The Detection Research to Night License Plate Based on Infrared Thermal Imaging Technology

Jiangfei Wang, Lihua Yuan*, Mingyuan Yuan
Key Laboratory of Nondestructive Testing (Ministry of Education), Nanchang Hangkong University, Nanchang 330063, China

*Corresponding author e-mail: lilyyuan99@qq.com

Abstract. To extract the license plate information in night scene and improve the vehicle safety management competence, the research extracts the license plate message of night driving vehicles based on the infrared image technology. The license plate number is located by using the log operator edge detection, and characters are segmented and analyzed for realizing the function that vehicle license plate information acquirement. The result of the research indicates that infrared thermal imaging technology is able to pick up the plate information at night, which provides the reference for night plate information detection.

1. Introduction
With the rapid development of science, infrared thermal imaging technology has entered more and more research areas and plays an ineligible role. Infrared Thermal Imaging Technology is a kind of science which detects the radiation through photoelectric equipment and builds the interrelation between it and the surface temperature. Such technology has widely used in some areas like military, testing industry, medical science, public safeguard and so on [1-3]. Automobile is one of the most significant transportation means, while the license plate is the “ID CARD” of every vehicle. So how to deal with the intelligent automatic car management problem will play an important role in promoting transportation safety, improving the transportation efficiency, and enhancing the economic vitality. However, there is a high probability time – evening – that some cars accidents and illegal actions will be happened easily. Therefore, the night vehicle automatic management and better night vehicle monitoring are strongly needed [4].

One of the most important parts in automobiles management is the way to recognize the license plate effectively and accurately in suitable region. What’s more, quick and accurate car information realization is a significant problem to be considered. Nowadays, the vehicle recognition in visible light is mature, and it is widely used in expressway, parking lot, vital communication line, traffic light intersection and any other places. But in some sections, normal cameras are unable to get the clear license plate detection photos due to the insufficient light which leads to the inaccurate plate identification. The joint element analysis to India plate with infrared and colorized image character segmentation use the method combined length-width ratio and pixel counts, and the final efficiency goes to 96.5% [5]. According to the plate number location in back lighted night. XieLihua and NieShiliang provide the way based on nonsubsampled contourlet transform and mathematical morphology, and they come up with the method for improving precision through finding the light and plate [6]. In M.A.Massoud, M.Sabee, M. Gergais and R. Bakhit’s [7] Egypt automatic plate recognition system, they firstly utilize the edge detection based on Sobel Operator, morphologic processing and natural
characteristics test for accurate locating. Normal cameras are easily being affected by light and environment brightness, while Infrared Thermal Imaging technology is imaging through checking the surface temperature discrepancy of certain item, it effectively solves the low brightness in night scene. Thus, it is meaningful to adopt the Infrared Thermal Imaging in plate detection.

2. Infrared Thermal Imaging System

Radiation means the heat movement while radiant energy (electromagnetic wave) is moving without direct conduction mode. All the items higher than absolute zero temperature (-273°C) will provide infrared radiation. A typical infrared imaging system is consisted of optical system, infrared detector and electronic processor. The working process is showed in Figure 1.

As for nondestructive testing, infrared testing has a rapid development, infrared nondestructive testing utilizes the thermal radiation properties of examination object. Due to the place with or without defects have different thermal characteristics, which leads to the temperature change. When heating the surface of the object, if there exist the defect, heat flow will be hindered, otherwise it stays in the object. After a long period time, the temperature gradient of the surface will be changed because of the thermal accumulation. After scanning and recording the surface temperature, and analyzing the thermal image, the defect information of examination object can be easily acquired according to the temperature distribution [8].

![Infrared thermal imaging working process.](image)

3. Night Plate Detection Working Principle

All the objects, whether high or low surface temperature, will absorb and emit electromagnetic thermal radiation, and its quantity are related to some characters not only material type, shape feature, chemical properties and physical structure (Surface oxidizability, roughness…), but also the wave length and temperature. Infrared Thermography can measure the temperature field under such principle. Also, it is able to observe the object configuration and surface heat distribution which unable observed directly with the naked eye, and present the temperature and temperature difference of each point in certain object on screen in gray image or pseudo – colorized image. So the range of people’s visual observation can be extended from the visual band to the infrared band.

