MODELING OF MERIDIAN CHANNELS

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Keywords: System identification, Modeling, Meridian systems, Acupuncture points.

Abstract: In this paper, the auto-regressive and moving average (ARMA) models are constructed for the meridian channels based on the measuring data obtained from the acupoints in the Lung Channel of Hand-Taiyin (LU), the Pericardium Channel of Hand-Jueyin (PC). For comparison, the ARMA models for the contrastive non-acupoints around the measured acupoints are also obtained. Then, the analysis based on the zeros-poles distribution of the obtained models is implemented.

1 INTRODUCTION

With the development of the research in the traditional Chinese medicine, many research reports had shown great interest in the acupuncture-therapy. It has been found that the acupuncture points (for abbreviation, we call them as acupoints) are distributed in the meridian system of the human body. Moreover, meridian system is an independent system which exists in parallel with neural systems and blood circulation systems. The acupuncture points distributed in the meridian system possesses many distinctive ways for transferring signals and processing information including electrical information (J. Julia and FACOG, 1998). Moreover, the experimental results have shown that the meridian system is an optimum path for transferring information and works with a close relation to the cerebral cortex and whole neural systems.

So far, the investigations on the meridian system for acupuncture points are mainly concentrated on the measurement of the resistance and potential, capacitance and conductivity distribution between acupoints (F. III John and Erlichman, 2005; Yang, 1997; W.Zhang and Zhu, 1999). However the research on the features as the electrical signal transmission through the meridian system with acupuncture points has seldom been involved. Motivated by the phenomenon that the meridian system is an optimum path for transferring information, in this paper, we use a sequence of pseudo-random signal to stimulate the Lung Channel of the Hand-Taiyin (LU) and the Pericardium Channel of the Hand-Jueyin (PC). Then the corresponding responses of the acupoints on those channels are measured. Based on the obtained data, the corresponding ARMA models are constructed by using least squares algorithm. Those derived ARMA models can be used to analysis the static and dynamic characteristics of the meridian channels.

The paper is organized as follows. Section II describes the experimental configuration for electric stimulation and measurement of the corresponding responses of the acupoints and non-acupoints. Then the AMRA models obtained based on measured data are illustrated in Section III. In Section IV, the conclusion will be given.

2 EXPERIMENTAL CONFIGURATION

In this paper, a method based on three detecting electrodes is used to measure the stimulation and the corresponding response of the acupuncture points on meridian systems. The architecture of the measurement for meridian signal is shown in figure 1. The

Wang Z., Tan Y. and Su M. (2009).
MODELING OF MERIDIAN CHANNELS.
In *Proceedings of the International Conference on Biomedical Electronics and Devices*, pages 167-172
DOI: 10.5220/0001433001670172

three-electrode method of detecting the acupoint signal has the advantage of good operability and high signal accuracy. The signal captured was affected by skin moisture and electrode contact pressure. In order to reduce the impact of test environment, we keep the same test condition on every volunteer.

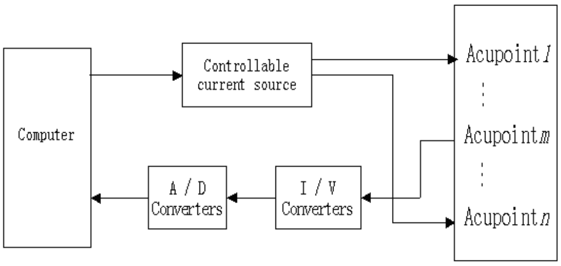

Figure 1: Acupoint signal measuring method using three-electrodes.

The stimulation signal was a sequence of pseudo-random current signal produced by a computer. This signal is shown in figure 2.

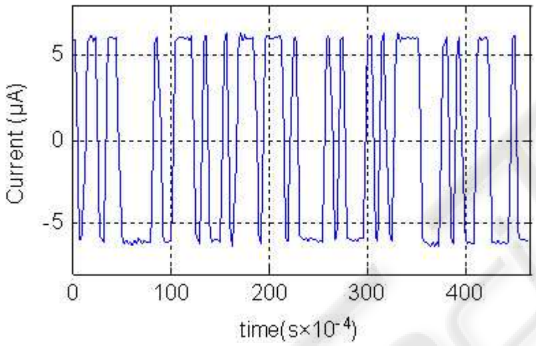

Figure 2: The stimulation signal fed to acupoints.

