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Multi-mode Detection Techniques of Video Visibility Based on Improved Dual Differential Luminance Algorithm

Zhao Jiandong[1,*], *Han Mingmin*[1], *Xin Xin*[2] *and Li Changcheng*[2]

[1] *School of Mechanical, Electronic and Control Engineering, Beijing Jiaotong University, Beijing, 100044, China*

[2] *Key Laboratory of Road Safety Technologies, Ministry of Transport, Beijing, 100088, China*

E-mail: zhaojd@bjtu.edu.cn[1]*;13121373@bjtu.edu.cn*[1]*; thuxin@gmail.com*[2]*; cc.li@rioh.cn*[2]

Abstract

The traditional dual differential luminance algorithm was influenced by the surrounding environment, and was not applicable to accurate detection at night. In view of the interference factors of reality, this paper improved the dual differential luminance algorithm by using the method of amending coefficient. Meanwhile, combined with the traffic emergency control measures under different visibility, ten detection modes were subdivided. The next, an experimental system was built in the Meteorological Observatory of Beijing, and the detection software was developed. At last, the experimental data was compared with the correlation values of scatterometer. The results show that the detection accuracies are raised, and the optimized algorithm and system can be used for highway network visibility detection.

***Keywords**: highway, visibility, dual differential luminance algorithm, multi-mode detection*

1. Introduction

According to road traffic accidents annual report in 2007-2012 of China, low visibility is a main cause of road traffic accidents. When the low visibility weather is below 200 meters, the number of accidents and deaths is more than 50% [1]. Once the visibility is poor, traffic accidents are prone to occur with the high speed or large traffic flow on highway. Sometimes, in such severe weather conditions, it would lead to more jams and traffic events that endanger human being and their properties directly [2].

For these problems, the forward scatterometers were equipped to detect meteorological visibility on highway. The scatterometers extrapolate the visibility data of several kilometers or even dozens of kilometers by using the extinction coefficient of limited capacity. With the sparse placement interval about 50 km, the detection coverage of scatterometer is limited, and the detect failure for slug flog happened often in some areas. Obviously, its detection principle cannot meet the practical requirements of highway traffic management for visibility monitoring [3]. With the popularization and application of image process technology, more cameras were equipped with 1-2 km interval on highway network. So how to use video cameras to detect road visibility has become a focus research among the world [4].

Refer to the literatures, there are many video visibility detection algorithms used in researches, such as template matching method [5], camera calibration method [6-7], and the dark channel prior image method [8]. The road area was mainly regarded as a

[*] Corresponding Author

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reference in these methods. The complex weather and environment would interference the detection accuracy, such as road markings covered by snow and road renovation. At the same time, these methods were limited to night detection. However, dual differential luminance algorithm [9] has significant advantages in terms of visibility all-weather detection with better reliability. This method needs to set up video visibility detection conditions and use blackbodies as artificial targets.

Due to nonideal site conditions of testing facilities and obvious difference of environment in different measuring points, the traditional dual differential luminance algorithm, which is deduced in the ideal case, cannot meet practice applications. Lv Weitao [10] measured and interpolated the sky background luminance distribution among the given target, and pointed out that it can reduce the detection error. With the use of region growing method, Chang Feng [11] fitted and reconstructed sky region information to get good results in the case of the uneven distribution of sky brightness and the presence of obstructions. These above researches adopt image processing technique or the average method to obtain approximate solutions, and reduced the error caused by uneven sky brightness. But they ignored the differences between two targets and the influence of stray light. For getting better results, an improved dual differential luminance algorithm based on correction coefficient method is proposed in this paper. Considering the various interference factors in reality, the new algorithm divides detection modes which are combined with the traffic emergency control measures under different visibility, and expect to achieve real-time detection of visibility daylong with high detection accuracy.

2. Detection Principle of Dual Differential Luminance Algorithm

2.1. Application fundamentals of dual differential luminance algorithm

Koschmieder's law describes the relationship of the apparent brightness B_t and surface intrinsic brightness B_{t0} of an object at a distance L from observing site, as follows:

$$B_t = B_{t0}e^{-\sigma L} + (1 - e^{-\sigma L})B_{g0} \tag{1}$$

Where, B_{g0} is intrinsic brightness of sky background at infinity; σ is extinction coefficient.

