Analysis of Deep Learning Cyclical order for Prediction of Fresh Milk Production in Sumatera

Asep Saefullah 1, Muhammad Hendri 2, Sri Lindawati 2, Muliati Badaruddin 3, Jeperson Hutahean 4

1Universitas Matana, Tangerang-Banten, Indonesia
2STMIK Logika, Medan, Indonesia
3STMIK Ichsan Gorontalo, Indonesia
4STMIK Royal Kisaran, Medan, Indonesia

*asep@matanauniversity.ac.id

Abstract. Milk is one of the most preferred and most easily absorbed nutrients. This drink naturally contains important nutrients, such as vitamins A, D, B12, protein, calcium, magnesium, phosphorus, and zinc, and others. Milk is also beneficial for children and adults. Starting from maintaining healthy bones and teeth, as a source of energy, and so on. In Indonesia, especially on the island of Sumatra, fresh milk production is carried out by cattle and goat farmers in cooperation with milk companies. This research have a purpose is to predict the production of fresh milk on the island of Sumatra so that the local government, as well as cattle and goat breeders on the island of Sumatra, have benchmarks to further increase the production of fresh milk in their respective regions in the future. The method that will be used in this research is Deep Learning Cyclical order which is the development of ANN. The research data used were data on the production of fresh milk on the island of Sumatra in 2009-2018 sourced from the Indonesian Statistics Agency. This research will be analyzed using 3 network architecture models, namely 4-5-1, 4-10-1 and 4-5-10-1 with the best network model chosen is 4-5-10-1 with an accuracy level of 90% and MSE value of 0.0157179042. Based on this best model a prediction of fresh milk production in Sumatra will be carried out in 2019-2020.

1. Introducing

Milk is rich in balanced nutrition sources and is very good for consumption. Fresh milk is a nutrient-rich beverage product that is good for the body and health. Milk is very healthy because it contains a lot of protein, vitamins, and minerals as well as one of the main components of human food, as a universal source of nutrition [1]. The content in fresh milk can make children grow big and smart. Of all types of milk, fresh milk is the best. Due to its high nutritional value, global production and consumption of milk has increased, especially in developing countries [2]. Fresh milk is a milk product directly obtained from milking cows or goats. The process of making this type of milk is simplest compared to other dairy products. After milking, the milk liquid will be filtered to remove impurities. But this fresh milk should not be heated to boiling. The heating process is only done to minimize the bacterial content in milk. Because the process is simple, fresh milk can not last long and even should be consumed immediately after processing. In addition to other types of milk, fresh milk has many nutritional and nutritional contents as well as the most natural flavor.

In Indonesia, especially on the island of Sumatra, fresh milk production is unstable, sometimes increasing and also decreasing. According to data from the Indonesian Central Statistics Agency the
highest production of fresh milk occurred in 2011 in North Sumatra with a production of 1850 tons. Whereas for 2018 fresh milk production continues to occur in North Sumatra, but the number has decreased to 1513 tons or decreased by 337 tons compared to 2011 [3]. Once the importance of fresh milk in Indonesia, especially in Sumatra, the production needs to be maintained in order to remain stable and not to decline. One of them is by predicting fresh milk production in Sumatra for the following years, so that the local government, as well as cattle and goat farmers in Sumatra, have a reference in making the right policies and strategic steps so that the production of fresh milk remains stable, even able to increase in each year. For this reason, in this study, the prediction method that will be used to predict fresh milk production in Sumatra is the Deep Learning Cyclical order method which is the development of ANN.

There have been many previous studies related to this research topic, including Application of the Cyclical order method to predict life expectancy for the world's population, with an excellent accuracy rate of 97% [4]. Furthermore, research to analyze the addition of meteorological data in the training process to estimate milk production using nonlinear autoregressive models with exogenous inputs (NARX) and multiple linear regression models (MLR). The results of this study that NARX provides greater prediction accuracy than the MLR model for estimating milk production [5].

2. Methodology

2.1. Research Methods
The research method used is Deep Learning Cyclical order. This method is able to make predictions based on past data (times series). The Cyclical Order method is a method that is able to conduct training from the network with the rules applied in the form of heavy learning from weight and bias by updating after the normalization input has been presented [6].

