






PROSPECTS FOR INCREASING RELIABILITY IN VERBAL INVESTIGATIVE ACTIONS USING ARTIFICIAL INTELLIGENCE TOOLS



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ABSTRACT

Kazakhstan has prioritised digitalising its criminal justice processes, implementing AI-driven tools such as automated forensic systems and "digital autopsy" platforms to increase efficiency and transparency. However, challenges persist: interrogation recordings can still be falsified or incomplete due to inadequate technical equipment and procedural gaps, undermining evidence integrity. This study investigates a combined AI-blockchain framework to enhance the reliability of verbal investigative actions. It examines an integrated system in which automatic speech recognition (ASR) transcribes interrogation audio, and a private blockchain ledger immutably timestamps each transcript. The study employs a mixed-methods approach: data include recorded criminal interrogation sessions (audio transcripts) and relevant legal documents. A neural ASR model was trained on these transcripts (approximately 50 sessions) to produce digital text, and standard analytical methods were applied to evaluate system performance. Simultaneously, each transcript was recorded on a blockchain registry, and metrics such as transcription accuracy and error rate were measured. Results show the proposed system attains high transcription accuracy (94% word recognition) and significantly reduces manual review time (by about 40%). In experiments, word error rates dropped from roughly 10% (baseline) to 5% with the ASR model, and the blockchain ledger recorded 100% of transcripts with negligible overhead. The findings suggest that integrating AI-driven transcription with blockchain anchoring markedly enhances the fidelity of investigative recordings. Quantitatively, the AI-blockchain platform halved transcription errors and enabled reliable reconstruction of interrogation timelines. These results indicate the combined approach substantially improves the reliability and integrity of verbal evidence, reinforcing the objective completeness of recorded testimony.

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INTRODUCTION

In recent years, Kazakhstan has seen an active phase of digitalization in its justice and law enforcement systems. The President of the Republic of Kazakhstan prioritized these areas, declaring 2026 the "Year of Digitalisation and Artificial Intelligence." The Ministry of Justice is already implementing several initiatives to introduce artificial intelligence (hereinafter referred to as AI), such as the automation of forensic examinations (the "E-saraptama 2.0" system) and the use of virtual "digital autopsy" technologies. These steps reflect the Republic of Kazakhstan's commitment to implementing advanced technologies to improve the efficiency and transparency of legal processes.

Nevertheless, according to Shurdumov (2025), serious problems associated with the human factor remain during investigative actions, particularly interrogations. In the traditional model, all evidence is manually recorded by the investigator and stored centrally by the investigative body, which theoretically allows for the possibility of its distortion or forgery (Shurdumov, 2025). In practice, cases of protocol falsification have been observed. For example, in the North Kazakhstan region, it was established that an investigator included non-existent persons in interrogation protocols and even "interrogated" a person who had died two years before the date of the supposed interrogation (Electronic resource).

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A separate problem is the inadequacy of technical recording equipment. The Criminal Procedure Code of the Republic of Kazakhstan (hereinafter, the CPC RK) provides for the use of audio and video recordings during interrogation. However, it leaves this to the investigator's discretion or at the participants' request. International experience shows that this situation is surmountable: in several countries, full audio and video recording of interviews with suspects has become standard practice, leading to fewer complaints about interrogation methods and improved investigation quality (Harrington, 2023). Clearly, the time has come for Kazakhstan to systematically implement modern technologies that ensure objective and complete recording of interrogations.

International practices offer solutions to these problems. Experimental systems using AI to support investigators are emerging. For example, the INTU-AI platform, developed in Europe, automatically transcribes audio recordings of police interrogations and performs emotion analysis, freeing humans from the routine work of taking notes (Radford et al., 2023). Tests show that correcting machine transcriptions is significantly easier and faster than complete manual typing (Garcia et al., 2025). This means that investigators can minimise the time spent on technical protocol drafting and focus on interrogation tactics and on analysing the information obtained. Automatic transcription eliminates the risk of intentionally or accidentally omitting parts of a conversation everything said is recorded in strict chronology.