When assuming that apparent brightness B_g of sky background is equal to B_{g0} and setting that C is luminance contrast between the object and sky background, we can get:

$$C = \left|\frac{B_t - B_g}{B_g}\right| = \left|\frac{B_{t0} - B_{g0}}{B_{g0}}\right| e^{-\sigma L} \tag{2}$$

According to World Meteorological Organization, contrast threshold is 0.05. Simplified formula is shown in (3) if the target is black enough that approximately being blackbody.

$$e^{-\sigma L} = 0.05 \tag{3}$$

The visibility is calculated as follows:

$$L = \frac{1}{\sigma}\ln\frac{1}{0.05} = \frac{2.996}{\sigma} \tag{4}$$

From (4), visibility can be gained just when σ is known. In this paper, σ is obtained by the improved dual differential luminance algorithm.

2.2. The Original Dual Differential Luminance Algorithm

Dual differential luminance algorithm uses luminance contrast between two groups of targets - background to calculate the meteorological visibility. Its detection principle is shown in Fig 1.

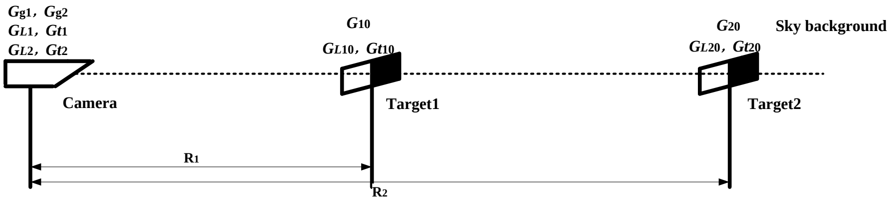


Figure 1. Dual Differential Luminance Method Diagram

Two practical blackbodies as artificial targets are used in the paper; and a set of formulas using Koschmieder's law is shown as follows:

$$\sigma R_1 = Ln[(B_{t10} - B_{g10})/(B_{t1} - B_{g1})] \quad (5)$$

$$\sigma R_2 = Ln[(B_{t20} - B_{g20})/(B_{t2} - B_{g2})] \quad (6)$$

Where, R_1, R_2 are respectively linear distance between the camera lens and double targets. As we all know, apparent brightness B_{t1} of target 1, apparent brightness B_{t2} of target 2, and apparent brightness B_{g1} , B_{g2} of sky background cannot be obtained directly, while their gray value can be gained easily.

The original dual differential luminance equation in the daytime is derived as (7).

$$V_{day} = \frac{2.996(R_2 - R_1)}{Ln[(B_{t1} - B_{g1})/(B_{t2} - B_{g2})] - Ln[(1 - B_{t10}/B_{g10})/(1 - B_{t20}/B_{g10})]} \quad (7)$$

According to the corresponding transform, there will be:

$$V_{day} = \frac{2.996(R_2 - R_1)}{Ln[(G_{t1} - G_{g1})/(G_{t2} - G_{g2})] - Ln[(1 - B_{t10}/B_{g10})/(1 - B_{t20}/B_{g10})]} \quad (8)$$

In which, gray value of target1 is G_{t1} as well as gray value of its sky background is G_{g1}; gray value of target 2 is G_{t2} as well as gray value of its sky background is G_{g2}.

The light sources are needed when using the algorithm for estimating visibility at night. We set that G_{L1} and G_{L2} are respectively gray value of light 1 and light 2. Let G_{10} and G_{20} be the inherent gray values of double light sources, and then the night visibility can be calculated with (9).

$$V_{night} = \frac{2.996(R_2 - R_1)}{Ln[(G_{L1} - G_{t1})/(G_{L2} - G_{t2})] - Ln(G_{10}/G_{20})} \quad (9)$$

Due to the fact that it is difficult to acquire part of parameters in the original formulas, traditional dual differential luminance algorithm is commonly used in practice. The traditional algorithm is derived under ideal conditions - same direction in the line of the goal-background, adopting practical blackbodies as targets, and uniform lighting conditions, as shown in (10) and (11).

$$V_{day} = \frac{2.996(R_2 - R_1)}{Ln[(G_{t1} - G_{g1})/(G_{t2} - G_{g2})]} \quad (10)$$

$$V_{night} = \frac{2.996(R_2 - R_1)}{Ln[(G_{L1} - G_{t1})/(G_{L2} - G_{t2})]} \quad (11)$$

2.3. Optimization of Dual Differential Luminance Algorithm

In the practical engineering calculation, we often obtained visibility by using the traditional method. Because of nonideal site conditions of testing facilities and obvious difference of environment in different measuring points, in which stray light has great effect on instruments, a large error may be generated by using traditional algorithm. For getting better results, considering the various interference factors in reality, an improved dual differential luminance algorithm based on correction coefficient method is proposed in this paper.