2.2. Research data
Fresh milk production data for 2009-2018 on the island of Sumatra. Data is taken from the Indonesian Central Statistics Agency [3].

| Province          | Fresh Milk Production in Sumatra (Ton) |
|-------------------|---------------------------------------|
|                   | 2009  | 2010  | 2011  | 2012  | 2013  | 2014  | 2015  | 2016  | 2017  | 2018  |
| Aceh              | 33.64 | 36.87 | 33.00 | 43.00 | 38.00 | 140.00| 94.30 | 88.74 | 77.00 | 83.00 |
| North Sumatra     | 1657.04 | 1762.35 | 1850.00 | 761.00 | 1369.00 | 783.00 | 776.16 | 1014.48 | 1403.00 | 1513.00 |
| West Sumatra      | 1263.78 | 1263.78 | 741.00 | 988.00 | 1685.00 | 1032.00 | 1298.63 | 1363.23 | 1270.00 | 1353.00 |
| Riau              | 125.00 | 130.05 | 164.00 | 177.00 | 151.00 | 81.00 | 79.38 | 74.84 | 52.00 | 54.00 |
| Jambi             | 0.07  | 0.00  | 0.00  | 0.00  | 0.00  | 18.00 | 18.00 | 8.50  | 6.82  | 12.00 | 23.00 |
| South Sumatra     | 15.40 | 15.71 | 62.00 | 66.00 | 325.00 | 95.00 | 124.25 | 127.25 | 112.00 | 112.00 |
| Bengkulu          | 1055.38 | 1127.93 | 356.00 | 401.00 | 265.00 | 275.00 | 273.55 | 183.82 | 205.00 | 273.00 |
| Lampung           | 178.06 | 109.57 | 162.00 | 279.00 | 216.00 | 223.00 | 678.16 | 669.33 | 618.00 | 653.00 |
| Bangka Belitung Islands | 67.26 | 68.61 | 185.00 | 210.00 | 600.00 | 19.00 | 83.17 | 99.70 | 328.00 | 328.00 |
| Riau islands      | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.01  | 0.01  | 12.00 | 12.00 |

2.3. Research Flow
Broadly speaking, the flowchart of research in this study can be described as follows:
Based on the picture (Figure 1), it can be explained that the first thing to do is to collect the research dataset. The dataset used is the production of fresh milk on the island of Sumatra. Next is the preprocessing stage and dividing the data into several parts, namely the data used for training and the data used for testing. Then determine the network architecture model that will be used for the training process and the testing process. Furthermore, the selection of the best choice architectural model used for prediction. After all, is done, predictions will be obtained based on the best architectural model.

2.4. Research Variable
The research variables used in this article have 2 parts, namely input variables, and output variables. There are 4 input variables, namely the amount of fresh milk production by year from training input data (2019-2012) and testing (2014-2017). While the output variable is 1, namely the amount of fresh milk production which is the target of training input data (2013) and testing (2018). While there are 10 criteria used, namely Aceh, North Sumatra, West Sumatra, Riau, Jambi, South Sumatra, Bengkulu, Lampung, Bangka Belitung Islands, and Riau Islands.

2.5. Normalization
The data was first divided into 2 parts, namely training data and testing data. Data for 2009-2012 with the 2013 target are used training, and 2014-2017 with the 2018 target are used as test data. Then the data that has been divided into two is normalized using equation (1) [7]-[21].

\[ x' = \frac{0.8(x-a)}{b-a} + 0.1 \]  

(1)

Explanation: \( x' \) is the result of normalization, \( x \) is data that will be normalized, \( a \) is the lowest data and \( b \) is the highest data from the dataset.

3. Results and Discussion

3.1. Results of Normalization Data
Table 2 below is the result of the normalization of training data used (in 2009-2012, 2013 target). While Table 3 is the result of the normalization of test data (2014-2017, 2018 target). This data is normalized using functions as written in equation (1).

