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AEGIS AI: An AI-Based Road Accident Evidence Analysis System

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Abstract— Road accident investigation requires systematic examination, organisation and documentation of photographic evidence collected from accident scenes. Traditional methods depend largely on manual inspection, which can be time-consuming when multiple photographs are involved. This paper presents AEGIS AI, an Android-based road accident evidence analysis system developed to support investigators through AI-assisted image analysis and structured evidence management. The application is developed using Flutter, Dart and Kotlin, with SQLite for local data storage and TensorFlow Lite for on-device inference. An experimental MobileNetV3 Small classifier is integrated for accident-related image classification, while EfficientDet-Lite0 identifies supported objects in photographs. The system incorporates accident case management, photographic evidence acquisition, image-quality assessment and SHA-256 hashing for evidence integrity verification. EvidenceLens enables detailed image inspection, while SceneCompare supports comparison of photographs captured from different viewpoints. Human verification and PDF report generation are integrated to support the review and documentation of findings. Functional testing on a Realme 11 smartphone running Android 15 confirmed the operation of the implemented application modules, including image navigation, object detection overlays and evidence inspection. The system distinguishes between accident evidence detected, no accident evidence detected and inconclusive outcomes. Although the integrated workflow was functionally tested, quantitative model accuracy and reliability require further evaluation using representative accident datasets. AEGIS AI demonstrates an approach to combining mobile computer vision with digital evidence management while retaining human responsibility for final interpretation.

Keywords — Road Accident Evidence, Computer Vision, TensorFlow Lite, Android, SHA-256 Integrity, Human Verification.

I. INTRODUCTION

Road accidents are a major concern for transportation safety and public well-being. Investigating an accident requires careful examination of evidence collected from the scene, including photographs of damaged vehicles, road conditions, vehicle positions and surrounding objects. Photographic evidence plays an important role in understanding the visible circumstances of an accident and supporting the investigation process. However, manually examining and organising multiple photographs can be time-consuming, especially when images are captured from different angles. Traditional investigation methods also depend heavily on human observation, which may result in inconsistent documentation or overlooked details.

Recent developments in Artificial Intelligence (AI), Machine Learning (ML) and Computer Vision have introduced new possibilities for analysing digital images. Deep learning models can identify objects, recognise visual patterns and assist in extracting useful information from photographs. Nevertheless, detecting a vehicle or visible damage does not necessarily confirm that an accident occurred. Therefore, AI-generated observations must be interpreted carefully and reviewed by a human rather than treated as final conclusions.

To address these challenges, this paper presents AEGIS AI, an Android-based road accident evidence analysis system designed to assist in the collection, organisation and examination of photographic evidence. The application is developed using Flutter, Dart and Kotlin, with SQLite for local data storage and TensorFlow Lite for on-device AI processing. An experimental MobileNetV3 Small classifier is integrated for accident-related image classification, while EfficientDet-Lite0 is used to identify vehicles and other supported objects. The system also incorporates image-quality assessment and SHA-256 hashing to support evidence integrity verification.

AEGIS AI allows users to create accident cases, capture or select multiple photographs and examine photographic evidence through its EvidenceLens interface. The classification workflow distinguishes between accident evidence detected, no accident evidence detected and inconclusive outcomes. The implemented system also includes SceneCompare for multi-image examination, human verification for reviewing AI-generated findings and structured PDF report generation for documenting case information and observations. These modules were included in functional testing on an Android smartphone. However, comprehensive evaluation of model accuracy and system performance remains necessary to establish reliability under different accident conditions.

The primary objective of AEGIS AI is to provide an organised and accessible platform for AI-assisted photographic evidence analysis. The system is intended to support investigators by improving evidence management and presenting visual observations for review. It does not determine accident causes, vehicle speeds or legal responsibility, and its experimental AI models require systematic evaluation before their reliability can be established.

II. LITERATURE REVIEW

A. Manual Accident Investigation

Traditional road accident investigation involves examining the accident scene, photographing damaged vehicles, observing road conditions and documenting visible evidence. Investigators manually analyse photographs to identify important details such as vehicle positions, collision damage and surrounding objects. Although these methods provide useful information, examining multiple photographs can require considerable time and effort. Evidence may also be stored across separate files and records, making systematic organisation and retrieval difficult. These limitations highlight the need for digital tools that support evidence management and examination.

B. Vision-Based Accident Analysis

Recent research has explored the application of deep learning and computer vision techniques to road accident analysis. Porwal and Singh [1] proposed a hierarchical deep learning framework for identifying vehicles involved in collisions in Indian traffic accident images. Gurusamy et al. [2] investigated road accident detection and severity assessment using deep learning models and Intersection over Union (IoU) measures. Pawar and Attar [3] studied accident detection and localisation using traffic surveillance videos.

