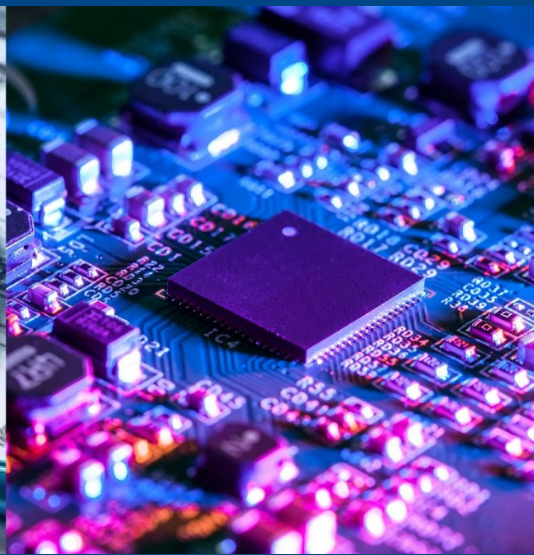
ISSN: 2582-7219

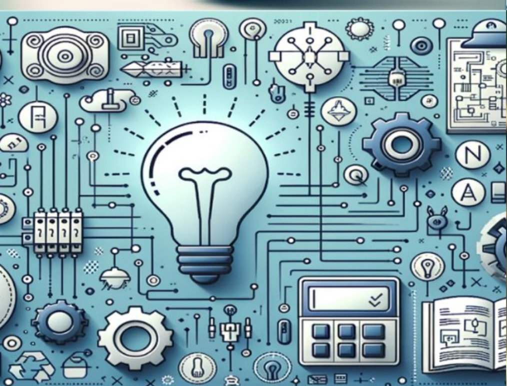




International Journal of Multidisciplinary Research in Science, Engineering and Technology

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)



Impact Factor: 8.206

Volume 9, Issue 4, April 2026

www.ijmrset.com   ijmrset@gmail.com   +91 6381 907 438   +91 63819 07438

© 2026 IJMRSET | Volume 9, Issue 4, April 2026 | DOI:10.15680/IJMRSET.2026.0904367

ISSN: 2582-7219 | www.ijmrset.com | Impact Factor: 8.206| ESTD Year: 2018|

International Journal of Multidisciplinary Research in Science, Engineering and Technology (IJMRSET)

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)

SmartBike Rental Application Using AI-Based Damage Detection and Cost Estimation

Dr.S.Pakkir Mohideen, Syed Zubair J, Ibrahim A

Department of Computer Applications, B.S.Abdur Rahman Crescent Institute of Science and Technology Chennai, Tamil Nadu, India

ABSTRACT: This paper presents a SmartBike Rental Application that leverages Artificial Intelligence (AI) and Computer Vision to automate bike damage detection and repair cost estimation. The system incorporates a multi-level user verification mechanism using Aadhaar, student ID, or company ID with an alternative OTP-based registration pathway for users without ID proof. A risk-based access control model dynamically adjusts user privileges based on verification level. A Convolutional Neural Network (CNN) analyzes before-and-after rental images to classify damage and generate automated repair cost estimates. A Data Analytics module provides an administrative dashboard displaying rental in come statistics and peak-hour usage patterns. Built on Python-Flask, MySQL, and HTML/CSS/JavaScript, the platform offers transparent, secure, and dispute-free rental management. Experimental results demonstrate 94% training accuracy and 91% validation accuracy.

KEYWORDS: bike rental; damage detection; CNN; computer vision; OpenCV; identity verification;risk-based access control; data analytics; smart transportation

