Gaussian Matched Filters

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Marzo del 2019
Cubo- I304, Ext. 4506

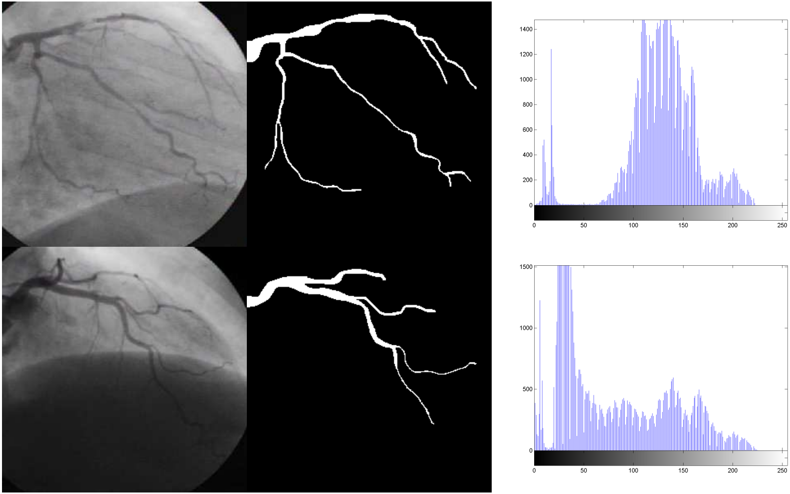
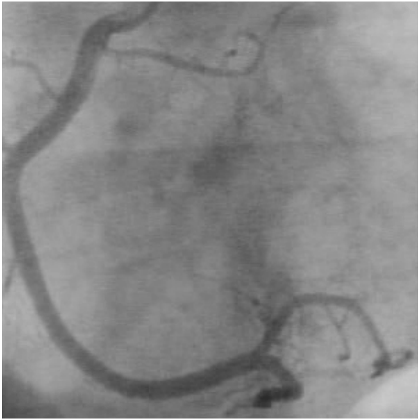


Figure: Angiograma original, ground-truth e histograma.

Seleccionando una ROI.



Seleccionando una ROI.

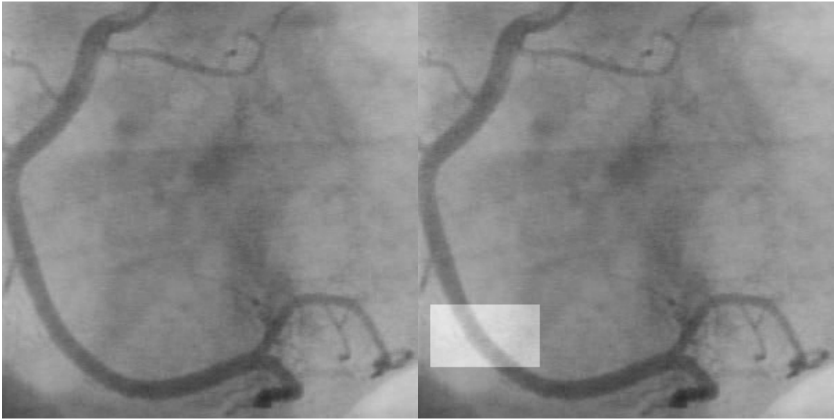


Figure: (a) Angiograma original, (b) ROI (resaltada).

ROI de 79×45 pixeles

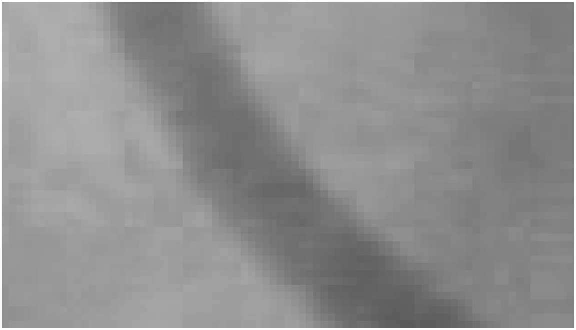


Figure: Región de interés original.

