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Determination System Of Food Vouchers For the Poor Based On Fuzzy C-Means Method

D R Anamisa, M Yusuf, M A Syakur

Department of Multimedia and Network Engineering, Faculty of Engineering, University of Trunojoyo Madura, Jl. Raya Telang, Kamal, Bangkalan, Madura 69162 Indonesia

Email: devros_gress@yahoo.com

Abstract. Food vouchers are government programs to tackle the poverty of rural communities. This program aims to help the poor group in getting enough food and nutrients from carbohydrates. There are several factors that influence to receive the food voucher, such as: job, monthly income, Taxes, electricity bill, size of house, number of family member, education certificate and amount of rice consumption every week. In the execution for the distribution of vouchers is often a lot of problems, such as: the distribution of food vouchers has been misdirected and someone who receives is still subjective. Some of the solutions to decision making have not been done. The research aims to calculating the change of each partition matrix and each cluster using Fuzzy C-Means method. Hopefully this research makes contribution by providing higher result using Fuzzy C-Means comparing to other method for this case study. In this research, decision making is done by using Fuzzy C-Means method. The Fuzzy C-Means method is a clustering method that has an organized and scattered cluster structure with regular patterns on two-dimensional datasets. Furthermore, Fuzzy C-Means method used for calculates the change of each partition matrix. Each cluster will be sorted by the proximity of the data element to the centroid of the cluster to get the ranking. Various trials were conducted for grouping and ranking of proposed data that received food vouchers based on the quota of each village. This testing by Fuzzy C-Means method, is developed and abled for determining the recipient of the food voucher with satisfaction results. Fulfillment of the recipient of the food voucher is 80% to 90% and this testing using data of 115 Family Card from 6 Villages. The quality of success affected, has been using the number of iteration factors is 20 and the number of clusters is 3

1. Introduction

Food vouchers are government programs to tackle poor communities by providing assistance to poor communities to meet basic needs. This program has been implemented by the government since 1998. Early on, the program was called as the Special Market Operation Program (OPK), then it has been changed to Rice Pad (RASKIN) in 2002 and at the end of February 2017, the government has officially converted the Raskin program into a voucher program Food by extending the function as part of the community's social protection program. The distribution mechanism of food voucher program has been conducted at 44 regencies in Indonesia[1]. Furthermore, acceptance mechanism of food vouchers becomes a complicated issue. The data dynamics of food voucher recipients require a local policy through village consultation. Moreover, the distribution of food voucher to the recipients is still through certain



community groups so often it is still lack on target. Therefore, supportive factors are needed to overcome this in order to improve Indonesia's economic stability [2]. One of the policies taken by the government is by issuing aid program policies in the form of food voucher.

Several solutions to decision making for the determination of food voucher recipients have been widely implemented. However, the solution has not provided satisfactory success, so various improvement efforts in this research need to be done. Based on the literature review, the Fuzzy C-Means method is one of the clustering algorithms as part of the C-Means method. The C-means method is well known for its ease and ability to cluster large data and outlier data very quickly. However, the disadvantage of the C-Means method is the result of ever-changing clustering[3]. Therefore, this research using Fuzzy C-Means for the determination of food voucher recipients. Fuzzy C-Means method has some advantages including simple, easy to implement, able for grouping large data, and precise placing the objects exactly on one partition or located between two or more in other partitions. It also has better output in term of stability rates rather than conventional method approaches, such as the C-Means method [4]. In addition, the Fuzzy C-Means method is a suitable clustering method for the selection process by determining the number of clusters to be established [5]. The FCM method is a clustering method without new supervision that allows one data to be owned by two or more clusters and has high classification test efficiency [6]. There is some research about Fuzzy C-Means as following: [7] captures the application of a novel intuitionistic fuzzy c means clustering algorithm in medical images; [8] presents a modified possibilistic fuzzy c-means for bias field estimation and segmentation of brain MR image; [9] examine a fuzzy c-means based on nearest-neighbor intervals for incomplete data. Based on the previous research, there is still limited research about application of the FCM for determining food voucher recipient.

Process of determining the food voucher recipient using the Fuzzy C-Means method is influenced by several factors, such as: employment, monthly income, tax and electricity bill, house size, number of family members, education certificate and total rice consumption per week. The objective of this study using Fuzzy C-Means method is calculating the change of each partition matrix and each cluster will be sorted based on the proximity of data elements with its centroid cluster, where data that have the same characteristics can be grouped into one cluster and the same data differently grouped into other groups. Therefore, the results of this study were obtained by the ranking process based on the centroid of the cluster for decision-making which entitled the food voucher so that the program is right on target. Hopefully this research makes contribution by providing higher result using Fuzzy C-Means comparing to other method for this case study.

