

Drug Demand Prediction Model Using Adaptive Neuro Fuzzy Inference System (ANFIS)

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Abstract—Drug planning is the process of activities in the selection of types, quantities, and prices in accordance with the needs and budget for the coming procurement period in order to avoid the occurrence of excess or emptiness of drug supplies when needed by patients. Management of planning that is not optimal drug needs will have a negative impact on hospitals, both medically and economically, because 50-60% of the total budget used for treatment and medical equipment, uncertainty of drug needs due to disease population and the number of patients can change according to conditions the volume of patient diagnostic data, thus requiring an automatic way to select drug needs according to disease progression. This study aims to create a prediction model for drug needs with the ANFIS method, the data analysis framework used is sourced from drug usage / sales data at the Royal Prima Hospital 2016-2017 by building a software that implements the ANFIS method. Stages of application testing are carried out by applying the previous year's data to predict the current year, namely the 2016 data for 2017 predictions, while the 2017 data for 2018 predictions. The data source will be used to analyze the ANFIS membership function that generates parameters for the ANFIS method in training and testing data. The results of the analysis of the ANFIS parameters will be updated to produce a small error value (close to 0), based on the value of Root Mean Square Error (RMSE), then an evaluation is carried out with a quantitative and qualitative analysis of the predicted results with the existing system.

Keywords—ANFIS method, Drug Demand Prediction, RSU Royal Prima

I. INTRODUCTION

Hospital is one of the healing and health recovery facilities for patients (DeKes RI, 2004). Medicine is a good need for sick people, 50-60% of the overall hospital budget is used for medication and medical equipment. Management of drug handling that is not optimal will have a negative impact on hospitals both medically and economically. Good drug management guarantees the availability of drugs whenever needed, in sufficient quantities and guaranteed quality, to support quality services in hospitals (Satibi, 2014). Drug planning is a process of activity in the selection of types, quantities and prices of drugs that are in accordance with the needs and budget for the coming procurement period, to avoid the occurrence of excess or emptiness of drug stocks when needed by patients (Satibi 2014), so it is necessary to plan optimal drug

needs for choose drugs that are really needed for most populations based on the patient's disease pattern.

II. LITERATURE REVIEW

Economic Order Quantity Method (EOQ is one of the inventory control techniques, it is easy to use but is based on several assumptions, namely: demand is known and is constant, time between order and receipt, known and constant, demand is received immediately, no discount, cost what happens is that only the set-up fee for ordering is known and is constant, there is no out of stock, but the model does not involve the uncertainty of the number of disease populations and the number of patients (Husein, Budhiarti & Mawengkang, 2012).

Uncertainty of drug needs is due to disease population and the number of patients can change according to the condition of the patient's diagnostic data volume, thus requiring an automatic way to

choose the drug needs according to disease development (Mawaddah, et all 2018). Adaptive Neuro Fuzzy Inference System (ANFIS) is an algorithm that combines fuzzy systems with artificial neural networks. ANFIS method can be used for forecasting or prediction (Agrawal S., Jindal, M., Pillai, G. N, 2010), (Verse, S., Khosravian, A. 2014), because it has a high degree of accuracy (Makridou, G ., Atsalakis, GS, & Zopounidis, C, 2013). Some researchers apply the ANFIS method for predictions, such as weather prediction (Dewi, Kartikasari & Mursityo, 2014), Fluctuations in Water Levels of Reservoirs (Piri & Kahkha, 2016), unemployment rates (Dewi & Himawati, 2015), inventories (Paul, SK, Azeem, A., & Ghosh, AK 2015), stock prices (Nhu, NH, Nitsuwat, S., Sodanil, M, 2013), but having a dependency on membership functions has a significant effect on the prediction results, so it is necessary to analyze ANFIS parameters (Husein, et all 2018).

From the results of several studies, the ANFIS method is proposed by applying the Root Mean Square Error (RMSE) method to measure the accuracy of the prediction of drug needs at Royal Prima Hospital Medan, so that it is expected that the method produces an optimal model of drug demand prediction. Accurate prediction results will greatly affect decision making and avoid excess or emptiness of drug stocks to improve medical services, in addition to a more optimal drug needs budget.

III. PROPOSED METHOD

In this section, a proposed model is proposed to optimize the prediction of optimal drug needs in a hospital, as shown in Figure 1.

