An Improved Traffic Image Defogging algorithm Haze Weather

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Abstract: The obtained degraded traffic images with the noise in haze weather have low contrast, an improved traffic image defogging algorithm in haze weather was proposed. The first step is bilateral filtering the dark-channel image of the degraded traffic image. And the second step is to use Guide filter to optimize the rough estimation of image transmittance. Image restoration is realized by the degradation model recovery and defogging image is obtained. Experimental results prove that the obtained defogging image in the proposed algorithm is more similar to the real scene brightness and with better color saturation and image quality.

Keywords: haze weather, color saturation, bilateral filtering, Guide filter

1. Introduction

The image detection algorithm in haze weather has become the current research focus[1]. The existing defogging algorithm can be divided into the defogging based on image enhancement and the scene restoration method based on physical model. Tan[2] achieved defogging based on single image for the first time by using the method of enhancing image local color contrast. Kim and others[3] use non block overlapping method for local histogram equalization, and reduce the haze to the useful information interference in the image. Image enhancement method is just used to reduce the haze’s interference, and the fog is not removed in essence. So the effect of defogging is not ideal. The scene restoration method based on physical model is to establish image degradation model based on atmospheric scattering, and then uses the prior knowledge and reasonable assumes some conditions for inversion of the degradation process. The degraded image can be restored. The method should be used to filter the image in the application. Because the image edge contains a lot of useful information, as far as possible, the noise should be have a better filtering effect, and at the same time it tries to keep the edge of the image and other important details[4]. C.Tomasi and R.Manduchi proposed a bilateral filtering strategy[5]. In the area of intense image...
change, the brightness value of the pixel near the edge point is used to averagely replace the original luminance value. The defogging images contains a lot of noise, and it affects the extraction of feature information, and it is also difficult to balance the filter and edge. So it is difficult to meet the needs.

On this basis, this paper proposed an improved filter, which can recover the image more close to the real scene, and obtain the quality of traffic image.

2. Image degradation system model

In haze weather, the suspended particles in the air will cause scattering and refraction to light. It makes the collected images blurred and contains more noise, resulting in the quality of the shooting image decline. And then establish the model, so as to analyze the reduction principle of image in haze weather. Through the analysis of the model, we can get the effect of haze particles on light and imaging. The model can be described by formula (1):

\[
\begin{align*}
I(x) &= E(d, \lambda), J(x) = E_s(\lambda) \\
t(x) &= e^{-k(\lambda)d}, A = E_s(\lambda)
\end{align*}
\]

In which, \(E(d, \lambda)\) is the image acquired by the visible light camera, which is the degraded image in haze weather. \(E_s(\lambda)\) represents the reflected light intensity of the scene, which is inherent light intensity in no attenuation. \(d\) represents scene depth, \(k\) is the atmospheric scattering coefficient. The corresponding \(I(x)\) represents a pixel in the haze image, and \(J(x)\) represents a pixel point in a clear haze image, and \(A\) represents atmospheric light in the scene. Then the image of fog and haze degraded model is shorthand for imaging model:

\[
I(x) = J(x)t(x) + A(1-t(x))
\]

3. A defogging method based on dark channel method

3.1 Dark channel

Take RGB color space image as an example, the dark channel can be expressed as follows:

\[
J_{dark}(x) = \min_{y \in \Omega(x)} \left( \min_c J_c(y) \right)
\]
In the above formula, $c$ represents $R$, $G$, $B$ a color channel, and $x$ is the center pixel in a local area $\Omega$, $y$ is a pixel in a local area $\Omega$. Then $J^c(y)$ represents the value of a color channel of the $y$ pixel point, and $J^{\text{dark}}(y)$ represents the local area of the dark channel value.

### 3.2 Parameter estimation

According to the description of the image degradation model obtained from the front, the formula (3) is deformed, and the image becomes:

$$J(x) = I(x) - A(1 - t(x))/t(x)$$

(4)

Obviously, the focus of defogging is to estimate the atmospheric light $A$ and the transmittance $t(x)$ of each pixel. It is very difficult to get three unknowns using an image. Dark channel a priority theory should be used as the constraint condition, and then depends on dark channel image containing fogging image to reflect the change of the concentration of mist and depth. So the transmittance $t(x)$ is estimated, which is the atmospheric light $A$, and then the restoration image can be solved.

