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Prediction of Life Expectancy in Aceh Province by District City Using the Cyclical Order Algorithm

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Abstract

Indicators to evaluate the role of the local and central government in the welfare of its population, especially in the health sector, can be seen from the life expectancy of the community. Therefore the aim of this study is to predict the life expectancy of the Acehnese using the Cyclical Order Weight / Bias Algorithm. This study uses life expectancy data for the population of Aceh in 2010-2019 based on city districts consisting of 23 regions, which were obtained from the Aceh Central Statistics Agency. This study uses 6 architectural models, including: 8-5-1, 8-6-1, 8-7-1, 8-8-1, 8-9-1 and 8-10-1. After analyzing and calculating the 6 architectural models, the 8-9-1 model was chosen as the best with an accuracy rate of 91% and MSE testing 0.0010800577. The results of this study are in the form of the best architectural model that can be used to predict the life expectancy of the Acehnese people.

Keywords: *Prediction, Life Expectancy, Aceh, District City, Cylical Order*

1. Introduction

Life expectancy is the average number of years of life that a person who has succeeded in reaching a certain age still lives. The benefit of knowing life expectancy is to evaluate the performance of the government in improving the welfare of the population in general and increasing the degree of health in particular [1]. Low life expectancy in an area must be followed by health development programs, and other social programs including environmental health, adequate nutrition and calories, including poverty eradication programs [2]. Based on data on the Life Expectancy Rate in Aceh Province from 23 Regencies / Cities in 2010-2019, which is sourced from the Central Statistics Agency (BPS) of Aceh Province, it is noted that the regions that have the highest average life expectancy in 2010-2019 are regions. Lhokseumawe with a life expectancy of 70.88 years. Followed by Banda Aceh with 70.80 years and Bireuen with 70.58 years. Meanwhile, the regions that had the lowest life expectancy were Subulussalam with a life expectancy of 63.19 years, South Aceh 63.50 years and Aceh Barat Daya 64.07 [3]. As shown in Table 1.

Table 1. Life Expectancy Rate of Aceh Province by City District, 2010-2019

No	Region	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
1	SIMEULUE	64,05	64,15	64,22	64,23	64,24	64,66	64,78	64,90	65,00	65,22
2	ACEH SINGKIL	66,71	66,76	66,85	66,91	66,94	66,97	67,02	67,07	67,16	67,36
3	ACEH SELATAN	62,92	63,03	63,12	63,16	63,18	63,64	63,75	63,89	64,02	64,27
4	ACEH TENGGARA	66,85	66,93	66,96	67,03	67,07	67,40	67,51	67,62	67,77	68,04
5	ACEH TIMUR	67,92	67,97	68,02	68,05	68,06	68,20	68,26	68,33	68,44	68,67
6	ACEH TENGAH	68,22	68,27	68,30	68,35	68,38	68,44	68,48	68,53	68,62	68,82
7	ACEH BARAT	67,16	67,21	67,25	67,30	67,33	67,49	67,56	67,62	67,72	67,93
8	ACEH BESAR	69,34	69,38	69,41	69,44	69,46	69,47	69,49	69,52	69,59	69,77
9	PIDIE	66,14	66,20	66,25	66,27	66,28	66,46	66,52	66,58	66,68	66,89
10	BIREUEN	70,27	70,30	70,32	70,34	70,35	70,64	70,72	70,80	70,92	71,16
11	ACEH UTARA	68,32	68,36	68,40	68,41	68,42	68,48	68,51	68,54	68,61	68,79
12	ACEH BARAT DAYA	63,44	63,55	63,63	63,69	63,72	64,20	64,35	64,51	64,65	64,91

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No	Region	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
13	GAYO LUES	64,24	64,31	64,38	64,42	64,44	64,77	64,88	64,98	65,12	65,38
14	ACEH TAMIANG	68,57	68,61	68,65	68,66	68,67	68,99	69,08	69,16	69,28	69,52
15	NAGAN RAYA	68,17	68,24	68,26	68,28	68,29	68,59	68,67	68,76	68,89	69,14
16	ACEH JAYA	66,29	66,35	66,39	66,45	66,48	66,63	66,70	66,77	66,88	67,11
17	BENER MERIAH	68,51	69,56	68,58	68,62	68,64	68,79	68,85	68,90	68,99	69,19
18	PIDIE JAYA	69,01	69,05	69,07	69,11	69,13	69,49	69,59	69,68	69,81	70,06
19	BANDA ACEH	70,71	70,74	70,76	70,79	70,80	70,89	70,92	70,96	70,10	71,36
20	SABANG	69,52	69,54	69,54	69,54	69,54	69,93	70,01	70,09	70,21	70,45
21	LANGSA	68,65	68,70	68,75	68,78	68,79	68,94	69,00	69,06	69,16	69,37
22	LHOKSEUMAWE	70,53	70,57	70,56	70,61	70,62	70,96	71,05	71,14	71,27	71,52
23	SUBULUSSALAM	62,59	62,83	62,83	62,86	62,87	63,27	63,42	63,56	63,69	63,94

