Data Optimization using PSO and K-Means Algorithm

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Abstract

Tourism is one of the industries that contribute considerably to the country's economy. Tourism helps the country's economy expand by providing and increasing jobs, living standards, and triggering the rise of other tourist-related production. The tourism industry will become a multinational industry and the primary driver of the global economy in the twenty-first century. Tourism has generated significant foreign exchange for a number of countries. Indonesia, the world's biggest archipelagic country with 17,508 islands, often known as the archipelago or maritime country, has recognized the importance of the tourist sector to the Indonesian economy because tourism growth consistently outpaces economic growth. The research's goal is to map the number of tourist visits. The mapping is in the form of clusters based on countries. The technology utilized is classification data mining with the K-Means method and Particle Swarm Optimization (PSO). The dataset came from the Central Bureau of Statistics, a government organization (abbreviated as BPS). The research outcomes in cluster mapping, with the cluster results compared to standard K-Means and K-Means + PSO. RapidMiner software is used during the analytical process. The calculation results in the form of clusters will be evaluated using the Davies-Bouldin Index (DBI) parameter. The cluster value (k) used is k = 2, 3, 4, 5. The findings show that the K-Means + PSO optimization has the minimum DBI value for k = 5. Meanwhile, the DBI value for k = 5 is 0.134.

Keywords: Foreign Tourist, Data Mining, K-Means, Particle Swarm Optimization, DBI.

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1 Introduction

Tourism is one of the industries that contributes considerably to the country's economy (Naseem, S., 2021) (Ikasari, H., 2020). Tourism helps to the country's economic prosperity since the industry can offer and enhance employment, living standards, and inspire the expansion of other tourist-related production (Manzoor, F., 2019) (Nanja, M., 2021) (Wahab, A., 2020) (Ausat, A.M.A., 2023). The tourism sector has the potential to be developed as a source of income and is projected to contribute to regional economic development (Mauludin, M.F., 2022) (Calero, C., 2020) (Abdullah, M.W., 2020) (Putri, R., 2023) (Wanof, M.I., 2023). The entrance of tourists at a tourist destination has resulted in prosperity and welfare for the local population, as well as advancement of the tourist destination's economy (Yanti, N.N.L.A., 2021). Countries throughout the world have designated tourism objects in Indonesia. The tourist industry is the largest and most powerful industry in financing the global economy in the current period of globalization (Enilov, M., 2022). Tourism will become the primary driver of the global economy in the twenty-first century, and one of the globalized industries. Tourism has supplied significant foreign cash for a number of countries. Indonesia, the world's biggest archipelagic country with 17,508 islands, commonly known as the archipelago or maritime country, has recognized the importance of the tourist sector to the Indonesian economy because tourism growth always outpaces economic growth (Brahmanto, E., 2015) (Suherlan, S., 2023). The tourist industry is currently one of the most important factors in the country's economic development (Rasool, H., 2021) (Rahmayani, D., 2022). As a result, practically every country seeks to promote domestic tourism to the rest of the world. These countries continue to upgrade the infrastructure of tourist sites in order to attract an increasing number of tourists. The more tourists who arrive, the stronger the country's economy. Indonesia is a popular tourism destination for international visitors. This is due to the fact that Indonesia is a tropical country in high demand by foreign tourists (Pranata, A., 2018). In Indonesia, there are 7 (seven) major tourist attractions that are always visited by tourists. Wakatobi National Park (Southeast Sulawesi), Komodo Island (West Nusa Tenggara), Trio Gili (Lombok), Raja Ampat (Papua), Lake Sentani (Papua), Bali (Bali), and Lake Toba (North Sumatra) are the most popular tourist destinations.

