

Automatic Segmentation of Gallbladder Using Intuitionistic Fuzzy Based Active Contour Model



V. Muneeswaran and M. Pallikonda Rajasekaran

Abstract The automatic and accurate image segmentation method is very essential requirement in image processing in various fields. Computer-based algorithms are needed to attain precise segmentation and classification results. In segmenting gallbladder, there are only very few automatic segmentation approaches. With a prima facie to exercise the fuzzy nature of energy equations, this work develops an intuitionistic fuzzy based active contour model for the process of segmenting B mode of ultrasound medical scan images. In preprocessing, histogram modification process and DooG filtering method were employed for amelioration of the quality of input image. Subsequently, task of boundary demarcation is performed by utilizing intuitionistic fuzzy based active contour model. The proffered method is validated by effectively comparing the inferred results over other conventional boundary demarcation techniques.

Keywords Gallbladder segmentation · Active contour model
Intuitionistic fuzzy sets

1 Introduction

In the medical science, the development of information technology leads a dominating role as it exhibits its significant value in capturing and diagnosing the internal parts of human beings. The information obtained from the diagnosis seems to be helpful for the physicians to identify the tumors, lesions, and some other pathological changes in the early days. Among the various computer diagnostic tools available in the present scenario, ultrasound scan images are generally used in diagnosing

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gallbladder. The normal shape of gallbladder along longitudinal line is pear-shaped or long eggplant-shaped. On the other hand, in the cross-sectional line, the shape is different like round or oval and also has different sizes because of various angles. In general, the fringes of the gallbladder with clear contour look alike attenuated and glazed. The length of the gallbladder is less than nine centimeters in ultrasonic scan. Ultrasound mode of image visualization is frequently adopted in diagnosis due to its property of nonionizing and noninvasiveness [1]. ACMs can be effectively connected to many fields in computer vision. Be that as it may, division consequences of conventional ACMs are purely reliant on starting shape areas, which are regularly done physically. This disadvantage has kept down ACMs pragmatic applications requiring full computerization. To overcome the need of manual in-statement, fuzzy rationale is brought into the system of ACMs. In this work, Intuitionistic Fuzzy Sets (IFS) are employed along with active contour model as a segmentation technique.

2 Literature Review

This section put forwards a brief discussion of previous works involved in gallbladder segmentation with their advantages and their disadvantages [2, 3]. Active contour models have been extensively implemented to carve the gallbladder by Marcin Ciecholewski [4]. Two effective descriptors of ACM such as the equation for membrane and motion equation are used to empirically trace the outline of gall shape and structure of polyps. Subsequently, the rest of the components in the image that was superfluous will be removed from the input medical image. To the statistical analysis of 600 input US diagnostic scan images, the absolute values of Dice Coefficient (DSC) were ensured in the service of comparison between traditional ACMs and their average values ranges approximately to 81.8%. The notion of histogram transformation was administered to convalesce the contrast of the input image. As a comparative investigation in 2011 [5], they incorporated the adaptively boosted SVM for tracking down and typecasting lesions whether it is a lithiasis or polyps. It is observed that there is a considerable decrease in accuracy value of 91% that was procured while discriminating lithiasis and during assorting, the tissue as lithiasis, and only a percentage of 80 in segregating structure of polyps, and 78.9% is procured in cases that have both. As a milestone of gallbladder shape analysis [6], Ogiela et al. completed the task of dissecting gall shape in an image by bestowing different processes. They have adopted Binarization and histogram analysis. Xie et al. [7] have propounded level set model for segmenting gallbladder. The prevailing view offered by the author as described as observations [8] are not assessed with numerous input images, even though this approach gives greater flexibility for gallbladder without lesions. Thus, the study encompasses more significantly the application of fuzzy concepts in gallbladder segmentation.

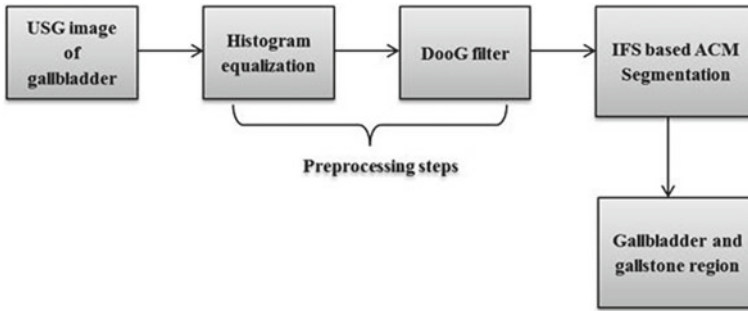


Fig. 1 Block diagram of the proposed intuitionistic fuzzy active contour model

3 Materials and Methods

The dataset for actualizing the recommended scheme encompasses 180 diagnostic frames (images) which were acquired from victims of cholelithiasis. It has been acquired from a diagnostic center in India.

