
CAR DAMAGE DETECTOR

Automated Car Damage Classification from Images

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PROBLEM STATEMENT

- Assessing car damage from images is challenging due to variations in lighting, angles, and vehicle positions, making manual inspection subjective and inconsistent.
- Traditional visual assessments by inspectors are time-consuming, prone to human error, and lack standardization, which can delay claims processing or resale evaluations.
- There is a critical need for an automated, objective system that can classify vehicle damage reliably and consistently across diverse car images.
- A deep learning-based approach enables scalable, fast, and repeatable assessments, reducing processing times and improving accuracy in estimating repair costs or validating insurance claims.

PROJECT OBJECTIVES

- Automatically classify car damage into one of six categories: Front Normal, Front Breakage, Front Crushed, Rear Normal, Rear Breakage, Rear Crushed.
- Achieve at least 75% accuracy on a validation dataset of labeled car images.
- Provide an interactive Streamlit web app allowing users to upload an image and instantly view the predicted damage class.
- Support fair and transparent claim settlements by providing objective, evidence-based damage assessments directly from uploaded images.

DATASET OVERVIEW

- The dataset consists of approximately 2300 labeled images of vehicles, carefully collected to capture various types of front and rear damage scenarios.
- Images are distributed across six predefined damage categories to ensure balanced learning:
 - Front Breakage (FB): 500 images
 - Front Crushed (FC): 400 images
 - Front Normal (FN): 500 images
 - Rear Breakage (RB): 300 images
 - Rear Crushed (RC): 300 images
 - Rear Normal (RN): 300 images
- The dataset includes images taken under different lighting conditions, angles, and backgrounds, with a focus on third-quarter front or rear views to mimic real-world scenarios encountered during insurance inspections or resale evaluations.

DATA PREPROCESSING

- **Image Transformations (Data Augmentation & Standardization)**

- RandomHorizontalFlip(): Introduces horizontal flips to improve model robustness and generalization to different car orientations.
- RandomRotation(10): Rotates images randomly up to ± 10 degrees to add rotational invariance and simulate real-world camera angles.
- ColorJitter(brightness=0.2, contrast=0.2): Varies brightness and contrast to mimic diverse lighting conditions and enhance model resilience.
- Resize((224, 224)): Rescales all images to a consistent 224×224 resolution required by the CNN architecture.
- ToTensor(): Converts images into PyTorch tensors, scaling pixel values to the [0,1] range for numerical stability.
- Normalize(mean=[0.485, 0.456, 0.406], std=[0.229, 0.224, 0.225]): Standardizes pixel values using ImageNet statistics – critical when leveraging pre-trained CNNs.

- **Data Splitting**

- Training Set: 75% of the dataset (1,725 images) used to optimize model weights during training.
- Validation Set: 25% of the dataset (575 images) reserved to evaluate model performance and detect overfitting.

- **Data Loaders**

- DataLoader Objects: Created for both the training and validation datasets to efficiently load mini-batches (batch size 32).
- Features: Include shuffling of training data to improve model generalization and multi-process data loading for faster throughput.

MODEL DEVELOPMENT & OPTIMIZATION

- **Baseline CNN Model**

- Started with a simple CNN architecture.
- Achieved an initial accuracy of 57.74%, providing a performance benchmark for further improvements.

- **Regularization Techniques Applied**

- Introduced Batch Normalization to stabilize and accelerate training.
- Added Dropout Regularization to reduce overfitting.
- Incorporated L2 Regularization to improve generalization.
- Together, these boosted accuracy to 58.60%.

- **EfficientNet-B0 Implementation**

- Transitioned to a more advanced EfficientNet-B0 model.
- Leveraged compound scaling to optimize parameters efficiently.
- Resulted in a notable performance improvement with 65.38% accuracy.

- **Adoption of ResNet50 Architecture**

- Adopted the deeper, residual-based ResNet50 network.
- Enabled better learning of complex damage patterns.
- Significantly increased accuracy to 76.70%.

- **Hyperparameter Tuning with Optuna**

- Performed extensive tuning of learning rate and dropout probability.
- Used the Optuna framework for efficient hyperparameter search.
- Final ResNet50 model achieved 79.48% accuracy, representing the best-performing solution.

