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# ROLE OF TECHNOLOGY AND FORENSICS IN CRIMINAL LAW

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## ABSTRACT

The administration of criminal law has undergone a substantial transformation due to the swift progress of technology and the field of forensics. The precision, effectiveness, and impartiality of criminal investigations have been improved by contemporary investigative methods like DNA profiling, digital forensics, surveillance technology, and artificial intelligence. In order for courts to depend on scientific evidence rather than just eyewitness testimony or confessions, forensic science is essential to the gathering, processing, and interpretation of evidence. Through e-courts and virtual hearings, technological technologies have also enhanced case oversight, evidence preservation, and courtroom processes. However, the growing reliance on technology brings up significant ethical and legal issues, such as data security, privacy violations, improper use of surveillance, and the possibility of forensic errors. This study looks at the function and effects of technology and forensic science in criminal law, assesses how they help ensure fair trials and the administration of justice, and identifies challenges in putting them into practice. In order to strike a balance between technological innovation and the defense of fundamental rights, the study highlights the necessity of appropriate legislative control, training, and protections.

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**INTRODUCTION:-**

Due to technological improvements, the profession of criminal investigation has seen tremendous change in recent years. Technology has completely changed how criminal investigations are carried out, from obtaining evidence to evaluating and presenting it in court. Using new instruments and methods, law enforcement agencies now have more effective and efficient ways to solve crimes and prosecute offenders. The criminal justice system has never been static. Its methods, institutions, and evidentiary standards have evolved continuously in response to changes in society. In recent decades, one of the most significant forces shaping criminal law has been the rapid growth of technology and forensic science. Criminal investigations that once depended almost entirely on oral testimony and circumstantial inference now increasingly rely on scientific techniques and digital tools. This shift has altered not only how crimes are detected but also how guilt is established in courts of law.

Technology has expanded the capacity of law enforcement agencies to collect, store, and analyse information. Surveillance cameras, mobile phone data, call detail records, GPS tracking, and digital databases have become routine features of criminal investigations. Alongside these developments, forensic science has emerged as a crucial aid in reconstructing criminal events. Methods such as fingerprint analysis, DNA profiling, forensic pathology, ballistic examination, and cyber forensics allow investigators to link suspects to crime scenes with a degree of precision that was previously unavailable. As a result, scientific evidence often occupies a central position in modern criminal trials.

In India, the relevance of technology and forensics has grown in response to the changing nature of crime. Offences involving cyber fraud, digital impersonation, terrorism, and organized criminal networks cannot be effectively addressed through traditional investigative techniques alone. The legal system has gradually acknowledged this reality. Amendments to procedural laws and the recognition of electronic records as evidence under the Indian Evidence Act demonstrate an attempt to align criminal law with technological realities. Judicial decisions have also reflected an increasing willingness to rely on forensic material, provided that it satisfies standards of relevance, reliability, and fairness.

At the same time, the use of technology and forensic evidence raises serious legal and ethical concerns. Scientific evidence is often perceived as infallible, yet forensic errors, faulty laboratory practices, and investigator bias have been documented both in India and abroad. The

absence of uniform protocols, delays in forensic reporting, and inadequate training of personnel frequently weaken the probative value of such evidence. Moreover, excessive dependence on technological surveillance poses risks to individual privacy and personal liberty, which are constitutionally protected rights.

Another important issue is accessibility. Advanced forensic facilities and technological tools are unevenly distributed across the country. While urban centres may benefit from well-equipped laboratories and skilled experts, many rural and semi-urban regions continue to suffer from infrastructural limitations. This disparity affects the quality of investigations and, ultimately, the fairness of criminal trials.

In this context, the role of technology and forensics in criminal law must be examined critically rather than uncritically celebrated. Their contribution to truth-finding is undeniable, but their effectiveness depends on proper regulation, judicial scrutiny, and institutional accountability. A balanced legal approach is essential to ensure that scientific advancement strengthens, rather than undermines, the principles of justice and due process.

#### **Objectives of the Study:-**

1. To examine the growing role of technology and forensic science in the investigation and prosecution of criminal offences.
2. To analyse the legal framework governing the admissibility and evidentiary value of technological and forensic evidence under criminal law.
3. To study the approach of courts in assessing the reliability and limitations of forensic methods in criminal trials.
4. To identify practical and institutional challenges faced in the use of technology and forensic science within the criminal justice system.

