Image Inpainting

Mid-Evaluation Project Report

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ANISOTROPIC DIFFUSION:

The information L is to be propagated in the time varying direction of the isophotes i.e., N(i,j,n). To ensure correct evolution of the direction, anisotropic diffusion is required. The direction estimation is coarse at the beginning but progressively achieves the desired continuity at boundary of the area to be inpainted.

Anisotropic diffusion is implemented by referring the following paper:

'P. Perona and J. Malik - *Scale-space and edge detection using anisotropic diffusion*'

Objectives achieved through anisotropic diffusion:
1) No spurious details generated passing from finer to coarser scales.
2) Boundaries should be sharp
3) Intraregion smoothing occurs preferentially over intraregion smoothing

Equations used:

Anisotropic Equation for 8-nearest neighbors :-

$$I_{i,j}^{t+H} = I_{i,j}^{t} + \frac{1}{8}\left[C_N \cdot \nabla_N I + C_S \cdot \nabla_S I + C_E \cdot \nabla_E I + C_W \cdot \nabla_W I + C_{NE} \cdot \nabla_{NE} I + C_{NW} \cdot \nabla_{NW} I + C_{SE} \cdot \nabla_{SE} I + C_{SW} \cdot \nabla_{SW} I \right]$$

Diffusion constants for eight directions:-

$$c\_N = g(\|\nabla_N I\|) \; ; \; c\_NE = g(\|\nabla_{NE} I\|)$$

$$c\_S = g(\|\nabla_S I\|) \; ; \; c\_NW = g(\|\nabla_{NW} I\|)$$

$$c\_E = g(\|\nabla_E I\|) \; ; \; c\_SE = g(\|\nabla_{SE} I\|)$$

$$c\_W = g(\|\nabla_W I\|) \; ; \; c\_SW = g(\|\nabla_{SW} I\|)$$

where

$$\nabla_N I_{ij} \equiv I_{i-1,j} - I_{i,j} \; ; \; \nabla_{NE} I \equiv I_{i-1,j+1} - I_{i,j}$$

$$\nabla_S I_{ij} \equiv I_{i+1,j} - I_{i,j} \; ; \; \nabla_{NW} I = I_{i-1,j-1} - I_{i,j}$$

$$\nabla_E I_{ij} \equiv I_{i,j+1} - I_{i,j} \; ; \; \nabla_{SE} I = I_{i+1,j+1} - I_{i,j}$$

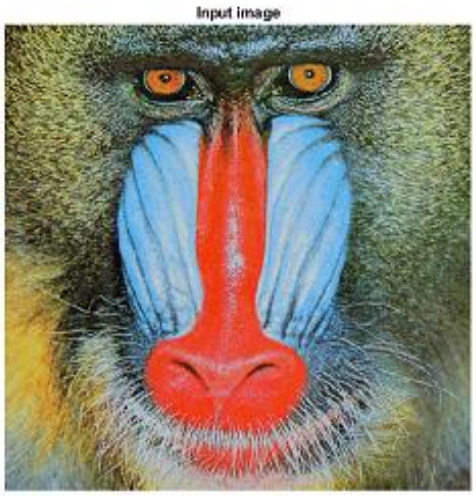
$$\nabla_W I_{ij} \equiv I_{i,j-1} - I_{i,j} \; ; \; \nabla_{SW} I = I_{i+1,j-1} - I_{i,j}$$

$$g(x) = \frac{1}{1 + \left(\frac{x}{K}\right)^2} \qquad (K = \text{user defined constant})$$

Outputs:


Input image


Image after anisotropic diffusion


Input image

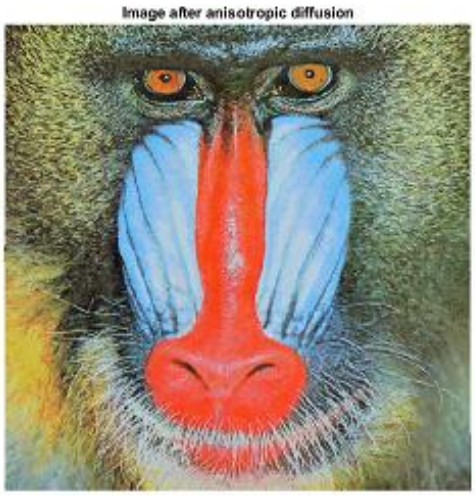


Image after anisotropic diffusion

Text Detection:

Objective: To detect text embedded in images or images with complex background.

