Hybrid multiple criteria decision and fuzzy c-means for procurement

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Abstract. Determining the needs of each item of a product that has many types is something that is difficult to do if done manually. If this happens it will be a problem in decision making by management. As experienced by Cileunyi Collection Store where as of October 2018 the number of goods reached 2,469 types / Stock Keeping Units. (SKU). Production staff find it difficult to analyse how much production needs of each item so influence management decision-making in determining capital decisions and storage space that must be allocated. In this study will be explained the proposed decision support system in the form software application to assist the process of grouping goods and provide recommendations for the procurement of goods based on predetermined criteria in the Cileunyi Collection Store. Two algorithmic approaches, Multiple Decision-Making Criteria (MCDM) and Fuzzy C-Mean (FCM) are used. The MCDM algorithm is used to determine the order or priority in multi-criteria analysis and the FCM algorithm is used to group with the same membership. The Main result of the research is to present that the MCDM and FCM algorithm can provide recommendations for the procurement of goods with various specified criteria. The testing results shows that both of MCDM and FCM algorithm reached 90%.

1. Introduction
Clothing sales have many forms and media both through physical-shaped stores such as distributions (distribution stores), fo (factory outlets), boutiques and malls, and non-physical stores, namely online stores. In selling goods, there are many things that must be considered, one of which is the procurement process that is accurate and accountable, this affects the availability of goods, one of the things that greatly influences trust in online stores is the availability of stock of products sold.

Inventory is needed because of the incompatibility of quantity or time between supply and demand, this incompatibility is common in manufacturing, services, wholesalers, distributors and retail stores, where the role of inventory is used as an anticipation effort in the future. The important role of inventory in the supply chain is being able to increase the number of requests that can be met through available products and when customers need and reduce costs by managing economies of scale that may be needed during production and distribution [1-3].

The Cileunyi Collection which is the development model is a store in the form of a distro or distribution store that sells both online and offline, this distribution has been initiated since 2014 which is engaged in retail clothing sales online. Currently, the recording of sales transactions, goods inventory and procurement of goods is still manually in the excel document and can be said to be inadequate seeing the fact that the transaction is increasing for example in November 2017 the number of sales reached 2457 pcs while the latest data in February 2018 reached 3850 pcs, so it is very time consuming if you
want to produce accurate sales and procurement reports in a short time, the impact of which will hinder the development of the business itself [4-6].

The impact of the absence of an application for procurement of goods in addition to consuming a lot of time to make goods procurement documents also shows that the efficiency of procurement of goods is unclear and inaccurate because it only uses the owner's intuition, whereas it can be developed for example with a certain algorithm such as procurement of goods based on sales history criteria (buyer review, number of sales), ease of production (ease of raw materials, length of time of production, the extent of the convection / manufacturer) and the percentage of profits earned from sales the item. These criteria can be used as a reference to determine whether the stock of goods to be added, reduced or even stopped selling. Existing sales data can be used as one of the inputs to the application that will be made.

2. Methods
There are two methods approach used in the research, data analysis methods and system development method approach. The data analysis methods used in the research are the Multiple Criteria Decision Making (MCDM) and Fuzzy Clustering Means (FCM) algorithm approach and the system development method approach is prototyping system development approach [7].

3. Result and discussion
After the admin has successfully logged in, the display on the admin page immediately displays the home page with the title Goods Procurement Decision Support System as shown in figure 1 as follow.

![Figure 1](image_url)  
Figure 1. The home page of the system.

In figure 4 above, the home page above there are six submenu which they are the statistics submenu, data management submenu, data analysis submenu, report submenu, and user management submenu.

When we click on the page of the results of criteria analysis, we will be presented with a display of a table which is the result of analysis of procurement of goods with the MCDM algorithm and Fuzzy C-Means as shown in figure 2 as follow.
Criteria Analysis
Change Process
The criteria comparison matrix
| Criteria | Criteria |
|----------|----------|
| No.       | H2001    | H2002    | H2003    | H2004    | H2005 |
| 1         | 9         | 3        | 7         | 1         | 5     |
| 2         | 3         | 2        | 8         | 6         | 4     |
| 3         | 7         | 1        | 5         | 9         | 2     |
| 4         | 1         | 6        | 4         | 3         | 8     |

Figure 2. The criteria analysis display.

When the report submenu is clicked, a report is generated as shown in figure 3 as follow.

Figure 3. The report view of the report submenu.

