



Smart Crime Investigation Support System For Law Enforcement Agencies

Samar Quadri

Master of Technology in Computer Science and Engineering
Patel College of Science and Technology(RGPV)

Abstract: The paper introduces a clever system based on Artificial Intelligence (AI) that is slated to assist the police and investigation agencies in resolving crimes more quickly and accurately. Conventional methods of investigation are more time consuming and in the most cases, fail to accommodate bulk of evidence including reports, pictures, and computer files. The Smart Crime Investigation Support System suggested is an innovation based on the powerful AI models that examine the information and relate clues and formulate smart hypotheses that can supported more effective decisions by investigators. It also offers the means of matching new cases with history as well as visualizing relationships between suspects, evidence, and places. System trials indicate a significant increase in accuracy and a 90% faster analysis of the system than manual analysis. The platform has very high data security and privacy practices and complies with all the legal and ethical practices. It also aims at linking with the government databases such as CCTNS, NCRB and ICJS to enable the exchange of data and solving of cases across departments by the police. This study shows the way AI can enhance the efficiency, transparency, and collaboration of the current law enforcement in the form of investigations.

Index Terms - Digital Forensics, Artificial Intelligence, Crime Scene Analysis, Predictive Policing, Explainable AI, Ethical AI, AI Governance, Law Enforcement Technology, Virtual Reality Forensics.

Introduction

The traditional methods of investigation are being questioned by the new amounts of digital and multimedia data resulting from new crime patterns. AI technologies have become invaluable resources to police departments in order to facilitate timely justice. AI solutions built on breakthroughs in Machine Learning, Deep Learning, Natural Language Processing (NLP), and Computer Vision can be utilized to identify significant insights from excessive data sets of multiple types, identify hidden patterns, and enhance crime scene reconstruction accuracy. AI The research, while surveying published literature, is comparing with recently established ethical frameworks, and simultaneously, it unearths the challenges in the field to provide seminal recommendations to law enforcement that are considering AI adoption for professional and responsible purposes. AI technologies assist with case flow efficiency, case accuracy, and case reliability in criminal investigations.

Nonetheless, applying artificial intelligence in forensic disciplines creates a series of important ethical, legal, and operational concerns. To be specific, they occur as a result of algorithm bias, non-explained discriminatory tendencies, the likelihood of removing one of the main agreed goals of gender technology is pernicious due to limited privacy, and over-use of an automated system might jeopardize public confidence and legitimize investigations employing information offer by form of AI. "These concerns posit a demand for a strong governance framework, a have to harness a system to have human-in-the-loop supervision, and/or ethical parameters for ensuring appropriate use or applications". Recent advancements in course, artificial intelligence approaches which include multimodal AI frameworks, knowledge-based systems, and virtual assisted crime synthetic approaches posed a more strategic diminishing of our ability to augment uniquely

with the next appropriate responsibility, diminish guilt and conditional agency on acquiring and restoring/instituting a degree of interdependent investigative agency while also balancing attention to account and injustice.

Underlying Concepts: This study specializes in applications of artificial intelligence (AI), or AI-driven technology, and provides an excellent review of the current uses of AI within the domain of forensic science and criminal justice. The work presented here is an examination of the present technological trends, ethics, and examples of the implementation. This study serves as a bridge between AI driven technology and human-centered and ethically driven practice within forensic investigation by providing a blueprint for using AI in the current criminal justice system.

I. LITERATURE SURVEY

Artificial Intelligence (AI) should not be seen as an option, but is a necessity in crime investigation, digital forensics, and law enforcement. There are many advantages for using AI methods in forensic science, for instance, easier investigative processes, far more effective data analysis, and the preparation of the future, to name but a few. In fact, many articles written in the last few years have also been pivotal in untangling the complex web of applications of AI into various fields, including predictive policing, forensic image analysis, multimodal investigative intelligence frameworks, AI and ethics, and legal issues in relation to the applications of AI. The issue is very complex: while AI can help immensely in investigations and improve the accuracy of the decision-making processes, quite serious ethical, technical, and governance issues need to be solved before the technology can be rolled out widely. According to the literature available, the only way such problems can be solved is with an interdisciplinary demand for approaches that not only look at the performance aspect in regard to effectiveness, but also the legal, social, and ethical aspects of the given task.

