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Performance Analysis of Adaptive Neuro-Fuzzy Inference System (ANFIS) with Subtractive Clustering in the Classification Process

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ABSTRACT

Adaptive neuro-fuzzy inference system (ANFIS) is a combination of artificial neural network and fuzzy inference system (FIS) techniques. ANFIS is used to significantly improve the results of the classification process, while substractive clustering is a method of grouping based on the potential density of the data to calculate the cluster center to the surrounding data points. With substractive clustering, large datasets are divided into groups and determined radii are also called cluster radii. The cluster radius serves to determine the area of influence that has a value between 0 and 1. The results of this study use the FIS substractive clustering parameter to minimize mean square error (MSE), root mean square error (RMSE), mean absolute error (MAE) with maximum epoch 1000, target error=0.01. Testing training data 60% of the dataset values, MSE=192750.4593, RMSE=439.0336 with epoch 369, and MAE=0.00012481 with epoch 94, radius=0.3 squash factor=1.5, accept ratio=0.7, reject ratio=0.35. Testing data testing 40% of the MSE dataset=205013,853, RMSE=452.7846 at epoch 49 and MAE=2.33968 at epoch 51, radius=0.9 squash factor=1.25, accept ratio=0.5, reject ratio=0.25. Testing uses 70% training data and 30% testing data from the dataset. In the 70% training data test, the minimum MAE value=0.00010119 with the radius value=0.2, accept ratio=0.3, reject ratio=0.15 and squash factor=1. 30% testing data test obtained the MAE drinking value=0.060341 with a radius value=0.1, accept ratio=0.7, reject ratio=0.35 and squash factor=1.5.

Keywords: Adaptive Neuro-Fuzzy Inference System, Substractive Clustering, Mean .Square Error, Root Mean Square Error, Mean Absolute Error

INTRODUCTION

Adaptive neuro-fuzzy inference system (ANFIS) is a technique of combining artificial neural network and fuzzy inference system which is used for the introduction and control of complex non-linear systems (Dubey, 2016). ANFIS consists of five layers and each layer has nodes (Swain et al., 2016).

To date many researchers have developed the adaptive neuro fuzzy inference system (ANFIS) to improve classification results. Arikat (2012) in his research used the substractive neuro fuzzy approach to extract dimensional features in solving short essay AEG problems and calculate performance evaluations with MAPE and RMSE.

Dubey et al. (2016) in his research using the support vector regression (SVR) method in ANFIS to predict models and calculate performance evaluations using RMSE, MAE, MAPE and E.

Zarbakhsh et al. (2017) in his study using ANFIS as a classification technique and association rule (AR) for feature selection algorithms. By proposing the cuckoo optimization algorithm (COA) method for feature selection by finding the optimal radius value. The proposed method is applied to the Wisconsin breast cancer database (WBCD) and the results show high detection accuracy.

Billalovic et al. (2018) in his research proposes using genetic algorithm (GA) algorithm techniques that optimize artificial neural network (ANN) and adaptive neuro fuzzy inference system (ANFIS) to significantly improve the classification process. In this study the voting method has been used in an optimized GA-ANFIS structure, to achieve a model with higher reliability.

Semero et al. (2018) in his research used a combination of genetic algorithm (GA), swarm particle optimization (PSO) and adaptive neuro fuzzy inference system (ANFIS) for prediction on electricity production in microgrids with solar photovoltaic (PV) installation. Forecasting results show good performance of the proposed method compared to the commonly used forecast approach. The proposed approach is better than artificial neural networks (ANN) and linear regression (LR).

Yeom and Kwak (2018) in their research compared and analyzed the predicted performance of ANFIS models with different input space partitioning methods. ANFIS 1 uses subscrative clustering. ANFIS 2 uses the fuzzy c-mean (FCM) grouping. ANFIS 3 uses context based fuzzy c-means (CFCM) to improve ANFIS performance using the RMSE performance evaluation method.

Research on ANFIS performance in the classification process requires measurement of performance evaluation with the criteria of mean square error (MSE), root mean square error (RMSE) and mean absoult error (MAE) to minimize errors.

RESEARCH METHODS

Based on the picture above, the following research procedures are explained:

1.The dataset used is taken from the UCI learning machine repository which will be used as a test. The dataset taken was the breast cancer dataset (Zarbakhsh et al. 2017).

