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NEXT GEN LEGAL EVIDENCE MANAGEMENT: A MULTIMODAL ARTIFICIAL INTELLIGENCE FRAMEWORK FOR DIGITAL FORENSICS

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Abstract: In the era of digital forensics and smart justice, managing large volumes of multimedia evidence has become a major challenge for law enforcement and legal professionals. The project "Next Gen Legal Evidence Management" introduces an AI-powered platform designed to analyze, summarize, and manage legal evidence efficiently using generative AI and multimodal processing. Leveraging Google's Gemini models, the system interprets both text and visuals to extract key insights from videos, images, and documents. The Next Gen Legal Evidence Management Chat Assistant enables users to upload evidence, ask case-related questions, and receive intelligent, context-aware responses. The Report Generator automates structured report creation using OpenCV and PIL for video frame analysis, while FAISS and HuggingFace embeddings store the processed data for efficient retrieval and similarity- based searches.

By combining AI-driven analytics, vector-based memory, and a Streamlit interface, the system accelerates evidence analysis and improves investigation accuracy. The integrated ReportLab PDF generator ensures secure report archiving in standardized formats. This solution reduces manual workload, enhances transparency, and supports scalability through integration with existing judicial and forensic tools. Ultimately, Next Gen Legal Evidence Management aims to build a smarter, faster, and more reliable digital justice system powered by artificial intelligence.

***Index Terms*- Artificial Intelligence (AI), Legal Evidence Management, Digital Forensics, Generative AI, Multimodal Analysis, Google Gemini Models, Computer Vision, OpenCV**

I INTRODUCTION

In today's rapidly evolving digital justice ecosystem, law enforcement agencies and legal professionals are overwhelmed by massive volumes of multimedia evidence ranging from surveillance footage and crime-scene images to digital documents and recorded statements. Traditional manual methods of analyzing, summarizing, and organizing this evidence are slow, labor-intensive, and prone to human error. As criminal investigations grow increasingly data driven, there is an urgent need for intelligent systems that can automate evidence processing, enhance accuracy, and support faster decision-making.

The Next Gen Legal Evidence Management system addresses this challenge by integrating advanced artificial intelligence, multimodal data processing, and automated documentation into a unified platform. By leveraging Google's Gemini models, the system can understand both textual and visual inputs, enabling it to analyze videos, images, and case files with high semantic precision — a capability aligned with current advancements in AI-driven evidence analysis and multimodal RAG frameworks.

With vector-based memory, similarity search through FAISS, and a user-friendly Streamlit interface, the system ensures efficient evidence retrieval, secure storage, and consistent documentation. Next Gen Legal Evidence Management represents a transformative step toward smarter and more efficient digital forensics.

II. NEED OF THE STUDY.

With the rapid growth of surveillance systems, CCTV cameras, and digital recording devices, a massive amount of video-based evidence is generated every day in legal and forensic investigations. While this data is highly valuable, analyzing it manually is a time-consuming and complex task. Investigators often need to review hours of footage to identify key details such as suspects, events, and suspicious activities. This process not only requires significant effort but also increases the chances of human error and inconsistency in report generation.

Most existing systems focus only on storing or displaying evidence rather than intelligently analyzing it. They lack advanced capabilities such as automated report generation, semantic search, and interactive querying. As a result, extracting meaningful insights from multimedia evidence becomes inefficient and slow. Additionally, there is limited use of modern AI techniques like multimodal analysis and Retrieval-Augmented Generation (RAG) in practical legal applications, creating a gap between research advancements and real-world implementation.

This creates a strong need for an intelligent and reliable system that can automate the analysis of video evidence and transform it into structured, investigation-ready reports. Such a system should also enable users to interact with the evidence through natural language queries, allowing faster and more accurate retrieval of information. The proposed system aims to address these challenges by integrating AI-based video analysis, vector-based retrieval, and conversational interfaces, thereby improving the efficiency, accuracy, and usability of legal evidence management.

