Visibility Detection Based on Traffic Camera Imagery

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Abstract— to make full use of traffic video along the highway, to achieve low-visibility weather monitoring, a meteorological visibility detection method is proposed on the traffic video. Fog causes the disappearance of edges in the frame, which is well reflected by the change in high frequency information. In order to extract out the edge feature that reflects the changes in visibility of the image feature parameters, the algorithm uses least squares method and the inverse transform to draw the fitting function, and analyzes the relations of the image characteristics and the distance to determine the visibility values. Algorithm satisfies the human visual system, and effectively improves the accuracy of visibility detection. Video visibility detection system has good real-time, high detection accuracy, a small error, and better robustness. System has function of real-time statistics and analysis.

Key Words—Image Processing, Edge Detection, Curve Fitting

I. INTRODUCTION

Traditional meteorological visibility detector of highway is high cost, and difficult to set up along the highway to achieve full monitoring of low-visibility weather. This paper presents a visibility meteorological based on traffic video, to make full use of cameras along the highway, which effectively improve the real-time response capabilities of visibility detection. Atmosphere visibility related to environments, and the fog mainly affects edges in the camera image. Thus, we use Canny algorithm to measure the change of edges in frequency domain. Composed by 4 feature parameters correlated to the visibility grades, we gain a vector to stand for camera images. Finally, video visibility detection system is designed in the paper.

II. VISIBILITY DEFINITION AND DETECTION COMPARISON

A. Visibility definition

By World Meteorological Organization and China National Weather Service weather, the day the visibility is defined as: that people with normal vision, in the weather conditions at that time, can identify the maximum distance of the targets from the sky background (black, size appropriate). In the definition of visibility, the so-called "identification" is the outline of a target [1, 2], which is calculated as:

$$C_L = \frac{B_0 - B'_0}{B'_0} \cdot (1 + \frac{D_L}{e^{-\sigma L} \cdot B'_0})^{-1} \quad (1)$$

Where, C_L is observed by the human eye contrast, B_0, B'_0 is the inherent brightness of target and its background, D_L is the additional air screen brightness of natural light in all directions the scattering of atmospheric column in the L direction on L path, σ is the atmospheric extinction coefficient . This article is for transportation and focuses on the visibility of the ground detection, and observes the brightness contrast in the horizontal direction.

B. Comparison of visibility detection

There are difference principle and different characteristics in the visibility detection methods of the traditional optical and digital image analysis because of sensor data collection and analysis, as shown in Table I.

TABLE I. ANALYSIS OF THE VISIBILITY DETECTION METHODS

Detection methods	Characteristics
Optical transmission method	Detection accuracy; Bulky; Pollution-sensitive optical.
Optical scattering	Small size; Easy installation and maintenance; Surveying of wide range; Weak interference.
Neural network and the visibility detection algorithm of infrared camera	Work around the clock; Classification accuracy; High cost; Unable to calculate the visibility of the value of specific.
Visibility based on fixed reference point detection method for video	Detection accuracy; Strong anti-interference; Need auxiliary signs; Set up complex.
Method using the known visibility image to calculate the relative visibility	No secondary target; Easy to install; Difficult to apply in the PTZ camera.

We compare the contrast with a reference value operated as threshold, to determine whether the object can be seen. There is a high correlation between the contrast and the edges in the image. A visible edge is formed by the difference of the luminance in its both sides. Meanwhile, the edge in the image is corresponded to the high measurements in the frequency

analysis. Therefore, we use Canny algorithm to detect edges in the image.

The core of video visibility detection algorithm is extracting the image feature parameters in response to the image changes, therefore through the analysis of image features change to calculate the value of visibility. Through the preset target markers to in the image provide the apparent characteristics of known distance, which can improve the detection accuracy.

III. FEATURE EXTRACTIONS

Canny algorithm takes gradient amplitude as the standard to detect and connect edge. In the case of poor image quality, the accuracy of detection was certainly appears down, but in the video visibility detection algorithm, interest edge of pending inspection is phase step type, so it little real impact [3-5].

As shown in follows figure, Figure 1 is original image for the road conditions, and Figure 2 is the results of Canny edge detection, and Figure 3 is the result of Sobel edge detection algorithm. Known by the Figure, Canny algorithm retains more image details to closer to the truth, and can effectively extract the edge of the step preset target value as the image features to reflect the impact of visibility on the image.

Figure 1. Traffic monitoring images

Figure 2. results of Canny edge detection

Figure 3. result of Sobel edge detection

Because the pre-target is divided into two main parts, black and white, and formed the largest brightness difference, therefore with the results of edge detection, we extract the edge of the largest brightness difference as the characteristic value. Calculation as follows:

$$E_n = TopAvg(C, r) \tag{2}$$

The formula, C is the output result of edge detection; r is a percentage point of all the edge of the pixel. Type (2) is calculated the average of the maximum brightness edge point accounting r% of the total number of edge points. *En* is image feature value.

IV. CURVE FITTING AND VISIBILITY VALUE DETERMINATION

The characteristic value is curve fitting using the curve regression analysis in the calculation of visibility distance, based on extracting image edge features. Then, the visibility is derived, according to the International Commission on Illumination the recommendations contrast threshold [6-8].

The exponential relationship between Image features and distance is such as the type (3) below.

$$y = C_1 e^{-c_2 d} \tag{3}$$

C_1, C_2 as the parameters to be estimated, d is the target image from the camera, y is image characteristic value of the corresponding target.

C_3 is the random noise of image, the type (4) becomes:

$$y = C_1 e^{-c_2 d} + C_3 \tag{4}$$

The image characteristic amount is normalized 0.05, that is: $y = 0.05$.