| Data | Fresh Milk Production in Sumatra (Ton) | 2009 | 2010 | 2011 | 2012 | Target |
|------|-------------------------------------|------|------|------|------|--------|
| 1    | 0.1145 0.1159 0.1143 0.1186 0.1164  |
| 2    | 0.8166 0.8621 0.9000 0.4291 0.6920  |
| 3    | 0.6465 0.6465 0.4204 0.5272 0.8286  |
| 4    | 0.1541 0.1562 0.1709 0.1765 0.1653  |
| 5    | 0.1000 0.1000 0.1000 0.1000 0.1078  |
| 6    | 0.1067 0.1068 0.1268 0.1285 0.2405  |
| 7    | 0.5564 0.5878 0.2539 0.2734 0.2146  |
| 8    | 0.1770 0.1474 0.1701 0.2206 0.1934  |
| 9    | 0.1291 0.1297 0.1800 0.1908 0.3595  |
| 10   | 0.1000 0.1000 0.1000 0.1000 0.1000  |
Table 3. Normalization of test data

| Data | Fresh Milk Production in Sumatra (Ton) |
|------|-------------------------------------|
|      | 2014       | 2015       | 2016       | 2017       | Target       |
| 1    | 0.1605     | 0.1408     | 0.1384     | 0.1333     | 0.1359       |
| 2    | 0.4386     | 0.4356     | 0.5387     | 0.7067     | 0.7543       |
| 3    | 0.5463     | 0.6616     | 0.6895     | 0.6492     | 0.6851       |
| 4    | 0.1350     | 0.1343     | 0.1324     | 0.1225     | 0.1234       |
| 5    | 0.1078     | 0.1037     | 0.1029     | 0.1052     | 0.1099       |
| 6    | 0.1411     | 0.1537     | 0.1550     | 0.1484     | 0.1484       |
| 7    | 0.2189     | 0.2183     | 0.1795     | 0.1886     | 0.2181       |
| 8    | 0.1964     | 0.3933     | 0.3894     | 0.3672     | 0.3824       |
| 9    | 0.1082     | 0.1360     | 0.1431     | 0.2418     | 0.2418       |
| 10   | 0.1000     | 0.1000     | 0.1000     | 0.1052     | 0.1052       |

Data processing is assisted by the Matlab 2011b tool in determining the best architectural model. This study was analyzed using 3 Architectural models, namely: 4-5-1, 4-10-1 and 4-5-10-1. The way to determine the best architectural model with the Cyclical order method is to determine the minimum error from the training and testing process carried out. The error rate used was 0.01 with an epoch level of 1000 each. In this study, the code parameters used were analyzed using the Matlab 2011b application.

3.2. Best Model Training and Testing
From 3 network models analyzed, the 4-5-10-1 is the best.

Figure 2. Training network model 4-5-10-1

Table 4. Training Network Model 4-5-10-1

| Data | Target | Output | Error | SSE       |
|------|--------|--------|-------|-----------|
| 1    | 0.1164 | 0.1536 | -0.0372 | 0.0013814281 |
| 2    | 0.6920 | 0.6979 | -0.0059 | 0.00000348100 |
| 3    | 0.8286 | 0.8189 | 0.0097 | 0.00000950362 |
| 4    | 0.1653 | 0.2437 | -0.0784 | 0.0001469838 |
| 5    | 0.1078 | 0.1088 | -0.0010 | 0.00000010327 |
| 6    | 0.2405 | 0.1836 | 0.0569 | 0.00332422252 |

Table 5. Testing Network Model 4-5-10-1

| Data | Target | Output | Error | SSE       |
|------|--------|--------|-------|-----------|
| 1    | 0.1359 | 0.1687 | -0.0328 | 0.0010763720 |
| 2    | 0.7543 | 0.8833 | -0.1290 | 0.0166486712 |
| 3    | 0.6851 | 0.8888 | -0.2037 | 0.0415013979 |
| 4    | 0.1234 | 0.1714 | -0.0480 | 0.00023086726 |
| 5    | 0.1099 | 0.1155 | -0.0056 | 0.0000308475 |
| 6    | 0.1484 | 0.2321 | -0.0837 | 0.00070002619 |

4
### Table 4. Training Network Model 4-5-10-1

| Data | Target Error | SSE         |
|------|--------------|-------------|
| 7    | 0.2146       | 0.0004      | 0.00000001557 |
| 8    | 0.1934       | -0.0207     | 0.0004282662   |
| 9    | 0.3595       | 0.0852      | 0.0072521335   |
| 10   | 0.1000       | -0.0088     | 0.0000077400   |

MSE 0.0186595114

### Table 5. Testing Network Model 4-5-10-1

| Data | Target Error | SSE         | Results |
|------|--------------|-------------|---------|
| 7    | 0.2181       | -0.0381     | 0.157179042 |
| 8    | 0.3824       | 0.0762      | 0.0003311453 |
| 9    | 0.2418       | -0.0262     | 0.0006844587 |
| 10   | 0.1052       | -0.0122     | 0.0001491039 |

MSE 0.0157179042 90%

### 3.3. Prediction results

In Table 6 below, we will see a comparison of the 3 architectural models.

