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Implementation of Fuzzy C-Means and Topsis in College Rankings

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Abstract

Prior to now, the ranking of higher education institutions, particularly those at the Regional II Palembang Higher Education Service Institution, was based on one component of the work unit's criteria. This makes the university ranking results superior on one criterion but inferior on another. The number of instructors and the number of students at 100 universities in the South Sumatra region were split into two groups based on the outcome of the fuzzy c means algorithm grouping and regional criteria and calculated based on the resulting mean value. The grouping results using a topsis algorithm decision-making system with a weight determined by the number of lecturers with functional positions, college accreditation, number of certified lecturers, and percentage level of higher education database reports are used as a reference to rank universities. Based on the mean value of the fuzzy c means algorithm and the grouping results, seven colleges were chosen. Using the topsis method's way of making decisions, the final score for the highest-ranked college is 0.850.

Keywords: Ranking, university, clustering, decision making, fuzzy c means

1. INTRODUCTION

The ranking of higher education institutions needs to be done selectively according to the category used. Higher Education Service Institutions, the scale of tertiary institutions has been carried out using one class in the Region II Higher Education Service Institutions work group, which causes universities to excel in a tiny aspect and be weak in other parts. As a result of the ranking that has been carried out so far, of course, you will not get the best tertiary ranking results based on many components as the basis for grouping and evaluating tertiary institutions.

To overcome this, the ranking of tertiary institutions needs to use several components to support the implementation of grouping by considering several aspects, namely the availability of lecturers at tertiary institutions as an aspect of human resources, the regional aspect of tertiary institutions, namely mapping the location of tertiary institutions and the student aspect, namely the number of tertiary students. the Higher education performance measurement can be carried out as a whole by grouping these tertiary institutions based on the criteria for the number of lecturers who have functional positions, university accreditation, lecturers who have lecturer certification and university data base reports so that more optimal results are obtained.

The method used for grouping in universities is data mining accompanied by clustering algorithms and decision support systems. Data Mining is a process of obtaining useful information from large databases [1], this aims to assist in decision making [2]. There are four main tasks in Data Mining including Grouping, Classification, Regression and association functions (Sahu et al. 2012). This method will later help process data processing. The method used for grouping is fuzzy c-means and ranking using topsis.

Fuzzy C-Means is a data grouping algorithm (clustering) based on the theoretical concept of fuzzy [3]. This algorithm was introduced by Dunn (1973) and then developed by Bezdek (1983). The Fuzzy C-Means algorithm uses a variable degree of membership for each data which indicates the level of data presence in the cluster [4]. Fuzzy C-Means is a soft clustering algorithm that allows data points to become members of groups of several clusters [5]. The advantage of the Fuzzy C-Means algorithm is that the 1-4 grouping algorithm is simple, easy to implement, capable of grouping large amounts of data [6].

Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) is a decision-making method used in solving Multi-Criteria Decision Making (MCDM) problems or making decisions with many criteria. This method was introduced by Yoon and Hwang (1981). The main concept of the TOPSIS method is to find the best alternative solution that has the closest distance to the positive ideal solution and the farthest distance from the negative ideal solution. The TOPSIS method is a multi-criteria decision-making method that is simple, efficient in the calculation process, and can measure the relative performance of many alternatives [7].

2. METHODS

The research method uses research stages which are described in the form of research diagrams as follows.

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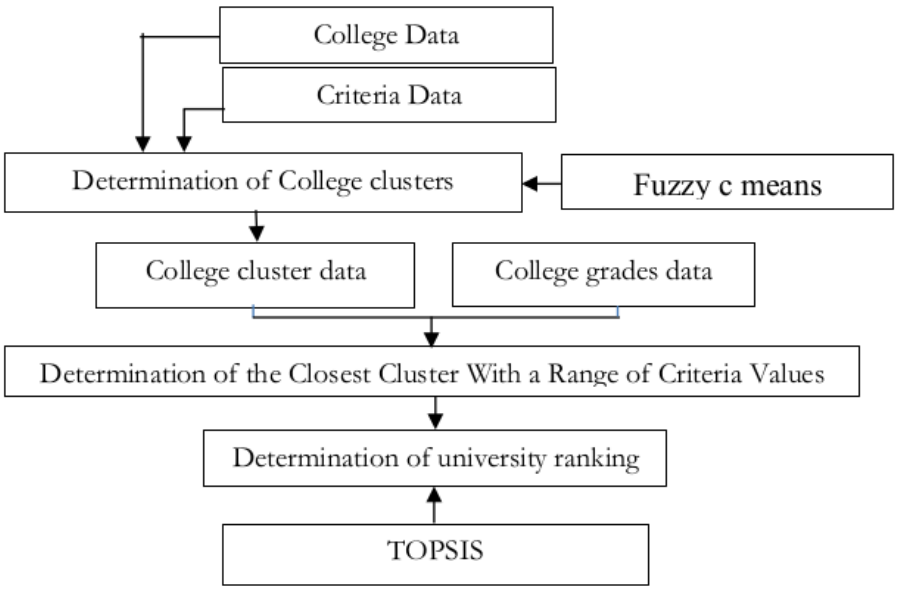