2.Pre Data Processing Consists of Cleaning Data, Sorting and Normalizing Data.

The cleaning data stage is used to replace the missing value with the median method contained in the breast cancer dataset.

Sorting data is used to separate data according to class, namely benign and malignant cancer classes. Breast cancer dataset totaling 699 data with a benign class with a value of 2 (two) which has a total data of 458 and a malignant class worth 4 (four) which has a total data of 241.

Normalized data according to Manman Wu et al. (2016) is a process to convert the existence of a single sample data in the range of 1-10 intervals, this is done to improve accuracy and shorten training time.

3.Data processing training and data testing. The data used is divided into two groups, namely Testing data and training data.

4.Formation of FIS by using the substractive clustering algorithm. In the process of forming FIS with the substractive clustering algorithm, it is done by determining the cluster radius for training and testing the dataset.

5.In the final stage of this research is after the ANFIS training process by evaluating performance to obtain better performance with the criteria of mean square error (MSE), root mean square error (RMSE) and mean absolute error (MAE) in minimizing errors.

The data used is the UCI machine learning repository dataset. The number of 699 records with the following class distribution is benign 458 (65.5%) and malignant class distribution of 241 (34.5%). The dataset attribute consists of 9 with a range of 1-10 intervals defined for each record in the dataset (Zarbakhsh et al., 2017).

Pre processing data through cleaning data missing values is data on breast cancer which has 9 (nine) attributes and 1 (one) output attribute that produces 2 (two) classes of output attributes in the breast cancer dataset. The number of breast cancer datasets is 699 data and no value is 16 data. Sorting data is used to separate data according to class that is benign and malignant. Breast cancer dataset consists of 699 data with benign classes that are worth 2 the amount of data 458 and malignant classes are worth 4 amount of data 241. At the data normalization stage is used to change the range values to 0 and 1 according to the needs used in this study. Data normalization is divided into 2 data classes, namely data normalization in the benign class and data normalization in the malignant class.

Data training processing and testing through data training is used to build the fis model that will be formed while data testing is used to test the FIS model that has been built. In determining the ratio of training data and testing data there are no definite rules in determining the ratio between training data and testing data. Determination of FIS initialization aims to determine initial values as parameters to form FIS with substractive clustering. There are 4 parameters used in substractive clustering, namely: radius value used in determining the distance between each cluster member, Squash factor is a positive constant that is used to reduce the density of cluster members. Accept ratios are used to determine whether cluster members can be accepted or not accepted. Reject ratio regulates the potential of each member to be rejected as the center of the cluster. If a member has potential under the reject ratio then the member will never be the center of the cluster. To obtain a low error value in the formation of FIS using Substractive Clustering, this research will be tested with several strategies in selecting several radius values for each training and testing data. The test was carried out using 9 radii consisting of 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9, target error 0.01 and epoch 1000.

RESULT

Training Data 60% of Dataset

Testing uses target error=0.01, epoch maximum is 1000. As for the results of testing with several radii using training data:

Table 1. 60% of MSE, RMSE and MAE Data Training Value from Dataset

Radius (r)	Squash Factor	Accept Ratio	Reject Ratio	Fuzzy Rule	Epoch	Performance Evaluation		
						MSE	RMSE	MAE
0,1	1	0,3	0,15	40	31	195598,8163	442,2655	0,00029728
	1,25	0,5	0,25	46	56	200060,1554	447,2808	0,00017872
	1,5	0,7	0,35	48	55	192915,9575	439,222	0,00031946
	1,75	0,9	0,50	44	249	196300,8202	443,0585	0,00012614
0,2	1	0,3	0,15	21	30	205569,1017	453,3973	9,4565
	1,25	0,5	0,25	18	43	207314,0442	455,3175	0,0003792
	1,5	0,7	0,35	18	104	209608,8899	457,8306	0,00036977
	1,75	0,9	0,50	21	351	203283,7427	450,87	0,00063629
0,3	1	0,3	0,15	14	51	206872,8327	454,8328	0,00026346
	1,25	0,5	0,25	14	57	209475,7314	457,6852	0,000146
	1,5	0,7	0,35	13	94	209418,9536	457,6232	0,00012481
	1,75	0,9	0,50	14	369	192750,4593	439,0336	0,00023421
0,4	1	0,3	0,15	9	33	212351,0576	460,8156	0,00020429
	1,25	0,5	0,25	7	59	204131,9363	451,8096	5,1554
	1,5	0,7	0,35	8	105	212940,253	461,4545	0,00016111
	1,75	0,9	0,50	7	103	219914,6243	468,9506	0,00013114
0,5	1	0,3	0,15	5	50	210716,4936	459,0387	0,0001451
	1,25	0,5	0,25	5	45	204849,3206	452,6028	1,0234
	1,5	0,7	0,35	5	71	214029,8015	462,6335	1,4863
	1,75	0,9	0,50	5	262	205717,2387	453,5606	0,00019427
0,6	1	0,3	0,15	4	49	213520,2721	462,0825	1,0081
	1,25	0,5	0,25	5	50	207063,1165	455,0419	0,00021413
	1,5	0,7	0,35	4	95	213799,8471	462,385	1,2429
	1,75	0,9	0,50	4	276	215897,6941	464,6479	1,9143
0,7	1	0,3	0,15	5	49	220720,9151	469,8094	0,00028493
	1,25	0,5	0,25	4	54	210945,5409	459,2881	0,00035161
	1,5	0,7	0,35	4	57	207707,9009	455,7498	1,5401
	1,75	0,9	0,50	4	198	214196,3391	462,8135	0,00030242

Table 1. 60% of MSE, RMSE and MAE Data Training Value from Dataset (Advanced)

Radius (r)	Squash Factor	Accept Ratio	Reject Ratio	Fuzzy Rule	Epoch	Performance Evaluation MSE	RMSE	MAE
0,8	1	0,3	0,15	3	34	215147,3428	463,8398	1,7683
	1,25	0,5	0,25	3	50	207791,98	455,8421	1,5551
	1,5	0,7	0,35	3	12	217268,5799	466,1208	2,162
	1,75	0,9	0,50	3	315	208135,6798	456,2189	1,3275
0,9	1	0,3	0,15	2	26	221839,4188	470,9983	1,0066
	1,25	0,5	0,25	2	51	211150,7281	459,5114	1,2674
	1,5	0,7	0,35	2	73	217604,3781	466,4808	1,5845
	1,75	0,9	0,50	2	23	208806,3512	456,9533	0,00016273

The test results with several radius values through training data training above, can be identified the radius value that produces an optimal FIS structure by considering the minimum MSE, RSME and MAE results produced by each FIS substractive clustering. The results of the minimum MSE and RMSE value process:

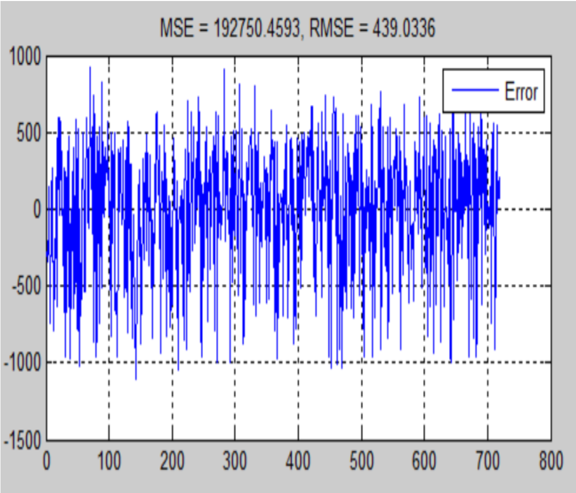

Figure 1. Graph of MSE and RSME Value Training Data 60% of Dataset

Figure 1 shows the results of MSE and RSME values using 60% training data from the breast cancer dataset. In training the value of the radius=0.3 Squash factor=1.75, accept ratio=0.9, reject ratio=0.5 obtained the minimum value of MSE=192750.4593 and RSME=439.0336 which is found in epoch 369.

