The possibility of the classification about Ht values using the AR model

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***Abstract*—There are various blood purifications. Plasma Exchange(PE) is one of them. It is very important for medical workers to classify the changing Hematocrit(Ht) values during PE. Ht values have been obtained by CLIT-LINE monitor. Ht values mean the circulating blood volume. At present, the medical worker classifies the changing Ht values during the PE. The classification is depended on their experiment. Therefore, the classification is subjective. If we can find the information of the changing Ht values using the AR model, and can predict the changing Ht values, PE is treated more safety. Hence, our purpose is the classification into the rest of Ht values using the Ht values for less than 20 minutes from the beginning of PE by AR model. Initially, we have classified the Ht data into 3 groups. The 3 groups are falling, constant, and rising Ht values.**

The coefficients of ARmodel have updated by the delta rule using the Ht values of less than 20 minutes from the beginning of PE. AR model has captured the character of Ht values for less than 20 minutes from the beginning of PE, and rest of Ht values have been classified by the coefficients about the AR model. As the result, it is difficult to classify the rest of Ht value using this method. However, we have found that Ht values for less than 20 minutes from the beginning of PE must include some information about the rest of Ht values.

Keywords—**Plasma Exchange(PE), Hematocrit(Ht), AR model**

I. Introduction

There are various blood purifications. Plasma exchange (PE) is one of the blood purifications. A patient's circulating blood volume is changing during the PE. Hence, the medical workers must treat to stabilize the circulating blood volume. They use the CLIT-LINE monitor (CLM) to obtain the hematocrit (Ht) values, because the circulating blood volume and Ht value are related [1]. The rate of circulating blood volume (ΔBV%) is very important during the blood purification including the PE. ΔBV% is calculated by the two Ht value. One is the Ht value at the beginning of the PE, and another is the present Ht value. The changing Ht values that we had obtained were classified into 3 groups. The Ht values were falling for 20 minutes from the beginning of PE for all patients. However, the change of Ht values is rising, constant or falling since then. We thought that the change of Ht values from the beginning of PE includes the information about the rising, constant or falling. If we can get the information and can predict the change of Ht values after that, PE is treated more safety. Hence, our purpose is the classification into the rest of Ht values using the Ht values for less than 20 minutes from the beginning of PE.

There are various methods to capture the character of the times series signal. For example, AR model, ARMA model, recurrent neural network etc… We used the very simple AR model at this research, because the changing of Ht values at the beginning of PE is depended on the instillation. The patient is inserted an intravenous line at constant during PE, therefore the change of Ht value from the beginning of PE is similar to linear change. The coefficients of AR model that we obtained are showed by 3 dimensions space. We analyze the Ht values for less than 20 minutes from the beginning of PE using these methods for the 9 patients.

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II. Methods

2.1 Classify the Ht data

We analyzed the Ht values for 9 patients.

At first, we classified the Ht data for 9 patients into the 3 groups(Fig.1, 2, 3).

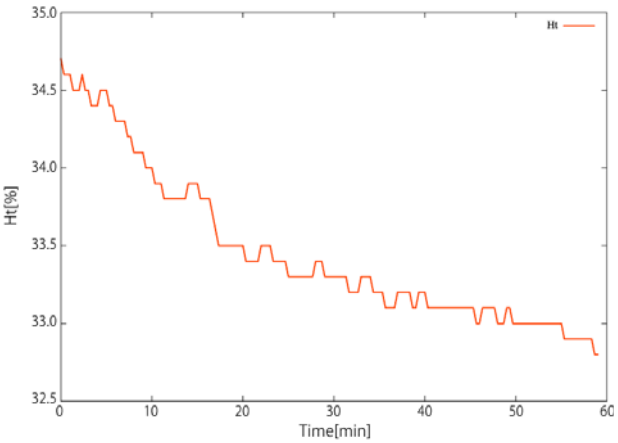

Fig.1 "falling" group

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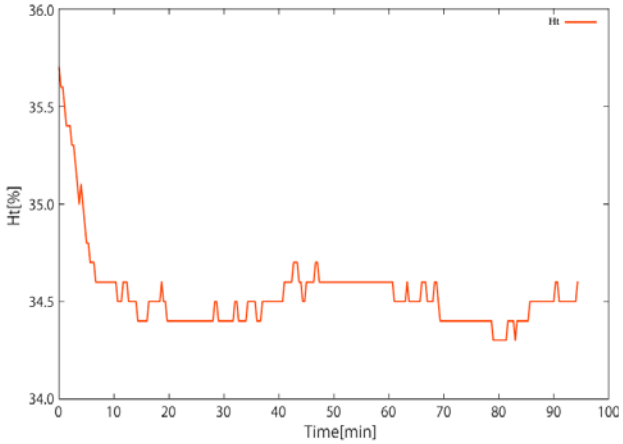

