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Accurate Border Detection of Skin Lesions in Skin Cancer Images using Log Edge Detector

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Abstract

Edge detection is an imperative method for image segmentation since edges frequently connote a transition area from one homogenous region to another. The human vision system is experimentally conformed to be very sensitive to edges while considering segmentation. Edge detection is a excellent choice for objects with strong edges. But all the images will not have strong edges and they may also have weak edges and hence need to exploit the weak edges to aid in segmentation. It becomes vital and hence need to propose a new segmentation algorithm that addresses weak edges gained attention. To address this problem, in this paper, we have proposed a segmentation algorithm based on log edge detector, it considers the finding of exact border even for medical skin cancer images with weak edges and other problems like low contrast, Irregular border, Variegated coloring, presence of Hairs and Bubbles. Through this method, we can improve segmentation accuracy. The experimental results of our proposed model demonstrated the successful segmentation of skin images with weak edges and other problems, and makes them accessible for further analysis and research. We conclude that our proposed algorithm is successful in segmenting medical skin cancer images and other skin lesion images and its performance is more reliable and accurate than the existing segmentation algorithms LSM and VLS.

Keywords: Segmentation; LOG Edge detector; Medical images; Median filtering

INTRODUCTION

Medical imaging refers to the techniques and processes used to generate images of the human body for assorted clinical purposes such as medical procedures and diagnosis or medical science including the study of normal anatomy and function[1].

In the last two decades, a lot of attempts have been made to improve the clinical diagnosis of melanoma, by the dermoscopy technique which is a non-invasive in clinical examination which allows for a magnified and lucid visualization of the morphological structures of the skin that are not visible to the naked eye[2].

Dermoscopy is one of the major imaging modalities used in the diagnosis of melanoma and other skin lesions. Melanoma can be cured by simple erasure, when diagnosed at an early stage. Early diagnosis is a challenge, especially for general practitioners, as melanomas are hard to distinguish from common moles, even for experienced dermatologists. Due to the difficulty and subjectivity of human interpretation, computerized analysis of dermoscopy images has become an key research area. One of the most significant steps in dermoscopy image analysis is the automated detection of lesion borders[3].

Automated border detection is a exigent task due to several reasons: (i) low contrast between the lesion and the surrounding skin (Fig. 1(a)), (ii) irregular (Fig. 1(b)) lesion borders, (iii) hairs (Fig. 1(c)), and air bubbles (Fig. 1(d)), (iv) variegated colouring inside the lesion (Fig. 1(e)) [4].

(a) (b) (c) (e) (d)

Figure 1. Problems with border detection

a) Low contrast (b) Irregular border (c) Hairs (d) Bubbles (e) Variegated coloring

In many systems of computer vision, image segmentation plays a vital role. Image segmentation is used to locate objects and boundaries in images. The good performance of recognition algorithms depend on the quality of segmented image[5]. In medical imaging applications, boundary detection has been renowned as one of the intricate problems in image processing and pattern analysis, in particular. The problem is complex because of other information corrupting the lucidity of the image.

Image segmentation algorithms are generally based on one of the two basic properties of intensity values: discontinuity and similarity. In the first category, the approach is to partition an image based on abrupt changes in intensity, such as edges in an image. The principle approaches in the second category are based on partitioning an image into regions that are similar according to a set of predefined criteria. Thresholding, region growing, and region splitting and merging are examples of methods in this category[6].

Edge detection is an important method for image segmentation since edges frequently represent a transition area from one homogenous region to another. The human vision system is experimentally conformed to be very sensitive to edges while considering segmentation. The common edge detection algorithms are Canny edge detector, Laplacian of Gaussian detector, Sobel edge detector, Prewitt edge detector, Roberts edge detector which comes under the first category, in which the segmentation algorithms are based on the approach to partition an image based on abrupt changes in intensity, such as edges in an image.

Edge detection is a good choice only with objects with strong edges. But all the images will not have strong edges and they may also have weak edges and hence need to exploit the weak edges to help in segmentation. It becomes essential and hence need to propose a new segmentation algorithm that addresses weak edges gained attention.

Hence in this paper we have proposed a segmentation algorithm based on log edge detector, it considers the finding of exact border point even for medical images with weak edges and other problems.

