Research on Road Pothole Detection Method Based on Computer Image Restoration Technology

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Abstract. The detection of road potholes plays an important role in understanding the road damage, formulating and evaluating maintenance strategies. The traditional road maintenance tech is mainly based on manual visual inspection, which has low efficiency, long cycle and high labor cost, which is not conducive to large-scale road maintenance. Based on this, this paper first analyzes the mathematical model of road pothole detection based on image restoration tech, and then studies the road pothole detection method and model construction based on computer image restoration tech.

Keywords: Computer Network, Road Pothole Detection, Image Restoration

1. Introduction
With the rapid development of social economy, infrastructure construction represented by roads has gained rapid growth and progress. In this context, higher requirements are put forward for the construction and maintenance level of roads. As one of the important means of road maintenance, the detection of road potholes is the premise and foundation for the implementation of road maintenance and maintenance, so as to ensure the safe passage of vehicles. The detection of road potholes plays an important role in understanding the damage of roads and formulating and evaluating maintenance strategies, so it has become an indispensable part of current road construction [1]. At present, the domestic road maintenance tech and concept still have a large space for improvement, mainly based on manual visual inspection. This detection method has low efficiency, long cycle and high labor cost, which is not conducive to large-scale road maintenance, but also can not guarantee the timeliness and quality of road maintenance.

On the other hand, with the iterative development of computer tech, the new tech represented by artificial intelligence and deep learning has made great progress and application. In particular, deep learning has made a breakthrough in the field of image detection and recognition. As for the detection of road potholes, the detection of potholes is mainly to find out the existing holes from the road detection images. In this process, the main solution is to locate and identify the hole. The location of the hole is mainly surrounded by a rectangular box to indicate the location of the hole, and the recognition of the hole is based on its semantic features. Based on the depth neural network RPN can effectively extract the candidate frame of road tunnel, so as to achieve positioning.
In addition, in the process of road tunnel detection based on computer tech, in order to protect the detection equipment and device, it is usually protected by transparent glass or lens, so the detection image is vulnerable to the influence of external environment such as haze, raindrop and water mist. In order to ensure the accuracy of hole detection, it is necessary to carry out the restoration of detection image. At present, there are mainly motion based image restoration tech and training convolution neural network based image restoration tech, but these technologies can not be used in the detection image, or it is difficult to deal with the intensive external factors, so there is still room for further improvement and improvement.

In a word, the application of image restoration tech based on computer deep learning in road pothole detection not only helps to improve the level of road maintenance, but also greatly expands to the detection under adverse weather conditions; so as to further improve the efficiency of maintenance. In addition, the application of image restoration tech based on computer deep learning can also improve the collection accuracy of road tunnel samples. Therefore, it is of great practical value to study the detection method of road potholes based on computer image restoration tech.

2. Mathematical model foundation of image restoration tech

2.1. Causes of image degradation and classification of restoration techniques
In the process of image formation, transmission and recording, due to the influence of many aspects, the image quality is degraded, and the image is fuzzy, distorted and noisy [2]. The purpose of image restoration is to improve the image visual effect and facilitate subsequent processing. It is based on the degraded image, based on prior knowledge, to establish a degradation model, and then use the opposite operation to restore the original scene image. At present, there are two main types of image restoration tech, one is non-stationary image processing and the other is non-linear processing. The former is represented by Kalman filter, and the latter is typical application of neural network.

2.2. Mathematical model of continuous image degradation
Generally, the degradation reason is regarded as a factor of linear system degradation, so the system degradation model is established to approximately describe the degradation of image function. The clear image $f(x, y)$ degenerates into an image $g(x, y)$ due to the introduction of additive noise $n(x, y)$ through a system $H$. When the degenerate operator $h$ represents a linear and space invariant system, the output of the input image $f(x, y)$ after degradation is $g(x, y)$, as shown in figure 1 below.

$$g(x, y) = Hf(x, y) = H\left[\int_{-\infty}^{+\infty} \int_{-\infty}^{+\infty} f(\alpha, \beta)\delta(x - \alpha, y - \beta)\,d\alpha\,d\beta\right]$$

$$= \int_{-\infty}^{+\infty} \int_{-\infty}^{+\infty} f(\alpha, \beta)H\delta(x - \alpha, y - \beta)\,d\alpha\,d\beta \quad (1)$$

$$= \int_{-\infty}^{+\infty} \int_{-\infty}^{+\infty} f(\alpha, \beta)h(x - \alpha, y - \beta)\,d\alpha\,d\beta$$

![Figure 1. Mathematical model of image degradation.](image-url)
2.3. Mathematical model of image restoration tech

For the degraded image, but without the knowledge of degradation function, one of the methods to estimate the function is to collect the sub image with simple structure, find the sub image which is less affected by noise, and construct an estimated image, which has the same size and characteristics as the observed sub image [3]. Secondly, it is necessary to build a degradation model, which takes into account the environmental factors such as rain drops, haze and other environmental factors. In addition, in the process of acquiring the road tunnel image, the image will be blurred due to the relative motion between the image acquisition device and the tunnel.

