IJNRD.ORG ISSN : 2456-4184
INTERNATIONAL JOURNAL OF NOVEL RESEARCH AND DEVELOPMENT (IJNRD) | IJNRD.ORG
An International Open Access, Peer-reviewed, Refereed Journal

SURVEY ON POTHOLE DETECTION AND COMPLAINT MANAGEMENT SYSTEM USING DEEP LEARNING

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Abstract : Potholes are a common problem in road maintenance, which can cause serious accidents and damages to vehicles. Traditional methods of pothole detection involve manual inspections, which are time-consuming, costly, and often result in missing some potholes. In recent years, the development of pothole detection systems using convolutional neural networks (CNNs) has shown great potential to improve road maintenance efficiency. This survey paper provides an overview of the recent advancements in the pothole detection system using CNNs. The paper discusses the state-of-the-art techniques and their limitations, as well as the challenges and future directions in this field. The survey paper reviews several state-of-the-art techniques in pothole detection using CNNs, including YOLOv4, Faster R-CNN, and Mask R-CNN. The paper also highlights the challenges in this field, including the limited availability of datasets and the need for real-time processing algorithms that can run on low-power devices. The survey paper concludes by emphasising the significance of pothole detection systems using CNNs in improving road safety, reducing repair costs, and improving the overall infrastructure.

Keywords: Pothole detection, Convolutional neural networks, Deep learning, Road maintenance, Image processing

I. INTRODUCTION

Potholes are one of the most significant problems on roads and can cause severe damage to vehicles, leading to accidents. With the advancements in computer vision and deep learning techniques, researchers have proposed various pothole detection systems to tackle this issue. These systems aim to detect potholes in real-time and alert drivers to avoid them. In recent years, convolutional neural networks (CNNs) have become the state-of-the-art technique for pothole detection due to their ability to extract features automatically from images.

This survey paper aims to provide a comprehensive review of pothole detection systems using CNNs and deep learning techniques. The paper will discuss the various approaches proposed by researchers and analyze their effectiveness. The survey will also compare the performance of different CNN architectures and evaluate their accuracy.

Some of the most promising approaches for pothole detection using CNNs have been proposed in recent years. For instance, Amita Dhiman and Reinhard Klette proposed a pothole detection system using computer vision and learning, which achieved an accuracy of 96% in detecting potholes [1]. Similarly, Ping Ping, Xiaohui Yang, and Zeyu Gao proposed a deep learning approach for street pothole detection, which achieved an accuracy of 94% [2].

Other approaches include a deep learning-based approach for road pothole detection proposed by Pereira et al. [4] and a deep learning approach to detect potholes in real-time using smartphones proposed by MIT World Peace University [3]. Additionally, some researchers have proposed low-cost pothole detection systems using ultrasonic sensors [11] and vehicle-mounted accelerometers [10].

Overall, this survey paper aims to provide a comprehensive analysis of pothole detection systems using CNNs and deep learning techniques. The survey will compare the performance of different approaches and highlight their strengths and limitations.

II. LITERATURE REVIEW

Road pothole identification is a difficult task, but it is now more doable because of the development of deep learning and computer vision algorithms. To address this issue, numerous studies have been done using various methods. Convolutional neural networks (CNN) are a technique that Amita Dhiman and Reinhard Klette proposed in [1] for detecting potholes in road pictures. Their approach entails labelling a sizable dataset of road photographs as having potholes or not. Based on this dataset, they trained their CNN model, which led to highly accurate pothole identification.

To detect roadway potholes, Ping Ping, Xiaohui Yang, and Zeyu Gao [2] devised a deep-learning method. To increase the pothole identification accuracy, they used a pre-trained CNN model (ResNet50) and fine-tuned it using a dataset of pothole photos. To eliminate false positives, their strategy also included a post-processing stage.

MIT World Peace University in Pune, India, suggested using smartphone cameras and deep learning to identify potholes in real time [3]. They classified a dataset of road photos captured by smartphones as having or not having potholes. Their CNN model was applied to a smartphone for real-time pothole identification after being trained on this dataset.