III. LITERATURE SURVEY

[1] “Big Data and AI-Driven Evidence Analysis: A Global Perspective” by Chaiyaporn Kerdvibulvech. Kerdvibulvech.
It surveys global trends in applying big data and AI to evidence analysis, mapping research activity across regions and describing common pipelines for legal evidence processing; the paper highlights prevalent use of NLP for document parsing, topic modeling for thematic clustering, and ML classifiers for automated tagging, while noting a relative lack of practical, evaluated systems for multimodal (video/image) evidence and uneven geographic adoption.

[2] “Retrieval-Augmented Generation (RAG): Evolution, Current Landscape and Future Directions” by Sunil Gupta, Ramesh Ranjan, and Sanjay N. Singh. Gupta, Ranjan, and Singh.
It presents a taxonomy of RAG architectures and components covering dense retrieval, hybrid retrieval with lexical re-ranking, embedding families (sentence-transformers and API embeddings), and generation models — and synthesize best practices for reducing hallucinations and improving citation fidelity, while calling for domain-specific benchmarks and deployment studies for high-stakes fields such as law.

[3] “Retrieval-Augmented Generation for Large Language Models” by Lawrence M. Amugongo, Priya K. Mehta, and Daniel J. Roberts. Amugongo, Mehta, and Roberts.
They experimentally compare retrieval+generation pairings on factuality tasks, demonstrating that grounding LLM outputs with high-quality retrieved context markedly reduces unsupported statements; their work leverages FAISS for dense retrieval, sentence-transformer embeddings for semantic matching, and controlled prompt templates for the generator.

[4] “QuIM-RAG: Inverted Question Matching for Enhanced QA Performance” by Bashir Saha, Ujjwal Saha, and Muhammad Z. Malik. Saha, Saha, and Malik.
It introduces QuIM-RAG, which inverts the retrieval process by matching questions to similar historical questions for improved retrieval precision; they implement fast indexing in FAISS and show gains on domain corpora relevant to question answering, noting further work required for legal evidence adaptation.

[5] “HyPA-RAG: Hybrid Parameter Adaptive Retrieval for Robust QA” by Rohan Kalra, Manisha Verma, and Arvind Kapoor. Kalra, Verma, and Kapoor.
It proposes HyPA-RAG, a system that adaptively tunes retrieval hyperparameters per query and combines lexical BM25 signals with dense semantic retrieval, improving robustness to ambiguity and lowering hallucination rates in multi-turn dialogues, with experiments focused on English textual datasets and suggestions to extend to multimodal evidence.

[6] “Dynamic Legal Retrieval-Augmented Generation for Summarization” by S. Ajay Mukund, Kavita Sharma, and Rohit N. Iyer. Mukund, Sharma, and Iyer.
Presents a domain-aware RAG pipeline for legal summarization that uses legal-tuned sentence embeddings, hierarchical chunking of statutes and precedents, and constrained decoding summarizers to produce more faithful legal summaries; the study emphasizes legal ontology integration and cross-jurisdictional limitations.

[7] “AI-Driven Digital Forensics: Techniques, Challenges and Use Cases” by Ravi Tahsildar Yadav. Tahsildar Yadav.
Surveys AI methods applied in digital forensics, covering CNN-based image and video analysis, sequence models for log analysis, anomaly detection in network artifacts, and automated timeline reconstruction, concluding that AI accelerates triage but that explainability and court admissibility remain open concerns.

[8] “Machine Learning in Digital Forensics: A Systematic Literature Review” by Taha Nayerifard, Reema Alavi, and Ignacio M. Costa. Nayerifard, Alavi, and Costa.
Systematically review ML approaches in forensic tasks, documenting dominance of convolutional architectures for image/video evidence, tree-based models for artifact classification, and gaps in multimodal pipelines and standardized benchmarks, while recommending reproducible datasets for legal contexts.

[9] “The Age of Synthetic Realities: Forensic Challenges and Detection Techniques” by João P. Cardenuto and Aisha R. Khan. Cardenuto and Khan.
Analyzes forensic methods for detecting synthetic media and deepfakes, detailing frequency-domain forensic features, artifact detection networks, and provenance approaches, and highlighting the pressing need for provenance metadata and adaptive detection methods as generative models evolve.