2.3.1 Improved Dual Differential Luminance Algorithm based on Correction Coefficient Method: In fact, blackbodies are not entirely black due to the different manufacturing processes, which lead to difference between inherent brightness B_{t10} of light 1 and inherent brightness B_{t20} of light 2. So two correction parameters a_{11} and a_{22} are introduced since it is not available to obtain the intrinsic brightness in real-time detection. In here, we set $a_{11} = B_{t10} / B_{g10}$, $a_{22} = B_{t20} / B_{g10}$, $b = G_{10} / G_{20}$. The values of a_{11} and a_{22} take the gray ratio of sky background to target 1or target 2 for reference. The value of b is obtained by testing the gray level ratio of light source 1 to light source 2.

Studies [12] on the sky background brightness in different elevation show that, sky background brightness is different in the vertical distribution of different elevation. So a correction parameter m is introduced to reduce error when extracting sky region gray.

The improved dual differential luminance equations are gained as follows.

$$V_{day} = \frac{2.996(R_2 - R_1)\ m}{Ln[(G_{t1} - G_{g1}) / (G_{t2} - G_{g2})] - Ln(a)} \tag{12}$$

$$V_{night} = \frac{2.996(R_2 - R_1)\ m}{Ln[(G_{L1} - G_{t1}) / (G_{L2} - G_{t2})] - Ln(b)} \tag{13}$$

In which, $a = \left(1\text{-}a_{11}\right) / \left(1 - a_{22}\right)$.

2.3.2 Multi-mode detection based on highway traffic management under different visibility: The existence of various defects in the turbulent atmosphere results in energy attenuation of light wave, and causes the impact of stray light on the algorithm is different in various visibility conditions. To solve the problem, different correction parameters are adopted in the different detection patterns which are divided based on highway traffic management under different visibility conditions.

According to "The Announcement on Highway Traffic Management in Low Visibility Conditions" [13] and "Specification for Surface Meteorological Observation" [14], highway visibility grade partition and the relative measures are available in table 1.

Table 1. Type Selection of Highway Visibility

Visibility grade	Visibility range(m)	Concentration of the mist	Control measures
-	1000<L<10000	Mist	Don't need to take measures
0	500<L≤1000	Fog	Don't need to take measures
1	200<L≤500		No more than 80 kilometers per hour; keep more than 150 meters

			from the vehicles in front in the same lane.
2	100<L≤200	Dense fog	No more than 60 kilometers per hour; keep more than 100 meters from the vehicles in front in the same lane.
3	50<L≤100		No more than 40 kilometers per hour; keep more than 50 meters from the vehicles in front in the same lane.
4	L≤50	Strong fog	Shuttering highways in partial or whole; the maximum speed of motor vehicles which have entered in expressways shall not exceed 20 kilometers per hour.

Accordingly, the visibility detection modes are shown in table 2:

Table 2. Visibility Detection Mode

Major mode	Detection mode(i, j)	Visibility range(m)
Daytime mode 1	1-1	L≤50
	1-2	50<L≤100
	1-3	100<L≤200
	1-4	200<L≤500
Daytime mode 2	2-1	500<L≤10000
Night mode 3	3-1	L≤50
	3-2	50<L≤100
	3-3	100<L≤200
	3-4	200<L≤500
Night mode 4	4-1	500<L≤10000

In the detection mode (i,j), the value of correction parameter m is $\mathrm{m}_{i.j}$; the value of a is $\mathrm{a}_{i.j}$; the value of b is $\mathrm{b}_{i.j}$. Thus, optimization formulas are derived in the case of multi-mode detection.

$$V_{day} = \frac{2.996(R_2 - R_1)\ \mathrm{m}_{i.j}}{Ln[(G_{t1} - G_{g1})/(G_{t2} - G_{g2})] - Ln(\mathrm{a}_{i.j})} \tag{14}$$

$$V_{night} = \frac{2.996(R_2 - R_1)\ \mathrm{m}_{i.j}}{Ln[(G_{L1} - G_{\mathrm{t}1})/(G_{L2} - G_{\mathrm{t}2})] - Ln(\mathrm{b}_{i.j})} \tag{15}$$

2.4. Calculating the Correction Parameters with Least Square Method

For one mode, different correction parameters may result in different performance, which requires us to adopt the best correction coefficients. In this paper, the optimal coefficients are gained by using the method of least square; and the error between theoretical calculating values and correlation data is considered as the objective function in the method.