Figure 1. Research diagram

Based on Figure 1, the stages of the research can be explained as follows:

1. Collection and download of datasets (databases of higher education) that will be used for research, including data on tertiary institutions in the province of South Sumatra
2. Determination of criteria, sub-criteria and alternatives followed by cluster determination using the fuzzy c-means model. The Fuzzy C-Means cluster method aims to classify universities into groups based on the variables determined by the researcher. The first stage was carried out by grouping 16 tertiary institutions in the Bengkulu province area based on the university ranking indicator variables originating from the higher education database and determining the cluster centre, which would mark the average location for each cluster. By repairing the cluster centre and degree of membership of each data point repeatedly, the cluster centre will move towards the right location. The loop is based on minimizing the objective function, which describes the distance from a given data point to the cluster centre weighted by the degree of membership of the data point. The output of Fuzzy C-Means is a cluster centre series and several degrees of membership for each data. The software used as a tool in this research is Matlab 2021A.
3. Topsis for determining university rankings using MS. Excel and Matlab. Testing is done to avoid errors from the system created. If an error occurs, the system will be repaired again until the process results are as expected.

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The research method used in this study uses data from the tertiary institutions in the higher education database with a dataset using 100 tertiary institutions in the South Sumatra region. The reason for selecting South Sumatra was due to geographical conditions, which reflect the area of LLDIKTI region II and the province with the highest number of tertiary institutions. Clustering using the Fuzzy C-Means Algorithm is as follows (Kusumadewi, 2010:80).

1. Determine the data be clustered X, in the form of a matrix of size nxm (n=number of data samples, m=attributes of each data). Xij=i-th sample data (i=1,2,...,n), jth attribute (j=1,2,...,m);
2. Determine the number of clusters (c), rank (w), maximum iteration (MaxIter), smallest expected error (ζ), the initial objective function (P0=0), initial iteration (t=1)
3. Generate random numbers μik, i=1,2,...,n; k=1,2,...,c; as elements of the initial partition matrix U. The partition matrix (U) in fuzzy grouping satisfies the following conditions.

$$\mu ik \in [0,1];\ 1 \leq i \leq n;\ 1 \leq k \leq$$

μik is the degree of membership which refers to how likely a data can be a member of a cluster. Count the sum of each column (attribute):

$$Qi = \sum_{k=1}^{c} \mu$$

Qi = μi1 + μi2 + ...+ μic
with i = 1,2,...,n

4. Calculate the k-th cluster center: Vkj, with k=1,2,...,c; and j=1,2,...,m;

$$V_{kj} = \frac{\sum_{i=i}^{n}((\mu ik))^{w} Xij)}{\sum_{i=i}^{n}((\mu ik))^{w`}}$$

5. Calculate the objective function in the t-th iteration, Pt; The objective function is used as a looping condition to get the right cluster center. So that the tendency of the data to enter which cluster is obtained in the final step. For the initial iteration the value of t = 1.

$$P_t = \sum_{i=1}^{n}\sum_{k=1}^{c}([\sum_{j=1}^{m}(x_{ij}-v_{kj})^2](\mu_{ik})^w)$$

Calculate the change in the partition matrix;
Check stop condition;
a) |Pt – Pt-1| < ζ) or (t>MaxIter) then stop;
b) If not, the iteration is increased t=t+1, repeat step 4

The grouping based on the initial dataset was divided into 2 clusters and based on three attribute data, namely 90 for the municipality of Palembang, 80 for

municipalities other than Palembang and 70 for the district. The data on the number of lecturers and data on the number of students can be seen in Appendix 1.

For ranking using the TOPSIS method, there are several steps that must be passed to get the ideal solution. Here are the steps of the TOPSIS method.

1. Build a decision matrix.
The X decision matrix refers to m alternatives that will be evaluated based on n criteria. An x decision matrix can be seen as follows:

$$Xij = \begin{array}{c} \\ a_1 \\ a_2 \\ a_3 \\ \vdots \\ a_m \end{array} \begin{array}{c} \begin{array}{cccccc} x_1 & x_2 & x_3 & & & x_4 \end{array} \\ \begin{bmatrix} x_{11} & x_{12} & x_{31} & . & . & x_{n1} \\ x_{12} & x_{22} & x_{32} & . & . & x_{n2} \\ x_{13} & x_{32} & x_{33} & . & . & x_{n3} \\ \vdots & \vdots & \vdots & . & . & \vdots \\ x_{m1} & x_{m2} & x_{m3} & . & . & x_{mn} \end{bmatrix} \end{array}$$

Information:
ai (i = 1,2,3,…,m) is a possible alternative,
xj (j = 1,2,3,…,n) is the attribute by which alternative performance is measured.
xij is per ai alternative formation with xij attribute.