[10] "Big Data and AI-Powered Evidence Analysis: Trends and Tools" by Maria L. Fernandez and Oliver J. Thompson. Fernandez and Thompson.
Synthesizes pipelines and tools used in large-scale evidence analytics, emphasizing scalable ingestion, preprocessing, automated tagging, and ML-backed analytics for investigative workflows; the paper notes that legal admissibility and auditability are often under-evaluated in existing toolsets.

IV. EXISTING SYSTEM

Existing systems for legal evidence management typically rely on manual workflows, digital document repositories, and standalone case management tools that mainly handle text-based files and simple metadata tagging. These platforms often lack advanced capabilities for processing and analyzing multimedia evidence such as videos, images, and audio recordings, and they offer limited support for semantic retrieval or contextual querying. While some modern tools integrate basic search functionality or automated document parsing, they generally do not harness generative AI, vector-based similarity search, or multimodal analysis resulting in slower retrieval, reduced insight depth, and less effective support for complex investigations.

V. PROPOSED SYSTEM

The proposed system is an AI-driven, multimodal evidence management platform that automates the ingestion, analysis, summarization, and retrieval of digital evidence. It processes video, image, audio, and document inputs using computer vision (OpenCV/PIL) and NLP models (Google Gemini/ LLMs), stores semantic embeddings in a FAISS vector store (HuggingFace or sentence-transformer embeddings), and exposes an interactive Next Gen Legal Evidence Management Chat Assistant via a Streamlit frontend and FastAPI backend. The platform generates concise, auditable incident reports (ReportLab PDFs), supports similarity-based search and cross-case comparison, and maintains secure, traceable metadata and audit logs to ensure evidentiary integrity and chain-of-custody.

VI. RESEARCH METHODOLOGY

The system architecture integrates user interaction, digital evidence ingestion, AI-driven interpretation, and automated documentation into a unified workflow. The platform comprises three major layers: Frontend (Streamlit)—Upload Evidence, Chat Assistant UI, Download Report; Backend (FastAPI)—API Gateway, Session Manager, PDF Report Generator; and AI Processing & Storage—Computer Vision (OpenCV/PIL), Multimodal LLM (Gemini), HuggingFace Embeddings Generator, and FAISSVectorStore..

