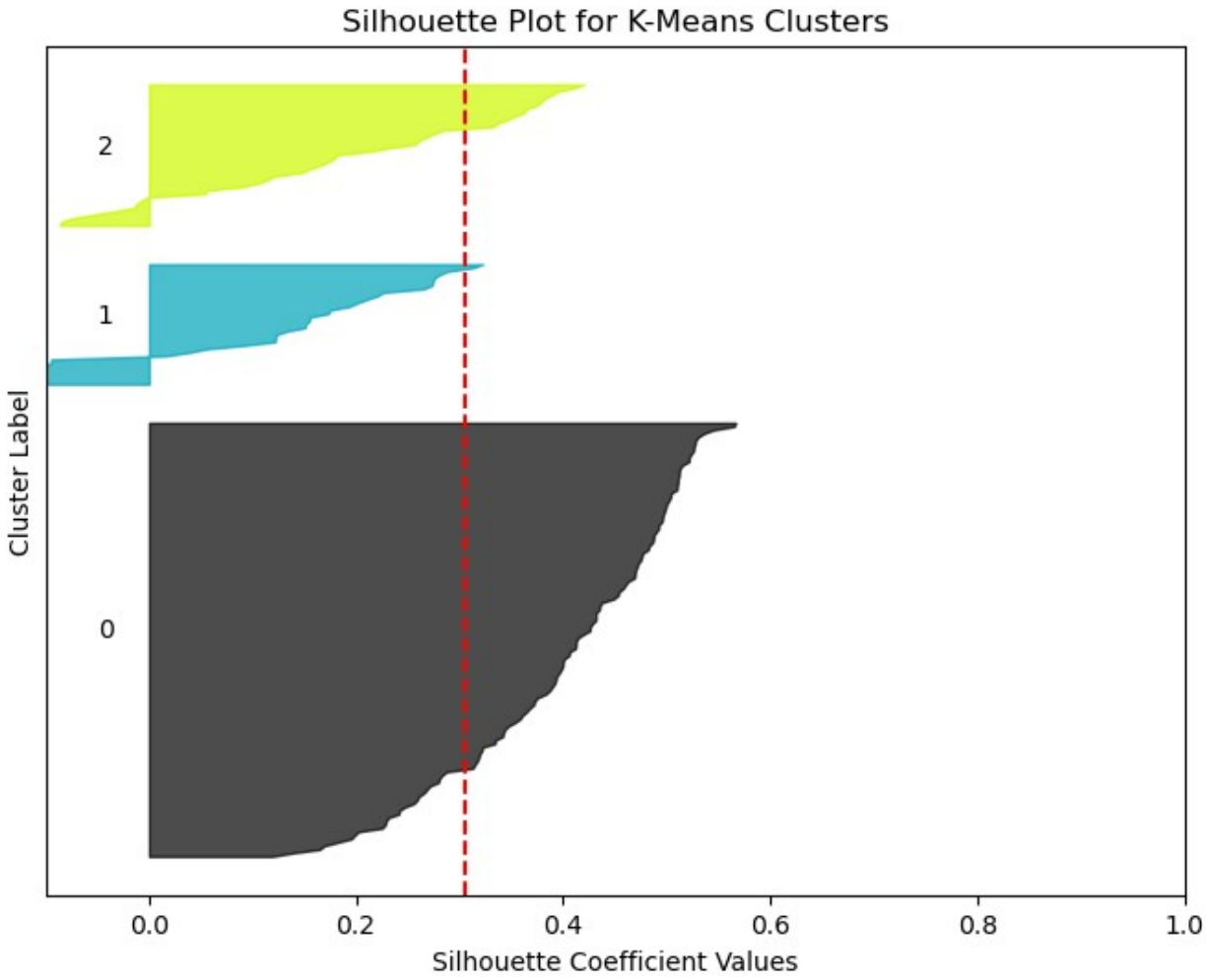
- Silhouette scores indicate the chosen number of clusters captures meaningful groupings, but further tuning may improve separation.