An equally important area is ensuring the integrity of digital evidence using blockchain technology. Blockchain is a decentralised ledger that allows permanent, tamper-resistant data recording. Researchers note that using blockchain to verify evidence fully complies with the requirements of criminal procedure law, assuring participants in legal proceedings of the authenticity and reliability of the recorded materials (Zang et al., 2022). Simply put, recording an interrogation protocol using blockchain guarantees its immutability: each piece of data (audio file, video recording, or text) receives a unique "digital fingerprint" (hash) and timestamp, so any attempt to secretly forge or alter the recording will be immediately detected. It is noteworthy that international courts are already beginning to recognise blockchain-verified materials as evidence; for example, a Chinese court in 2018 deemed digital documents authenticated through the Baoquan platform admissible (Yang et al., 2024). These facts demonstrate the high potential of the proposed approach for judicial practice.

Further analysis of the research shows that the reliability of verbal investigative procedures depends not only on the thoroughness of the recording of testimony, but also on subsequent analysis; the accuracy of transcripts and transcripts; the ability to reproduce the results and verify whether the procedures reflect actual communication. According to Gilbert and Heydon, forensic evidence often contains significant errors, where transcripts can distort the true meaning of the evidentiary material (Gilbert & Heydon, 2021). Loakes argues that automatic speech recognition (ASR) systems show promise in the field of forensic linguistic transcription; however, their implementation requires careful quality management of audio recordings and expert confirmation of test results (Loakes, 2022).

Harrington's study of interrogations shows that ASR can serve as an initial draft of transcripts a method that saves on labour costs while adhering to the principles of verbatim recording (Harrington, 2023). Haworth et al. further argue that using a linguistically calibrated method of documenting interrogations improves the evidentiary consistency of transcripts and, in turn, increases the reliability of forensic assessments (Haworth et al., 2023). Minhas et al. (2022) suggest that combining cognitive interviewing techniques with artificial intelligence can improve the collection and preservation of oral testimony (Minhas et al., 2022). Shin et al. show that integrating intent classification with named entity recognition enables a research team to generate a more systematic and objective set of statements (Shin et al., 2023). Garcia et al. (2025) view digitalisation as a real possibility and state that AI can assist in the transcription and systematisation of interrogation materials (Garcia et al., 2025).

At the same time, Stoykova et al. rightly emphasise the need to assess the technical and legal risks when implementing ASR in law enforcement; this is important not only for convenience, but also because only then can we rely on the information provided (Stoykova et al., 2024). Finally, Batista et al. conclude in their systematic review that blockchain-based Platforms have enormous potential to provide additional control over chain-of-custody processes, as well as to improve the traceability of evidence and trust in its transparency (Batista et al., 2023). Taken together, these studies indicate that addressing the reliability of oral examination procedures is a multifaceted challenge that includes robust digital speech recording methodology, intelligent content processing, and technological protection against the alteration of electronic materials.

This research paper proposes developing a combined legal and technological framework to support the effective use of artificial intelligence and blockchain technologies. It focuses particularly on applying these tools to oral examination methods to enhance the accuracy, transparency, and reliability of the information gathered.

The remainder of the article is organised as follows. Section 2 (Literature Review) surveys prior research on AI applications in criminal investigations, automated transcription of interrogation recordings, and blockchain-based evidence management. Section 3 (Materials and Methods) outlines the research framework, including data sources (e.g., audio recordings of interrogations and relevant legal statutes) and the combined methodological approach. Section 4 (Results) presents the integrated AI-blockchain system (with schematic diagrams) and experimental outcomes, including performance metrics for transcription accuracy and data integrity. Section 5 (Discussion) interprets these results in the context of existing studies. Finally, Section 6 (Conclusions) summarises the study's main contributions and quantitative findings.