The rest of the paper is organized as follows: section 2 states about the related work regarding this topic, section 3 states the proposed methodology, section 4 demonstrates the results to show the effectiveness of our new method and the conclusion is drawn in section 5.

REVIEW OF RELATED WORKS

In medical image analysis image segmentation is a vital task. Because of the diversity and complexity of images, the design of robust and efficient segmentation algorithm is still a very challenging research topic. The main challenge is to retrieve high-level information from low-level image signals, by minimizing the effect of noise, intensity inhomogeneity, and other factors in low-level image signals [13]. To address the challenges, a variety of image segmentation methods have been proposed for this purpose.

Li Wang et al. [7] proposed a new region-based active contour model in a variational level set formulation for image segmentation. The local image intensities are described by Gaussian distributions with different means and variances. With a level set function and local means and variances as variables, a local Gaussian distribution fitting energy was defined. In an iterative process, the energy minimization is achieved by an interleaved level set evolution and estimation of local intensity means and variances. To handle intensity inhomogeneities and noise of spatially varying strength (e.g. multiplicative noise), the means and variances of local intensities are considered as spatially varying functions.

F. Ercal et al. [8] proposed, a simple and yet effective method to find the borders of tumours as an initial step towards the diagnosis of skin tumours from their colour images. To discriminate the tumour from the background, this method makes use of an adaptive colour metric from the red, green, and blue (RGB) planes that contain information. The image is segmented, using this suitable coordinate transformation, from the segmented image, the tumour portion is then extracted and borders are drawn.

L. Xu et al. [9] developed a three step segmentation method using the properties of skin cancer images. Their method has the following steps: 1.Preprocessing: a color image is first transformed into an intensity image in such a way that the intensity at a pixel shows the color distance of that pixel with the color of the background. The color of the background is taken to be the median color of pixels in small windows in the four corners of the image. 2. Initial segmentation: In the obtained intensity image, a threshold value is determined from the average intensity of high gradient pixels. The approximate lesion boundaries are found using this threshold value. 3. Region refinement: using edge information in the image, a region boundary is refined. This involves, at the approximate boundary, initializing a closed elastic curve, and shrinking and expanding it to fit to the edges in its neighbourhood.

Chunming Li et al. [10] presented a new variational formulation for geometric active contours that completely eliminates the need of the costly reinitialization procedure, since it forces the level set function to be close to a signed distance function. Their variational formulation consists of signed distance function, an internal energy term that penalizes the deviation of the level set function, and an external energy term that drives the motion of the zero level set toward the desired image features, such as object boundaries.

Roberto Rodriguez et al. [11] developed a segmentation algorithm where the entropy is used as stopping criterion in the segmentation process by using recursively the mean shift filtering.

Chunming Li et al. [12] proposed a method based on the assumption that the image can be approximated locally by a binary image. By introducing a local binary fitting energy, the proposed method is able to include local image intensity information into a region-based active contour model. This energy functional is further integrated into a variational level set formulation without reinitialization. Therefore, reinitialization is not needed in this model. This method is able to segment images with nonhomogeneous regions, weak object boundaries, and vessel like structures.

Meng-Husiun Tsai et al. [13] developed a cytoplast and nucleus contour (CNC) detector to divide the nucleus and cytoplast from a cervical smear image. This paper proposes the bi-group enhancer to make a clear-cut separation for the pixels laid between two objects, and the maximal colour difference (MCD) method to draw the exact nucleus contour.

M. Emre Celebi et al. [14] proposed an unsupervised approach to border detection in dermoscopy images based on the statistical region merging (SRM) algorithm. The SRM algorithm is adapted to this problem due to its simplicity, computational efficiency, and excellent performance in a variety of image domains.

M. Emre Celebi et al. [15] presented an overview of recent border detection methods and described the pre-processing, segmentation, and post processing steps involved in each method.

Kaihua Zhang et al. [16] proposed a new region-based active contour model that embeds the image local information. The model is able to segment images with intensity inhomogeneities, by introducing the local image fitting (LIF) energy to extract the local image information. To regularize the level set function, a novel method based on Gaussian filtering for variational level set is proposed. It can not only guarantee the smoothness of the level set function, but also remove the necessity of re-initialization, which is computationally very expensive.