Idea: The edges of text symbols are stronger than those of noise or background areas.

Algorithm:

1.If the given image is an RGB image Converted it to grayscale else proceeded from step2.

2.A Gradient image(G) and an edge image (E) is obtained by applying the edge detection filters such as sobel operator(Simple and widely used) and setting the threshold to t1(suppresses the weak edges) .

$$t_1 = \sqrt{4\sum_{i=1}^{h-1}\sum_{j=1}^{w-1}(G_x^2(i,j) + G_y^2(i,j))/(h-1)(w-1)},$$

3.Now the edge image is partitioned into pixel blocks of nxn. The number n and significance of edges within the block determine if the block contains the text or non text.

4.Created a new image B where each pixel represents the corresponding block of I.

5.For each pixel in B(i.e for each block in I) calculated the values of R using edge and gradient image. If R>=t2,the block is informative(contains text) otherwise it is non informative(do not contain text).

$$\Re = \sum_{i=1}^{n}\sum_{j=1}^{n}\mathcal{H}(G(i,j) - t_1)\mathcal{H}(E(i,j) - 1), \quad (3)$$

$$\Re = \frac{\sum_{i=1}^{n}\sum_{j=1}^{n} G(i,j)\mathcal{H}(G(i,j) - t_1)\mathcal{H}(E(i,j) - 1)}{n^2}, \quad (4)$$

$$\Re = \frac{\sum_{i=1}^{n}\sum_{j=1}^{n} G(i,j)\mathcal{H}(G(i,j) - t_1)\mathcal{H}(E(i,j) - 1)}{\sum_{i=1}^{n}\sum_{j=1}^{n} \mathcal{H}(G(i,j) - t_1)\mathcal{H}(E(i,j) - 1)}, \quad (5)$$

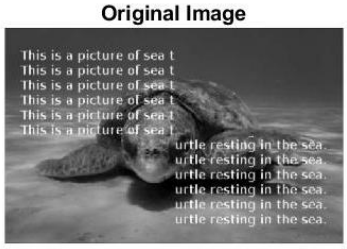
where $\mathcal{H}$ is the step function:

$$\mathcal{H}(x-a) = \begin{cases} 1 & \text{if } x \geq a, \\ 0 & \text{if } x < a. \end{cases} \quad (6)$$

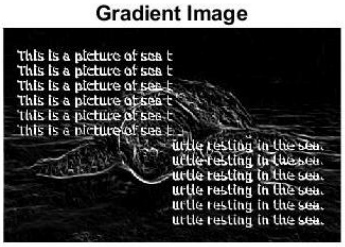
6.Finally the output image is given by thresholding B with a threshold t2.

Outputs :

