Ultrasound Bionic Eye Design Based on Adaptive Control Algorithm

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Abstract. In order to solve the pathological diagnosis of wrist and other local human tissues, an adaptive motor control algorithm based on Markov chain is proposed in this paper. The design of ultrasound bionic eyes can meet the needs of local ultrasound diagnosis in community hospitals. It has strong applicability and high cost-effectiveness, and has certain popularization value.

1. Introduction
In recent years, with the development of mobile devices, especially the rapid updating of smart phones, more and more people like to play mobile phones in bed at night. However, this is not a good habit, because if you spend too much time in bed playing mobile phones, it may cause serious consequences. Keeping a posture for a long time while lying in bed and playing with mobile phones results in nerve compression in the back and blockage of wrist meridians. In modern society, people over-use mobile phones, resulting in blockage of hand veins, has become a more common disease.

In order to solve the problem of high blockage rate of wrist vessels, cysts and so on, it is necessary to improve the pathological manifestation of veins and surrounding tissues, and effectively distinguish veins from surrounding bones. Many scholars at home and abroad have done a lot of research on this. In practice, large-scale instruments are in public hospitals, and the diagnostic process is complex and time-consuming. If small equipment can be used in community hospitals to achieve local ultrasound diagnosis, it is not only in time, but also economic, more suitable for mass medical treatment [1].

2. Design of Bionic Eye with Ultrasound
Ultrasound is a kind of sound wave whose frequency is higher than 20KHz. It has good direction and strong penetration ability. Therefore, ultrasound technology is widely used in medical field. Through the understanding of ultrasound, we have provided a new idea. Through the rational application of existing equipment in the laboratory, we have realized the experimental device for ultrasonic imaging of objects. Compared with other instruments, the cost is lower and the operation is simple. Ultrasound imaging is ubiquitous in medical practice and is used to image all areas of the body, including soft tissue, blood vessels and muscles. The machines used for ultrasound imaging include small hand-held ultrasound devices that do not exceed smartphones, and more complex systems capable of performing high-dimensional imaging technologies, such as three-dimensional imaging. Although cardiac and vascular imaging has traditionally been called "echocardiography", the basic physical principles of image generation are common to all ultrasound devices. These principles should be familiar to end users because they are essential for understanding the practicability and limitations of ultrasound and...
the interpretation of ultrasound images, and can help optimize the use of ultrasound systems to obtain the highest quality images [2-3].

Ultrasound bionic eye design principle is to use ultrasound beam to scan the experimental object, to receive the reflected signal by an oscilloscope, to record the peak values of multiple groups of voltage at the receiving end by a motor control, and then to process the data with MATLAB, so as to obtain the internal structure distribution of the object. The methods are as follows:

Experimental steps one
Connect the experimental device correctly and turn on the power supply. Firstly, the arbitrary waveform generator is used to connect one end of the sonic velocity measuring instrument as the experimental originating end, and the oscilloscope is used to connect the other end of the sonic velocity measuring instrument as the experimental receiving end (such as the right picture). The parameters are adjusted so that it can be output in sinusoidal waveform at 40KHz frequency. The left picture shows the object under test, in which the screw is placed to create a sealed environment.

Figure. 1 Screw simulating meridian blockage.

Experimental steps two
Fixed the elevator to a certain height, and used the motor to drive the receiver of the spectrometer to adjust the beam for scanning. The angle range is about 60 degrees from the central object, marked as a point at certain intervals, and then read the value and record it after the oscilloscope shows the image stabilization. Then the object to be measured is placed in the center of the carrier platform in the middle of the spectrometer, and the image is stably read again and recorded. Fifty sets of data were recorded twice (as shown in Figure 2).

Figure. 2 Oscilloscope and display device

Experimental steps three
The elevator height is adjusted by motor drive. Step 2 is repeated again until the object is scanned in the radial range. A total of 50 adjustments are made to obtain a 200 X 200 square array.
Experimental steps four

All the recorded data are arranged into matrix form and input to MATLAB for data collation, and then the internal structure imaging of the measured object is obtained.

