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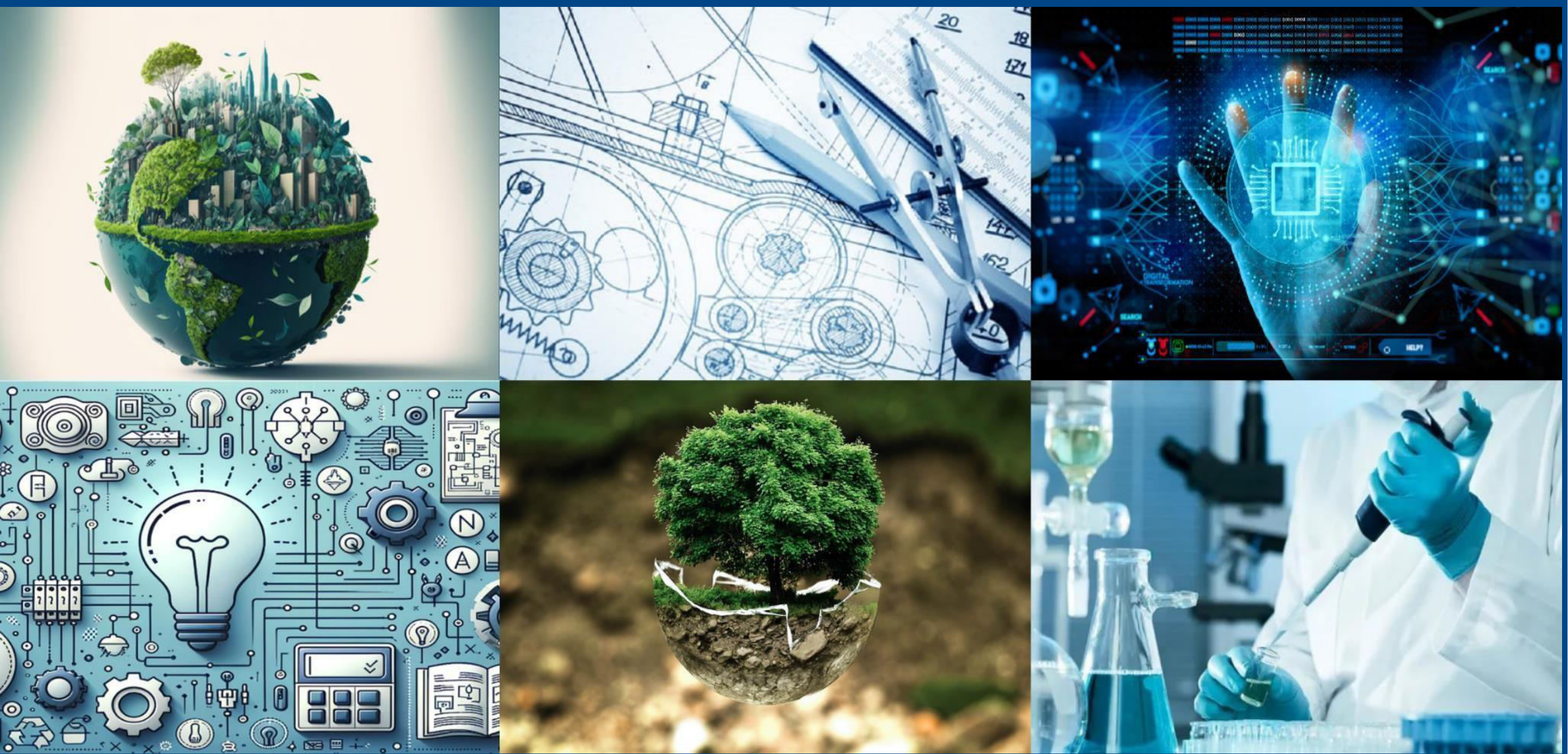

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Vision-Based Vehicle Damage Classification and Repair Cost Forecasting System

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ABSTRACT: This paper presents a Vision-Based Vehicle Damage Classification and Repair Cost Forecasting System that automates vehicle damage assessment using computer vision and deep learning. The system employs a YOLOv8-based object detection model to identify and classify damaged vehicle parts such as the bonnet, bumper, door, fender, light, windshield, and dickey from uploaded images. By visually highlighting damaged regions, the system ensures accurate and consistent damage detection while reducing dependence on manual inspection.