2. Methodology

The input data in this research are the criteria data from 6 Villages in Pragaan Sub-district, Sumenep Regency, East Java, Indonesia. Details of the data were collected from 44 candidates at Aeng Soka Village, 45 candidates at Maronggi Laok Village, 56 candidates at Dung Daja Village, 45 candidates at Dung Laok Village, 22 candidates at Maronggi Daja Village, 45 candidates at Mornangka Village) based on 8 criteria as shown in Table 1. Assessment is needed for determining the food voucher recipient, particularly the value in each aspect. The assessment in this model uses the weighting for each sub criterion on each criterion. The weight of the value, such as value of very good is 5, value of good is 4, value of enough is 3, value of less is 2, and value of very less is 1.

Table 1. Data Criteria of Voucher Food Programs

No.	Type's Criteria	Sub Criteria	No.	Type's Criteria	Sub Criteria		
1.	Job	Farmer	3.	Salary	Income per month		
		Fisher			4.	Building Tax	Tax cost
		Asistant of house			5.	Electricity bills	Monthly account fees

		Government Employees	6. House size	Wide of the house
		Private Employees	7. Rice Needs	Consumption of rice every week
2.	Graduate Education	Not certified	8. Number of family members	Number of dependents of family members
		Primary school		
		Junior high school / equal		
		Senior high school / equal		
		Diploma/ Bachelor /		
		Magister		

Decision support system is the process for selecting alternative ways of acting with an efficient method according to the circumstances that support a decision. It is solving a problem with system support in determining the taken solution [10]. Furthermore, decision support system for determining the voucher recipient is based on the fuzzy set of concepts that is the basis of the fuzzy logic system. Membership function is a curve showing the mapping of data points of input into its membership value. A fuzzy set can be defined based on linguistic variables that have a value of words in natural language [11] [12]. There are several data clustering algorithms, one of which is Fuzzy C-Means (FCM). FCM is a data clustering technique that the existence of each data in a cluster is determined by a certain value or degree of membership. The basic concept is to determine the center of the group that will mark the average location for each cluster. The output of FCM is a cluster of central clusters and some degree of membership for each data point. However, this information can be used to build a fuzzy inference system [12]. If there is a set of data (input or output data from the fuzzy system), then it can be seen in Equation 1. The objective function of the P threshold iteration P(c) in the partition matrix can be seen in Equation 4.

$$X = (x_1, x_2, x_3, \dots, x_N) \tag{1}$$

The degree of membership of k data point in the ith cluster can be seen in Equation 2.

$$\mu_{ik}(x_k) \in [0, 1] \text{ with } (1 \leq i \leq c; 1 \leq k \leq N) \tag{2}$$

In the FCM method, the partition matrix can be seen in Equation 3.

$$\mu_f(c) = \begin{bmatrix} \mu_{11}[X_1] & \mu_{21}[X_1] & \mu_{31}[X_1] \\ \mu_{12}[X_2] & \mu_{22}[X_2] & \mu_{32}[X_2] \\ \mu_{13}[X_3] & \mu_{23}[X_3] & \mu_{33}[X_3] \\ \mu_{1N}[X_N] & \mu_{2N}[X_N] & \mu_{3N}[X_N] \end{bmatrix} \tag{3}$$

with $\sum_{i=1}^c \mu_{ik} = 1$, which means that the number of degrees of membership of a data in all clusters must be equal to 1.

$$Pt(c) = \sum_{k=1}^N \sum_{i=1}^c (\mu_{ik})^w |x_k - v_{fi}|, \text{ where } v_{fi} = \frac{\sum_{k=1}^n (\mu_{ik})^w x_k}{\sum_{k=1}^n (\mu_{ik})^w} \tag{4}$$