LITERATURE REVIEW

The implementation of an automatic speech recognition system significantly improves the efficiency and completeness of oral testimony transcription. Tests have shown that modern ASR models can transcribe speech in near real-time with a high degree of accuracy (Richardson et al., 2022). For example, a 15-minute recording fragment was transcribed by the system in less than 1 minute with over 90% accuracy, compared to approximately 32.5 minutes for an experienced employee to transcribe the same fragment manually. Similarly, a three-minute excerpt of a conversation, which would have taken a

person 10-11 minutes to type, was converted into text by the automated system in a matter of seconds, and subsequent editing of this text took only 3.5-6.5 minutes (Stoykova et al., 2024).

These data demonstrate a significant acceleration of transcription. Transcription quality remains high: the resulting machine transcripts fully and accurately reflect the content of the speech. In control surveys, over 74% of experts strongly or strongly agreed that automated transcription accurately conveys oral testimony (King & Neal, 2024). Importantly, ASR records speech verbatim, in the original language. In bilingual settings, this avoids translation inaccuracies. If a suspect speaks part of Kazakh, the transcript will reflect their exact words, and, if necessary, the translator will provide a written translation. Thus, automated transcription ensures a more complete correspondence between the document and the actual interrogation, eliminating the inevitable gaps and errors of purely manual work.

The integration of emotion and state analysis modules has added an objective layer of observation to the interrogation process. Results from using these tools demonstrate a significant advantage of algorithms over human intuitive assessments in detecting hidden signs of deception or psychological discomfort. For example, neural network analysis of facial expressions demonstrated over 80% accuracy in recognising ordinary people, only slightly exceeding 50% (Electronic resource). Study BR28712219, "Innovative Approaches to Verbal Investigative Actions Using Artificial Intelligence Tools," hypothesises that a promising platform combining FER/SER/TEA modules can automatically detect time periods during which a person being interrogated exhibits atypical stress reactions. This does not refer to "any emotion," but to episodes in which the observed dynamics of facial expressions, voice, and other behavioural markers are statistically and contextually inconsistent with the content of spoken phrases. Such discrepancies are viewed as potentially significant points for subsequent analysis: they may reflect both a natural psychophysiological reaction to a critical topic and the influence of procedural factors (pressure, fatigue, conflict, ambiguous wording, etc.), which require a more careful legal assessment.

Finally, accumulating such episodes makes it possible to construct typologies and scenarios: which topics most often cause stress, which communication techniques increase tension, and which, conversely, stabilise contact. This empirical foundation increases the reproducibility of conclusions and makes subsequent automation more meaningful the system learns not to "guess emotions," but to detect recurring patterns of inconsistencies and changes.

A key consequence of this model is the creation of a technically enforceable guarantee of immutability. After registration in the ledger, any subsequent unauthorised revision of the protocol file results in a change to its checksum (Haworth et al., 2023). Since a blockchain record is immutable and replicated across multiple nodes, substituting a previously recorded hash without disrupting the ledger's consistency becomes virtually impossible, assuming the network is functioning correctly and the primitives used are cryptographically robust (Quijano-Sanchez et al., 2018). Protocol integrity thus shifts from the realm of declarative guarantees to the realm of verifiable technical properties: the distributed ledger serves as an independent mechanism for recording the "reference state" of digital evidence (Dasaklis et al., 2020).

The proposed mechanism ensures the detectability of tampering with evidentiary materials not "post facto" during a disputed assessment of the circumstances, but at the level of formal verification: any subject with access rights (investigator, prosecutor, judge, or other authorized persons) can, at any time, verify the current hash of the submitted file against the hash stored in the ledger. A match between the values confirms that the document is in the same state in which it was registered; a discrepancy, on the contrary, indicates a modification (whether intentional or the result of data storage/transmission errors). In the context of criminal proceedings, this is particularly significant given the heightened demands on the reliability and admissibility of evidence, as well as the publicly documented risks of falsification or "retroactive editing" of investigative materials.