ROI en Negativo

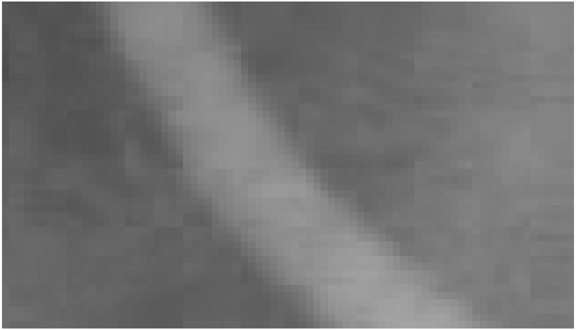


Figure: ROI en Negativo. $g(x, y) = 255 - f(x, y)$

ROI en Negativo

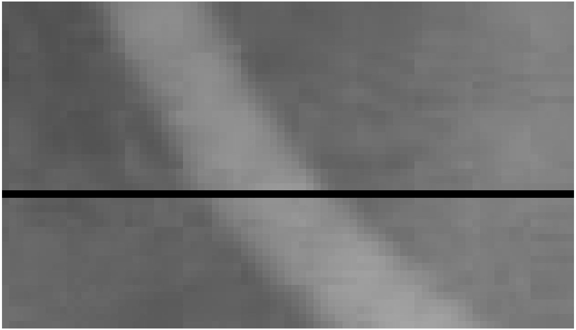
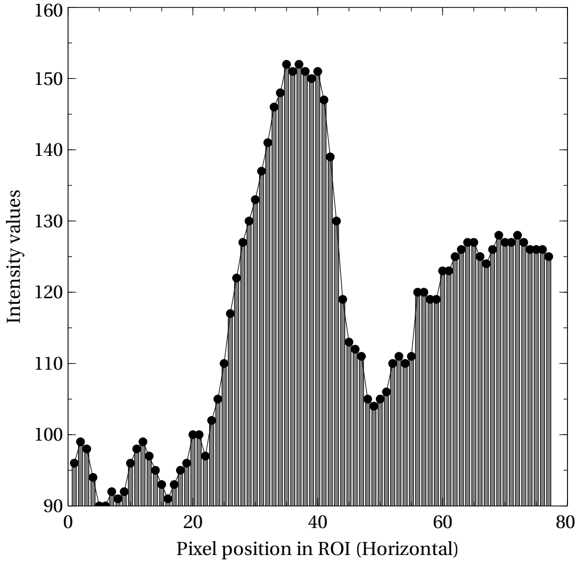


Figure: ROI en Negativo. $g(x, y) = 255 - f(x, y)$

Intensidad vs Posición



Propuesta original

IEEE TRANSACTIONS ON MEDICAL IMAGING, VOL. 8, NO. 3, SEPTEMBER 1989 263

Detection of Blood Vessels in Retinal Images Using Two-Dimensional Matched Filters

SUBHASIS CHAUDHURI, STUDENT MEMBER, IEEE, SHANKAR CHATTERJEE, MEMBER, IEEE, NORMAN KATZ, MARK NELSON, AND MICHAEL GOLDBAUM

***Abstract*—Although current literature abounds in a variety of edge detection algorithms, they do not always lead to acceptable results in extracting various features in an image. In this paper, we address the problem of detecting blood vessels in retinal images. Blood vessels usually have poor local contrast and the application of existing edge detection algorithms yield results which are not satisfactory. We introduce an operator for feature extraction based on the optical and spatial properties of objects to be recognized. The gray-level profile of the cross section of a blood vessel is approximated by a Gaussian shaped curve. The concept of matched filter detection of signals is used to detect piecewise linear segments of blood vessels in these images. We construct 12 different templates that are used to search for vessel segments along all possible directions. We discuss various issues related to the**

of noise in the image degrades the performance of gradient based algorithms appreciably. The use of gray-scale morphology has been suggested in [3]. It involves simple erosion and dilation operators and can be implemented for real time processing by using suitable hardware. This algorithm appears to work better in extracting edges from images with salt-and-pepper type of noise.

The Sobel operator involves the computation of local intensity gradients and the responses due to nonideal step edges are not good. A modification of that is the detection of second-order zero-crossings, and the corresponding

Método de detección Gaussian Matched Filters[1]

$$K(x, y) = -\exp\left(-\frac{x^2 + y^2}{2\sigma^2}\right)$$

[1] S. Chaudhuri, S. Chatterjee, N. Katz, M.Nelson, and M. Goldbaum, "**Detection of blood vessels in retinal images using two-dimensional matched filters**", *IEEE Transactions on Medical Imaging*, vol. 8, pp. 263-269, 1989.