- Dendrogram shows hierarchical relationships and potential for sub-cluster identification.

```
X_scaled = scaler.fit_transform(train_X)

k = 3

kmeans = KMeans(n_clusters=k, random_state=42)
clusters = kmeans.fit_predict(X_scaled)

sil_score = silhouette_score(X_scaled, clusters)
print(f"Silhouette Score for k={k}: {sil_score:.3f}")
```

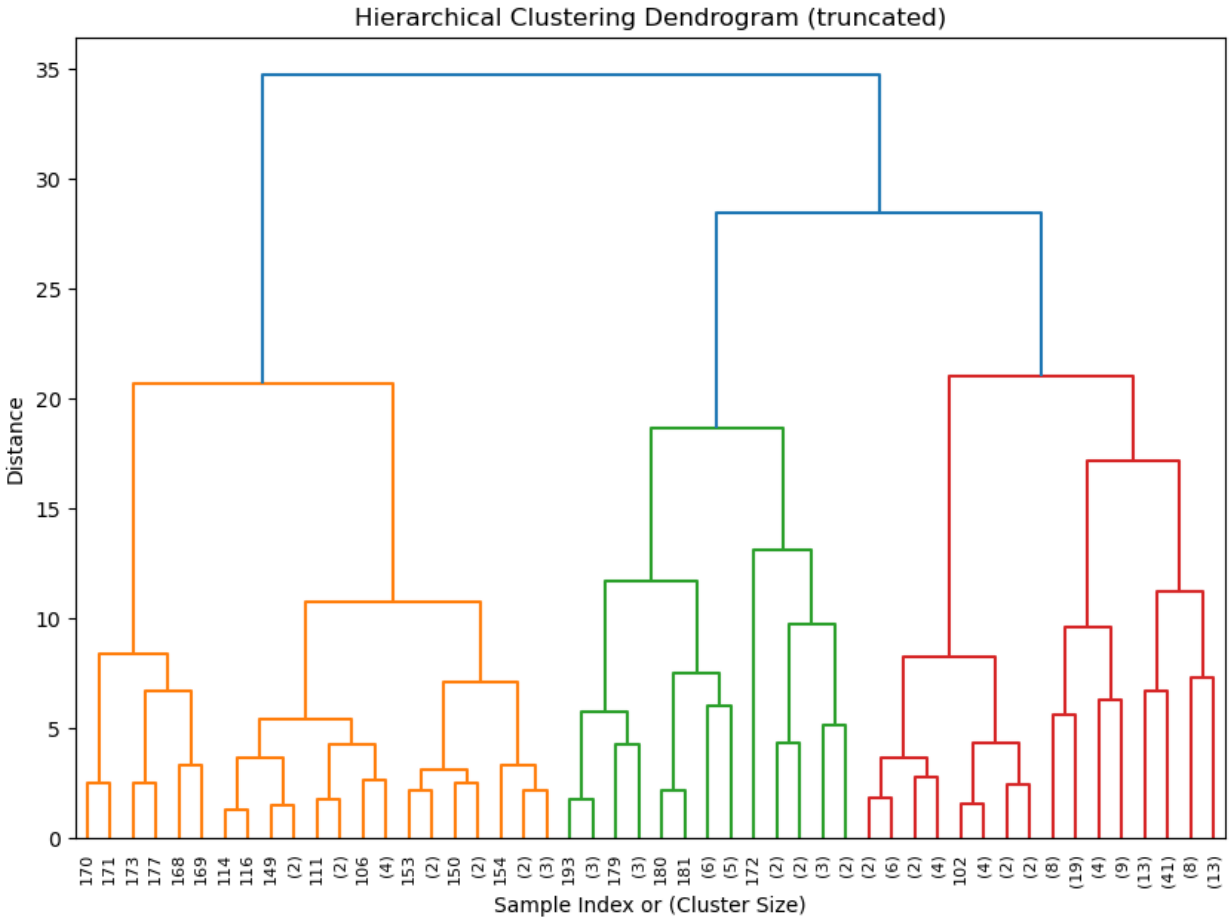
```
Silhouette Score for k=3: 0.306

/opt/anaconda3/lib/python3.11/site-packages/sklearn/cluster/
_kmeans.py:870: FutureWarning: The default value of `n_init` will
change from 10 to 'auto' in 1.4. Set the value of `n_init` explicitly
to suppress the warning
  warnings.warn(
```

```
fig, ax1 = plt.subplots(figsize=(8,6))
```

```
sample_silhouette_values = silhouette_samples(X_scaled, clusters)
y_lower = 10
for i in range(k):
    ith_cluster_silhouette_values = sample_silhouette_values[clusters
== i]
    ith_cluster_silhouette_values.sort()

    size_cluster_i = ith_cluster_silhouette_values.shape[0]
    y_upper = y_lower + size_cluster_i

    color = cm.nipy_spectral(float(i) / k)
    ax1.fill_betweenx(np.arange(y_lower, y_upper),
                      0, ith_cluster_silhouette_values,
                      facecolor=color, edgecolor=color, alpha=0.7)
    ax1.text(-0.05, y_lower + 0.5 * size_cluster_i, str(i))
    y_lower = y_upper + 10

ax1.set_title("Silhouette Plot for K-Means Clusters")
ax1.set_xlabel("Silhouette Coefficient Values")
ax1.set_ylabel("Cluster Label")