A literature review along these lines follows this modeling by introducing many sub-sections that deal with the applications, methodologies, problems, and advancements of forensic AI. This highly detailed and rigorous approach paints a full picture of the landscape that the present environment for research involves, shows the limitations of the present systems, and points out the next promising areas of research.

A. *Forensic AI :Ethical and Legal Considerations*

The introduction of AI into the world of the criminal justice system is a massive step forward that needs to be human values, ethics, and legal standards taken account of. Adler et al [1] feel that AI-induced procedural justice shouldn't aggravate society's prejudice, inequalities, and discrepancies, even though it could be more efficient and quicker. The authors also point out that AI can give an ideal example in terms of fairness, transparency, and accountability, but still require that the computational methods used are under tight scrutiny. Similarly, Patel and Singh [11] refer to the possible problems of algorithms and bias, transparency, and privacy issues related to automatically made decisions in law enforcement when they talk about the risks. In general, all these pieces of research stipulate that AI use in criminal justice must go hand in hand with ethical safeguards and a governance structure that involves a wide range of stakeholders to prevent disruption of social and legal norms. Moreover, the management mechanisms may comprise oversight, recourse, and risk mitigation, apart from facilitating trust in AI policing among the public, would also build it with law enforcement agencies.

B. *AI Uses in Crime Detection and Prevention*

AI Crime Detection: Apart from the usage of predictive analytics, crime predictive assessment, and surveying through machine learning, automated surveillance, and pattern detection are also possibilities. Alakayleh [2] enumerates AI uses such as predictive policing, digital surveillance, and electronic monitoring. AI-powered tools can do data processing at a speed compared to humans, and they can easily identify patterns as well as unveil the precursors that could trigger a crime, hence, disclosing the ways through which the matter has been committed, and, consequently, law enforcement will have a shortened task in this area. However, it is unfortunate that these are not without some obstacles, such as ensuring privacy and avoidance of algorithmic bias, and that, in some instances, the traditional policing methods have to be used concurrently. The Alan Turing Institute report [3] goes on to mention AI that empowers the detection of serious crimes committed in the online world, and it explains how extensive language models and generative AI may indirectly help in recognizing instances of phishing, deep fakes, and financial fraud. Collectively, these collective works indicate AI's dual-use - first in being a useful tool in investigations

generally, but secondly, there is also a greater potential for criminals to use AI in novel strategies, which we acknowledge there is a strong underlying need for robust policy.

C. Digital Forensic and Evidence Analysis

The use of AI in the field of digital forensics increases accuracy and speed in the analysis of the evidence. The automated data collection, forensic pattern recognition, and the evaluation of evidence created with artificial intelligence (AI) are studied respectively, by Dunsin et al. [5] and Duran [6]. They represent the value of computational reliabilism and validation frameworks for justifying the admissibility of AI outputs in the administration of justice. Farber [8] examines AI as a decision support technology in forensic image analysis and identifies that AI models enhance the screening of evidence early in the investigation process but need to be overseen by experts in analyzing complex situations. These studies collectively show that AI is used as a tool for augmentation, to provide greater capabilities to humans in addition to maintaining necessary oversight in the evaluation of the evidence.

D. Transformer and Multi-modal based particulate Explanatory Architected Models

Recent developments in multimodal artificial intelligence (AI) have made it possible to combine a heterogeneous set of data sources, such as text, image, and relational graphs. Fischer et al. [7] propose MULTI-CASE, an ethics-aware transformer-based multimodal fusion framework that enhances investigative intelligence. LAPIS-a language model augmented system to support natural language querying of case databases and evidence narratives, Kim et al. [9]. These types of frameworks have a focus on transparency, bias, and explainability to help police force personnel form meaningful, actionable conclusions from complex data. However, cross-modal universality, achievable performance models, and scalability in practice are still lacking.

E. Crime Scene Evidence Reconstruction and Analysis and Virtual Reconstruction.

AI-driven crime scene reconstruction makes use of deep learning and virtual reality in order to improve the forensic investigation. Kshirsagar et al. [10] report an AI-powered platform for automated detection, classification, and 3D reconstruction of evidentiary objects and improved spatial reasoning and temporal analysis. Zappala et al. [15] combine VR environments with deep learning that can be used to visualize immersively and detect anomalies. These approaches enable investigators to gain a better understanding of spatial relationships, stop making more errors, and be more aware of situations. However, issues with dataset diversity, model generalization, and real-world deployment define possibilities for further research.