Taking detection mode (x,y) for example, the objective function model is established as (16) if the mode is used during daytime.

$$\varphi(m,\mathrm{a}) = \min\sum_{i=0}^{n}\left[\frac{2.996(R_2-R_1)\ \mathrm{m}_{x,y}}{Ln[(G_{t1_i}-G_{g1_i})/(G_{t2_i}-G_{g2_i})]-Ln(\mathrm{a}_{x,y})}-L_i\right]^2 \tag{16}$$

In which, L_i is correlation data; measurement a_0 can be a reference for a ; and m_0 is a reference for m . The constraint conditions of the daytime mode according to the scope of parameters are shown as follows:

$$\text{s.t}\begin{cases}\dfrac{2.996(R_2-R_1)\ \mathrm{m}_{x,y}}{Ln[(G_{t1_i}-G_{g1_i})/(G_{t2_i}-G_{g2_i})]-Ln(\mathrm{a}_{x,y})}\geq 0 & (17)\\ \mathrm{m}_0-0.5\leq \mathrm{m}_{x,y}\leq \mathrm{m}_0+0.5 & (18)\\ \mathrm{a}_0-0.1\leq \mathrm{a}_{x,y}\leq \mathrm{a}_0+0.1 & (19)\end{cases}$$

Objective function model at night is established as (20) if the mode is used at night.

$$\varphi(m,\mathrm{b}) = \min\sum_{i=0}^{n}\left[\frac{2.996(R_2-R_1)\ \mathrm{m}_{x,y}}{Ln[(G_{L1_i}-G_{t1_i})/(G_{L2_i}-G_{t2_i})]-Ln(\mathrm{b}_{x,y})}-L_i\right]^2 \tag{20}$$

b_0 can be used as a reference for b , and the constraint conditions of the night mode are shown as follows:

$$\text{s.t}\begin{cases}\dfrac{2.996(R_2-R_1)\ \mathrm{m}_{x,y}}{Ln[(G_{L1_i}-G_{t1_i})/(G_{L2_i}-G_{t2_i})]-Ln(\mathrm{b}_{x,y})}\geq 0 & (21)\\ \mathrm{m}_0-0.5\leq \mathrm{m}_{x,y}\leq \mathrm{m}_0+0.5 & (22)\\ \mathrm{b}_0-0.2\leq \mathrm{b}_{x,y}\leq \mathrm{b}_0+0.2 & (23)\end{cases}$$

Similarly, a set of optimal coefficients in different detection mode are presented.

3. Realization on Visibility Detection

As shown in Fig.2, the whole system mainly includes setting up of experimental system, data collection, analysis on the images extracted from the video stream, choosing the corresponding optimized formula by selecting the detection mode, optimizing the method through amendment of coefficients etc.

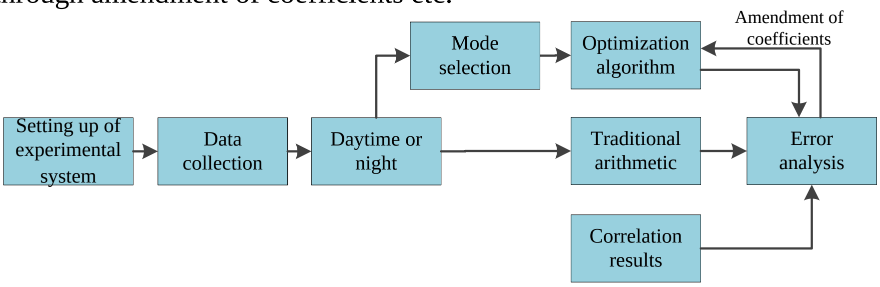


Figure 2. System Structure Diagram

3.1. Setting up of Experimental System and Data Collection

The experimental system was established in the Meteorological Observatory of Beijing to verify the effectiveness of the algorithm, as shown in Fig.3, including a camera, two blackbodies and two light sources. A picture was acquired every one minute from the video captured by the camera, and nearly 20000 photos were collected. To be matched with video, the correlation data were obtained by means of a scatterometer (vaisala PWD 20) equipped in the same place.