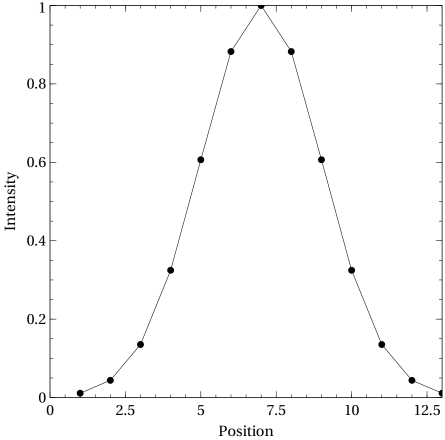
Método de detección Gaussian Matched Filters[1]

$$K(x, y) = -\exp\left(-\frac{x^2 + y^2}{2\sigma^2}\right)$$

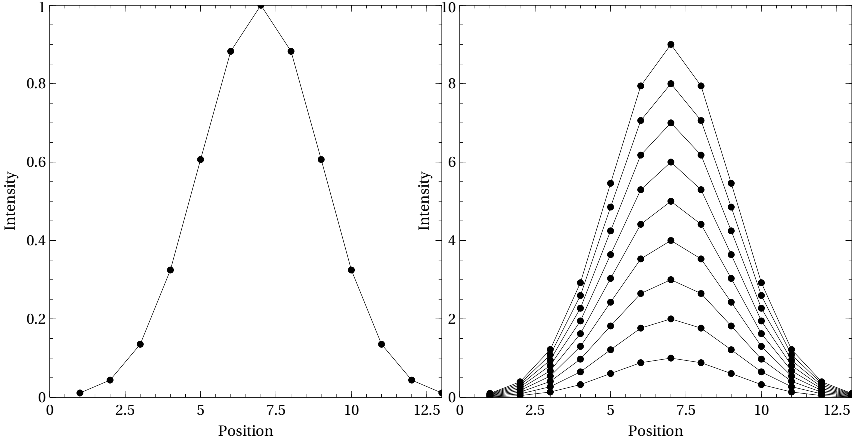
```
T=13;
sigma = 2;
x = [-floor(T/2): floor(T/2)];
tmp1 = exp(-(x.*x) / (2*sigma*sigma));
figure;plot(tmp1);
```

[1] S. Chaudhuri, S. Chatterjee, N. Katz, M.Nelson, and M. Goldbaum, "**Detection of blood vessels in retinal images using two-dimensional matched filters**", *IEEE Transactions on Medical Imaging*, vol. 8, pp. 263-269, 1989.

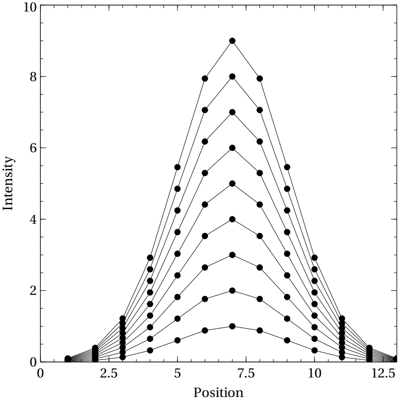
Generando Gaussianas



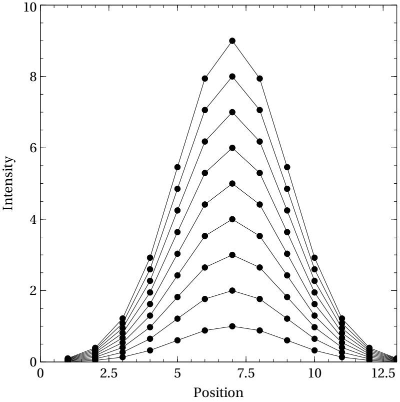
Generando Gaussianas

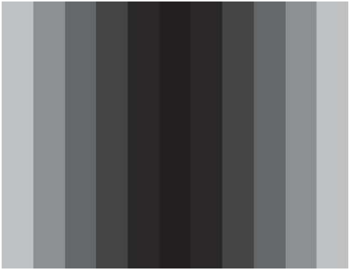


Generando una plantilla Gaussiana

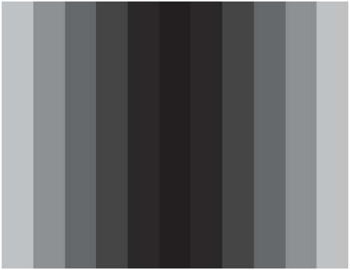


Generando una plantilla Gaussiana





Respuesta del filtro Gaussiano



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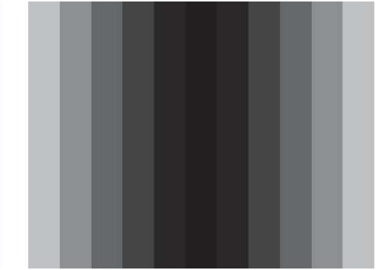