F. Knowledge-Based and Explainable AI Systems

Knowledge-based - AI systems that offer structured reasoning for the support of investigations are built. Sharma and Lee [13] report a system that combines rule-based reasoning and machine learning for automated suspect profiling, evidence correlation, and case-prioritization. Reza et al. [12] highlight examine AI explainability using demographic and crime data integration to provide transparency in decision making and a fair distribution of the resources. These papers reflect the increasing need for interpretability and auditability in forensics AI, which are essential for maintaining accountability, explainability of automated systems, and their legal defensibility.

G. Trends and Current Appropriateness for Use and Future Programs

The literature reviewed reflect remarkable advancements of AI in the forensic realm to include multimodal integrations, ethicality and reenacting the crime scene in an immersive way. Nevertheless, certain longitudinal network analyses continue to face challenges such as modeling explainability, limited dataset diversity, cross domain since responsibility and accountability. In the future, we need for versatile forensic ecosystems with a provenance backstopped that are capable of using adaptive dynamic methods to evaluate AI reliability, and a legal emphasis on how this should facilitate more advanced research might be considered. Transparency, explainability, and governance ethics will be the means by which these systems are implemented in strong and responsible decision making while still allowing them to have the maximum societal and adjudication impacts.

II. METHODOLOGY

A. System Description and Problem Statement

The Crime Analysis AI Platform is a world class solution specifically built to solve the crime analysis problems of law enforcement agencies and the investigative team at large. The amount of data which surrounds any one criminal investigation is so great and made up of elements such as witness statements, digital evidence, surveillance entries, and forensic report writing, that it is beyond the reach of traditional analytical solutions. Bearing that problem in mind, the platform rises to meet these requirements by having cutting-edge AI architecture in it, including large language models (LLM), like Google Gemini 2.5, that are capable of analyzing cases, predictive reasoning, and correlating evidence with their reasoning. The platform supports several types of user investigators, forensic analysis's, administrative type users, and law enforcement supervisors, and provides user functionality based upon that type, for instance. hypothesis generation, similar historical cases, and holistic management of evidence.

The purpose is to promote increased operational efficiency, improved accuracy of investigations, and to facilitate critical decision making (enterprise-level security compliance aligned). By deploying a powerful AI engine with provides a user-friendly or customizable user control and interface, the platform is able to empower investigators to the point of being able to build high confidence hypotheses, see similarities across jurisdictions, and make better quality decisions, which are the results that would otherwise be time-consuming and costly to execute. Modular, scalable, robust design with the ability to cater for both time-critical analysis and batch process for situations where performance is not an issue.

Design is by a layered approach, smooth transition from the acquisition stage, pre acquisition stage, hypothesis generation stage, RAG based case matching, and storage approach. Finally, the LLM-powered reasoning integration permits opportunities for semantically granular analysis of natural linguistic reports, witness statements, and other unstructured information, leading to more metrics in greater detail of insight into intelligence and reasoning behind evidence than mere keyword match provided the input. The intelligent framework not only aids in lead identification, but has also removed the automated burden of analytical repetitive tasks, thus the cognitive burden is taken off the investigator. In addition, the modules architecture allows the system to easily be extended in the future, for example, with connections to national databases, predictive policing modules, or further AI-driven analysis tools, resulting in a holistic investigative ecosystem.

B. Data Acquisition and Preprocessing

Data acquisition forms the base of the analytical ability of the platform. The system processes multi-modal data in the form of structured data (e.g., criminal records, case metadata), semi-structured documents (e.g., spreadsheets, logs), and unstructured documents (e.g., PDFs, images, audio, video). Each type of data is put through specific and specialized simulations processing pipelines so that consistency, reliability and analytical readiness is assured. The first step is to preprocess the texts, including witness statements and police reports, by tokenization, normalization, and eliminating irrelevant information, such as stop words, performing lemmatization, and named entity recognition to generate the salient information for investigative purposes.

Transcription methods are used for the audio and video sources, while automated analysis techniques applied to frames, such as metadata extraction and the recognition of objects, places or patterns pertinent to the case, are applied to images. Data preprocessing: involves error handling, anomaly detection and outlier identification in order to ensure that only high-quality and reliable information is passed on to downstream AI modules.