In this experiment, the pseudo-random currents through two electrodes stimulate acupoint 1 and acupoint n of the measured meridian. Then detecting electrode was used to measure the response of acupoint m located in between acupoint 1 and acupoint n. The outputs of the measured acupoints were transferred through a current/voltage conversion circuit then sampled by an analog / digital convertor. The sampled signals were sent to the computer for further processing. There were 20 healthy volunteers accepted the test. Before the test, the volunteers were relaxed to avoid the strenuous disturbance. Based on the theory of Chinese medicine, there are 11 acupoints in the Lung Channel of Hand-Taiyin. In this experiment, the stimulating acupoints are Tianfu (LU 3) and Taiyuan (LU 9) which is considered as the ground, the detecting acupoints are Xiabai(LU 4), Chize (LU 5), Kongzui (LU 6), Lieque (LU 7) and Jinqu (LU 8) respectively. The Pericardium Channel of Hand-Jueyin includes a total of 9 acupoints. In the experiment, Tianquan (PC 2) and Laogong (PC 8) are respectively the stimulating point and ground. The detecting acupoints are respectively Quze (PC 3), Ximen (PC 4), Jianshi (PC 5), Neiguan (PC 6), and Daling (PC 7). To test the signal of non-acupoint, five contrast points of non-acupoints are selected. All the acupoints and non-acupoints used for experiment in this paper are shown in Figure 3.

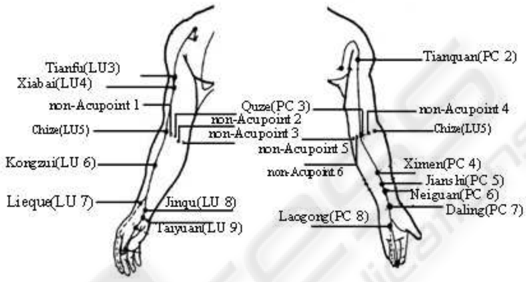

Figure 3: The acupoints of LU, PC and non-acupoints.

Due to the limited space, we only illustrate one of the measuring results of the responses of acupoints and non-acupoints here. The response measured from acupoint Chize (LU 5) is shown in Figure 4. On the other hand, the corresponding response of the non-acpoint 1 which is 3cm away from acupoint Chize (LU 5) is illustrated in Figure 5. The purpose of this investigation is to look for some differences between the meridian system and the contrast tissue around the meridian. From figures 4 and 5, it can be seen that there are some differences between the responses of the acupoint and that of the non-acupoint. In our previous works, we have applied technique of wavelet transform to the derived signals to find the different characteristic of those two kinds of signals. In the following, we will analyze the AMRA model parameters of the acupoint signals and contrastive non-acupoint signals.

3 PARAMETER MODEL OF MERIDIAN CHANNELS

According to the theory of Chinese medicine, the meridian system contains different channels. There are several acupoints distributed in each channel. Naturally, it motivates us to investigate the characteristic of these channels when electric signals pass by. In this section, the auto-regressive and moving average (ARMA) model is utilized to describe the dynamic features of the meridian channels. It is known that the autoregressive part of the ARMA model with a non-trivial denominator polynomial A(z) ('all-pole' model) is very appropriate to describe spectra with high and narrow peaks (Korosec, 2000), each sharp spectrum peak corresponds to the pole located close to unit circle at certain frequency.

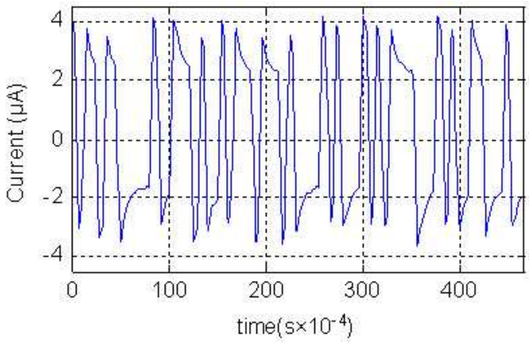

Figure 4: The response of acupoint Chize (LU 5).

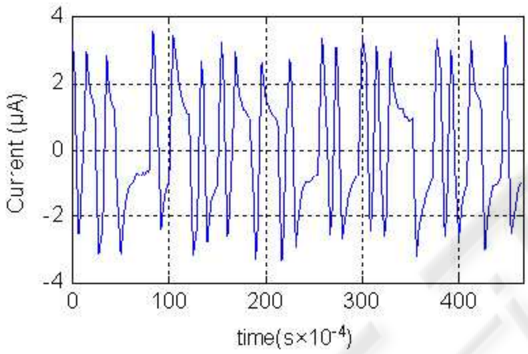

Figure 5: The response of non-acupoint 1.