The training data test results are processed to a minimum MAE value:

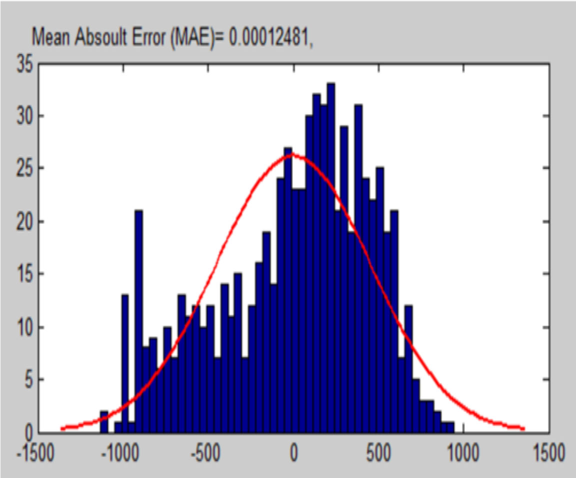

Figure 2. Graph of MAE Training Data Value 60% of Dataset

Figure 2 is the result of MAE values using 60% training data from the breast cancer dataset. In training the value of the radius=0.3, Squash factor=1.5, accept ratio=0.7, reject ratio=0.35 obtained a minimum value of MAE=0.00012481 found in epoch 94.

Training Data 40% of Dataset

In this test using 40% data testing from the breast cancer dataset, the optimal FIS testing based on Substractive Clustering also uses the criteria of mean square error (MSE), root mean square error (RMSE) and minimum mean absolute error (MAE). Testing using target error=0.01, maximum epoch 1000.

The results of testing with several radii use testing data 40% of the dataset:

Table 2. 40% of MSE, RMSE and MAE Data Testing Value from Dataset

Radius (r)	Squash Factor	Accept Ratio	Reject Ratio	Fuzzy Rule	Epoch	Performance Evaluation MSE	RMSE	MAE
0,1	1	0,3	0,15	40	31	265613,6226	515,3772	7,2927
	1,25	0,5	0,25	46	56	269369,4365	519,0081	7,6906
	1,5	0,7	0,35	48	55	263420,7909	513,2454	38,8734
	1,75	0,9	0,50	44	249	604116,908	777,2496	13,7976

0,2	1	0,3	0,15	21	30	250169,1382	500,1691	8,0596
	1,25	0,5	0,25	18	43	231294,8522	480,9312	3,277
	1,5	0,7	0,35	18	104	225330,4994	474,6899	7,2724
	1,75	0,9	0,50	21	351	245350,455	495,3286	22,3521
0,3	1	0,3	0,15	14	51	238649,6735	488,5178	13,109
	1,25	0,5	0,25	14	57	219534,4923	468,5451	19,2276
	1,5	0,7	0,35	13	94	218402,2118	467,3352	61,8448
	1,75	0,9	0,50	14	369	240722,3895	490,6347	44,0338
0,4	1	0,3	0,15	9	33	217440,7434	466,3054	12,2561
	1,25	0,5	0,25	7	59	224058,2916	473,348	15,0559
	1,5	0,7	0,35	8	105	227452,2179	476,9195	21,1969
	1,75	0,9	0,50	7	103	208086,3879	456,1649	49,5457
0,5	1	0,3	0,15	5	50	219096,3076	468,0772	30,3382
	1,25	0,5	0,25	5	45	235114,009	484,8856	15,3165
	1,5	0,7	0,35	5	71	215199,2218	463,8957	15,2892
	1,75	0,9	0,50	5	262	229632,5347	479,1999	34,9078
0,6	1	0,3	0,15	4	49	215014,196	463,6962	37,695
	1,25	0,5	0,25	5	50	207063,1165	455,0419	7,3042
	1,5	0,7	0,35	4	95	222852,5038	472,0726	23,4994
	1,75	0,9	0,50	4	276	213966,2356	462,5648	19,337
0,7	1	0,3	0,15	5	49	205013,853	452,7846	42,5725
	1,25	0,5	0,25	4	54	220122,0639	469,1717	16,8339
	1,5	0,7	0,35	4	57	227420,8586	476,8866	28,2046
	1,75	0,9	0,50	4	198	216601,9551	465,4052	12,7127
0,8	1	0,3	0,15	3	34	212002,5267	460,4373	6,8903
	1,25	0,5	0,25	3	50	22063,5779	469,7058	4,127
	1,5	0,7	0,35	3	12	216249,5116	465,0264	24,3466
	1,75	0,9	0,50	3	315	220913,2074	470,0141	16,3503

