Computer-Aided Diagnosis of Gastrointestinal Radiographs Using Adaptive Differential Filter

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Outline

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3. Edge Detection Method by Adaptive Differential Filter
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Background-1

- Radiographic contrast media images (contrast radiographs) make it easier to distinguish features of interest, such as gastric intestines or blood vessels.
- Contrast radiographs are not always taken in the same direction. Moreover, even if in radiographs taken in the same direction, stomach forms differ for each person.
- Because of the complexity of these images, remarkable years will be required until the doctor can diagnose the stomach with contrast radiographs.

Background-2

- The automatic diagnostic support system using a computer (Computer-Aided Diagnosis, CAD) with contrast radiographs of gastric intestines (stomach, colon, etc.), which have many variations of images, is needed for the purpose of helping a quick decision.

Stomach

colon

colon plype

Objectives-1

- We discuss the preprocessing methods for the cancer classification.
- We focus on the edge detection method and the segmentation of the detected edges.

Edge detection method ⇒ **Adaptive differential filter**

S.-H. Park and T. Matsuo: Time-Derivative Estimation of Noisy Movie Data Using Adaptive Control Theory, International Journal of Signal Processing (2005).

Objectives-2

- We apply the adaptive differential filter to detect the spatial derivative of contrast radiographs in order to detect lesions of gastric intestines.
- Next, the level set method is adopted to carry out the segmentation of the edges.
- Furthermore the numerical examples are carried out, using the case radiograph of the gastric intestines medical image database produced by National Kyushu Cancer Center.

Diagnostic Procedures of Gastrointestinal Radiographs

The profile line of the stomach is checked from upright positioning and prone position's front images.

Abnormality None. End.

And abnormal.

Detection of lesions from a series of radiographs.

＊Template matching is done by the database of the computer.

Diagnosis of the disease.

The doctor decides the final diagnosis based on the procedure.

Edge Detection Method by Adaptive Differential Filter-1

$f(I(x,y))$:Nonlinear Intensity function $I(x,y)$:Intensity function

$f(I(x,y))$ nonlinear differential spatial Intensity function is as follows.

$$\frac{\partial f(I(x,y_0))}{\partial x} = \frac{df(I)}{dI}\frac{dI(x,y_0)}{dx}$$
$$\frac{\partial f(I(x_0,y))}{\partial y} = \frac{df(I)}{dI}\frac{dI(x_0,y)}{dy}$$

(1)

Differentiation of composite function

$I(x,y)$ Derivative of the spatial intensity function is indicated by the following equation.

$$\frac{dI(x,y_0)}{dx} = I(x+1,y_0) - I(x,y_0) = \xi(I(x,y_0))\theta_x(x,y_0)$$
$$\frac{dI(x_0,y)}{dy} = I(x_0,y+1) - I(x_0,y) = \xi(I(x_0,y))\theta_y(x_0,y)$$

(2)

$$\xi(I(x,y)) = \left(\frac{df(I)}{dI}\right)^{-1}, \quad \theta_x(x,y_0) = \frac{\partial f(I(x,y_0))}{\partial x}, \quad \theta_y(x_0,y) = \frac{\partial f(I(x_0,y))}{\partial y}$$

(3)

Edge Detection Method by Adaptive Differential Filter-2

The dynamic estimator is given by

$$\hat{I}(x+1, y_0) = \hat{I}(x, y_0) + \xi(x, y_0)\hat{\theta}_x(x, y_0) - ke_x(x, y_0)$$
$$\hat{I}(x_0, y+1) = \hat{I}(x_0, y) + \xi(x_0, y)\hat{\theta}_y(x_0, y) - ke_y(x_0, y)$$

$$\hat{\theta}_x(x+1, y_0) = \hat{\theta}_x(x, y_0) - \gamma_x \xi(x, y_0) e_x(x, y_0)$$
$$\hat{\theta}_y(x_0, y+1) = \hat{\theta}_y(x_0, y) - \gamma_y \xi(x_0, y) e_y(x_0, y)$$