Source: Aceh Province Central Statistics Agency (BPS) [3]

Because of the importance of Life Expectancy in Indonesia, especially in Aceh Province, it is necessary to predict the level of Life Expectancy in the following years, so that it becomes an input and reference for the Aceh regional government to determine policies or make appropriate strategic steps so that the numbers Life expectancy in Aceh Province should not decrease in the future, it can even increase every year. One of the good algorithms used to make predictions is the Cyclical Order weight / bias algorithm. This algorithm is one of the Algorithms of the Artificial Neural Network [4]. Artificial Neural Networks are widely used for problem solving related to estimation (prediction), pattern recognition, data analysis, control and grouping [5]–[10]. The Cyclical Order weight / bias algorithm is an artificial neural network algorithm that trains the network with heavy and biased learning rules with additional updates after the data is presented in the input. The input data is presented in a circular order [11]. Based on this algorithm, the community life expectancy data will be divided into 2 parts, namely training data and testing data, each of which has different targets. Just like other ANN Algorithms, this algorithm also uses parameters with hidden layer neurons to obtain the best network architecture model. This best network architecture model will later be used to predict the Life Expectancy Rate in Aceh Province by City District in the years to come. In general, the way this algorithm works is to update the weights and bias values according to the data presented [12].

Based on this background, a study was conducted to predict the Life Expectancy Rate of the Population in Aceh Province by City District using the Cyclical Order weight / bias algorithm. The results of this study are expected to contribute to the Aceh local government as a reference and reference in determining policies to increase the life expectancy of the community.

2. Research Methodology

2.1. Research Data

Data on life expectancy for the population of Aceh for 2010-2019 is based on municipal districts consisting of 23 regions, which were obtained from the Central Statistics Agency of Aceh Province (can be seen in table 1).

2.2. Research Flow

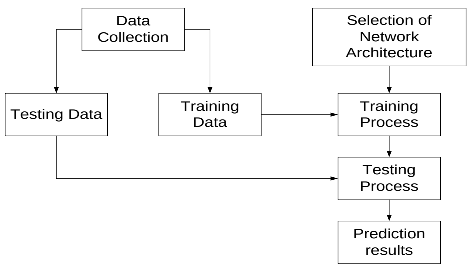

Figure 1. Research Flow

Figure 1 explains that the first thing to do is collect a research dataset. The research dataset used is the life expectancy data of the Acehnese people obtained from 23 regions. Then, preprocessing is carried out and the data is divided into several parts, namely the data used for training and the data used for testing, after which the data is normalized first. After that, determine the network architecture model that will be used for the training process and the testing process. After everything is done, the architectural model will be used. Furthermore, some of the architectural models used are selected the best. After that, predictions will be made using the best architectural model that has been selected.

2.3. Normalization Formula

The data in table 1 will be normalized using the following formula [13]–[20]:

$$x' = \frac{0.8(x-a)}{b-a} + 0.1 \quad (1)$$

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

3. Results and Discussion

3.1. Normalized Result Data

The life expectancy data for the Acehnese community is divided into two parts, the first data from 2010-2017 is used as training data, while the data for 2018 is used as training targets. The second data from 2011-2018 is used as test data, while the 2019 data is used as test target data.