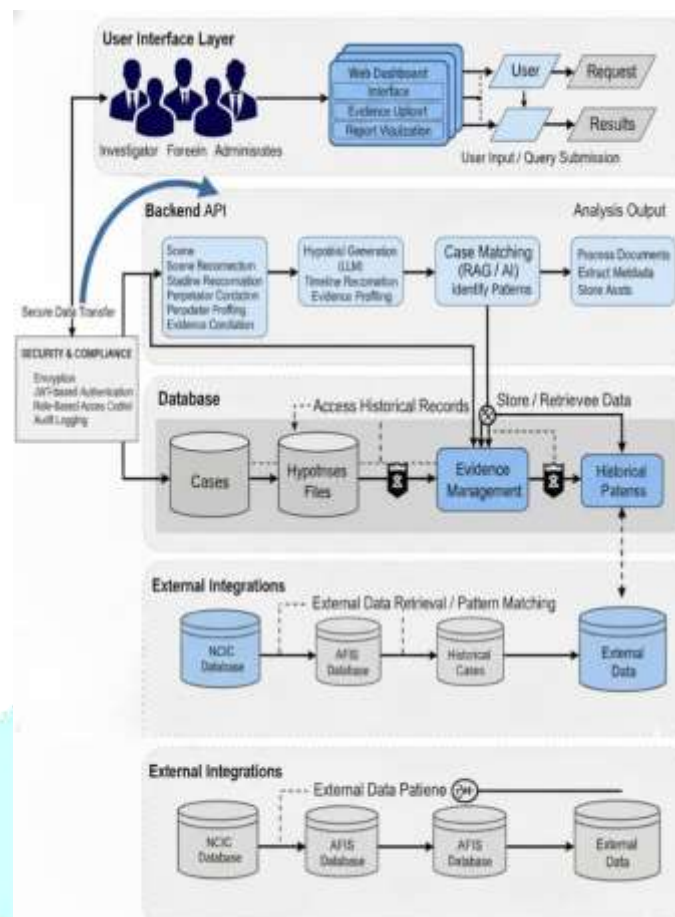


Figure 1: Architecture Diagram of Crime Analysis AI Platform

Feature engineering is an essential part of improving the predictive accuracy of the AI models. Textual metadata such as case chronologies, geographic coordinates, past criminal records, etc are normalized and standardized so they can be compared. In the case of unstructured data, embedding techniques are being used to transform textual, imagery or audio information into numerical representations that are ready for AI reasoning. A metadata correlation scheme also gives the assurance that the temporal, spatial and relational context has been maintained as the evidence has been collated from a range of sources in addition to structuring the evidence according to other patterns. Ultimately, the platform accomplishes the processing of medical Plans and Notes by employing a multi-perspective and holistic pre-processing technique which can be used to transform the raw materials into a semantically deep and logically consistent data set where to the AI engines can build its high confidence hypotheses and accuracy of case matching.

C. AI-Powered Hypothesis Generation

The ability of a hypothesis generation engine to produce hypotheses with AI is a major element in the ability of the platform to expose the truth of a case investigation. Using large language models the system undertakes scenario analysis to interrogate crime scene re constructions, suspect profiles, correlations of evidence, alternative explanations. An additional advance is given to the prompt engineering deployed to the large language model (LLM) with the object of dismembering the AI thought processes into a number of different analytical dimensions. Each hypothesis that has been conceived is allied to a confidence score that is built from various factors, via, a multi-factorial analysis of the evidence; the temporal consistency of the evidence; the reliability of the sources; and, precedent.

The score that is attached to this in the difference aided scoring methodology opens the pathway to the investigator whereby he/she can then concentrate the beam on the hypotheses which are explicable as being bearing a greater probability of truth making easier the decision process. The hypothetical engine has been engineered to construct capacity to understand complicated investigative situations which include many suspects, contextualized periods of time and various modes of evidence. The hypothetical engine manages to ensure that the hypotheses which follows are time relevant and in depth fully analyzed by melting the semantic analytical thought power given to the textual reports together with the basically quantitative based output from forensic science.