These studies demonstrate the potential of computer vision for recognising accident-related visual information. However, their primary focus is on specific tasks such as accident detection, vehicle identification or severity assessment. They do not establish a complete photographic evidence management workflow that combines case organisation, file-integrity checking and human review.

C. Lightweight Deep Learning Models

Deploying artificial intelligence models on mobile devices requires consideration of processing speed, memory consumption and computational resources. Howard et al. [7] introduced MobileNetV3, a lightweight convolutional neural network architecture designed for efficient mobile image classification. Tan et al. [8] proposed EfficientDet, an object detection architecture that combines efficient feature fusion with compound scaling.

These architectures provide a foundation for mobile image analysis. AEGIS AI incorporates an experimental MobileNetV3 Small classifier and an EfficientDet-Lite0 object detector through TensorFlow Lite. However, the efficiency of the underlying architectures does not guarantee accurate accident classification or detection. Their

performance must be evaluated using appropriate datasets and testing procedures.

D. Digital Evidence Integrity and Management

Maintaining the integrity of digital evidence is important in accident investigation. The National Institute of Standards and Technology (NIST) provides guidance on digital evidence preservation and handling procedures [4]. The Secure Hash Standard defines SHA-256, a cryptographic hashing algorithm that produces a fixed-length digest for digital data [5]. Comparing a stored digest with a newly calculated digest can help identify whether an evidence file has changed.

Verdoliva [6] examined digital media forensics and challenges associated with determining the authenticity of visual content. This distinction is important because file-integrity verification does not establish whether a photograph genuinely represents an accident scene. AEGIS AI uses SHA-256 for detecting modifications to stored evidence files, while recognising that authenticity verification and complete chain-of-custody management require additional safeguards.

E. Research Gap

AEGIS AI addresses this integration problem through an Android-based application that combines accident case management, photographic evidence acquisition, experimental image classification, object detection and SHA-256 integrity verification. The implemented workflow also incorporates EvidenceLens for detailed evidence inspection, SceneCompare for multi-image examination, human verification of AI-generated findings and structured PDF report generation. These components were included in functional testing on an Android smartphone. The primary contribution of AEGIS AI is the integration of mobile computer vision and digital evidence management into a structured examination process rather than the development of a new deep learning architecture. Further experimental evaluation using representative accident datasets is necessary to establish the reliability and practical effectiveness of the complete system.

III. METHODOLOGY

A. System Architecture

AEGIS AI follows a modular architecture designed to support the collection, management, analysis and documentation of road accident photographic evidence. The application is developed using Flutter and Dart, with Kotlin for native Android integration. SQLite is used for local data storage, while TensorFlow Lite enables on-device execution of deep learning models. The architecture integrates evidence acquisition, image-quality assessment, accident classification, object detection, evidence inspection, multi-image comparison, human verification and report generation within a unified Android application.

The system follows a structured workflow beginning with accident case creation and photographic evidence collection. Each image is associated with its corresponding case and stored locally. The application then performs image-quality assessment and AI-assisted analysis. Users can inspect individual images, compare multiple photographs and review the generated findings before preparing a report. This approach combines automated image analysis with human decision-making.



Fig. 1. Evidence Processing Workflow of AEGIS AI

B. Evidence Acquisition and Case Management

The evidence acquisition module allows users to capture photographs using the smartphone camera or select existing images from the device gallery. Multiple photographs can be associated with a single accident case, allowing evidence from different viewpoints to be organised together. Each

case contains identifying information and associated photographic records.

SQLite maintains structured information about accident cases, evidence files and analysis results. Photographs are stored in local device storage, with their corresponding file references linked to database records. This organisation enables users to retrieve evidence, navigate between images and maintain a structured record of each accident case.

C. Image Quality Assessment

The image-quality assessment module examines photographs before AI-based analysis to identify conditions that may affect the reliability of visual interpretation. Factors such as image blur, insufficient illumination, low resolution and incomplete visibility can make important details difficult to identify.

The module provides quality-related information to support the examination of uploaded photographs. This helps users recognise images that may require additional inspection or replacement. Image-quality assessment is treated as a supporting process rather than proof that an image is suitable for every investigation purpose.

D. Accident Evidence Classification

AEGIS AI incorporates an experimental MobileNetV3 Small classification model executed using TensorFlow Lite. The model processes photographic evidence and produces predictions related to the presence of accident evidence. Before inference, images are resized and normalised according to the model's input requirements.

The application supports three classification outcomes: accident evidence detected, no accident evidence detected and inconclusive. The inconclusive category allows uncertain results to be distinguished from definite classifications. This is important because a photograph may contain vehicles or visible damage without providing sufficient information to establish that an accident occurred.

