

# Breakdown of Key Hyperparameters

## 1 KMeans Hyperparameters

Hyperparameter	Current Setting	Role & Impact
n_clusters	6 (Optimized via Silhouette Method)	Defines the number of clusters. Directly impacts results.
init	Defaults to 'k-means++'	Helps with better initial centroid placement to improve convergence.
max_iter	Defaults to 300	Limits how long the algorithm runs before stopping.
tol	Defaults to 1e-4	Determines when the model converges (stops updating centroids).
n_init	Defaults to 10	Runs KMeans multiple times to avoid poor local minima.

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Training KMeans with different K values...

K=2: Silhouette Score=0.5673, Inertia=83212.63, Training Time=0.0194 sec
K=3: Silhouette Score=0.5858, Inertia=47215.83, Training Time=0.0190 sec
K=4: Silhouette Score=0.6813, Inertia=19465.56, Training Time=0.0228 sec
K=5: Silhouette Score=0.6976, Inertia=14089.74, Training Time=0.0253 sec
K=6: Silhouette Score=0.7251, Inertia=9835.57, Training Time=0.0333 sec
K=7: Silhouette Score=0.7026, Inertia=6635.59, Training Time=0.0661 sec
K=8: Silhouette Score=0.7160, Inertia=4525.62, Training Time=0.0413 sec
K=9: Silhouette Score=0.7161, Inertia=3701.13, Training Time=0.0447 sec
K=10: Silhouette Score=0.7126, Inertia=3250.03, Training Time=0.0444 sec
```

Highest Silhouette Score: 0.7251

## 2 DBSCAN Hyperparameters

Hyperparameter	Current Setting	Role & Impact
eps	1.50 (Optimized)	Defines how far two points must be to be in the same cluster. A crucial tuning parameter.
min_samples	10 (Optimized)	The minimum number of points required to form a dense cluster.
metric	Defaults to 'euclidean'	Defines how distance between points is measured.
algorithm	Defaults to 'auto'	Automatically chooses the best implementation of DBSCAN.

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Training DBSCAN with different parameter combinations...

eps=0.50, min_samples=3: Silhouette Score=0.3488, Clusters Found=45, Training Time=0.012365 sec
eps=0.50, min_samples=5: Silhouette Score=0.2887, Clusters Found=23, Training Time=0.016127 sec
eps=0.50, min_samples=7: Silhouette Score=0.3358, Clusters Found=8, Training Time=0.031650 sec
eps=0.50, min_samples=10: Silhouette Score=0.4491, Clusters Found=4, Training Time=0.037517 sec
eps=1.00, min_samples=3: Silhouette Score=0.7135, Clusters Found=6, Training Time=0.029120 sec
eps=1.00, min_samples=5: Silhouette Score=0.7070, Clusters Found=6, Training Time=0.024105 sec
eps=1.00, min_samples=7: Silhouette Score=0.6807, Clusters Found=7, Training Time=0.014233 sec
eps=1.00, min_samples=10: Silhouette Score=0.6190, Clusters Found=9, Training Time=0.022724 sec
eps=1.50, min_samples=3: Silhouette Score=0.6894, Clusters Found=5, Training Time=0.030598 sec
eps=1.50, min_samples=5: Silhouette Score=0.6894, Clusters Found=5, Training Time=0.034070 sec
eps=1.50, min_samples=7: Silhouette Score=0.6888, Clusters Found=5, Training Time=0.032876 sec
eps=1.50, min_samples=10: Silhouette Score=0.7223, Clusters Found=6, Training Time=0.033617 sec
eps=2.00, min_samples=3: Silhouette Score=0.6133, Clusters Found=5, Training Time=0.043511 sec
eps=2.00, min_samples=5: Silhouette Score=0.6133, Clusters Found=5, Training Time=0.037941 sec
eps=2.00, min_samples=7: Silhouette Score=0.6133, Clusters Found=5, Training Time=0.044316 sec
eps=2.00, min_samples=10: Silhouette Score=0.6133, Clusters Found=5, Training Time=0.036891 sec
eps=2.50, min_samples=3: Silhouette Score=0.6923, Clusters Found=5, Training Time=0.034854 sec
eps=2.50, min_samples=5: Silhouette Score=0.6923, Clusters Found=5, Training Time=0.040720 sec
eps=2.50, min_samples=7: Silhouette Score=0.6923, Clusters Found=5, Training Time=0.041262 sec
eps=2.50, min_samples=10: Silhouette Score=0.6923, Clusters Found=5, Training Time=0.035165 sec
eps=3.00, min_samples=3: Silhouette Score=0.6923, Clusters Found=5, Training Time=0.043361 sec
eps=3.00, min_samples=5: Silhouette Score=0.6923, Clusters Found=5, Training Time=0.028957 sec
eps=3.00, min_samples=7: Silhouette Score=0.6923, Clusters Found=5, Training Time=0.036390 sec
eps=3.00, min_samples=10: Silhouette Score=0.6923, Clusters Found=5, Training Time=0.019533 sec
eps=3.50, min_samples=3: Silhouette Score=0.6923, Clusters Found=5, Training Time=0.018263 sec
eps=3.50, min_samples=5: Silhouette Score=0.6923, Clusters Found=5, Training Time=0.018759 sec
eps=3.50, min_samples=7: Silhouette Score=0.6923, Clusters Found=5, Training Time=0.018493 sec
eps=3.50, min_samples=10: Silhouette Score=0.6923, Clusters Found=5, Training Time=0.023596 sec
eps=4.00, min_samples=3: Silhouette Score=0.6923, Clusters Found=5, Training Time=0.018119 sec
eps=4.00, min_samples=5: Silhouette Score=0.6923, Clusters Found=5, Training Time=0.033741 sec
eps=4.00, min_samples=7: Silhouette Score=0.6923, Clusters Found=5, Training Time=0.017404 sec
eps=4.00, min_samples=10: Silhouette Score=0.6923, Clusters Found=5, Training Time=0.026521 sec
eps=4.50, min_samples=3: Silhouette Score=0.5180, Clusters Found=4, Training Time=0.019079 sec
eps=4.50, min_samples=5: Silhouette Score=0.5180, Clusters Found=4, Training Time=0.018052 sec
eps=4.50, min_samples=7: Silhouette Score=0.5180, Clusters Found=4, Training Time=0.017792 sec
eps=4.50, min_samples=10: Silhouette Score=0.5180, Clusters Found=4, Training Time=0.017603 sec
eps=5.00, min_samples=3: Silhouette Score=0.5866, Clusters Found=3, Training Time=0.017943 sec
eps=5.00, min_samples=5: Silhouette Score=0.5866, Clusters Found=3, Training Time=0.018959 sec
eps=5.00, min_samples=7: Silhouette Score=0.5866, Clusters Found=3, Training Time=0.017376 sec
eps=5.00, min_samples=10: Silhouette Score=0.5866, Clusters Found=3, Training Time=0.017498 sec