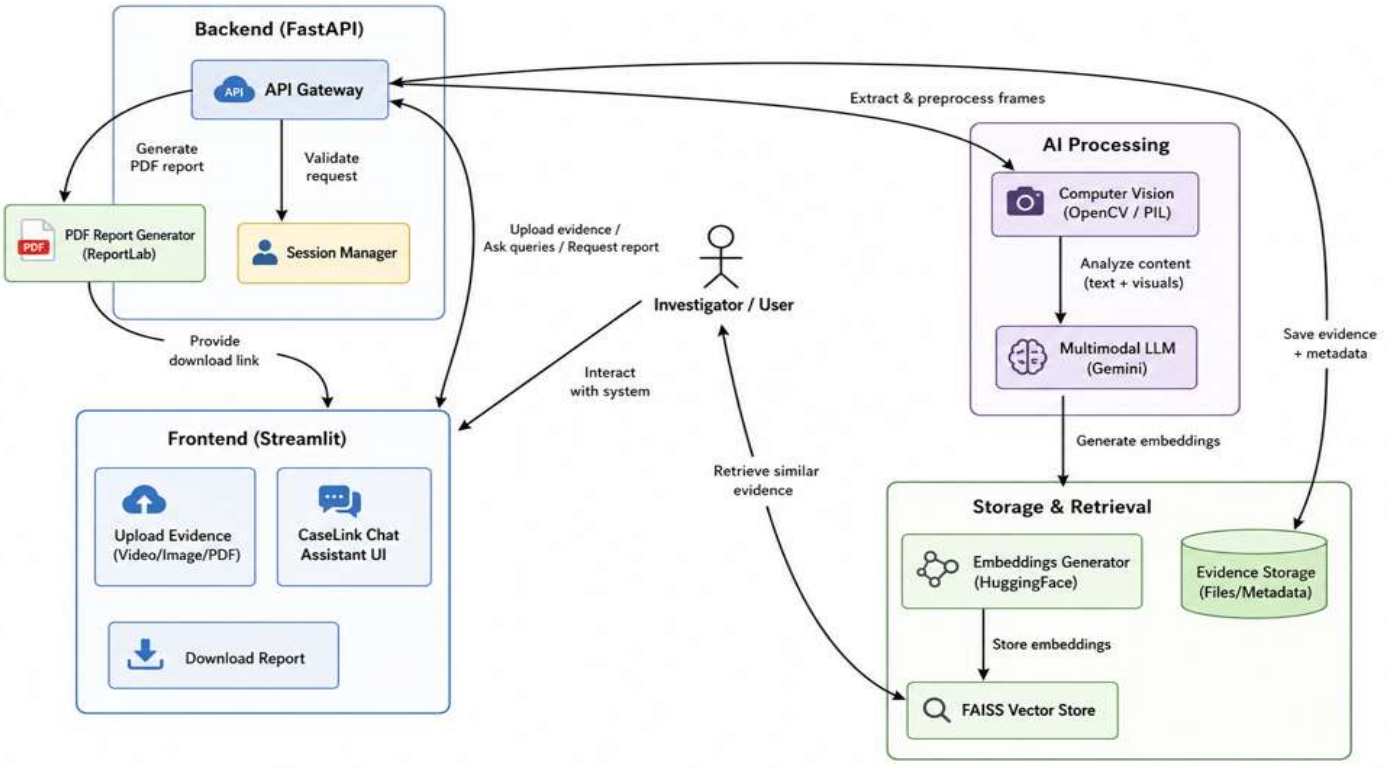

Fig 4.1: Architecture of Next Gen Legal Evidence Management

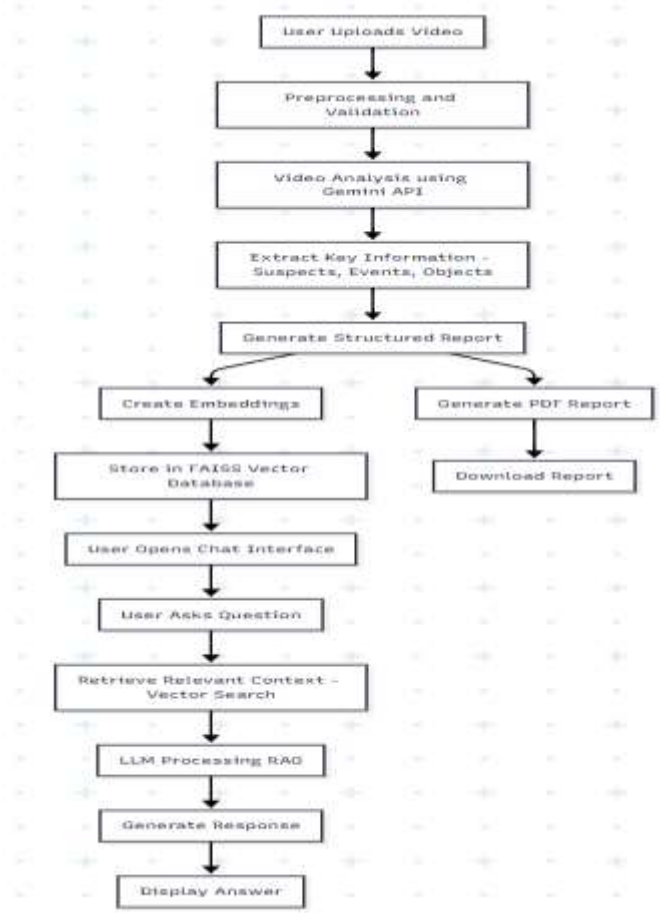

Fig 4.2: Process Flow Diagram of Next Gen Legal Evidence Management

VII. RESULTS AND DISCUSSION

The Next Gen Legal Evidence Management System was tested to ensure correctness, reliability, and usability of all core functionalities, including video processing, report generation, vector storage, and conversational querying. Both frontend interactions and backend AI processes were evaluated to verify system performance under different scenarios.