The system also estimates repair costs by mapping detected damaged parts to predefined spare-part prices stored in a database. A web-based interface allows users to upload images, view results, and generate printable repair cost reports for insurance and repair documentation. The proposed system improves processing speed, reduces human error, and enhances transparency in damage assessment, making it suitable for real-world applications in automobile service centers and insurance industries.

KEYWORDS: Vehicle Damage Detection, YOLOv8, Computer Vision, Repair Cost Forecasting, Deep Learning

I. INTRODUCTION

Vehicle damage assessment is a crucial process in automobile repair and insurance claim management. Traditional damage inspection methods rely heavily on manual evaluation, which is time-consuming and prone to human error. With advancements in computer vision and deep learning, automated damage detection has become a practical solution. The Vision-Based Vehicle Damage Classification and Repair Cost Forecasting System aims to identify damaged vehicle parts from images accurately. It uses deep learning models to classify damages and highlight affected areas. The system also estimates repair costs by mapping detected damages to spare-part prices. This approach improves accuracy, reduces processing time, and enhances transparency. As a result, the system is highly beneficial for insurance companies and automobile service centers.

II. LITERATURE SURVEY

- Early vehicle damage detection systems used traditional image processing techniques such as edge detection, segmentation, and texture analysis, which were sensitive to lighting and background variations.
- Handcrafted feature-based methods using SIFT, HOG, and LBP combined with classifiers like SVM improved performance but lacked robustness and scalability across different vehicle models.
- The introduction of deep learning and Convolutional Neural Networks (CNNs) significantly improved damage detection accuracy by automatically learning relevant image features.
- Several studies focused on classifying images as damaged or undamaged, but these methods did not precisely localize damaged vehicle parts.
- Object detection models such as Faster R-CNN, SSD, and YOLO enabled simultaneous localization and classification of damaged parts, making them more suitable for real-world applications.
- YOLO-based approaches gained popularity due to their real-time performance and ability to detect multiple damaged parts in a single image.
- Research indicates that detecting small damages like scratches and minor dents remains challenging due to occlusion and low visual contrast.
- Repair cost estimation has been addressed using rule-based and regression-based models, with cost mapping typically based on detected parts and severity.
- Studies show that combining damage detection with severity analysis improves repair cost accuracy.

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- Limited availability of large, well-annotated vehicle damage datasets remains a major challenge in this research area.
- Existing systems often focus only on detection and do not provide integrated, printable repair cost reports.
- These gaps highlight the need for an end-to-end system that combines accurate damage detection, reliable repair cost forecasting, and user-friendly deployment

EXISTING SYSTEM

In the existing system, vehicle damage assessment is carried out mainly through manual inspection by insurance surveyors or automobile service experts. The vehicle must be physically present at the inspection location, where the assessor visually examines the damaged parts and prepares a report based on personal experience and judgment. This process is time-consuming and can lead to inconsistent evaluations, as different inspectors may provide different assessments for the same damage. Minor damages such as small dents or scratches may also be overlooked, affecting the accuracy of the inspection.

Moreover, repair cost estimation in the existing system is performed manually by referring to spare-part price lists and labor charges, which increases the chances of calculation errors. The system lacks automation, remote accessibility, and visual evidence of damage, making the process less transparent. Documentation is often paper-based or maintained in spreadsheets, resulting in delayed insurance claim processing and inefficient record management. These limitations highlight the need for an automated and vision-based damage assessment system.

PROPOSED SYSTEM

In the proposed system, vehicle damage assessment is automated using computer vision and deep learning techniques, removing the dependency on manual inspection. Users can upload images of damaged vehicles through a web-based interface, allowing remote damage analysis without visiting a service center. The system uses a YOLOv8-based object detection model to accurately identify and classify damaged vehicle parts such as the bonnet, bumper, door, fender, light, windshield, and dickey. The detected damages are visually highlighted on the uploaded image, ensuring accurate and consistent assessment.

Additionally, the system estimates repair costs by mapping the detected damaged parts to predefined spare-part prices stored in a database. An itemized repair cost summary is generated along with a print option, enabling users to print the repair cost estimation report for insurance claims, repair approvals, and official documentation. By automating both damage detection and cost estimation, the proposed system reduces processing time, minimizes human error, enhances transparency, and provides a practical and user-friendly solution for insurance companies and automobile service centers.

