

# Segmentation of Salient Objects in Digital Image using Hybridization Gradient Based Technique

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**Abstract-** Segmentation of salient objects is essential application for classification of image, recognition of object and CBIR tasks. In this paper, authors implement a new approach for segmentation of salient region from a digital image using hybridization gradient techniques. Here authors project, smoothing a low intensity values using L<sub>0</sub> gradient minimization technique. After smoothing an image, applying gradient based segmentation. In experimental results, we use Flowers-17 database to check the effectiveness of the proposed approach. Authors show that proposed approach outperforms with gradient methods using recall, precision and F1-score.

**Index Terms-** Flower-17 Datasets, F1- Score, Gradient Based Method, L<sub>0</sub> Gradient Minimization, Precision, Recall.

## 1. INTRODUCTION

Image segmentation is an important procedure in image analysis, and it splits an image into its essential parts or objects in the image. The level of segmentation build on the problem of application. Segmentation method for images usually solves using two categories such as discontinuity and similarity of image intensity values. A rapid change in intensity comes in similarity and discontinuity category based on image partition into region [7][3]. Edge detection is a part of segmentation and it comes under discontinuity category. They are deals with changes in the pixel which differentiate object boundaries in an image [4]. Smoothing techniques useful in many applications such as image recognition, object classification and segmentation, numerous photo editing and non-photorealistic rendering tasks whereas smoothing techniques minimizing low amplitude values [8]. Always edge detection finds some sharp edges. when image is fully smoothing Gradient method is suitable for segmentation. It clearly identifies magnitude edges in x and y-direction gradient intensity distribution, it computes the overlap of image gradient with the boundaries determined by intensity distribution through introducing a probability offset to intensity distribution. The maximum overlap indicates the optimal boundaries of the interested objects [2].

In the overview of this paper, Authors describe review of segmentation using gradient method in Section 2. The segmentation using Hybridization Gradient Techniques is designed in Section 3, Then,

presented proposed experimental results discussed in Section 4. Lastly, in section 5 conclusion of our work.

## 2. RELATED WORK

In [7], proposed a modern technique related on segmentation in image processing, Analysis and Machine Vision techniques. In [Madhuri], presented a deep introduction to the fundamental concepts and methodologies of image processing. In [5], proposed classification of flower-17 dataset using bag of visual words model. In this paper, created the visual vocabulary in various aspects like color, shape, and texture. Experiment was conducted flower-17 dataset and it contains 1360 images in 17 categories of flower. In [8], proposed a new image editing method for natural images. The main aim of this work is sharpening major edges and eliminating minor edge of images using L<sub>0</sub> gradient minimization techniques. In [4], presented an edge detection technique for segmentation and comparison is done in experiment using matlab software. In [2], proposed a level set method using gradient information of image. It can tolerate estimation error in intensity distribution and detect object boundaries whose gradient is low and experimental results proved that proposed approach produces efficient results of segmentation on public lung image data. In [6], presented an image analysis based on first-order or second-order derivatives techniques. In this work, gradient method using edge detection is used on natural images. In [1], proposed novel techniques for preserving edges using multi-

scale image decompositions. This works based on bilateral filter for edge-preserving .

### 3. PROPOSED METHODOLOGY

To the best of authors knowledge, it is a novel work for segmentation of digital images using Hybridization Gradient based Techniques. The proposed methodology is shown in the Fig. 1. In this approach, smoothing an original image using L0 gradient minimization techniques. After smoothing an image Sobel operator used for gradient based segmentation. Kernel Sobel shown in Fig.3 .L0 gradient minimization technique is operative on major edges sharpening by growing the gradient of transition whereas eliminating a low-amplitude structure. It can control globally and count non-zero gradients result into the eminent structure in a sparsity approach. Edge-preserving smoothing approaches shown in Fig.2 [8].