2. Create a normalized decision matrix.
The equation used to transform each element x_{ij} is:

$$r_{ij} = \frac{X_{ij}}{\sqrt{\sum_i^m 1x^2\, ij}}$$

Information:
r_{ij} are elements of the normalized decision matrix R.
x_{ij} are elements of the decision matrix X.

3. Create a weighted normalized decision matrix.
With weights $w\,j = (w\,1, w\,2, w\,3, \ldots, w\,n)$, where $w\,j$ is the weight of the jth criteria and $\sum_{j=1}^{n} wj = 1$, then the normalization of the Y matrix is:

$$Y_{ij} = w_j r_{ij}$$

Information:
Y_{ij} is an element of the Y-weighted normalized decision matrix
Wij _is the weight of the jth criterion
Rij _are elements of the normalized decision matrix R.

4. Determine the positive ideal solution matrix and negative ideal solution.
Positive ideal solutions are denoted by A^+, while negative solutions are denoted by A^-. Here are the equations of:

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$$A^+ = \{(\max v_{ij} \mid j \in J), (\min v_{ij} \mid j \in J'), \quad i=1,2,3,\ldots,m\}$$
$$= \{(V1^-, V2^-, V3^-, \ldots, Vn^- \}$$
$$A^- = \{(\min v\,ij \mid j \in J), (\max v\,ij \mid j \in J'), i = 1, 2, 3, \ldots, m\}$$
$$= \{ v\,1^-, v\,2^-, v\,3^-, \ldots, v\,n^- \}$$

J = { j = 1,2,3,…,n and J is a set of *benefit criteria* }.
J' = { j = 1, 2, 3, . . . , n and J' is a set of cost criteria (cost criteria)}
Information :
Y_{ij} are elements of the weighted normalized decision matrix V,
Y_j^+ = (j = 1, 2, 3, . . . , n) are the elements of the solution matrix positive ideal,
Y_j^- = (j = 1, 2, 3, . . . , n) are elements of the negative ideal solution matrix.

5. Calculating separation.
D_i^+ is the alternative distance from the positive ideal solution defined as:

$$D_i^+ = \sqrt{\sum_j^n (Y_{ij} - Y_j^+)}, \text{ dengan } i=1,2,3,\ldots,m$$

D_i^- is the alternative distance from the negative ideal solution defined as:

$$D_i^- = \sqrt{\sum_j^n (Y_{ij} - Y_j^-)}, \text{ dengan } i=1,2,3,\ldots,m$$

Information :
D_i^+ is the distance of the I-th alternative from the positive ideal solution,
D_i^- is the distance of the I-th alternative from the negative ideal solution,
Y_{ij} is the element of the decision matrix that is weighted normalized Y,
Y_j^+ are elements of the positive ideal solution matrix,
Y_j^- are elements of the negative ideal solution matrix.

6. Calculates the closeness to the positive ideal solution.
The relative closeness of each alternative to the positive ideal solution can be calculated using the following equation:

$$V_i^+ = \frac{D_i^-}{D_i^+ + D_i^+}, \; 0 \leq C_i^+ \leq 1,$$

With i = 1,2,3,…,m
Information :
V_i^+ is the relative proximity of the I-th alternative to the positive ideal solution.
D_i^+ is the I-th alternative distance from the positive ideal solution.
D_i^- is the distance of the I-th alternative from the ideal solution negative.

7. Alternate ranking.
Alternatives are sorted from the largest C^+ value to the smallest value. The alternative with the largest C^+ value is the best solution.

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3. RESULTS AND DISCUSSION

The research results are seen in table 1, and the next step is to determine the initial parameters that will be used to solve the problem with the Fuzzy C-Means algorithm. These parameters are the number of clusters (c = 2), power (w = 2), maximum iteration (MaxIter = 100), smallest expected error (ξ = 0.01), the initial objective function (P 0 = 0), and the initial iteration (t = 1). The number of clusters specified is two. Using MatLab 2021A software, the results of calculating cluster centres, membership degrees or U matrices and the value of the objective function or object. Requires an initial iteration of 51 times before obtaining the optimal solution for the functional value Jw (U, V) of 3326327.260926. In the 51st iteration, the cluster center produced by MatLab software k = 1.2; and j=1,2,3 is

$$V_{ij} = \begin{bmatrix} 83.75887524 & 24.79758911 & 106.1899471 \\ 87.84208908 & 204.3439597 & 1221.395041 \end{bmatrix}$$