III. SYSTEM ARCHITECTURE

The system architecture of the Vision-Based Vehicle Damage Classification and Repair Cost Forecasting System follows a modular client–server design. Users interact with the system through a web-based interface to upload images of damaged vehicles. The uploaded images are processed by a Flask-based application server, which handles image validation and preprocessing before forwarding them to the YOLOv8 deep learning model. The model detects and classifies damaged vehicle parts, and the results are sent back to the server. Based on the detected parts, the system calculates the repair cost by mapping them to spare-part prices stored in the database. The annotated damage image and estimated repair cost are displayed to the user, along with a print option

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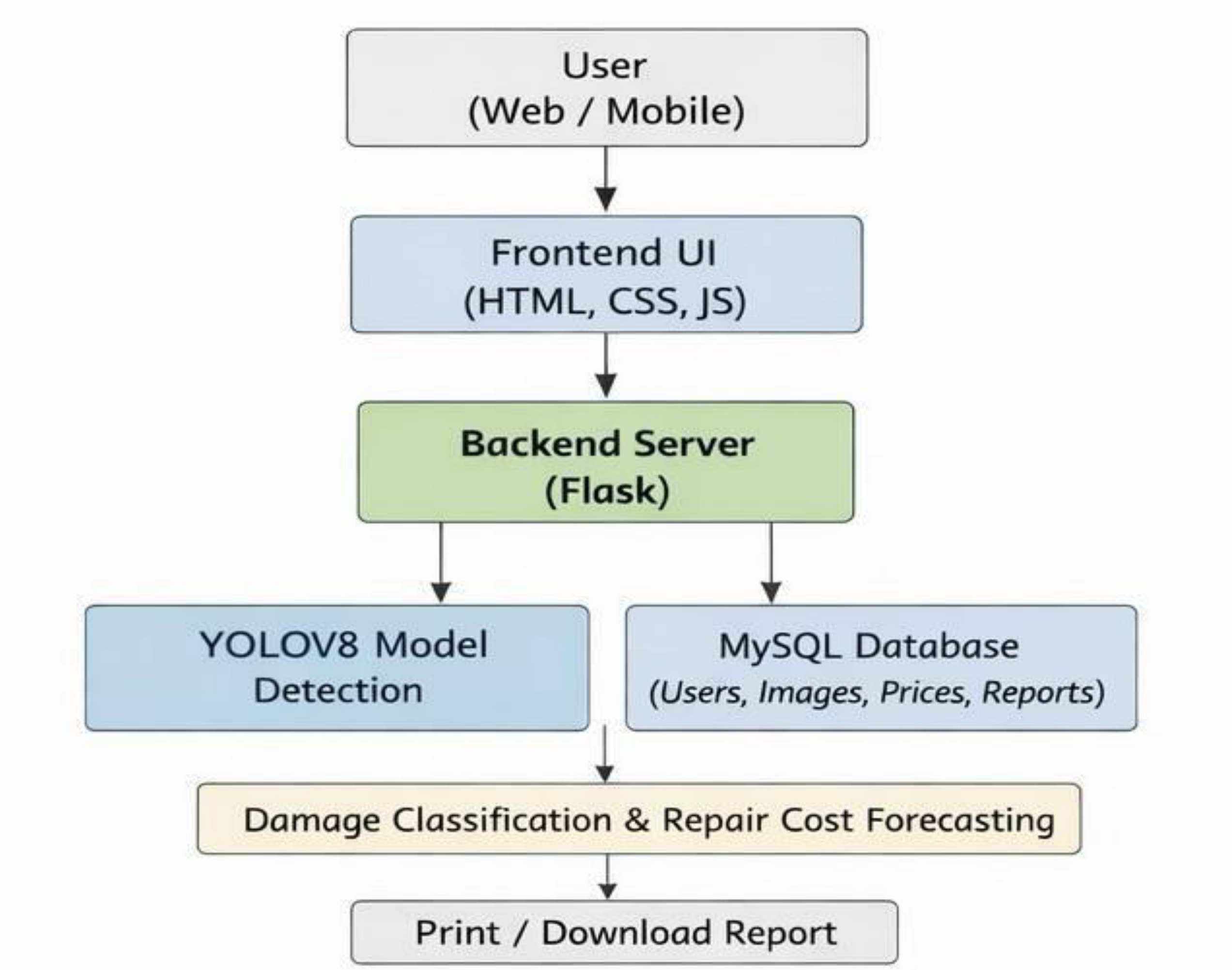