### Table 6. Comparison of Architectural Models

| Model   | Epoch Times | MSE Training | MSE Testing | Accuracy |
|---------|-------------|--------------|-------------|----------|
| 4-5-1   | 1000        | 0.0044746596 | 0.0254912202 | 90%      |
| 4-10-1  | 1000        | 0.0039095828 | 0.0279487590 | 90%      |
| 4-5-10-1| 1000        | 0.0018659511 | 0.0157179042 | 90%      |

Next, you will predict 4-5-10-1 using a formula that returns a value:

\[ x_{n} = \frac{r_{(b-a)} + 0.3}{a} + a \]

### Table 7. Comparison of Fresh Milk Production in Sumatra and Predicted Results (Ton)

| Province               | Fresh Milk Production in Sumatra (Ton) | Predictions 2019 | Predictions 2020 |
|------------------------|---------------------------------------|------------------|------------------|
| Province               | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 |                |                 |
| Aceh                   | 33.00 | 43.00 | 38.00 | 140.00 | 94.30 | 88.74 | 77.00 | 83.00 | 65.85 | 75.45 |
| North Sumatra          | 1850.00 | 761.00 | 1369.00 | 783.00 | 776.16 | 1014.48 | 1403.00 | 1513.00 | 1182.59 | 773.12 |
| West Sumatra           | 741.00 | 988.00 | 1685.00 | 1032.00 | 1298.63 | 1363.23 | 1270.00 | 1353.00 | 1159.51 | 731.72 |
| Jambi                  | 164.00 | 177.00 | 151.00 | 81.00 | 79.38 | 74.84 | 52.00 | 54.00 | 78.79 | 48.43 |
| South Sumatra          | 62.00 | 66.00 | 325.00 | 95.00 | 124.25 | 127.25 | 112.00 | 112.00 | 174.86 | 113.77 |
| Bengkulu               | 356.00 | 401.00 | 265.00 | 275.00 | 273.55 | 183.82 | 205.00 | 273.00 | 222.89 | 153.56 |
| Lampung                | 162.00 | 279.00 | 216.00 | 223.00 | 678.16 | 669.33 | 618.00 | 653.00 | 552.17 | 358.22 |
| Bangka Belitung Islands| 185.00 | 210.00 | 600.00 | 19.00 | 83.17 | 99.70 | 328.00 | 328.00 | 231.71 | 149.15 |
| Riau islands           | 0.00  | 0.00  | 0.00  | 0.00  | 0.01  | 0.01  | 12.00 | 12.00 | 10.31 | 8.79  |

### 4. Conclusion

The Deep Learning Cyclical order algorithm can be used to predict the level of fresh milk production in Sumatra because of the good level of accuracy. Based on the analysis of 3 architectural models used in this study (4-5-1, 4-10-1 and 4-5-10-1), the best architectural model is obtained 4-5-10-1 with prediction accuracy of 90%. MSE training of this model is 0.0018659511 and MSE testing is 0.0157179042.

### References

[1] N. Núñez-Sánchez et al., “Near Infrared Spectroscopy (NIRS) for the determination of the milk fat fatty acid profile of goats,” Food Chem., vol. 190, pp. 244–252, 2016.

[2] C. F. Nascimento, P. M. Santos, E. R. Pereira-Filho, and F. R. P. Rocha., “Recent advances on determination of milk adulterants,” Food Chem., vol. 221, pp. 1232–1244, 2017.

[3] BPS, “Produksi Susu Segar menurut Provinsi, 2009-2018,” Badan Pusat Statistik (BPS) Indonesia, 2018. Available: https://www.bps.go.id/linkTableDinamis/view/id/1083.

[4] M. K. Z. Sormin, P. Sihombing, A. Amalia, A. Wanto, D. Hartama, and D. M. Chan,
“Predictions of World Population Life Expectancy Using Cyclical Order Weight / Bias,” J. Phys. Conf. Ser., vol. 1255, no. 12017, pp. 1–6, 2019.