Infrared Thermal Imaging technology is to receive the infrared thermal energy of examination object through infrared detector and objective lens, then the distribution of object is sent to the photosensor of infrared detector, and finally the infrared thermography is acquired. The thermography is corresponding to the thermal distribution field of actual item surface. In general, infrared detector is to converse the invisible infrared thermal energy to the visible heat distribution image. The measurement principle is Stefan – Boltzmann Law:

\[ S = \varepsilon \cdot \sigma \cdot T^4 \]  

\( \sigma \): Stefan – Boltzmann Constant, the average emissivity of examination object surface panel.  
\( T \): Temperature  
\( S \): Sum radiosity of the object surface
4. Infrared Plate Image Cognition and Treatment

In visible light, the license plate cognition utilizes the blue pixel point of received images to assure the place of plate, but the color of the infrared image is depending on the temperature difference of object surface and the color cannot be determined, so it is not an effective way to locate plate. The edge detection is able to determine the position with the infrared image which transformed into gray image. The recognition flow chart is shown in Figure 2.

![Recognition flow chart](image)

Figure 2. License plate infrared image cognition flow chart.

Owing to the 3-Dimensional object while the 2-Dimensional image, there must exist the information loss in the process of transformation. And some factors like the light evenness and noise level in the vicinity of object will influence the edge detection. Those factors lead to the edge of the item perhaps is unable to be detected or is not real edge. However, the edge of one image has 2 attributes – Direction and Amplitude, and the pixel change paralleled the edge is much more gentle than vertical, such change can be found out by different operator. Commonly used are Roberts Operator, Prewitt Operator, Sobel Operator, Log Operator and so on[9-10].

5. Log Operator

Log Operator is one of the best edge detection operators which come from the Marr visual theory. First, the image needs to do a series of smoothing processing for farthest inhibit the noise. At last, the edge extraction is being used in the worked image. Log Operator firstly needs to smoothing filter the image by 2D Laplace Operator, finally zero crossing edge detection by second derivative.

The function of 2D Gaussian Filter is:

\[
G(x, y) = \frac{1}{2\pi\sigma^2} \exp\left(-\frac{x^2+y^2}{2\sigma^2}\right)
\]  \hspace{1cm} (2)

Convolute the G(x, y) and cognition image F(x, y) for getting the smoothing image J(x, y):

\[
J(x, y) = G(x, y) * F(x, y)
\]  \hspace{1cm} (3)

Get the second direction derivative diagram M(x, y) by Laplace Operator:

\[
M(x, y) = \nabla^2[J(x, y)] = \nabla^2[G(x, y) * F(x, y)] = [\nabla^2G(x, y)] * F(x, y)
\]  \hspace{1cm} (4)
But in real-world application, Log Operator is strongly affected by noise, and the noise smoothing competence has a contradiction to edge cognition ability. The Log Operator is used to extract plate information in infrared plate image.

![Infrared thermal image and after gray processing](image)

**Figure 3.** Infrared thermal image graying example.

Figure 3 shows the infrared thermal image before and after graying process and Figure 4 shows the plate after extraction by Log Operator.

![The plate image after extraction](image)

**Figure 4.** The plate image after extraction.

### 6. Infrared Plate Image Character Segmentation

In visible light, binary processing of gray image immediately start after extract the license, but due to the less temperature difference between license plate character and floor in infrared image, which leads to the low contrast ratio. After graying, it still has low gray difference, so the image after binary processing only has some fuzzy dots. To disposal such problems, it is quite good to do character segmentation before binary processing, and reduce the graying value, at the same time, the graying rate can also be reduced. For example, the threshold of the first character and floor are 1 and 2 respectively, and the rate of the whole plate is 1-6. If the value is 3, the first character cannot be presented. But if the value is picked among the first character area, the pixel point which threshold is 1 can be settled as 0 – black, the threshold more than 2 can be settled as 255 – white. Thus, the character can be picked up, the character segmentation result shows in Figure 5.