Fig 3.1 System Architecture

IV. METHODOLOGY

The methodology of the Vision-Based Vehicle Damage Classification and Repair Cost Forecasting System involves a systematic process that integrates image processing, deep learning, and web-based technologies to automate vehicle damage assessment. Initially, the user uploads an image of the damaged vehicle through the web interface. The uploaded image is validated for format and quality, and basic preprocessing such as resizing and normalization is performed to make it suitable for model inference.

Next, the preprocessed image is passed to a YOLOv8-based object detection model trained on vehicle damage datasets. The model identifies and classifies damaged vehicle parts such as bonnet, bumper, door, fender, light, windshield, and dickey, and generates bounding boxes around the damaged regions. The detection results are then sent back to the application server, where each detected part is mapped to its corresponding spare-part price stored in the database. Based on this mapping, the system calculates the total estimated repair cost.

Finally, the system displays the annotated image and the estimated repair cost to the user through the web interface. A print option is provided to generate a printable repair cost estimation report for insurance and repair documentation. All user inputs, images, detection results, and cost details are securely stored in the database for future reference. This methodology ensures accurate damage detection, transparent cost estimation, and efficient system operation.

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V. DESIGN AND IMPLEMENTATION

The design of the Vision-Based Vehicle Damage Classification and Repair Cost Forecasting System follows a modular client–server architecture to ensure scalability, accuracy, and ease of maintenance. The system is divided into major components including the user interface, application server, deep learning module, and database. The user interface is designed to be simple and intuitive, allowing users to upload damaged vehicle images and view results easily. The application server, built using the Flask framework, acts as the central controller that manages image uploads, request handling, communication with the deep learning model, and interaction with the database. This modular design ensures smooth data flow and clear separation of responsibilities among system components.

The implementation phase focuses on translating the system design into a functional application. When a user uploads an image, the Flask backend validates and preprocesses it before sending it to the YOLOv8 deep learning model for damage detection and classification. The model identifies damaged vehicle parts and returns the detection results to the server. Based on the detected parts, the system calculates the repair cost by mapping them to predefined spare-part prices stored in the database. The annotated image and estimated repair cost are then displayed to the user through the web interface. A **print option** is implemented to generate a printable repair cost estimation report for insurance claims and documentation. All user data, images, detection results, and reports are securely stored in the database, ensuring reliability and efficient system operation.