At this point, equation (5) becomes:

$$C_1 e^{-c_2 V} + C_3 = 0.05 \tag{5}$$

The value of meteorological visibility can be calculated:

$$V = -\frac{\ln(\frac{0.05 - C3}{C1})}{C2} \quad (6)$$

According to 4 groups preset target, 4 groups (*y, d*) value are gotten. Nonlinear least squares estimation fits coefficients C_1, C_2, C_3 through the four sets of data, to obtain the relationship between image features value and distance.

According to Table II of visibility classification, we give the current level of weather visibility. This division of visibility is established by China Weather Bureau in 2006.

TABLE II. VISIBILITY (L) GRADING

Class	Visibility grading
0	L＞500m
1	200m＜L≤500m
2	100m＜L≤200m
3	50m＜L≤100m
4	L≤50m

V. SYSTEM WORKFLOW AND EXPERIMENTAL ANALYSIS

A. System Workflow

The workflow is shown in Figure 4. Visibility Detection System receives video stream from the original digital, and decodes it to get traffic images.

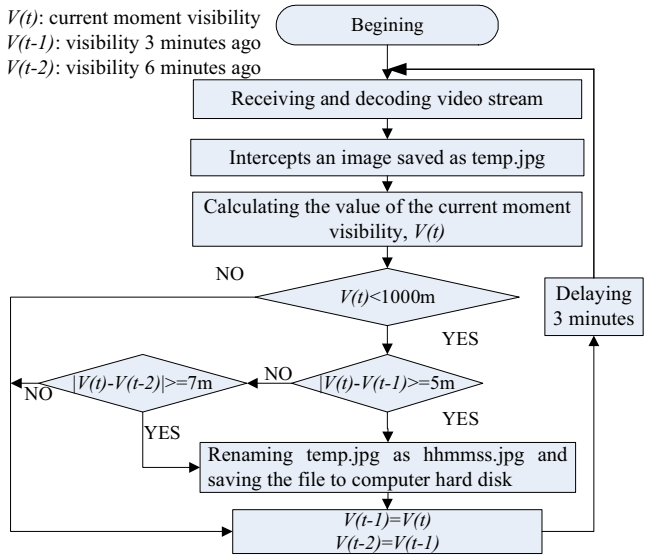

Figure 4. Work flow chart of video visibility detection system

Through the analysis of road image, system can calculate the visibility value of the current monitoring spot, and saved the traffic images of the abnormal visibility in to the file system. Decoding the received video stream, Video visibility detection system intercepts an image saved as temp.jpg. Through the analysis of the image temp.jpg, system calculates the value of the current moment visibility, *V (t)*. If *V (t)* is greater than 1000m, System does not to save the current time images, and can delays 3 minutes for the next test. If the value of the current time visibility, *V (t)*, has a difference of greater than 5m with the preeminent visibility value 3 minutes ago, or greater than 7m with the preeminent visibility value 6 minutes ago, *V (t-2)*, System take for a more significant change and will rename temp.jpg as hhmmss.jpg (hhmmss: hours minutes and seconds), and save the file to computer hard disk.

B. System testing and experimental analysis

Figure 5 shows a certain time visibility test results.

Figure 6 is the error curve of detection algorithms compared with standard reference value. The errors are within 10%, and the system is robust in noisy environments. Detection precision meets basically the safety requirements of the highway safety running.

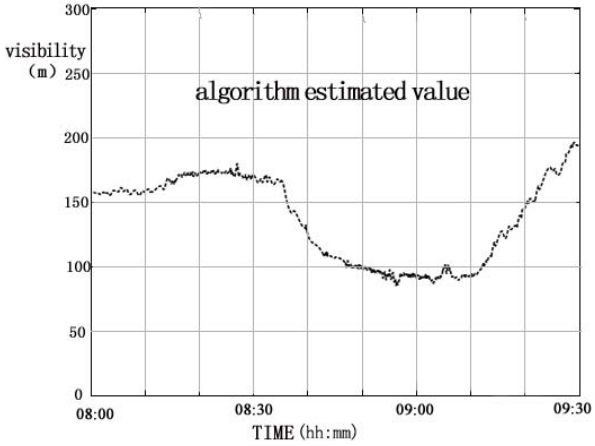

Figure 5. Algorithm estimated value curve

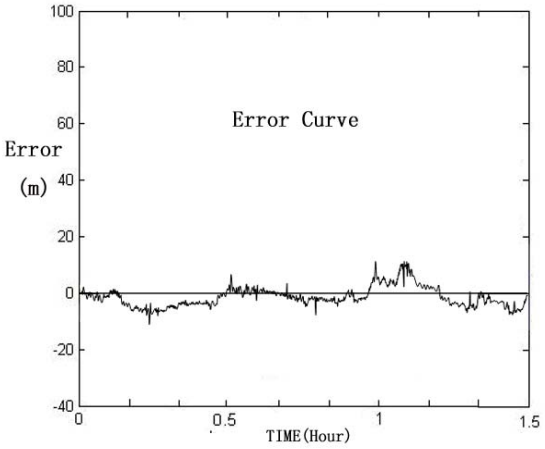

Figure 6. Error curve of the system detects

VI. CONCLUSIONS

Through the extraction of the image feature parameters that response the change of the image, Video visibility detection algorithm analyses the image features to calculate the visibility value. It better meets the human visual system, and effectively improves the visibility detection accuracy. Detection system is compatible with highway monition system, and intuitive and

accurate, and consistent with the characteristics of human visual habits. System can take real-time statistics and analysis the all road sections of visibility. Currently, highways has set up a test system, and test results show that real-time video detection system has good visibility, detection accuracy, the small error.

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