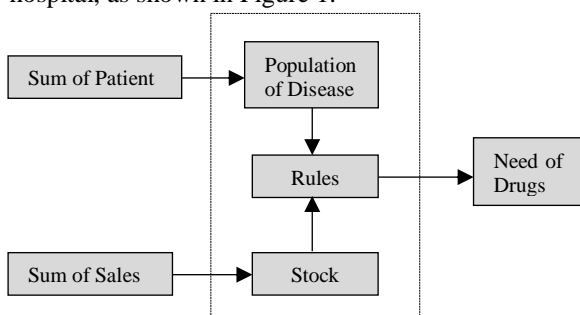


Figure 1 Proposed Model

In the figure above, the dataset used is sourced from the number of patients, then the stages of disease population classification are carried out to form the ANFIS method rules, then the next data source is from the amount of stocking and stock, both of these data sources will be applied to the ANFIS method so

as to produce a prediction of drug needs based on classification disease, the number of sales and stock of drugs available, the final results are expected to facilitate the leadership in making plans for drug needs.

1. Test the proposed model

In this study we propose 2 (two) methods to be applied to the proposed model for prediction of drug needs.

A. Adaptive Neuro-Fuzzy Inference System (ANFIS)

ANFIS is a Neuro-Fuzzy approach which was introduced by Jang (Jang et all 1997,1993) which is confronted with the Takagai and Sugeno fuzzy system models (1985) and can be used for control, prediction or forecasting applications. ANFIS architecture is the same as a neural network with radial functions with some specific limitations. Neural network learning process is used to optimize the value of fuzzyfication parameters. In Neuro-Fuzzy consists of five layers of processes. At layer 1 parameter is the fuzzy set membership function parameter that is nonlinear to the system output. The learning process on parameters uses a Reverse Propagation error (EBP) to update parameter values. At the 4th layer, the parameters are linear parameters to the system output that compiles the fuzzy prize base. In the 4th layer, the Least-Squares Estimotor (LSE) method is used as in Figure 2.

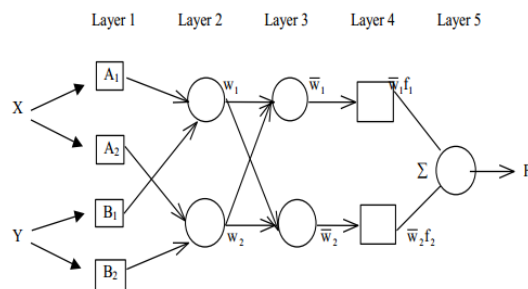


Figure 2 ANFIS network architecture (Jang et all, 1997,1993)

The learning phase of the ANFIS method is as follows:

layer 1: Each node in this layer is an adaptive node with a node

$$\begin{aligned}
 O_{1,i} &= \mu A_i(x) \text{ untuk } i=1,2 \\
 O_{1,i} &= \mu B_{i-2}(x) \text{ untuk } i=3,4
 \end{aligned}
 \tag{1}$$

Where x, y is the input node i and μ_{Ai} and μ_{Bi-2} are linguistic values. $O_{1, i}$ is the degree of membership of the fuzzy set $T(A) = \{A_1, A_2, B_1, B_2\}$ where A_1, A_2, B_1, B_2 are linguistic variables. The membership function used is gbell.

$$\mu_{Ai}(x) = \frac{1}{1 + \left\{ \left(\frac{x - c_i}{a_i} \right)^{b_i} \right\}} \quad (2)$$

Layer 2: The multiplication operator of the fuzzy rule at this node is AND.

$$O_{2,i} = w_i = \mu_{Ai}(x) \cdot \mu_{Bi}(y) \text{ for } i=1,2 \quad (3)$$

With w_i is the activation path at the i -node

Layer 3: the i -th node counts the ratio of the i -th degree membership rule to the number of membership degree rules.

$$O_{3,i} = \bar{w}_i = \frac{w_i}{w_1 + w_2}, \quad \text{by } i=1,2 \quad (4)$$