The lower the transmittance is, the more difficult the light pierce through the haze into the image acquisition equipment. The light is largely effected by scattering, so only a few parts can go into the image acquisition equipment to participate in imaging. Image degradation equation deformation can be obtained:

$$I^c(x)/A^c = t(x)J^c(x)/A^c + (1 - t(x))$$

(5)

In the above formula, represents $R$, $G$, $B$ a color channel. The corresponding $A^c$, $I^c(x)$, $J^c(x)$, respectively, represent a color channel atmospheric light intensity, a pixel point of fogging image and defogging image in the value of the color channel. The assumption has been determined, in order to facilitate the calculation, when it is in the estimation of transmittance, we make an assumption that the local small range of transmission is same that is to say, the size $\tilde{t}(x)$ is the same. And take the minimum value on both sides of the equation, then it can be deformed into:

$$\min_c(\min_{y \in \Omega(x)} I^c(y)/A^c) = \tilde{t}(x) \min_c(\min_{y \in \Omega(x)} J^c(x)/A^c) + (1 - \tilde{t}(x))$$

(6)

The dark channel that does not contain the haze’s image has the following law, that is:
\[ J_{\text{dark}}(x) = \min_{y \in \Omega(x)} \left( \min_{c \in [r, g, b]} J^c(y) \right) \approx 0 \]  

And the value of atmospheric light \( A^c \) is relatively large, so it can be introduced:

\[ \min_{c} \left( \min_{y \in \Omega(x)} \left( I^c(y)/A^c \right) \right) \rightarrow 0 \]  

Transmittance \( \tilde{t}(x) \) is:

\[ \tilde{t}(x) = 1 - \omega \min_{c} \left( \min_{y \in \Omega(x)} \left( I^c(y)/A^c \right) \right) \]  

\( \min_{c} \left( \min_{y \in \Omega(x)} \left( I^c(y)/A^c \right) \right) \) can be regarded as the dark channel image normalized by the atmospheric light \( A^c \) on the fogging image, so the value of the transmittance is between 0 and 1. \( \omega \) is a coefficient in order to keep a certain amount of fog.

In the dark channel image of defogging image, the pixel brightness can be regarded as a reflection of the concentration of mist. In order to prevent the estimation of the white objects from being misused to estimate atmospheric light in the image, and in the dark channel image can be selected as a part of the brightness of the pixel, reflecting the image of the most concentrated in the fog, which is a large depth of field. This part of the pixel is used to estimate atmospheric light value \( A \). The estimation transmittance of the atmospheric light \( A \) and the coarse estimation can be refined. Then put it into the formula (4), you can get the image restoration.

## 4. Algorithm design steps

The specific process of the algorithm is as follows:

1. At first, enter into the fogging traffic image, then find the dark channel image of fogging image by using the formula (3). The bilateral filtering is used to filter the dark channel image, and in this paper the filtering window size is 3*3. The Gauss function standard deviation of similarity factor and distance similarity factor in bilateral filter core is is respectively: 0.1 and 3.

2. According to the atmospheric light estimation method, the step (2) makes the bilateral filtering, and then take the front 0.1% points in dark channel image brightness. The three channel values corresponding to this point in the haze image are used as atmospheric light estimates.

3. According to the calculation of the transmittance of formula (6), take the filtered dark channel obtained by the step (2) into it, and calculate the coarse estimation \( \tilde{t}(x) \) of the transmittance, and get the transmittance image \( t \).
(4) Take the gray image \( I \) of traffic fogging image as the guiding image, and the coarse estimation \( \tilde{t}(x) \) of the transmission is to be filtered image which the window size is 60*60. Then the coarse estimation of the transmission is carried out by the filtering operation, and the method is shown in the formula (1).

\[
t(x) = \text{guide}(\text{rgb2gray}(I(x)), \tilde{t}(x))
\]

(5) The transmittance after guiding filter is accurate transmittance, and Combine steps (2) to calculate the value of atmospheric light \( A \). Then take it into the formula (3) to get the output \( J \) which is the defogging image.

### 5. Experimental test

In the experiments, we respectively utilize the traditional bilateral filtering defogging algorithm and the algorithm of this paper to image defogging processing. The experimental results are shown in figure 1. In which, figure(a) is the original fogging image, and figure (b) is the image after utilizing the traditional bilateral filtering algorithm to defog, and figure (c) is the defogging image by using the algorithm in this paper. Observing the figure (b) and figure (c) we can know that the two methods have a certain defogging effect. The image in figure (b) is dark and the contrast is low. There are some distortions of the image. As a whole, figure (c) is relatively bright and has a contrast. The background light is more close to the original image, and it is more in line with the real scene.

![Experimental results](image)

(a) Original image  (b) Defogging results of bilateral image filtering (c) Defogging results of twice filtering

**Figure 1 experimental results**

### 6. Conclusion

In view of the calculation of the existing image defogging algorithm in haze weather is very large, the problem of the image is dark, and this paper puts forward the two filtering method based on bilateral filtering and filtering. Compared with the traditional
bilateral filtering algorithm, after the two sides filter guided filtering defogging algorithm defogs, the brightness of the scene in the image is more in line with the real scene. It has a certain effect on improving the quality of traffic images collected in haze weather.

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