After obtaining the Centroid or centre point, the next step is to calculate the distance between the input criteria values from the user to each of the existing cluster centre points. The following is the Euclidean Distance formula:

$dist\,(x, y) = \sqrt{\sum}\,(xi - yi)$

The following is the source code of the Euclidean Distance calculation used in this study.

```
for i=i:row
        for j=1: column
        ke1=sqrt(sum((A(i,j)-C(1,j)).^2));
        2nd=sqrt(sum(A((i,j)-C(2,j)).^2));
        end
        if((to1<to2)
                H(i)="to1";
                else
                H(i)="2nd"
        end
end
```

So that the results of the grouping are obtained as in the Appendix 2.

3.1 Ranking Using Topsis

Based on the cluster data obtained after using the algorithm, fuzzy c means will be processed using the topsis method with four criteria which will then be

processed into a matrix like the following: The percentage value of each criterion is calculated as follows.

percentage 0 - 10, then value = 1
percentage 11 - 20, then value = 2
percentage 21 - 30, then value = 3
percentage 31-40, then value = 4
percentage 41 - 50, then value = 5
percentage 51 - 60, then value = 6
percentage 61 - 70, then value = 7
percentage 71 - 80, then value = 8
percentage 81 - 90, then value = 9
percentage 91 - 100, then value = 10

1. The weight of each criterion is determined as follows:

Table 3. The weight of each criterion

ID	Criteria	Weight (%)
C1	Jafung lecturer	30
C2	Accreditation	40
C3	Certified lecturer	25
C4	Report	5

2. For the first cluster after using the fuzzy-c-means algorithm as follows:

Table 4. The first cluster after using the fuzzy c-means algorithm

Alternative	Code	Criteria			
		Responsive Lecturer	Accreditation	Certified Lecturer	Report
		C1	C2	C3	C4
A1	021015	9	7	7	10
A2	021024	6	10	5	10
A3	022005	9	1	4	10
A4	021016	10	8	5	10
A5	021001	8	7	5	10
A6	021008	9	9	6	10
A7	021019	8	8	6	10

3. Normalized matrix = root of the power of the value on each criterion (x=√C^2)

Table 5. Normalized matrix

X1	X2	X3	X4
22.5166605	20.19900988	14.56021978	26.45751311

Table 6. Normalized Performance Rating

Alternative	NAME	C1	C2	C3	C4
Normalization		R1	R2	R3	R4
A1	021015	0.3997	0.3466	0.4808	0.3780
A2	021024	0.2665	0.4951	0.3434	0.3780
A3	022005	0.3997	0.0495	0.2747	0.3780
A4	021016	0.4441	0.3961	0.3434	0.3780
A5	021001	0.3553	0.3466	0.3434	0.3780
A6	021008	0.3997	0.4456	0.4121	0.3780
A7	021019	0.3553	0.3961	0.4121	0.3780

Table 7. Normalized Weight Rating(yij)

Alternative	Name	C1	C2	C3	C4
Criteria		Y1	Y2	Y3	Y4
A1	021015	11.99112098	13.8620656	12.01904935	1.889822365
A2	021024	7.99408065	19.80295086	8.585035247	1.889822365
A3	022005	11.99112098	1.980295086	6.868028197	1.889822365
A4	021016	13.32346775	15.84236069	8.585035247	1.889822365
A5	021001	10.6587742	13.8620656	8.585035247	1.889822365
A6	021008	11.99112098	17.82265577	10.3020423	1.889822365
A7	021019	10.6587742	15.84236069	10.3020423	1.889822365

4. Determine Positive Ideal Solutions (A+) and Negative Ideal Matrix (A-). Formula : A+ = max(y1+,y2+,…,yn+) and A- = max(y1-,y2-,…,yn-)

Table 8. Positive Ideal Solution and negative ideal matrix

POSITIVE	A+	NEGATIVE	A-
Y1+	13.32346775	Y1-	7.99408065
Y2+	19.80295086	Y2-	1.980295086
Y3+	12.01904935	Y3-	6.868028197
Y4+	1.889822365	Y4-	1.889822365

The distance between the value of each alternative with the positive ideal solution matrix & the negative ideal solution matrix.