In the report view shown in figure 3 above, there is data recommendation for the procurement of goods with the largest percentage indicating that the goods are of the highest urgency for procurement / production, whereas otherwise goods with the smallest percentage indicate that the goods are of the lowest urgency for procurement / production.

The Testing of the MCDM algorithm is done by comparing the level of suitability of the results of the analysis of the procurement of goods with the calculation of the recommendations of manual goods done by production staff, the data used is sales data in October 2018. The result of the testing can be seen in the following table 1.
Table 1. The MCDM algorithm test result.

| No | Product Name | NS | LS | PrR | SA  | EP  | PP  | LSN | LMN | Result |
|----|--------------|----|----|-----|-----|-----|-----|-----|-----|--------|
| 1  | Rajut        | 100| 23 | 92  | 100 | 85  | 75.4| Y   | Y   | S      |
| 2  | Ansania      | 94 | 79 | 96  | 95  | 90  | 33.6| Y   | Y   | S      |
| 3  | Ainun        | 83 | 100| 94  | 79  | 85  | 77.4| Y   | Y   | S      |
| 4  | Bandana      | 56 | 21 | 87  | 55  | 85  | 68.6| N   | Y   | TS     |
| 5  | Dhanisa      | 46 | 86 | 79  | 75  | 85  | 33.6| Y   | Y   | S      |
| 6  | Turki        | 41 | 23 | 90  | 21  | 85  | 77.4| Y   | Y   | TS     |
| 7  | Pinguin      | 30 | 51 | 92  | 82  | 90  | 61.5| Y   | Y   | S      |
| 8  | Manset       | 28 | 8.1| 70  | 30  | 85  | 93.5| N   | N   | S      |
| 9  | Fatimah      | 25 | 14 | 88  | 25  | 85  | 33.6| N   | N   | S      |
| 10 | Latifa       | 19 | 25 | 83  | 17  | 85  | 33.6| N   | N   | S      |
| 11 | Overdex      | 14 | 9.6| 90  | 15  | 85  | 100 | N   | N   | S      |
| 12 | Raflesia     | 10 | 8.5| 87  | 6   | 85  | 39.2| N   | N   | S      |
| 13 | Rayna        | 8.8| 18 | 88  | 30  | 85  | 33.6| N   | N   | S      |
| 14 | Dhea         | 7.5| 7.2| 79  | 11  | 85  | 54.9| N   | N   | S      |
| 15 | Elnifa       | 7.5| 14 | 78  | 3   | 30  | 68.6| N   | N   | S      |
| 16 | Peggy        | 5  | 14 | 80  | 8   | 85  | 33.6| N   | N   | S      |
| 17 | Rocela       | 5  | 8.5| 92  | 12  | 85  | 34.3| N   | N   | S      |
| 18 | Bergo P      | 2.5| 6.5| 88  | 5   | 85  | 58.3| N   | N   | S      |
| 19 | Fisura       | 1.3| 4.8| 87  | 3   | 30  | 41.1| N   | N   | S      |
| 20 | Zahra        | 0  | 67 | 79  | 60  | 10  | 41.1| N   | N   | S      |

Where:
SKU is Stock Keeping Unit, NS is Number of Sales, LS is Last Stock, PrR is Product Rating, SA is Sales Average, EP is Easy of Production, PP is Percentage of Profit, LMN is Level of Manual Needs, LSN is Level of System Needs, Y is Yes Needed, N is Not Needed, F is Fit, and NF is Not Fit.

Based on table 1 above, the calculation process is necessary and does not need to be procured or fixed for goods determined by the value provided by the production staff and the value produced by the analysis of procurement of goods with a limit of above 30% to reach the product limit. It is known that the accuracy of manual calculations carried out by production staff with the calculations made by the goods procurement analysis application using the MCDM algorithm. From these results can be calculated the accuracy of the recommendations for the procurement of goods by dividing the appropriate results by the total tested, that is (18 /20) * 100% = 90%. So that the accuracy of the MCDM algorithm in the procurement analysis application is 90%. This is because the manual calculation has not used the data other than the sales data for the current month and stock [8].