Table 2. 40% of MSE, RMSE and MAE Data Testing Value from Dataset (Advanced)

Radius (r)	Squash Factor	Accept Ratio	Reject Ratio	Fuzzy Rule	Epoch	Performance Evaluation		
						MSE	RMSE	MAE
0,9	1	0,3	0,15	2	26	206559,9988	454,4887	23,9492
	1,25	0,5	0,25	2	51	220316,1208	469,3784	2,3968
	1,5	0,7	0,35	3	73	213342,7085	461,8904	5,5567
	1,75	0,9	0,50	2	23	221435,5562	470,5694	7,9422

The results of testing data testing 40% of the dataset obtained the minimum value of MSE and RMSE:

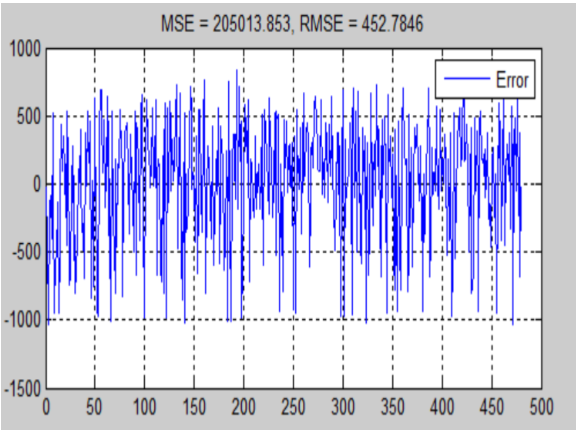

Figure 3. Graph of MSE and RSME Value Testing Data 40% of Dataset

Figure 3 is the result of MSE and RSME values using 40% testing data from the breast cancer dataset. In testing the radius value=0.7 Squash factor=1, accept ratio=0.3, reject ratio=0.15, the minimum value of MSE=205013.853 and RSME=452.77846 are found in epoch 49.

The results of testing data testing 40% of the dataset obtained the minimum value of MAE:

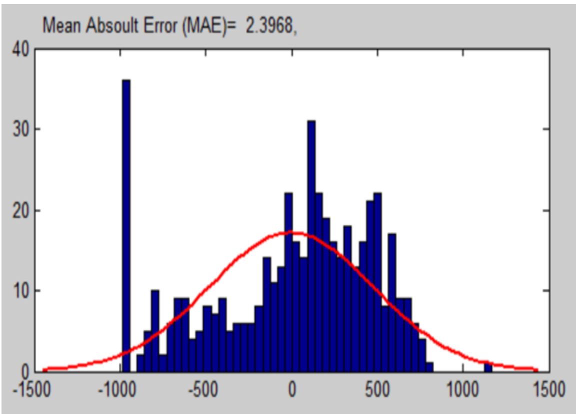

Figure 4. Graph of MAE Data Testing Value of 40% of Dataset

Figure 4 is the result of MAE values using 40% testing data from the breast cancer dataset. In testing the radius value=0.9 Squash factor=1.25, accept ratio=0.5, reject ratio=0.25, the minimum MAE value=2.33968 is found in epoch 51.

Training Data 70% of Dataset

Testing uses target error=0.01, epoch maximum 1000. Initialization of parameters with substractive clustering.

Table 3. The Value of MSE, RMSE and MAE Training Data is 70% of the Dataset

Radius (r)	Squash Factor	Accept Ratio	Reject Ratio	Fuzzy Rule	Epoch	Performance Evaluation		
						MSE	RMSE	MAE
0,1	1	0,3	0,15	40	31	201036,4023	448,3708	0,00018521
	1,25	0,5	0,25	46	56	197223,3749	444,0984	0,0004077
	1,5	0,7	0,35	43	82	201396,7414	448,77725	0,00012559
	1,75	0,9	0,50	49	459	202662,8332	450,1809	0,00014897

Tabel 3. The Value of MSE, RMSE and MAE Training Data is 70% of the Dataset (Advanced)