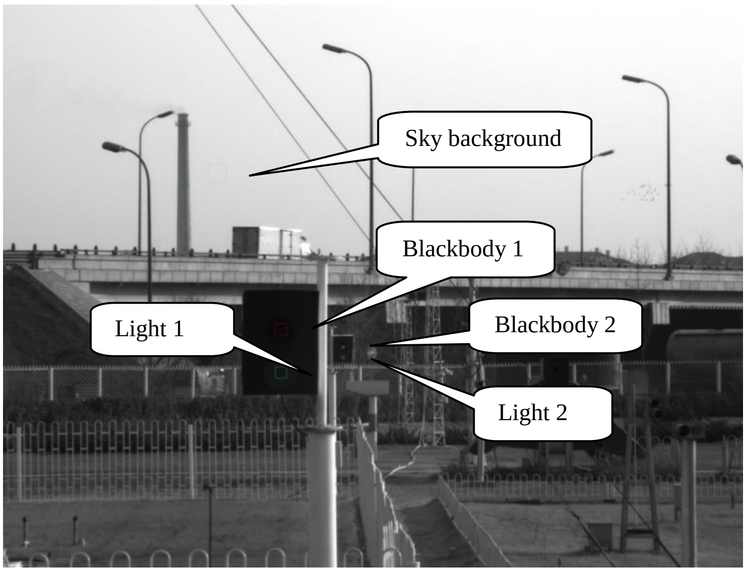
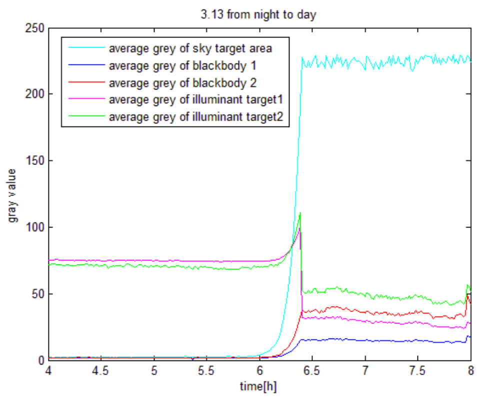


Figure 3. Experimental Site

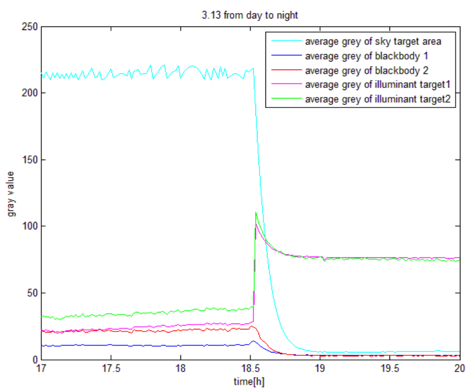
3.2. Research on Transitional Condition

One of the difficulties in the implementing process is to choose different calculation model by judging it is daytime or night. Through analyzing a variety of techniques, such as time nodes and brightness mutation of sky background [15-16], a rather effective solution is presented to direct judge according to the gray level range of the target area.

In the paper, two transition periods in March 13, 2013, are selected, and the gray level curve of each target area is showed in Fig.4. Fig.4-(a) shows that the grey levels of five target areas are dynamically stable from 4:00 to 6:00, mutate during the period of 6:00 to 6:30, and tend to become steady after 6:30. Similarly, from daytime to night, the grey levels of five target areas maintain stable within a small range from 17:00 to 18:30, dramatically change between 18:30 to 19:00, and tend to be steady after 19:00, as shown in Fig.4-(b).



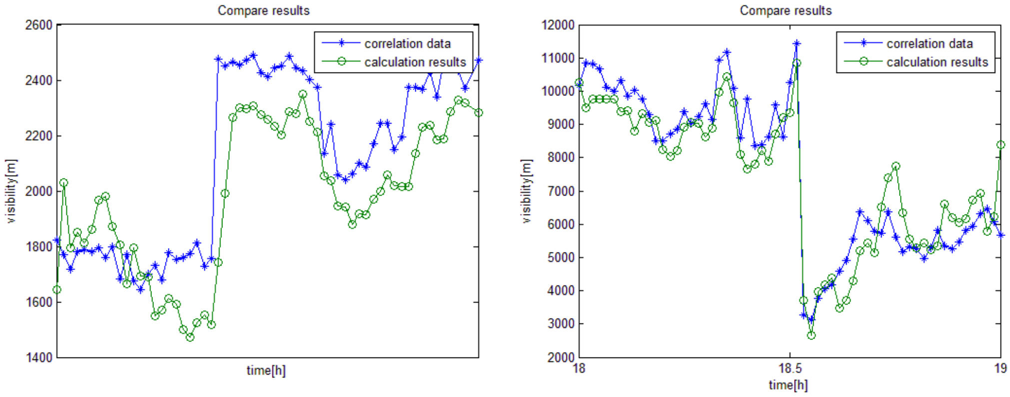
(a) Grayscale curve from night to daytime



