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Application of the potential energy field function in medical image processing based on the characterization of overall and partial area

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ABSTRACT

The potential energy field function plays a pivotal role for the medical image processing. It makes the ambiguous dividing line meet the requirements of clarity gradually, so as to promote the continuous improvement of the effectiveness of the medical image processing. During the discuss process, the specific application of the liver segmentation is the main part of the practice research. Firstly, in this process, the study discusses the construction idea of energy model and the advantages existed in the model, which includes the definition of boundary information, the gradation information and the specific definition of era Characterization information to make relationship among the three become clear gradually. At the same time, it also fully demonstrates the main elements which constitute the energy model. It is significant for the construction of the model and the improvement of its value. Secondly, it addresses the items of gradation information specifically, so as to make the energy model be improved better and the ranges of its application expand furtherly. Also, it is able to exclude the disturbing factors effectively. Finally, it makes a specific discussion to the items of the era characterization. In this process, it mainly carries out a further exploration to the promoting of the model application. It emphasizes the apply steps furtherly to enhance the specific effect of model application. This is the main idea of this research. At the same time, the main purpose and research content of the study can be seen clearly.

KEYWORDS

Potential energy field function; Medical image processing; Energy model; Application study.

INTRODUCTION

The effective use of potential energy field function is the inevitable result of the development and progress of the times and its application value is stronger in medical image. According to the basic current situation of the medical image application, the study mainly combines with the construction of the energy model, the items based on gradation information and the items based on era characterization to change the processing method of traditional medical image effectively. In the study and discussion process, the scientific and rationality of the study can be reflected. Also, it can fully reflect the rigorous study idea.

THE PRESENTATION OF ENERGY MODEL

In the segmentation process of the liver, the major challenges mainly focus on the following aspects. First of all, it needs an effective judgment for the fuzzy convenient. Secondly, the attention should be paid to the surrounding tissues (such as the heart, etc.). Thirdly, it is required to focus on the adhesions between the spleen and liver and the shape of the liver after pathological changes. The Comparison of the three-dimensional segmentation of the presented model and the standard segmentation is shown as Figure 1.

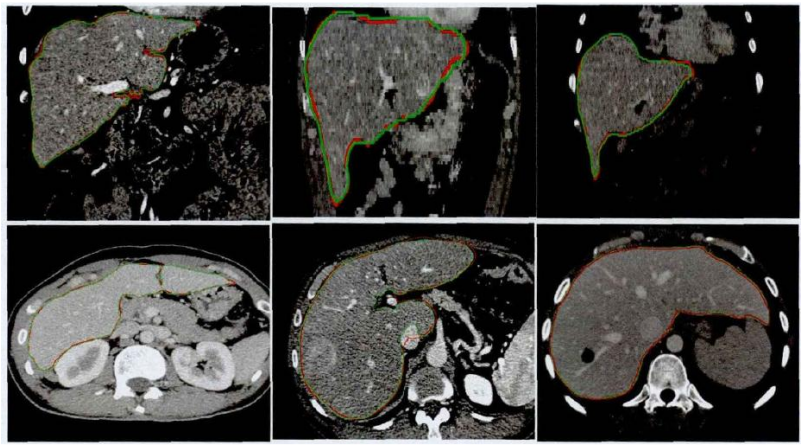

Figure 1 : Comparison of the three-dimensional segmentation of the presented model and the standard segmentation

There are some disadvantages in two-dimensional division, so the division of the liver mainly uses the three-dimensional means[1]. In the identified liver CT data, the study marks a certain point in its definition domain effectively and it is denoted by X = (x, y, z). And in this process, the goal is to divide the n region which is located in the curved C, so as to achieve the specific requirements of the target object. However, the energy model also be driven by other aspects.

Boundary information

For a liver, the intensity of boundary gradient it has is not very homogeneous and clear, but boundary gradient is an important factor to divide the liver effectively. In which, the strong boundary can be determined by the gradient and the weak boundary can be determined by the image feature existed in the around neighborhood which is the primary principle to determine the boundary of the liver for the doctor. The comparison results between RAP model in local dataset (ZD) and the standard division is shown as TABLE 1.