#### 3.1. L0 Gradient Minimization Technique

Image representation of 2D, I symbolize the input image and S denotes the resultant image. The gradient  $\nabla S_p = (\partial_x S_p, \partial_y S_p)^T$  is gradient for each pixel p and calculated as color change between next to pixels of x and y directions [8] [1]. shown in equation-(1).

$$C(S) = \#\{p | |\partial_x S_p| + |\partial_y S_p| \neq 0\} \quad (1)$$

It calculate number of p and its magnitude  $|\partial_x S_p| + |\partial_y S_p|$  is not zero and S is estimation.

$$\min_S \left\{ \sum_p (S_p - I_p)^2 + \lambda \cdot C(S) \right\}$$

In the concept of color images,  $|\partial S_p|$  denote summation of gradient magnitudes in color image. The expression  $\Sigma(S-I)2$  gives structure similarity of an image [Farbman].

Equation-(2) produced discrete counting metric. So that, it is very problematic to solve by the two reason respectively i.e., global discontinuity statistically and pixel-wise difference. To solve this problem, implemented an optimization strategy with half-quadratic splitting techniques Based on auxiliary variables  $h_p$  and  $v_p$  develop original images update iteratively.

$$\min_{s, h, v} \left\{ \sum_p (S_p - I_p)^2 + \lambda \cdot C(h, v) + \beta \left( (\partial_x S_p - h_p)^2 + (\partial_y S_p - v_p)^2 \right) \right\} \quad (3)$$

Where  $C(h, v) = \#\{p | |h_p| + |v_p| \neq 0\}$  and  $\beta$  an parameter to control the similarity between auxiliary variables  $(h, v)$  and their similar gradients. Equation-(3) is shows alternatively minimizing  $(h, v)$  and S.

Subproblem 1: To computing S: The equation is quadratic and therefore has a global minimum even by gradient decent. Instead, transform derivative operators afterward Fast Fourier Transform (FFT) for speedup. This yields solution

$$\min_p \left\{ \sum_p (S_p - I_p)^2 + \beta \left( (\partial_x S_p - h_p)^2 + (\partial_y S_p - v_p)^2 \right) \right\}, \quad (4)$$

$$S = \mathcal{F}^{-1} \frac{\mathcal{F}(I) + \beta \left( \mathcal{F}(\partial_x)^* \mathcal{F}(h) + \mathcal{F}(\partial_y)^* \mathcal{F}(v) \right)}{\mathcal{F}(1) + \beta \left( \mathcal{F}(\partial_x)^* \mathcal{F}(\partial_x) + \mathcal{F}(\partial_y)^* \mathcal{F}(\partial_y) \right)}, \quad (5)$$

Subproblem 2: computing  $(h, v)$  The objective function for  $(h, v)$  is

$$\min_{h, v} \left\{ \sum_p \left( (\partial_x S_p - h_p)^2 + (\partial_y S_p - v_p)^2 \right) + \frac{\lambda}{\beta} C(h, v) \right\}, \quad (6)$$

$$\sum_p \min_{h_p, v_p} \left\{ \sum_p \left( (h_p - \partial_x S_p)^2 + (v_p - \partial_y S_p)^2 \right) + \frac{\lambda}{\beta} H(|h_p| + |v_p|) \right\} \quad (7)$$

$$E_p = \left\{ \left( (h_p - \partial_x S_p)^2 + (v_p - \partial_y S_p)^2 \right) + \frac{\lambda}{\beta} H(|h_p| + |v_p|) \right\}, \quad (8)$$

$$(h_p, v_p) = \begin{cases} (0, 0) & (\partial_x S_p)^2 + (\partial_y S_p)^2 \leq \frac{\lambda}{\beta} \\ (\partial_x S_p, \partial_y S_p) & \text{otherwise} \end{cases} \quad (9)$$

(2) Proof,

When  $\frac{\lambda}{\beta} \geq (\partial_x S_p)^2 + (\partial_y S_p)^2$ , non-zero  $(h_p, v_p)$  yields

$$E_p = \left( (h_p, v_p) \neq (0, 0) \right) = (h_p - \partial_x S_p)^2 + (v_p - \partial_y S_p)^2 + \frac{\lambda}{\beta} \geq \frac{\lambda}{\beta} \geq (\partial_x S_p)^2 + (\partial_y S_p)^2 \quad (10)$$

Note that  $(h_p, v_p) = (0, 0)$  lead to

$$E_p \left( (h_p, v_p) = (0, 0) = (\partial_x S_p)^2 + (\partial_y S_p)^2 \right) \quad (11)$$

Comparing Equation (10) and (11), the minimum energy  $E_p^* = (\partial_x S_p)^2 + (\partial_y S_p)^2$  is produced when  $(h_p, v_p) = (0, 0)$ .

