Using Distance Measure to Perform Optimal Mapping with the K-Medoids Method on Medicinal Plants, Aromatics, and Spices Export

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Abstract

About 80% of the world's medicinal plants grow in Indonesia. The Negeri Rempah Foundation also said that Indonesia has more kinds of spices than any other country in Southeast Asia. To figure out the best way to export plants, you need to do a study that groups them by their main destination country. This is called "clustering," and it can be done by doing regional mapping. In the clustering process, measuring deviation/distance or distance space is a key part of figuring out how similar or regular data and items are. K-Medoids is one way to group things together. K-Medoids is an algorithm that groups data based on how far apart they are. Distance Measure is a way to measure the distance between two points. It can help an algorithm sort object into groups based on how similar their variables are. The dataset used comes from the Customs Documents of the Directorate General of Customs and Excise on the official website of the Central Bureau of Statistics for the period of 2012-2021 about the Export of Medicinal, Aromatic, and Spices Plants. This study uses mixed measures (mixed euclideandistance), numerical measures (camberradistance), and bregmandivergences (generalizeddivergence). The mapping results are compared with the validation of the Davies Bouldin Index (DBI). With the help of the rapidminer software, a number of tests were done. The results showed that using mixed measures (mixed euclideandistance) with a

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value of k=4 gave a DBI value of 0.021. Because it gives a DBI value close to 0, the K-Medoids algorithm with mixed measures (mixedeuclideandistance) is thought to work better than other distance measures.

Keywords: Optimization, Mapping, K-Medoids, Clustering, Data Mining, Davies Bouldin Index.

1 Introduction

Big Data is now known to be one of the most important technologies for brand growth in all ways. Today, organizations use techniques for analyzing big data to reach their most important business goals, such as growth and customer satisfaction (Mikalef, P., 2019) (Court, David, D., 2015) (Wanof, M.I., 2023). At the same time, it's important to know that an organization's growth and expansion depends on its ability to understand and analyze Big Data. This is why data mining techniques are so useful: they help organizations analyze large amounts of data in a useful way (Osman, A.S., 2019) (Cheng, R., 2021). Data Mining is the process of finding useful new correlations, patterns, and trends by storing a lot of data and using pattern recognition techniques like static and mathematical techniques (Rahman, F., 2020) (Ji, W.T., 2013) (Perundurai, E., 2015) (Dewi, I.C., 2017) (Zalmi, W.F., 2023). Clustering is a type of data mining that is used to put together groups of data with the same characteristics and groups of data with the same characteristics. One way to group things together is to use K-Medoids (IR, G.P., 2022). K-Medoids is a version of K-means that can handle noise and outliers better. K-medoids are a method for partition clustering that uses the actual points in the cluster to show what they look like. Medoids are things that represent a cluster. K-Medoids use a distance measure and an unsupervised algorithm to group data. The measurement of deviation/distance or distance space is a very important part of the clustering process for figuring out how similar or regular the data and items are (Wanto, A., 2020). The k-medoids algorithm is similar to the k-means algorithm in that they both use algorithms to divide things up. Both the k-Medoids algorithm and the k-Means algorithm are similar because they both use partition algorithms (Ningsih, S.R., 2019). In contrast to the K-Means algorithm, the data point is chosen as the center in the K-Medoids algorithm (Kamila, I., 2019).

This study employs clustering with the K-Medoids algorithm and employs Mixed Measures (Mixed Euclidean Distance), Numerical Measures (Camberra Distance), and Bregman Divergences (Generalized Divergence), after which the cluster results are validated using the Davies Bouldin Index. The algorithm's distinguishing feature is that it calculates the distance between each pair of objects and uses that distance for each iteration step. Several studies have been conducted that use distance metrics to enhance mapping in the form of clusters. Among them is research Fajriah, Sutisna, and Simpony (Fajriah, R.I., 2019) that conducts cluster mapping in identifying promotions so that they may carry out marketing with the correct plan to attract prospective new students (Sun, L., 2013). According to the results, the best number of clusters for Cimanggu Muhammadiyah Vocational High School student data is three, as determined by the distance measure where the euclidean is less than the manhattaan, namely 15,115 15,398. Furthermore Nishom (Nishom, M., 2019), this study was carried out to determine the differential status of teacher needs in Tegal City by comparing three techniques (euclidean distance, manhattan distance, and minkowski distance). According to the study's findings, Distance Measures performed the best cluster optimization. It is envisaged that the findings of the study will raise global market demand for medicinal, aromatic, and spice plants. It is vital to organize them in order to design the best export strategy for medicinal, aromatic, and spice plants. So, we need a study that uses the K-Medoids method to map clusters of coffee exports based on the primary destination nations. The dataset was obtained from the Customs Documents of the Directorate General of Customs and Excise on the official website of the Central Bureau of Statistics for the period 2012-2021 regarding the Export of Medicinal, Aromatic, and Spice Plants.