Radius (r)	Squash Factor	Accept Ratio	Reject Ratio	Fuzzy Rule	Epoch	Performance Evaluation		
						MSE	RMSE	MAE
0,2	1	0,3	0,15	25	41	204172,6431	451,8547	0,00010119
	1,25	0,5	0,25	22	56	199879,9726	447,0794	0,00016807
	1,5	0,7	0,35	19	124	203215,7851	450,7946	0,00012288
	1,75	0,9	0,50	23	303	207749,2914	455,7952	0,00023023
0,3	1	0,3	0,15	13	42	202701,415	450,2237	0,00041664
	1,25	0,5	0,25	14	66	206925,4233	454,8906	0,00030141
	1,5	0,7	0,35	13	86	205944,6113	453,8112	0,00051705
	1,75	0,9	0,50	16	233	211080,3094	459,4348	0,00018404
0,4	1	0,3	0,15	9	47	210798,6559	459,1281	0,00026771
	1,25	0,5	0,25	8	65	208537,1769	456,6587	0,00021672
	1,5	0,7	0,35	9	113	211882,3116	460,3068	0,00020422
	1,75	0,9	0,50	9	217	212007,169	460,4424	0,0004128
0,5	1	0,3	0,15	5	26	210716,4936	459,0387	0,0001451
	1,25	0,5	0,25	5	60	214272,7781	462,8961	0,00018837
	1,5	0,7	0,35	5	101	214029,8015	462,6335	1,4863
	1,75	0,9	0,50	5	249	214195,3929	462,8125	0,00011613
0,6	1	0,3	0,15	4	33	213520,2721	462,0825	1,0081
	1,25	0,5	0,25	5	50	212203,4457	460,6555	1,0743
	1,5	0,7	0,35	4	71	215049,2016	463,734	1,1276
	1,75	0,9	0,50	4	214	215062,6556	463,7485	1,1712
0,7	1	0,3	0,15	4	35	213688,7017	462,2648	1,4739
	1,25	0,5	0,25	4	43	215014,8742	463,697	2,1993
	1,5	0,7	0,35	4	69	215168,2076	463,8623	4,6464
	1,75	0,9	0,50	4	218	215399,5253	464,1115	3,0269
0,8	1	0,3	0,15	3	40	215895,648	464,6457	2,7609
	1,25	0,5	0,25	3	47	215815,6738	464,5597	1,6254
	1,5	0,7	0,35	3	74	215131,7412	463,823	3,4016
	1,75	0,9	0,50	3	26	212447,6002	460,9204	1,3085
0,9	1	0,3	0,15	2	36	215747,567	464,4863	2,599
	1,25	0,5	0,25	2	17	216113,3698	464,88	3,85522
	1,5	0,7	0,35	2	11	216207,3172	464,981	1,7056
	1,75	0,9	0,50	2	23	216331,5811	465,1146	1,1638

The results of testing 70% of training data from the dataset obtained the minimum value of MSE and RMSE are:

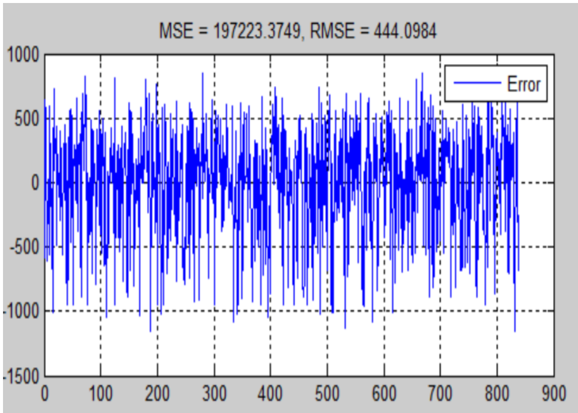

Figure 5. Graph of MSE and RSME Value of Training Data 70% of Dataset

Figure 5 is the result of MSE and RSME values using 70% training data from the breast cancer dataset. In testing the radius value=0.1 Squash factor=1.25, accept ratio=0.5, reject ratio=0.25 obtained a minimum value of MSE=197223.3749 and RMSE=444.0984 contained in Epoch 56.