In the process of image acquisition, the image is often blurred due to the relative motion between the scene and the camera. The restoration of blurred image caused by uniform linear motion is more universal. Let \( f(x, y) \) have a plane motion, let \( x_0(t) \) and \( y_0(t) \) be the variation components of motion in \( x \) and \( y \) directions respectively. \( t \) is the time of movement. The total exposure of the recording medium is the integral of the time between the opening and closing of the shutter. Then the blurred image is as follows:

\[
g(x, y) = \int_0^T f[x - x_0(t), y - y_0(t)] dt
\]  

(2)

Based on the above formula, the model of image blur caused by relative motion of object or camera is obtained. In addition, let \( g(u, v) \) be the Fourier transform of blurred image \( g(x, y) \):

\[
G(u, v) = \int_0^T F(u, v) \exp\{-j2\pi[ux_0(t) + vy_0(t)]\} dt
= F(u, v) \int_0^T \exp\{-j2\pi[ux_0(t) + vy_0(t)]\} dt
\]

(3)

Fourier transform based on degenerate model. If the properties of \( x(t) \) and \( y(t) \) are known, the transfer function can be obtained directly. Therefore, \( f(x, y) \) can be recovered, as shown in Figure 2.

(a) Original image  (b) Blurred image  (c) Restore image

Figure 2. Restoration of blurred image caused by motion.

3. Road pothole detection method based on computer image restoration tech

3.1. Difficulties in road pothole detection based on computer image restoration tech

In order to further improve the efficiency and level of road tunnel detection, it is necessary to improve its detection ability in complex environmental conditions, especially in complex weather conditions, such as detection accuracy and ability in rain and snow weather and haze weather [4]. The existing road tunnel detection based on computer image restoration tech has many shortcomings; mainly in the detection accuracy needs to be further improved, as well as the lack of sufficient learning and iteration of bad weather data such as rainy days.
In addition, because the detection image in rainy days and other bad weather will cause occlusion interference, so it is difficult to carry out the training of road tunnel detection. The multi-scale network of traditional network structure has a higher level, so its ability to represent multi-scale features at a more fine-grained level is poor [5]. But generally speaking, the tunnel area of the road is small, so the application based on multi-scale network needs to further optimize the detection accuracy of small targets represented by road potholes.

At the level of paired data collection, the images used in the training image restoration network under rainy weather conditions need to appear in pairs, that is, the same background, one with raindrops and the other without raindrops. Real data acquisition needs to be carried out on the road, but the road is too dangerous. It is planned to shoot raindrop pairs in other scenes to cover all the raindrop types contained in the real scene as far as possible. However, the recovery ability of the current generation network for raindrop coverage area is still insufficient, as shown in Figure 3 below, so it is necessary to improve the scheme of advantages and disadvantages theory.

![Figure 3](image-url)

**Figure 3.** Resilience of raindrop covered areas.

### 3.2. Road pothole detection based on computer image restoration

In the road tunnel image detection based on computer image restoration, it is more sensitive to multi-scale features [6]. The existing network architecture is based on layer by layer stacking. In order to further improve the detection accuracy of road tunnel detection for small and medium-sized targets, it is necessary to improve the multi-scale representation ability of the network neural network at a more fine-grained level, so as to construct a CNN module of information, as shown in Figure 4. This module is significantly different from the traditional hierarchical representation of multi-scale feature learning method. It replaces the general 3x3 convolution kernel, so it can represent multi-scale features at a more fine-grained level and enhance the receptive field of network layer.

![Figure 4](image-url)

**Figure 4.** Combination of new CNN module and network design.
In addition, in the CNN module, the data set is applied to test, so that the effect of the model can be significantly better than the traditional benchmark model. In the above modules, each convolution operation can accept the feature information, thus greatly increasing the receptive field, and allowing more features to have richer receptive field learning. The analysis residuals in a single residual block can provide detailed and global features in the upper part of the fine-grained or road pit, so the module can significantly improve the performance of the network.

3.3. Detection results of road potholes based on computer image restoration

In this paper, the technical route of target detection network experiment and image restoration network experiment is the same. Through the detection data set of target detection network experiment and the paired data set of image restoration network experiment, the improved scheme is designed on the basis of reference network model. And through the construction of the new CNN model, we can get the network model which can be used for training, and the data set can be better applied in the network. In addition, the target detection network is verified and compared, and the image restoration network is evaluated by human observation. The output of the image restoration network is sent to the target detection network for detection and the final result is obtained.

4. Conclusion

In summary, deep learning has made a breakthrough in the field of image detection and recognition. The detection of road potholes is mainly from the road detection image to solve the positioning and recognition of holes. The application of computer deep learning image restoration tech in road pothole detection not only helps to improve the level of road maintenance, but also greatly expands to the detection under bad weather conditions, so as to further improve the efficiency of maintenance. In this paper, the mathematical model of image restoration tech is studied, and the model analysis and the basis of the mathematical model are analyzed. Through the analysis of road pothole detection method based on computer image restoration tech, this paper studies the difficulties of road pothole detection based on computer image restoration tech, the construction of new network model, and analyzes the detection process.

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