Chunming Li, et al. [17] proposed a novel region-based method for image segmentation. A local intensity clustering property was derived, from a generally accepted model of images with intensity inhomogeneities, and therefore defines a local clustering criterion function for the intensities in a neighbourhood of each point. To define energy functional, this local clustering criterion is integrated over the neighbourhood center, which is converted to a level set formulation. By an interleaved process of level set evolution and estimation of the bias field, minimization of this energy is achieved. As a significant application, the method can be used for segmentation and bias correction of magnetic resonance (MR) images.

Kaihua Zhang et al. [18] proposed a novel locally statistical active contour model (LSM) for image segmentation in the presence of intensity inhomogeneity. The inhomogeneous objects are modelled as Gaussian distributions of different means and variances, and a moving window is used to map the original image into another domain, where the intensity distributions of inhomogeneous objects are still Gaussian but are better separated. The means of the Gaussian distributions in the transformed domain can be adaptively estimated by multiplying a bias field with the original signal within the window. A statistical energy functional is then defined for each local region, which combines the bias field, the level set function, and the constant approximating the true signal of the corresponding object.

PROPOSED APPROACH

Improved Iterative Edge Based Medical Image Segmentation Algorithm (IESIMF) using Iterative Log Edge Detector with Iterative Median Filtering.

In the proposed model, iterative median filtering is followed by the process of estimating the accurate border point. Estimation of accurate border is based on the iterative edge detection and the lesion border for medical skin image are traced by 8-connectivity.

In order to separate the lesion from the surrounding normal skin, a new improved iterative edge based segmentation algorithm using Log edge detector with iterative median filtering (IESIMF) for Medical skin images to detect the border of the lesion, has been developed and discussed. This algorithm is applied to the image containing the lesion. For edge detection Log edge detector is used.

The proposed algorithm consists of several steps which are explained below.

Step 1: Convert the RGB image to grayscale image .

Step 2: Add salt and pepper noise to the grayscale image. The noisy image is the input image.

Step 3: Filter the noise using iterative median filter as the background noise reduction technique . And the filtering is done by convolution of the image with a median filter mask of 3x3 neighbourhood and replacing the value of the center pixel in the neighborhood by the median value in the neighborhood. We obtain the filtered image when the center of the neighborhood passes through all the pixels in the image.

Step 4:Find the optimal threshold using ostu method.

Step 4: Convert the filtered image to a black and white image, based on the threshold obtained.

Step 5: Convert the black and white image obtained into xor image by performing xor operation of the black and white image with a matrix of all ones which is as the same size as the original image.

Step 6: Find the edges in the xor image using the Log edge detector .And the edge detected image is obtained.

In log edge detector the edge detection is based on second order derivatives.

Step 7: Trace the skin lesion Border of the image in any of the iterations from 1 to n using iterative edge detection.

After getting the edge detected image, then for each iteration i, for i=1 to n, n=2, 3, ,…….. the border of the object (Lesion) is traced. The border traced image obtained as output for iterations i=1 to n, as following:

Step7.1: For iteration 1

Give the edge detected image obtained at step 6, as input to the edge detector for the iteration 1. The edge detected image for the iteration 1 is obtained. Next find the pixel on the border of the object. The pixels with value one for the selected row is selected as the border pixel to trace the border of the skin for image segmentation at each iteration. Now the row and column co-ordinates of the pixel on the border of the object are found. Using this pixel found on the border of the lesion as the starting pixel the border of the lesion is traced for iteration 1, by 8-connectivity, using the improved iterative segmentation algorithm (IESIMF), successfully.

Step 7.2: For iteration 2 to n

For iterations 2 to n, give the output of the edge detector in the previous iterations (iteration 1 to iteration (n-1)) as input to the edge Detector. Next the pixel on the border of the object is found as said above. Using this pixel found on the border of the object (Lesion) as the starting pixel, the border of the lesion is traced for each iteration i, for i=2 to n, by 8-connectivity using the improved iterative segmentation algorithm with iterative filtering (IESIMF), successfully and the process ends when i > n.

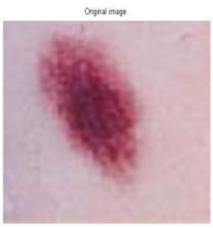
The Border detection sequence using the proposed Improved Iterative Edge based Segmentation Algorithm with iterative median filtering (IESIMF) is shown in Figure. 2. Here the edge detector used is LOG edge detector.

