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Monte Carlo Simulation in Predicting Trends in Demand for Coconut Milk at PT. Flash Food

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Abstract

Coconut milk is one of the perishable food ingredients. PT. Flash Food receives daily orders for coconut milk from hospitals in the city of Padang. Every day, PT. Flash Food must provide coconut milk in the required quantity and at the right time. Therefore, a method is needed to predict the coconut milk demand for the next day. The Monte Carlo simulation method is used to predict the demand for several days ahead based on the existing data. The data used is from October and November. This data will be simulated to generate predictions for the next 7 days. To test the accuracy of the Monte Carlo simulation, the simulated data is compared with the actual data. The comparison results show an average accuracy of 90.6%. The Monte Carlo simulation is then translated into a programming language so that PT. Flash Food can easily use the simulation.

Keywords: *Coconut milk, Monte Carlo, predict*

1. Introduction

Providing food every day is a necessity for every institution, one of which is hospitals. Food is a basic need for every human being, so fulfilling food is fulfilling the human rights of every Indonesian people [1]. Hospitals in Padang City make requests to suppliers to meet food needs. This is done so that food is available every day. The food needed is food that is fresh and appropriate according to the time and quantity requested.

PT Flash Food is a supplier of food ingredients for a hospital in the city of Padang. PT. Flash Food provides food ingredients according to the number of requests received. One food ingredient that is always in demand every day is coconut milk. PT Flash Food must always provide the requests it receives so that it continues to gain trust as a supplier. To obtain consumer satisfaction, it is necessary to have goods that are always available, competitive prices, quality goods and timely supply of requests [8].

Coconut milk is a food that spoils easily. Meanwhile, the number of requests from hospitals to PT Flash Food is uncertain. So a simulation is needed to predict the trend in the amount of coconut milk demand for the next few days. This is necessary to ensure coconut milk is available on time according to demand. Also so that the stock of coconut milk doesn't go to waste because there is no demand.
Prediction is generally defined as predicting an event in the future based on previous data [6]. Prediction is a way of comparing data in the past to become a guide for the future. Predictions are used to find uncertain answers. Meanwhile, simulation is a modeling that describes cause and effect which is often used to analyze and study the behavior of systems [12]. Monte Carlo simulation is a test using random numbers using mathematical equations [5]. This method uses random values to get values in the future. This research uses Monte Carlo simulation based on previous demand data.

Monte Carlo simulation was used in previous research to make predictions. Several previous studies used Monte Carlo simulations, namely predicting gas distribution [14], predicting the number of student arrivals [6] and also predicting the number of blood donors [5]. In this research, Monte Carlo simulation will be used to predict the amount of food demand at PT Flash Food. The demand data used is coconut milk demand data. Coconut milk data was chosen because there is demand for coconut milk every day.
This research aims to test Monte Carlo simulations in predicting the amount of demand for coconut milk. The simulation results will be compared with the original data to see the accuracy of the simulation results against the original data. This research also aims to predict trends in demand for coconut milk from hospitals to PT Flash Food. By knowing future trends, PT Flash Food will be better prepared to provide coconut milk. So the coconut milk that needs to be prepared is not in excess or less than demand, so the coconut milk will be guaranteed to be fresh, thereby providing consumer satisfaction to PT Flash Food.

2. Research Methods

Simulation of the estimated quantity of demand for bulk coconut milk at PT Falsh Food Padang using the Monte Carlo method has 7 processes. The process is described in the state of process. The state of process of the simulation process for estimating the number of patients for laboratory examinations using the Monte Carlo method can be seen in Figure 1

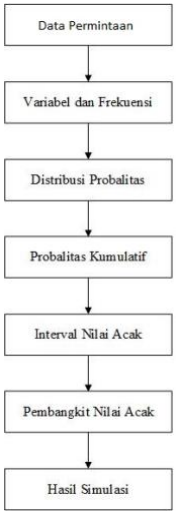

Fig.1: State of Process

2.1. Request Data

The data used is bulk coconut milk demand data. Data taken based on PT invoice. Flash Food. Every request to PT. Flash Food creates an invoice. Every day the amount of bulk requests is recorded based on the invoice. The bulk coconut milk demand data used is data from October and November 2024.

2.2. Variables and Frequency

The data that has been collected is then determined by the variables. The variable used is the daily demand for bulk coconut milk in liters. Data is sorted from the smallest variable value to the largest variable value. For each variable, the number of occurrence frequencies is calculated.