ax1.axvline(x=sil_score, color="red", linestyle="--")
ax1.set_yticks([])
ax1.set_xlim([-0.1, 1])
plt.show()
```




```
linked = sch.linkage(X_scaled, method='ward')

plt.figure(figsize=(10, 7))
dendro = sch.dendrogram(linked, truncate_mode='level', p=5)
plt.title('Hierarchical Clustering Dendrogram (truncated)')
plt.xlabel('Sample Index or (Cluster Size)')
plt.ylabel('Distance')
plt.show()
```



PART 6: NLP Sentiment

Price tends to move with nature of the news! - which seems contradictory to the results in the NLP quiz.

```
tickers = ['AAPL', 'SPY']
all_articles = []

for ticker in tickers:
    rss_url = f'https://news.google.com/rss/search?q={ticker}
+when:7d&hl=en-US&gl=US&ceid=US:en'
    feed = feedparser.parse(rss_url)

    for entry in feed.entries:
        all_articles.append({
            'timestamp': entry.published,
            'ticker': ticker,
            'headline': entry.title,
            'source': entry.source.title if 'source' in entry else
'Google News'
        })
```

```
news_df = pd.DataFrame(all_articles)
news_df['timestamp'] = pd.to_datetime(news_df['timestamp'])
news_df['date'] = news_df['timestamp'].dt.date

print(f"Collected {len(news_df)} news headlines")
news_df.head()
```

```
Collected 200 news headlines
```

```
            timestamp ticker  \
0 2025-08-11 14:08:28   AAPL
1 2025-08-08 10:02:05   AAPL
2 2025-08-06 14:46:00   AAPL
3 2025-08-09 21:52:09   AAPL
4 2025-08-06 23:02:00   AAPL