**Algorithm for L0 Gradient Minimization**

**Input:** image I, smoothing weight  $\lambda$ , parameters  $\beta_0, \beta_{max}$ , and rate  $\kappa$   
 Initialization:  $S \leftarrow I, \beta \leftarrow \beta_0, i \leftarrow 0$   
**repeat**  
 With  $S(i)$ , solve for  $h(i)$   
 $p$  and  $v(i)$   
 $p$  in Eq. (9).  
 With  $h(i)$  and  $v(i)$ , solve for  $S(i+1)$  with Eq. (5).  
 $\beta \leftarrow \kappa \beta, i++$ .  
 until  $\beta \geq \beta_{max}$   
**Output:** result image S.

$$\nabla f = \begin{bmatrix} G_x \\ G_y \end{bmatrix} = \begin{bmatrix} \frac{\partial f}{\partial x} \\ \frac{\partial f}{\partial y} \end{bmatrix}, \tag{11}$$

where  $\nabla f$  = Gradient vector

$G_x$  = Gradient of x-direction

$G_y$  = Gradient of y-direction

$$\nabla f = \text{mag}(\nabla f)$$

$$|G| = \sqrt{G_x^2 + G_y^2}$$

$$|G| = |G_x| + |G_y|, \tag{12}$$

Where  $\nabla f$  = Magnitude of gradient vector

$|G_x|$  = Magnitude of gradient x-direction

$|G_y|$  = Magnitude of gradient y-direction

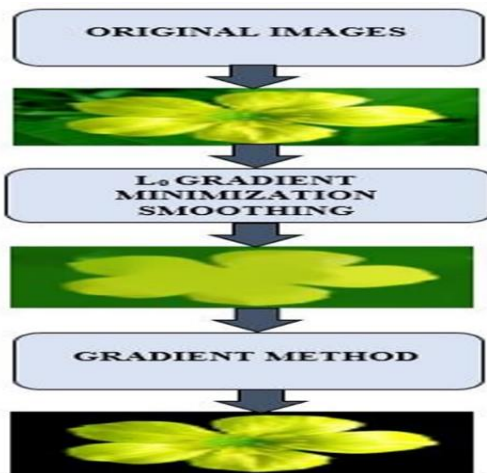


Fig.1: Proposed methodology for Segmentation of salient objects.

$$\text{Grad} = \max(\nabla f) \tag{13}$$

where Grad = maximum of magnitude of gradient.

$$h(\text{Grad}) = \text{hist}(\text{Grad}) \tag{14}$$

Where  $h(\text{Grad})$  = histogram of Magnitude of gradient vector

$$Q = \text{prctile}(h(\text{Grad}), 0.1) \tag{15}$$

Where

$Q$  = Percentiles of a data set histogram of Magnitude of gradient vector

$$\text{marker image} = \text{Grad} > Q \tag{16}$$

$$h(\text{marker image}) = \text{hist}(\text{marker image}) \tag{17}$$

where  $h(\text{marker image})$  = histogram of marker image

$$\text{Tresh} = \begin{cases} 1 & \text{if } h(\text{marker image}) \geq T \\ 0 & \text{otherwise} \end{cases} \tag{18}$$

where  $\text{Tresh}$  is a thresholded image  $h(\text{marker image})$  at global threshold  $T$ . Next step image converted into black and white image using  $\text{Tresh}$  value finally convolution function applied for original and  $\text{Otsuthresh}(\text{Tresh})$  image after obtaining segmented image.

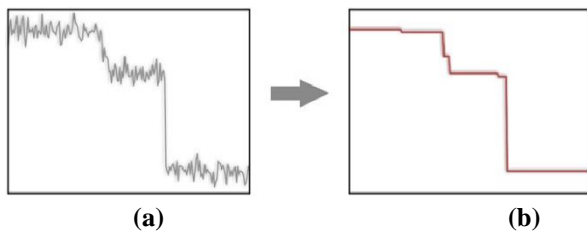


Fig.2: Smoothing edges using L0 gradient (a) Significant edges (b)Suppression of significant edges.

