A Gray Level Image Detection and Segmentation Algorithm Based on Average Intensity Project and Shift Gaussian Model

Zhang fuchun[1,a] , Hao Yanzhong[1,b]

[1] Department of Aviation Theory, Aviation University of Air Force, Changchun, China

[a] Zhanfuchun1175@163.com

[b] Haoyanzhong123@163.com

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Abstract: A gray level image segmentation algorithm is proposed based on Average Intensity Project (AIP) and shift Gaussian model for gray level images with connection between thread and area with similar gray level. The evaluation is performed on 30 gray level images, and the results show area overlap measure of 91% between the extracted characteristic parameter and the manual segmentation.

Introduction

Gray level image segmentation algorithm is one of main support to judge the edge parameter which be used to recognize the great value target. Due to some target is very similar in pixel gray with its surrounding environment; therefore, it is an emphases and a difficulty that research to how to divide exactly vascular adhesion area.

Now, mainly methods to divide similar gray level image are these: utilizing morphological method to divide vascular adhesion in literature [1], but the parameter of canker bulgy is to be control difficulty, so make for lack or exorbitance, and probably eliminate its edge burrs. In literature [2], to use with these step that threshold segmentation, model setting, and nodule segmentation, due to modeling pertinence is weak relatively, so its effect is not good. In literature [3], an amelioration method on C equal-value clustering is used to divide gray lever image, the characteristic parameter can be picked up, but this method can be used to divide 2 or more. In literature [4], it rebuilt three-dimensional image in utilizing planar CT image, it can be revert characteristic parameter of the area, but its computation is very most, and can not solve effectively the problem in great area, or its borderline is not clear. The reason which not to pick up characteristic parameter exactly is, that the information of gray lever images is not use sufficiently, other said that module building is not based on point of pixel gray and geometry characteristic, so some information on originality image is lost.

Algorithm

Now, the thin slice gray data can be used in testing great value target, compared with thick slice gray lever, using thin slice gray data can improve test resolution, it can provide more detail information to help us to test target, but in same time there are some bug: one is there are a large of data, the other is the more image details, the more interfere. So used AIP can solve efficaciously these problems.

AIP[5],which used average value of whole pixel gray that located radial direction on sequence images, treat as the gray value of corresponding pixel in project image, as Fig 1:

$$\boldsymbol{AIP}(x,y)=\frac{1}{SN_r}\sum_{k=1}^{SN_r}\boldsymbol{I}_k(x,y)\ ,\ \ 1\le x\le H\ \ ,\ \ 1\le y\le W \tag{1}$$

In formula 1, $\boldsymbol{AIP}(x,y)$ is the pixel (x,y) gray value, SN_r is the layer number of project, $\boldsymbol{I}_k(x,y)$ is the pixel (x,y) gray value in k layer image in.

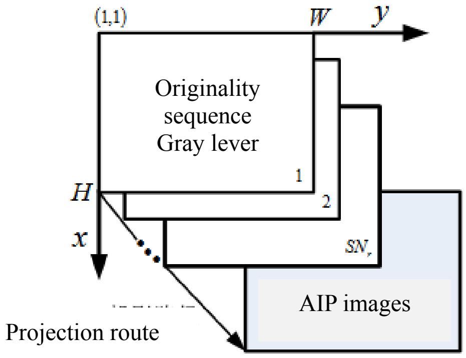

Fig 1 the theory of AIP imaging

Basing on AIP, sampling sparsely form originality sequence CT images, we can obtained a serial AIP images, in these, the parameter relationship in AIP projection is as follows:

$$SN_r = \left\lfloor \frac{S_r}{U} + 0.5 \right\rfloor \tag{2}$$

$$IN_r = \left\lfloor \frac{I_r}{U} + 0.5 \right\rfloor \tag{3}$$

$$N_r = \left\lfloor \frac{N_o - SN_r}{IN_r} + 1 \right\rfloor \tag{4}$$

In these formula, $\lfloor g \rfloor$ is rounded down, U is layer thickness of, S_r is layer thickness of AIP sequence image, SN_r is the number of layer in the rebuilt space, I_r is the distance between AIP rebuilt layers, IN_r is the number of layers on rebuilt space, N_o is the total number of s, N_r is the total number of sequence AIP rebuilt images. S_r and I_r can be set with concrete situation, in order to use nodule information sufficiently, $S_r = 2 \times I_r$ be set in this literature.