Positive = the root of the result (A+ minus the weighted data) to the power of 2
Negative = the root of the result (A- minus the weighted data) to the power of 2

Table 9. The distance between the value of each alternative with the positive ideal solution matrix & the negative ideal solution matrix

Alternative Distance	Positive (+)	Negative (-)	D+ + D-
A1	6.088453463	13.55307422	19.64152768
A2	6.339938461	17.90517166	24.24511012
A3	18.59987166	3.997040325	22.59691198
A4	5.24201558	14.95016197	20.19217755
A5	7.361192987	12.29736458	19.65855756
A6	2.940209136	16.69578319	19.63599233
A7	5.072965546	14.52755682	19.60052237

5. Preference Value of each Criterion
   Result = negative ideal solution (D-) / sum of positive and negative ideal solutions (D+ + D-)

   Vi = D- / (D+ + D-) $\frac{D_i^-}{D_i^- + D_i^+}$

Table 10. Preference Value of each Criterion

No	Name	Alternative	V	Ranking
1	021008	A6	0.850	Best alternative 1
2	021019	A7	0.741	Best Alternative 2
3	021016	A4	0.740	Best Alternative 3
4	021024	A2	0.739	Best Alternative 4
5	021015	A1	0.690	Best Alternative 5
6	021001	A5	0.626	Best Alternative 6
7	022005	A3	0.177	Best Alternative 7

4. CONCLUSION

This study shows that the weaknesses in the ranking of tertiary institutions in Region II Higher Education Service Institutions, which rely on one category for each work section, can be overcome using the fuzzy c-means and topsis methods. The use of the Fuzzy C-Means method can divide college clusters by region, number of lecturers and number of students. By taking the mean value from the results of the calculation of the fuzzy c-means algorithm, two college clusters are created where there are seven universities with scores above the cluster mean value. Furthermore, from these clusters, the topsis method can be a solution for ranking the results of the clustering, where seven alternatives for the best higher education rankings are obtained.

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Appendix 1. The grouping based on the initial dataset

No	Code	College Name	Region	Lecturers	Students
1	23044	Sekolah Tinggi Ilmu Ekonomi Rahmaniyah	70	27	144
2	23055	Sekolah Tinggi Ilmu Hukum Rahmaniyah	70	11	71
3	25012	Politeknik Sekayu	70	18	62
4	24136	Akademi Kebidanan Agung Husada	70	4	9
5	21022	Universitas Islam Ogan Komering Ilir Kayuagung	70	54	127
6	23043	Sekolah Tinggi Ilmu Ekonomi Dwi Sakti Baturaja	70	10	34
7	21015	Universitas Baturaja	70	148	781
8	23080	Sekolah Tinggi Ilmu Kesehatan Al Ma arif	70	20	82
9	23023	Sekolah Tinggi Ilmu Ekonomi Serasan Muara Enim	70	10	24
10	23038	Sekolah Tinggi Ilmu Teknik Serasan	70	7	20
11	23037	Sekolah Tinggi Ilmu Hukum Serasan Muara Enim	70	10	68
12	23025	Sekolah Tinggi Ilmu Ekonomi Serelo Lahat	70	39	152
13	23138	Sekolah Tinggi Keguruan dan Ilmu Pendidikan Muhammadiyah OKU Timur	70	16	207
14	23074	Sekolah Tinggi Ilmu Pertanian Belitang	70	25	98
15	23108	STKIP Nurul Huda di Sukaraja	70	60	470
16	23123	STISIP Bina Marta	70	9	38
17	24138	Akademi Keperawatan Al Ma Arif	70	12	14
18	23094	STMIK Muara Dua	70	8	0
19	24040	Akd Teknik Radiodiag. Dan Radioterapi Widya Dharma	90	9	0
20	24114	Akademi Kebidanan Tunas Harapan Bangsa	90	3	0
21	21011	Universitas Tamansiswa	90	93	329
22	23083	Sekolah Tinggi Ilmu Farmasi Bhakti Pertiwi	90	32	277
23	26003	Akademi Komunitas Industri Pertambangan Bukit Asam	70	7	67
24	21006	Universitas Palembang	90	96	265
25	23142	Sekolah Tinggi Kesehatan Pondok Pesantren Assanadiyah Palembang	90	0	0
26	23143	Sekolah Tinggi Ilmu Kesehatan Al-Sua'ibah	90	19	61
27	23027	Sekolah Tinggi Ilmu Ekonomi Trisna Negara	70	61	229
28	24032	Akademi Analis Kesehatan Widya Dharma	90	4	0
29	23124	STIKES Aisyiyah Palembang	90	34	98
30	23095	STIA & Pemerintahan Annisa Dwi Salfarizi	90	26	101