Classification results are presented as AI-generated observations and remain subject to human review. The model's quantitative accuracy requires evaluation using an independently labelled dataset.

E. Object Detection

The object detection module uses EfficientDet-Lite0 through TensorFlow Lite to identify supported objects in photographic evidence. The detector processes an input image and returns predicted object categories, confidence scores and bounding-box coordinates.

Detected objects are displayed using bounding-box overlays, allowing users to examine their positions within the original photograph. Confidence information helps users understand the model's predictions. Object detection supports the identification of visible scene elements but does not independently establish accident occurrence, collision cause or legal responsibility.

F. Evidence Integrity Verification

AEGIS AI uses the SHA-256 cryptographic hashing algorithm to support photographic evidence integrity. When an image is stored, a hash value is calculated from its binary content and associated with its evidence record.

During integrity verification, the application recalculates the hash and compares it with the previously stored value. Matching values indicate that the file content remains consistent with the stored digest, while a mismatch indicates a change in the file.

The hashing operation is represented as:

$$H = \text{SHA-256}(F) \quad (1)$$

where F represents the evidence file and H represents its calculated hash value.

SHA-256 supports file-integrity checking but does not independently establish image authenticity, prevent unauthorised access or provide a complete chain of custody.

G. Evidence Inspection and Multi-Image Comparison

The EvidenceLens module provides an interface for examining photographic evidence and associated AI findings. Users can navigate between images, zoom into specific regions and inspect object detection overlays. This allows the original photographic content to be examined alongside the model-generated observations.

The SceneCompare module supports comparison of multiple photographs associated with the same accident case. By examining images captured from

different viewpoints, users can compare visible scene elements and review the available evidence more systematically. The comparison process assists visual examination without independently reconstructing the accident scene.

H. Human Verification and Report Generation

Human verification is incorporated to ensure that AI-generated findings are reviewed before being treated as confirmed observations. The verification workflow allows users to examine classification results, detected objects and supporting photographs, and to accept, modify or reject findings based on their assessment.

The reporting module organises case information, photographic evidence, analysis results and reviewed findings into a structured PDF report. This provides a consolidated record of the investigation-related observations.

The system is designed as a decision-support application. Final interpretation remains the responsibility of the investigator, and automated results are not presented as independent proof of accident cause or legal liability.

IV. RESULTS

A. Functional Testing Results

The AEGIS AI application was functionally tested on a Realme 11 smartphone running Android 15. Testing focused on the operation of the major application modules, including accident case management, photographic evidence acquisition, image-quality assessment, AI-based classification, object detection, evidence inspection, multi-image comparison, human verification and PDF report generation.

The case management module supports the creation, storage and retrieval of accident cases. The evidence acquisition module allows photographs to be captured using the device camera or selected from the gallery. Multiple photographs can be associated with a single case, allowing evidence from different viewpoints to be organised and examined together.

The AI processing module integrates an experimental MobileNetV3 Small classifier and an EfficientDet-Lite0 object detector through TensorFlow Lite. The classification workflow supports three outcomes: accident evidence detected, no accident evidence detected and inconclusive. The object detection module provides predicted object labels, confidence scores and bounding boxes, which can be examined through the application interface.

EvidenceLens supports photographic evidence inspection using image navigation, zooming and detection overlays. SceneCompare provides a workflow for comparing photographs associated with the same accident case. Human verification allows findings to be reviewed before documentation, while the reporting module generates a structured PDF containing relevant case information and reviewed observations.

B. Application Interface and Screenshots

The AEGIS AI application provides a mobile interface designed to simplify photographic evidence management and examination. The Home screen allows users to access the main application functions, including accident case management and evidence acquisition.

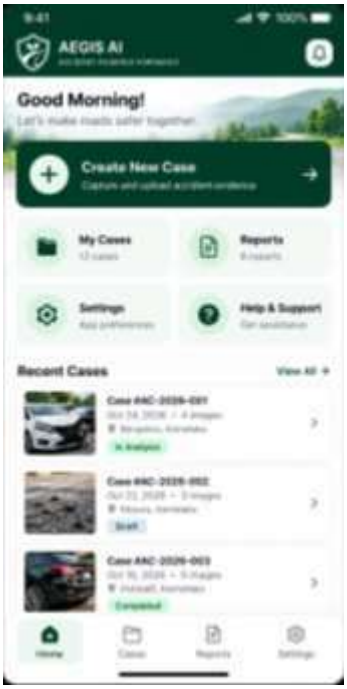


Fig. 2. AEGIS AI Home Screen

The EvidenceLens interface supports detailed examination of photographic evidence. Users can navigate between images, inspect visible details and review object detection overlays alongside the original photographs. This helps users assess AI-

generated observations against the available visual evidence.