(b) Grayscale curve from daytime to night

Figure 4. Grayscale Curve of Each Target Area

Based on the analysis of transition periods, we set the terms of the transition: when the grayscale of sky target area is greater than 200, daytime formula will be used; when the grayscale of sky target area is less than 200, night algorithm will be adopted. By comparing calculation results with correlation data, feasibility and effectiveness of the approach is proved. As shown in Fig.5, the green curve is the result gained by using the transition condition, the blue line stands for correlation data. The contrasting results show that trend of the results by using the transition condition is accord with comparison results and the error is within the prescribed scope.



(a) Compare results from night to daytime

(b) Compare results from daytime to night

Figure 5. The Verification Results

3.3. Implementation Process of Video Visibility and Software Design

After analyzing the detecting principle, application of the new arithmetic in visibility detection is achieved. As shown in Fig.6, we need to calibrate the video picture at first, and extract gray value of target domain to get the visibility before correction. And then, the corrected visibility is obtained through the advanced algorithm. Meanwhile, good man-machine interface is written by C# according to the implementation process of video visibility, making it easier and more directly to get the value of visibility, as shown in Fig.7.

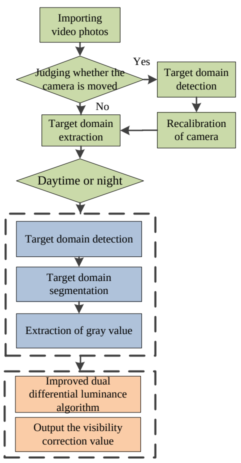


Figure 6. Flow Charts of the Improved Algorithm

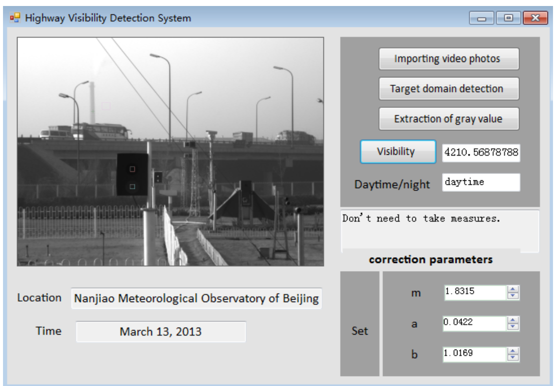


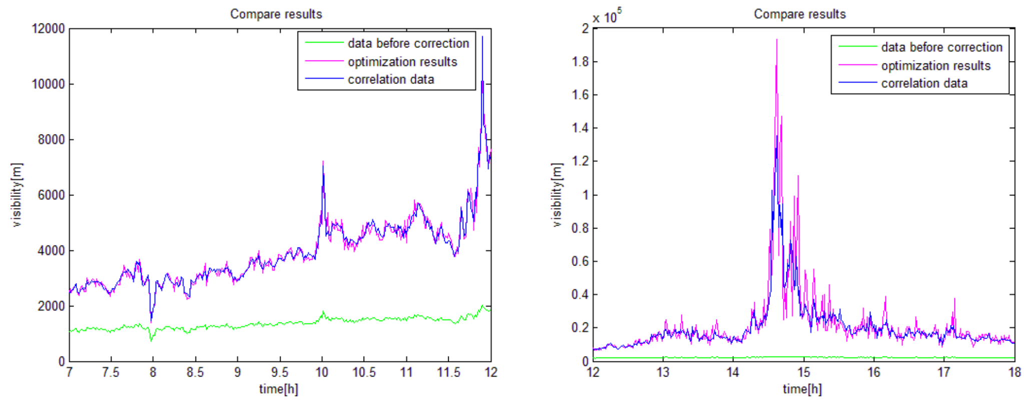
Figure 7. Man-machine Interface

3.4. Analysis of Experimental Results

By processing the acquired video images with software, we can obtain the corresponding visibility values, and compare them with the correlation data from the scatterometer. Fig.(8) and Fig.(9) show that green curve corresponds to the data with traditional dual differential luminance algorithm; blue curve is the result gained by using optimization algorithm; and red line stands for correlation data.