The moving average part of the model is that, for which a numerator polynomial B(z) exists. Predominant features of their spectra are 'valleys', corresponding to the 0 near the unit circle at the specific frequencies. On many occasions, a series is not exclusively fitted to one model, but rather various models may equally well fit the series (I. Rojasa and M.Pasadasb, 2007; Hwang, 2001). If we follow the norms of Box and Jenkins, the model chosen is nearly always the simplest one, i.e. that involving the fewest terms (GEP Box and Reinsel, 1994). The ARMA model used to describe the dynamic behaviour of the meridian channels is described by

$$y(t)+a_1y(t-1)+\ldots+a_{n_a}y(t-n_a)$$
$$=b_1u(t-1)+\ldots+b_{n_b}u(t-n_b+1)+e(t) \qquad (1)$$

where y(t) is the output at time t, n_a and n_b are orders of the polynomials $A(z^{-1})=1+a_1z^{-1}++a_{n_a}z^{-n_a}$ and $B(z^{-1})=b_1z^{-1}++b_{n_b}z^{-n_b}$, and e(t) is the white-noise disturbance value. To determine the orders of the ARMA model, the Akaike Information Criterion (AIC) (Akaike, 1969) to perform a relative comparison of models with different structures is appled. Smaller value of AIC indicates a better model.

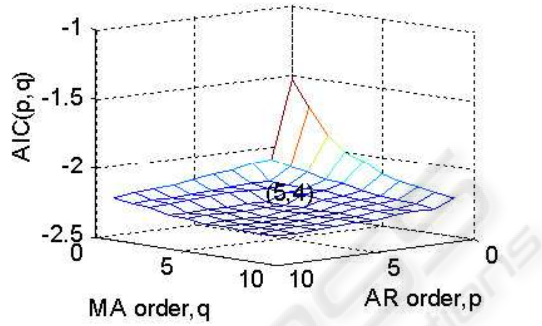

Figure 6: Order identification for acupoint signal using AIC.

By comparing the AIC values between the different orders of ARMA model, finally na and nb, are respectively set to na=5 and nb=4 for the model to describe the behaviour of the transmission channel between acupoints Tianfu (LU3) and Chize (LU 5).

Figure 7 demonstrates the model validation result of the channel between acupoints Tianfu (LU3) and Chize (LU 5). Figure 8 shows the corresponding model residual. It can be seen that the obtained model can describe the dynamic characteristic of the measured meridian channel quite well.

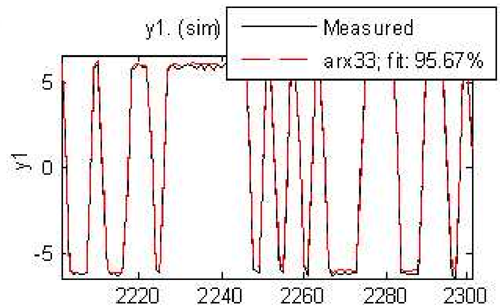

Figure 7: Model validation result of the model.

The identified model coefficients are illustrated in Table 1. Based on the obtained model, the corresponding poles-zeros distribution chart is shown in Figures 9. We can see that this channel is a stable system since all the poles are located within the unit circle. However, the response of this channel may demonstrates some oscillation since the complex poles are included in this model.

For comparison, the measured point 3cm away from acupoint Chize (LU5) is defined as non-acupoint

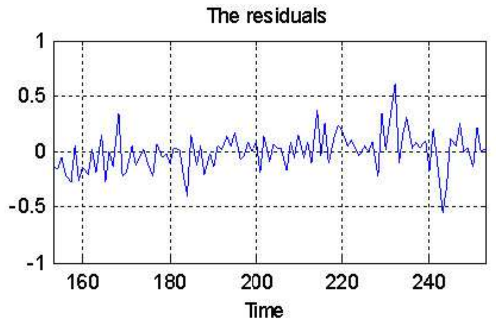

Figure 8: Residual of the obtained model.

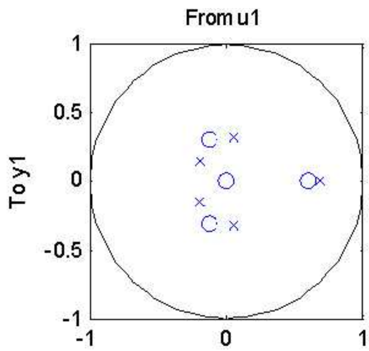

Figure 9: Poles and zeroes of the model for the channel between LU3 and LU5.

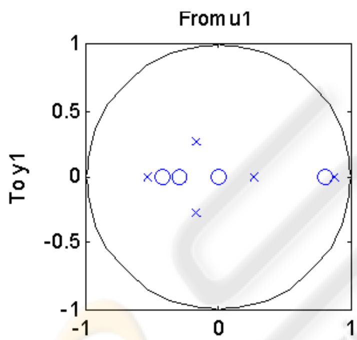

Figure 10: Poles and zeroes of the model for the channel between LU3 and non-acupoint 1.

1. The measured data from this point is also used to identify the model between the stimulated point (LU3) and non-acupoint 1. The identification procedure is similar to what has been shown-above. The obtained model parameters can also be seen in Table 1.