Where $e_x(x, y) = \hat{I}(x, y) - I(x, y)$ **and,**

k, γ_x, γ_y **is a positive design parameter.**

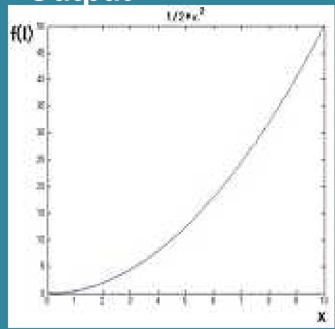
and $\widehat{\theta}$ **the final image.**

Nonlinear Intensity function

Intermediate Intensity (tone) of the Intensity function for nonlinear conversion.

$$\begin{cases} f_1(I) = \frac{1}{2} \cdot I^2 \\ f_2(I) = \log I \\ f_3(I) = -\frac{1}{I} \\ f_4(I) = \log(\cosh(I)) \end{cases} \Rightarrow \begin{cases} \xi_1 = \frac{1}{I} \\ \xi_2 = I \\ \xi_3 = I^2 \\ \xi_4 = \frac{1}{\tanh(I)} \end{cases}$$

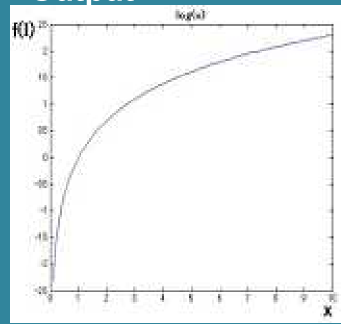
Output



Input

$\frac{1}{2}x^2$

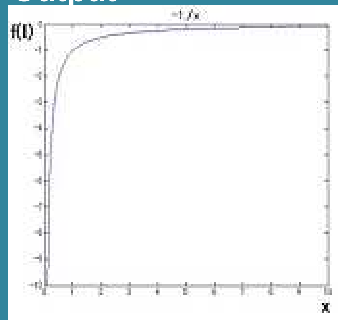
Output



Input

$\log(x)$

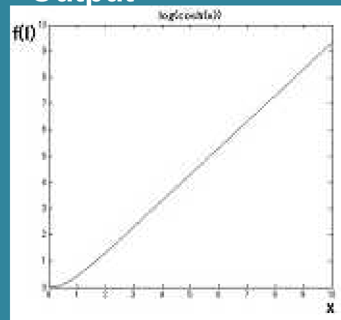
Output



Input

$-\frac{1}{x}$

Output



Input

$\log(\cosh(x))$

Inverse function of the differential value of Intensity.

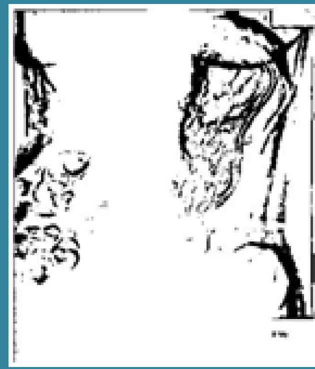
Comparison of the adaptive differential filter with the conventional filter.

Original image

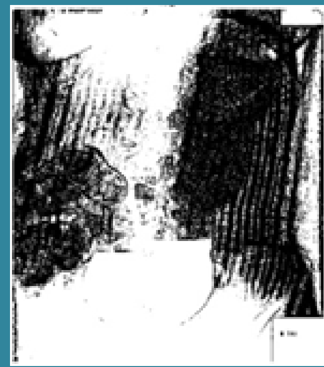
Lumbar vertebrae, ribs, soft tissue shadow erase.

○

$\log(\cosh(x))$



$\log(x)$



$-1/x$

Pretreatment

Bilateral filter

Smoothing filter

Adaptive differential filter

Sobel, Prewitt

Determine threshold method "Otsu method"

Differential filter. ⇒ To emphasize noise.

Lumbar, demonstration of soft tissue shadow (the interpretation of radiogram disorder).

×

by C.Tomasi 1998

Prewitt

Sobel

LEVEL SET METHOD FOR SEGMENTATION

- In this paper, we apply Li's variational level set method to the output of the adaptive differential filter.

In the level set formulation, the segmentation problem is equivalent to the computation of a surface Γ(t) that propagates in time along to its normal direction.