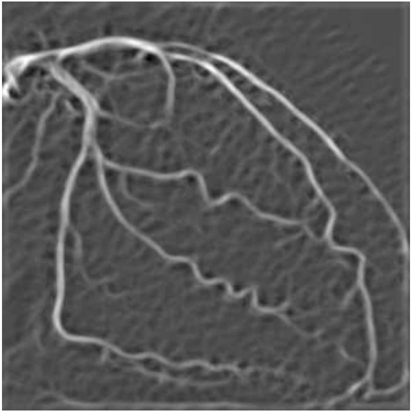

GMF: 4 parámetros

$T = 13, L = 9, \sigma = 2.0$
$\kappa = 12, \theta = 15$

$$G(x,y) = -\exp\left(-\frac{x^2+y^2}{2\sigma^2}\right), \quad |y| \leq L/2 \tag{1}$$

$$\kappa = \begin{bmatrix} \cos\theta_i & -\sin\theta_i \\ \sin\theta_i & \cos\theta_i \end{bmatrix}, \tag{2}$$

$\kappa \in [-\frac{\pi}{2}, \frac{\pi}{2}]$,
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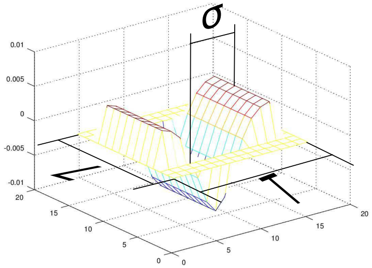

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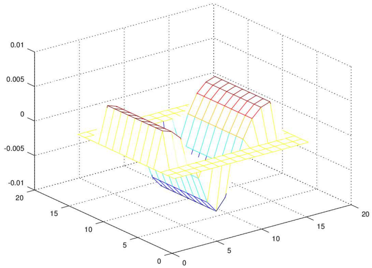

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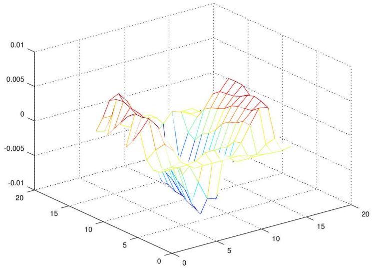

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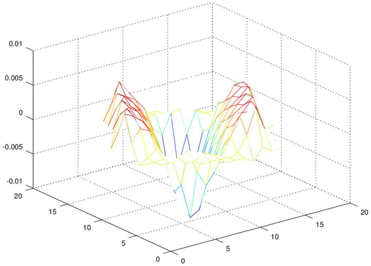

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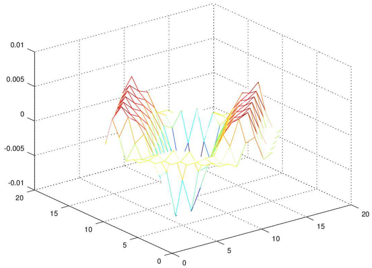

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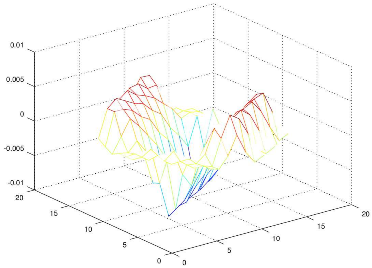

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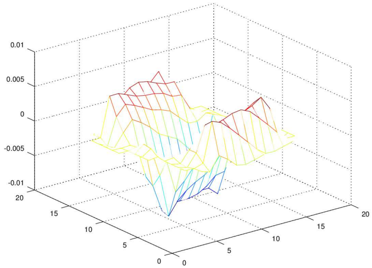

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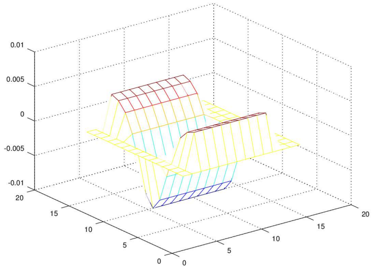

$\kappa \in [-\frac{\pi}{2}, \frac{\pi}{2}]$,
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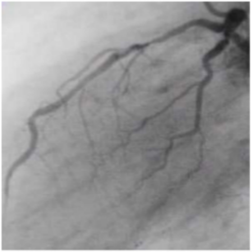
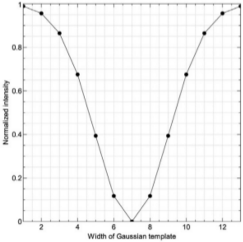
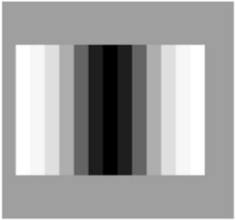