**3.2. Gradient Based Technique**

The Sobel edge detection significantly detect local variation in image intensity level. The intensity variation is measured by the image gradient. Since an image  $f(x, y)$  is a two-dimensional and its gradient is form of vector. The vector and gradient magnitude computed in x and y-direction shown in Equation (10)-(11).

$$f = \sum_{i=1}^i \sum_{j=1}^j f(x, y) \tag{10}$$

**4. RESULT AND DISCUSSION**

In this work, proposed approach on flower-17 category benchmark dataset is used [5] and considered 321 images for experiment. Fig 4 displays the Comparison of Gradient method and proposed method. Fig. 5 shows experimental result in graphical representation.

**4.1. Precision and Recall and F1-Score**

In experimental results, Hybridization Gradient Technique and traditional Gradient Techniques is comparison of accuracy using Precision and Recall and F1-Score. In this work, the target region segmentation is called True Positive (TP) class, non-target region segmentation is called True Negative (TN) class.

$$Precision = \frac{TP}{TP + FP} \quad (19)$$

$$Recall = \frac{TP}{TP + FN} \quad (20)$$

$$F1\ Score = 2 * \frac{(Precision * Recall)}{(Precision + Recall)} \quad (21)$$

Table 1. Evaluate performance of proposed method with Gradient technique.

Sl.no	Techniques	Precision	Recall	F1 Score
1	Proposed method	57.43	98.25	80.02
2	Gradient based method	52.10	94.08	75.57

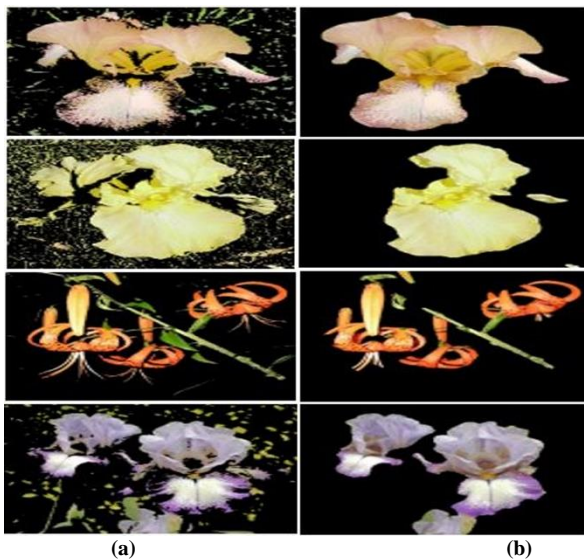


Fig. 4: Comparison of Gradient based segmentation and proposed method (a)Gradient method (b) proposed method.

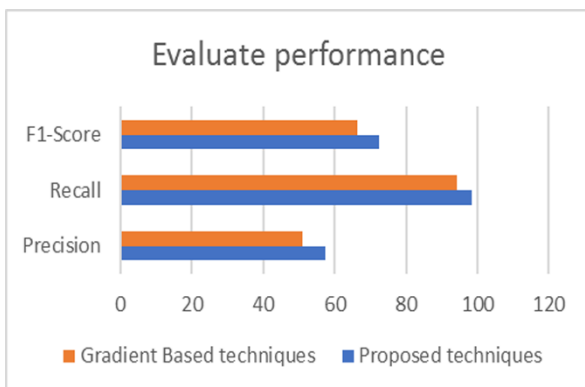


Fig. 5: Comparison of proposed techniques with Gradient based technique.

## 5. CONCLUSION

In this paper, Authors proposed a novel approach hybridization of gradient based technique for segmentation of salient objects. First, existing editing tool  $L_0$  gradient minimization techniques significantly supportive for describing and enhancing essential image elements, i.e., salient sharpening major edges and diminishing insignificant minor edge details. It relays in essence to edge-preserving smoothing. Second, gradient method applies for  $L_0$  gradient minimization smoothing images. finally, obtained segmented images and it depend on important global edges. Experimentally demonstrates that proposed method for Flowers-17 dataset images, it shows good segmentation results compares to the traditional gradient based method.

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