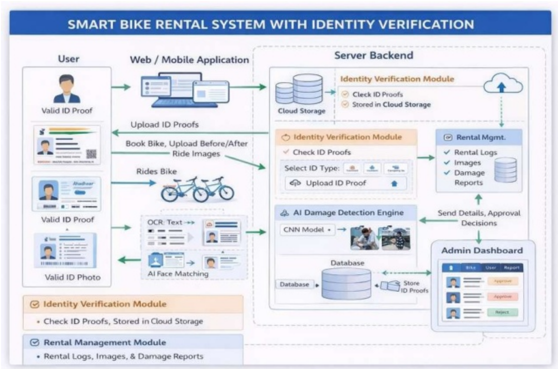


Figure1:SmartBike Rental System Architecture with Identity Verification

I. INTRODUCTION

The rapid growth of urban transportation and increasing demand for eco-friendly mobility solutions have accelerated the adoption of bike rental services worldwide. These services offer a sustainable and cost-effective alternative to conventional transportation, particularly in smartcity environments. However, accurate assessment of vehicle condition and user accountability remain persistent challenges in rental operations.

Conventional bike rental systems depend on manual inspection by staff, which is subjective and frequently misses minor damages. Traditional systems also lack robust identity verification, leading to misuse and accountability gaps. This causes financial loss and disputes between customers and operators.

This paper proposes a Smart Bike Rental Application that integrates AI-based damage detection, automated cost estimation, multi-level identity verification, and a DataAnalytics dashboard. A risk-based access control model ensures security while maintaining inclusiviy for users without formal IDproo.

The paper is organized as follows: Section II reviews related work. Section III describes the system architecture. Section IV details user verification and access control. Section V presents technologies. Section VI shows the interface. Section VII

developed a deep learning-based crack detection system using a sliding-window CNN, highlighting the effectiveness of image processing in automating structural inspection analogous to bike surface damage assessment.

Zhang et al. [4] examined challenges in dockless bike-sharing systems including damage reporting, maintenance tracking, and user accountability, noting that absence of automated tools creates operational inefficiencies.

Romanillos et al. [5] demonstrated that temporal usage pattern analysis in shared cycling systems enables more effective fleet management, directly motivating the analytics dashboard in the proposed system.

Kumar et al. [7] explored risk-based access control in shared mobility platforms, demonstrating thattiered verification models reduce misuse while maintaining accessibility. The proposed system builds on this with a hybrid ID and OTP-based verification pathway.

II. SYSTEM ARCHITECTURE

A. SystemOverview

The proposed application is organized across four principal layers: (1) Frontend Layer, (2) Python-Flask Backend with Identity Verification and AI/CV modules, (3) Data Analytics Module, and (4) MySQL and Cloud Database Layer. The full system flow is shown in Figure 1.

B. SystemWorkflow

Step1—UserRegistration: Users register with validID proof (Aadhaar, studentID, or companyID)or via OTP-based mobile verification for users without ID proof.
Step2 — Identity Verification: Uploaded IDproofs are verified using OCR text extraction and AI face matching. Verified users receive full access; OTP-only users receive partial access.
Step 3 — Bike Booking: Users browse and reserve available bikes based on their verified access level.
Step4—Pre-RentalImageUpload: Userphotographsthebike before the ride to establish a condition baseline.
Step 5 — Post-Rental Image Upload: User submits a second photograph upon return for damage comparison.
Step6—AIDamageDetection:CNNmodelclassifiesdamage into scratches, dents, broken parts, or surface damage.
Step 7 — Severity & Cost Estimation: OpenCV classifies severity as low, medium, or high; rule-based module estimates repair cost.
Step 8 — Report Generation: A full inspection report is generated. Admin can review, approve, or escalate damage claims.

C. Data Analytics Module

The analytics module provides an intelligent operational dashboard computing two key outputs:
- Rental Income Analytics: Daily, weekly, and monthly revenue charts via Chart.js enabling revenue trend tracking and anomaly detection for fleet operators.
- PeakHours Analysis: Hourly usage heat maps identifying demand peaks to support optimized scheduling and maintenance planning.

D. CNN Model Architecture

The damage detection module employs a CNN trained on RGB images resized to a uniform input dimension. Multiple convolutional and pooling layers extract spatial features, followed by fully connected layers and a softmax output. Transfer learning from pre-trained Image Netweights accelerates convergence. Data augmentation reduces overfitting.Themodel achieved 94% training accuracy and 91% validation accuracy over 20 epochs with a final loss of 0.18.

