Warehouse Space Optimization using Smart Clustering

Approach

1. Data Cleaning & Imputation – Handled missing values (mean for numeric, most frequent for categorical) and removed outliers using Z-score.
2. Feature Scaling – StandardScaler was used to normalize product dimensions and daily demand to ensure fair clustering.
3. Clustering – K-Means algorithm applied to group products with similar size and demand patterns. Elbow and Silhouette methods helped determine optimal cluster count.
4. Dimensionality Reduction – PCA reduced features to 2 components for clear cluster visualization.
5. Cluster Profiling – Calculated average dimensions and demand within each cluster to recommend storage zones.

Key Findings

• Visual separation of product clusters in PCA plots confirmed distinct groupings based on size and demand.
• Optimal product groupings were identified, enabling better warehouse layout and reduced retrieval times.
• High-demand, small-sized items can be positioned near exit zones, while large, low-demand items can be stored deeper in the warehouse.

Actionable Insights

• Allocate dedicated zones for high-demand clusters to speed up order fulfillment.
• Group products with similar shapes and sizes to minimize space wastage.
• Dynamic layout planning can be implemented based on cluster profiles to improve overall efficiency.

Visualizations Explained

• PCA Cluster Plot: Displays 2D representation of product clusters, showing clear separation and validating the clustering approach.
• Elbow Plot: Helps identify the optimal number of clusters by showing where the inertia value sharply decreases.
• Silhouette Score Plot: Confirms the quality of clustering by measuring how well products fit within their assigned clusters.

Conclusion

The Smart Clustering approach provides a data-driven method for optimizing warehouse space. By understanding natural groupings of products based on size and demand, managers can design efficient layouts that reduce retrieval times and improve operational efficiency.