The results of testing 70% of training data from the dataset obtained a minimum MAE value:

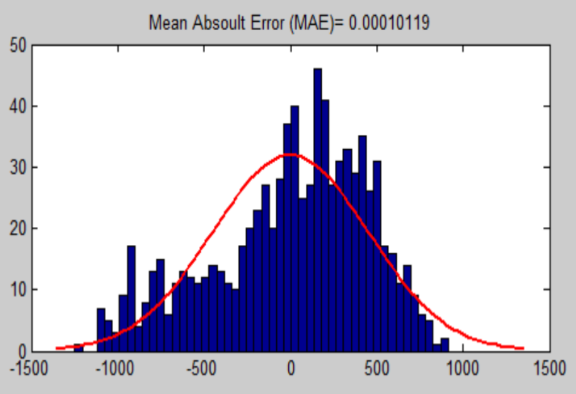

Figure 6. Graph of MAE Data Training Value 70% of Dataset

Figure 6 is the result of MAE values using 70% training data from the dataset. In testing the radius value=0.2 squash factor=1, accept ratio=0.3, reject ratio=0.15, the minimum MAE value=0.00010119 is found in epoch 41.

Training Data 30% of Dataset

This test uses 30% data testing from the dataset. Tests using target error=0.01, epoch=1000 as explained in Table 4.

Table 4. 30% of MSE, RMSE and MAE Value Testing Data from the Dataset

Radius (r)	Squash factor	Accept Ratio	Reject Ratio	Fuzzy Rule	Epoch	Performance Evaluation		
						MSE	RMSE	MAE
0,1	1	0,3	0,15	40	31	279994,842	529,1454	4,5464
	1,25	0,5	0,25	46	56	234875,0182	484,6391	1,7561
	1,5	0,7	0,35	43	82	325557,7202	570,5767	0,060341
	1,75	0,9	0,50	49	459	237243,2497	487,0762	7,0344
0,2	1	0,3	0,15	25	41	258976,61	508,8974	4,9556
	1,25	0,5	0,25	22	56	239168,0519	489,0481	0,10238
	1,5	0,7	0,35	19	124	233800,6028	483,5293	5,4246
	1,75	0,9	0,50	23	303	222499,4873	471,6985	0,17009
0,3	1	0,3	0,15	13	42	232719,7396	482,4103	3,7091
	1,25	0,5	0,25	14	66	222430,7809	471,6257	3,0471
	1,5	0,7	0,35	13	86	223728,6879	472,9997	0,70065
	1,75	0,9	0,50	16	233	216155,9761	464,9258	3,1723
0,4	1	0,3	0,15	9	47	216220,9843	464,9957	4,4297
	1,25	0,5	0,25	8	65	234897,6794	484,6624	0,86218
	1,5	0,7	0,35	9	113	217407,4933	466,2698	2,7844
	1,75	0,9	0,50	9	217	215842,1988	464,5882	2,1731
0,5	1	0,3	0,15	5	26	214079,0889	462,6868	3,787
	1,25	0,5	0,25	5	60	211194,108	459,5586	2,8233
	1,5	0,7	0,35	5	101	212138,5303	460,585	4,2603
	1,75	0,9	0,50	5	249	210964,3667	459,3086	2,3543
0,6	1	0,3	0,15	4	33	212563,8524	461,0465	0,6928
	1,25	0,5	0,25	5	50	218101,2822	467,0131	3,1015
	1,5	0,7	0,35	4	71	209706,6225	457,9374	3,9314
	1,75	0,9	0,50	4	214	210193,0386	458,4681	3,8002

Table 4. 30% of MSE, RMSE and MAE Value Testing Data from the Dataset (Advanced)

Radius (r)	Squash factor	Accept Ratio	Reject Ratio	Fuzzy Rule	Epoch	Performance Evaluation		
						MSE	RMSE	MAE
0,7	1	0,3	0,15	4	35	214233,2202	462,8533	4,1222
	1,25	0,5	0,25	4	43	210088,5996	458,3542	3,3535
	1,5	0,7	0,35	4	69	208940,1464	457,0997	0,79161
	1,75	0,9	0,50	4	218	208204,5992	456,2944	1,5592
0,8	1	0,3	0,15	3	40	208640,0638	456,7713	3,0648
	1,25	0,5	0,25	3	47	209006,2355	457,172	2,1462
	1,5	0,7	0,35	3	74	209646,9272	457,8722	4,3104
	1,75	0,9	0,50	3	26	215710,753	464,4467	2,2776
0,9	1	0,3	0,15	2	36	208171,4825	456,2581	2,1485
	1,25	0,5	0,25	2	17	208150,3122	456,2349	2,6153
	1,5	0,7	0,35	2	11	208150,5615	456,2352	2,1465
	1,75	0,9	0,50	2	23	207975,8982	456,0437	0,31136