2.3. Monte Carlo Calculation

Data containing the number of requests for bulk coconut milk and the frequency of occurrence, then the probability value is calculated. The probability is calculated for each frequency of occurrence of the request. The formula for the probability distribution function is:

$$PDF = \frac{f}{j} \quad (1)$$

Where *PDF* is the frequency distribution probability, f is the frequency of occurrence and j is the amount of data.
After determining the probability distribution, the next step is to calculate the cumulative probability. Cumulative probability is obtained from the probability distribution value. Cumulative probability is calculated for each request frequency. The cumulative calculation is the previous probability plus the current probability. Calculations are carried out by rounding to the 3 digits after the comma, while for the last cumulative value rounding is done without a comma.
After determining the cumulative probability, the next step is to determine the random value interval. This random value interval aims to determine the simulation results. Random value intervals are searched for each request. The random value interval is obtained based on the Cumulative probability value.

$$Initial\ Interval = Previous\ Cumulative \times 1000 \quad (2)$$
$$End\ Interval = (Cumulative \times 1000) - 1 \quad (3)$$

2.4. Random Number Generator

Generating random numbers using Pseudo Congruential Random Number Generator (PCR) using Linear Congruent Generator (LCG). LCG produces a sequence of integers Z1, Z2, between 0 and m-1 according to the following iterative relationship:

$$Z_{(i+1)} = (a.Z_i + c)\ mod\ m \quad (4)$$

Where *i* is 0,1,2…. *a* is the multiplicative constant. *c* is the addition constant, m is the modulus and *Z* is a random value. If $c \neq 0$, then it is said to be a Mixed Congruential Method. When $c = 0$, it is said to be a Multiplicative Congruential Method. The generating key is Z_0 which is called the decoy. LCG has a period not greater than m and in most cases the period is less than *m*.
Determining a good constant value in order to produce a random value that does not repeat itself by fulfilling the following conditions [3] :

1. The values *a*, *c* and *m* must be positive and within the range of random values sought
2. The value (*a*-1) is a multiple of 4 if the value of *m* is a multiple of 4

3. The values *c* and *m* are relatively prime numbers

By fulfilling the conditions, you will get a non-repeating random number with a number corresponding to the value of *m*.

2.5. Simulation Results

Simulation results are obtained by matching random values with intervals of random values for each frequency. The simulation results show the estimated demand for bulk coconut milk at PT. Flash Food. The simulation results will be tested with actual data to find their accuracy.

The Monte Carlo simulation method is a computational mathematical calculation technique. Monte Carlo simulation calculations will be translated into computer programming language. The programming language used is the Java programming language.

3. Results and Discussion

After carrying out the Monte Carlo simulation calculation process for bulk coconut milk demand data at PT. Flash Food then you get results. Results will be displayed for each calculation process.

3.1. Request Data

The bulk coconut milk demand data used is data from October 2024 and November 2024. The amount of data is 61 according to the number of days in these 2 months. Demand data can be seen in table 1.

Table 1: Data on Bulk Coconut Milk Demand for October and November 2024

Date	October	November
1	4	9
2	5.5	5
3	5.5	5
4	7	6.5
5	5	6.5
6	7.5	11.5
7	6.5	5.5
8	8	5.5
9	6.5	7
10	8	7
11	9.5	13.5
12	8	7
13	9	5.5
14	7	5.5
15	8	7
16	8	5
17	6.5	6.5
18	6.5	6.5
19	8	9
20	5	9.5
21	8	9.5
22	12	8
23	7	5
24	12	5
25	7	6
26	4	7
27	8.5	6.5
28	7	5.5
29	10	5
30	6	8.5
31	10	

3.2. Variables and Frequency

The frequency of occurrence based on the bulk unit demand variable is arranged from the highest value to the lowest value. The number of frequencies is 61 according to the number of request data. Requests and the frequency of occurrence can be seen in table 2.

Table 2: Number of Requests and Frequency of Appearance

Num	Requests	frequency
1	4	2
2	5	8
3	5.5	7
4	6	2
5	6.5	9
6	7	10
7	7.5	1
8	8	8
9	8.5	2
10	9	3
11	9.5	3

12	10	2
13	11.5	1
14	12	2
15	13.5	1

3.3. Monte Carlo Calculation

Monte Carlo calculations start from finding probabilities. Probality is calculated using the probability formula. Where f = frequency of each request and j = 61. The calculation results are displayed with 3 digits after the comma. Then the value of the cumulative probability is calculated. The results of the cumulative probability calculation are displayed with 3 digits after the comma. Next, determine the random number interval. The interval number is a random number consisting of a start interval and an end interval. The results of the mote Carlo calculation to determine the random number interval can be seen in table 3.

Table 3: Calculation Results Up to the Random Number Interval Stage

No	Request	Frequency	Probability	Cumulative	Random Number Interval
1	4	2	0.033	0.033	0 sampai 32
2	5	8	0.131	0.164	33 sampai 163
3	5.5	7	0.115	0.279	164 sampai 278
4	6	2	0.033	0.311	279 sampai 310
5	6.5	9	0.148	0.459	311 sampai 458
6	7	10	0.164	0.623	459 sampai 622
7	7.5	1	0.016	0.639	623 sampai 638
8	8	8	0.131	0.770	639 sampai 769
9	8.5	2	0.033	0.803	770 sampai 802
10	9	3	0.049	0.852	803 sampai 851
11	9.5	3	0.049	0.902	852 sampai 901
12	10	2	0.033	0.934	902 sampai 933
13	11.5	1	0.016	0.951	934 sampai 950
14	12	2	0.033	0.984	951 sampai 983
15	13.5	1	0.016	1	983 sampai 999