E. OpenCV SeverityAnalysis

Open CV performs image segmentation and morphological analysis on detected damage regions. Severity is classified based on damaged-area ratio and edge intensity metrics, producing low, medium, or high severity classifications.

© 2026 IJMRSET | Volume 9, Issue 4, April 2026 | DOI:10.15680/IJMRSET.2026.0904367

ISSN: 2582-7219 | www.ijmrset.com | Impact Factor: 8.206| ESTD Year: 2018|

International Journal of Multidisciplinary Research in Science, Engineering and Technology (IJMRSET)

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)

III. USERVERIFICATIONANDRISK-BASEDACCESS CONTROL

To enhance security and ensure accountability, a multi-level user verification mechanism is implemented. Users are required to provide valid identity proof such as Aadhaarcard, studentID,or company ID during registration. This information is securely stored in cloud storage and verified by the admin before ranting full access to rental services.

Recognizing that some users may not possess valid ID proof at the time of booking, the system introduces an alternative verification approach. Such users can register using mobile number-based OTP authentication and are categorized as partially verified users. To mitigate risks, the system applies a risk-based access control model where privileges are dynamically adjusted based on verification level.

Partially verified users pay a higher refundable security deposit of ₹2000 and are restricted to basic bikes for limited durations. They must also provide an emergency contact number for accountability. This hybrid approach ensures inclusivity while maintaining system security and minimizing misuse.

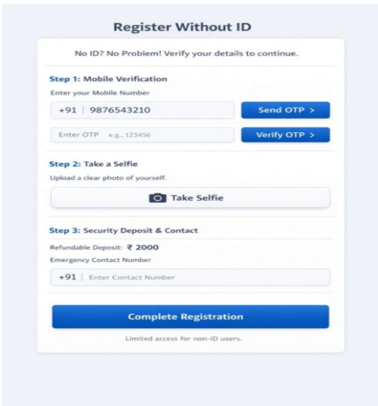


Figure2:RegisterWithoutID—OTPVerificationFlow

The combination of identity verification, financial assurance, and access restriction provides a balanced solution for real-world bike rental operations. Table I summarizes the access control tiers.TableI:Risk-BasedAccessControlTiers

Feature	Verified	Partial
IDProof Required	Yes	No(OTP only)
SecurityDeposit	₹500	₹2000
BikeAccess	All bikes	Basiconly
Rental Duration	Unlimited	Limited
EmergencyContact	Optional	Mandatory
AdminApproval	Standard	Required

IV. TECHNOLOGIESUSED

TableII:TechnologiesUsedintheProposed System

Component	Technology
ProgrammingLanguage	Python3.x
WebFramework	Flask
AI/ Deep Learning	CNN—TensorFlow/Keras
ImageProcessing	OpenCV
Database	MySQL

Frontend	HTML5,CSS3, JavaScript
Chart Visualization	Chart.js
AnalyticsBackend	Flask RESTAPI+MySQL
IDVerification	OCR+AIFaceMatching
Cloud Storage	Cloud-basedIDStorage

V. SYSTEMINTERFACE

Figures 3 and 4 illustrate the login interfaces and the administrative dashboard of the Smart Bike Rental Application. The user login and owner admin login screens provide secure role-based access, while the admin dashboard presents a real- time overview of all rental, verification, and damage activity.