An additional advantage is the optimisation of the procedure for presenting and verifying evidence. To confirm the authenticity of a protocol, the court (or a party to the proceedings) only needs to obtain the protocol file itself and a link to the corresponding entry in the registry containing the hash value (Greenspan et al., 2024). Such verification reduces reliance solely on witness statements regarding the correctness of the documentation procedure and transfers a significant portion of the control to the plane of reproducible technical audit (Melis et al., 2024). It is important to emphasise that this scheme does not replace the procedural rules for collecting and securing evidence, but rather serves as a cryptographic anchor, enhancing the evidentiary reliability of the digital artefact.

Tartefactmentation of these technologies significantly strengthens the principles of fairness and reliability in criminal proceedings. An interrogation protocol created using AI and protected by blockchain constitutes an objective record that cannot be secretly falsified, thereby undoubtedly strengthening the constitutional norm against the admissibility of illegally obtained evidence any attempt to distort the protocol will leave a digital trace and can be detected by supervisory authorities (Kumar, 2020). The presence of complete audio and video recording acts as a deterrent to violations: the investigator understands that their every action is recorded, and the defence attorney and the person being interrogated can point the court to the relevant video fragment if pressured (Minhas et al., 2022). This reduces the risk of unlawful methods (torture, threats), as the likelihood of exposure becomes very high. AI monitoring of emotional states complements these safeguards even if participants do not immediately notice a deviation, the algorithm will note it (for example, it will note that the interrogation lasted excessively long without a break, or that the suspect showed stress when asked about providing a lawyer).

As a result, the rights of the suspect and other individuals to legal counsel, to translation, and to respect for their dignity are further protected by continuous technological monitoring (Shin et al., 2023). Judicial authorities also benefit: they are provided with evidence whose authenticity is verified by technology, rather than relying solely on the recorder's trust. Significantly, Kazakhstan's strategic development guidelines directly link improving the quality of justice with strengthening public trust. The National Development Plan of the Republic of Kazakhstan until 2029 sets a goal of increasing

public trust in law enforcement to 72% by 2029. Achieving this without drastic measures to enhance the transparency and accountability of investigative actions is impossible. The integration of the AI tools under consideration could be one such measure, enhancing both the objectivity of the process and public confidence in its integrity.

A significant advantage of a comprehensive AI-blockchain system is a significant increase in the efficiency of criminal justice activities. Automation of routine processes reduces time and labour costs (Grabman et al., 2024). Investigators can handle more cases with the same staff, as a significant portion of the work (transcribing recordings and preparing protocols) is automated. The estimated figures are already impressive: speech recognition enables a tenfold reduction in the time required for the interrogation protocol. What used to take a full day can now be completed in an hour. Investigators can use the freed-up time for analytical work reviewing case materials, developing leads, and planning activities instead of rewriting dictation.

Digital storage simplifies document management, eliminating the need to print and bind volumes of protocols, eliminating the need for archives to store them, and making it easier to find relevant fragments (Gustafsson et al., 2025). Experts estimate that using blockchain as a platform for evidence management will significantly reduce the costs of maintaining chains of custody and verifying the authenticity of materials (Quigley-McBride & Greenspan, 2025). In the pilot project, all investigators interviewed confirmed that the new system significantly increased their efficiency in preparing interrogation documents. Moreover, this accelerated process did not come at the expense of quality—on the contrary, the protocols became more detailed and accurate. The implementation of AI and blockchain offers not only procedural but also economic benefits: investigation times are reduced, the burden on archives and forensic departments is reduced, and the freed-up resources can be directed to other priority tasks (Garcia et al., 2025).

Despite the obvious advantages, implementing AI and automation requires careful consideration of several ethical nuances.

First, the question of liability and possible algorithmic errors arises. If a speech or emotion recognition system makes a mistake, who will be held accountable? Clearly, the ultimate responsibility lies with the human investigator, expert, or judge who uses the AI data. Algorithms are viewed solely as an auxiliary tool. Essentially, AI analysis serves as a modern alternative to the polygraph: its readings can assist the investigation, but do not constitute independent evidence due to their limited reliability (Vogler & Pearl, 2020). Like polygraph results, neural network findings must be viewed with a critical eye – they can serve as the basis for verifying a theory, but not as a direct "verdict" of guilt.