3.4. Random Number Generator

The process carried out after determining the random value interval is generating random values. The random numbers generated are 7 numbers. The number of random numbers of 7 is due to the simulation results to determine the estimated amount of coconut milk demand for the next 7 days. Generating random values using the LCG method. The i value is 0 to 7 because the simulation results show the estimated demand for the next 7 days. Determining the constant value is carried out by fulfilling the requirements so that the random value generated is a good random value with no repetition and no pattern. The specified constant value is

$$a = 113$$
$$Z_0 = 603$$
$$c = 451$$
$$m = 1000$$

The values a, c, and m are in the range of random values sought, namely between 0 and 1000. The value m = 1000 is a multiple of 4, namely 4×250=1000, so the value (a-1) = 112 is a multiple of 4, namely 4×19=112. The values c and m are relatively prime numbers. The m value is obtained from the interval number of the last random number plus 1. So the random number that can be generated is in the range 0 to 999. Table 4 shows the results of the random number.

Table 4: Results of random number

Z	Random Number
1	590
2	121
3	124
4	463
5	770
6	461
7	544

3.5. Simulation Results

Simulation results are obtained by matching random values with intervals of random values for each frequency. The random value interval obtained for each request is adjusted to the appropriate random number. The simulation results show the estimated amount of demand for bulk coconut milk at PT. Flash Food for the next 7 days. The simulation results can be seen in table 5.

Table 5: Simulation Results

No	Random Number	Request
1	590	7
2	121	5
3	124	5
4	463	7
5	770	8.5
6	461	7
7	544	7

3.6. Comprasion Results

The calculated simulation results are then compared with the actual data. The data in the simulation calculations in this research is data on the number of requests for bulk coconut milk from 1 October 2024 to 30 November 2024. The simulation results display the estimated number of requests for the next 7 days. The data used to compare the simulation results is data from 1 - 7 December 2024. The comparison was carried out to determine the accuracy of the Monte Carlo simulation method in determining the number of requests. Table 5 shows data on the number of requests for December 1-7 2024.

Table 6: Comprasion

Date	Actual Data	Monte Carlo Results	Accuracy
1	7	7	100%
2	5.5	5	91%
3	5.5	5	91%
4	5	7	71%
5	8	8	100%
6	8	7	88%
7	6.5	7	93%
Average Amount	45.5 6.5	46 6.6	

Table 6 shows a comparison of the original demand data on December 1 to 7 2024 with data from the Monte Carlo simulation. Table 5 also shows the accuracy of the calculation results with the original data. The average amount of original data is 6.5 per day compared to the average Monte Carlo result of 6.6 per day.
Table 5 also shows the accuracy of the Monte Carlo results with the original data. Accuracy is calculated by comparing the original data with the Monte Carlo data. Accuracy is displayed as a percentage.

3.7. Monte Carlo Simulation Application

Monte Carlo calculations are translated into programming language and made into an application. The application consists of 2 forms, namely a data form and a simulation results form. Figure 2 shows the data form display

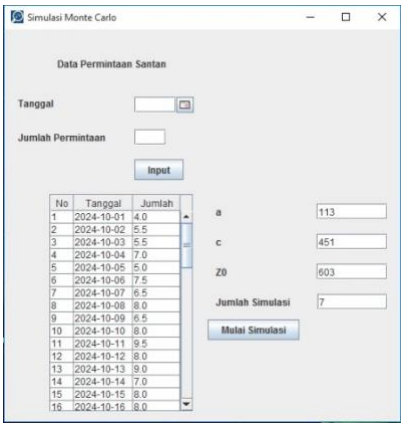

Fig. 2: Data Form

The next form is the simulation results form. The simulation results are obtained from the data in the data form. The simulation results form can be seen in Figure 3.

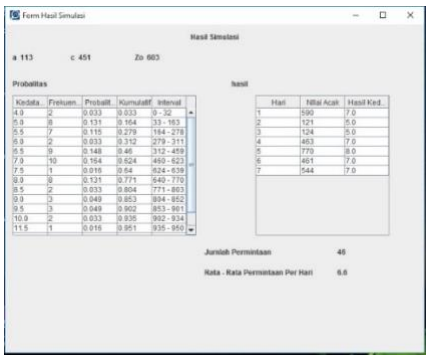

Fig. 3: Simulation Results Form

It can be seen that the simulation results in the application are the same as the simulation results in manual calculations.

4. Conclusion

Based on simulation research on the estimated number of patients with laboratory examinations that have been carried out, the following conclusions can be drawn:

The Monte Carlo simulation method predicts the amount of demand for coconut milk at PT. Flash Food uses data from October and November 2024, totaling 61 data, resulting in an accuracy of up to 91%.
Monte Carlo simulation relies on random number, so the random number generated must not be repeated.
The choice of constant values *a* and *c* in generating random number and the choice of the Z_0 value greatly influences the accuracy of the simulation results.

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