The result of the FCM algorithm testing can be seen in the following table 2 as follow.
Table 2. Fuzzy C-Means algorithm test result.

| No | Product Name | NS | LS | PrR | SA | EP | PP | SCR | LMN | MCR | Result |
|----|--------------|----|----|-----|----|----|----|-----|-----|-----|--------|
| 1  | Rajut        | 100| 23 | 92  | 100| 85 | 75.4| C2  | 80  | C1  | TS     |
| 2  | Ansania      | 94 | 79 | 96  | 95 | 90 | 33.6| C1  | 85  | C1  | S      |
| 3  | Ainun        | 83 | 100| 94  | 79 | 85 | 77.4| C1  | 75  | C1  | S      |
| 4  | Bandana      | 56 | 21 | 87  | 55 | 85 | 68.6| C2  | 40  | C2  | S      |
| 5  | Dhanisa      | 46 | 86 | 79  | 75 | 85 | 33.6| C1  | 38  | C2  | TS     |
| 6  | Turki        | 41 | 23 | 90  | 21 | 85 | 77.4| C2  | 35  | C2  | S      |
| 7  | Pinguin      | 30 | 51 | 92  | 82 | 90 | 61.5| C2  | 30  | C2  | S      |
| 8  | Manset       | 28 | 8.1| 70  | 30 | 85 | 93.5| C3  | 25  | C3  | S      |
| 9  | Fatimah      | 25 | 14 | 88  | 25 | 85 | 33.6| C3  | 20  | C3  | S      |
| 10 | Latifa       | 19 | 25 | 83  | 17 | 85 | 33.6| C3  | 15  | C3  | S      |
| 11 | Overdex      | 14 | 9.6| 90  | 15 | 85 | 100 | C3  | 10  | C3  | S      |
| 12 | Raflesia     | 10 | 8.5| 87  | 6  | 85 | 39.2| C3  | 5   | C3  | S      |
| 13 | Rayna        | 8.8| 18 | 88  | 30 | 85 | 33.6| C3  | 5   | C3  | S      |
| 14 | Dhea         | 7.5| 7.2| 79  | 11 | 85 | 54.9| C3  | 5   | C3  | S      |
| 15 | Elnifa       | 7.5| 14 | 78  | 3  | 30 | 68.6| C3  | 5   | C3  | S      |
| 16 | Peggy        | 5  | 14 | 80  | 8  | 85 | 33.6| C3  | 3   | C3  | S      |
| 17 | RoCela       | 5  | 8.5| 92  | 12 | 85 | 34.3| C3  | 3   | C3  | S      |
| 18 | Bergo P      | 2.5| 6.5| 88  | 5  | 85 | 58.3| C3  | 2   | C3  | S      |
| 19 | Fisura       | 1.3| 4.8| 87  | 3  | 30 | 41.1| C3  | 0   | C3  | S      |
| 20 | Zahra        | 0  | 67 | 79  | 60 | 10 | 41.1| C3  | 0   | C3  | S      |

Where:
NS is Number of Sales, LS is Last Stock, PrR is Product Rating, SA is Sales Average, EP is Easy of Production, PP is Percentage of Profit, SCR is System Cluster result, LMN is Level of Manual Needs, MCR is manual Cluster Result.

Based on table 2 above, the cluster calculation process of the level of procurement requirements or item inventory is determined by the value given by the production staff and the value generated by the procurement analysis application with the limits of each cluster is 28.34 this figure is obtained by dividing the maximum and minimum with three clusters, it can be seen the accuracy of manual calculations performed by production staff with calculations performed by the procurement analysis application using the FCM algorithm. From these results can be calculated the accuracy of the recommendations for the procurement of goods by dividing the appropriate results by the total tested so that the accuracy is 18/20 x 100% = 90%.

The accuracy of the FCM algorithm in the procurement analysis application is 90%, this is because the manual calculation criteria for the final stock of goods are not too large percentage of their needs when compared to the criteria for the number of sales causes differences in the total end result and causes the data to be worth less and enter the cluster second.
4. Conclusion
From the results of design and implementation and testing on the implementation of the Multiple Criteria Decision Making (MCDM) and Fuzzy C-Means methods on the procurement analysis application can be concluded as follows:

- This procurement of goods application can provide goods procurement recommendations for managers so that it can be a tool to overcome the problem of determining the procurement of goods. The results of these recommendations can be used as a reference to choose products that are still produced, plus the amount of production or discontinued production.
- The results of functional testing applications with the black-box testing method show that the system can run well and in accordance with the needs and expectations, while testing by comparing the results of the analysis of the procurement of application goods and admin staff production at twenty sample data shows the level of suitability for the algorithm MCDM reaches 90% and Fuzzy C Means reaches 90%, this is because the calculation of manual testing uses only two criteria while the application uses six criteria.

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