Layer 4: each layer in this layer is an adaptive node

$$O_{4,i} = w_i f_i = w_i(p_i x + q_i y + r_i) \quad (5)$$

Layer 5: is a single node that calculates output by summing all input signals

$$O_{5,i} = \sum \bar{w}_i f_i = \frac{\sum_i w_i f_i}{\sum_i w_i} \quad (6)$$

1. K-Means Clustering

K-means clustering is one of the most popular clustering algorithms used because it has a simple algorithm that is easy to implement and efficient in its complexity [5]. Algoritma K-Means determines the cluster of objects based on the attributes / features of the object into the cluster (K). The groups are distinguished by their center. This algorithm is very sensitive to the initial cluster center value placement. Determination of the partition number of clusters (k) is very important in this algorithm, but there are no provisions that apply to determine the number of clusters (k) formed [34]. The steps in the K-means algorithm are as follows:

1. Prepare training data.
2. Set K cluster value.
3. Set the initial value of centroids.

4. Calculate the distance between data and centroid using the formula (Euclidean Distance).
5. Data partitioning is based on a minimum value.
6. Then iterate as long as the data partition is still moving (no more moving objects to another partition), if it is still then go to point 3.
7. If the current data group is the same as the previous data group, then stop iteration.
8. Data has been partitioned according to final centroid values.

2. Stages of Model Implementation

Good drug management guarantees the availability of drugs whenever needed, in sufficient quantities and guaranteed quality, to support quality services in hospitals. The goal of drug management in a hospital is that the required drugs are available at all times when needed, in sufficient quantities, guaranteed quality and affordable prices to support quality services. One function of drug management is the selection of drugs that are really needed for most populations based on existing disease patterns. The selection process is a very decisive start in drug planning because through drug selection will be reflected in how many drug items will be consumed in the future. Drug planning is a process of activity in the selection of types, quantities and prices of drugs that are in accordance with the needs and budget for the coming procurement period.

From the results of observations for drug planning in public and private hospitals. The drug planning process at a government hospital is based on collecting drug needs data from medical service fields such as polyclinics, radiology, pharmacology and others. Drug needs data will be collected in the logistics section to be submitted to the drug planning section, the planning section conducts the drug needs selection for the next one year. however, the drug planning budget is not based on needs because the budget proposed by the hospital can change according to the results of a meeting with parliament and the hospital director's decision. Data on drug needs from the fields of medical services does not make a reference, and drugs that enter hospitals are not necessarily in accordance with needs. Budget

dependency causes planning to not run well, and results in frequent drug shortages and excesses.

In private hospitals, the planning process relies more on sales data, stock and experience of the head of IFRS, but is still considering the proposed drug needs in the field of medical services. Drug planning cannot run well due to the absence of the latest formulary so that there are no restrictions on the number and type of drugs, the lack of budget planning for bill payments and drug procurement in the short and long term, the small role of doctors, the discount factor from suppliers causes excess in purchasing drug because it is not in accordance with the needs and the length of time for making a drug stock report card from the field of medical services.

The conclusion from interviews with hospital leaders, the head of IFRS and the head of the pharmacy is the difficulty in getting data on the frequency of patient visits, disease patterns, patient age, drug use and stock available so that following the drug planning method will require a long time, while patients need medication according to the doctor's prescription. The unavailability of drugs in hospitals makes patients prefer to buy drugs to foreign pharmacies.

