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Local Chan-Vese Model for Segmenting Nighttime Vehicle License Characters

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Abstract. Aiming at the gray uneven distribution in the night vehicle images, a new local Chan–Vese (LCV) model is proposed for image segmentation. The energy functional of the proposed model consists of three terms: global term, local term and regularization term. By incorporating the local image information into the proposed model, the images with intensity inhomogeneity can be efficiently segmented. Finally, experiments on nighttime plate images have demonstrated the efficiency and robustness of our model. Moreover, comparisons with recent popular local binary fitting (LBF) model also show that our LCV model can segment images with few iteration times.

Keywords: license character segmentation; CV model; intensity inhomogeneity; LBF

1. Introduction

A typical Automatic License Plate Recognition system[1] consists of three major phases: license plate detection, geometric correction, character segmentation, size or aspect ratio normalization, character recognition and application of grammatical rules [2], [3], [4]. Among them, a very critical step is the license plate location and character segmentation, which directly affects the overall system performance. Here, we pay attention to the character segmentation. The characters are most susceptible to the environment, especially in nighttime. Because of low visibility at night, uneven illumination of street lamps and so on, the intensities of license plate image are not evenly distributed. Thus, it is difficult to set a global threshold of accurate and effective segmentation of license plate characters. Here, we choose the active contour model to overcome this problem.

Active contour model proposed by Kass et al.[5] has been proved to be an efficient framework for image segmentation. Level set method is based on active contour model and particularly designed to handle the segmentation of deformable structures. Chan-Vese(CV) model [6] has achieved good performance in image segmentation task due to its ability of obtaining a larger convergence range and handling topological changes naturally. However, it still has the intrinsic limitation, i.e., it generally works badly for images with intensity homogeneity. The reason is due to that the intensities in each region are assumed to maintain constant.

In this paper, we propose a local Chan-Vese model which utilizes both global image information and local image information for character segmentation. The energy functional for the proposed model consists of three parts: global term, local term and regularization term.

2. The review of the CV model and intensity inhomogeneity

2.1. Chan-Vese model

Chan and Vese [6] proposed an active contour model which can be seen as a special case of the Mumford–Shah problem [7]. For a given image I in domain Ω, the CV model is formulated by minimizing the following energy functional:

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$$E(C,c_1,c_2)=\lambda_1\int_{inside(C)}\left|I(x,y)-c_1\right|^2 dxdy+\lambda_2\int_{outside(C)}\left|I(x,y)-c_2\right|^2 dxdy,\ (x,y)\in\Omega \tag{1}$$

where c_1 and c_2 are two constants which are the average intensities inside and outside the contour, respectively. With the level set method, we assume

$$\begin{cases} C=\{(x,y)\in\Omega:\phi(x,y)=0\}, \\ inside(C)=\{(x,y)\in\Omega:\phi(x,y)>0\}, \\ outside(C)=\{(x,y)\in\Omega:\phi(x,y)<0\}, \end{cases} \tag{2}$$

$$c_1(\phi)=\frac{\int_\Omega I(x,y)\cdot H(\phi)dxdy}{\int_\Omega H(\phi)dxdy},\quad c_2(\phi)=\frac{\int_\Omega I(x,y)\cdot(1-H(\phi))dxdy}{\int_\Omega(1-H(\phi))dxdy} \tag{3}$$

By incorporating the length and area energy terms into Eq. (1) and minimizing them, we obtain the corresponding variational level set formulation as follows:

$$\frac{\partial\phi}{\partial t}=\delta(\phi)\left[\mu div\left(\frac{\nabla\phi}{|\nabla\phi|}\right)-\nu-\lambda_1(I-c_1)^2+\lambda_2(I-c_2)^2\right] \tag{4}$$

where $\mu\geq 0,\nu\geq 0$, $\lambda_1>0$, $\lambda_2>0$ are fixed parameters, μ controls the smoothness of zero level set, ν increases the propagation speed, and λ_1 and λ_2 control the image data driven force inside and outside the contour, respectively. ∇ is the gradient operator. $H(\phi)$ is the Heaviside function and $\delta(\phi)$ is the Dirac function.

CV model can segment all the characters of the plate well for the located homogenous plate images. It can be seen from Fig. 2. But for the nighttime plate, due to the uneven illumination, the segmentation results are not desired.

(a) homogenous plate image (b) the segmentation result of CV model

Fig. 1: The segmentation result by CV model for homogenous plate image

(a) inhomogeneous plate image (b) the segmentation result of CV model

Fig. 2: The segmentation result by CV model for inhomogeneous plate image

2.2. Intensity inhomogeneity

Intensity inhomogeneity often occurs in real images from different modalities. For nighttime images, intensity inhomogeneity is usually due to the illumination is not homogenous (see Fig. 3 for example).

Fig .3 the inhomogeneous nighttime plate image