In the paper, according to the “Monitoring of Visibility and Warning of Heavy Fog on Highway”, visibility on highway is monitored ranging from ten meters to five kilometers [17]. Thus we take this standard as an acceptable level and ignore the errors or change trend of the visibility values higher than five kilometers.

When visibility is lower than five kilometers during daytime, as shown in Fig.8-(a), visibility values before correction in the daytime have a big difference with the correlation data. Considering the impact of the two target blackbodies’ manufacturing technologies, we introduce two correction parameters, and get their values by using the least square method. It proves that the trend of the optimized results after applying the correction algorithm is virtually consistent with the correlation data, which completely satisfies the requirements of real-time detection with high precision. When beyond five kilometers, Fig.8-(b) shows that very good conformance has been reached between the optimized visibility and the correlation data. Although the visibility varies over a wide range within hours, optimization algorithm can reduce the errors and greatly improve the performance of detection by adopting multi-mode detection techniques which adjusts the correction parameters continuously.



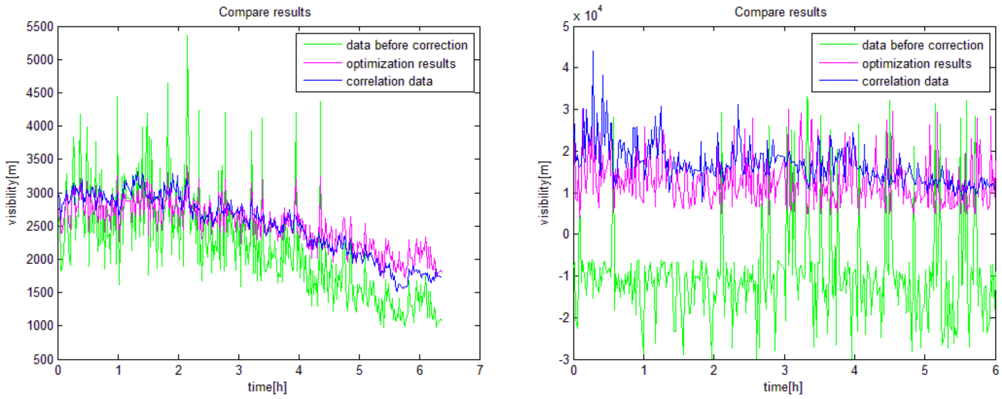
(a) Visibility comparison results during the daytime below 5 kilometers

(b) Visibility comparison results during the daytime beyond 5 kilometers

Figure 8. Visibility Comparison Results in the Daytime

Due to the influence of vehicle light and stray light in measurement at night, the data with the traditional method is likely to subject to the interference and results in large fluctuation. As shown in Fig.9-(a) and Fig.9-(b), data before correction has a big fluctuation while data after correction is more flat. However, relative error also exists, which is caused by the measurement accuracy of inherent brightness difference between two light sources and the unevenness of light conditions in the observation field. It is also able to improve the correction effects by enhancing the accuracy.

Because of the different inherent brightness of the light sources, there are a large number of negative values with the traditional method. In condition of clear night, the error of part uncorrected negative values can be corrected by the new algorithm.



(a) Visibility comparison results at night below 5 kilometers

(b) Visibility comparison results at night beyond 5 kilometers

Figure 9. Visibility Comparison Results at Night

Table 3 shows that the traditional algorithm cannot fulfill practical requirement in real-time detection, due to considerable errors, while the proposed algorithm in this paper gets favorable application effect, with the relative error less than 10%.

Table 3. Comparison Results of Relative Error

	Traditional algorithm	Optimization method in this paper
Relative error during daytime	43.7%	3.3%
Relative error at night	21%	8.3%

4. Conclusion

According to the limitations of traditional dual differential luminance applied in actual scenes, a kind of improved dual differential luminance algorithm based on correction coefficient method is proposed. Simultaneously, combined with the traffic emergency control measures under different visibility, the new algorithm divides detection modes to raise the accuracy. Through building the experimental system, the experimental results show that the model is highly accessible and feasible with relative error less than 10 percents in low visibility conditions, which meets the requirements of the provisions of the standard visibility instrument error.