```

**Highest Silhouette Score: 0.7223**

### 3 Agglomerative Hyperparameters (WINNER)

Hyperparameter	Current Setting	Role & Impact
n_clusters	6 (Optimized via Silhouette Method)	Defines the number of clusters.
linkage	'ward' (Fixed)	Uses variance minimization to merge clusters.
affinity	Defaults to 'euclidean'	Determines distance measure for clustering.

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Training Agglomerative Clustering with different K values...

K=2: Silhouette Score=0.5698, Inertia=86589.58, Training Time=0.0339 sec
K=3: Silhouette Score=0.5806, Inertia=47923.96, Training Time=0.0562 sec
K=4: Silhouette Score=0.6813, Inertia=19483.46, Training Time=0.0664 sec
K=5: Silhouette Score=0.6978, Inertia=14107.64, Training Time=0.0536 sec
K=6: Silhouette Score=0.7257, Inertia=9854.77, Training Time=0.0593 sec
K=7: Silhouette Score=0.7015, Inertia=6705.23, Training Time=0.0593 sec
K=8: Silhouette Score=0.7086, Inertia=4819.96, Training Time=0.0641 sec
K=9: Silhouette Score=0.7088, Inertia=3821.04, Training Time=0.0557 sec
K=10: Silhouette Score=0.7088, Inertia=3354.75, Training Time=0.0575 sec

```

**Highest Silhouette Score: 0.7257**