Road Obstacle Detection in Bad Weather Based on Deep Learning

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Abstract. With the progress of the scientific era, people's way of travel has become more diverse, not like the ancient carriage travel, but now the car, bus, train, high-speed rail, aircraft and so on for people to choose more, but the emergence of science and technology is like a double-edged sword, the convenience of travel mode will lead to traffic congestion, especially in bad weather. In this paper, the deep learning method is used as the basic prediction algorithm to realize the road obstacle detection in bad weather. Under the influence of bad weather, people cannot judge the obstacles clearly, and 87 traffic accidents have occurred in two and a half years. The average number of accidents per day is 1.2, which is higher than that of 1.1 accidents/day in normal weather. The average number of accidents increases by about 20%.

Keywords: Deep Learning; Road Obstacle Detection; Neural Network Optimization

1. Introduction
With the rapid increase in the number of private cars, taxis and buses in recent years, many convenient and fast means of transportation bring convenience to people's daily travel, but also bring great pressure to the traffic road. But in recent years, road traffic accidents have seriously harmed people's lives and property safety. One of the main causes of traffic accidents is the reduction of visibility and road adhesion coefficient caused by bad weather.

In this way, people began to consider how to ensure the safety of the road with the development of science and technology. Gibson [1] extends the image enhancement algorithm after defogging through the brightness characteristics of foggy scenes and the nonblack pixel constraint of non-foggy images. This method can be regarded as an extension of the combination of local visibility enhancement algorithm and road specific scene enhancement algorithm. Jordan R [2] used the image enhancement framework of computational theory of color constancy perception to restore the image without fog. This method is a local and global defogging algorithm based on processing perception. The model of haze free image is established by Bayesian model, and atmospheric light coefficient and transmittance are estimated to improve the image quality after defogging. Wang [3] proposed an efficient and real-time video based fog removal method from the perspective of image restoration and image enhancement, aiming at the global dark channel prior theory and image contrast enhancement effect. Firstly, the global dark channel prior method is used to remove fog, and then histogram equalization is used to enhance the brightness and contrast of the image. Finally, the color clarity of the image can be effectively improved and the anti-interference ability of the vision sensor system can be enhanced.
Histogram based defogging algorithm can enhance the image contrast, but it can not accurately restore the original color of the image, so the image is prone to oversaturation after defogging. Although the above scholars have put forward a lot of ideas for the judgment of obstacles when driving in complex weather, the algorithm based on external constraints, given physical model and histogram has the disadvantages of poor real-time performance and weak flexibility.

This study will identify the risk sources, including the identification of risk weather which affects the normal operation of highway traffic, and analyze its characteristics and disaster mechanism. Risk assessment is mainly based on the identification of risk sources and the classification of driving risk level. After risk identification and risk evaluation, risk early warning is carried out. In order to judge the judgment of obstacles under bad weather.

2. Method

2.1. Deep Learning

Deep learning belongs to a branch of machine learning, from the early perception machine, after a series of development, it has evolved into today's deep neural network [4]. With the rapid development of artificial intelligence technology, many research fields have made great progress. Machine learning related research is the beginning of artificial intelligence. Machine learning makes the computer not simply according to the programmed program to execute people's specified command, but has certain autonomous learning ability. Given the input data, machine learning can take the initiative to extract the required information, learn behavior patterns from the input, and the final behavior or prediction is driven by data. The advantages of machine learning make it widely used in many fields, such as computer vision, computer learning, character recognition, pattern recognition, automatic driving and natural language processing, which bring great convenience to our life. Although machine learning methods have achieved remarkable success in the above fields compared with the traditional methods, and there are still some new machine learning theories proposed, such as artificial neural network (ANN), support vector machine (SVM), and k-nearest neighbor (KNN) algorithms have been continuously improved and combined to further improve the performance, but in the fields of natural language processing, computer vision, etc, When simulating the complex biological sensing and processing functions of human beings, the limitations of machine learning algorithms show. The existing machine learning algorithms can not meet the specific requirements. Deep learning was first proposed at the end of last century. Researchers at that time naturally associated the concept of deep network in the study of human complex language and visual system [5].

Big data technology and deep learning technology can promote each other. With the development of modern information technology and network technology, network learning has a large amount of data for reference, which is conducive to network training; at the same time, deep learning can input unlabelled data, extract deep features from a large number of unlabelled data, grasp the essence of data, and improve the ability of data analysis, Provide guarantee for data analysis. Because of the development of big data, cloud computing technology, and deep learning in processing nonlinear input data, in recent years, deep learning has achieved success in computer vision, natural language processing, recommendation system, pattern recognition, language recognition and other fields.

2.2. Road Obstacle Detection

Because the color of structured road is usually fixed and has clear lane mark and road boundary, the identification problem of structured road can be simplified as the detection of lane line, road boundary line or road area segmentation. According to the current research results, the identification methods of structured road can be roughly divided into three categories

The following categories:

(1) Because the color and form of lane line and road boundary line of structured road are uniform, scholars have proposed a variety of road recognition methods based on edge detection. Firstly, the road model is established, and the constraints of the model are established, such as the continuity of
vehicle trajectory and lane width. Then, the visual feature measurement results are used to fit the road model, so as to obtain the estimation of model parameters, and continuously track the lane line to improve the anti-interference ability of the algorithm [6].