4 Proposed Intuitionistic Fuzzy Active Contour Model

The diversified mechanism drawn in this work is exemplified in Fig. 1.

4.1 Preprocessing Steps

Preprocessing becomes a vital task in ultrasound image processing [9, 10]. Considering B as the resultant image for input image A after modifying histogram with equalization measures, p and q are regarded as the heterogeneous gray-level approximations of A image and B image, respectively. After the alteration of the histogram on p and q , the resultant will be $H(p)$ and $H(q)$. In signal processing operations, it usually represents the density functions of gray level (probability supported). The transformation function in Eq. (1) generates a gray-level value (q_i) as equivalent to the (p_i).

$$q = F(p) \quad (1)$$

This transformed output image is the result of HE process. A two-dimensional isotropic Gaussian functional is delineated as in Eq. (2)

$$\mathbb{G}(a, b) = \frac{1}{\sqrt{2\pi\sigma}} e^{-\frac{(a^2+b^2)}{2\sigma^2}} \tag{2}$$

The derivative at the first step is given as

$$\mathbb{G}'_{\sigma}(a, b) = \frac{\partial \mathbb{G}_{\sigma}(a, b)}{\partial \alpha} = \frac{-a}{\sigma^2} \mathbb{G}_{\sigma}(a, b) \tag{3}$$

the horizontal axis of DooG is represented in Eq. (4).

$$DooG_{\sigma}(a, b) = G_{\sigma}(a, b) - G_{\sigma}(a + \delta, b) \tag{4}$$

where δ is outweighed at intervals of the corresponding centrum of two kernels. The filter concerns for all angles could be calculated by circumducting the functions in Eqs. (3) and (4) and is shown in Eqs. (5) and (6)

$$\mathbb{G}'_{\sigma,\alpha}(a, b) = \mathbb{G}'_{\sigma}(a \cos \alpha + b \sin \alpha, -a \sin \alpha + b \cos \alpha) \tag{5}$$

$$DooG'_{\sigma,\alpha}(a, b) = DooG'_{\sigma}(a \cos \alpha + b \sin \alpha, -a \sin \alpha + b \cos \alpha) \tag{6}$$

4.2 Intuitionistic Fuzzy Based Active Contour Segmentation

Before embarking on a discussion of introducing fuzzy concepts in existing active contour model, it is important to know about its existing version. An active contour is considered as a model of a definable curve which was assumed to be constructed by an elusive, tangible material that behaves tentatively as rubber or spring-like material at the same moment. Within the framework of 2D image understanding, an active contour is a basic tenet of a flat curve that keeps on changing its shape periodically and accommodates within or on to image elements. The prima facie of outline locomotion is to hypothesize the possible fit, with the assumed condition, which is variation amongst outline deflection and the boundary of the shape under analysis. The potential energy constituent produced that tends to cause shrink or expanding action in the contour was almost considered as the suitable objective criterion for cost function and is given in Eq. (7):

$$E_y = \int_0^{Y_{m-1}} [E_i(v(y)) + E_e(v(y)) + E_p(v(y))] ds \tag{7}$$

in which the problem-specific equation $v(s)$ delineates the curve topography, E_i symbolizes the indigenous potential energy, E_e is the potency that imparts the extrinsic conditions to the contour outline produced, and E_p corresponds energy factor

acquired from intrinsic features of the image. The representation of the energy equation in the discontinuous mode is highly contributive in the machine-based modeling of retractable models in Eq. (8)

$$E_y = \sum_{s=0}^{Y_{m-1}} [E_i(v(y)) + E_e(v(y)) + E_p(v(y))] \quad (8)$$

Let “A” be an Intuitionistic fuzzy set in an object “E” represented in Eq. (9)

$$A = \{ \langle x, \mu_A(x), \nu_A(x) \rangle | x \in E \} \quad (9)$$

in which $\mu_A : E \rightarrow [0, 1]$ exemplifies the associativeness and non-associativeness, respectively, of every element $x \in E$ to the set A, which is a subset of E, and for every $x \in E$ [11].