2 Methodology

The method of research used is a quantitative method (Ausat, A.M.A., 2023) (Yusupa, A., 2023). The purpose of quantitative research is to come up with conclusions or a general theory that can be used to make predictions. The steps that were taken to finish this research are as follows.

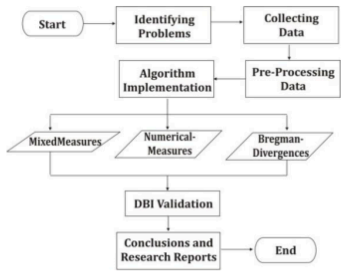

Figure 1: Research Flowchart

Data Collection

By accessing the website of the Central Bureau of Statistics (abbreviated as BPS), secondary data types can be gathered for research purposes. The used dataset is derived from the Customs Documents of the Directorate General of Customs and Excise (abbreviated as PEB and PIB) on the official website of BPS for the period of 2012-2021 pertaining to the Export of Medicinal, Aromatic, and Spice Plants.

Pre-Processing Data

The process of cleaning, converting, and normalizing data before it can be processed by an algorithm is known as data pre-processing. The dataset is cleansed by removing or deleting invalid data, verifying data consistency, and rectifying inaccurate data. Because the dataset utilized for clustering must be numeric, the dataset must be changed by converting the categorical data type to a numeric form prior to its incorporation into the k-medoids algorithm's computational procedure.

Algorithm Implementation

At this point, the dataset that has passed the data processing phase is prepared for the K-Medoids algorithm. K-medoids models the data in a very similar manner, but employs "k" representative objects called medoids, which can serve as cluster "prototypes" rather than explanations for segregation and arbitrariness. Various input intervals employ absolute error criteria (Ji, W.T., 2013) (Dewi, I.C., 2017) (Cynthia, E.P., 2021). A medoid is the object in a cluster with the smallest average deviation from the other objects in the cluster. The K-medoids algorithm begins by calculating K-medoids and mapping each object in the dataset to the nearest medoids using the distance metric (Rahman, F., 2020) (Elsi, Z.R.S., 2020). The K-Medoids clustering procedure is as follows (Jin, X., 2010) (Windarto, A.P., 2020) (Atmaja, E.H.S., 2019):

1. Initialize k cluster center positions (number of clusters).
2. Assign each piece of data (object) to the closest cluster.
3. Select objects at random from each cluster as potential new medoid candidates.
4. Determine the distance between each object in each cluster and the new candidate medoid.
5. Calculate the total deviation (S) by subtracting the current total distance from the previous total distance. If S is greater than zero, swap objects and data clusters to generate a new set of k objects as medoids.
6. Repeat steps 3 to 5 until there is no medoid change, thereby obtaining a cluster and each member of the cluster.

Validation Using the Davies Bouldin Index (DBI)

After obtaining the clustering results from three distinct distance calculations, the Davies Bouldin Index (DBI) approach was applied to determine the optimality of the clusters. The DBI value of each cluster will be compared in order to determine which distance computation yields the optimal cluster results. A medoid can be thought of as the object in a cluster with the smallest average difference from other objects in the cluster. The K-medoids technique begins by calculating the K-medoids and mapping each dataset object to the closest medoids based on the distance metric (Rahman, F., 2020) (Perundurai, E., 2015) (Sun, D., 2018). The lower the obtained DBI value (non-negative > 0), the better the cluster obtained by the cluster group (Singh, A.K., 2020).