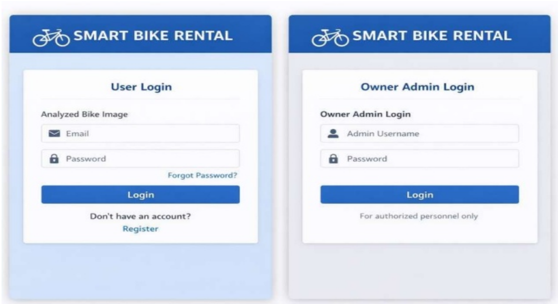


Figure3:UserLoginandOwnerAdminLogin Interface

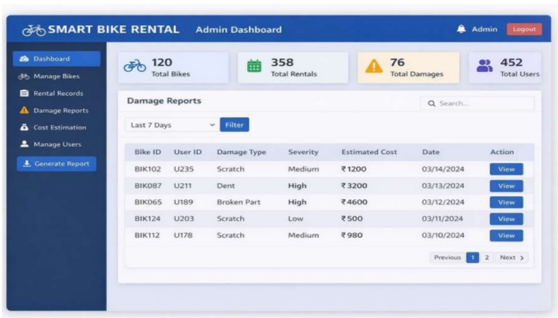
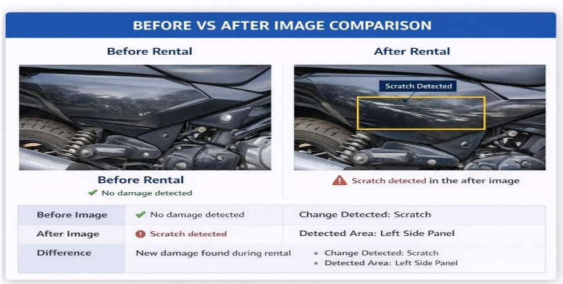


Figure4:AdminDashboard—DamageReports View

VI. SAMPLEOUTPUT

Figures5,6,and7presenttheend-to-endsampleoutputforBike ID BIK102, User ID U235, on 14-03-2026. The figures demonstrate the complete pipeline: before-and-after image comparison, AI detection with bounding box annotation, and CNN model training performance curves.



DamageType	Prec.(%)	Recall(%)	F1(%)
Dents	93	94	93
BrokenParts	95	96	95
SurfaceDamage	90	88	89

© 2026 IJMRSET | Volume 9, Issue 4, April 2026 | DOI:10.15680/IJMRSET.2026.0904367

ISSN: 2582-7219 | www.ijmrset.com | Impact Factor: 8.206| ESTD Year: 2018|

International Journal of Multidisciplinary Research in Science, Engineering and Technology (IJMRSET)

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)

Figure5:Beforevs.AfterRentalImageComparison—ScratchDetected

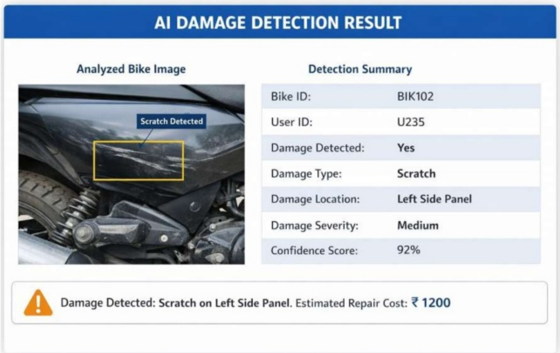


Figure6:AIDamage DetectionResult—MediumSeverity,₹1200EstimatedCost

TheAIdetectionmodulecorrectlyidentifiedamedium-severity scratch on Bike BIK102 with 92% confidence, estimating the repaircost at₹1200.TheOpenCVseveritymoduleachieved89% correctclassification.Costestimationwasconsistentwithexpert estimates within 10%. Partially verified users completed OTP and selfie verificationinunder60seconds.AI inspectionreduced averageinspectiontimefrom8–10minutestounder30seconds.

VII. ADVANTAGES

- Multi-levelidentityverificationensuresuseraccountability and system security.
- OTP-basedalternativeregistrationensuresinclusivityfor users without ID proof.
- Risk-basedaccesscontroldynamicallyadjustsprivileges by verification level.
- AIdamagedetectioneliminatessubjectivemanual inspection entirely.
- Automatedcostestimationensurestransparentand consistent repair cost reporting.
- Dataanalyticsdashboardenablesdata-drivenfleet management decisions.
- Reducesinspectiontimefrom8–10minutestounder30 seconds.