Fig.2 “constant” group

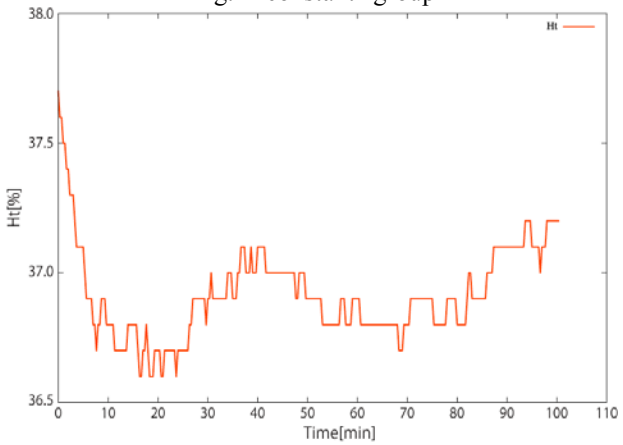

Fig.3 “rising” group

Fig.1 shows that Ht values after 20 minutes have been falling. Fig.2 shows that Ht values after 20 minutes have been constant.Fig.3 shows that Ht values after 20 minutes have been rising.

2.2 AR model

Ht values are defined as:

$$x(0),x(1),\cdots,x(t),\cdots,x(last) \tag{1}$$

Where $x(t)$ is the Ht value at the sampling time t. The *last* is the end of Ht value. We used AR model to capture the character of Ht values for less than 20 minutes from the beginning of PE. The AR model is defined as:

$$x(t+2) = w1x(t+1) + w2x(t) + w3 \tag{2}$$

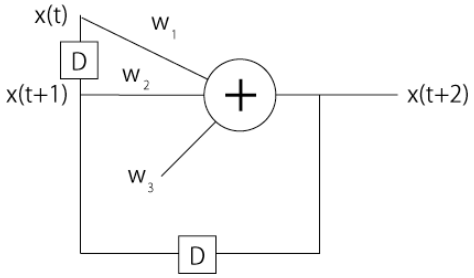

Fig.4 AR model

Fig.4 shows the relation between input and output.

We used this ARmodel, and weights($w1,w2,w3$) were updated by the Delta rule in a training period.

In this research, we used the Ht values for less than 20 minutes from the beginning of PE as a training period.

2.3 Auto Correlation Function

We checked the auto correlation function for the error between the measured values and the output values in the training period after updated the weights. This error is the delta error between the measured and output values. The delta errors are defined as :

$$e(0),e(1),\cdots,e(t),\cdots,e(last) \tag{3}$$

Where $e(t)$ is the error value at the sampling time t. The *last* is the end of error value. Auto Correlation is defined as:

$$R(t) = \frac{1}{N-l}\sum_{l=0}^{N-1-l} e(t)e(t+l) \tag{4}$$

Where N is the number of delta error between the measured and output values. l is the time lag. After thatm the weights were expressed on the 3 dimensions graph.

III. Results

We shows the result about one sample. The sample is showed the Fig.1.

Fig.5 rms error in the each training period

Fig.5 shows the rms error in the training period. The x-axis is the number of Ht value in the training period, the y-axis is the rms error in the each training period. In this case, we can get the smallest rms error using 19 Ht values as the training period