#### **Research Questions:-**

1. How has technology and forensic science influenced criminal investigation and trial processes?
2. What standards have Indian courts applied while assessing forensic and technological

evidence?

3. What challenges arise from the growing dependence on technology in criminal justice administration?

### **Hypotheses:-**

1. The incorporation of technology and forensic science has improved investigative accuracy in criminal cases.
2. Forensic evidence, despite its scientific character, requires strict judicial scrutiny to prevent error and misuse.
3. Structural and institutional limitations reduce the effective implementation of forensic technologies in criminal law.

## **I. INTRODUCTION**

Criminal law has historically evolved in response to social and technological change. In the contemporary era, crime has transcended physical boundaries and entered digital spaces. Cyber fraud, identity theft, online harassment, and digital espionage represent new dimensions of criminal activity. Consequently, investigative agencies have increasingly relied on scientific and technological tools to detect and prosecute offences.

Forensic science refers to the application of scientific principles to legal matters. Techniques such as fingerprint analysis, ballistic examination, toxicology, DNA profiling, and digital forensics assist courts in determining guilt or innocence. The Supreme Court of India has repeatedly emphasized the importance of scientific investigation, particularly in cases where ocular evidence is unreliable.

The landmark privacy judgment in *Justice K.S. Puttaswamy v. Union of India*<sup>3</sup> recognized privacy as a fundamental right, raising important concerns about surveillance technologies and state power. Similarly, in *Selvi v. State of Karnataka*<sup>4</sup>, the Court restricted involuntary narco-

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<sup>3</sup> *Justice K.S. Puttaswamy v. Union of India*

<sup>4</sup> *Selvi v. State of Karnataka*

analysis and brain mapping, reinforcing constitutional safeguards under Articles 20(3) and 21<sup>5</sup>.

Thus, while technology enhances investigative precision, it simultaneously demands stricter legal oversight. This study explores this duality. In India, the relevance of technology and forensics has grown in response to the changing nature of crime. Offences involving cyber fraud, digital impersonation, terrorism, and organized criminal networks cannot be effectively addressed through traditional investigative techniques alone. The legal system has gradually acknowledged this reality. Amendments to procedural laws and the recognition of electronic records as evidence under the Indian Evidence Act demonstrate an attempt to align criminal law with technological realities. Judicial decisions have also reflected an increasing willingness to rely on forensic material, provided that it satisfies standards of relevance, reliability, and fairness.

## **II. Evolution of Forensic Science in Criminal Law.**

### **Early Foundations:-**

In ancient civilizations such as Ancient China and Ancient Rome, rudimentary forensic practices were visible. Chinese texts documented methods for distinguishing drowning from strangulation, while Roman law recognized the importance of medical opinion in cases of suspicious death. However, these early efforts lacked standardized scientific methodology.

A significant milestone occurred in the 13th century with the Chinese medico-legal text *The Washing Away of Wrongs* by Song Ci, which described systematic examination of corpses to determine cause of death. This marked one of the earliest recorded attempts to integrate observation and medical knowledge into legal proceedings.

### **Emergence of Scientific Techniques (19th Century).**

The 19th century witnessed the formalization of forensic science as a distinct discipline. The development of toxicology by figures such as Mathieu Orfila enabled courts to detect poisons with scientific certainty. Around the same period, fingerprint identification emerged as a revolutionary tool. The classification system advanced by Sir Edward Henry in British India

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<sup>5</sup> Articles 20(3) and 21

laid the foundation for modern fingerprint bureaus.

The acceptance of fingerprint evidence in courts significantly strengthened evidentiary standards, shifting criminal trials toward objective identification methods rather than subjective testimony.

### **20th Century Expansion.**

The 20th century marked rapid growth in forensic disciplines, including ballistics, serology, and questioned document examination. The establishment of the first crime laboratory by Edmond Locard in Lyon in 1910 institutionalized scientific investigation within policing systems. Locard's Exchange Principle—"every contact leaves a trace"—became a cornerstone of forensic reasoning.

The discovery of DNA profiling by Sir Alec Jeffreys in 1984 revolutionized criminal law. DNA evidence provided unprecedented accuracy in identifying perpetrators and exonerating the innocent. Courts worldwide began to treat forensic genetics as highly persuasive evidence, reshaping standards of proof and appellate review.