$|x_k - v_{fi}|$ is the normal form of Euclidean used as the distance between x_k and v_{fi} with v_{fi} is the center of the cluster on the ith fuzzy and w is the weighted rank on the membership values. In the process of determining the food voucher recipient using FCM method, the data input will be clustered in the form of data from the population in the form of X matrix of size n x m, where n = number of data samples and m = attribute of each data. X_{ij} = ith sample data (i = 1, 2, ..., n), j of attribute (j = 1, 2, ..., m). Then perform the following steps [7]: (a) initialization parameters, including number of clusters (c), weighted rank (w) = 2, maximum iteration (maxIter), least expected error (ξ) = 10^{-5} , initial objective function (P_0) = 0, initial iteration = 1; (b) Generate random numbers μ_{ik} , where i = 1, 2, ..., n; k = 1, 2, ..., c; as elements of the initial partition matrix ($\mu_f(0)$). Calculate the number of each column (attribute) as shown in Equation 4, then normalized on μ_{ik} , as shown in equation 5; (c) Calculate the center of the cluster for the partition matrix, as shown in equation 3; (d) Calculate the objective function in the t iteration; (e) Calculating error, can be seen in equation 6; (f) Calculating euclidean, where euclidean is the airspace value between the clusters to the center of the cluster, the distance is taken by a straight line and the rectilinear count, where rectilinear is the value, , can be seen in equation 7; (g) Calculating the change in matrix as shown in

Equation 8; (h) Checking the stop condition, If ($|P_t - P_{t-1}| < \xi$) or $t > \text{MaxIter}$ then stop and if it is not $t = t + 1$, repeat step (c). Equation 11 shows the calculating process for the success rate in the fulfillment of the food voucher recipients.

$$Q_j = \sum_{k=1}^c \mu_{ik} \quad , \text{ where } j = 1, 2, \dots, m \quad (5)$$

$$\mu_{ik} = \frac{\mu_{ik}}{Q_i} \quad (6)$$

$$P_t = \sum_{i=1}^n \sum_{k=1}^c ([\sum_{j=1}^m (x_{ij} - v_{kj})^2] (\mu_{ik})^w) \quad (7)$$

$$\text{Euclidean} = \sum_{i=1}^k \frac{\sum_{i=1}^n \sqrt{(x_{[1,i]} - v_{[1,i]})^2 + (y_{[1,i]} - v_{[1,i]})^2} x \text{ weight}_i}{\sum_{i=1}^k \sqrt{(x_{[1,i]} - v_{[1,i]})^2 + (y_{[1,i]} - v_{[1,i]})^2} x \text{ weight}_i} \quad , \text{ and} \quad (8)$$

$$\text{Rectilinear} = \sum_{i=1}^k \frac{\sum_{i=1}^n |x_{[1,i]} - v_{[1,i]}| + |y_{[1,i]} - v_{[1,i]}| x \text{ weight}_i}{\sum_{i=1}^k |x_{[1,i]} - v_{[1,i]}| + |y_{[1,i]} - v_{[1,i]}| x \text{ weight}_i}$$

$$\mu_{ik} = \frac{[\sum_{j=1}^m (x_{ij} - v_{kj})^2]^{-\frac{1}{w-1}}}{\sum_{k=1}^c [\sum_{j=1}^m (x_{ij} - v_{kj})^2]^{-\frac{1}{w-1}}} \quad (9)$$

$$\text{Percentage of result (\%)} = \frac{\frac{\sum \text{Proximity Feasibility Value}}{\text{Value of Each Cluster}}}{\sum \text{Total Criteria}} \times 100\% \quad (10)$$

3. Results and Discussion

Determining process of the food voucher recipient has been conducted through several steps as following: entering the village proposal data, the criteria for each village and determining the parameters, then generating random numbers as the initial partition matrix element, calculating the number of each matrix column, counting the cluster center, calculating the objective function, calculating the change of each partition matrix. Check the stop condition, if ($|P_t - P_{t-1}| < \xi$) or ($t > \text{MaxIter}$) then stop, otherwise $t = t + 1$ then it will be repeated to the cluster calculation. The cluster center has been obtained if the condition stops fulfilling. A data which has the greatest degree of membership belong to a cluster. Each cluster will be sorted based on the proximity of the data element to the center of the cluster to obtain the friction. While the implementation of the 8 criteria as the proposed data of the food voucher recipient and the FCM parameter as shown in Figure 1.

Several trials have been conducted in this study with data processing of 115 Family Card from 6 Villages. The condition of the data is greater than the number of iterations and the number of clusters are 3 and the maximum iterations are 20, resulting in data of 25 food voucher recipients. This study has been tested using 5 data sample as shown Table 2. Furthermore, it is a sample of FCM calculation for determining the food voucher recipients. Then, the next process is to generate a random value as the element of initial partition matrix (μ_{25}) after the candidate data is formed, such as:

$$\mu_{25} = \begin{bmatrix} 0.12 & 0.46 & 0.68 & 0.33 & 0.42 \\ 0.88 & 0.54 & 0.32 & 0.67 & 0.58 \end{bmatrix}$$

The next step are calculating the cluster center, then improving the degree of membership (μ_{ik}^2) and the objective function (P_t) after a random number is created. As a results, two clusters in this study are shown in Table 3. Next, the matrix improvement as shown in Table 4. Finally, the last step is checking the stop condition ($|P_t - P_0|$). The result shows that P_t in the 1st iteration is still greater than error (0.00001), therefore the next iteration has done. This is conducted repeatedly for the 25th iteration. When the 25th iteration of the cluster center is generated, it can be seen in Table 3. Table 4 shows the partition matrix information is obtained on the tendency of candidate receiving food vouchers to enter clusters with the highest membership level to become members of the selected group.