2. Data obtained

Table 1 Sample data for 2015

Nama Obat	TAHUN 2015												JUMLAH
	1	2	3	4	5	6	7	8	9	10	11	12	
ACICLAZ 30 MG KAPSUL	371	2	2	2	9	2	14	38	33	33	7	21	504
ACYCLOVIR 400 MG TABLET	34	287	456	17	5	59	7	24	4	29	149	2	1073
ACYCLOVIR 5% CREAM	14	3	1	142	315	11	123	257	140	10	2	9	1028
ALBOTHYL GEL	3	16	16	4	80	240	2	1	8	264	23	151	808
ALBUMINAR 25% 100 ML INJEKSI	20	1	1	88	57	9	4	42	124	24	71	18	459
ALCO ORAL 15 ML DROPS	1	5	80	15	1	15	52	1	17	77	8	12	284
AUNAMIN F INJEKSI	45	1	75	29	7	30	1	1	14	179	36	58	476
AUNAMIN F TABLET	2	74	4	7	14	3	13	63	78	6	169	2	435
ALLUPURINOL 100 MG TABLET	6	1	2	51	117	14	48	123	199	2	40	6	609
ALLUPURINOL 300 MG TABLET	11	1	4	10	2	139	120	2	2	12	10	28	341
ALPRAZOLAM 0.5 MG TABLET	199	13	6	7	3	13	6	1	4	8	4	103	367
ALPRAZOLAM 1 MG TABLET	13	322	1	4	11	2	2	2	28	75	2	53	515
AMARYL 3 MG TABLET	3	18	5	1	1	8	32	8	84	6	19	2	187
AMARYL M 1/250 MG TABLET	4	20	110	2	28	7	2	50	1	1	5	24	254
AMARYL M 2/500 MG TABLET	10	56	7	2	7	95	17	9	7	12	82	8	312
AMBROXOL 60 ML SIRUP	21	8	4	1	13	3	17	29	3	22	5	160	286
AMINEFRON TABLET	66	5	14	41	29	21	422	21	39	639	25	7	1329
AMINOFILID 1000 ML INFUS	4	23	286	6	29	57	24	716	360	13	5	43	1566
AMINOFILID 500 MG INFUS	4	2	69	7	1	331	19	41	182	13	5	479	1153
AMINOFUSIN HEPAR INFUS	10	9	17	251	339	101	2	5	33	124	516	97	1504
AMINOFUSIN PAED 250 ML INF	4	11	1	39	79	5	83	48	82	81	14	56	523
AMINOPHILIN 24 MG INJEKSI	9	3	92	2	3	40	60	31	37	184	2	97	560

Table 2 Sample data for 2016

Drugs Name	Year 2016												Total
	1	2	3	4	5	6	7	8	9	10	11	12	
ACARBOSE 50 MG TABLET	18	20	16	223	27	9	22		9	15	41	10	410
ACID SALICYLICUM 1 KG	16	5	9	37	5	93	179	21	160	116	2	35	678
ACICLAZ 30 MG KAPSUL	124	128	162	2	89	21	18	72	113	118	176	84	1107
ACYCLOVIR 400 MG TABLET	145	44	3	27	10	2	79	148	6	19	4	8	495
ACYCLOVIR 5% CREAM	1	29	10	2	76	22	11	8	35	20	13	121	348
ADALAT OROS 30 MG TABLET	24	2	110	1	25	2	142	117	4	3	2	3	425
ADALAT OROS 30 MG TABLET	142	76	6	4	4	2	8	1	10	4	17	18	292
ADONA 10 ML INJEKSI	2	1	9	1	95	8	1	18	1	9	140	139	424
ALBUMINAR 25% 100 ML INJEKSI	20	86	33	80	1	3	48	4	9	32	12	3	351
ALCO ORAL 15 ML DROPS	6	2	2	43	2	64	12	45	6	24	5	4	215
AUNAMIN F INJEKSI	79	20	230	28	12	16	32	41	50	35	20	6	569
ALLUPURINOL 100 MG TABLET	2	2	26	546	102	26	610	13	101	482	34	3	3856
ALLUPURINOL 300 MG TABLET	56	14	8	17	33	12	2	41	564	1	15	18	782
ALPRAZOLAM 0.5 MG TABLET	453	1	1	2	35	10	44	120	12	159	1	11	850
ALPRAZOLAM 1 MG TABLET	105	67	96	144	1	24	92	120	5	182	147	34	1017
AMBROXOL 30 MG TABLET	16	9	27	103	531	109	8	24	51	524	36	30	1468
AMBROXOL 60 ML SIRUP	120	20	570	2	9	753	2	2	1062	7	177	477	3201
AMINEFRON TABLET	376	432	16	6	248	4	3	56	17	0	787	111	2056
AMINOFILID 1000 ML INFUS	3	99	64	2	10	1	44	3	4	40	-1	141	410
AMINOFILID 500 MG INFUS	24	1	18	5	579	3	71	115	2	5	5	916	1744
AMINOFUSIN HEPAR INFUS	1	102	7	1	2	59	575	507	8	116	122	8	1508
AMINOPHILIN 24 MG INJEKSI	4	400	6	3	4	3	1	2	385	14	299	68	1189