                                            headline
source  \
0  Apple Inc (AAPL) Increases its Total Investmen...         Yahoo
Finance
1  After Earnings, Is Apple Stock a Buy, a Sell, ...
Morningstar
2  $AAPL stock is up 3% today. Here's what we see...  Quiver
Quantitative
3  Apple Stock (AAPL) Pops as Trump Vows 100% Tar...
TipRanks
4  Apple stock extends gains, rises 3% postmarket...         Seeking
Alpha

         date
0  2025-08-11
1  2025-08-08
2  2025-08-06
3  2025-08-09
4  2025-08-06
```

```
nltk.download('stopwords')
nltk.download('wordnet')

stop_words = set(stopwords.words('english'))
lemmatizer = WordNetLemmatizer()

def preprocess_text(text):
    text = text.lower()
    text = text.translate(str.maketrans('', '', string.punctuation))
    tokens = text.split()
    tokens = [w for w in tokens if w not in stop_words]
    tokens = [lemmatizer.lemmatize(w) for w in tokens]
    return ' '.join(tokens)
```

```
news_df['clean_headline'] =
news_df['headline'].astype(str).apply(preprocess_text)
news_df.head()
```

```
[nltk_data] Downloading package stopwords to
[nltk_data]     /Users/shubhaankargupta/nltk_data...
[nltk_data]   Unzipping corpora/stopwords.zip.
[nltk_data] Downloading package wordnet to
[nltk_data]     /Users/shubhaankargupta/nltk_data...
```

```
             timestamp ticker  \
0 2025-08-11 14:08:28   AAPL
1 2025-08-08 10:02:05   AAPL
2 2025-08-06 14:46:00   AAPL
3 2025-08-09 21:52:09   AAPL
4 2025-08-06 23:02:00   AAPL

                                              headline
source  \
0  Apple Inc (AAPL) Increases its Total Investmen...         Yahoo
Finance
1  After Earnings, Is Apple Stock a Buy, a Sell, ...
Morningstar
2  $AAPL stock is up 3% today. Here's what we see...  Quiver
Quantitative
3  Apple Stock (AAPL) Pops as Trump Vows 100% Tar...
TipRanks
4  Apple stock extends gains, rises 3% postmarket...         Seeking
Alpha

         date                                      clean_headline
0  2025-08-11  apple inc aapl increase total investment 600 b...
1  2025-08-08  earnings apple stock buy sell fairly valued mo...
2  2025-08-06  aapl stock 3 today here see data quiver quanti...
3  2025-08-09  apple stock aapl pop trump vow 100 tariff reli...
4  2025-08-06  apple stock extends gain rise 3 postmarket con...
```

```
nltk.download('vader_lexicon')

sid = SentimentIntensityAnalyzer()

news_df['sentiment_score'] = news_df['clean_headline'].apply(lambda x:
sid.polarity_scores(x)['compound'])
news_df.head()
```

```
[nltk_data] Downloading package vader_lexicon to
[nltk_data]     /Users/shubhaankargupta/nltk_data...
[nltk_data]   Package vader_lexicon is already up-to-date!
```

```
            timestamp ticker  \
0 2025-08-11 14:08:28   AAPL
1 2025-08-08 10:02:05   AAPL
2 2025-08-06 14:46:00   AAPL
3 2025-08-09 21:52:09   AAPL
4 2025-08-06 23:02:00   AAPL

                                              headline
source  \
0  Apple Inc (AAPL) Increases its Total Investmen...         Yahoo
Finance
1  After Earnings, Is Apple Stock a Buy, a Sell, ...
Morningstar
2  $AAPL stock is up 3% today. Here's what we see...  Quiver
Quantitative
3  Apple Stock (AAPL) Pops as Trump Vows 100% Tar...
TipRanks
4  Apple stock extends gains, rises 3% postmarket...         Seeking
Alpha

         date                                      clean_headline  \
0  2025-08-11  apple inc aapl increase total investment 600 b...
1  2025-08-08  earnings apple stock buy sell fairly valued mo...
2  2025-08-06  aapl stock 3 today here see data quiver quanti...
3  2025-08-09  apple stock aapl pop trump vow 100 tariff reli...
4  2025-08-06  apple stock extends gain rise 3 postmarket con...