Figure 1. (a) Implementation of Criteria Candidate of the food Voucher Receptient, (b) Parameter of FCM

Table 2. Data of the proposed food voucher recipients by weighting

No	Name	Job	salary	Tax	Billing	Number of Family	Rice needs	House Size	Graduated
1.	Suja'i	5	470000	5000	18000	5	6.2	63	7
2.	Moh. Syafi'e	2	2037000	12000	22000	3	1.5	102	5
3.	Nur Holis	5	260000	3600	8000	4	2.3	84	7
4.	Abdurrahman	4	320000	2500	10000	3	1.7	63	8
5.	Akhmad Faru	2	2700000	10000	23000	4	4.5	88	2

Table 3. Calculation of cluster center 1 and cluster 2

Iteration, Cluster	μ_{i1}^2	$\mu_{i1}^2 \cdot x_{i1}$	$\mu_{i2}^2 \cdot x_{i2}$	$\mu_{i3}^2 \cdot x_{i3}$	$\mu_{i4}^2 \cdot x_{i4}$	$\mu_{i5}^2 \cdot x_{i5}$	$\mu_{i6}^2 \cdot x_{i6}$	$\mu_{i7}^2 \cdot x_{i7}$	$\mu_{i8}^2 \cdot x_{i8}$
$\sum \mu_{11}$	0.97	3.59	1069149.2	6312.09	13759.8	3.5887	2.44913	83.7159	5.6196
$\frac{\sum_{k=1}^5 (\mu_{11})^2 x_{12}}{\sum_{k=1}^n (\mu_{11})^2}$		3.6927	1098027.3	6482.58	14131.4	3.6856	2.5152	85.977	5.77138
$\frac{\sum_{k=1}^5 (\mu_{25,1})^2 x_{25,2}}{\sum_{k=1}^5 (\mu_{25,1})^2}$		2.00002	2375287.8	10979.4	22510.2	3.5102	3.0308	94.8559	6.65836
$\sum \mu_{12}$	1.953	7.4356	2036509.2	12226.0	33399.8	7.8487	7.75113	145.015	11.8596
$\frac{\sum_{k=1}^5 (\mu_{12})^2 x_{12}}{\sum_{k=1}^n (\mu_{12})^2}$		3.8059	1042385.8	6257.91	17095.6	4.0173	3.9674	74.2262	6.07032
$\frac{\sum_{k=1}^5 (\mu_{25,2})^2 x_{25,2}}{\sum_{k=1}^n (\mu_{25,2})^2}$		4.6638	350924.30	3701.81	11995.9	3.9970	3.3935	70.020	7.1503
P_1			2.79917E+12		P_{25}			2.36865E+11	
$= \sum_{i=1}^5 \sum_{k=1}^2 ([\sum_{j=1}^8 (x_{ij} - v_{kj})^2] (\mu_{ik})^2)$					$= \sum_{i=1}^5 \sum_{k=1}^2 ([\sum_{j=1}^8 (x_{ij} - v_{kj})^2] (\mu_{ik})^2)$				

Table 4. Members of groups selected as the food voucher recipients

Type's Data	Matrix of patition		Selected Candidat	
	Cluster 1	Cluster 2	Cluster 1	Cluster 2
1	0.0039	0.9960		3 th

2	0.9613	0.0386	1 st	
3	0.0018	0.9981		4 th
4	0.0002	0.9997		5 th
5	0.9812	0.0187	2 nd	

4. Conclusions

The test results of the system for determining the food voucher recipient using FCM have conclusions as following: the cluster formed is influenced by some input criteria which is used as a reference in decision making based on 8 criteria. Furthermore, the determination of the food voucher recipient is affected by the maximum iteration and the smaller error value of the cluster's center result shows the correct position. In addition, the use of random matrices in the determination of cluster centers has significant impact to the calculation process for determining the proximity of proposals to a particular cluster center. The success rate of the food voucher recipient is 80% to 90% using 115 Family Card data from 6 Villages. Additionally, the quality of success affecting the number of iteration factors is 20 and the number of groups is 3.

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