A deep learning-based method for road pothole detection in Timor-Leste was put forth by Pereira et al. in [4]. Their approach includes using a dataset of road photos with and without potholes to train a CNN network. To enhance the effectiveness of their approach, they applied transfer learning.
Different methods for pothole identification employing accelerometer sensors and vehicle-mounted sensors, respectively, have been proposed in other publications, such as [6] and [10]. These techniques use the vibrations that a car makes as it passes over potholes to identify them.

Overall, these experiments show that computer vision and deep learning approaches can accurately and quickly identify potholes in road photos. In terms of lowering false positives and integrating these systems with the current transportation infrastructure, there is still potential for improvement

III. RESEARCH METHODOLOGY

There are various steps in the process of employing convolutional neural networks (CNNs) to detect potholes. A dataset of images is first gathered using a variety of onboard or mobile devices with attached cameras or sensors. After gathering the photos, they are preprocessed to get rid of noise and other undesirable artifacts. The preprocessed images are then fed into a CNN architecture for training, which entails feeding the images through the network numerous times, modifying the network's weights and biases, and assessing the network's performance using different metrics like accuracy, precision, and recall.

The LeNet-5, AlexNet, VGG-16, and ResNet-50 CNN architectures have all been employed in pothole detection studies, as have other CNN architectures. After being trained, CNN may be used to categorize new photos as either having potholes or not. Some strategies also entail post-processing the CNN output to weed out false positives and boost the system's precision.
Numerous studies have suggested various modifications and enhancements to the fundamental CNN methodology for pothole detection, including using smartphone sensors [3, 5], ultrasonic sensors [11], or accelerometers [10] for data collection, assessing the effectiveness of various CNN architectures [7], or training the CNN in a virtual environment [8].

To construct an accurate and efficient pothole detection system, the methodology for pothole identification using CNNs combines data gathering, preprocessing, training, and post-processing.

IV. RESULTS & DISCUSSION

A CNN model in a deep learning-based system for detecting potholes gives it the ability to accurately and automatically locate potholes in road images. The implementation, dataset, and training procedure can all affect the precise metrics and performance of the model. Here are some possible results or outcomes:

Accuracy in detecting potholes in road photos: The CNN model can offer a measure of accuracy in detecting potholes in road images. Metrics like precision, recall, F1 score, or accuracy score are frequently used to assess this accuracy. For instance, if the model's accuracy is 90%, it will accurately identify 90% of the potholes in the test dataset.

Pothole localization: The CNN model is also capable of providing information on the location or bounding box coordinates of any potholes that are found in the road photos. This geolocation data enables accurate pothole identification and potential repair.

False positives and false negatives: The CNN model could occasionally produce either false positives or false negatives. False positives happen when a non-pothole region is mistakenly classified as a pothole by the algorithm, and false negatives happen when a pothole isn't detected. Through repeated iterations of model training, dataset improvement, and parameter optimization, these mistakes can be minimized.

Real-time or almost real-time inference: The CNN model can be used to detect potholes in real-time or nearly real-time after being trained. It can instantly detect the existence of potholes by processing real-time photos of the road.

Generalisation of unknown data: The CNN model's performance on unknown or test data is essential for evaluating its generalizability. A properly trained model should be able to correctly identify potholes on both fresh, unexplored road photos and the training dataset.

The amount and quality of the dataset, the model architecture, the settings for the hyperparameters, and the complexity of the road conditions are just a few examples of the variables that might affect the actual outcomes and performance of a CNN model in a pothole detection system. The model is often improved and refined continuously to increase performance through validation and feedback.

V. Conclusion

In conclusion, the development of pothole detection systems has demonstrated encouraging results when convolutional neural networks (CNNs) and deep learning have been used. As can be seen from the survey of recent research articles, the proposed methodologies vary in terms of the data types utilized, the CNN architectures used, and the evaluation measures used. Nevertheless, they all aim to increase road safety by spotting potholes early and alerting drivers and authorities on time. Some of the suggested solutions rely on video or lidar-based methods, while others use smartphone sensors, ultrasonic sensors, or accelerometers mounted to moving vehicles to gather data.

Additionally, comparison tests of various CNN architectures reveal that some perform better than others, and ensemble models can be utilized to boost the system's accuracy even more. Overall, there is still much to learn about the research into pothole identification using CNNs and deep learning and more research is required to solve some issues like robustness to changing environmental conditions and scalability to large-scale deployments.

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