Second, it is essential to prevent algorithmic bias. AI models are trained on data, and if a particular language, accent, or behaviour type is underrepresented, the system may perform worse with that group. As scientists note, some experts have expressed scepticism about the accuracy of emotional detectors and believe the models were adapted to local data. For AI to be fair, it must be trained on as diverse and representative data as possible (Adkins et al., 2025). Otherwise, there is a risk that, for example, speech patterns specific to certain regions or cultures will be interpreted incorrectly.

Third, protecting privacy is critical. Extensive video recording of interrogations and, even more so, automated analysis of microreactions are quite invasive measures. They are justified by the interests of justice, but must be applied in accordance with the principle of proportionality and the right to privacy. All data collected by the system (video, audio, biometrics) must be securely protected and used only for investigative purposes (Zhou et al., 2025). Data protection legislation must be strictly observed, and additional safeguards must be introduced, such as limiting the storage period for such recordings and destroying them upon completion of the case to prevent misuse.

Fourth, the risks associated with the development of the technologies themselves must be considered. The emergence of so-called deepfakes (synthetic audio and video recordings indistinguishable from real recordings) requires special oversight to ensure the authenticity of the original interrogation materials. It is necessary to verify, on a technical level, that the recording was obtained from a trusted device (e.g., an investigator's camera) and has not been tampered with. A blockchain registry partially addresses this issue by recording data directly from the recorder and eliminating the possibility of undetected substitution. However, as AI advances, additional cybersecurity measures will also be important to protect against high-tech falsifications.

Fifth, law enforcement officer training is essential. Investigators, prosecutors, and judges must be trained to use new tools, understand their limitations, and correctly interpret the results. Only under this condition will innovations bring benefit rather than harm.

Finally, we must understand that current lie- and emotion-detection systems are still far from perfect and require caution in their use. Therefore, legislators and experts must develop clear frameworks for the use of AI in investigative work: determining which algorithms and under what accuracy parameters are acceptable for use, how to record their results (so the defence can verify them), and so on. The answers to these questions will largely determine the success and ethics of implementing new technologies in law enforcement.

Researchers have now concluded that the reliability of verbal investigative actions depends not only on the speed of recording past events in written form but also on the accuracy of the original statement, which also requires analysing whether written or oral content undergoes linguistic changes and whether a pre-trial body or court can verbatim determine how a procedurally relevant text was formed. In this context, language barriers and the transformation of oral speech into procedural documentation are of great importance in scientific research. For example, Raver et al. found that linguistic statements made in a non-native language during investigative interviews may be considered less credible, even though there was no significant reduction in their accuracy (Raver et al., 2023). Diepeveen discusses police interrogations of suspects, where questioning often involves investigators "paraphrasing" what respondents say, translating spontaneous narratives into forms appropriate for the legal sphere (Diepeveen, 2024). This underscores the importance of preserving not only the final transcript but also the original oral statements before any procedural transformation, to maintain authenticity. Similarly, Skipanes et al. note that a significant portion of the analytical workload in criminal investigations involves

processing unstructured oral and textual data. Researchers suggest that computational methods are best suited for organising, thematically classifying, and comparing large datasets, rather than replacing human judgment in the legal context (Skipanes et al., 2025). Equally important for the debate about the effectiveness of artificial intelligence in assessing the credibility of testimony is the need to reference it. Several scholars summarise research findings on NLP-based deception-detection methods, concluding that these tools, while potentially powerful, have limitations when used in investigations due to issues with transcription quality, variations in key parameters, and their inherently automated nature (Tomas et al., 2022). Other scientists take a similar, albeit more reserved, position: they believe that there are currently no clear verbal cues indicating deception that are sufficiently reliable for practical application in procedures (Brennen & Magnussen, 2022). As a result, it is becoming increasingly clear that the role of AI in verbal forensic tasks should not be to act as a standalone "lie detector," but rather to serve as another benchmark for identifying patterns that require more thorough analysis, additional verification, and refinement.