### **Forensic Science in the Digital Age.**

In the 21st century, forensic science expanded into digital forensics, cybercrime investigation, and biometric technologies. Advancements in artificial intelligence, facial recognition, and data analytics now assist in criminal detection. However, these innovations also raise constitutional and ethical concerns relating to privacy, admissibility standards, and potential bias.

Judicial systems increasingly scrutinize forensic reliability, emphasizing accreditation, chain of custody, and expert testimony standards. The integration of forensic science with procedural safeguards reflects an effort to balance technological efficiency with fundamental rights.

## **III. Legal Framework Governing Technological Evidence**

The rapid integration of digital technologies into everyday life has fundamentally altered the nature of evidence in criminal proceedings. Emails, call records, CCTV footage, GPS data, biometric identifiers, and cloud-stored documents now routinely form the backbone of prosecutions and defenses. As a result, modern legal systems have developed a structured

framework to regulate the admissibility, authenticity, reliability, and constitutional validity of technological evidence.

## **1. Statutory Recognition of Electronic Evidence**

In India, the primary statutory foundation lies in the Indian Evidence Act, 1872<sup>6</sup>, particularly Sections 65A and 65B, which were introduced through the Information Technology Act, 2000<sup>7</sup>. These provisions recognize electronic records as admissible evidence, subject to specific certification requirements ensuring authenticity and integrity.

Section 65B mandates a certificate confirming:

- The lawful control of the device,
- Proper functioning of the computer,
- Accuracy of the electronic record, and
- Compliance with procedural safeguards.

Judicial interpretation has significantly shaped this framework. In *Anvar P.V. v. P.K. Basheer*<sup>8</sup>, the Supreme Court of India clarified that electronic evidence is admissible only if accompanied by a proper 65B certificate. Later, *Arjun Panditrao Khotkar v. Kailash Kushanrao Gorantyal* reaffirmed the mandatory nature of this requirement while allowing certain procedural flexibility in exceptional circumstances.

With the enactment of the *Bharatiya Sakshya Adhiniyam, 2023*<sup>9</sup>, the framework for electronic evidence has been modernized, though the emphasis on authenticity and certification continues.

## **2. Constitutional Safeguards and Privacy**

Technological evidence often intersects with fundamental rights. The landmark judgment in *Justice K.S. Puttaswamy v. Union of India* recognized the right to privacy as a fundamental

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<sup>6</sup> Indian Evidence Act, 1872

<sup>7</sup> Information Technology Act, 2000

<sup>8</sup> *Anvar P.V. v. P.K. Basheer*

<sup>9</sup> *Bharatiya Sakshya Adhiniyam, 2023*

right under Article 21 of the Constitution. This decision has profound implications for digital searches, surveillance, phone tapping, and data interception.

Search and seizure of digital devices must comply with constitutional protections against arbitrary intrusion. Courts increasingly examine whether digital evidence was obtained through lawful authorization, proportionality, and procedural fairness.

### **3. Admissibility Standards and Expert Testimony**

Technological evidence must satisfy general evidentiary principles:

- Relevance,
- Authenticity,
- Reliability,
- Proper chain of custody.

Expert testimony plays a crucial role in explaining complex forensic processes such as data recovery, encryption analysis, or digital fingerprinting. Courts assess the credibility and qualifications of forensic experts, often requiring accreditation of laboratories and standardized operating procedures.

Comparatively, jurisdictions such as the United States rely on the *Daubert* standard to assess scientific reliability, while Indian courts apply judicial discretion guided by statutory provisions and precedent.

### **4. Chain of Custody and Integrity**

Maintaining the integrity of digital evidence is particularly challenging because electronic data can be easily altered, duplicated, or corrupted. The legal framework therefore emphasizes:

- Secure seizure procedures,
- Hash value verification,
- Forensic imaging techniques,

- Proper documentation at every stage.

Failure to maintain chain of custody may render technological evidence inadmissible or weaken its probative value.

## **5. Emerging Challenges**

The legal framework must now address:

- Artificial intelligence-generated evidence,
- Deepfakes and manipulated media,
- Cross-border data storage,
- Encryption and access barriers.

Cloud computing and transnational servers raise jurisdictional questions, often requiring mutual legal assistance treaties and international cooperation.

## **IV. ADVANTAGES OF TECHNOLOGY IN CRIMINAL LAW**

The incorporation of technology and forensic science into criminal law has fundamentally transformed investigative processes, evidentiary standards, and trial procedures. Its advantages extend beyond efficiency; they directly influence fairness, accuracy, and public confidence in the justice system.