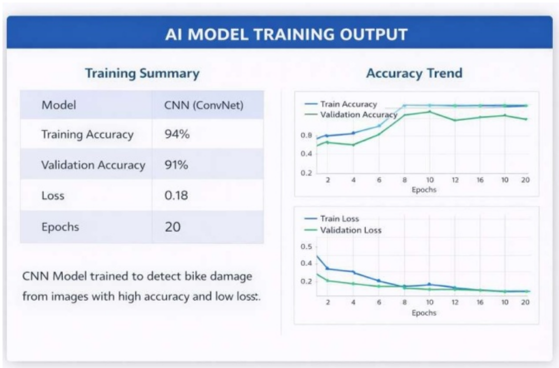


Figure7:CNNModelTrainingOutput—AccuracyandLossCurvesover 20 Epochs

VIII. EXPERIMENTALRESULTS

TheCNNmodelwastrainedon80%ofthecollecteddatasetand tested onthe remaining20%.The modelachieved94% training accuracy and 91% validation accuracy over 20 training epochs with a final loss of 0.18, confirming strong generalization with minimal overfitting.

Table III presents per-category precision, recall, and F1-score achieved on the test set.

ISSN: 2582-7219 | www.ijmrset.com | Impact Factor: 8.206| ESTD Year: 2018|

International Journal of Multidisciplinary Research in Science, Engineering and Technology (IJMRSET)

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)

TableIII:CNNModelClassificationPerformance

DamageType	Prec.(%)	Recall(%)	F1(%)
Scratches	91	89	90

IX. APPLICATIONS

- Bike and scooter rental companies requiring automated condition monitoring.
- Smartcity transportation systems with high vehicle turn over demands.
- Peer-to-peer vehicle sharing platforms needing objective damage verification.
- Fleet operators requiring real-time revenue analytics and identity management.
- University and campus rental programs serving students without formal ID proof.

X. CONCLUSION

This paper presented a Smart BikeRental Application integrating multi-level identity verification, risk-based access control, AI- based damage detection, automated repair cost estimation, and a Data Analytics dashboard. The CNN model achieves 94% training accuracy and 91% validation accuracy over 20 epochs. The hybrid verification system successfully balances security and inclusivity, supporting both fully verified users and partially verified users through OTP-based registration with tiered access privileges.

The system significantly reduces inspection time, provides objective damage accountability, and empowers operators with actionable analytics. Future work will explore real-time video- based detection, biometric face matching enhancement, GPS- based incident mapping, edge computing deployment, and insurance API integration for automated claims processing.

REFERENCES

[1] Y. LeCun, Y. Bengio, and G. Hinton, "Deep learning," Nature, vol.521, pp. 436–444, May 2015.
[2] K. Patil, M. Kulkarni, A. Sriraman, and S. Karande, "Deep learningbased car damage classification," in Proc. IEEE ICMLA, 2017, pp.50–54.
[3] Y.-J.Cha,W.Choi,andO.Buyukozturk,"Deeplearning-basedcrackdamage detection," Computer-Aided Civil and InfrastructureEngineering, vol. 32, no. 5, pp. 361–378, 2017.
[4] Y. Zhang, E. Fricker, and Y. Li, "Challenges in dockless bike-sharing," Transportation Research Part C, vol. 103, pp. 198–214,2019.
[5] G.Romanilloset al.,"Bigdataandcycling,"TransportReviews,vol.36, no. 1, pp. 114–133, 2016.
[6] S. Shaheen and A. Cohen, "Shared mobility: currentpractices," U.S.DOT, Tech. Rep. FHWA-HOP-16-022, 2016.
[7] R. Kumar, A. Sharma, and P. Singh, "Risk-based access control inshared mobility platforms," Journal of Transportation Security, vol.15, no. 2, pp. 88–102, 2022.
[8] A. Krizhevsky, I. Sutskever, and G. E. Hinton , "ImageNetclassificationwithdeepCNNs,"inAdvancesinNIPS,vol.25,2012.
[9] R. Girshick et al., "Rich feature hierarchies for accurate objectdetection," in Proc. IEEE CVPR, 2014, pp. 580–587.

INTERNATIONAL JOURNAL OF MULTIDISCIPLINARY RESEARCH

IN SCIENCE, ENGINEERING AND TECHNOLOGY

| Mobile No: +91-6381907438 | Whatsapp: +91-6381907438 | ijmrset@gmail.com |

www.ijmrset.com