No	Code	College Name	Region	Lecturers	Students
31	21007	Universitas IBA	90	60	170
32	24139	Akademi Keperawatan Pembina	90	4	6
33	23127	STIA Bala Putra Dewa	90	18	102
34	24087	Akademi Kebidanan Budi Mulia Palembang	90	14	24
35	24120	AMIK Bina Sriwijaya	90	29	75
36	23068	Sekolah Tinggi Ilmu Ekonomi Abdi Nusa	90	16	41
37	23017	Sekolah Tinggi Ilmu Pertanian Sriwigama	90	23	22
38	23125	STMIK MBC Palembang	90	20	56
39	24134	Akademi Keperawatan Kesdam II Sriwijaya	90	21	108
40	23065	STIKESMAS Nusantara	90	13	32
41	21017	Universitas Kader Bangsa	90	135	646
42	21030	Universitas Sumatera Selatan	90	54	423
43	23069	STIKESMAS Abdi Nusa	90	15	27
44	23051	STIKESMAS Widya Dharma Palembang	90	4	6
45	21024	Universitas Indo Global Mandiri	90	146	916
46	24088	Akademi Maritim Bina Bahari	90	9	45
47	24091	Akademi Kebidanan Heppy Zal	90	7	0
48	23047	Sekolah Tinggi Bahasa Asing Methodist	90	19	10
49	23024	Sekolah Tinggi Ilmu Hukum Sumpah Pemuda	90	33	477
50	21013	Universitas Sjakhyakirti	90	130	621
51	23041	STIPSI Widya Dharma	90	9	16
52	23053	Sekolah Tinggi Bahasa Asing Widya Dharma Palembang	90	2	0
53	22005	Institut Ilmu Kesehatan dan Teknologi Muhammadiyah Palembang	90	63	1475
54	24050	Akademi Bahasa Asing Bina Insan Indonesia	90	8	6
55	24035	Akademi Keuangan Dan Perbankan Mulia Darma Pratama	90	9	39
56	23042	Sekolah Tinggi Ilmu Ekonomi Mulia Darma Pratama	90	20	100
57	24125	Akademi Kebidanan Pondok Pesantren Assanadiyah	90	11	0
58	23078	STIPSI Abdi Nusa	90	9	10
59	25011	Politeknik Akamigas Palembang	90	36	212
60	24007	AMIK Sigma	90	25	115
61	23059	Sekolah Tinggi Ilmu Ekonomi Prabumulih	80	21	118

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No	Code	College Name	Region	Lecturers	Students
62	24124	Akademi Kebidanan Rangga Husada Prabumulih	80	7	16
63	24130	Akademi Kebidanan Budi Mulia Prabumulih	80	12	6
64	23066	STMIK Prabumulih	80	19	114
65	21032	Universitas Bina Insan	80	78	611
66	23097	Sekolah Tinggi Ilmu Kesehatan Siti Khadijah	90	65	224
67	23107	STMIK Bina Nusantara Jaya	80	22	14
68	23137	Sekolah Tinggi Ilmu Ekonomi dan Bisnis Prana Putra	80	8	60
69	23102	Sekolah Tinggi Teknologi Pagaralam	80	38	140
70	23061	STKIP Muhammadiyah Pagaralam	80	32	126
71	22006	Institut Teknologi dan Bisnis Lembah Dempo	80	37	471
72	23067	Sekolah Tinggi Ilmu Teknik Prabumulih	80	10	24
73	25006	Politeknik YPPB Belitang	70	10	22
74	25009	Politeknik Muara Dua	70	6	0
75	21016	Universitas PGRI Palembang	90	335	1878
76	21001	Universitas Muhammadiyah Palembang	90	417	1996
77	23019	Sekolah Tinggi Ilmu Ekonomi Aprin	90	43	450
78	23057	Sekolah Tinggi Ilmu Kesehatan Bina Husada	90	76	277
79	23002	STKIP PGRI Lubuk Linggau	80	117	555
80	21025	Universitas Musi Rawas	80	55	247
81	24116	Akademi Kebidanan Nusantara Indonesia Lubuklinggau	80	8	34
82	23099	Sekolah Tinggi Ilmu Kesehatan Fitrah Aldar	80	12	16
83	24006	Akademi Sekretari Dan Manajemen Sriwijaya	90	13	0
84	23052	Sekolah Tinggi Ilmu Administrasi Satya Negara	90	37	258
85	24044	Akademi Manajemen Informatika Dan Komputer Mdp	90	6	14
86	21027	Universitas Katolik Musi Charitas	90	110	469
87	23098	STIKES Pembina Palembang	90	13	10
88	24107	Akademi Kebidanan Persada Palembang	90	7	0
89	24110	Akademi Kebidanan Rizki Patya	90	11	9
90	25002	Politeknik Anika Palembang	90	21	0
91	23134	Sekolah Tinggi Ilmu Kesehatan Abdurahman Palembang	90	23	39
92	24034	Apikes Widya Dharma	90	11	89

