Computer-Aided Diagnosis of Gastrointestinal Radiographs Using Adaptive Differential Filter

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Outline

1. Background and Objectives
2. Diagnostic Procedures of Gastrointestinal Radiographs
3. Edge Detection Method by Adaptive Differential Filter
4. Level Set Method for Segmentation
5. Discussions and Conclusion
• 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.
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.
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

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

Abnormality None.  End.

Detection of lesions from a series of radiographs.

* And abnormal.

Diagnosis of the disease.

The doctor decides the final diagnosis based on the procedure.
Edge Detection Method by Adaptive Differential Filter

\[ f(I(x, y)) \quad I(x, y) \]

\[
\frac{\partial f(I(x, y))}{\partial x} = \frac{df(I)}{dl} \frac{dl}{dx} (x, y_0) \\
\frac{\partial f(I(x_0, y))}{\partial y} = \frac{df(I)}{dl} \frac{dl}{dy} (x_0, y)
\]

\[ I(x, y) \]

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

\[ \xi(I(x, y)) = \left( \frac{df(I)}{dl} \right)^{-1} \]

\[ \theta_x(x, y_0) = \frac{\partial f(I(x, y_0))}{\partial x}, \quad \theta_y(x_0, y) = \frac{\partial f(I(x_0, y))}{\partial y} \]
The dynamic estimator is given by

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

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

\[
e_x(x, y) = \hat{I}(x, y) - I(x, y)
\]

\[
k, \gamma_x, \gamma_y
\]
Nonlinear Intensity function

\[
\begin{align*}
    f_1(I) &= \frac{1}{2} \cdot I^2 \\
    f_2(I) &= \log I \\
    f_3(I) &= -\frac{1}{I} \\
    f_4(I) &= \log(\cosh(I))
\end{align*}
\]

\[
\begin{align*}
    \xi_1 &= \frac{1}{I} \\
    \xi_2 &= I \\
    \xi_3 &= I^2 \\
    \xi_4 &= \frac{1}{\tanh(I)}
\end{align*}
\]
Comparison of the adaptive differential filter with the conventional filter.

Lumbar vertebrae, ribs, soft tissue shadow erase.

\[
\log(\cosh(x)) \quad \log(x) \quad - \frac{1}{x}
\]

Lumbar, demonstration of soft tissue shadow (the interpretation of radiogram disorder).
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 \( \Gamma(t) \) 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 \( \Phi(x,t) \)

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

NUMERICAL EXAMPLE-1 (stomach polyp)

Adenoma

$log(x)$

$-1/x$

$log(cosh(x))$
NUMERICAL EXAMPLE-2 (advanced Gastric cancer)
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  \( \gamma_3 = 0.08, \ \sigma_3 = -0.3 \),

Level set program default value
\( \epsilon=1.5, \ \text{timestep}=5, \ \lambda=5, \ \alpha=1.5, \ \text{W}=8, \ \text{n}=1:500 \)
(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.
Finally, this is my hometown of Mt. Aso. Please visit us if you have a chance.