For two intuitionistic fuzzy sets A and B in $X = x_1, x_2, \dots, x_n$, the Hamming distance [12] is calculated as in Eq. (10)

$$d_{IFS}(A, B) = \sum_{i=0}^n (| \mu_A(x_i) - \mu_B(x_i) | + | \nu_A(x_i) - \nu_B(x_i) | + | \pi_A(x_i) - \pi_B(x_i) |) \quad (10)$$

The existence of obsolete calcification makes the process of gall shape extrication which is the essential detail which a radiologist has an inclination for. 1.a–4.a of Fig. 2 manifests the four input of medical images contained in the dataset. 1.b–4.b of Fig. 2 delineates the ability of proposed intuitionistic fuzzy based active contour model in drawing out gallbladder from the clinical image. It is noticeable that substantial effort of preprocessing contributed to effacing noise and also the interference caused due to acoustic shadows. The repercussed outcome that eliminates superfluous details is retrieved after the postprocessing operations, and it has been illustrated in which is an inherent result of the preprocessing process which removes speckle noise and in the input images. Features of the successful outcome of preprocessing the input diagnostic image will give an additional help to the process of demarcation. Eventual outline of the gall region excluding the insignificant details accumulated in given US diagnostic scan image is reaped subsequently on postprocessing and exemplified in 1.c–4.c of Fig. 2. Statistical analysis of the well-known quality indicator is shown in Table 1. The effectiveness of intuitionistic fuzzy based active contour model was directly pointed out by the highest value of qualitative measurements.

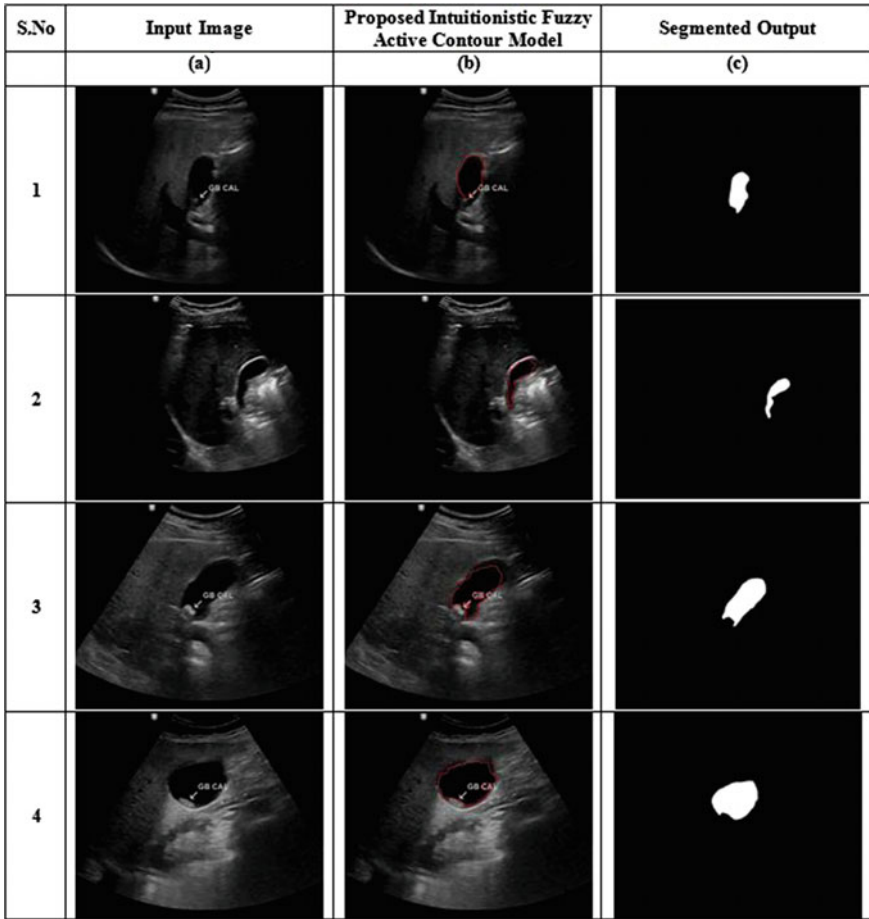


Fig. 2 Output of the proposed intuitionistic fuzzy active contour model

Table 1 Comparison for evaluation metrics for Gallbladder segmentation

Images	Conventional ACM			Proposed IFACM		
	Metrics			Metrics		
	Sensitivity	Specificity	Accuracy	Sensitivity	Specificity	Accuracy
Image 1	0.786410	0.813428	0.842710	0.875482	0.853172	0.892910
Image 2	0.761352	0.804172	0.829132	0.885741	0.843754	0.844351
Image 3	0.798134	0.822951	0.854917	0.841445	0.857175	0.859642
Image 4	0.800156	0.837159	0.842781	0.875362	0.891521	0.853147
Image 5	0.741325	0.785927	0.800183	0.874260	0.830008	0.852086

5 Conclusion and Future Work

The outline of the gallbladder and gallstone are extensively highlighted by the ultrasound scan image with the help of fuzzy incorporated algorithms. In this paper, intuitionistic fuzzy sets based active contour method is proposed and it precisely articulates the silhouette of gallbladder and lineates the profile of gallstone in the diagnostic US image. The values of qualitative parameters like sensitivity, specificity, and accuracy are more balanced than those procured in previous works. From the relative experiments, it has been perceived that articulated gall shape from the intended practice was analogous to experts demarcation.

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