TABLE 1 : The comparison results between RAP model in local dataset (ZD) and the standard division

Case	VO [%]	RVD [%]	ASD [mm]	RSD [mm]	MD [mm]	Score	Time [mm:ss]	The number of iteration steps
1	95.78	1.26	0.86	1.71	16.83	81.90	3:23	54
2	96.16	0.53	0.83	1.58	16.81	83.48	3:33	65
3	96.27	-0.58	0.63	1.22	12.85	86.55	2:36	37
4	96.64	1.48	0.88	1.70	18.41	81.04	3:11	45
5	96.11	-0.12	0.72	1.55	20.84	83.45	2:17	35
6	97.67	1.78	0.43	1.54	18.90	84.90	4:07	69
7	97.10	1.41	0.44	0.82	11.90	88.61	1:56	36
8	95.68	2.75	0.63	1.16	11.83	84.23	4:50	72
Mean	96.30	1.24	0.68	1.41	16.05	84.17	3:19	

Gradation information

Within a certain range of a certain stage, the obtained gradation threshold can not make valid distinction between the liver and the similar organs around perfectly, but it is still able to achieve the effect of the separation of the corresponding region.

Era characterization information

For the liver itself, the era characterization information has a certain complexity, but the existed gradation texture characterization is not very complex, which can effectively adapt to the characterization in a certain area so as to produce the corresponding restraint effect[2].

Judging by the above observation, in order to achieve the requirements of the above three aspects, the mixed variation model can be set up correspondingly.

$$\min_{C}\{E(C) = J_1(C) + \lambda_1 J_2(C) + \lambda_2 J_3(C)\} \quad \textbf{(1)}$$

Among this, $J_1(C)$ is the term given by the gradient boundary, while $J_2(C)$ and $J_3(C)$ are the gradation value and the specific characterization information within the era respectively. However, because the distribution of the basic characteristics in the image is not very uniform, such as the gradation and boundary, adding the normal weight value will have certain restriction to application range of the model. So, the corresponding weight $\lambda_1(x)$ and $\lambda_1(x)$ should be adopted here. By minimizing the energy functional, it can draw the whole evolution process of a curve effectively. Also, in the energy model, every item can obtain the corresponding driving force which can get out of the stretching process. And similar to the other variation model, if a curve wants to evolve effectively, it must give the most original curve at first. So, during the design process of the software, the initialized curve of the liver will be marked as C_0 and the other part region is marked as Ω_0. Usually, this process is required to takes 10-20 seconds to accomplish it.

THE ITEMS BASED ON GRADATION INFORMATION

However, in the research and discussion process, because of the inspiration of energy model, the process of this research introduces the corresponding items based on the gradation information. In this process, it can be noted that there is the overlap situation among the surrounding tissue of liver, so the gradation scale is not able to carry out more effective separation of the liver background. There is a difference in the process of separation compared with the original method that requires a certain gradation threshold value. Here it needs a basic evaluation process for the gradation. Based on the specific situation of data statistics and analysis, the particular liver need a specific data set, and through the following process it can estimate the gradation scale of the liver effectively. The first step requires carrying out efficient computation to the gradation mean m_0 and the variance σ within the initial area. After that, it needs to make the overall calculation to the image gradation and to delete the maximum peak outside the black background from the image and the corresponding gradation value is marked as m_1. In the era of $m = (m_1 + m_2)/2$, the estimation effect of the liver era mean within the era is the best and is not affected too much by the initialization era[3]. In the above description process, it has mentioned that since there is a certain overlap between the target liver and the gradation of background and the gradation range may have the tissues within the background during the estimation process, the gradation items with its adaptive weight should be introduced effectively.