Table 2. Normalization of Training Data

Data	2010	2011	2012	2013	2014	2015	2016	2017	Target
1	0,2308	0,2398	0,2460	0,2469	0,2478	0,2854	0,2962	0,3069	0,3159
2	0,4691	0,4736	0,4816	0,4870	0,4897	0,4924	0,4969	0,5013	0,5094
3	0,1296	0,1394	0,1475	0,1511	0,1529	0,1941	0,2039	0,2165	0,2281
4	0,4816	0,4888	0,4915	0,4978	0,5013	0,5309	0,5408	0,5506	0,5641
5	0,5775	0,5820	0,5865	0,5891	0,5900	0,6026	0,6080	0,6142	0,6241
6	0,6044	0,6088	0,6115	0,6160	0,6187	0,6241	0,6277	0,6321	0,6402
7	0,5094	0,5139	0,5175	0,5219	0,5246	0,5390	0,5452	0,5506	0,5596
8	0,7047	0,7083	0,7110	0,7137	0,7155	0,7163	0,7181	0,7208	0,7271
9	0,4180	0,4234	0,4279	0,4297	0,4306	0,4467	0,4521	0,4574	0,4664
10	0,7880	0,7907	0,7925	0,7943	0,7952	0,8212	0,8283	0,8355	0,8462
11	0,6133	0,6169	0,6205	0,6214	0,6223	0,6277	0,6303	0,6330	0,6393
12	0,1761	0,1860	0,1932	0,1985	0,2012	0,2442	0,2577	0,2720	0,2845
13	0,2478	0,2541	0,2604	0,2639	0,2657	0,2953	0,3052	0,3141	0,3267
14	0,6357	0,6393	0,6429	0,6438	0,6447	0,6733	0,6814	0,6886	0,6993
15	0,5999	0,6062	0,6080	0,6097	0,6106	0,6375	0,6447	0,6527	0,6644
16	0,4315	0,4368	0,4404	0,4458	0,4485	0,4619	0,4682	0,4745	0,4843
17	0,6303	0,7244	0,6366	0,6402	0,6420	0,6554	0,6608	0,6653	0,6733
18	0,6751	0,6787	0,6805	0,6841	0,6859	0,7181	0,7271	0,7352	0,7468
19	0,8274	0,8301	0,8319	0,8346	0,8355	0,8436	0,8462	0,8498	0,7728
20	0,7208	0,7226	0,7226	0,7226	0,7226	0,7576	0,7647	0,7719	0,7826
21	0,6429	0,6474	0,6518	0,6545	0,6554	0,6689	0,6742	0,6796	0,6886
22	0,8113	0,8149	0,8140	0,8185	0,8194	0,8498	0,8579	0,8660	0,8776
23	0,1000	0,1215	0,1215	0,1242	0,1251	0,1609	0,1744	0,1869	0,1985

As for the results of Normalization of test data can be seen in table 3.

Table 3. Normalization of Testing Data

Data	2011	2012	2013	2014	2015	2016	2017	2018	Target
1	0,2398	0,2460	0,2469	0,2478	0,2854	0,2962	0,3069	0,3159	0,3356
2	0,4736	0,4816	0,4870	0,4897	0,4924	0,4969	0,5013	0,5094	0,5273
3	0,1394	0,1475	0,1511	0,1529	0,1941	0,2039	0,2165	0,2281	0,2505
4	0,4888	0,4915	0,4978	0,5013	0,5309	0,5408	0,5506	0,5641	0,5882
5	0,5820	0,5865	0,5891	0,5900	0,6026	0,6080	0,6142	0,6241	0,6447
6	0,6088	0,6115	0,6160	0,6187	0,6241	0,6277	0,6321	0,6402	0,6581
7	0,5139	0,5175	0,5219	0,5246	0,5390	0,5452	0,5506	0,5596	0,5784
8	0,7083	0,7110	0,7137	0,7155	0,7163	0,7181	0,7208	0,7271	0,7432
9	0,4234	0,4279	0,4297	0,4306	0,4467	0,4521	0,4574	0,4664	0,4852
10	0,7907	0,7925	0,7943	0,7952	0,8212	0,8283	0,8355	0,8462	0,8677
11	0,6169	0,6205	0,6214	0,6223	0,6277	0,6303	0,6330	0,6393	0,6554
12	0,1860	0,1932	0,1985	0,2012	0,2442	0,2577	0,2720	0,2845	0,3078
13	0,2541	0,2604	0,2639	0,2657	0,2953	0,3052	0,3141	0,3267	0,3499
14	0,6393	0,6429	0,6438	0,6447	0,6733	0,6814	0,6886	0,6993	0,7208
15	0,6062	0,6080	0,6097	0,6106	0,6375	0,6447	0,6527	0,6644	0,6868
16	0,4368	0,4404	0,4458	0,4485	0,4619	0,4682	0,4745	0,4843	0,5049
17	0,7244	0,6366	0,6402	0,6420	0,6554	0,6608	0,6653	0,6733	0,6913
18	0,6787	0,6805	0,6841	0,6859	0,7181	0,7271	0,7352	0,7468	0,7692
19	0,8301	0,8319	0,8346	0,8355	0,8436	0,8462	0,8498	0,7728	0,8857
20	0,7226	0,7226	0,7226	0,7226	0,7576	0,7647	0,7719	0,7826	0,8041
21	0,6474	0,6518	0,6545	0,6554	0,6689	0,6742	0,6796	0,6886	0,7074
22	0,8149	0,8140	0,8185	0,8194	0,8498	0,8579	0,8660	0,8776	0,9000
23	0,1215	0,1215	0,1242	0,1251	0,1609	0,1744	0,1869	0,1985	0,2209