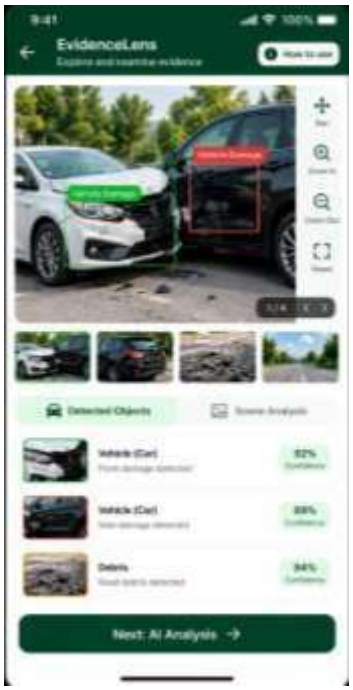


Fig. 3. EvidenceLens Evidence Inspection Interface

C. AI Analysis Results

The integrated AI models were exercised as part of the application's functional testing. MobileNetV3 Small processes photographic evidence for accident-related classification, while EfficientDet-Lite0 identifies supported objects within the images. The resulting predictions are presented through the application interface to assist evidence examination.

The three-outcome classification design distinguishes accident-related predictions from non-accident and inconclusive results. This distinction is important because the presence of vehicles or damaged objects does not independently establish that an accident occurred.

Although the models have been integrated and functionally tested, their quantitative accuracy has not been established using an independently labelled evaluation dataset. Consequently, classification accuracy, precision, recall, F1-score and detection mean Average Precision are not reported.

D. Evidence Integrity and Report Generation

AEGIS AI incorporates SHA-256 hashing to support the integrity verification of stored photographic evidence. A hash value is calculated for each evidence file and stored with its associated record. During verification, the application compares the stored digest with a newly calculated value to identify changes in file contents.

The human verification module allows users to review AI-generated findings before their inclusion in the final documentation. The PDF reporting module organises case details, photographic evidence and reviewed findings into a structured document.

These features support systematic evidence management and documentation. However, SHA-256 verification alone does not establish the authenticity of an image or provide a complete legally admissible chain of custody.

V. DISCUSSION

The functional testing of AEGIS AI demonstrates the integration of photographic evidence management, AI-assisted analysis and digital evidence documentation within an Android application. Unlike systems that focus primarily on accident detection, AEGIS AI combines evidence acquisition, case management, image inspection, integrity verification and human review in a single workflow.

The integration of MobileNetV3 Small and EfficientDet-Lite0 enables the application to generate accident-related predictions and identify supported objects in photographic evidence. These results can assist investigators in examining visual information. However, AI-generated predictions should be treated as supporting observations rather than definitive conclusions about accident occurrence, responsibility or cause.

The EvidenceLens and SceneCompare modules provide additional opportunities for examining individual photographs and comparing evidence from multiple viewpoints. SHA-256 hashing supports the detection of changes to stored evidence files, while human verification allows users to review findings before report generation. Together, these features improve the organisation and traceability of the evidence examination process.

Despite successful functional testing of the application modules, several limitations remain. The reliability of AI predictions may be affected by poor lighting, blurred photographs, occlusion, unusual camera angles and differences between training images and real accident scenes. Furthermore, quantitative model performance has not yet been established through evaluation on a sufficiently representative, independently labelled dataset. The system also cannot independently determine accident causation or establish legal responsibility.

Future improvements should focus on systematic model evaluation, testing across a wider range of accident conditions, improved handling of uncertain predictions and further validation of evidence management procedures. These developments would help establish the reliability and practical suitability of AEGIS AI for accident evidence examination.

VI. CONCLUSION

AEGIS AI: An AI-Based Road Accident Evidence Analysis System was developed to support the systematic examination, management and documentation of photographic accident evidence. The Android application integrates accident case management, evidence acquisition, image-quality assessment, AI-assisted classification, object detection, evidence inspection, multi-image comparison, integrity verification, human review and PDF report generation within a unified workflow.

The system uses MobileNetV3 Small and EfficientDet-Lite0 to assist in identifying accident-related visual information and detecting supported objects in photographs. EvidenceLens and SceneCompare provide additional facilities for examining individual images and comparing multiple photographs. SHA-256 hashing supports evidence integrity verification, while human verification ensures that AI-generated observations can be reviewed before documentation.

Functional testing on an Android smartphone demonstrated the operation of the implemented application modules. However, further evaluation using representative accident datasets is necessary to establish quantitative model accuracy, reliability and performance under different environmental conditions. The system is intended to assist evidence examination rather than independently determine accident causes or legal responsibility.

Overall, AEGIS AI demonstrates the practical integration of mobile computer vision and digital evidence management. By combining automated analysis with human oversight, the application provides a structured approach to photographic accident evidence examination and establishes a foundation for further research and improvement.

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