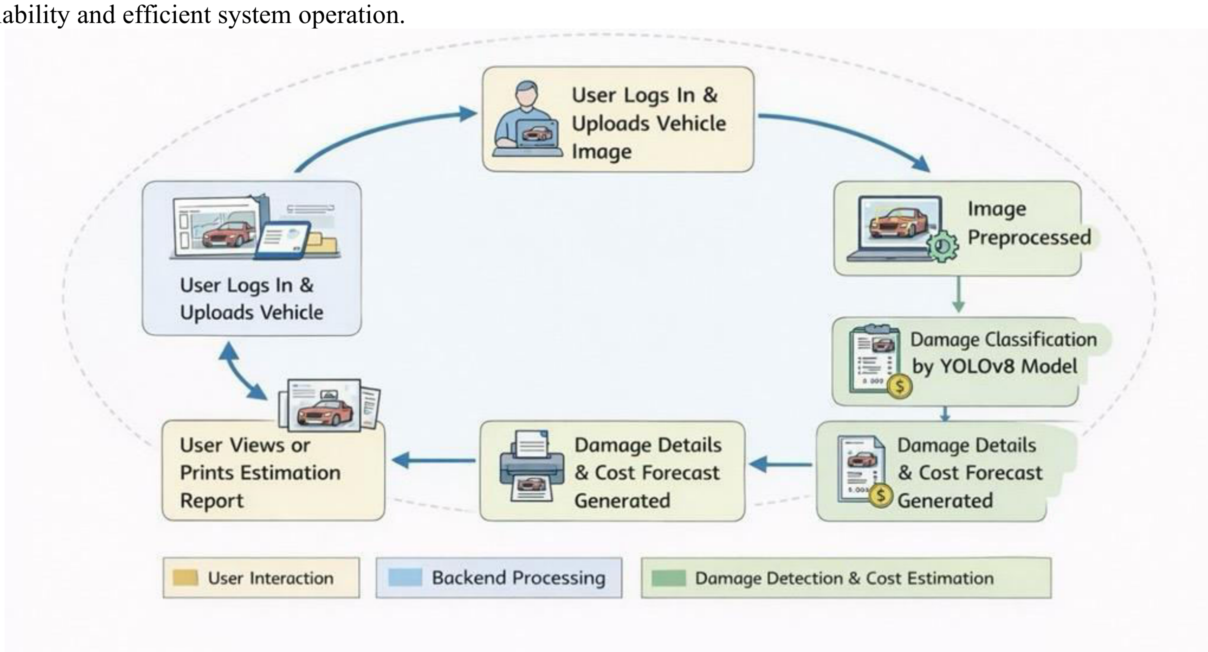

Fig. workflow of The Vision-Based Vehicle Damage Classification and Repair Cost Forecasting System i need in the form of image

VI. OUTCOME OF RESEARCH

The research on the Vision-Based Vehicle Damage Classification and Repair Cost Forecasting System successfully achieved its primary objective of automating vehicle damage assessment using computer vision and deep learning techniques. The developed system accurately detects and classifies damaged vehicle parts from uploaded images using a YOLOv8-based model, significantly reducing the dependency on manual inspection. The visual highlighting of damaged parts provides clear and consistent damage identification, improving the reliability and objectivity of the assessment process.

Furthermore, the research demonstrated effective repair cost forecasting by mapping detected damaged components to predefined spare-part prices stored in a database. The system generates detailed and printable repair cost estimation reports, which are useful for insurance claims, repair approvals, and documentation. The integration of a user-friendly web interface enables remote damage assessment, reduces processing time, and minimizes human error. Overall, the

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outcomes of this research indicate that the proposed system is efficient, reliable, and suitable for real-world application in automobile service centers and insurance industries, with strong potential for future enhancements.

VII. RESULT AND DISCUSSION

The experimental results show that the Vision-Based Vehicle Damage Classification and Repair Cost Forecasting System effectively detects and classifies damaged vehicle parts from uploaded images. The YOLOv8-based deep learning model successfully identified damaged components such as the bonnet, bumper, door, fender, light, windshield, and dickey under various lighting and background conditions. The system produced accurate bounding boxes and clear visual annotations, which helped in improving transparency and understanding of the detected damage. The automated damage detection significantly reduced the time required for inspection when compared to traditional manual methods.

In terms of repair cost estimation, the system accurately calculated costs by mapping detected damaged parts to predefined spare-part prices stored in the database. The generated repair cost reports were consistent, itemized, and easy to interpret. The inclusion of a print option further enhanced usability by allowing users to generate physical reports for insurance claims and repair documentation. Overall, the results indicate that the system is efficient, reliable, and user-friendly. The discussion highlights that automation minimizes human error, improves consistency, and provides a scalable solution for real-world deployment in automobile service centers and insurance industries, while also leaving scope for future enhancements such as damage severity analysis and mobile application integration.

VIII. CONCLUSION

The Vision-Based Vehicle Damage Classification and Repair Cost Forecasting System successfully demonstrates how computer vision and deep learning can be applied to automate vehicle damage assessment. By utilizing a YOLOv8-based model, the system accurately detects and classifies damaged vehicle parts from uploaded images, significantly reducing the need for manual inspection. The visual highlighting of damaged areas improves clarity and consistency in damage evaluation, while the web-based interface enables users to perform remote assessments easily and efficiently.
In addition to damage detection, the system provides reliable repair cost estimation by mapping detected vehicle parts to predefined spare-part prices stored in a database. The generation of detailed and printable repair cost reports supports insurance claims, repair approvals, and official documentation. Overall, the system improves accuracy, reduces processing time, minimizes human error, and offers a practical and scalable solution for real-world deployment in automobile service centers and insurance industries.

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