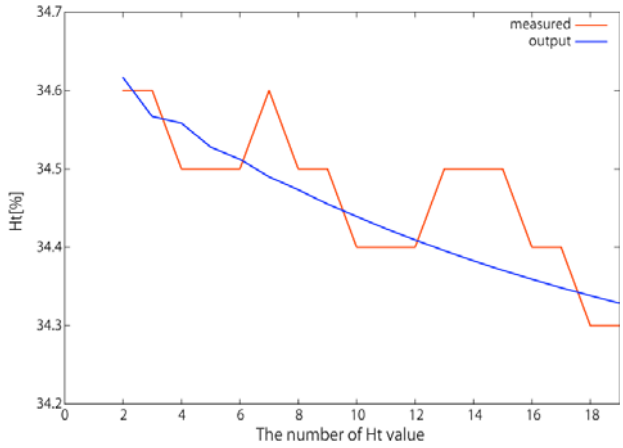

Fig.6 measured and output value in the best training period

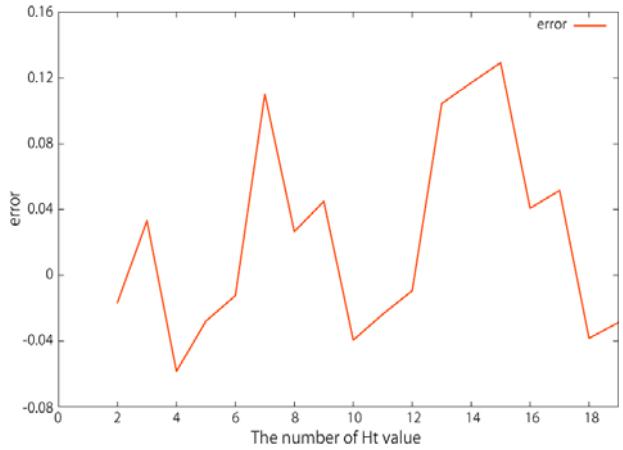

Fig.7 error between measured and output in the training period

Fig.6 shows the measured and output value in the best training period. The x-axis is the number of Ht value, and the y-axis is the Ht values. The red line is the measured values, and the blue line is the output values. Fig.7 shows the error between the measured and output values in the best training period. The x-axis is the number of Ht value, and the y-axis is the error between the measured and output values. In this case, error is not the rms error but the delta between the measured and output values.

Fig.8 Auto Correlation

Fig.8 shows the auto correlation for the delta between the measured and output values. From Fig.8, this errors between the measured and output value is the low correlation. We checked the low correlation. The weights were expressed on the 3 dimensions graph. We analyzed the Ht data for 9 patients. The results were shown Fig.9.

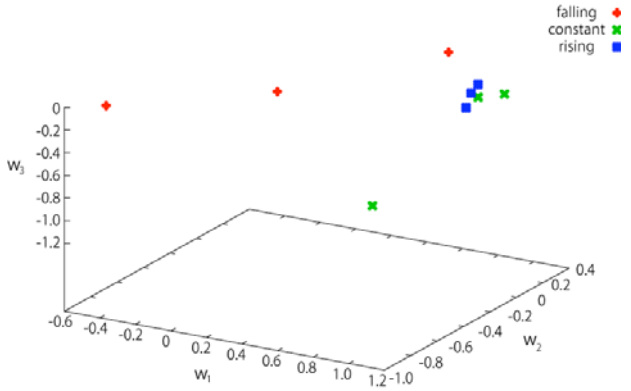

Fig.9 The weights on 3 dimensions

Table 1 The weight values for each patient

status	patient	w1	w2	w3
down	1	−0.51	−0.08	−0.088
	2	0.56	0.35	−0.048
	3	0.091	−0.32	−0.098
constant	4	0.97	0.021	−0.11
	5	1.1	−0.027	−0.021
	6	0.48	−0.12	−1.1
rising	7	0.92	0.035	−0.1
	8	0.9	0.12	−0.072
	9	0.95	−0.051	−0.16

In Fig.9, the x-axis is $w1$, the y-axis is $w2$,and the z-axis is $w3$. Red points are weights about the falling graph, green points are weights about the constant graph and blue points are weights about the rising graph. Table1 shows the weight values for 9 patients.

IV. Discussion

From Fig.9, the weights for patients about the constant group and rising group are similar, but the weights for patients about the falling group is not similar. The weights about the constant group and rising group are similar. From these results, the Ht values about constant group and rising group could not be classified using this AR model and delta rule. However, Ht values about the falling group and the other groups could be classified using this methods. Therefore, Ht values for less than 20 minutes from the beginning of PE must include some information about the rest of Ht values. AR model is the low dimension in this research, because the weights were expressed on the 3 dimension graph. If the information in high dimension can change to 3 dimension, the weights for each group must be classified using other methods. For example, AR model, ARMA model, Neural Network etc...

Otherwise, we must define how to classify the Ht data. In this research, we classified Ht data into 3 groups(falling, constant and rising groups), but this classification was depended on our subjective aspect. Ht values change small and are included the quantization error. We must define the threshold to classify the character like this signal.

V. Conclusion

There are various blood purification. PE is one of them. It is very important for medical workers to classify the changing Ht values during PE. Hence, our purpose was classification into the rest of Ht values using the Ht values for less than 20 minutes from the beginning of PE. AR model was used for the analysis method. At first, we classified the Ht data into 3 groups(falling, constant and rising). AR model captured the character of Ht values for less than 20 minutes from the beginning of PE, rest of Ht values was classified by the coefficients about AR model. The Ht values about constant group and rising group could not be classified using this AR model and delta rule. However, Ht values about the falling group and the other groups could be classified using these methods. It is difficult to classify the rest of Ht value using this method. However, we thought that Ht values for less than 20 minutes from the beginning of PE must include some information about the rest of Ht values.

Therefore, it was suggested that the possibility of classification using the Ht values for less than 20 minutes from the beginning of PE using AR model.

References

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