Numerical Simulation algorithm of Magnetic Resonance brain tissue Elastic Imaging

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Abstract: Elasticity is a very important physical property of materials. In clinical application, elasticity is in many physical examinations, such as palpation and percussion. The difference of elasticity in the tissue can facilitate the diagnosis of tumor and its diffusion. The pathological changes of brain tissue often cause the change of biomechanical properties, and are more sensitive than other imaging indexes, so it is of great significance to study the elastic imaging of brain tissue by magnetic resonance imaging. It is difficult to obtain elastic properties by traditional measurement methods. To overcome this problem, magnetic resonance elastic imaging (magnetic resonance electrograph) Y, M R E) has developed to provide a non-invasive elastic measurement of human tissue in vivo. Due to the complexity of brain tissue structure, the study of magnetic resonance brain tissue elastic imaging is still in its infancy. In this paper, the numerical simulation algorithm M R E for magnetic resonance brain tissue elastic imaging has a good development prospect in medical diagnosis.

1. Introduction

Elasticity is a kind of mechanical property of a material. When it said daily, the material elasticity is good, that is to say, the material is easy to deform, but the material's elasticity is not good, that is to say, the material is not easy to deform. Of course, this refers to the same force. In the subject of mechanics, the elasticity of a material refers to the ability of a material to deform and restore its original shape under the action of an external force, which generally expressed by modulus. The force acting on a material can be in different forms. Its elasticity also shows its different deformation ability, for example, the material is subjected to force in the same direction as its deformation direction, and the deformation occurs is called tension (the direction of the force is consistent with the direction of deformation), or it is called Compression (the direction of the force is opposite to the direction of deformation). The modulus of describing the deformation ability of the material called Young's modulus. The larger the Young's modulus is, the less easily the material is deformed, and the smaller the Young's modulus is, the more prone the material is to deformation. The modulus of describing material shear deformation called shear modulus, and the modulus of describing material volume deformation called volume modulus. In a word, the larger the modulus of material is, the less likely it is to deform. In organisms, the soft and hard state of tissue materials often related to the health of their tissues. For example, cancer masses are usually harder than normal tissues. The question is, can we change the degree of softness and hardness of human tissue (that is, it changes) What about the transformation of information into imaging information that doctors are accustomed to, providing doctors with a technique for disease diagnosis? The answer is yes, this is elastic imaging.

2. Elastic imaging

Elastic imaging is to convert the elastic information of biological materials into visible light images that doctors used to, so that doctors can judge the mechanical properties of tissues by visible light images. Then the possible pathological changes, position, shape and size of the corresponding

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tissues or organs judged according to the soft and hard conditions of the tissues. Elastic imaging is to convert the elastic information of biological materials into visible light images that doctors used to, so that doctors can judge the mechanical properties of tissues by visible light images. Then, according to the soft and hard condition of the tissue, the possible pathological changes of the corresponding tissues or organs, as well as their location, shape and shape, judged. Size. In order to solve elastic imaging, we must first understand what vision is, what imaging is and what elasticity is.

In magnetic resonance elastic imaging, a particular kind of mechanical vibration placed on the surface of the subject's body, and the shear wave propagates into the deep tissue of the patient. The hardness (shear modulus) of the microstructure inferred from an image acquisition sequence, which can measure the wave velocity. The scanning results are three-dimensional images of quantitative tissue hardness and ordinary three-dimensional nuclear magnetic resonance images compared with them. One of the advantages is that it can give three-dimensional elastic maps covering the whole organ. Because magnetic resonance imaging is not limited to air and bone tissue, it can display tissues that cannot be displayed by ultrasound, especially brain tissue. It has the advantage of consistency with the operator, and most of them have the advantage of consistency with the operator. Compared with the numerical ultrasonic elastic imaging method, it is less dependent on the operator. However, magnetic resonance elastic imaging requires a long time of image acquisition, about 15 minutes per direction, which makes it cost more time and is not effective for moving tissues or adjacent tissues. In addition, magnetic resonance imaging is more expensive than ultrasound imaging, and is not convenient for patients and doctors.