Figure 10 shows the corresponding zeros and poles distribution chart of the model to describe the dynamic feature beyween the stimulation point LU3 and the non-acupoint 1.

From Figures 9 and 10, we note that the models, which respectively to describe the behaviour of the channels on the meridian system and non-meridian system, have shown quite different characteristics.

We also identify the channel between the stimulation point LU3 and the measured acupoint Xiabai (LU4) with an ARMA model. The corresponding zeros-poles distribution chart is shown in Figure 11. By comparing with Figure 9, it is seen that the model between LU 3 and LU5 and the model between LU3 and LU4 have the rather similar zeros- poles distributions.

Moreover, the locations of zeros-poles shown in Figure 11 are also rather different from those shown in Figure 10.

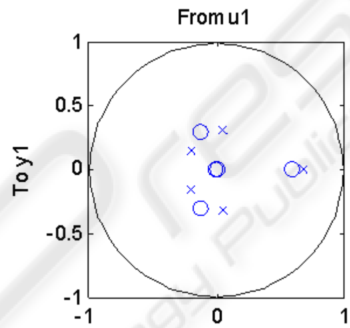

Figure 11: Poles and zeroes of the model between LU3 and acupoint Xiabai.

The zeros-poles distribution charts of the model of the channel between Tianquan (PC 2) and Quze (PC 3), as well as the model of the channel between Tianquan (PC 2) and Ximen (PC 4) are shown in Figures 12 and 13.

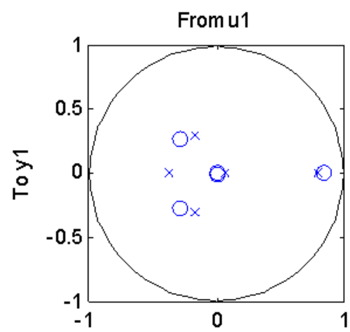

Figure 12: Poles and zeroes of the model for the channel between PC2 and PC4.

Moreover, the zeros-poles distribution chart of the model between Tianquan (PC 2) and non-acupoint 5 is illustrated in Figure 14.

From the zeros-poles distribution charts shown-above, we know that there exist some differences between the models on the meridian channels and the

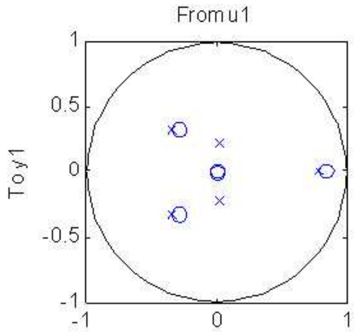

Figure 13: Poles and zeroes of the model for the channel between PC2 and PC5.

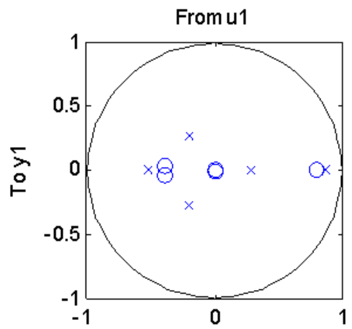

Figure 14: Poles and zeroes of the model between PC2 and non-acupoint 5.

models on non-acupoints.

The obtained models can also demonstrate the dynamic performance of the meridian channels when electric signals pass through. Based on the obtained models, one can further analyze the characteristic of the meridian systems. Especially, they would be a potential ways when we intend to use them for disease diagnosis and treatment.

Table 1: The comparison of the ARMA parameters between acupoint and contrast non-acupoint signal.

ARMA Parameters	Acupoint signals	Non-Acupoint signals
a1	-0.3819	-0.2639
a2	-0.0800	-0.4880
a3	-0.0490	-0.0687
a4	-0.0175	0.0043
a5	-0.0046	0.0131
b0	1.1158	1.2334
b1	-0.3857	-0.1057
b2	-0.0526	-0.5601
b3	-0.0721	-0.1239

4 CONCLUSIONS

In this paper, based on the electric-stimulation, the signal characteristics of the meridian system in the human body are presented. Based on the measured data, the corresponding ARMA models for the meridian channels between the stimulating points and the measured acupoints are constructed. Then models between the stimulating points and the measured non-acupoints are also identified in order to make comparison.

According to the zeros-poles charts of the obtained models, we can see some difference existing in the meridian channel models and the non-accupoint models. Some similarity seems to be observed among the meridian channel models.

Those phenomena may have some potential to find a new way for disease diagnosis and treatment.

However, what we present in this paper is just a primal investigation. The further research should be implemented to see more details of the meridian systems.

ACKNOWLEDGEMENTS

This research is partially supported by Guangxi Science Foundation (GXSF Grant No.: 0728210) and Guilin University of Electronic Technology Research Foundation (Z20507).

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