   sentiment_score
0           0.7506
1           0.4404
2           0.0000
3           0.4767
4           0.5994

daily_sentiment = news_df.groupby(['date', 'ticker'])
['sentiment_score'].mean().reset_index()
daily_sentiment.head()

         date ticker  sentiment_score
0  2025-08-05   AAPL        -0.120400
1  2025-08-05    SPY        -0.120040
2  2025-08-06   AAPL         0.147259
3  2025-08-06    SPY        -0.163194
4  2025-08-07   AAPL         0.055640

market_df =
clean_close[['AAPL']].reset_index().rename(columns={'Date': 'date',
'AAPL': 'close'})
sent_aapl = daily_sentiment[daily_sentiment['ticker']=='AAPL']
[['date', 'sentiment_score']]
```

```
market_df['date'] = pd.to_datetime(market_df['date'])
sent_aapl['date'] = pd.to_datetime(sent_aapl['date'])

merged_df = pd.merge(market_df, sent_aapl, on='date', how='left')

merged_df['sentiment_score'].fillna(method='ffill', inplace=True)

merged_df.tail()
```

```
/var/folders/0f/l_wv06ws6k3063l3r6mv6xb80000gn/T/
ipykernel_8265/2557188174.py:14: FutureWarning: A value is trying to
be set on a copy of a DataFrame or Series through chained assignment
using an inplace method.
The behavior will change in pandas 3.0. This inplace method will never
work because the intermediate object on which we are setting values
always behaves as a copy.

For example, when doing 'df[col].method(value, inplace=True)', try
using 'df.method({col: value}, inplace=True)' or df[col] =
df[col].method(value) instead, to perform the operation inplace on the
original object.


  merged_df['sentiment_score'].fillna(method='ffill', inplace=True)
/var/folders/0f/l_wv06ws6k3063l3r6mv6xb80000gn/T/ipykernel_8265/255718
8174.py:14: FutureWarning: Series.fillna with 'method' is deprecated
and will raise in a future version. Use obj.ffill() or obj.bfill()
instead.
  merged_df['sentiment_score'].fillna(method='ffill', inplace=True)
/var/folders/0f/l_wv06ws6k3063l3r6mv6xb80000gn/T/ipykernel_8265/255718
8174.py:17: FutureWarning: A value is trying to be set on a copy of a
DataFrame or Series through chained assignment using an inplace
method.
The behavior will change in pandas 3.0. This inplace method will never
work because the intermediate object on which we are setting values
always behaves as a copy.

For example, when doing 'df[col].method(value, inplace=True)', try
using 'df.method({col: value}, inplace=True)' or df[col] =
df[col].method(value) instead, to perform the operation inplace on the
original object.


  merged_df['sentiment_score'].fillna(method='ffill', inplace=True)
/var/folders/0f/l_wv06ws6k3063l3r6mv6xb80000gn/T/ipykernel_8265/255718
8174.py:17: FutureWarning: Series.fillna with 'method' is deprecated
and will raise in a future version. Use obj.ffill() or obj.bfill()
instead.
  merged_df['sentiment_score'].fillna(method='ffill', inplace=True)
```

```
           date       close  sentiment_score
1251 2025-08-06  213.008255         0.147259
1252 2025-08-07  219.780563         0.055640
1253 2025-08-08  229.090012         0.141709
1254 2025-08-11  227.179993         0.167882
1255 2025-08-12  228.899994        -0.216200
```

```
import matplotlib.pyplot as plt

fig, ax1 = plt.subplots(figsize=(12,6))

ax1.plot(merged_df['date'][1200::], merged_df['close'][1200::],
color='blue', label='AAPL Close Price')
ax1.set_ylabel('Close Price', color='blue')
ax1.tick_params(axis='y', labelcolor='blue')

ax2 = ax1.twinx()
ax2.plot(merged_df['date'], merged_df['sentiment_score'],
color='orange', label='Sentiment Score', alpha=0.7)
ax2.set_ylabel('Sentiment Score', color='orange')
ax2.tick_params(axis='y', labelcolor='orange')

plt.title('AAPL Close Price and Daily Average Sentiment')
fig.tight_layout()
plt.show()
```