(2) The basic working principle of threshold method is to set one or more thresholds to divide the target areas with different colors in the image for classification. Because the threshold method only considers the color information of the image, the overall characteristics of the image are not considered fully. When the road surface changes due to illumination, the effect is not ideal.

(3) Due to the complexity of the actual road environment, the traditional methods such as pattern recognition and image processing have some limitations. Most of the methods based on machine learning are to design a feature classifier to learn and train the features of road samples in advance, and then use the classifier to identify and classify road images according to the learned features, which transforms road recognition into the problem of feature extraction and classification [7].

2.3. Neural Network Optimization Method
The optimization of neural network is the basis of deep learning algorithm. The optimization process of convolutional neural network can be seen as the process of solving the scoring function and loss function describing the network, updating the weight in the network to approach the ideal network model performance [8].

The gradient descent algorithm is implemented by following the objective function $J(\theta)$ (gradient inside (first derivative) in the opposite direction $-\nabla \theta J(\theta)$ to continuously update the model parameters to reach the minimum value of the objective function $\eta$.

If the gradient descent method is used to find the local minimum value of a function, iterative search must be conducted to the current point on the function or the specified step distance point in the opposite direction of the corresponding gradient corresponding to the approximate gradient [9]. The formula is as follows:

$$\theta = \theta - \eta \nabla \theta J(\theta)$$  \hspace{1cm} (1)

The gradient descent algorithm needs to traverse the whole data set when updating the regression coefficient. When the amount of training data is very large, there may be problems such as slow convergence speed and falling into local minimum points. Therefore, in practical application, random gradient descent method (SGD) is more common. SGD is a training method based on a single sample, that is, one sample is randomly selected for learning each time. Among $X_i, y_i$, them are training sample.

The update formula is as follows:

$$\theta = \theta - \eta \nabla \theta J(\theta, X_i, y_i)$$  \hspace{1cm} (2)

SGD algorithm will bring high variance oscillation when updating parameters, which makes it difficult for the network to converge stably. Therefore, a momentum based updating method is proposed:

$$v_i = \gamma v_{i-1} + \eta \nabla \theta J(\theta)$$
$$\theta = \theta - v_i$$  \hspace{1cm} (3)

This method updates the components of the vector in the previous step, “$\eta$”Add to the current update vector, $V_i$ is an intermediate variable representing the update speed.

3. Experiment
3.1. Neural Network Experiment Method
In this paper, neural network is used for experiment. Due to the large amount of data and complex calculation process, the training process of neural network takes a long time [10]. In order to solve the problem that the training time of neural network is too long and the speed is too slow, the parallel acceleration and neural network are used to optimize the road obstacle detection in bad weather environment.

3.2. Social Investigation Method
By using big data technology and consulting relevant materials, effective data are collected and sorted out to ensure the validity of data and avoid the inaccuracy of experimental results. According to different research problems, different research methods are adopted.

4. Discussion

4.1. Bad Weather Impact on Line Of Sight

| Weather type | Sunny | Overcast | Rain | Snow | Fog | Ice |
|--------------|-------|----------|------|------|-----|-----|
| Number of accidents | 560 | 75 | 39 | 28 | 500 | 4 |
| Accident proportion | 72 | 9 | 5 | 3.4 | 6 | 0.5 |
| Proportion of non-sunny accidents | 37 | 20.1 | 13 | 25.1 | 2.4 |

According to the statistical data in Table 1, it can be concluded that the main adverse weather affecting the traffic safety of Expressway includes cloudy, rainy, snowy, and foggy and ice weather. In non-sunny days, the highest proportion of accidents occurred in cloudy and foggy days. When the two are added up, the proportion of accidents in non-sunny days is very large. Therefore, we can get that the influence of bad weather on expressways mainly comes from the obstruction of sight caused by cloudy and foggy days.

4.2. Statistics of Accidents and Damage Degree Caused by Obstacles under Bad Weather
Traffic accident is a destructive event. A traffic accident must cause certain personal or property losses. According to the degree of damage, traffic accidents can be divided into three types: death accident, injury accident and only property loss accident. Especially in bad weather, under the premise of not seeing the obstacles ahead, traffic accidents are more likely to happen.

| weather | Days | Number of accidents | Average number of accidents | Number of injured | death toll | Average casualties |
|---------|------|---------------------|-----------------------------|-------------------|------------|-------------------|
| Ice and snow normal | 66 | 86 | 1.2 | 69 | 14 | 0.95 |
| Ice and snow normal | 729 | 795 | 1.1 | 552 | 104 | 0.85 |
It can be seen from table 2 that in nearly two and a half years, 87 traffic accidents have occurred, with an average of 1.2 accidents per day, which is higher than 1.1 accidents / day in normal weather, and the average number of accidents increases by about 20%. The reason may be closely related to the special driving conditions in ice and snow weather. Under the ice and snow weather, the road adhesion performance and visibility are seriously reduced, and the driving environment is very bad, which greatly increases the driving difficulty and is more prone to traffic accidents.