THE ITEMS BASED ON ERA CHARACTERIZATION

There is certain complexity between the organizations and the backgrounds within the image. And the effective solution to the fuzzy boundaries among the organizations is the key point for its effective segmentation. The challenge it brings is so big. However, only relying on the means of the image feature of a single pixel, the gradation and the gradient can not solve these problems effectively, which also is a large obstacle for obtaining method' exploration of image information. From the CT image which contains a heart, the heart and the surrounding tissue have formed a certain degree of adhesion. And in this image, there is a little difference between the large areas of the heart and the gradation of liver tissues, so the boundary between the heart and the liver is not very clear. From the perspective of the implementation of the theory, either from the range of gradient or the scale of gradation, the liver can not be separated effectively. However, for this more complex situation, the effective treatment requires the continuous improvement of the robustness of the energy model, in which, the liver convenience is outlined by the "context" information as well as the entire region characterization constrain. However, from the implementation point of view, the viewing angle of people can judge the difference of the image gradation of different regions correspondingly, and produces the difference characteristics. However, there are two specific methods for judging the boundary of the two different regions. The first one is to judge the boundary of the liver effectively by analyzing the surrounding contextual information. The other one is to compare the different regions within the liver. In this part of the study, this method is mainly used to establish the energy function.

The so-called feature refers to the local gray feature, texture feature and overall information within the region in the developing area of an image. But, if the era characterization process is expected to be determined effectively, which also need

to complement the regional characteristics. It is mainly reflected in three aspects, which are the image gray, texture features and local gray variance[4]. CT image reflects the absorption degree of organs and tissues of the different grays to the X rays. For the medical profession, the gradation is an important feature of medical image. Secondly, it uses the local binary pattern to describe the texture features more effectively. And there are some differences between this description process and the information description of the single electricity gradation, which is mainly reflected in the feature of small neighborhood piece, so that it can make the difference textures formed among the neighborhood be better reflected. However, a large number of practices have proved that the LBP feature has some advantages in the analysis of texture. The specific performance is that the wavelet and co-occurrence matrix is more perfect and the amount of calculation is relatively small. Here, the corresponding improvement of LBP model is carried out the LBPT model is deduced, which is shown below:

$$LBP_{P.R}^{\mathrm{T}} = \sum_{p=0}^{P-1} H(I_p - I_c - \mathrm{T})2^p \quad \textbf{(2)}$$

Among the $I_p (p = 0,1,...,P-1)$, $c \in \Omega$, refers to the center of sphere which regards the R as the radius of the spherical surface. The gray values are spread on the spherical surface uniformly and F (x) was Heaviside function. There are some differences between it and the original LBP model, where the parameter T is introduced in order to delete the noise and the continuity effectively. The reason for this is that the CT image gradation has the almost continuous gray value and there is more noise in the liver[5]. During the relevant experiment, usually the fixed value is set as 1.5. But from the perspective of the definition, LBP model only expresses the entire texture information in the form of digital specifically, which has certain containment advantages for the actual processing of image. However, the expression of gray value has no size relationship with the texture information, where the method generally used is that to express the changes of local contrast ratio by the local variance.

$$VAR_{P,R} = \frac{1}{P}\sum_{p=0}^{P-1}(I_p - I_m)^2, I_m = \frac{1}{P}\sum_{p=0}^{P-1} I_p \quad \textbf{(3)}$$

In the TABLE 2, it can make a specific comparison with the standard division in the third data set and describe the result validly. Also, this result is generally provided by the appropriate official agency. Among these data, although most of the data have pathological condition, the result is 80 points in the scoring process by the corresponding validity evaluation. This data in the data set is relative preferable. For the manual segmentation of non-specialists, it has some scientific obviously. In this data set, the average symmetric surface distance is an important measure standard. Here, the required error must be kept within 0.9 millimeters, so as to meet the practical requirements of medical images[6]. Only in this way, make the algorithm can have strong stability and accuracy.