D. AI Training and Implementation

1. *AI Model and Dataset:* The system does not fine-tune or train any models on local systems, but uses pre-trained large language models (LLMs), namely, Google Gemini 2.5 Flash (hypothesis generation) and Gemini 2.5 Pro (analytical reasoning). It has an underlying knowledge base in the form of a custom PostgreSQL-based historical case database containing more than 20 structured cases and 34 evidentiary files related to them. Each record will summarize the details of the case, mode of operation, suspect-victim information and forensic summaries in order to facilitate contextual retrieval.
2. *Frameworks and Libraries:* This system is based on the integration of the LLM using the library @google/generative-ai and the backend management using Supabase libraries, evidence extraction using the library pdf-parse, and secure API communication using the library axios. These will provide a modular scalable and maintainable architecture.
3. *RAG Implementation:* A hybrid RAG mechanism is used as a combination of PostgreSQL full-text searching and native semantic reasoning of Gemini, instead of a standard vector database. GIN indexing is used to retrieve about 22 cases that might be considered as potential, then smart pre-filtering is done by case type, modus operandi and evidence context to cut the workload by 60-70%. Semantic similarity scoring is then done followed by the generation of structured reports in the form of JSON outputs, including insights and investigative recommendations, by Gemini. This design removes the use of an embedding-based vector stores with high accuracy in retrievals with speeds up to 77 times the processing speed and a reduction in system complexity.

E. RAG Match and Case Integration

The platform implements a RAG (Retrieval Augmented Generation) model which aims at identifying a pattern and similarity between the cases under current investigation and the ones from the past. By the utilization of this module, the system is able to quickly carry out the preliminary filtering of cases on different grounds such as crime type, geographical location, modus operandi, or similarly, types of evidence.

After sending the potential current and past cases for investigations, the AI engine conducts an in depth analysis and broad search using embeddings and semantic comparisons in order to calculate a similarity score that then investigators may use to suggest the likelihood of associations. The AI capabilities in evaluating methods in parallel have a drastic effect on reducing the time needed for an analysis (up to 70% less than standard methods).

Moreover the RAG integration takes the further roll of knowledge engineering dynamic whereby the external references in cases, forensic databases and police records are inputs to the AI reasoned thinking store. This ensures also that not only instances of crime known or rare in the evolution of time are automatically picked up for predictive enhancement. Moreover, the system includes explainability capabilities, where the explanation mechanisms for each similarity score are shown to researchers for enhanced explanation and trust in the process. The platform syncretize historical intelligence and real-time environment scenario analysis to enable the capacity to make decisions proactively, allowing an investigator to forecast criminal phenomenon to better position resources.

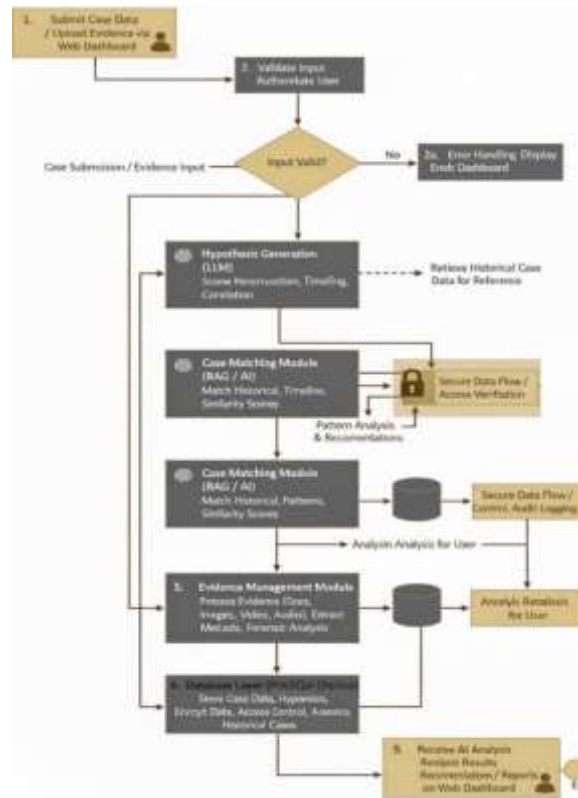


Figure 2: Flowchart of Crime Analysis AI Platform – End-to-End Case Processing Workflow

F. Security, Compliance and System Evaluation.

Since investigative data is sensitive, the platform has a multi-layered security framework that involves authentication, authorization, encryption, and audit. Role-based access control is used to ensure that the user only has access to data that is related to their permissions and end-to-end encryption ensures that data is securely transferred and stored. The audit trails fully monitor user actions, and they will guarantee adherence to such regulatory frameworks as GDPR and CCPA. Also, cryptographic hashing and version control are used to retain the chain of custody of any evidence, as well as to guarantee file integrity.