The curve is defined as a set of a zero level of a time-varying function :Φ(x,t)

$$\Gamma(t) = \left\{ x \in R^2 \middle| \phi(x,t) = 0 \right\}$$

C Li, C.Gui, and M. Fox: Level Set Evolution Without Re-initialization: A New Variational Formulation, Proc. of the IEEE Conf. on Computer Vision and Pattern Recognition, CVPR 2005, 430-436 (2005).

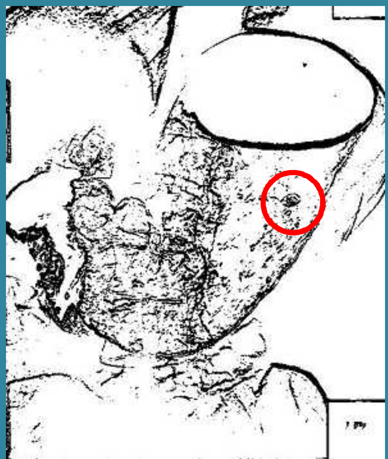
NUMERICAL EXAMPLE-1 (stomach polyp)

Original image

Prewitt ×

Sobel ×

Adaptive differential filter



$\log(\cosh(x))$

$\log(x)$

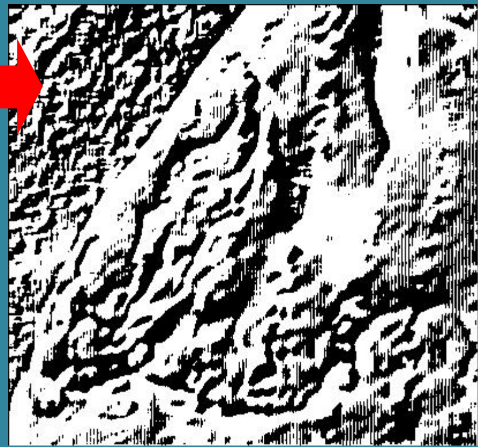
$-1/x$ ×

NUMERICAL EXAMPLE-2 (advanced Gastric cancer)

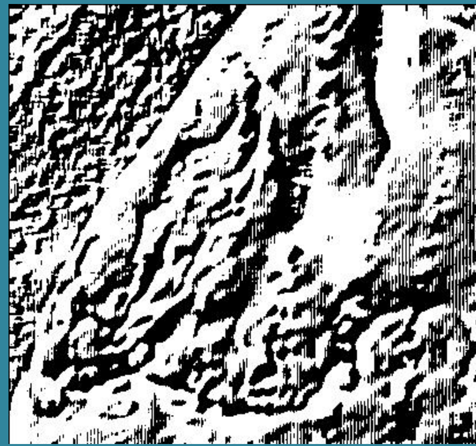
Outside of the stomach

Original image: Borr Ⅰ -type advanced gastric cancer.