3 Results and Discussion

Dataset Analysis

The process of analyzing datasets occurs following the collecting of research-supporting evidence and data. This study makes use of datasets derived from the Customs Documents of the Directorate General of Customs and Excise (abbreviated as PEB and PIB) on the official BPS website for the period of 2012-2021 pertaining to Exports of Medicinal, Aromatic, and Spice Plants. The dataset is then processed with RapidMiner 5.3 to determine the data's correctness.

Table 1: Exports of Medicinal, Aromatic and Spice Plants by Main Destination Countries, 2012-2021

Country of destination	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Pakistan	79860.9	91948	121912.1	104871	114499.8	90975.6	2379.1	1653	1057.3	5416.5
Thailand	1710.3	2706.8	6510.4	66390.3	60117.4	68299.9	101664	162812.3	64560.9	117489.3
United States of America	5844.7	6043.1	5763.9	5046.6	10531.4	13347.7	12619.8	7182	12918.3	14389.3
India	15417	38288.8	35504.1	38944.7	22589.3	24169.8	33572	31939.9	33995.1	28252.8
Vietnamese	14280.1	14620.9	18641.2	23101.2	20640.6	29159.6	29977.8	11480.8	9349.5	6617.1
Singapore	34087.6	22176.2	20011.9	18171.1	11218	11179.9	10170.5	5007	4276.3	5922.6
Dutch	2406.8	2473.8	3803.2	3051.9	2336.5	3799.9	2672.2	2235.9	2666.1	2223.5
China	23917.3	18464.6	17857.2	6252.9	15900.4	5496.1	4413.2	10297.8	18950.5	37067.8
Bangladesh	39525.2	64049.2	78300.5	35779.6	16309.1	23004.4	6278	10899.1	7407.9	17284.3
German	1301.7	1452.1	1349.4	1520	897.8	1305.9	1357.1	1341.3	1515.3	1653.6
Other	31997.2	47120.8	77289.9	73391.6	41123.6	55053.4	130989.5	73291.2	118597.9	58371.3

After completing the data preprocessing phase, the data are initialized by passing the k-medoids parameter to rapidminer, which then imports the data in excel format. 12 trials were conducted to compare the three forms of distance measures by dividing the cluster values into k = 2, 3, 4, and 5. The clustering outcomes obtained by comparing the three distance measures are displayed in Table 2 below.

Table 2: Cluster Members

K	Distance Measure		
	Mixed Measures (Mixed Euclidean Distance)	**Numerical Measures (Camberra Distance)**	**Bregman Divergences (Generalized Divergence)**
2	cluster 1= 8 (United States of America, India, Vietnamese, Singapore, Dutch, Tiongkok, Bangladesh, German) cluster 2= 3 (Pakistan, Thailand, Other)	cluster 1= 3 (United States of America, Dutch, German) cluster 2= 8 (Pakistan, Thailand, India, Vietnamese, Singapore, Tiongkok, Bangladesh, Other)	cluster 1= 8 (Pakistan, United States of America, Vietnamese, Singapore, Dutch, Tiongkok, Bangladesh, German) cluster 2= 3 (Thailand, India, Other)
3	cluster 1= 1 (Pakistan) cluster 2= 8 (United States of America, India, Vietnamese, Singapore, Dutch, Tiongkok, Bangladesh, German) cluster 3= 2 (Thailand, Other)	cluster 1= 2 (Dutch, German) cluster 2= 7 (Pakistan, United States of America, India, Vietnamese, Singapore, Tiongkok, Bangladesh) cluster 3= 2 (Thailand, Other)	cluster 1= 4 (Pakistan, India, Singapore, Bangladesh) cluster 2= 2 (Thailand, Other) cluster 3= (United States of America, Vietnamese, Dutch, Tiongkok, German)
4	cluster 1= 1 (Pakistan) cluster 2= 1 (Thailand) cluster 3= 8 (United States of America, India, Vietnamese, Singapore, Dutch, Tiongkok, Bangladesh, German) cluster 4= 1 (Other)	cluster 1= 2 (Dutch, German) cluster 2= 2 (United States of America, Tiongkok) cluster 3= 5 (Pakistan, India, Vietnamese, Singapore, Bangladesh) cluster 4= 2 (Thailand, Other)	cluster 1= 1 (Thailand) cluster 2= 1 (Other) cluster 3= 5 (United States of America, Vietnamese, Dutch, Tiongkok, German) cluster 4= 4 (Pakistan, India, Singapore, Bangladesh)
5	cluster 1= 1 (Pakistan) cluster 2= 1 (Thailand) cluster 3= 2 (India, Bangladesh) cluster 4= 6 (United States of America, Vietnamese, Singapore, Dutch, Tiongkok, German) cluster 5= 1 (Other)	cluster 1= 1 (Pakistan) cluster 2= 2 (United States of America, Tiongkok) cluster 3= 4 (India, Vietnamese, Singapore, Bangladesh) cluster 4= 2 (Dutch, German) cluster 5= 2 (Thailand, Other)	cluster 1= 1 (Pakistan) cluster 2= 1 (Thailand) cluster 3= 3 (India, Singapore, Bangladesh) cluster 4= 5 (United States of America, Vietnamese, Dutch, Tiongkok, German) cluster 5= 1 (Other)