Acknowledgements

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References

[1] Sun Xin. Research on Risk Coupling of Highway Traffic Safety Based on Catastrophe Theory. Beijing Jiaotong University, **(2015)**.

[2] Jinrong Ye, Xiqiang Zhang. Highway Characteristics and Cautions in Driving. Highway Transportation Digest, 8, **(2003)**.

[3] Wang Jingli. The Research in Digital Photograph Visibility Device System. The 2010 Academic Annual Conference of CSIST, **(2010)**.

[4] Zhongjie Zhao, Shiyan Xu, Linying Zhou. Highway Monitoring System. Beijing: China Communications Press, **(2014)**.

[5] Hallowell R G, Matthews M P, Pisano P A. Automated extraction of weather variables from camera imagery. Proceedings of the 2005 Mid-Continent Transportation Research Symposium, Ames, IA, **(2005)**.
[6] Nicolas Hauti`ere, Jean-Philippe Tarel, Jean Lavenant, Didier Aubert. Automatic fog detection and estimation of visibility distance through use of an onboard camera. Machine Vision and Applications, vol.17, no.1, **(2006)**.
[7] Chen Zhaozheng, Chen Qimei. Video Contrast Visibility Detection Algorithm and Its Implementation Based on Camera Self-calibration. Journal of Electronics and Information Technology, vol.32, no.12, **(2010)**.
[8] Shangshu Guo, Wenxin Qi, Yu Qi. Video Visibility Measurement Method Based on Dark Channel Prior. Computer and digital Engineering, vol.42, no.4, **(2014)**.
[9] Lv Weitao, Tao Shanchang, Liu Yifeng, Tan Yongbo, Wang Benge. Measuring Meteorological Visibility Based on Digital Photography-Dual Differential Luminance Method and Experimental Study. Chinese Journal of Atmospheric Sciences, vol.28, no.4, **(2004)**.
[10] Lv Weitao, Tao Shanchang, Tan Yongbo. Error Analyses of Daytime Meteorological Visibility Measurement Using Dual Differential Luminance Algorithm. Journal of Applied Meteorological Science, vol.14, no.5, **(2005)**.
[11] Chang Feng, Chen Xiaoting, Xiao Mingxia, Jiang Weiwei. Visibility algorithm design and implementation of digital camera visibility instrument. Microcomputer and Its Applications, vol. 32, no. 9, **(2013)**.
[12] Bian Jian, Qie Lili, Xu Wengqing, Xu Qingshan. Effect of aerosol vertical inhomogeneity on sky background brightness. High Power Laser and Particle Beams, vol.25, no.5, **(2013)**.
[13] The Ministry of Public Security of the People’s Republic of China. The announcement on highway traffic management in low visibility conditions, **(1998)**.
[14] China meteorological administration. Specification for Surface Meteorological Observation. Beijing: China Meteorological Press, **(2003)**, 1, pp.155-156.
[15] Feng Minxue. Research on intelligent traffic meteorologically monitoring and warning system. Beijing: China Meteorological Press, **(2007)**.
[16] Chen Xiaoting. Research of Several Key Technologies for Digital Camera Visibility Monitoring. Hefei University of Technology, **(2013)**.
[17] QX/T76-2007. Monitoring of Visibility and Warning of Heavy Fog on Highway, **(2007)**.

Authors

Zhao Jiandong, He is a Ph. D, graduated from the Tsinghua University, China. He received his B.S. and M.S degree in 1997 and 2000 respectively from Xi'an Jiaotong University, China. From 2007 , He is an associate professor of Beijing Jiaotong University, China. His research interests include traffic control and safety, traffic emergency management, traffic safety lighting and transport energy-saving.

Han Mingmin, She is a master of School of Mechanical, electronic and control Engineering, Beijing Jiaotong University, and professional for safety science and engineering. She received her B.S. degree in 2012 from Hebei University of Science and Technology. Her research interests include computer vision, pattern recognition, and traffic control and safety.

Xin Xin, He is a Master, graduated from the University of Washington, U.S, mainly specializes in traffic equipment development and implementation. His research lays emphasis on traffic devices innovation and industrialization. He is also engaged in consultation on highway traffic safety and weather information

collection system as well as in highway network emergency management.

Li Changcheng, He is a Ph. D, National Certified Safety Engineer, mainly specializes in research and consultation in highway traffic and weather information system as well as in highway network emergency management. He has enriched experience in set-up of highway weather information system, safe operation under special weather conditions, operation evaluation of highway network and emergency management.