Table 2 also shows that the casualty rate of traffic accidents increases under ice and snow weather, which is shown in the average number of casualties per accident is higher than the normal weather level. The main reason may be that the skid resistance of the road surface can be sharply reduced in the snow and ice weather, and the vehicle handling stability is poor. In addition, the driver’s reaction in the cold weather is late and pure, the action is rigid and the hands and feet are not flexible. Once an accident occurs, it is difficult to take remedial measures, which often leads to serious consequences.

4.3. Distribution of Accident Duration
The main characteristics of traffic accident duration include concentration degree and dispersion degree. The commonly used duration statistics include mean, median, variance, standard deviation, coefficient of variation, range, etc.

![Figure 1. Distribution of accident duration](image)

Figure 1 shows the distribution of accident duration. The above figure shows that the overall trend of the duration of traffic accidents under snow and ice weather is consistent with that under normal weather, that is, most of the accidents are within 1 hour, and most of the accidents lasting less than 2 hours. Although the change trend of the accident duration under the two kinds of weather is similar, both show a V-shaped curve, but there are some differences: in the 0-1 hour interval, the proportion of ice and snow weather is lower than that of normal weather, and the proportion of ice and snow weather is higher in the other three intervals, which indicates that the duration of traffic accidents under ice and snow weather is generally longer.

4.4. Traffic Mode Distribution of Accidents Can Not Be Judged by Obstacles in Bad Weather
Freeway is a high-grade highway dedicated to high-speed driving of motor vehicles. There are no motorcycles, bicycles and other non-motor vehicles, that is, the main mode of transportation is all kinds of motor vehicles. The collected accident data are divided into cars, buses and trucks. The type of vehicle determines the overall size, dynamic performance, climbing ability, speed, and load degree.
and so on. Different vehicle types have different operation characteristics, different impact on traffic accidents, and different reaction time for obstacle detection.

**Figure 2.** Distribution of vehicles in snow and ice weather accidents

**Figure 3.** Normal weather accident vehicle distribution

It can be seen from the figure that the car is the main vehicle causing the accident, followed by the truck. This phenomenon is closely related to the traffic flow composition of Taichang expressway. In addition, the proportion of car accidents increased significantly in snow and ice weather. This result may be due to the better technical performance of small cars, higher driving speed and serious overtaking phenomenon of cars. If encountering ice snow weather, in the case of bad weather, the ability to judge obstacles is insufficient, it is more likely to cause accidents.

5. **Conclusion**

As a new branch of machine learning, deep learning is a hot research point in the field of artificial intelligence in recent years. The neural network model in deep learning classifies and regresses the data by approximately simulating the structure of human brain neurons. In this paper, through the study of a large number of relevant literatures at home and abroad, combined with the actual situation encountered in the experiment, a recognition method with high robustness in complex situations is proposed. In this paper, for unstructured road, the collected image is preprocessed, shadow is removed, road area detection and tracking are carried out.
In the harsh driving environment, due to the influence of illumination, shadow and obstacles, the road edge is often irregular and contains a large number of noise points, which leads to the problem that the accuracy of the road edge fitting method based on the least square method decreases.

References
[1] Gibson, Eli, et al. "NiftyNet: a deep-learning platform for medical imaging." Computer Methods & Programs in Biomedicine (2018):113.
[2] Ubbens, Jordan R., and S. Ian. "Deep Plant Phenomics: A Deep Learning Platform for Complex Plant Phenotyping Tasks." Front Plant 8(2017):1190.
[3] Wang L, Zhang J, Liu P, et al. Spectral–spatial multi-feature-based deep learning for hyperspectral remote sensing image classification [J]. Soft Computing, 2017, 21(1):213-221.
[4] Liu, Ziwei, et al. "Deep Learning Markov Random Field for Semantic Segmentation." IEEE Trans Pattern Anal Mach Intell (2018):1-1.
[5] Matthew, Hohman Fred, et al. "Visual Analytics in Deep Learning: An Interrogative Survey for the Next Frontiers." IEEE Transactions on Visualization & Computer Graphics PP (2018):1-1.
[6] Surani, Salim, et al. "Diagnosis of Sleep Apnea Using Artificial Neural Network and Binary Particle Swarm Optimization for Feature Selection." Chest 156.4(2019):A136.
[7] Fotios S, Qasem H, Cheal C, et al. A pilot study of road lighting, cycle lighting and obstacle detection [J]. Lighting Research & Technology, 2017, 11(5):586-602.
[8] Rateke T, Wangenheim A V. Passive vision road obstacle detection: a literature mapping [J]. International Journal of Computers and Applications, 2020(1):1-20.
[9] A, Jijun Zhang, H. L. B, and Z. C. A. "The technology of intelligent recognition for drilling formation based on neural network with conjugate gradient optimization and remote wireless transmission." Computer Communications 156(2020):35-45.