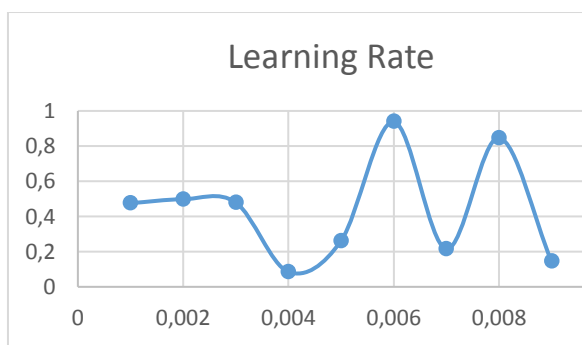
The data needs for ANFIS training and testing are sourced from the previous year's data obtained from actual data in 2015 and 2016 at one of the hospitals in Medan. Input data for 2015 will be used for predictions in 2016 and compare the results of ANFIS predictions with actual data in 2016 and so on until the comparison of predictions for 2017 with actual data for 2017.

IV. RESULT AND DISCUSSION

Training and testing in the first approach directly apply the ANFIS method to the data source with five input indicators namely gender, patient age, diagnosis code, length of stay, stock, and one output. There are 34 rules that are used in the ANFIS Sugeno Order one model. In the first stage is looking for learning rates for optimal learning. This test uses the amount of training data as much as 50% of the total data.

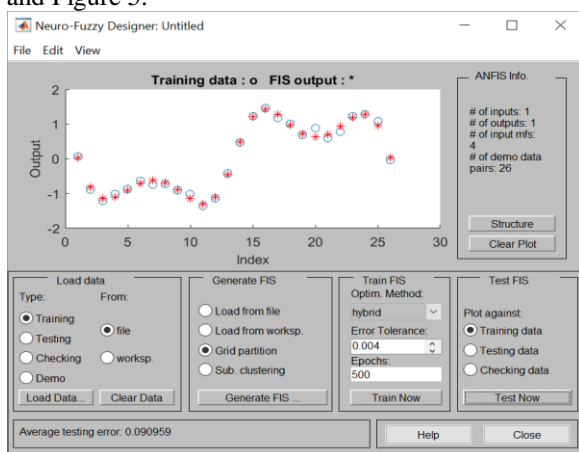
Table 3. Learning Rate

Learning rate	RMSE
0,001	0,47542
0,002	0,49789
0,003	0,47943
0,004	0,08513
0,005	0,26143
0,006	0,93914
0,007	0,21528
0,008	0,84704
0,009	0,14502



Picture 3. Learning Grate Graphic

Based on table 3, that the value of the RMSE learning rate tested is very well below the number one, but the smallest RMSE value produced is 0.004. The smallest RMSE value will be used for RMSE testing and accuracy with a combination of training data and test data. For testing RMSE and accuracy in training used 85% of the total amount of data. For testing data used 70% of the total amount of data. Each data combination was repeated ten times to retrieve the RMSE value and accuracy of the test results. The results of training and testing can be seen in Figure 4 and Figure 5.