3.2. Training and Testing

This study was analyzed with 6 architectural models, including: 8-5-1 (8 input layer neurons, 5 hiding layer neurons and 1 output layer), 8-6-1 (8 input layer neurons, 6 hiding layer neurons and 1 output layer). layer), 8-7-1 (8 input layer neurons, 7 hiding layer neurons and 1 output layer), 8-8-1 (8 input layer neurons, 8 hiding layer neurons and 1 output layer), 8-9-1 (8 input layer neurons, 9 hiding layer neurons and 1 output layer) and 8-10-1 (8 input layer neurons, 10 hiding layer neurons and 1 output layer). Training and testing parameters: Epoch = 1000, Goal = 0, max_fail = 5, show = 25, showCommandLine = false, showWindow = true and time = inf. The method used is cyclical order weight / bias (trainc). Based on the analysis using the matlab tool and Microsoft Excel, the best architectural model is 8-9-1 with 91% accuracy. Training using the 8-9-1 architectural model can be seen in Figure 2.

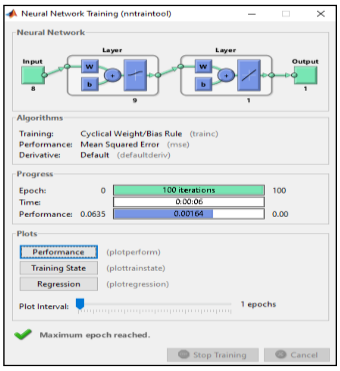

Figure 2. Training Results with Architectural Models 8-9-1

Figure 2 is the result of training using the 8-9-1 model with an epoch of 100 iterations, 6 seconds of training time and a performance of 0.00164. For training and testing tables can be seen in table 4 and table 5.

Table 4. Training with Models 8-9-1

Data	Target	Output	Error	SSE
1	0,3159	0,2599	0,0560	0,0031361630
2	0,5094	0,5536	-0,0442	0,0019530659
3	0,2281	0,2472	-0,0191	0,0003645234
4	0,5641	0,6013	-0,0372	0,0013872830
5	0,6241	0,6350	-0,0109	0,0001193305
6	0,6402	0,6523	-0,0121	0,0001463721
7	0,5596	0,5959	-0,0363	0,0013195443
8	0,7271	0,7395	-0,0124	0,0001537683
9	0,4664	0,4829	-0,0165	0,0002720726
10	0,8462	0,8136	0,0326	0,0010659311
11	0,6393	0,6510	-0,0117	0,0001367564
12	0,2845	0,2612	0,0233	0,0005450578
13	0,3267	0,2642	0,0625	0,0039002193
14	0,6993	0,6639	0,0354	0,0012551508
15	0,6644	0,6471	0,0173	0,0002989336
16	0,4843	0,5147	-0,0304	0,0009227920
17	0,6733	0,7167	-0,0434	0,0018793730
18	0,7468	0,6923	0,0545	0,0029711777
19	0,7728	0,8651	-0,0923	0,0085214400
20	0,7826	0,7267	0,0559	0,0031295943
21	0,6886	0,6766	0,0120	0,0001434684
22	0,8776	0,8364	0,0412	0,0016977353
23	0,1985	0,2468	-0,0483	0,0023286191
			Sum SSE	0,0376483720
			MSE	**0,0009907466**