[5] F. Zhang, J. Upton, L. Shalloo, P. Shine, and M. D. Murphy, “Effect of introducing weather parameters on the accuracy of milk production forecast models,” Inf. Process. Agric., no. xxxx, 2019.

[6] M. O. Shabani and A. Mazahery, “Prediction Performance of Various Numerical Model Training Algorithms in Solidification Process of A356 Matrix Composites,” Indian J. Eng. Mater. Sci., vol. 19, no. 2, pp. 129–134, 2012.

[7] Budiharjo, T. Soemartono, A. P. Windarto, and T. Herawan, “Predicting School Participation in Indonesia using Back-Propagation Algorithm Model,” Int. J. Control Autom., vol. 11, no. 11, pp. 57–68, 2018.

[8] A. Wanto et al., “Analysis of the Accuracy Batch Training Method in Viewing Indonesian Fisheries Cultivation Company Development,” J. Phys. Conf. Ser., vol. 1255, no. 12003, pp. 1–6, 2019.

[9] T. Afriliansyah et al., “Implementation of Bayesian Regulation Algorithm for Estimation of Production Index Level Micro and Small Industry,” J. Phys. Conf. Ser., vol. 1255, no. 12027, pp. 1–6, 2019.

[10] W. Saputra, P. Poninghsih, M. R. Lubis, S. R. Andani, I. S. Damanik, and A. Wanto, “Analysis of Artificial Neural Network in Predicting the Fuel Consumption by Type of Power Plant,” J. Phys. Conf. Ser., vol. 1255, no. 12069, pp. 1–5, 2019.

[11] Budiharjo, T. Soemartono, A. P. Windarto, and T. Herawan, “BudiharjoPredicting Tuition Fee Payment Problem using Backpropagation Neural Network Model,” Int. J. Adv. Sci. Technol., vol. 120, pp. 85–96, 2018.

[12] A. Wanto et al., “Analysis of the Backpropagation Algorithm in Viewing Import Value Development Levels Based on Main Country of Origin,” J. Phys. Conf. Ser., vol. 1255, no. 12013, pp. 1–6, 2019.

[13] E. Siregar, H. Mawengkang, E. B. Nababan, and A. Wanto, “Analysis of Backpropagation Method with Sigmoid Bipolar and Linear Function in Prediction of Population Growth,” J. Phys. Conf. Ser., vol. 1255, no. 12023, pp. 1–6, 2019.

[14] P. Parulian et al., “Analysis of Sequential Order Incremental Methods in Predicting the Number of Victims Affected by Disasters,” J. Phys. Conf. Ser., vol. 1255, no. 12033, pp. 1–6, 2019.

[15] A. Wanto et al., “Forecasting the Export and Import Volume of Crude Oil, Oil Products and Gas Using ANN,” J. Phys. Conf. Ser., vol. 1255, no. 12016, pp. 1–6, 2019.

[16] M. R. Lubis, W. Saputra, A. Wanto, S. R. Andani, and P. Poninghsih, “Analysis of Artificial Neural Networks Method Backpropagation to Improve the Understanding Student in Algorithm and Programming,” J. Phys. Conf. Ser., vol. 1255, no. 12032, pp. 1–6, 2019.

[17] G. W. Bhawika et al., “Implementation of ANN for Predicting the Percentage of Illiteracy in Indonesia by Age Group,” J. Phys. Conf. Ser., vol. 1255, no. 12043, pp. 1–6, 2019.

[18] I. S. Purba et al., “Accuracy Level of Backpropagation Algorithm to Predict Livestock Population of Simalungun Regency in Indonesia Accuracy Level of Backpropagation Algorithm to Predict Livestock Population of Simalungun Regency in Indonesia,” J. Phys. Conf. Ser., vol. 1255, no. 12014, pp. 1–6, 2019.

[19] B. Febriadi, Z. Zamzami, Y. Yunefri, and A. Wanto, “Bipolar function in backpropagation algorithm in predicting Indonesia’s coal exports by major destination countries,” IOP Conf. Ser. Mater. Sci. Eng., vol. 420, no. 12089, pp. 1–9, 2018.

[20] N. Nasution, A. Zamsuri, L. Lisnawita, and A. Wanto, “Polak-Ribiere updates analysis with binary and linear function in determining coffee exports in Indonesia,” IOP Conf. Ser. Mater. Sci. Eng., vol. 420, no. 12089, pp. 1–9, 2018.