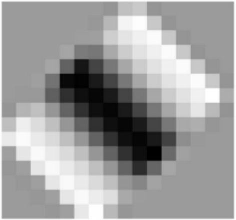
(a)

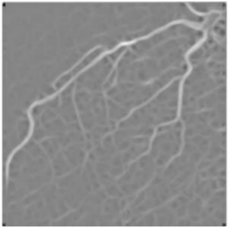
(b)


Normalized intensity
Width of Gaussian template
0
0.2
0.4
0.6
0.8
1
2
4
6
8
10
12

(c)







Variantes en literatura

I. Cruz-Aceves et al. / Computers and Electrical Engineering 53 (2016) 263–275

Table 1
Optimal parameters of different GMF vessel detection methods of the state-of-the-art.

Vessel detection method	Parameters					
Chaudhuri et al. [14–16]	$\sigma = 2.0$	$L = 9$	$T = 13$	$\kappa = 12$	$\theta = 15^{\circ}$	
Cinsdikici and Aydin [19]	$\sigma = 2.0$	$L = 9$	$T = 13$	$\kappa = 18$	$\theta = 10^{\circ}$	
Kang et al. [6,17,18]	$\sigma = 1.5$	$L = 9$	$T = 13$	$\kappa = 6$	$\theta = 30^{\circ}$	$S = 19$
Al-Rawi et al. [20]	$\sigma = 1.9$	$L = 11$	$T = 9$	$\kappa = 12$	$\theta = 15^{\circ}$	
Cruz et al. [21]	$\sigma = 2.41$	$L = 15$	$T = 15$	$\kappa = 12$	$\theta = 15^{\circ}$	

Para profundizar

Applied Soft Computing 46 (2016) 665–676

Contents lists available at ScienceDirect

Applied Soft Computing

journal homepage: www.elsevier.com/locate/asoc

On the performance of nature inspired algorithms for the automatic segmentation of coronary arteries using Gaussian matched filters

Ivan Cruz-Aceves [a,*], Arturo Hernandez-Aguirre [b], S. Ivvan Valdez [b]

[a] CONACYT Research Fellow – Centro de Investigación en Matemáticas (CIMAT), A.C., Jalisco S/N, Col. Valenciana, C.P. 36000 Guanajuato, Gto, Mexico
[b] Centro de Investigación en Matemáticas (CIMAT), A.C., Jalisco S/N, Col. Valenciana, C.P. 36000 Guanajuato, Gto, Mexico

ARTICLE INFO

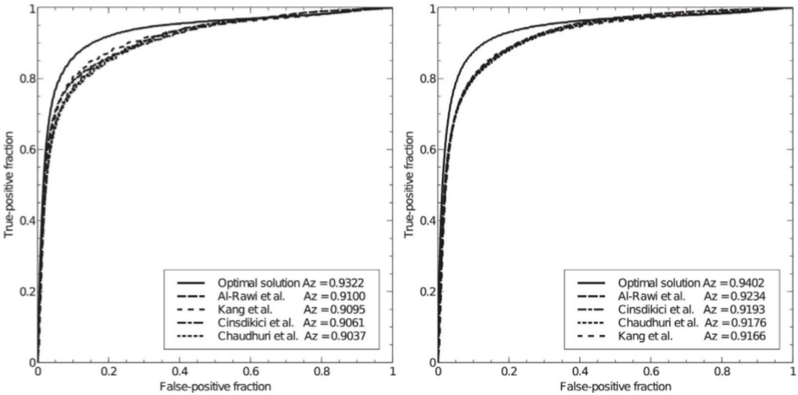
Article history:
Available online 28 January 2016

Keywords:
Automatic segmentation
Coronary angiograms

ABSTRACT

This paper presents a comparative analysis of four nature inspired algorithms to improve the training stage of a segmentation strategy based on Gaussian matched filters (GMF) for X-ray coronary angiograms. The statistical results reveal that the method of differential evolution (DE) outperforms the considered algorithms in terms of convergence to the optimal solution. From the potential solutions acquired by DE, the area (A_z) under the receiver operating characteristic curve is used as fitness function to establish the best GMF parameters. The GMF-DE method demonstrated high accuracy with A_z = 0.9402 with a training

Análisis Cuantitativo



Análisis Cualitativo