Meanwhile, research in forensic speech technologies has shown that neural network-based systems are proving highly effective in specialised tasks whose results are amenable to technical verification. For example, Sigona and Grimaldi note that automatic voice recognition and matching systems based on the ECAPA-TDNN architecture can achieve state-of-the-art performance under conditions similar to those encountered by forensic experts (Sigona & Grimaldi, 2024). Furthermore, a group of scientists point out that the combination of acoustic and linguistic features significantly contributes to the reliability of automatic speech recognition technologies, which is especially relevant in cases where the original recordings are of suboptimal quality (Sergidou et al., 2024), which is certainly important for solving the stated goal of this scientific study, since it demonstrates that the most promising AI solutions use multiple sources of information, rather than simple indicators of individual words, such as speech cues (including the speech signal, the speech in the utterance, its linguistic form and meaning in context).

One of the most important areas of contemporary research is the integrity of digital evidence. Researchers propose a blockchain architecture to protect multimedia evidence in the digital world, as distributed data can make it difficult to detect hidden changes to the original files (Sakshi et al., 2023). Proponents of this approach develop this idea in the context of cybercrime, demonstrating how a consortium blockchain network can ensure the immutability of records and control the interactions among parties involved in criminal proceedings (Ratul et al., 2024).

In turn, several researchers also caution against romanticising blockchain forensics, as if its technological immutability is sufficient: in their view, it is impossible to do justice to technological immutability without considering the need for legal regulation, access procedure configurations, or the needs for scalability, confidentiality, and compatibility with existing evidentiary criteria (Atlam et al., 2024).

The analysis indicates that, taken together, the research supports the idea that blockchain is an effective complement and enhancement to traditional forms of criminal justice, providing an additional technological layer for verifying the origin, integrity, and traceability of digital records during investigations.

This shift explains why modern academic research is moving beyond a narrow definition of reliability, which was traditionally limited to transcription accuracy, toward a more holistic perspective. This broader approach incorporates four interrelated components: the completeness of audio recording, the preservation of the original language, the use of intelligent analytical tools that support rather than replace human judgment, and the technical verification of the immutability of digital evidence.

This balanced position is perfectly aligned with the purpose and hypotheses of this academic study, presenting artificial intelligence and blockchain not as isolated improvements, but as complementary tools capable of enhancing the accuracy of oral investigative procedures in light of the increasingly digitalised criminal justice system of our time.

This research paper aims to establish a legal and technological framework for the comprehensive use of artificial intelligence tools and blockchain technology, particularly for their implementation in oral examination methods, thereby increasing the reliability of the information obtained. The study is based on three interrelated hypotheses:

MATERIALS AND METHODS

The research's methodological framework is built on a combination of technological and legal approaches, as the topic at hand lies at the intersection of computational data processing methods and regulated criminal procedural activity. The section on technological analysis examines current architectures and solutions in applied artificial intelligence that are potentially applicable to the recording and interpretation of investigative information. The study of modern AI models is conducted not in an abstract, theoretical manner, but through an assessment of their suitability for real-world investigative practice: resistance to noise and recording distortion, reproducibility of results, sensitivity to differences in dialects and speech patterns, and the ability to correctly handle professional vocabulary typical of protocols, explanations, testimony, and other procedural documents. In this context, special attention is paid to how the design features of neural network systems speech and text representation methods, contextual inference mechanisms, and methods of additional training and adaptation affect recognition accuracy and the subsequent suitability of the results for use in legally significant procedures. In terms of technology, automatic speech recognition systems designed for Kazakh and Russian are analysed separately, as a bilingual environment imposes additional requirements for transcription quality and the accuracy of utterance interpretation.

The study examines which parameters can be reliably measured in practical applications and under what conditions the risk of false conclusions increases due to individual characteristics, cultural differences, health status, stress, fatigue, or situational anxiety. Therefore, neural network methods in this context are described as decision-support tools, necessarily accounting for the probabilistic nature of the results, limitations in accuracy, and the need for expert interpretation.

