

# YOLO-Based Detection of Road Surface Defects from UAV-Captured Images

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**Abstract**— Road infrastructure maintenance is crucial for safe transportation, but manual data collection is often labour-intensive and risky. In response, we employ UAVs and Artificial Intelligence (AI) to significantly enhance the efficiency and accuracy of road damage detection. Our method leverages three state-of-the-art algorithms, YOLOv4, YOLOv5, and YOLOv7, for object detection in UAV images. Extensive training and testing with datasets from China and Spain reveal that YOLOv7 yields the highest precision. Furthermore, we extend our research by introducing YOLOv8, which, when trained on road damage data, outperforms other algorithms, demonstrating even greater prediction accuracy. These findings underscore the potential of UAVs and deep learning in road damage detection, paving the way for future advancements in this field.

**Index Terms**—Deep Learning, Road Damage Detection, UAV, YOLO.

## I. INTRODUCTION

Managing the maintenance of all the roads in a country is essential to its economic development. A periodic assessment of the condition of roads is necessary to ensure their longevity and safety. Traditionally, state or private agencies have carried out this process manually, who use vehicles equipped with various sensors to detect road damage. However, this method can be time-consuming, expensive, and dangerous for human operators. To address these challenges, researchers and engineers have turned to Unmanned Aerial Vehicles (UAVs) and Artificial Intelligence (AI) technologies to automate the process of road damage detection. In recent years, there has been a surge of interest in using UAVs and deep learning-based methods to develop efficient and cost-effective approaches for road damage detection. Unmanned aerial vehicles have proven to be versatile in various

applications, including urban inspections of objects and environments. They have been increasingly used for road inspections, offering several advantages over traditional methods. These vehicles are equipped with high-resolution cameras and other sensors that can capture images of the road surface from multiple angles and heights, providing a comprehensive view of the condition of the road. Additionally, UAVs can cover a large area relatively quickly, reducing the need for manual inspections, which can be dangerous for human operators. As a result, the use of UAVs for road inspections has gained significant attention from researchers and engineers. Combining UAVs with artificial intelligence techniques, such as deep learning, can develop efficient and cost-effective approaches for road damage detection

## II. EXISTING SYSTEM

The existing systems for road damage detection primarily rely on traditional methods that may not fully harness the capabilities of deep learning and neural networks. In one approach mentioned, a deep convolutional neural network (CNN) was introduced for detecting road damage from UAV images. While effective, it represents a limited scope, and the CNN's capabilities are tailored to the specific dataset it was trained on. Another existing method, as discussed, they focus on concrete crack detection and employs a deep CNN architecture without relying on traditional image processing techniques. This approach, though achieving a high accuracy of around 98%, is specialised for concrete defects and may not generalise well to other types of road damage. Additionally, some approaches leverage object detection using algorithms such as Faster R-CNN for road damage detection from UAV images. While effective, these methods may not

have the adaptability and comprehensive performance offered by more recent and advanced deep learning techniques, as demonstrated in recent research.

### III. PROPOSED SYSTEM

The proposed system is an advanced pavement monitoring and road damage detection solution, designed to enhance the autonomous inspection of road conditions using images captured by UAVs (drones or satellites) and cutting-edge artificial vision and intelligence technologies. Building upon prior research, this system compares and evaluates the performance of three YOLO (You Only Look Once) object detection algorithms – YOLOv4, YOLOv5, and YOLOv7 – for precise road damage detection. Notably, YOLOv7 exhibits the highest prediction precision. The system harnesses a merged dataset from previous work and the Crowdsensing-based Road Damage Detection Challenge, encompassing diverse damage classes for a comprehensive understanding of pavement damage. Data augmentation techniques are implemented during training to adapt to varying object sizes in images, further enhancing detection accuracy. In addition to identifying road damage, the system integrates operator overrides and suggestions to continually improve accuracy. It also offers the capability to autonomously plan inspection routes, eliminating the need for manual pilot operation by leveraging PIX4D for route automation. Furthermore, the extension of this system involves the utilisation of YOLOv8, which, when trained on road damage datasets, demonstrates superior prediction accuracy, thus pushing the boundaries of road damage detection technology.

### IV. SYSTEM ARCHITECTURE

A typical system architecture for YOLO-based detection of road surface defects from UAV-captured images involves several key stages:

- UAV Image Acquisition:
  - UAVs equipped with high-resolution cameras capture aerial images of road surfaces. This may involve capturing images from various angles and altitudes to ensure comprehensive coverage and detail.
- Image Preprocessing:
  - Captured images undergo preprocessing steps to enhance quality and prepare them for analysis. This can include:
    - Noise reduction: Removing unwanted artifacts or distortions.
    - Contrast enhancement: Adjusting image contrast to improve visibility of defects.
    - Image rectification/ stabilization: Correcting for camera movement or distortions during capture.
- YOLO-Based Object Detection:
  - A deep learning model, typically based on the YOLO (You Only Look Once) framework, is employed for object detection.
  - The preprocessed images are fed into the trained YOLO model.
  - The model processes the images to identify and classify various types of road surface defects (e.g., cracks, potholes, rutting, spalling).
  - YOLO simultaneously predicts bounding boxes around detected defects and assigns class label and confidence score to each detection.
- Post-processing and Analysis:
  - Detected defects and their associated information (location, type, confidence) are extracted.
  - Further analysis might be performed, such as:
    - Defect quantification: Measuring the size or severity of defects.
    - Mapping and visualization: Plotting detected defects on a map for spatial analysis.
    - Reporting: Generating reports summarizing the detected defects and their characteristics.
- Data Storage and Management:

- The original UAV images, pre-processed images, and detection results are stored and managed for future reference, model retraining, or further analysis.