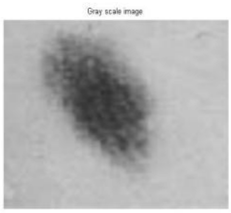
The iterative median filtering used helps in noise reduction and the iterative edge detection helps to identify the accurate border points of the lesion and then the border is traced by 8-connectivity.The advantage of the approach is that it will improve the performance of segmentation of medical images in terms of reliability and accuracy.

The performance of this newly proposed segmentation algorithm (IESIMF) is compared with the other skin image segmentation algorithms and the newly proposed algorithm performs better than other existing segmentation algorithms.

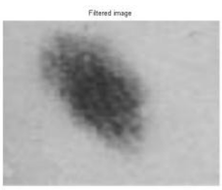
EXPERIMENTAL RESULTS

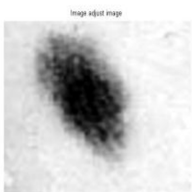
The proposed medical image segmentation algorithm has been implemented in MATLAB. The proposed algorithm is tested on assorted types of skin cancer images and skin lesion images and the segmentation results are obtained. The border detection sequence using the proposed algorithm is shown below.



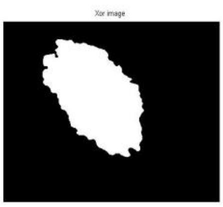


(a) Original image (b) Gray Scale Image.

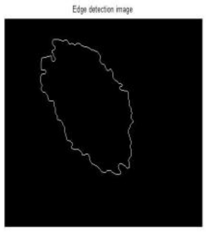


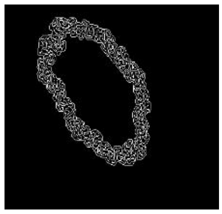


(c) Filtered image (d) Intensity Adjusted Image



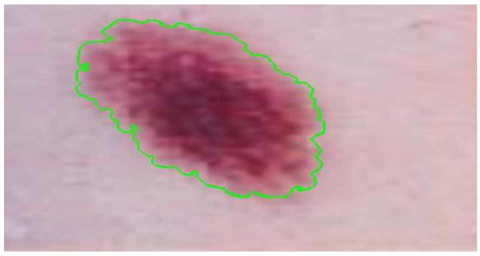
(e) Black and white image (f) xor image





(g) Edge Detected Image (h) Edge Detected Image at iteration i-1

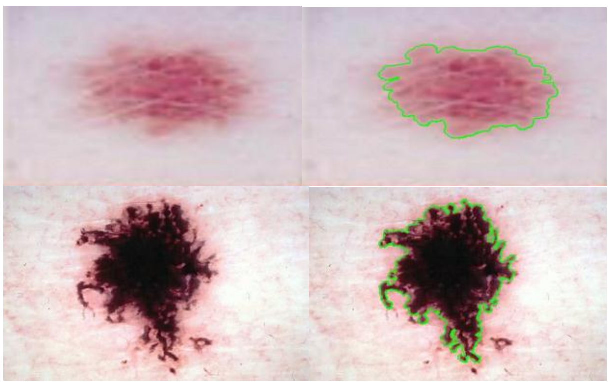
(i) Border detected image at iteration1 by proposed algorithm

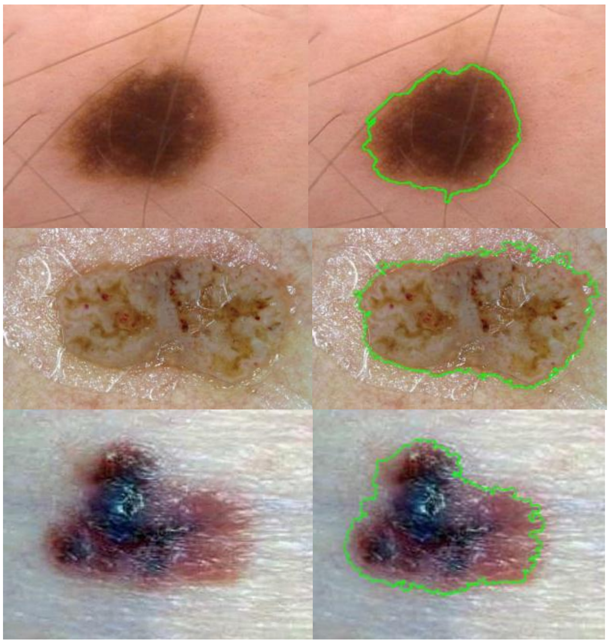


(j) Accurate Border detected image at iteration 10 by proposed algorithm due to the noval technique of iterative median filtering and iterative Log edge detection