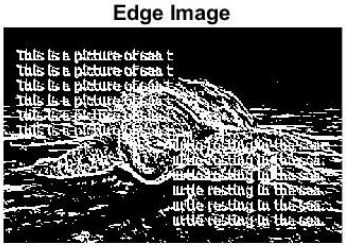
Original Image



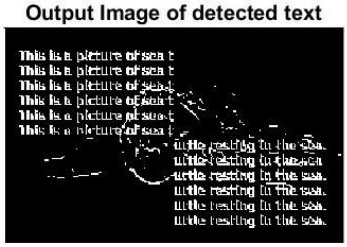
Gradient Image



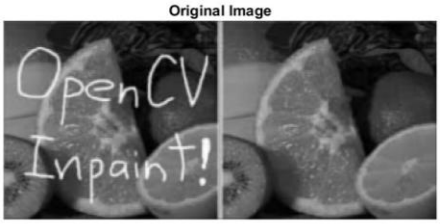
Edge Image



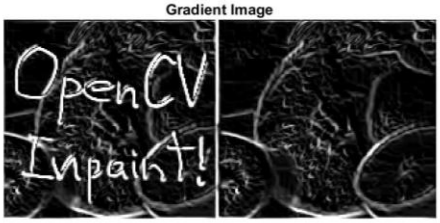
Output Image of detected text



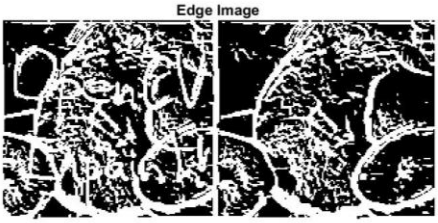
Original Image



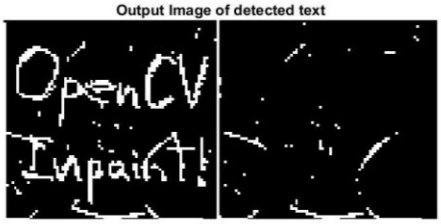
Gradient Image



Edge Image



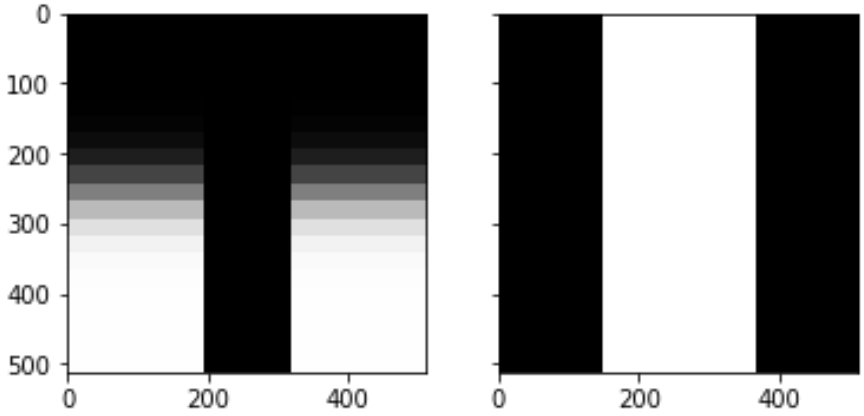
Output Image of detected text

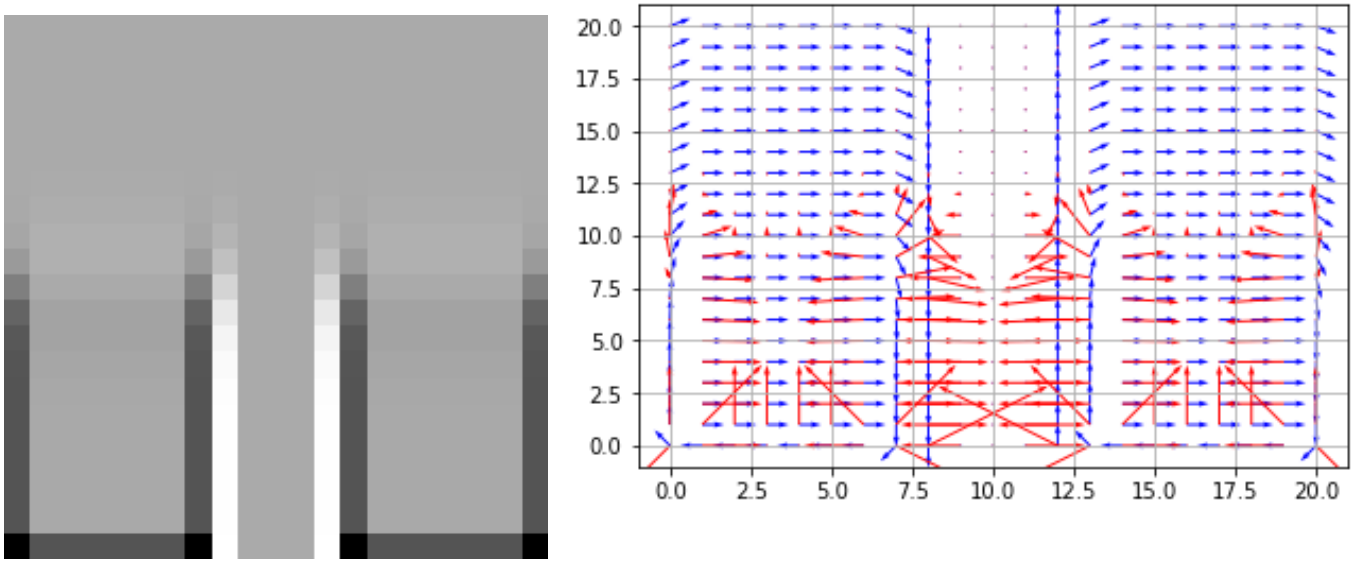


ISOPHOTE PROPAGATION

The inpainting algorithm was coded and run on a test image.