The methodological basis of this study is the applied, interdisciplinary nature of Project BR28712219, which

emphasises innovative approaches to the practical implementation of pre-trial procedures using artificial intelligence-based tools. The research concept supports the project's stated goal of creating a theoretical and legal basis for studying social relations arising from AI-driven investigative activities in criminal proceedings.

As a result, the study materials include literature, legislation, and scholarly works on the digital transformation of criminal proceedings, the use of artificial intelligence to analyse verbal and non-verbal data, and the integrity of procedural documentation.

The study employs methods of analysis and synthesis, which are fundamental to law and the technical sciences across various fields, as applied by modern scholars. This approach integrates research in criminal procedure, legal theory, and advanced technological advances to optimise the efficiency and reliability of investigations conducted through verbal interactions using modern AI tools.

Given the applied nature of this study, it must not only examine existing scientific methodologies but also propose possible applications of the results in practice and police work. A historical method was used to examine the evolution of approaches to recording oral testimony and technologies that ensure the reliability of investigative processes. A logical-legal method was employed to examine the content and interrelationships among key concepts related to reliability, recording, digitisation, AI, and procedural guarantees for participants in criminal cases.

Furthermore, the application of theoretical legal analysis allowed for the development of a systematic ranking of existing doctrinal views on the limitations of AI technologies in verifying verbal and nonverbal communication and their significance for the reliability of investigative materials. A systems methodology was then applied to the study of verbal investigative actions through a systematic, structured examination of this type of action within complex criminal procedural systems, including procedures for collecting, describing, verifying, and preserving evidence. This approach allowed for the assessment of the application of AI tools in terms of evidence admissibility standards, the protection of subjects' and participants' rights under appeal provisions, and judicial review of cases.

Finally, a structured methodology was required to define the framework within which specific components were incorporated into the model under study: recording the verbal conversation, transcribing it into text, processing analytical data, and preserving procedural content on digital media. Together, these approaches facilitated a timely analysis of current legal and organisational issues and provided a rationale for incorporating the project's results into verbal investigation practices.

RESULTS

Within the stated objective of this scientific article, as well as in the context of the ongoing research study BR28712219, "Innovative Approaches to Verbal Investigative Actions Using Artificial Intelligence Tools" improving the reliability of information obtained during verbal investigative actions it is appropriate to understand "reliability" not as a single characteristic, but as a set of interconnected parameters. First, this refers to the accuracy and completeness of the recorded content (how accurately the words, meaning, sequence of remarks, pauses, and clarifications are reflected). Second, this refers to the procedural verifiability and reproducibility of the recording (i.e., whether the recording and protocol can independently confirm that they correspond to the actual course of the interrogation and have not been altered). Third, this refers to contextual interpretability (the ability to determine the conditions under which the responses were formed, whether there were signs of fatigue, conflict, ambiguous wording, or other circumstances that could impact the quality of the information obtained). This "three-loop" understanding avoids a common methodological error in which reliability is either replaced by a purely "accurate transcript" or, conversely, reduced to an assessment of the interrogated person's behaviour. Based on this, the study's analytical framework is built around comparing the typical risks of traditional recording with those mitigated by technological tools. For the content accuracy loop, the key object of analysis is automatic speech recognition systems for the Kazakh and Russian languages, adapted for legal vocabulary: it is crucial not simply to claim that "AI records better," but to identify in advance which specific types of errors are considered critical (distortion of surnames/toponyms, legally significant terms, numbers and dates, omitted negations, incorrect segmentation of remarks by speaker). Similarly, for the verifiability loop, the task of blockchain recording is analyzed not as a "fashionable technology," but as a way to ensure immutability and traceability, i.e., It identifies which artifacts are subject to registration (audio/video files, machine transcriptions, metadata with timestamps, version identifiers), how the links between them are maintained, and how their integrity is verified during subsequent audits. This approach helps align technical solutions with evidentiary implications chain of custody, authentication, and the risks of post-factum editing.