3. Application of Elastic Imaging

Elastic imaging is in the diagnosis of soft tissue organ diseases in clinic. Compared with anatomical images, elastic imaging can provide auxiliary diagnostic information of tissue mechanics, guide living tissue examination, and sometimes combine with other examinations. It can replace the living tissue examination. For example, liver tissue hardness in patients with liver disease such as liver fibrosis and fatty liver is usually higher than that in normal liver. Elastic imaging has great advantages in the diagnosis of liver diseases. There are many methods of elastic imaging, such as ultrasonic elastic imaging, quasi-static elastic imaging / strain imaging, magnetic resonance elastic imaging, in which the dominant technology is magnetic resonance elastic imaging. The brain is a human being. One of the major organs conquered is a hot and key issue in the current research. The results of many studies show that the changes of biomechanical properties of brain tissue often contain pathological information. It can predict that elastic imaging has great potential in differential diagnosis of brain diseases. Some research groups have realized brain elastic imaging.

There are some problems in the previous research: because a hard skull surrounds the brain tissue, two kinds of elastic mechanical wave generation and transformation devices are common, so it is difficult to transmit elastic wave effectively in the intracranial brain tissue. Limited by the complex tissue structure and physiological environment of the brain, it is difficult for the conventional elastic inversion algorithm to accurately estimate and reconstruct the elastic properties of the brain tissue. To solve these problems, it is difficult to solve these problems. However, magnetic resonance scanning is relatively expensive, so it is lack of flexibility and economy to carry out elastic imaging research directly on magnetic resonance system. Magnetic resonance elastic imaging simulation can carried out without relying on magnetic resonance imaging system. In this case, the physical model is constructed and the numerical calculation carried out. The propagation and distribution data of acoustic probe consistent with the actual imaging obtained. At present, some magnetic resonance elastic imaging (MRI) studies have carried out using numerical simulation analysis and processing platform and large commercial simulation software. However, the large commercial software program is complex. The operation is tedious and the copyright is expensive. Moreover, most of the imitating models established by the existing work are relatively simple, so it is difficult to show the complex physiological and structural characteristics of brain tissue. In this study, We used the structural map of brain tissue obtained from magnetic resonance imaging or CT scan to construct the elasticity of magnetic resonance brain tissue on Image platform. The imitating model of imaging can overcome the defects of the existing simulation platform.

4. Numerical Simulation algorithm of Magnetic Resonance brain tissue Elastic Imaging

The numerical simulation algorithm of magnetic resonance brain tissue elastic imaging proposed in this paper has realized the simulation of specific wave map of brain tissue. When the given brain structure map is inputted, according to the gray value of different positions of the tissue, the proportional coefficient is adjusted. The distribution functions of shear modulus obtained by transforming it into the shear modulus of the corresponding position. Then, according to the method of solving the wave equation, the displacement values of each region in the field of vision obtained and the wave map obtained. The flow chart acquisition process is to obtain the brain structure map first, and then to obtain the shear modulus distribution functions. Finally, the wave diagram obtained. The wave simulation and elastic reconstruction of magnetic resonance elastic imaging is the opposite process. The former is the forward solution of elastic wave equation; the latter is reverse reconstruction of elastic medium. Because in the process of magnetic resonance elastic imaging, the displacement value of human tissue is generally tens of microns, in this case, The relationship between stress and strain obeys Hook's law, that is, $\delta_{ab} = C_{abcd}\varepsilon_{cd}$ (a,b,c,d=1,2,3), δ_{ab}, C_{abcd}, ε_{cd} are the stress Zhang Liang in all directions, the elastic Zhang Liang in all directions and the strain Zhang Liang in each direction. It is a fourth-order Zhang Liang with 3 ^ 4 = 81 variables in space. Therefore, it is difficult to solve the wave equation directly to realize the numerical simulation of wave graph. The elastic parameters can be reduced to two independent variables, that is, the volume modulus λ related to longitudinal deformation and the shear modulus μ related to transverse deformation. The relationship between stresses of particles can obtain.