![Character segmentation](image)

**Figure 5.** Character segmentation.

The result after binary processing shows in Figure 6.

![Binary processing](image)

**Figure 6.** Binary processing.
Because of the noise and resolution, though it is obvious to see some redundant white dots or character loss, it cannot hinder the plate cognition.

7. Character database and recognition
In visible light, the plate recognition is comparing the monochrome percentage of the examination image with model image. While the binary image in infrared processing image contains too many redundant dots and character loss, the recognition rate is not high. Therefore, every image can be seen as a 2D matrix, 2 matrixes with high similarity can be regarded as the same image. The character database build needs the mat format in MATLAB. Using character database can promote the recognition efficiency.

First, the model image needs to be transformed into a 100*100 matrix for comparison, then logicalize the image – change the value 255 (White pixel Point) into 1. For instance:

After building the database, every character which had been segmented before can be converted into 100*100 matrix, and compare with the mat document, a model with high acquaintance degree can be seen as the goal character. Finally the recognition result is “赣 A02E99”, as the Figure 7:

![Figure 7](image)

Figure 7. Recognition result.

8. Conclusion
The detection research to night license plate based on infrared thermal imaging technology improves the vehicle management more effectively, it can help officials to do some necessary detections in some roads with dizzy or no light, also it provides convenience for road safeguard. Therefore, this research has a high practical value. Through the literature review of license plate cognition in visible light, and some characters – low resolution and fuzzy colorized of the infrared image. Finally it can be found that it is effective to extract the plate information by edge detection, promote resolution by graying, character segmentation and binary processing. Through these methods, license plate information can be recognized, and it provides the reference of night plate detection research.

Acknowledgments
This work was financially supported by the Chinese Government Scholarship for studying abroad and Postgraduate Innovation Project Fund of Nanchang Hangkong University (YC2018037).

References
[1] Pavlidis I, Levine J, Baukol P. Thermal imaging for anxiety detection [C] Computer Vision Beyond the Visible Spectrum: Methods and Applications, 2000. Proceedings. IEEE Workshop on. IEEE, 2000: 104-109.
[2] Ring E F J, Ammer K. Infrared thermal imaging in medicine.[J]. Physiological Measurement, 2012, 33 (3): R33
[3] Zhang W, Cai D. Research and applications of infrared thermal imaging systems suitable for developing countries [J]. International Journal of Infrared & Millimeter Waves, 1986, 7 (1): 65-70.
[4] Robert K. Video-based traffic monitoring at day and night vehicle features detection tracking [C]/ International IEEE Conference on Intelligent Transportation Systems. IEEE, 2009: 1-6.
[5] N.Vishwanath, S.Somasundaram, M.R. Rupesh Ravi, N. Krishnan Nallaperumal. Connected Component Analysis for Indian License Plate Infra-Red and Color Image Character Segmentation [C].International Conference on Computational Intelligence and Computing Research, 2012.
[6] Ma Y, Xie J, Luo J. Image Enhancement Based on Nonsubsampled Contourlet Transform [J].
Journal of Yangzhou University, 2011, 1 (4): 31-34.

[7] M.A. Massoud, M. Sabee, M. Gergais, R. Bakhit. Automated new license plate recognition in Egypt. Alexandria Engineering Journal, 2013, 52: 319–326.

[8] Dereniak E L, Boreman G D. Infrared detectors and systems [J]. 1996, 93 (5-6): 294-299.

[9] Acharjya P P, Das R, Ghoshal D. Study and Comparison of Different Edge Detectors for Image Segmentation [J]. Global Journal of Computer Science & Technology, 2012.

[10] Ramadevi Y, Poornima B, Sridevi T. Threshold Based Edge Detection Algorithm [J]. International Journal of Engineering Science & Technology, 2012, 3(4).