With today's technological advancements, it is simple to collect statistical data on the number of foreign tourist visits to Indonesia, one of which is data mapping. The data mapping in question is the grouping of a region using the artificial intelligence branch. There are several approaches to dealing with this issue. Data mining (Bardab, S.N., 2021) (Waluyo, A., 2020) (Abubakari, M.S., 2021) (Elsi, Z.R.S., 2020) (Hossain, M.Z., 2019) (Fauzi, N., 2023) is one of them. Data mining is a method for businesses to convert raw data into useful information (Hartama, D., 2019) (Supriyadi, B., 2018) (Firdaus, W., 2020). Furthermore, data mining aims to model data structures in order to further study these data (Jatnika, H., 2021) (Wahidin, W., 2021) (Rahmat, A., 2021) and identify patterns in a set of data that is not typically classified or labeled (Windarto, A.P., 2022) (Mardiana, H., 2023). Clustering (Elsi, Z.R.S., 2020) (Supriyadi, B., 2018) (Windarto, A.P., 2019) with the K-Means algorithm is one of several data mining techniques. The most accurate model will yield the best results. K-Means is a popular and uncontrolled clustering method(Ismkhan, H., 2018). Building a model with K-Means from large data sets can improve grouping results. The primary goal of K-Means is to group or cluster objects. The first step is to determine the number of k, which represents the number of clusters to be formed, followed by determining the center point or centroid for each cluster and grouping(Martiano, M.Z., 2019) (Soleman, C.D.O., 2020). However, because the center point is determined at random in the first stage and the average value is used for the next step, the results are less than optimal and local optimal convergence is obtained. This issue can be solved by optimizing the center point value so that the maximum center point is obtained for calculating K Means. There are several meta-heuristic methods

for problem optimization(Kareem, S.W., 2022) (Suwarno, I., 2021) (Suwarno, I., 2021). Particle Swarm Optimization (PSO) is a method for optimizing K-Means center point values with good results(Huang, S., 2018) (Hariyanto, R., 2020) (Septiantina, A.A., 2020). PSO can be used to optimize the center point value by presenting the problem solution in real numbers. The first focus of the research will be to map the number of foreign tourist visits to Indonesia in the form of clusters. Second, by optimizing the central point with PSO (Bekri, M. E., 2023), we can achieve maximum cluster mapping results while avoiding local optimum convergence. The third step is to evaluate the formed clusters in order to find the best cluster using a variety of parameters.

2 Methodology

The experimental research method was used in this study, as shown in Figure 1. The study started with datasets obtained from government agencies, specifically the Central Statistics Agency (abbreviated as BPS), which has an official website (https://www.bps.go.id/). The dataset used is the number of foreign tourist visits to Indonesia by nationality from 2016 to 2021, with a total of 55 countries represented. Following the acquisition of the dataset, the next step will be data preprocessing. Preprocessing is used to remove outlier data from the dataset. The Davies-Bouldin Index (DBI) method with equation (1) will be used to calculate the optimal number of clusters:

$$DBI = \frac{1}{k}\sum_{i=1}^{k} max_{i \neq j}(R_{i,j}) \quad (1)$$

The better the K-Means cluster algorithm will be, the smaller the DBI value obtained (non-negative >= 0). Figure 1 depicts a summary of the stages of the research.

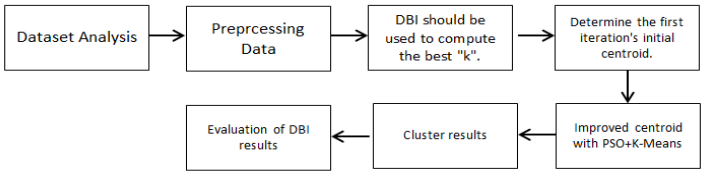


Figure 1: Research Flow

The steps taken in the K-Means method to form clusters are as follows:

a) Determine the number of clusters (k) from the existing dataset;
b) Determining k as Centroid, usually done randomly (random);
c) Calculate the distance between the data and the centroid using the distance formula using the Euclidean formula;

$$d(x_i, \mu_j) = \sqrt{\sum(x_i, \mu_j)^2} \quad (2)$$

where d is the document point, xi is the criterion data and μj is the centroid in the jth cluster.