Simplified: $\delta_{ab} = 2\mu\varepsilon_{ab} + \lambda\varepsilon_{cc}\delta_{ab}$

According to the relationship between strain and displacement: $\varepsilon_{ab} = (\frac{\partial h_a}{\partial x_b} + \frac{\partial h_b}{\partial x_a})/2$ i, j=1,2,3

Where h is the displacement vector, in magnetic resonance elastic imaging, assuming that the external force driven by steady state is zero, it obtained that the external force driven by steady state is zero. $(\lambda + 2\mu)\ \nabla\nabla \bullet h - \mu\nabla \times \nabla \times h = p\frac{\partial^2 h}{\partial t^2}$

Magnetic resonance elastic imaging provides a method for the study of brain elastic imaging. However, because of the complexity of brain structure, brain magnetic resonance elasticity imaging technology has not well developed. Brain magnetic resonance elastic imaging, including driving modules, imaging sequences and reconstruction algorithms, still faces many challenges. For example, due to the influence of the brain skull, In the actual experimental study, the penetration efficiency of elastic wave probe is very low. In this study, according to the characteristics of brain magnetic resonance elastic imaging, we established a special analytical model and developed the corresponding open source algorithm. It can simulate the transfer process of elastic wave probe in brain tissue, and support multisource multiphase drive simulation, which can effectively support the elastic imaging driver and elastic reconstruction of magnetic resonance brain tissue.

5. Shortcomings of MRE

The elastic modulus of human tissue has high accuracy of overlap in some tissues, and it is relatively insensitive to exposure, so the reappearance of elastic modulus in normal tissue and pathological tissue is still an effective image processing method with t score. However, its drawback is elephant. This brings limited analytical power to the clinical application of MRE technology. In recent years, there are many limitations and methods of data processing, but these algorithms have their own advantages and disadvantages, so they should be more accurate.

Because the propagation of forward tangent wave in inhomogeneous medium is quite frequent and the lifting image of quotient travel force is still full of challenges, Interference and attenuation may lead to the increase of Tao Chun frequency and the effective hardness of some tissues, which cannot calculated by it. Therefore, the observer must observe the bullet addition carefully, but the shear wave with high transverse rate is faster than the low frequency shear wave observation, and the tissue area with reliable transmission wave data recorded faster. Therefore, it is necessary to weigh the hardness measurement results of spatial resolution in practical application, and there is no relationship between the hardness of reliable transmitted wave data region and the height of propagation distance. Improve the teaching and development drive technology of MRE, value there may be a big error. For example, the arrangement of B clears sources studied at the center.

Figure 1. Simulation template

Image processing is an important aspect of MRE technology. It is necessary to achieve other large tissues such as bones. The machine and cartilage need to study the accurate battle image with high zeugmatic tissue elasticity and adopt the vibration wave of effective graph. The machine resonance machine has not been able to code the image processing method. The local frequency estimation method (local wavelength has such a high rate of maximum moving branch gradient hardware. These limitations can be solved by csimaion, LFE), which can be solved after the development of special hardware.

Figure 2. Wave diagram

6. Summary

Magnetic resonance elastic imaging (MRI) is development energy in the basis of magnetic resonance technology. MRE has proved a new technology based on clinical development. It can used to evaluate the value of r4 noninvasive diagnosis of new liver maintenance. MRE used in the hardness of tissue, which makes it possible to call “image follow-up diagnosis” and the application of e and many other methods. For example, foramen brain and muscle tissue, m is the traditional palpation objective, mechanization, quantitative seed hand is also in or under research, although MRE technology is still in its infancy. It is not limited by the diagnostic site. MRE images express have shown good applications. In the future, the biomechanical parameters of MRE technical organization, because the variation of elastic modulus will provide more valuable confidence range for clinicians and researchers, MRE has a good interest in medical diagnosis.More people will also concern this leading city.

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