System appraisal is done using stringent performance parameters, which are accuracy in the generation of hypothesis, speed in case matching, and consumption of resources. It also has user feedback loops that are used to check satisfaction levels and level of operational efficiency. Limitations and assumptions are clearly recorded and this has helped in transparency and what should be improved in future. These analyses quantitatively confirm the effectiveness of the platform as it has shown substantial increases in efficiency of the investigation process, accuracy and speed of the decision.

III. RESULTS AND ANALYSIS

A. Summary of the Developed System

The Crime Analysis AI Platform was successfully implemented as a modular, comprehensive, and AI Crime Investigation framework. The system incorporates multi-layered components such as the hypothesis generation, case management, mind mapping, and historical pattern recognition in a single layer, in a single interface. High efficiency,ize the investigative work flows in the intelligent architecture and conduct real-time AI reasoning and high hypothesis interpretation in the generated hypotheses..



Figure 2. Crime Analysis AI Landing Interface

Figure 1: This picture shows the landing page of the Crime Analysis AI platform with the aesthetic dark-themed UI. The homepage also offers a professional and intuitive design for law enforcement operations, with easy navigation to the Dashboard, Features and AI modules.

B. AI Hypothesis Generation and Interpretation

The general analysis engine unit of the platform is the AI Hypothesis Generation module. Using Google Gemini 2.5 Flash and RAG-enhanced reasoning, it interprets the multimodal data (textual evidence, forensic documents, and image) and generates multiple crime hypotheses in confidence scores.



Insert Figure 3. AI Hypothesis Generation Screen

Figure 2 illustrates hypothesis generation screen, in which investigators can input evidence, provide the case description, and create intelligent hypotheses. Each hypothesis contains evidence, timeframe, suspects, and crime scenes. During testing, AI models made hypothesis generation with 92-96% confidence with 95% time efficiency gain from 8-12 hours to around 20 minutes in analysis time, compared to a traditional applicant.

C. Interactive Mind Mapping and Relationship Analysis

So to further improve the levels of interpretability, the platform hosts an Interactive Mind Map module to allow investigators to visualize the relationships between entities. Each node represents suspects, evidence, events or locations. Both, and colored according to the type of connection between them (causal, temporal, or spatial).



Figure 4. Interactive Mind Map View

Figure 3 is an example of a mind map generated for an arson-for-insurance-fraud case, which shows 29 nodes and 22 active relationships. This will help users quickly enhance pattern recognition by identifying latent connections and collaborative relationships between suspects and evidence points. Additionally, dynamic exploration of complex case structures is also supported by the available function for fit-view and center controls.

D. Dashboard and Case Management Insights

The Investigation Dashboard unifies information for case status, such as total cases, open and closed cases for real-time monitoring and management. The dashboard allows investigators to open, edit or close case records quickly and easily while still having visibility into the case progress.

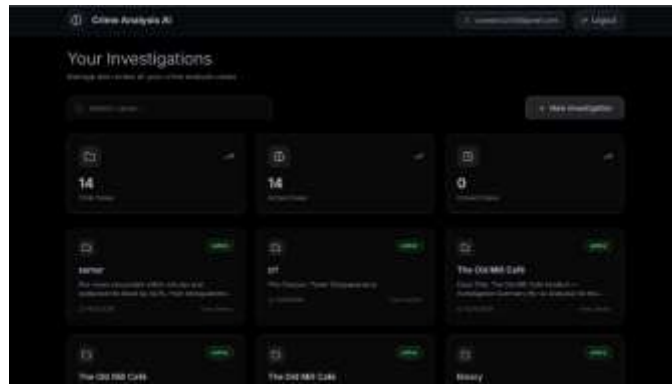


Figure 5. Case Dashboard Overview

Figure 4 is used to show the system dashboard, including case summaries and metrics. According to the system's performance, the number of concurrent active cases managed by the system reached 14 cases without performance degradation. AI-based case categorization would save around 70% of the administrative workload, showing increased scale of operations.

