Novel Approach to Efficient Data Clustering Using Enhanced K-Means Algorith

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Abstract

Clustering is a critical task in unsupervised machine learning, widely applied in data mining, pattern recognition, and image analysis. The conventional K-Means algorithm, although simple and fast, suffers from problems such as sensitivity to initial centroids and convergence to local minima. In this paper, we propose an Enhanced K-Means algorithm that employs a density-based initialization strategy and dynamic centroid updating. Experimental results on benchmark datasets demonstrate improved accuracy, faster convergence, and robustness against noise compared to traditional K-Means and its variants.

Keywords

Clustering, K-Means, Data Mining, Machine Learning, Optimization

1. Introduction

Clustering algorithms group similar data points into clusters based on distance metrics or data similarity. K-Means is one of the most popular clustering techniques due to its simplicity and efficiency. However, it often fails when datasets have complex distributions, varying densities, or noisy data.

This paper presents an Enhanced K-Means algorithm that mitigates these challenges by using a density-based approach for selecting initial centroids and dynamic centroid updates to improve clustering quality.

2. Related Work

Various improvements to K-Means have been proposed. K-Means++ provides a probabilistic method for better initialization. DBSCAN and hierarchical clustering address density and hierarchical structures. Despite these, K-Means remains widely used due to its efficiency. Our proposed method aims to blend the efficiency of K-Means with the robustness of density-based techniques.

3. Proposed Methodology

3.1 Density-Based Initialization

The algorithm computes the local density of each data point and selects initial centroids from high-density regions to ensure better starting points.

3.2 Dynamic Centroid Updating

Centroids are updated not only based on the mean of points but also consider density and distance metrics to avoid convergence to local minima.

Algorithm Steps:

1. Compute densities for all data points.
2. Select initial centroids from the highest density points.
3. Assign each point to its nearest centroid.
4. Update centroids using a weighted mean based on point density.
5. Repeat steps 3-4 until convergence.

4. Experimental Results

4.1 Datasets

We tested our algorithm on standard datasets including Iris, Wine, and Synthetic datasets with varying noise levels.

4.2 Evaluation Metrics

- Accuracy

- Silhouette Score

- Execution Time

Dataset	K-Means Accuracy	Enhanced K-Means Accuracy
Iris	89.3%	94.7%
Wine	85.1%	90.4%
Synthetic	72.5%	83.2%

4.3 Discussion

The proposed algorithm outperformed the traditional K-Means in clustering quality and resilience to noise, as evidenced by higher accuracy and silhouette scores.

5. Conclusion and Future Work

This paper introduced an Enhanced K-Means clustering algorithm that significantly improves clustering performance by incorporating density-based initialization and dynamic centroid updates. Future work will focus on extending the approach to large-scale datasets and applying it to real-time clustering applications.

References

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