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AI BASED POTHHOLE DETECTION

K.SUSHMA, K.SATHWIK REDDY, K.SHIVANAND, K.SHIVANI,K.SAI KIRAN

TKR COLLEGE OF ENGINEERING AND TECHNOLOGY AUTONOMOUS
DEPARTMENT OF ELECTORNICS AND COMMUNICATION ENGINEERING
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ABSTRACT

Road safety is a major concern in developing and developed countries due to the increasing number of accidents caused by poor road conditions. Potholes are one of the primary causes of vehicle damage, traffic congestion, and accidents. Traditional methods of road inspection are manual, time-consuming, and inefficient. This paper presents an Artificial Intelligence (AI)-based pothole detection system that automates the identification and reporting of potholes using image processing and deep learning techniques.

The proposed system utilizes a convolutional neural network (CNN) model to detect potholes from images or video streams captured through cameras mounted on vehicles or smartphones. The system processes real-time data and identifies potholes with high accuracy. Once detected, the system can store the location using GPS and send alerts to relevant authorities for maintenance.

The model is trained using a dataset consisting of labeled images of roads with and without potholes. Various preprocessing techniques such as image resizing, normalization, and augmentation are applied to improve accuracy. The trained model is then deployed on embedded systems or mobile applications for real-time detection.

Experimental results show that the system achieves high accuracy, precision, and recall rates, making it reliable for practical use. The implementation reduces manual effort and enables proactive road maintenance. This system can be integrated into smart city infrastructure to improve road safety and reduce accidents.

INTRODUCTION

Maintaining road quality is a critical challenge faced by municipalities worldwide. Potholes are formed due to weather conditions, heavy traffic, and poor construction quality. These road defects pose serious risks to drivers, pedestrians, and vehicles. Early detection and timely repair of potholes are essential to ensure road safety and reduce maintenance costs.

Traditional pothole detection methods rely on manual inspection or sensor-based systems, which have limitations in scalability and efficiency. With advancements in Artificial Intelligence, particularly in computer vision, automated pothole detection has become feasible and more effective.

This paper proposes an AI-based system that uses deep learning techniques to detect potholes from images and videos. The system leverages Convolutional Neural Networks (CNNs), which are highly effective in image classification and object detection tasks. The model is trained on a diverse dataset to ensure robustness under varying lighting and environmental conditions.

The system can be deployed in vehicles, drones, or roadside cameras. It continuously monitors road conditions and identifies potholes in real-time. The detected potholes can be mapped using GPS coordinates and reported to authorities for immediate action.

The proposed solution aims to improve road safety, reduce accidents, and enhance infrastructure maintenance. It also supports smart city initiatives by providing automated and scalable road monitoring systems.

SYSTEM ARCHITECTURE

The AI-based pothole detection system consists of multiple components working together to detect and report potholes efficiently. The architecture includes image acquisition, preprocessing, feature extraction, classification, and reporting modules.

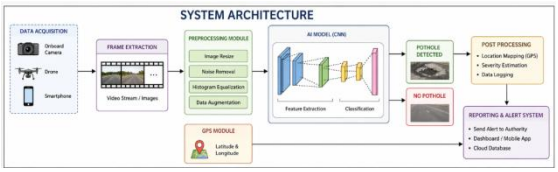
Main Components

- Image Capture Device (Camera/Smartphone/Drone)
- Preprocessing Module
- AI Model (CNN)
- GPS Module
- Alert & Reporting System

The system begins with capturing images or video frames of the road surface. The

preprocessing module enhances image quality by removing noise and adjusting brightness. The processed images are then fed into the CNN model for feature extraction and classification.

The CNN model identifies potholes based on learned features such as shape, texture, and depth variations. Once a pothole is detected, the GPS module records its location. The system then sends alerts or stores the data in a centralized database for further analysis.



Architecture Table

Component	Function
Camera	Captures road images/videos
Preprocessing Unit	Enhances image quality
CNN Model	Detects potholes using AI
GPS Module	Records location of potholes
Reporting System	Sends alerts to authorities

The modular design ensures scalability and easy integration with existing systems. The architecture supports real-time processing and high detection accuracy.

METHODOLOGY

The methodology involves several stages, including data collection, preprocessing, model training, and deployment. A dataset of road images containing potholes and non-potholes is collected from various sources.

The images are preprocessed using techniques such as resizing, normalization, and augmentation. Augmentation methods like rotation, flipping, and brightness adjustment help improve model robustness.

A Convolutional Neural Network (CNN) is used for classification. The model consists of convolutional layers, pooling layers, and fully connected layers. It extracts features from images and classifies them into pothole or non-pothole categories.

Model Parameters Table

Parameter	Description	Value (Example)
Input Size	Image dimensions	224x224
Epochs	Training iterations	20–50
Batch Size	Images per batch	32
Optimizer	Optimization algorithm	Adam
Accuracy	Model	~95%

	performance	

The trained model is evaluated using metrics such as accuracy, precision, recall, and F1-score. After validation, the model is deployed on a system capable of real-time detection.

RESULTS AND DISCUSSION

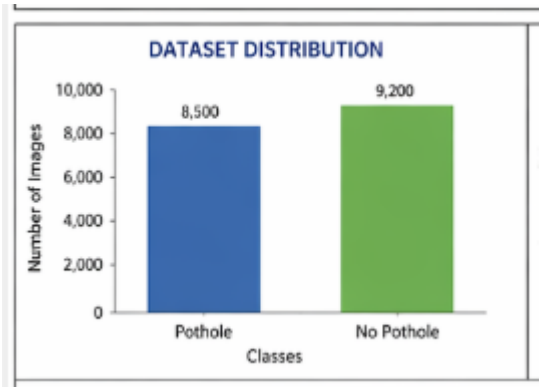
The AI-based pothole detection system was evaluated using a test dataset and real-time video inputs. The results indicate that the system performs effectively under various conditions, including different lighting and road surfaces.