So, used formula 1, based on some layers in originality sequence images, projected on average density were made, Num i image in AIP sequence images can be created, as AIP_i ,in these $i = 1, 2, \ldots, N_r$, j is sequence layer num, $j < N_0$. So as a example with $SN_r = 4$, $I_r = 2$,

Rebuilt sequence images used with AIP, can utilize sufficiently part three dimension gray information, not only reduce data redundancies, but also weaken gray information of the target.

By using AIP, the value of gray of the geometry characteristic is weakened; its figure is reverted. In the same time, the edge information of characteristic parameter can be weakened also, so in the process of target area testing and dividing, reverting the edge information of characteristic parameter is needed.

Based on the AIP sequence images, the characteristic parameter of the image can be obtained, and then through threshold segmenting, morphological processing, the image dividing coarsely, the sharp of suspected area can be confirmed approximately, the step in detail as follows:

Step 1. pick up characteristic parameter. Using the method of grade distinguish, save the information of lung, eliminate useless information which caused by examination table.

Step 2. threshold segmenting. Using double mixture modeling, the gray histogram of the images were fitted, so can obtain the collectivity threshold of these images, and can do binaryzation in area.

Step 3. Morphological processing. Using expand operation, to resume the target outline. Due to the bulk of target is small, and the number of pixel which it appeared is less, so do expand operation to it only. But to the target which conglutinated with blood vessel, must do erode operation firstly, and can be obtained some independence sub-area, some thread e sub-area must are nodules possibly, or the target possibly and etc.

Step 4. In order to eliminate disturb caused by area which its sharp is more different to some area, can use circular degree to compute and analysis the area. Circular degree can be defined as follows:

$$CD = \frac{4\pi S}{P^2} \tag{5}$$

In this, S is area, P is perimeter, η is setting threshold value. If $CD \geq \eta$, then the area is preserved, otherwise eliminated.

Step 5. Target dividing coarsely. Due to some superposition should be occurred, so the same image compared with some AIP images. so a sort of non-superposition must be built, so make $\{SA_{il}\}_{l=1}^{Nm}$ back to originality gray lever sequence image layer $\{SC_j\}_{j=(i-1)\times IN_r+1}^{i\times IN_r}$ correspondingly, then do threshold segmenting, in this time the image which contain geometry information of thread and area were obtained. last put $\{SA_{il}\}_{l=1}^{Nm}$ and $\{SC_j\}_{j=(i-1)\times IN_r+1}^{i\times IN_r}$ do "and" operation, we can obtain the result of Lung nodule dividing coarsely $\{G_{lj}\}_{j=(i-1)\times IN_r+1}^{i\times IN_r}$, $l = 1, 2, \ldots, Nm$.

Through target dividing coarsely, the result of dividing coarsely would be picked up, as Fig1. Due to the sharp of target is rotundity appeared in planar images, its gray obeys from gauss distributing, but the sharp of similar geometry is strip in these images, and the change of gray of center line of similar geometry is less. The target which conglutinated to similar geometry can be seemed as superposed with lung nodule and blood vessel. Fig5b is the gray bend figure compared with Fig5a. The image framework can response these characteristic better, first the image framework can be picked up in using the method that keep the characteristic planar as framework, and mark the projection of framework curve in x axial as $g_{ij}(x)$, then build the one dimension gauss model to imitate gray distribution of lung nodule which conglutinated on blood vessel.

$$f_{ij}(x) = \frac{1}{\sqrt{2\pi}\sigma} e^{-\frac{(x-\mu)^2}{2\sigma^2}} + C \qquad (6)$$

In this formula, μ and σ is average value and square difference, they can reflect the gray characteristic of target, is the translation value, that reflect the gray average value of other organization such as similar geometry.