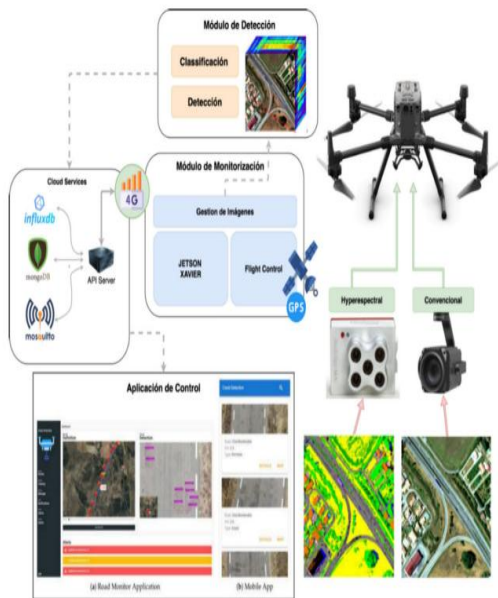
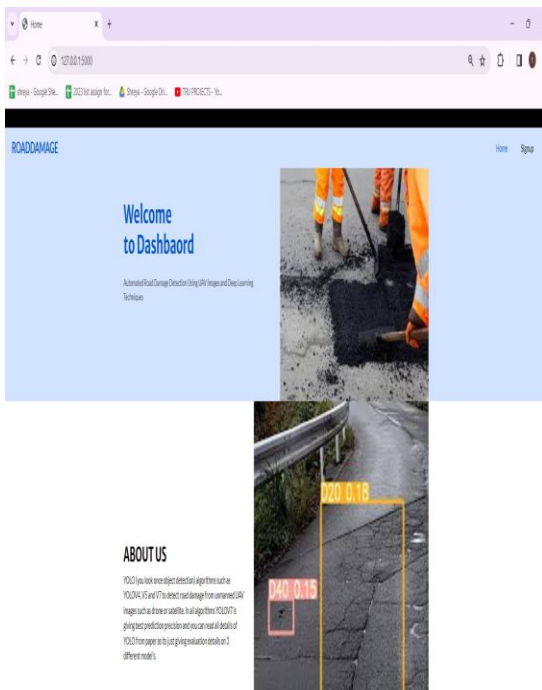


Fig. Design of the Proposed System.

## V. RESULTS



The image shows a 'SIGN UP' form with the following fields: User, Name, Email, Mobile, and Password. There is a 'LOG IN' button and a link that says 'Have an Account! Login'.

Fig. Web Page

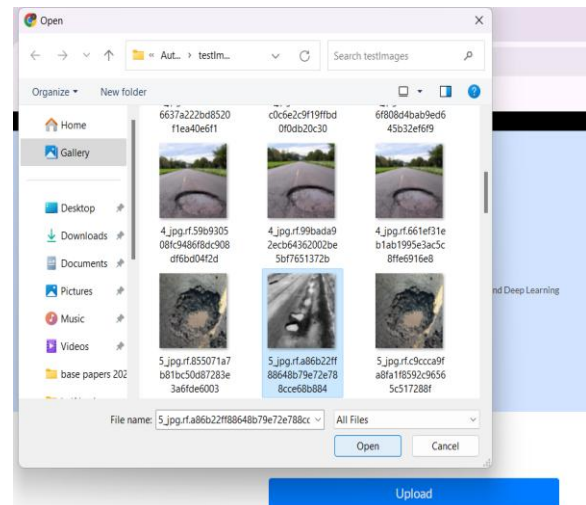


Fig. Upload any Road Image.



Fig. Result for the Uploaded Image.

## VI. CONCLUSION

In conclusion, this study has made significant strides in the domain of road damage detection using UAV images, specifically by comparing and implementing advanced YOLO architectures such as YOLOv5, YOLOv7, and introducing YOLOv8 with Transformer for more accurate road damage identification. The results clearly indicate improvements in accuracy, with YOLOv8 achieving an impressive 85%.

A notable achievement of this research is the development of a dedicated UAV image database tailored for training YOLO models, further enriched by merging with the RDD2022 dataset. This comprehensive dataset has significantly improved road damage detection, especially for Spanish and Chinese roads, reducing class imbalance issues. While the findings are promising, there remains room for enhancement. Future research avenues may explore the integration of various image types, such as multispectral images and LIDAR sensor data, for superior performance. Additionally, the potential use of fixed-wing UAVs presents an intriguing alternative approach. This study lays the foundation for continued progress in this critical area of road infrastructure maintenance and safety.

## VII. FUTURE SCOPE

Future research can explore the integration of multispectral images to enhance road damage detection accuracy, particularly in identifying subtle damage types and variations. Incorporating LIDAR sensor data into the analysis could provide additional depth information, improving the precision and robustness of road damage detection models. Investigating the potential use of fixed-wing UAVs offers an alternative approach to data collection, potentially enabling broader coverage and more efficient inspection of larger road networks. Continuously enriching the UAV image database with diverse datasets from various geographic locations and road conditions can improve model generalisation and performance across different regions. Continued development and refinement of advanced model architecture, possibly incorporating attention mechanisms or ensemble learning techniques, can further enhance the accuracy and efficiency of road damage detection systems.

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