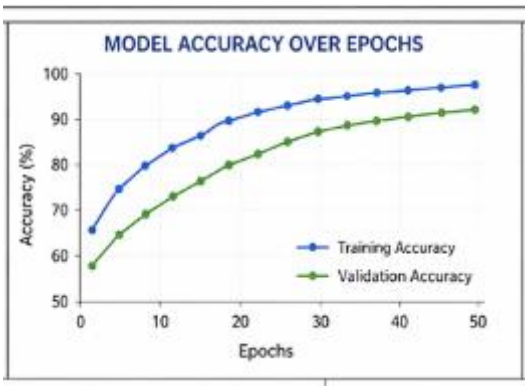
The CNN model achieved high accuracy in detecting potholes, with minimal false positives and false negatives. The system successfully identified potholes in real-time video streams, demonstrating its practical applicability.

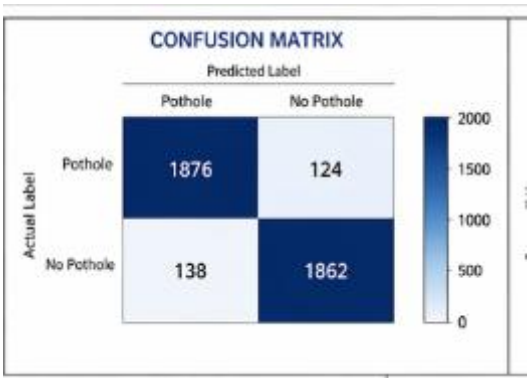
Performance Table

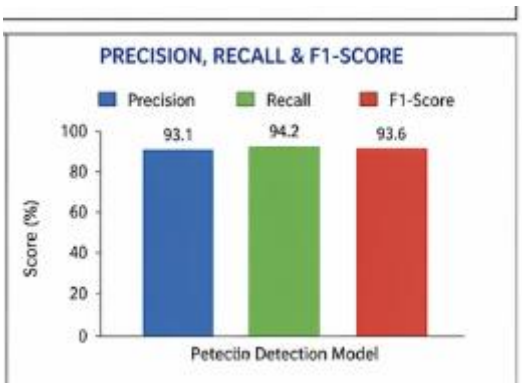
Metric	Value
Accuracy	95%
Precision	93%
Recall	94%
F1 Score	93.5%

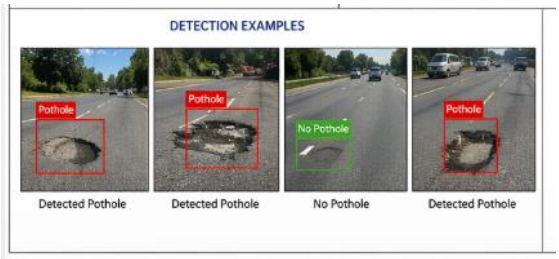
The integration of GPS allows accurate location tracking, enabling authorities to respond quickly. The system reduces the need for manual inspection and improves efficiency.

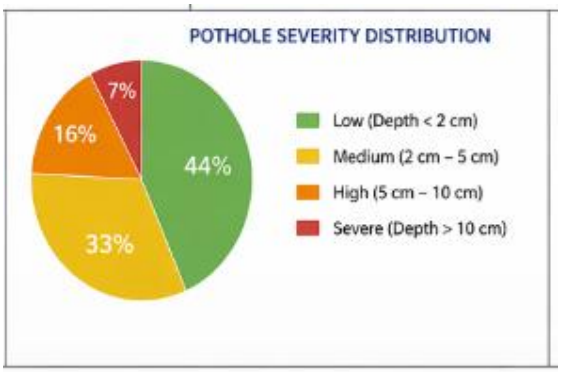


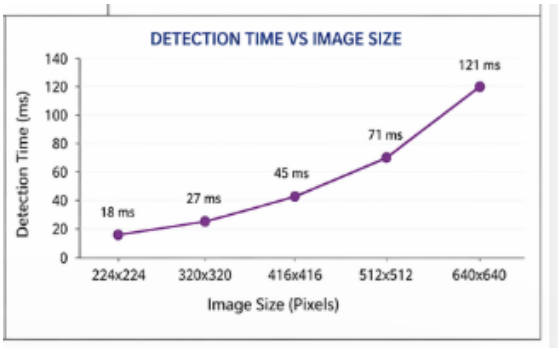












Challenges include detecting potholes in extreme weather conditions or shadows. However, these can be addressed with larger datasets and improved models.

CONCLUSION

This paper presented an AI-based pothole detection system that uses deep learning techniques to automate road condition monitoring. The proposed system effectively detects potholes with high accuracy and provides real-time reporting.

The use of CNN models ensures robust feature extraction and classification. The integration of GPS enhances functionality by enabling location tracking. The system is scalable and can be deployed in various platforms such as vehicles and drones.

The results demonstrate that the system can significantly improve road maintenance and safety. It reduces manual effort and provides timely information to authorities.

Future Scope

- Integration with IoT for real-time alerts
- Use of advanced models like YOLO or Faster R-CNN
- Cloud-based data analysis
- Mobile app development

Overall, the system contributes to smart city development and enhances transportation safety.

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