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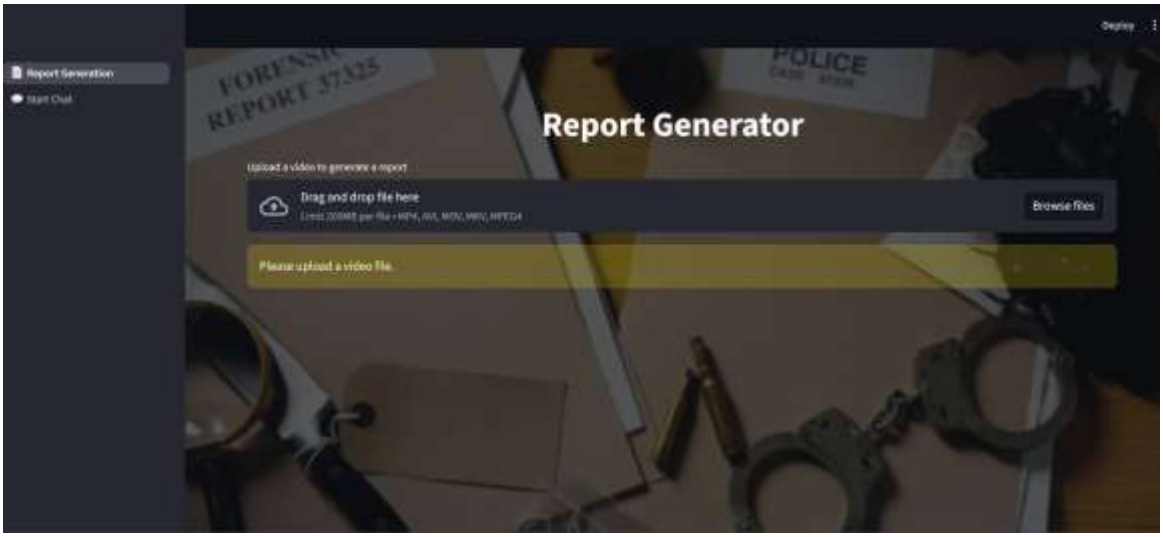