d) Sort data by proximity to the centroid, then update the new centroid value with the cluster center's location;

$$\mu_j(t+1) = \frac{1}{N_{sj}}\sum_{j \in j} x_j \quad (3)$$

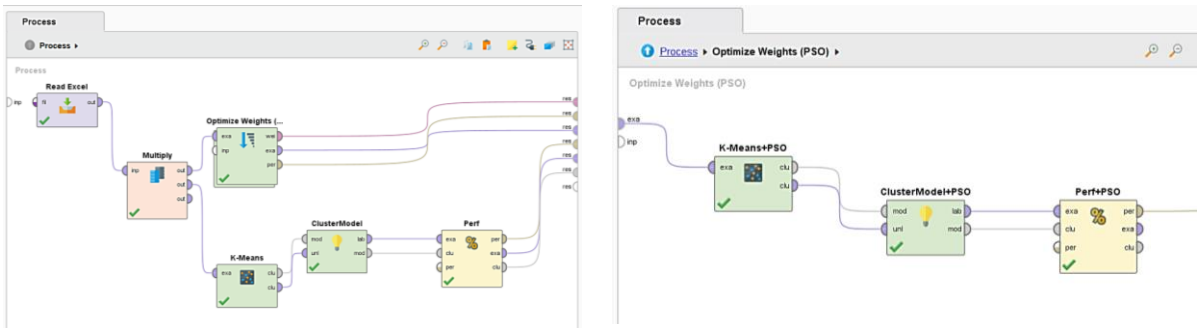
Where μj(t+1) is the new centroid in the (t+1) iteration and Nsj is the amount of data in the sj cluster.

e) Repeat steps b–d until no one in each cluster has changed.

While Particle Swarm Optimization (PSO) is a population-based technique (a number of particles) that refers to the optimum particle by adjusting the position and speed. PSO is a programming language used to solve optimization problems (Irnanda, K.F., 2022).

3 Result and Discussion

The following is the outcome of a comparison of K-Means with K-Means + PSO for the analysis process that was carried out using RapidMiner tools. Before beginning the analysis process, here is a model created with RapidMiner, as shown in Figures 2 and 3.



a b

Figure 2a: K-Means Model with K-Means + PSO; b: K-Means + PSO Detailed Models

Before beginning the analysis, the following dataset is used, which is taken from the official BPS website and consists of 55 countries visiting Indonesia between 2016 and 2021.

Table 1: Shows a Data Set of Foreign Tourist Arrivals in Indonesia

Country	2016	2017	2018	2019	2020	2021
Brunei Darussalam	23695	23455	17279	19278	2701	144
Malaysia	1541197	2121888	2503344	2980753	980118	480723
Philippines	298910	308977	217874	260980	50413	9375
Singapore	1515699	1554119	1768744	1934445	280492	18704
Thailand	124569	138235	124153	136699	21303	3992
Vietnamese	60986	77466	75816	96024	19608	2008
Myanmar	44720	48133	28612	46381	12669	3093
Other Asians	207727	252373	717508	682630	154143	10187
Hong Kong	101369	98272	91182	50324	2625	2432
India	422045	536902	595636	657300	111724	6670
Japan	545392	573310	530573	519623	92228	5952
South Korea	386789	423191	358885	388316	75562	9497
Pakistan	10100	11424	13448	14663	4110	974
Bangladesh	39028	56503	56564	59777	12866	1001
Sri Lanka	24258	35669	32508	28907	4300	620
Taiwan	252849	264278	208317	207490	35680	1398
Chinese	1556771	2093171	2139161	2072079	239768	54713
Timor Leste	1188720	960026	1762422	1178381	994590	819488
Other Asian	180544	67659	58625	68062	18584	2096
Saudi Arabia	197681	182086	165912	157512	31906	2053
Bahrain	2243	2457	2324	2631	373	35
Kuwait	6368	5760	5551	5762	846	75
Egypt	19948	20345	18075	21354	4337	611
United Arab Emirates	9016	8387	7100	9065	1093	384
Yemen	9478	8453	10008	9221	2094	758
Qatar	1856	1859	2104	1989	225	43