The results of testing data testing 30% of the dataset obtained the minimum value of MSE and RMSE are:

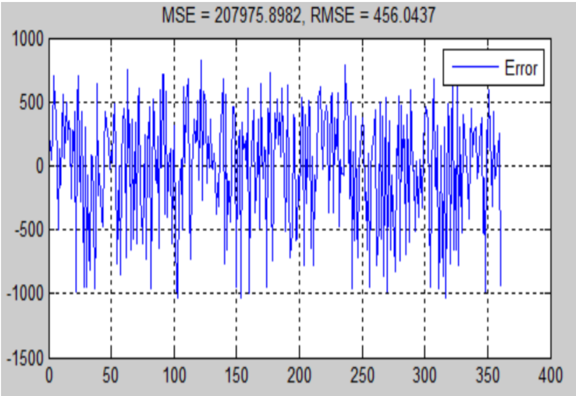

Figure 7. Graph of MSE Value and RSME Data Testing 30% of Dataset

Figure 7 is the result of MSE and RSME values using 30% testing data from the dataset. In testing the radius value=0.9 squash factor= 1.75, accept ratio=0.9, reject ratio=0.5, the minimum value of MSE=207975.88982 and RMSE=456.0437 are found in epoch 23.

The results of testing data testing 30% of the dataset obtained the minimum value of MAE:

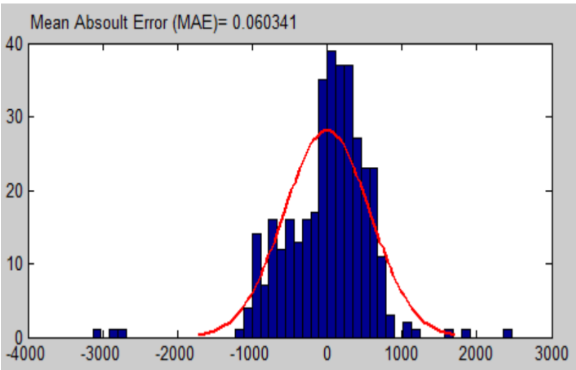

Figure 8. Graph of MAE Data Testing Value of 30% of the Dataset

Figure 8 is the result of MAE values using 30% testing data from the dataset. In testing the radius value=0.1 squash factor=1.5, accept ratio=0.7, reject ratio=0.35, the minimum MAE value=0.060341 found in epoch 41.

CONCLUSION AND SUGGESTION

CONCLUSION

The conclusions from the results of research conducted are:

1.Fuzzy inference system (FIS) substractive clustering applied can help improve the performance of the adaptive neuro fuzzy inference system (ANFIS) in learning and testing by looking at the best epoch process in each iteration for the minimum value of MSE, RMSE and MAE. In testing the training data 70% of the dataset obtained a minimum value of MSE= 197223.3749, RMSE=444.0984 and MAE=0.00010119 with a radius value=0.2, accept ratio=0.3, reject ratio=0.15 and squash factor=1. Testing data testing 30% obtained the value of drinking MAE=0.060341 with a radius value=0.1, accept ratio=0.7, reject ratio=0.35 and squash factor=1.5.

2.The test results using FIS substractive clustering can improve ANFIS performance by minimizing errors and obtaining optimal radius values.

3.The greater the radius value, the smaller the fuzzy rule or the number of clusters in the training and testing data.

SUGGESTION

The advice given by the author is as follows:

1.The use of new methods to get the minimum error value so that it reaches the specified error target and a low number of epochs.

2.Determination of the optimal radius value (radius) to improve the performance of the adaptive neuro-fuzzy inference system (ANFIS).

3.Using training data ratios and testing data from the dataset with another percentage.

4.The use of performance evaluation criteria on ANFIS by using a dataset with character data types.

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