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Review

Study on infrared image detail enhancement algorithm based on adaptive lateral inhibition network

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ABSTRACT

Aiming at traditional lateral inhibition network enhancement algorithm's disadvantages such as poor anti-noise performance and complicated calculation, this paper proposed a novel infrared image detail enhancement algorithm based on adaptive lateral inhibition network. The algorithm can not only reduce noise by adaptively changing lateral inhibition coefficients adaptively according to image scene, but also produce strong contrast between sharp edge and even part. Compared with traditional lateral inhibition network algorithm, the experimental results show that the image details are obviously highlighted, and the image's contrast increases by 1.25 times and the information entropy increases by 1.15 times.

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1. Introduction

Because infrared image is blur and low contrast, it has become an important research concentration in infrared image detail enhancement processing. The purpose of enhancement processing is to enhance weak edges and weak texture features of infrared image in order to improve image quality [1]. Traditional infrared image enhancement algorithms include histogram equalization, gray-scale transformation, local contrast enhancement and so on [2]. The traditional algorithms can improve image effect, but their anti-noise performances are poor. In order to improve algorithms' anti-noise ability, an infrared image detail enhancement algorithm based on adaptive lateral inhibition network is proposed in this paper.

Nowadays there are a few lateral inhibition enhancement methods, but their lateral inhibition coefficient distribution only include Gaussian model, Hyperbolic model and so on, which have a slow convergence rate. In order to speed up the algorithm convergence rate we proposed an exponential coefficients distribution model. The exponential function is less complicated compared to traditional Gaussian function and Hyperbolic function. Distribution of lateral inhibition coefficients directly determine the effect of image enhancement. Different from traditional methods of lateral inhibition coefficients determination, the proposed algorithm

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adaptively determines distribution of lateral inhibition coefficients according to obtain image scene. In the proposed algorithm three aspects are studied: lateral inhibition network; lateral inhibition coefficients' adaptive determination; lateral inhibition field selection.

2. Lateral inhibition network

Lateral inhibition is found and confirmed by the Limulus' visual physiological electrical experiments. The Limulus's eye is compound, and each of its small eyes in compound eye can be considered as a single receptor [3]. When these receptors receive the same uniformity light stimulus, the center receptor's excitability will be affected by excitability of its surrounding receptors, that is to say the center receptor is inhibited by its surrounding receptors. In the compound eye every receptors inhibits its surrounding receptors while being inhibited by surrounding ones, and these mutual inhibitions can increase the visual contrast. Besides the strength of these inhibitions is also reduced with the increase of the distance between two different receptors. Experimental results show that a similar phenomenon is also present in the human eye. Human eye optic cells are equivalent to receptors, when the cells are stimulated by light, cells in bright area are inhibited more intensively than ones in dark area. This can exacerbate the inconsistencies of these cells response, and it is these inconsistencies which increase the human visual contrast.

There are a few models for lateral inhibition. The most common one is Hartline-Ratliff model, which can be expressed as:

$$\begin{cases} r_1 = e_1 - k_{12}e_2 \\ r_2 = e_2 - k_{21}e_1 \end{cases} \quad (1)$$

$$\begin{cases} r_1 = e_1 - k_{12}r_2 \\ r_2 = e_2 - k_{21}r_1 \end{cases} \quad (2)$$

where e_1, e_2 represent receptor' input stimulus; r_1, r_2 represent receptor' response output; k_{12}, k_{21} are the inhibition coefficients between two receptors. And (1), (2) respectively represents nonrecurrent lateral inhibition network model and recurrent lateral inhibition network model.

The recurrent lateral inhibition model is a large amount of calculation, and it is difficult to implement in engineering applications. In the proposed algorithm we adopt nonrecurrent lateral inhibition network model. Expressed as follow:

$$G(m,n) = F(m,n) - \sum_{i=-l}^{l}\sum_{j=-l}^{l} k(i,j)F(m+i,n+j) \quad (3)$$

where $F(m,n)$ is the gray value of the original image, $G(m,n)$ is the gray value of the response output pixel; $k(i,j)$ is the lateral inhibition coefficients which are determined according to experience value in traditional lateral inhibition network, l represents inhibit field radius.

The traditional lateral inhibition network is sensitive to noise which not only enhances the image target but also enhances the noises. Thus in the proposed algorithm we would process image with lateral inhibition network combined with mean filter to remove noise, which is expressed as:

$$G(m,n) = \overline{F(m,n)} - \sum_{i=-l}^{l}\sum_{j=-l}^{l} k(i,j)F(m+i,n+j) \quad (4)$$

where $\overline{F(m,n)} = \frac{l'}{(2\times l'+1)^2}\sum_{k1=-l'}^{l'}\sum_{k2=-l'}^{l'} F(k1,k2)$, $\overline{F(m,n)}$ represents $F(m,n)$'s mean value in its neighborhood, l' is the size of mean filter window.

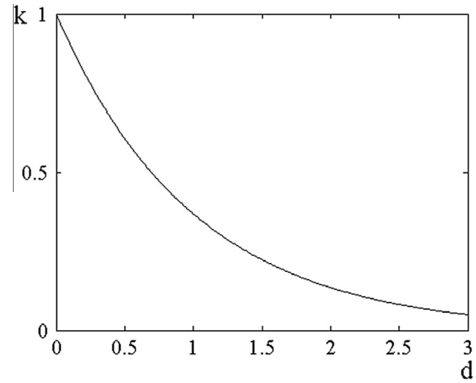

Fig. 1. Exponential function.

3. Inhibition coefficients' adaptive determination

Lateral inhibition coefficient's value is inversely proportional to the distance between two receptors. Traditional lateral inhibition coefficients are chosen according to experience value, which would not change along with the image scene changing. An anisotropic filtering method proposed by SHI [4,5] can determine inhibition coefficients according to scene. But the lateral inhibition coefficient distribution needs to satisfy the Gaussian function which expression is over complicated [6]. In the proposed algorithm, on the basis of analyzing traditional algorithms, we propose exponential lateral inhibition coefficient distribution combined with the characteristics of infrared image.

The exponential function has rapid attenuation character with the increase of independent variable, which is similar to the effect of the lateral inhibition with distance between two different receptors. Taking receptors'characteristic into account, the distance d is a positive value. And the change tendency of lateral inhibition coefficient distribution is shown in Fig. 1, as the expression is shown in (5).

$$k = A\exp\left(-\frac{d_{ij,pq}}{\rho}\right) \quad (5)$$

$$\rho = \frac{1}{I(m,n)} \quad (6)$$

In the expression (5) the A is constant. $d_{ij,pq} = \sqrt{(i-p)^2 + (j-q)^2}$, which represents distance between the (p,q) receptor and the central (i,j) receptor in one inhibition field. In the Eq. (6), the $I(m,n)$ represents (m,n) pixel' gray value in infrared image.

Assume that A has been given in Eq. (5), then the different ρ determines the exponential function's different decay rate, thereby

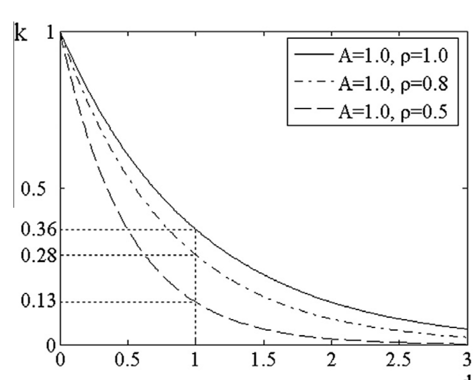

Fig. 2. Exponential function's different decay rate under different values of ρ.