No	Code	College Name	Region	Lecturers	Students
93	25010	Politeknik Palcomtech	90	15	151
94	23103	STMIK Palcomtech	90	31	197
95	24095	Akademi Kebidanan Nusantara Palembang	90	6	0
96	21008	Universitas Tridinanti	90	215	894
97	25004	Politeknik Darussalam	90	23	72
98	23005	STISIPOL Candradimuka	90	81	405
99	21019	Universitas Bina Darma	90	232	1181
100	23111	Sekolah Tinggi Ilmu Kesehatan Mitra Adiguna	90	37	129

Appendix 2. College cluster data after using the fuzzy c-means algorithm

No	Code	College Name	Region	Lecturers	Students	Cluster
1	23044	Sekolah Tinggi Ilmu Ekonomi Rahmaniyah	70	27	144	1
2	23055	Sekolah Tinggi Ilmu Hukum Rahmaniyah	70	11	71	1
3	25012	Politeknik Sekayu	70	18	62	1
4	24136	Akademi Kebidanan Agung Husada	70	4	9	1
5	21022	Universitas Islam Ogan Komering Ilir Kayuagung	70	54	127	1
6	23043	Sekolah Tinggi Ilmu Ekonomi Dwi Sakti Baturaja	70	10	34	1
7	21015	Universitas Baturaja	70	148	781	2
8	23080	Sekolah Tinggi Ilmu Kesehatan Al Ma arif	70	20	82	1
9	23023	Sekolah Tinggi Ilmu Ekonomi Serasan Muara Enim	70	10	24	1
10	23038	Sekolah Tinggi Ilmu Teknik Serasan	70	7	20	1
11	23037	Sekolah Tinggi Ilmu Hukum Serasan Muara Enim	70	10	68	1
12	23025	Sekolah Tinggi Ilmu Ekonomi Serelo Lahat	70	39	152	1
13	23138	Sekolah Tinggi Keguruan dan Ilmu Pendidikan Muhammadiyah OKU Timur	70	16	207	1
14	23074	Sekolah Tinggi Ilmu Pertanian Belitang	70	25	98	1
15	23108	STKIP Nurul Huda di Sukaraja	70	60	470	1
16	23123	STISIP Bina Marta	70	9	38	1
17	24138	Akademi Keperawatan Al Ma Arif	70	12	14	1
18	23094	STMIK Muara Dua	70	8	0	1
19	24040	Akd Teknik Radiodiag. Dan	90	9	0	1

No	Code	College Name	Region	Lecturers	Students	Cluster
		Radioterapi Widya Dharma				
20	24114	Akademi Kebidanan Tunas Harapan Bangsa	90	3	0	1
21	21011	Universitas Tamansiswa	90	93	329	1
22	23083	Sekolah Tinggi Ilmu Farmasi Bhakti Pertiwi	90	32	277	1
23	26003	Akademi Komunitas Industri Pertambangan Bukit Asam	70	7	67	1
24	21006	Universitas Palembang	90	96	265	1
25	23142	Sekolah Tinggi Kesehatan Pondok Pesantren Assanadiyah Palembang	90	0	0	1
26	23143	Sekolah Tinggi Ilmu Kesehatan Al-Sua'ibah	90	19	61	1
27	23027	Sekolah Tinggi Ilmu Ekonomi Trisna Negara	70	61	229	1
28	24032	Akademi Analis Kesehatan Widya Dharma	90	4	0	1
29	23124	STIKES Aisyiyah Palembang	90	34	98	1
30	23095	STIA & Pemerintahan Annisa Dwi Salfarizi	90	26	101	1
31	21007	Universitas IBA	90	60	170	1
32	24139	Akademi Keperawatan Pembina	90	4	6	1
33	23127	STIA Bala Putra Dewa	90	18	102	1
34	24087	Akademi Kebidanan Budi Mulia Palembang	90	14	24	1
35	24120	AMIK Bina Sriwijaya	90	29	75	1
36	23068	Sekolah Tinggi Ilmu Ekonomi Abdi Nusa	90	16	41	1
37	23017	Sekolah Tinggi Ilmu Pertanian Sriwigama	90	23	22	1
38	23125	STMIK MBC Palembang	90	20	56	1
39	24134	Akademi Keperawatan Kesdam II Sriwijaya	90	21	108	1
40	23065	STIKESMAS Nusantara	90	13	32	1
41	21017	Universitas Kader Bangsa	90	135	646	1
42	21030	Universitas Sumatera Selatan	90	54	423	1
43	23069	STIKESMAS Abdi Nusa	90	15	27	1
44	23051	STIKESMAS Widya Dharma Palembang	90	4	6	1
45	21024	Universitas Indo Global Mandiri	90	146	916	2
46	24088	Akademi Maritim Bina Bahari	90	9	45	1
47	24091	Akademi Kebidanan Heppy Zal	90	7	0	1