Other Middle East	45810	55022	55949	56389	8907	1680
Austria	24375	27208	29492	28476	4858	2103
Belgium	43607	48477	50050	46780	5902	798
Denmark	36380	43721	46825	45090	10533	557
France	256229	274117	287917	283814	43438	3776
German	243873	267823	274166	277653	46361	3429
Italy	79424	90022	94288	91229	13260	2339
Dutch	200811	210426	209978	215287	53495	12229
Spanish	68840	81690	85560	83373	11829	3255
Portugal	29286	33223	36804	35434	6245	476
Sweden	45934	51417	50381	56402	17600	3516
Switzerland	56700	61191	60293	57484	8362	782
English	352017	378131	392112	397624	69997	5177
Finland	21031	24447	27127	22665	6376	240
Norway	19478	22838	24906	23886	5072	336
Other Western Europe	35324	40211	35203	35272	6269	374
Russia	88520	117532	125728	158943	67491	8392
Other Eastern Europe	165316	201741	180081	216452	64091	8127
United States of America	316782	344766	387856	457832	91782	21962
Canada	86807	96139	97908	103616	23200	1242
Central America	2538	7542	2629	2786	529	87
South America	55256	71915	62868	65630	15142	1450
Other America	14596	16669	17137	19039	3419	332
Australia	1302292	1256927	1301478	1386803	256291	3196
New Zealand	105393	106914	128366	149010	19947	482
Papua New Guinea	68440	141299	142648	78433	20975	31703
Other Oceanians	164240	2794	2064	2987	573	123
South Africa	29223	38073	41962	47657	7350	572
Other Africa	45955	53126	46804	51262	9271	1769

The results of testing the cluster values (k = 2, 3, 4, and 5) for the standard K-Means and K-Means + PSO models differ. The formed clusters' results are then evaluated using the Davies-Bouldin Index (DBI) parameter. DBI is an internal evaluation method that evaluates clusters in a grouping method using cohesion and separation values. Cohesion is defined in a clustering as the sum of the data's proximity to the centroid of the cluster being followed. Meanwhile, the separation is based on the distance between the cluster's centroids (Muhammad, A.F., 2015). DBI K-Means + PSO is compared to standard DBI K-Means as shown in Table 2

Table 2: Compares the Results of DBI K-Means + PSO and Standard DBI K-Means

Cluster	**DBI K-Means + PSO**	**DBI K-Means**
K=2	0,357	0,362
K=3	0,404	0,481
K=4	0,508	0,684
K=5	0,134	0,561

Table 2 shows that for the values of k = 2, 3, 4, and 5, the overall optimization yields the best results when compared to no optimization. In this study, k= 5 is the optimal cluster for K-Means + PSO, as shown graphically in Figure 3 below.

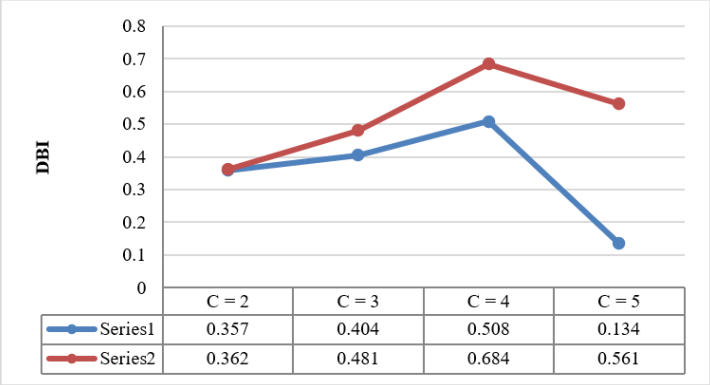


Figure 3: DBI Value Comparison Graph for Each k Value

Grafik pada Gambar 3 menunjukkan bahwa proses K-Means + PSO (Series1) menghasilkan hasil yang lebih baik daripada proses standar K-Means (Series2). Hasil akhir klaster optimal untuk nilai k = 5 terhadap jumlah kunjungan wisman ke Indonesia adalah sebagai berikut.