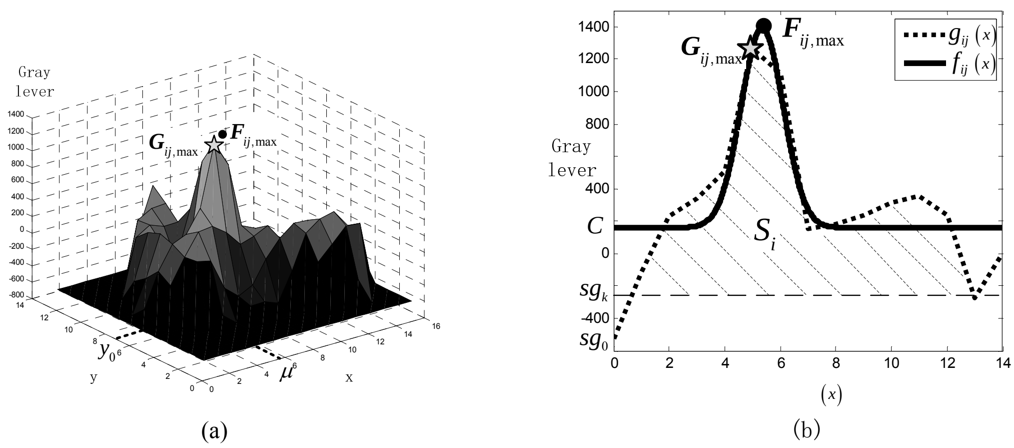

Fig. 1 precision divided base on translation of gauss model

May be able to use this iterative algorithm to estimate the parameters of Formula 6, steps as follows:

Step 1. mark the minimum of framework gray as sg_0, regarded as original value of framework dividing.

Step 2. mark the NO k dividing value of framework gray as sg_k, $G_{ij,\max}$ is maximum of gray of image G_{ij}, so it is maximum of gray of framework curve, the framework curve can be divided in two part by sg_k, compute the area of the form made of $G_{ij,\max}$ and sg_k axial, as S_k.

Step 3. increase sg_k by step of δ. Compute the area of the form made of $G_{ij,\max}$ and sg_{k+1} axial, as S_{k+1}.

$$sg_{k+1} = sg_k + \delta \quad , \quad sg_{k+1} \leq G_{ij,\max} \qquad (7)$$

Step 4. make the compared error which the area obtained by twice iterative algorithm as the determining reason of convergent.

$$\left| \frac{S_k - S_{k+1}}{S_k} \right| \leq \xi \qquad (8)$$

In this, ξ is convergent modulus, if formula 8 was satisfaction, then $C = sg_k$, if not, then turn back to step 2.

Step 5. make the value of framework $g_{ij}(x)$ subtract translation C, then the parameter μ and σ would be solved by non-liner lease two multiplications, using these parameters, the planar translation of gauss model was built.

$$\boldsymbol{F}_{ij}(x,y) = \frac{1}{2\pi\sigma^2}\exp\left\{-\frac{(x-\mu)^2+(y-y_0)^2}{2\sigma^2}\right\}+C \qquad (9)$$

In this, y_0 is vertical coordinate corresponding with abscissa μ, its maximum is marked as $\boldsymbol{F}_{ij,\max} = \boldsymbol{F}_{ij}(\mu, y_0)$

Step 6. basing on the model, the precision threshold which picked up is set.

$$\left|\boldsymbol{G}_{ij}(x,y)-\boldsymbol{F}_{ij}(x,y)\right| < \varepsilon \qquad (10)$$

In this, ε is threshold, if the formula 10 is succeed, hold this point, if not, eliminate it.

Conclusion

Using average intensity project (AIP) technology , utilizing sufficiently local three-dimensional image, sampling sparsely is used to deal with originality gray lever images, so that can induce computation and reduce interfere form segment. And then, we can do these that area picking up, threshold segmenting, morphological managing and early dividing for lung nodule, in order to pick up approximate outline of the target in holding whole information for image. last, the translation module can be built, so the problem can be solved that dividing exactly in the condition of great value target conglutinated with geometry characteristic in large area, so false positive rate can be reduced largely, the veracity can be improved.

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