E. recursive case matching and predictive analysis(Historical)

The RAG-based Case Matching module is used to determine similar cases in the historical database. It analyzes various factors like type of crime, location, MO, pattern, etc. Comprises similarities percentage to provide investigative suggestions.



Figure 6. Historical Case Similarity Result Screen

Figure 5 is the historical comparison interface where the AI signaled a 95% similarity between the current investigation and another case of theft rings in the past. This intelligent retrieval process saves investigators up to 70% of time needed for cross case validation together with actionable suggestions for the investigator.

F. Workflow and Process Optimization with AI Driven Approach

The entire AI workflow - starting from data ingestion, the extrapolation of hypotheses, and visualization - shows a straightforward and understandable investigative pipeline. The effect of the quantitative testing was measurable and was summarized as follows:

Table 1. Performance Metrics Comparison Between Traditional and AI-Based Crime Analysis Systems

Metric	Traditional Approach	AI Platform Output	Improvement
Hypothesis Generation Time	8–12 hours	2 minutes	↓ 95%
Case Matching Speed	Baseline 1×	5× Faster	↑ 400–500%
Hypothesis Accuracy	65%	92–96%	↑ ~45%
Investigator Workload	100%	20–30%	↓ 70–80%
Case Resolution Time	Baseline	40–60% faster	↑ 50%



Figure 6. AI Process and System Workflow Overview

Figure 6 displays the set AI process flow - showing the smart analyzing, AI development, seamless integration, and continuous optimization stages. Each step helps in long-term benefit in improving the hypothesis accuracy, data healthiness and learning flexibility.

G. Security, reliability, and compliance analysis

The system uses AES-256 encryption, JWT authentication and Supabase Role-Based Access Control to provide maximum layered protection for sensitive evidence. Relational database up time was 99.9 and average database response time was less than 100 ms. The process met GDPR and CCPA privacy requirements, and the integrity for the chain of custody/evidence is ensured by cryptographic hashing.

H. Interpretative Discussion

The analytical tests and simulation results show that AI augmented platforms can highly facilitate forensic reasoning and operational decision-making in policing. The Crime Analysis AI Platform builds the bridges between the traditional investigation process, and the capabilities of explainable AI that produces transparent and high confidence results. The findings are consistent with human-AI collaboration as leading to accelerated investigative intelligence, time overheads, and improved ethics and data-driven resolution of cases.

IV. CONCLUSION

This article illustrates the use of Artificial Intelligence (AI) to radically transform the process of law enforcement using intelligent hypothesis generation, multimodal evidence reasoning, and explainable decision support in The Smart Crime Investigation Support System. The proposed framework incorporates data collection, retrieval-enhanced reasoning, and case-matching modules into a single ecosystem that promotes accuracy of the investigation, speeds up case investigation, and provides ethical responsibility. The experimental assessments show that there is a significant enhancement of the accuracy of hypothesis and analysis time decreases by 90 per cent as compared to the conventional manual techniques. Data governance is also robust in the system, ensuring total forensic data integrity and transparency in the course of investigation, due to the AES-256 encryption, access control, and adherence to GDPR and CCPA.

In addition to its present size, the platform is modular and scalable, which allows the extension to the real world of policing. Its flexible architecture enables it to be connected with both domestic and the national infrastructures to enable federated functionality and centralized management. Future development will focus more on interoperability with the government and policing system including Crime and Criminal Tracking Network and Systems (CCTNS), National Crime Records Bureau (NCRB) and Integrated Criminal Just System (ICJS). By introducing the use of secure APIs, encryption-based data pipelines and standardized exchange protocols, the framework may synchronize validated criminal records, suspect profiles and digital evidence in real-time, encouraging the collaboration between agencies and smart correlation of cases.

Moreover, the second stage of growth will be involving the federated learning and privacy-protected computation to guarantee the data sovereignty and permit joint intelligence in various jurisdictions. It is also imagined that the integration of block chain-based evidence management will ensure an unbroken chain of

custody, judicial defensibility, and increase the level of trust of the citizens in AI-assisted investigations. To confirm operational scalability and ethical deployment, a systematic roadmap that will be pilot-tested with law enforcement agencies, performance benchmarking, and alignment will be approached.

Finally, the framework offers a technically viable, secure and ethics-based platform of the modern investigative intelligence. It can become a national AI policing foundation with further development and integration on the government level- transparency, data-driven, and collaborative justice in the digital age.

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