Cluster Model

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Cluster 0: 41 items
Cluster 1: 1 items
Cluster 2: 9 items
Cluster 3: 2 items
Cluster 4: 2 items
Total number of items: 55
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Figure 4: Optimal Cluster Results (K=5)

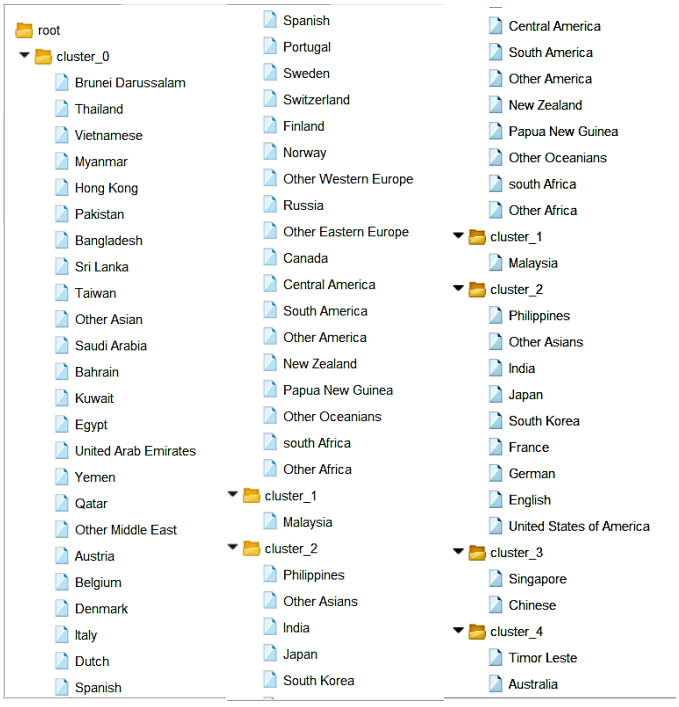

Figure 5: The Regional Division Based on Optimal Clusters (K=5)

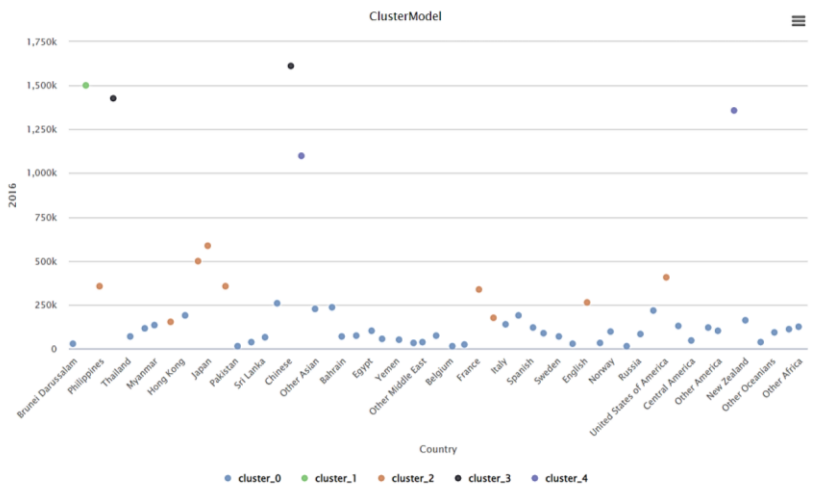

Figure 6: Regional Map based on Optimal Clusters (K=5)

The test results from K-Means + PSO optimization yield an optimal cluster with the smallest DBI value of 0.134 at k = 5. It will produce a final centroid value for each cluster after the formation of optimal clusters, as shown in Figure 7 below.

Attribute	cluster_0	cluster_1	cluster_2	cluster_3	cluster_4
2016	64438.829	1541197	336640.444	1536235	1245506
2017	65709.220	2121888	373287.778	1823645	1108476.500
2018	62747.049	2503344	418058.556	1953952.500	1531950
2019	64115.146	2980753	436196.889	2003262	1282592
2020	13805.268	980118	81738.667	260130	625440.500
2021	2553.195	480723	8447.222	36708.500	411342

Figure 7: The Optimal Cluster's Final Centroid Value (K=5)

4 Conclusion

The results of the experiments show that mapping of areas in the form of clusters can be utilised, with the approaches used being K-Means optimization and Particle Swarm Optimization (PSO). According to the study's findings, the mapping performed was superior than K-Means in terms of the number of international tourist visits to Indonesia. The Davies-Bouldin Index is the parameter used to evaluate the clusters generated (DBI). The ideal number of clusters is 5 (k=5), with a DBI K-Means + PSO value of 0.134.

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