Figure 2. Border detection sequence using the proposed Improved Iterative Segmentation Algorithm using LOG Edge Detector with iterative Median filtering

In the present research we have used iterative median filtering followed by an approach of pre-processing the medical image into xor image. The preprocessing is followed by edge detection using log edge detector. For accurate border point identification we have employed iterative edge detection of edge detected image of the previous iteration, and then the accurate border of the skin lesion is traced by 8-connectivity. Through this method, segmentation accuracy is improved.





(a) (b)

Figure 3. Segmentation results of the of the proposed algorithm (IESIMF)

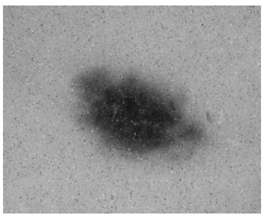
a)Original image b) Segmented image by proposed algorithm (IESIMF)

In Figure 3. first row shows segmentation results of low contrast image, second row shows segmentation results of image with irregular border, third row shows segmentation results of image with hairs, fourth row shows segmentation results of image with bubbles, fifth row shows segmentation results of image with variated colouring by the proposed algorithm(IESIMF).

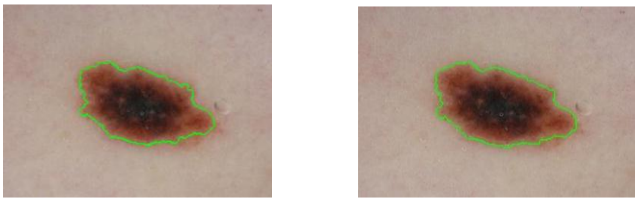
The proposed algorithm (IESIMF) is able to segment images with weak edges and other problems like low contrast irregular border,hairs, bubbles, and variated colour .

The method was tested for segmentation on a variety of medical skin images. It is found that the method is reliable on images even with and without noise. Furthermore, the method is simple but robust; it can extract objects and boundary smoothly.

(a)Original image without noise

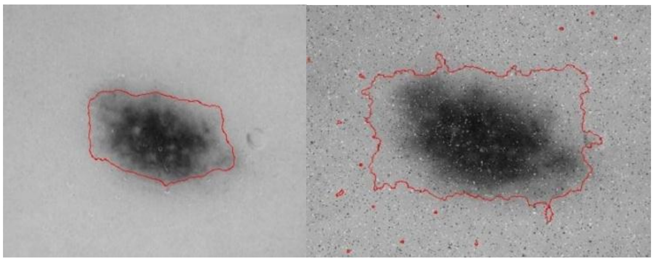


(b) Original image with noise



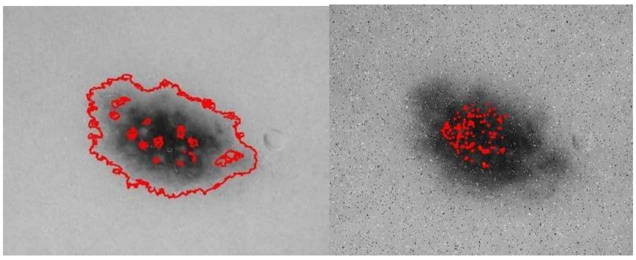
(e) Segmented output of original image without noise using proposed algorithm (IESIMF)

(f) Segmented output of original image with noise noise by proposed algorithm (IESIMF)



(e) Segmented output of original image without noise using VLS algorithm

(f) Segmented output of original image with noise by VLS algorithm.