No	Code	College Name	Region	Lecturers	Students	Cluster
48	23047	Sekolah Tinggi Bahasa Asing Methodist	90	19	10	1
49	23024	Sekolah Tinggi Ilmu Hukum Sumpah Pemuda	90	33	477	1
50	21013	Universitas Sjakhyakirti	90	130	621	1
51	23041	STIPSI Widya Dharma	90	9	16	1
52	23053	Sekolah Tinggi Bahasa Asing Widya Dharma Palembang	90	2	0	1
53	22005	Institut Ilmu Kesehatan dan Teknologi Muhammadiyah Palembang	90	63	1475	2
54	24050	Akademi Bahasa Asing Bina Insan Indonesia	90	8	6	1
55	24035	Akademi Keuangan Dan Perbankan Mulia Darma Pratama	90	9	39	1
56	23042	Sekolah Tinggi Ilmu Ekonomi Mulia Darma Pratama	90	20	100	1
57	24125	Akademi Kebidanan Pondok Pesantren Assanadiyah	90	11	0	1
58	23078	STIPSI Abdi Nusa	90	9	10	1
59	25011	Politeknik Akamigas Palembang	90	36	212	1
60	24007	AMIK Sigma	90	25	115	1
61	23059	Sekolah Tinggi Ilmu Ekonomi Prabumulih	80	21	118	1
62	24124	Akademi Kebidanan Rangga Husada Prabumulih	80	7	16	1
63	24130	Akademi Kebidanan Budi Mulia Prabumulih	80	12	6	1
64	23066	STMIK Prabumulih	80	19	114	1
65	21032	Universitas Bina Insan	80	78	611	1
66	23097	Sekolah Tinggi Ilmu Kesehatan Siti Khadijah	90	65	224	1
67	23107	STMIK Bina Nusantara Jaya Lubuk Linggau	80	22	14	1
68	23137	Sekolah Tinggi Ilmu Ekonomi dan Bisnis Prana Putra	80	8	60	1
69	23102	Sekolah Tinggi Teknologi Pagaralam	80	38	140	1
70	23061	STKIP Muhammadiyah Pagaralam	80	32	126	1
71	22006	Institut Teknologi dan Bisnis Lembah Dempo	80	37	471	1
72	23067	Sekolah Tinggi Ilmu Teknik Prabumulih	80	10	24	1
73	25006	Politeknik YPPB Belitang	70	10	22	1
74	25009	Politeknik Muara Dua	70	6	0	1
75	21016	Universitas PGRI Palembang	90	335	1878	2

No	Code	College Name	Region	Lecturers	Students	Cluster
76	21001	Universitas Muhammadiyah Palembang	90	417	1996	2
77	23019	Sekolah Tinggi Ilmu Ekonomi Aprin	90	43	450	1
78	23057	Sekolah Tinggi Ilmu Kesehatan Bina Husada	90	76	277	1
79	23002	STKIP PGRI Lubuk Linggau	80	117	555	1
80	21025	Universitas Musi Rawas	80	55	247	1
81	24116	Akademi Kebidanan Nusantara Indonesia Lubuklinggau	80	8	34	1
82	23099	Sekolah Tinggi Ilmu Kesehatan Fitrah Aldar	80	12	16	1
83	24006	Akademi Sekretari Dan Manajemen Sriwijaya	90	13	0	1
84	23052	Sekolah Tinggi Ilmu Administrasi Satya Negara	90	37	258	1
85	24044	Akademi Manajemen Informatika Dan Komputer Mdp	90	6	14	1
86	21027	Universitas Katolik Musi Charitas	90	110	469	1
87	23098	STIKES Pembina Palembang	90	13	10	1
88	24107	Akademi Kebidanan Persada Palembang	90	7	0	1
89	24110	Akademi Kebidanan Rizki Patya	90	11	9	1
90	25002	Politeknik Anika Palembang	90	21	0	1
91	23134	Sekolah Tinggi Ilmu Kesehatan Abdurahman Palembang	90	23	39	1
92	24034	Apikes Widya Dharma	90	11	89	1
93	25010	Politeknik Palcomtech	90	15	151	1
94	23103	STMIK Palcomtech	90	31	197	1
95	24095	Akademi Kebidanan Nusantara Palembang	90	6	0	1
96	21008	Universitas Tridinanti	90	215	894	2
97	25004	Politeknik Darussalam	90	23	72	1
98	23005	STISIPOL Candradimuka	90	81	405	1
99	21019	Universitas Bina Darma	90	232	1181	2
100	23111	Sekolah Tinggi Ilmu Kesehatan Mitra Adiguna	90	37	129	1

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