### **1. Enhanced Accuracy in Identification**

One of the most significant contributions of technology is precise identification of suspects and victims. Traditional identification methods relied heavily on eyewitness testimony, which is often unreliable due to memory distortion or bias. Scientific techniques such as DNA profiling, fingerprint comparison, facial recognition systems, and biometric databases provide objective and verifiable results.

DNA evidence, in particular, has revolutionized criminal adjudication. It not only strengthens prosecution cases but also helps exonerate wrongfully accused individuals. Courts in India have

increasingly recognized the evidentiary value of DNA under the Indian Evidence Act, 1872<sup>10</sup>, treating scientific evidence as highly reliable when properly collected and preserved.

This scientific accuracy reduces dependence on confession-based investigations and minimizes the scope of custodial coercion.

## **2. Strengthening Electronic Evidence and Digital Proof**

In the digital era, crimes frequently leave electronic footprints—emails, CCTV footage, mobile call records, GPS data, and social media interactions. The legal recognition of electronic records under Section 65B of the Indian Evidence Act, 1872<sup>11</sup> has strengthened the admissibility of such evidence.

The Supreme Court's ruling in *Anvar P.V. v. P.K. Basheer* clarified procedural safeguards for electronic evidence, thereby enhancing authenticity and preventing tampering. Digital forensics enables recovery of deleted files, tracking of cryptocurrency transactions, and identification of cybercriminal networks.

This technological capability ensures that even sophisticated crimes committed in virtual spaces can be effectively prosecuted.

## **3. Faster Investigation and Case Resolution**

Technological integration significantly reduces investigation time. Automated fingerprint identification systems, centralized criminal databases, and digital record management accelerate suspect identification and evidence correlation.

For example, the use of forensic databases allows law enforcement agencies to match crime scene evidence with existing records in minutes, rather than weeks. Surveillance technologies such as CCTV networks and automated number plate recognition assist in rapid suspect tracking.

Speedy investigations contribute to timely trials, which uphold the constitutional guarantee of speedy justice under Article 21 of the Constitution of India.

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<sup>10</sup> Indian Evidence Act, 1872

<sup>11</sup> Section 65B of the Indian Evidence Act, 1872

#### **4. Reduction of Human Error and Bias**

Scientific techniques introduce objectivity into criminal proceedings. Unlike oral testimony, which may be influenced by prejudice or intimidation, forensic results rely on measurable and reproducible scientific standards.

Technological tools also reduce investigative arbitrariness. Data-driven analysis helps identify crime patterns without discriminatory profiling. When properly regulated, such tools promote neutrality and fairness.

#### **5. Prevention and Deterrence of Crime**

Technology does not merely react to crime; it plays a preventive role. Surveillance systems, cyber monitoring mechanisms, and predictive analytics assist authorities in anticipating criminal activity.

The regulatory framework under the Information Technology Act, 2000 addresses cyber offences proactively by criminalizing unauthorized access, identity theft, and digital fraud. The presence of digital tracking systems acts as a deterrent by increasing the likelihood of detection. The knowledge that scientific tools can conclusively link individuals to criminal acts discourages potential offenders.

#### **6. Exoneration of the Innocent**

An equally important advantage is the protection of innocent individuals. Post-conviction DNA testing has led to the release of wrongfully convicted persons in several jurisdictions worldwide. Scientific re-evaluation of evidence corrects miscarriages of justice caused by faulty eyewitness testimony or coerced confessions.

Thus, technology serves both prosecutorial and defensive purposes, strengthening the principle that it is better that ten guilty persons escape than one innocent suffer.

#### **7. Improved Courtroom Presentation and Transparency**

Modern courtrooms increasingly use digital displays, forensic animations, and electronic document management systems. These tools enhance clarity and comprehension for judges and

juries. Digital documentation also improves record-keeping and appellate review. Properly maintained electronic records reduce procedural delays and ensure transparency.

### **8. Professionalization of Criminal Investigation**

Technological advancement has encouraged specialization within law enforcement. Forensic experts, cyber analysts, and digital evidence examiners contribute scientific expertise to investigations. This professionalization enhances credibility and reduces reliance on outdated investigative practices. Training initiatives and institutional reforms have strengthened scientific capacity within the criminal justice system.