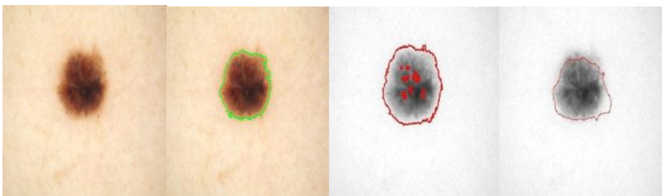


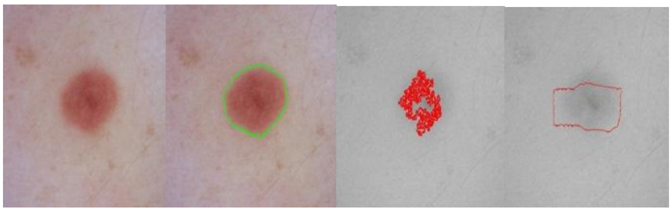
(e) Segmented output of original image without noise using LSM algorithm

(f) Segmented output of original image with noise by LSM algorithm

Figure 4. Segmentation of the original image with and without noise by the proposed IESIMF approach using log edge detector and by existing algorithms VLS,LSM

Figure 4. shows the better segmentation of the proposed approach IESIMF even with noise than the existing approaches VLS, LSM.





(a) (b) (c) (d)

Figure 5. Comparison of the accuracy of the proposed algorithm, (IESIMF), with the existing algorithms such as LSM,VLS.

a)Original image b) Segmented image by proposed algorithm (IESIMF) c) Segmented image by existing LSM
d) Segmented image by existing VLS

It can be seen from Figure 5 that the segmentation result of the proposed algorithm (IESIMF) is better than the existing algorithms

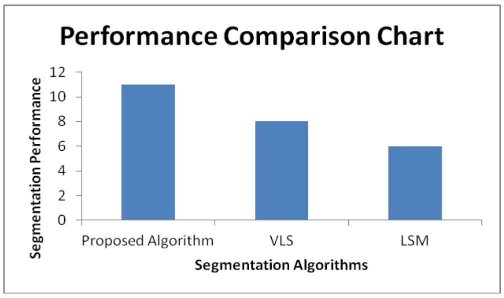


Figure 6. Performance comparison chart of the proposed Algorithm (IESIMF) with the existing VLS, LSM Algorithms

Figure 6. shows that the segmentation performance of the proposed Algorithm (IESIMF) is better than the existing algorithms like VLS, LSM . Here segmentation performance means number of correctly segmented medical images.

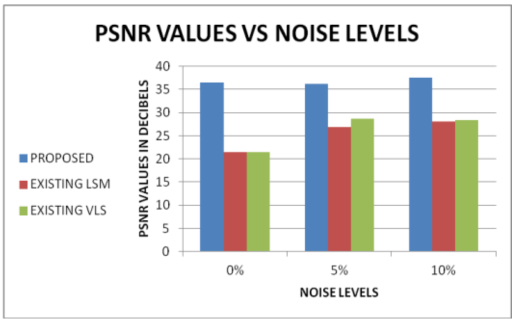


Figure 7. The PSNR values of segmented image of the proposed approach, the Existing LSM and VLS approaches, for different noise levels

It can be seen from Figure 7 that the PSNR value of the proposed algorithm (IESIMF) is better than the existing algorithm LSM for various noise levels.

CONCLUSION

In conclusion the proposed algorithm (IESIMF) has been designed to address the problem of segmentation of medical skin cancer images and other skin lesion images with weak edges and other problems. The main advantage of this approach is that there is no existing algorithm that combines iterative median filtering and iterative edge detection using log edge detector for accurate border point search for tracing the lesion border in skin images by 8-connectivity. Since in log edge detector the edge detection is based on second order derivatives which are very sensitive to noise and the use of iterative median filter reduce noise and makes the image more suitable for edge detection by log edge detector that is followed by iterative edge detection by log edge detector for accurate border point search and to trace the border of the skin lesion by 8-connectivity thus achieving better segmentation results, than the existing methods LS M [18] and VLS[10].

To validate the capability of the proposed segmentation algorithm in segmenting medical skin images with weak edges and other problems, the algorithm was applied on various skin images.The experimental results demonstrated the successful segmentation of images with and without weak edges and other problems by our proposed method and makes them available for further analysis and research. We conclude that our proposed algorithm IESIMF is successful in segmenting medical skin images with and without weak edges and other problems and its performance is more reliable and accurate than the existing segmentation algorithm LSM and VLS.

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