MODEL EVALUATION

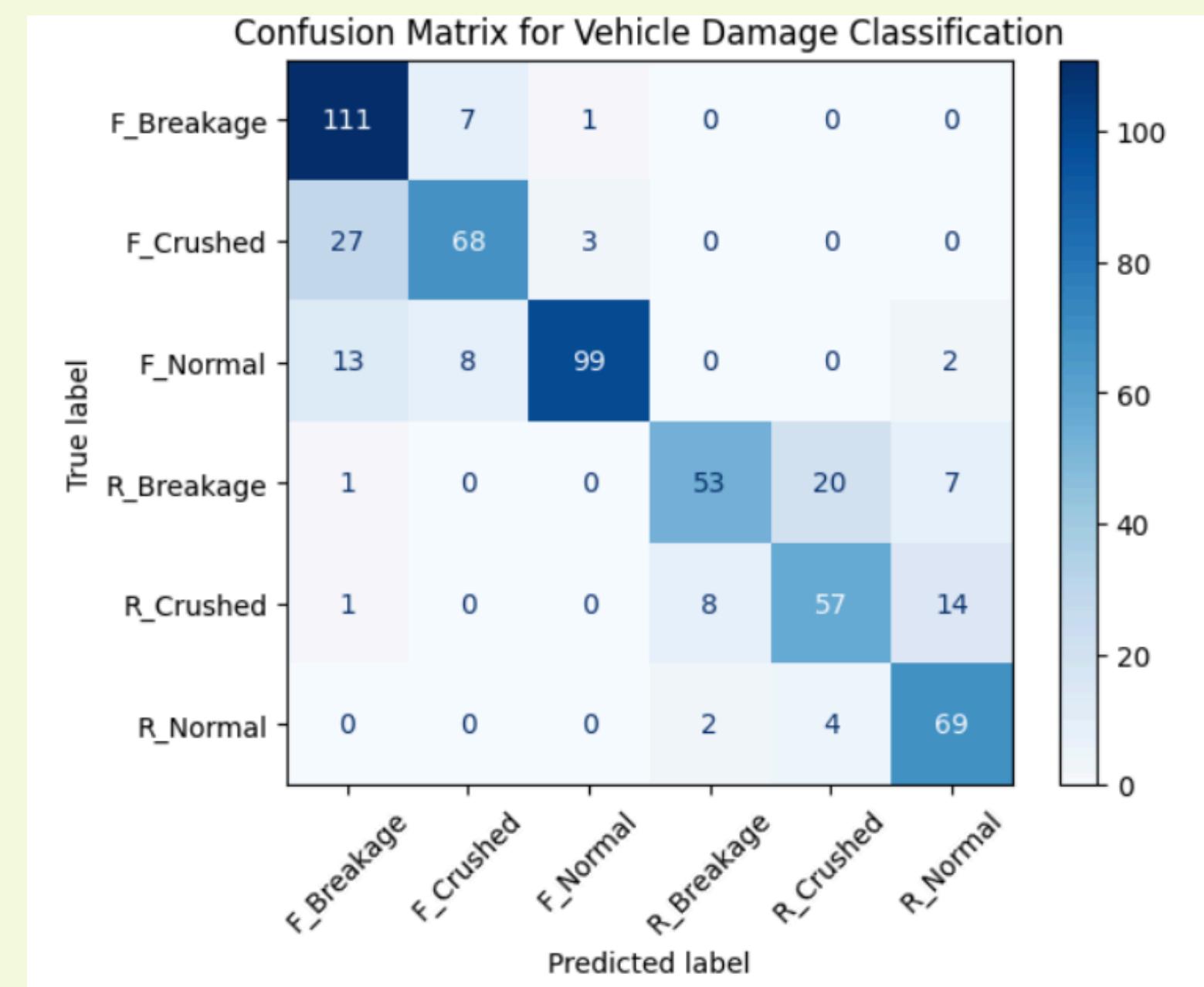
- **Classification Report**

- Generated precision, recall, and F1-score for each damage class.
- Report included overall accuracy > 75% after hyperparameter tuning, meeting the project objective.
- Demonstrated substantial improvement over initial baseline models.

	precision	recall	f1-score	support
0	0.73	0.93	0.82	119
1	0.82	0.69	0.75	98
2	0.96	0.81	0.88	122
3	0.84	0.65	0.74	81
4	0.70	0.71	0.71	80
5	0.75	0.92	0.83	75
accuracy			0.79	575
macro avg	0.80	0.79	0.79	575
weighted avg	0.81	0.79	0.79	575

- **Confusion Matrix**

- Visualized actual vs. predicted labels across six classes.
- Identified patterns of misclassification between similar damage classes.



STREAMLIT APP INTEGRATION

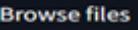
- Developed an interactive web application using Streamlit for real-time car damage classification.
- Integrated the trained ResNet50 model and preprocessing for seamless predictions.
- Allows users to upload a car image (preferably third-quarter front or rear view) directly through the app's intuitive interface.
- On clicking “Predict Damage Class,” the app provides:
 - Predicted damage category (e.g., Front Breakage, Rear Normal).
 - Visual display of the uploaded image alongside the prediction.
- Handles all preprocessing within the app (resizing, normalization) to ensure consistent and reliable model inference.
- Deployed the app on Streamlit Cloud (streamlit.io) for public access.
- Designed for business and non-technical users (e.g., insurers, fleet managers) to enable quick, consistent, and objective car assessments.

USER INTERACTION PREVIEW

 **Car Damage Detector**

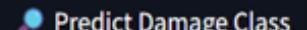
 **Upload a vehicle image:** 

Choose a vehicle image (JPG/PNG)
Drag and drop file here
Limit 200MB per file • JPG, PNG, JPEG



 RB_12.jpg 243.7KB 


Uploaded Vehicle Image



Prediction complete!



PROJECT SUMMARY

- Built a deep learning system to detect and classify car damage from images into six categories: Front/Rear – Normal, Breakage, Crushed.
- Prepared a dataset of 2300 images with augmentations for better generalization.
- Split dataset into 75% training and 25% validation sets, ensuring balanced class representation for accurate evaluation.
- Trained baseline CNN, EfficientNet-B0, and ResNet50 with batch norm, dropout, and L2; tuned ResNet50 with Optuna, achieving 79.48% final accuracy.
- Evaluated results using classification reports and confusion matrices, identifying key misclassification patterns.
- Created a Streamlit app for real-time car damage classification from uploaded images.
- Live App: <https://vaibhav-project-car-damage-detector.streamlit.app/>
- GitHub: <https://github.com/vaibhavgarg2004/Car-Damage-Detector>

THANK YOU