Fig 1: Home Page

Fig 2: Video Upload and Processing

Fig 3: Report Generation

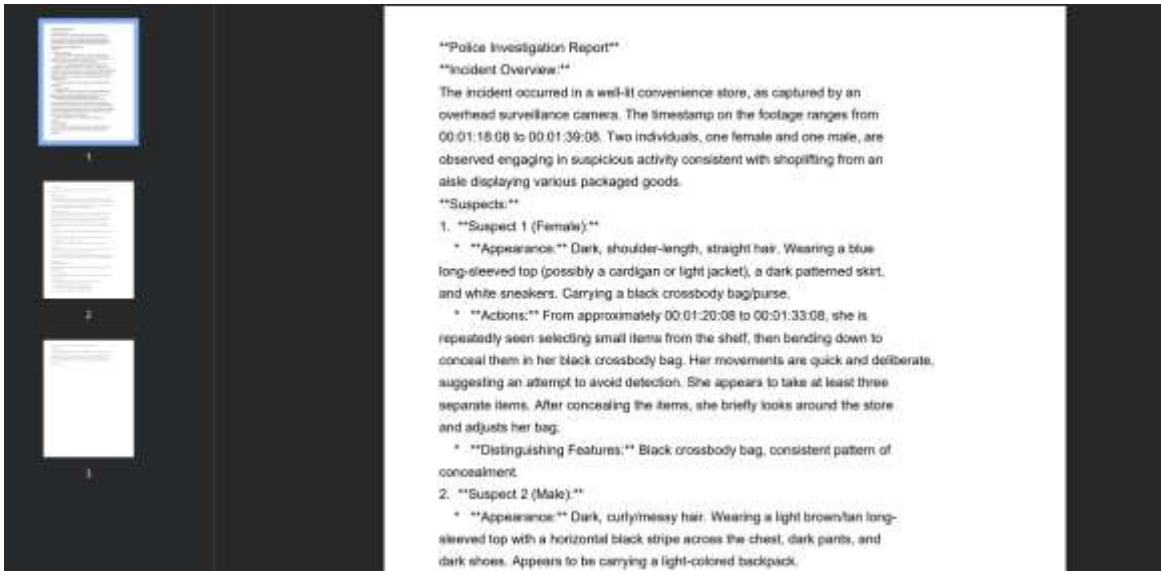

Fig 4: PDF Report Generation

Fig 5: Chat Based Query System

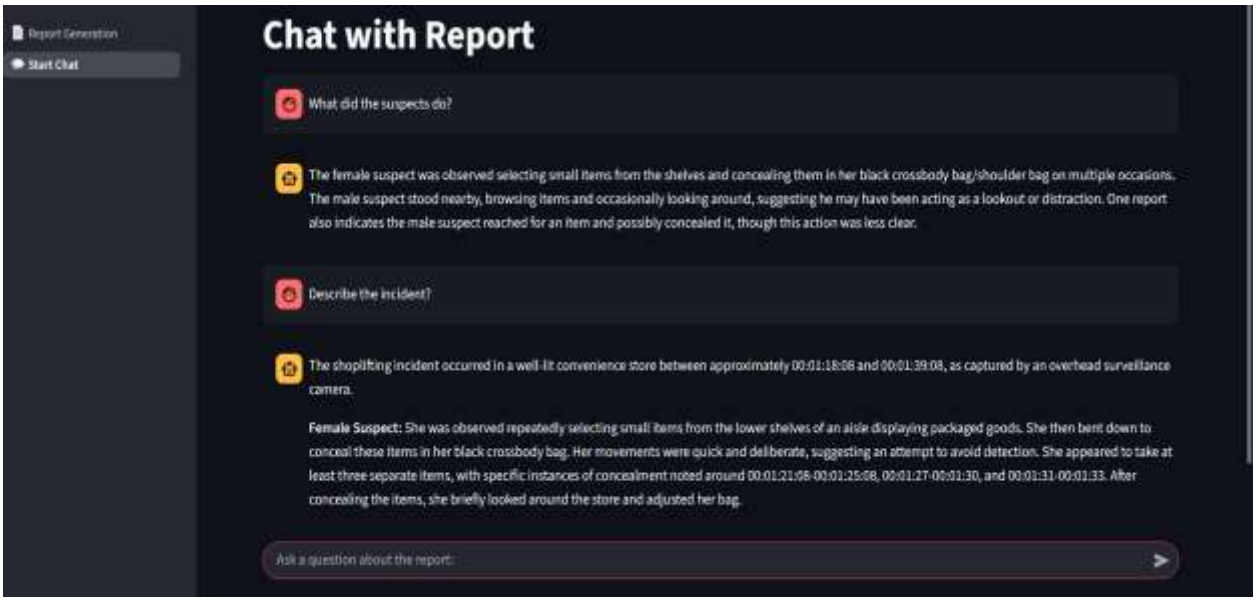

Fig 6: Context-Aware Conversation

VIII. CONCLUSION AND FUTURE SCOPE

The Next Gen Legal Evidence Management System provides an innovative AI-driven solution for modernizing digital evidence analysis by integrating video processing, automated report generation, and intelligent querying within a unified platform. By utilizing technologies such as Streamlit, LangChain, FAISS, and Google, the system transforms raw video evidence into structured investigation reports and enables context-aware interaction through a RAG-based chatbot. This approach significantly reduces manual effort, enhances accuracy, and improves the efficiency of investigative processes, demonstrating the practical application of AI in the legal and forensic domain.

The proposed system has significant potential for further enhancement and real-world deployment in legal and forensic environments. Future improvements can focus on integrating advanced capabilities such as real-time video analysis, face recognition, and license plate detection to enhance the accuracy and depth of evidence extraction. Additionally, incorporating blockchain-based chain-of-custody mechanisms can ensure data integrity and provide tamper-proof evidence management, which is crucial for legal admissibility.

Further development may include role-based access control for different stakeholders such as investigators, legal professionals, and administrators, along with integration into national crime databases and legal information systems. Expanding the system with multimodal Retrieval-Augmented Generation (MRAG) and deploying it as a cloud-based or mobile application can improve accessibility, scalability, and usability, enabling the system to evolve into a comprehensive digital forensic platform for end-to-end investigation workflows.

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