Table 5. Testing with Models 8-9-1

Data	Target	Output	Error	SSE	Results
1	0,3356	0,3064	0,0292	0,0008532418	1
2	0,5273	0,5591	-0,0318	0,0010097378	1
3	0,2505	0,2810	-0,0305	0,0009300109	1
4	0,5882	0,6327	-0,0445	0,0019765243	1
5	0,6447	0,6480	-0,0033	0,0000110167	1
6	0,6581	0,6579	0,0002	0,0000000478	1
7	0,5784	0,6116	-0,0332	0,0011030729	1
8	0,7432	0,7424	0,0008	0,0000006808	1
9	0,4852	0,5087	-0,0235	0,0005513872	1
10	0,8677	0,8420	0,0257	0,0006630192	1
11	0,6554	0,6580	-0,0026	0,0000065991	1
12	0,3078	0,3080	-0,0002	0,0000000260	1
13	0,3499	0,3070	0,0429	0,0018441879	1
14	0,7208	0,6934	0,0274	0,0007523318	1
15	0,6868	0,6720	0,0148	0,0002186292	1
16	0,5049	0,5362	-0,0313	0,0009779873	1
17	0,6913	0,6312	0,0601	0,0036078520	0

Data	Target	Output	Error	SSE	Results
18	0,7692	0,7257	0,0435	0,0018926787	1
19	0,8857	0,8279	0,0578	0,0033369447	0
20	0,8041	0,7661	0,0380	0,0014472955	1
21	0,7074	0,6914	0,0160	0,0002557062	1
22	0,9000	0,8646	0,0354	0,0012531600	1
23	0,2209	0,2673	-0,0464	0,0021491894	1
			Sum SSE	0,0248413272	**91%**
			MSE	**0,0010800577**	

Explanation:
Data = The number of areas (districts and cities) in Aceh Province
Target = obtained from data of training years and normalized testing data.
Output = obtained from Matlab with the formula [a,Pf,Af,e,Perf]=sim(net,P,[],[],T),
Error = obtained from the value Target-Output
SSE = obtained from the value error ^ 2
Sum SSE = overall value SSE
Results = If the error value <= 0.05 then the result is true (1), otherwise it is false (0).
91% = obtained from the number of correct results / 23 × 100
MSE = obtained from total (SSE) / 23 (amount of data)
Margin error = obtained from the number of false results (0) / 12 × 100 or obtained from the maximum amount of accuracy of 100% minus the resulting accuracy, yielding 9%.

3.3. Determination of the Best Architectural Model

After the training process and data testing on models 8-5-1, 8-6-1, 8-7-1, 8-8-1, 8-9-1 and 8-10-1 using Matlab and Microsoft Excel, then The 8-9-1 architectural model is obtained as the best with an accuracy rate of 91% or the highest compared to the other 5 models. So it is known that the error margin of 9% is obtained from the maximum accuracy (100%) reduced by the resulting accuracy. Comparison of the level of accuracy of the 6 architectural models used can be seen in table 6.

Table 6. Comparison of Overall Results of the Architectural Model Used

No	Model	MSE Training	MSE Testing	Accuracy
1	8-5-1	0,0016524361	0,0032518144	74%
2	8-6-1	0,0022644298	0,0050925141	70%
3	8-7-1	0,0016498479	0,0021446460	74%
4	8-8-1	0,0022282395	0,0044749101	48%
5	8-9-1	0,0009907466	0,0010800577	91%
6	8-10-1	0,0011626474	0,0022476613	70%

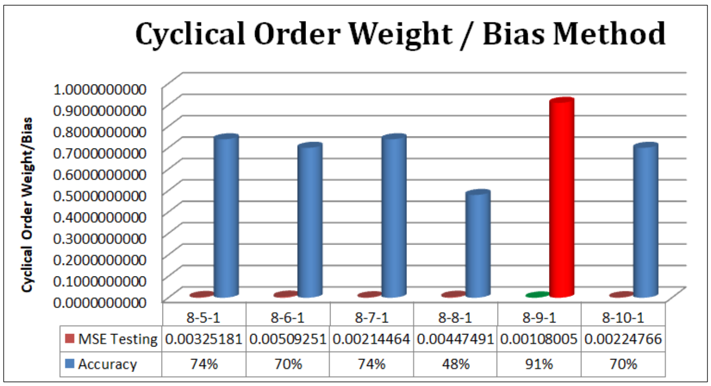

Figure 3. Comparison of Accuracy with the Cyclical Order Method

Based on Figure 3, it can be seen the difference in the level of accuracy of the overall network architecture model used by the Cyclical Order Weight / Bias method. Based on the 6 models used, the lowest MSE level and the highest accuracy are in the 8-9-1 model.

4. Conclusion

The Cyclical Order Weight / Bias method with the 8-9-1 model can be used to predict the life expectancy of the Acehnese with an accuracy rate of 91%. The architectural model and the parameters used have an effect on the resulting level of accuracy.

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