Based on the cluster results presented in table 2, each distance metric yields a different number of cluster members. The clustering findings were then used to determine the performance of each distance measure in the K-Medoids algorithm using the Davies Bouldin Index (DBI).

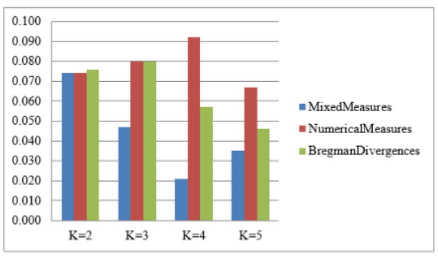

Figure 2: Evaluation Results of the Davies Bouldin Index

Figure 2 shows how the DBI values that were found after the mapping process was evaluated as groups. Based on a number of tests, using mixed measures (mixed euclideandistance) at k=4 gave a DBI value of 0.021. In Table 3, you can see the full results of the DBI value evaluation.

Table 3: DBI Value Results

	Distance Measure		
K	**DBI (Mixed Measures)**	**DBI (Numerical Measures)**	**DBI (Bregman Divergences)**
2	0.074	0.074	0.076
3	0.047	0.080	0.080
4	**0.021**	0.092	0.057
5	0.035	0.067	0.046

Based on table 3, it can be determined that the studied dataset is valid. Following is a textual representation of the cluster model generated by the RapidMiner 5.3 application using all Distance Measure parameters (Mixed Measures, Numerical Measures, and Bregman Divergences) with k values of 2, 3, 4, and 5.

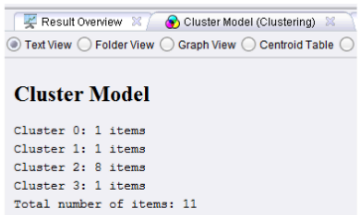

Figure 3: The Cluster Model for the Export of Medicinal, Aromatic and Spices Plants by Main Destination Country with a Value of DBI = 0.021

Figure 4 shows the Folder view display in the RapidMiner 5.3 application, which uses optimal cluster optimization with k = 4 and Distance Measure = Mixed Measures.

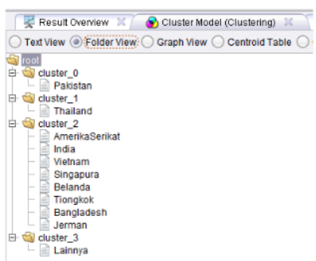

Figure 4: Folder View Exports of Medicinal, Aromatic and Spice Plants by Main Destination Country with a Value of DBI = 0.021

4 Conclusion

Based on the results and discussion, it is possible to conclude that the distance metric chosen has a significant influence on the clustering outcomes. When compared to Numerical Measures (Camberra Distance) and Bregman Divergences, the usage of Mixed Measures (Mixed Euclidean Distance) in the K-Medoids algorithm generates ideal clusters (Generalized Divergence). The Davies Bouldin Index (DBI) value created by Mixed Measures (Mixed Euclidean Distance) with a value of k = 4 of 0.021

reveals that the cluster results with Mixed Measures (Mixed Euclidean Distance) have a great similarity height between objects in the group. The K-Medoids method performs better with mixed measurements (mixed euclide and distance) than with other types of distance measures. The closer it gets to a DBI value of zero, the better the cluster optimization.

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