Picture 4. Training

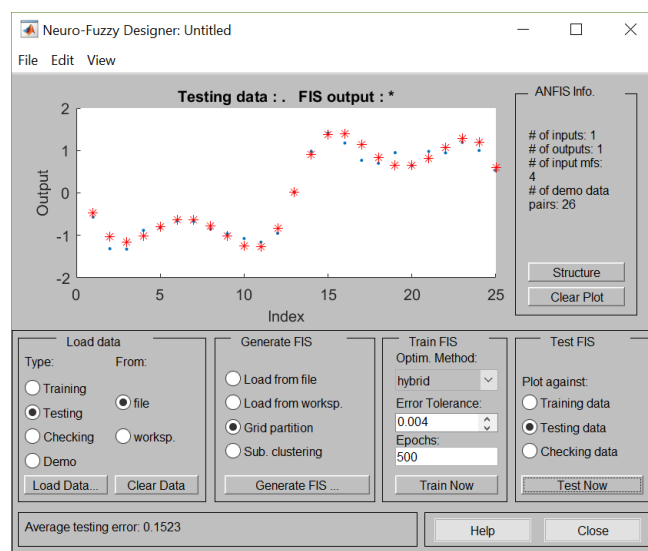


Figure 5. Testing

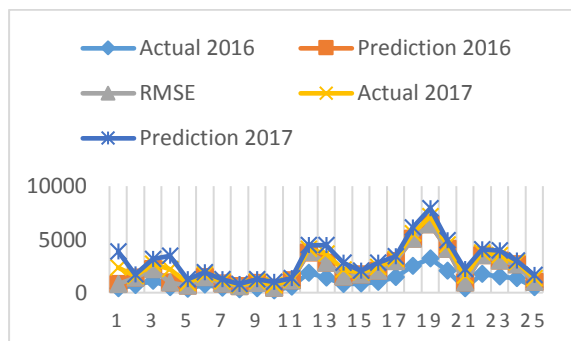
In Figure 4 the results of training data are 80% of the total data, with an error value of 0.004, epoch 500, the results of the training will be used as a test for the prediction of drug needs with an error of 0.004, the epoch 500 test results are shown in table 4 for predictions of 2016 and year needs 2017.

Table 2. Prediction year 2016 and year 2017

No	Drugs Name	Actual 2016	Prediction 2016	RMSE	Actual 2017	Prediction 2017	RMSE
1	ACID SALICYLICUM 1 KG	410	414	0,816	1521	1524	0,612
2	ACILAZ 30 MG KAPSUL	678	734	1,880	131	132	0,034
3	ACTOMET TAB 15 MG	1107	1105	0,067	475	478	0,101
4	ADONA 10 ML INJEKSI	495	345	5,037	1241	1239	0,067
5	ALBOTHYL CONCENTRATE 10 ML	348	298	1,679	267	342	2,518
6	ALBUMINAR 25% 100 ML INJEKSI	734	731	0,101	224	234	0,336
7	ALCO ORAL 15 ML DROPS	425	434	0,302	205	210	0,168
8	ALINAMIN F INJEKSI	292	289	0,101	112	119	0,235
9	ALLUPURINOL 100 MG TABLET	424	456	1,074	167	165	0,067
10	ALLUPURINOL 300 MG TABLET	215	211	0,134	291	289	0,067
11	ALPRAZOLAM 0.5 MG TABLET	569	561	0,269	94	121	0,907
12	ALPRAZOLAM 1 MG TABLET	1856	1923	2,250	328	327	0,034
13	AMBROXOL 30 MG TABLET	1400	1398	0,067	838	829	0,302
14	AMBROXOL 60 ML SIRUP	782	734	1,612	642	649	0,235
15	AMINEFRON TABLET	850	852	0,067	184	184	0,000
16	AMINOFOLID 1000 ML INFUS	1017	1020	0,101	383	389	0,201
17	AMINOFOLID 500 MG INFUS	1468	1470	0,067	229	229	0,000
18	AMINOFUSIN HEPAR INFUS	2519	2515	0,134	545	534	0,369
19	AMINOPHILIN 24 MG INJEKSI	3201	3207	0,201	742	765	0,772
20	AMINOSTERIL INFANT 6%	2056	2051	0,168	386	398	0,403
21	AMITRIPTYLINE TABLET	410	420	0,336	640	612	0,940
22	AMLODIPINE 5 MG TABLET	1744	1740	0,134	276	198	2,619
23	AMLODIPINE BESYLATE 10 MG TAB	1508	1510	0,067	468	412	1,880
24	AMLODIPINE BESYLATE 10 MG TAB	1339	1339	0,000	163	172	0,302
25	AMOXAN 500 MG KAPSUL	487	490	0,101	353	311	1,410

In the table above is the result of testing 70% of the data from the total amount of data for the prediction of drug needs in 2016 using 2015 data, while in 2017 using the 2016 data. Overall the prediction results for drug needs in 2016 and 2017,

the ANFIS method is accurate based on comparison of values predictions with actual data, but there are still data on RMSE values above 0, the average RMSE value of 0.0669 for predictions in 2016 and 0.0594 for predictions for 2017. The graph of prediction results is seen in Figure 6.



Picture 6. Graphic prediction year 2016 and year 2017

V. SUGGESTION

Based on the results of testing using patient medical data in 2015 and 2016, for the prediction of the need for drugs in 2016 and 2017, overall the ANFIS method is accurate in predicting this. But the testing phase still needs to be done using the K-Means classification method to optimize computational time so that it is more efficient

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