noise



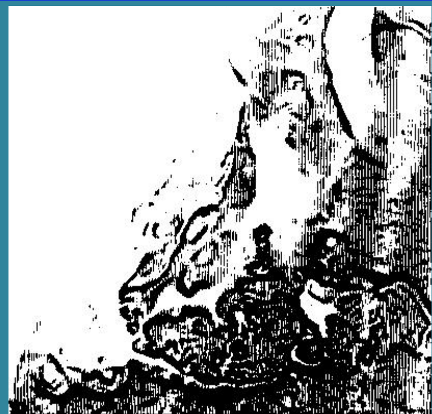
Prewitt



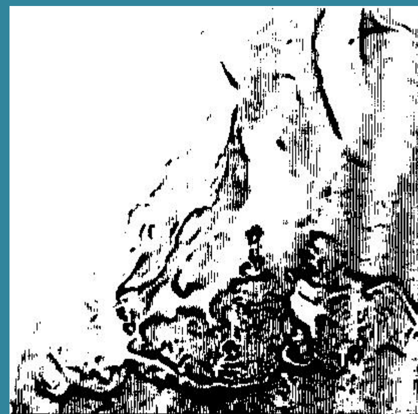
Sobel

Adaptive differential filter

$\log(\cosh(x))$

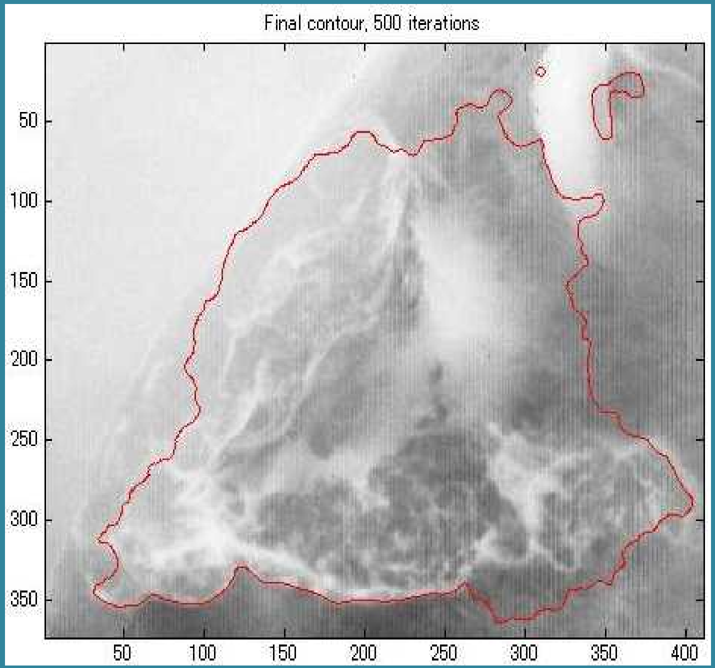


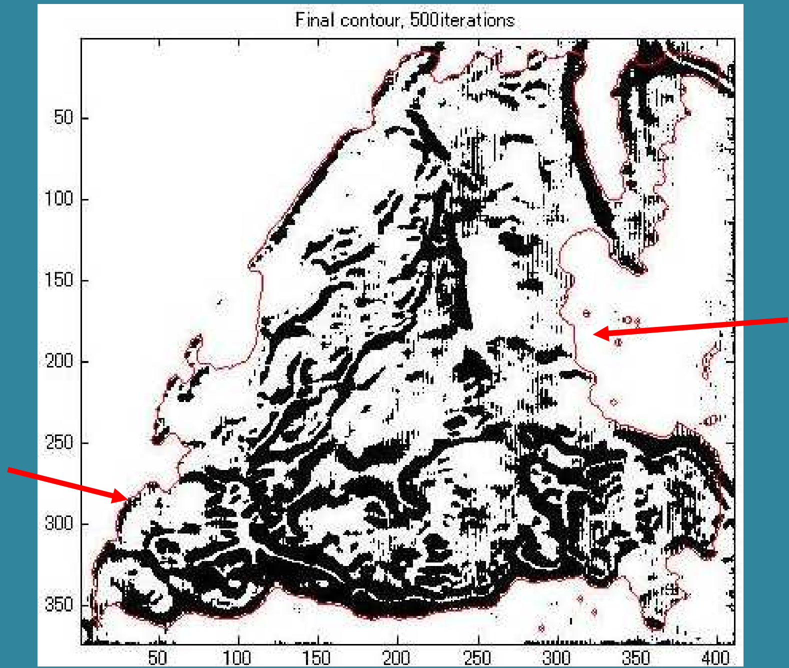
$\log(x)$



$-1/x$

Contour tracing of the lesion.





Level set program default value
epsilon=1.5, timestep=5, lambda=5, alf=1.5, W=8, n=1:500

Adaptive differential filter for edge detection
Filter function gamma3 = 0.08, sigma3 = -0.3,

Level set program default value
epsilon=1.5, timestep=5, lambda=5, alf=1.5, W=8, n=1:500

Conclusion

(1) We propose the adaptive differential filter to detect the spatial derivative of contrast radiographs in order to detect lesions of gastric intestines.

(2) Moreover, we adopted the level set method to the segmentation for the cancer classification.

Thank you.

Finally, this is my hometown of Mt. Aso.
Please visit us if you have a chance.