3. Motors Driving Algorithms Based on Markov Chain

The scattering angle distribution of ultrasound is quantitatively studied based on Markov chain. Markov chain theorem is widely used in decision-making, queuing theory, physics, games, network applications and so on. A transition matrix $R(m, n)$ is used to describe the transition probability from one state to another. For example, the record transition probability from state $m$ to state $n$ is $P(m, n)$. $P(m, n)$ can be used to predict the transition state of the transfer matrix. From the beginning to the end of the steps are solved $P^*(m, n)$. When there is a state in the system, the transition probability from this state to other states is 0. We define this as an absorption state. When this state exists, the absorption Markov chain theory is applicable. The transformation matrix will be in the standard form

$$
T = \begin{bmatrix}
R & P \\
0 & I
\end{bmatrix}.
$$

Assuming that there is a transition state and B absorption state, it is a transition matrix, which shows the transition probability between the transition states. Yes, the absorptive matrix, 0 is the zero matrix multiplied by, and we multiply by the unit matrix.

3.1. The thickness of wrist is stratified and the transfer matrix is determined

Ultrasound scattering is fully consistent with the absorption Markov chain theory. Each discrete layer is considered as a transition state, with two absorption states, the top plane and the bottom plane, because...
when they leave the wrist, the ultrasound will never return. We assume that there are layers in the graph, that is, there are transitional states. For simplicity, we only consider the transmission factor at the computational stage. Therefore, the probability matrix of the absorption factor represents the probability that will occur in the first layer by past scattering or reflection propagation.

3.2. The absorption probability matrix is discussed to determine the intensity of the transmitted ultrasound in the last scattering event

$Q(z)$ Intensity of transmitted ultrasound in $Z$ for the last scattering event, Absorption probability matrix B, commonly considered as absorbing Markov chain theorem.

$$B = NR = (1 - P)^{-1} R$$

(1)

Among them, N is called the basic matrix, It is defined as $N = (1 - P)^{-1}$. Therefore, the above formula can be rewritten to

$$[\begin{bmatrix} B(1) \\ M \\ B(Z) \end{bmatrix} = \begin{bmatrix} N_{11} & A & N_{1Z} \\ M & O & M \\ N_{Z1} & A & N_{ZZ} \end{bmatrix} \begin{bmatrix} R_1 S_1 \\ M \\ R_Z S_Z \end{bmatrix}$$

(2)

$s_j$ represents the last scattering event in Layer $i$ as a symbolic variable.

It can be expressed as

$$B(i) = \sum_{k=1}^{r} N_{ik} \cdot R_k S_k$$

(3)

It can be explained as follows: if the ultrasonic wave starts to scatter in the first layer and then transmits, The probability of the last scattering event in layer $K$ is $N_{ik} R_k$. In this particular problem, the first scattering event does not occur in a particular layer (e.g. the first layer). On the contrary, the probability that the first scattering event will occur in each layer and the first scattering event can be predicted using $I = I_0 \exp(-\alpha x)$. Finally, if we assume that the probability of the first scattering event is $P'$ at the $i$ level, the function can be expressed as follows:

$$Q = \sum_{i=1}^{r} P'_i \cdot B(i) = \sum_{i=1}^{r} \left( P'_i \cdot \sum_{k=1}^{r} N_{ik} \cdot R_k S_k \right) = \sum_{i=1}^{r} D_i S_i$$

(4)

$D_i$ is the simplified coefficient of $s_j$, which is actually equal to the probability of the last scattering event in layer $i$. Therefore, we transform the problem of finding $Q(z)$ into finding $D_i$, which can be solved by absorbing Markov chain theorem. Then the intensity of ultrasonic transmission can be easily predicted by the formula.
Comparing the two pictures, we can see clearly that there is a black area in the middle, that is, the screw placed in advance for us, within the allowable range of experimental error. It can be seen that the device can clearly scan the image of the internal structure of the object. Therefore, the adaptive motor driving algorithm based on Markov chain is more successful.

4. Conclusion
At present, there are two ways of ultrasonic imaging: electronic scanning and mechanical scanning. Electronic scanning is the generation of scanning beams by electronic control of many elements and the focusing of wave numbers by delay lines. Mechanical scanning generates ultrasonic beams by mechanical movement of single or multiple elements. This paper solves the problem of large data and slow scanning speed in electronic scanning, which is not suitable for community hospitals. Relatively speaking, the experimental devices we use are very common instruments in university physics laboratories, which are convenient, fast, simple to operate and relatively low cost. Moreover, ultrasound imaging has a very wide application prospect, whether in the medical field for the diagnosis and treatment of stones or other related diseases. This kind of adaptive algorithm based on Markov chain motor-driven acoustical bionic eye has no similar design at this stage, and has a certain degree of innovation. At the same time, it should be pointed out that there are still some areas for further discussion in this design, such as the frequency effect of ultrasound, the vibration effect in motor drive, etc., in the hope of further detailed solution in future research.

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