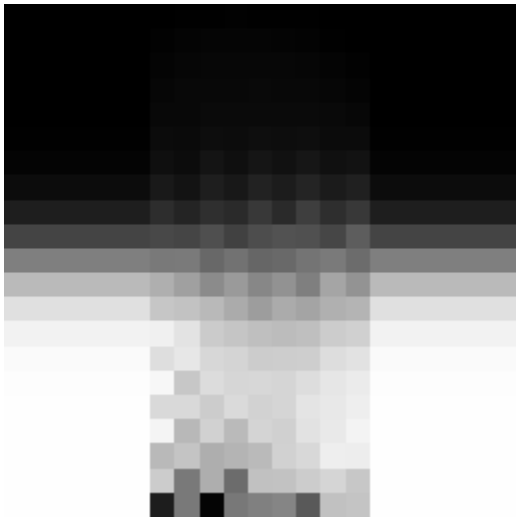
The start point was as follows:

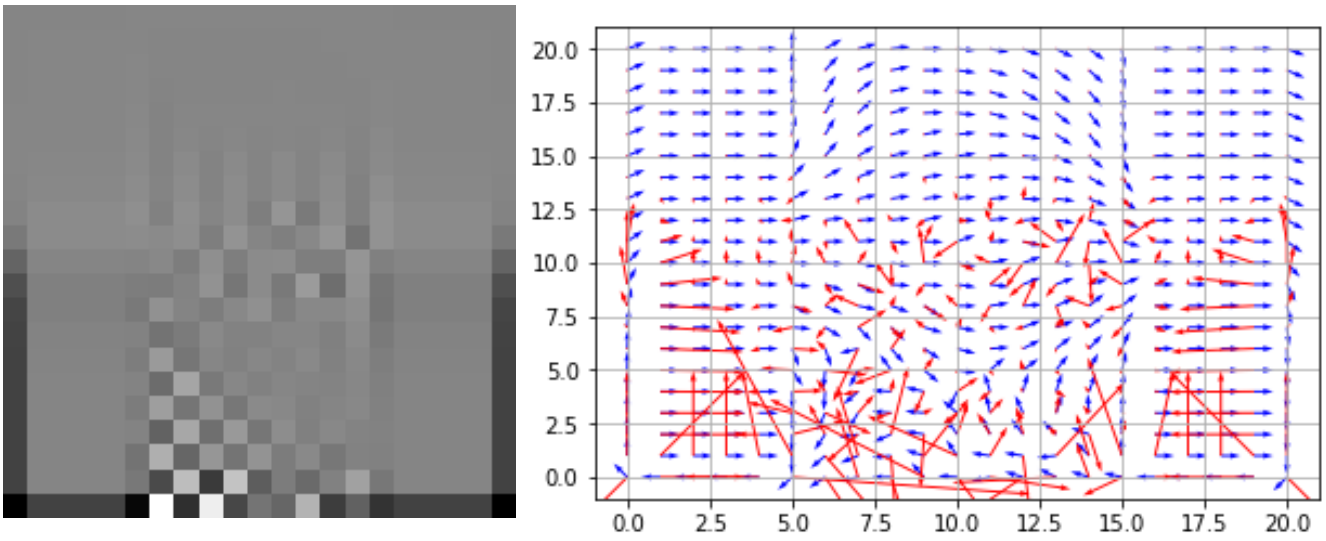




(i) The original image followed by mask. (ii) Laplacian (iii) norm of gradient in blue, gradient of L in red

and after 10000 iterations we get:





(i) The resulting image followed by mask. (ii) Laplacian (iii) norm of gradient in blue, gradient of L in red

Things to do:

1. Show how values of L (Laplacian) and deL (gradient of L) and norm change

2. Significance of sL_Grad (normalised gradient) and B (sign of dot(deL,norm))

3. Why is anisotropic diffusion required?

4. Should part to be inpainted be set to zero or any value?

5. How much does bad text detection matter?

6. Best padding that we can use? Constant values may cause inconsistencies.

7. Explain why L is used.

8. Explain how isophote is propogated.