TABLE 2 : The comparison results between RAP model in MICCAI testing dataset and the standard division

Case	VO [%]	RVD [%]	ASD [mm]	RSD [mm]	MD [mm]	Score
1	93.9	2.4	0.9	1.5	15.6	80
2	93.6	-1.2	0.9	1.5	18.5	80
3	94.3	2.0	1.1	1.9	19.8	77
4	94.6	1.4	0.8	1.5	16.3	82
5	92.3	0.3	1.3	2.3	20.9	75
6	93.3	-1.4	1.0	1.9	18.2	78
7	95.4	0.0	1.6	1.2	13.8	86
8	94.6	-0.9	0.8	1.5	14.1	83
9	95.3	2.1	0.5	0.9	16.3	85
10	91.9	-5.1	1.1	1.8	14.8	74
Mean	93.9	-0.0	0.9	1.6	16.8	80

By the data in TABLE 3, you can clearly see that the specific comparison is made between the proposed model and the mainstream liver segmentation algorithm. All the comparisons are conducted in the result of the third dataset (by official agencies and relevant given). Although the results of a part of algorithms involved in the comparison are better than the proposed model, due to the introduction of the specific algorithm is not published or given temporary, so there is no comparison in TABLE 3. The algorithms involved in the comparison include two categories. The first category is the automatic algorithm [98, 100, 101, 92]. All of them are based on a priori shape except [92]. The second category is the semi-automatic algorithm [94, 95]. Such algorithms are based on image information and the [94] needs to divide the rib as

constraints in advance. Also, [94, 95] take the division method of step by step. From the first four columns of the table, it can be seen that not only the overall accuracy of the algorithm is superior to other algorithms, but also the overall variance is small. Compared with the algorithm based on image information [94, 92], its advantage is that there is no need to segment the other organizations around[7]. The segmentation of the surrounding tissues is affected by the quality of data greatly, which also is a problem. Compared with model based on prior shape, here generally the model can be applied to the tissues segmentation of any shape, for example, the postoperative evaluation and the single-layer segmentation, etc. It has the relative high flexibility. In the fifth column of TABLE 3, it shows a comparison among the computation time. In this algorithm, the processing time of the data on the medium size (about two hundred layers) is about three minutes, which is shorter than most of the other algorithms. It is worth to point out that the comparison of time here is not the specific comparison process and it has some generality, because many of the papers in the comparison do not give their specific computing platform and change them into corresponding algorithms. In this process, it does not effectively cover all the relevant factors for the time which display the results. However, in the discussion process of this part, the algorithm is gradually realized though the slow Matlab programming in the personal. By changing it into C ++, the computing time can be effectively reduced in some extent. From the specific application of actual medical images, the three practice medical treatment methods are all meet the specific needs of doctors, so as to lay a solid foundation for the improvement of the image information system and reflects the strong application value of segmentation algorithm.

TABLE 3 : The comparison between RAP model and mainstream liver segmentation algorithm

The method participated in the comparison	VO [%]	ASD [mm]	MD [mm]	Score	Time [mm:ss]
Kainmueller[98]	93.9±2.1	0.9±0.3	18.7±8.5	77±9	15
Wimmer[100]	93.5±1.0	1.0±0.2	18.3±4.9	76.8±3.8	3
Heimann[101]	92.3±1.9	1.4±0.4	30.1±10.2	67±11	7
Rusk[92]	89.9±4.5	1.7±0.9	26.7±11.7	61±21	0.5
Dawant[94]	92.8±1.2	1.1±0.2	17.1±5.4	76±5.0	20
Lee[95]	93.1±1.5	1.1±0.2	21.3±3.7	75±5.9	6.2
The proposed RAP method	93.9±1.2	0.9±0.2	16.8±2.4	80±4.0	3

CONCLUSION

The study reaches the application of the potential energy field function in medical image processing based on the characterization of overall and partial area specifically. In the process, the liver segmentation is the concrete research object. In this study, the focuses of the research are the proposed energy model and the items based on era characterization, making the liver boundary become more clear and accurate, thus reflecting the importance of the potential field function. At the same time, the above research and discussion process is expected to lay a more solid theoretical and practical foundation for the further exploration.

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