## **V. Challenges and Ethical Concerns in the Use of Technology and Forensics in Criminal Law**

1. Privacy Invasion and Mass Surveillance
2. Risk of Coercive Scientific Techniques
3. Reliability and Scientific Validity Issues
4. Chain of Custody and Data Integrity
5. Technological Disparities and Infrastructure Gaps
6. Algorithmic Bias and Artificial Intelligence
7. Threat to Presumption of Innocence
8. Data Protection and Cybersecurity Risks
9. Wrongful Convictions and Forensic Misconduct

Technology in criminal law is a double-edged sword. While it enhances precision and efficiency, it simultaneously expands state power and introduces new vulnerabilities. Constitutional jurisprudence emphasizes that technological advancement must operate within the boundaries of fairness, dignity, and proportionality.

Effective regulation requires:

- Independent accreditation of forensic laboratories.
- Transparent auditing mechanisms.

- Judicial training in evaluating scientific evidence.
- Strong data protection and privacy safeguards.
- Clear statutory guidelines on emerging technologies such as AI-based investigation tools.

## **VI. AI-based Technology in criminal investigation :-**

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Effective regulation requires:

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- Judicial training in evaluating scientific evidence.
- Strong data protection and privacy safeguards.
- Clear statutory guidelines on emerging technologies such as AI-based investigation tools.

## **Advantages of AI in Criminal Investigation**

1. **Speed and Efficiency** – AI processes massive datasets within seconds, reducing investigation time.
2. **Pattern Recognition** – Detects hidden connections among suspects, financial transactions, and communication networks.
3. **Enhanced Identification** – Facial recognition improves suspect tracing and missing person identification.
4. **Resource Optimization** – Predictive analytics assist in better deployment of police

forces.

5. **Reduction of Human Bias (Potentially)** – Data-driven systems may reduce subjective investigative errors if properly designed.

## **VII. CONCLUSION:-**

The expanding interface between technology and criminal law has fundamentally reshaped the investigation, prosecution, and adjudication of crime. Traditional methods of evidence collection, once dependent primarily on eyewitness accounts and confessions, have gradually given way to scientific and data-driven approaches. The integration of forensic science and digital technology has strengthened the capacity of the criminal justice system to uncover truth with greater precision and reliability. From DNA profiling and cyber-forensics to artificial intelligence-based analytics, technological advancements have enhanced both the efficiency and credibility of criminal proceedings.

Judicial systems across jurisdictions have increasingly acknowledged the evidentiary value of scientific techniques. In India, courts have recognized the importance of forensic evidence under the framework of the Indian Evidence Act, 1872, while simultaneously safeguarding constitutional protections such as those affirmed in cases like *Selvi v. State of Karnataka*, where the Supreme Court addressed the limits of involuntary narco-analysis and brain-mapping tests. Such decisions demonstrate that while technology offers powerful investigative tools, its application must remain consistent with fundamental rights and procedural fairness. Similarly, developments in DNA jurisprudence have strengthened prosecutorial capabilities while also serving as a mechanism for exonerating the innocent.

The rise of cybercrime has further emphasized the need for technologically informed criminal law. Offences involving digital fraud, identity theft, and data breaches require specialized investigative methods that extend beyond conventional policing. Statutory measures such as the Information Technology Act, 2000 illustrate legislative attempts to adapt legal frameworks to technological realities. Forensic laboratories, digital evidence preservation protocols, and specialized cyber units now form an essential part of modern criminal justice administration.

However, the reliance on technology is not without concerns. Issues relating to privacy, data protection, chain of custody, and the possibility of technological manipulation demand constant

scrutiny. Overdependence on forensic results without critical evaluation may risk miscarriages of justice, particularly where procedural safeguards are weak or forensic infrastructure is inadequate. The credibility of technological evidence depends not merely on scientific advancement but also on institutional integrity, expert competence, and judicial understanding.

In conclusion, technology and forensic science have become indispensable pillars of contemporary criminal law. They enhance accuracy, promote objectivity, and contribute to the realization of justice by reducing investigative arbitrariness. Yet, their effective use requires a balanced approach—one that harmonizes innovation with constitutional values, human rights, and ethical standards. The future of criminal law lies not in replacing human judgment with machines, but in responsibly integrating technological progress with principled legal reasoning to ensure that justice remains both efficient and equitable.