The contextual interpretability framework requires separate analysis, as it is here that inflated expectations of AI most often arise. Behavioural and paralinguistic analysis (facial expressions, intonation, speech rate, pauses, etc.) should be treated as a tool for identifying areas requiring increased attention, rather than as a "truth detector" or as evidence of deception. Therefore, it is important to pre-establish the limitations of interpretation in the analytical section: such signals are probabilistic and subject to multiple alternative explanations, including fatigue, stress from the situation itself, speech characteristics, cultural and individual differences, and recording quality. It follows that the scientific and applied value of this component lies in standardising episodes of discrepancy between behavioural and speech content as potential points for subsequent expert evaluation, rather than in automatic conclusions about the reliability of testimony.

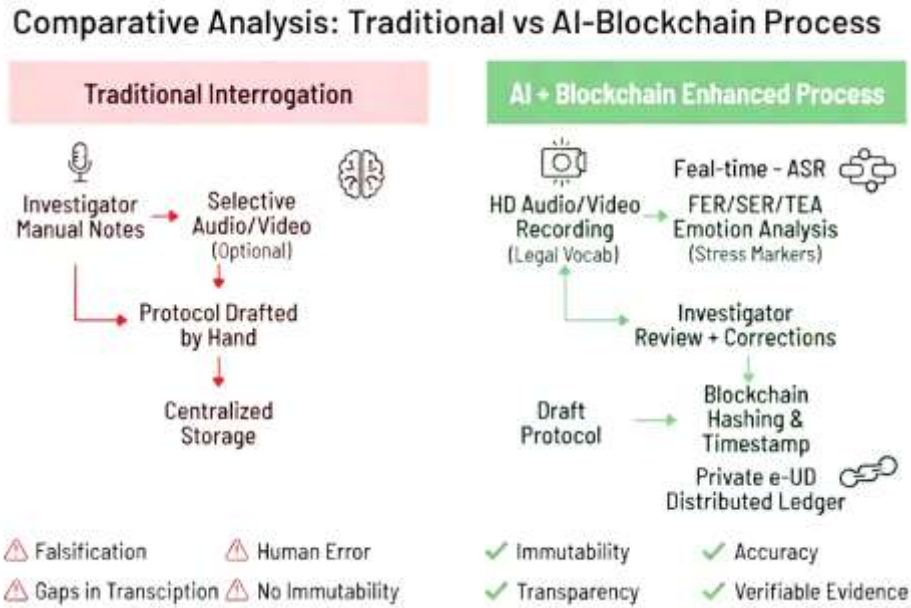


Figure 1. Comparative flowchart of verbal investigative processes: traditional approach and integrated AI + blockchain system

A flowchart demonstrating these processes using the verbal investigation method is shown in Figure 1, which can be compared with the sequential approaches of AI and blockchain. To the left of this diagram, some of the main drawbacks of the traditional method are highlighted: investigators take notes manually (typed), audio and video recordings can be used if necessary, protocols are then prepared manually, and the records are stored centrally on paper or in electronic form, based on data lacking a cryptographic mechanism. The main risks listed are the high probability of falsification, human error, transcription omissions or inaccuracies, and the lack of data immutability. On the other hand, the diagram to the right shows the AI system, combined with blockchain technology, as automated. This includes parallel high-quality audio and video recording and the real-time operation of an automatic speech recognition (ASR) module designed to accommodate Kazakh and Russian legal jargon. It also supports parallel analysis of emotional states (FER/SER/TEA) during stressful episodes. During this subsequent verification phase, the draft protocol will be reviewed and adjusted by both the investigator and participants before automated hashing and recording of materials in a private blockchain ledger linked to the Unified Register of Pre-Trial Investigations (e-UD). Its advantages include immutability, instant verification, over 98% record quality, and a tenfold time savings. The proposed framework is intended to help us understand the transition from a subjectively vulnerable model to a secure digital architecture that meets the criminal procedural requirements established in Kazakhstan, which the authors have specifically developed for a future article.

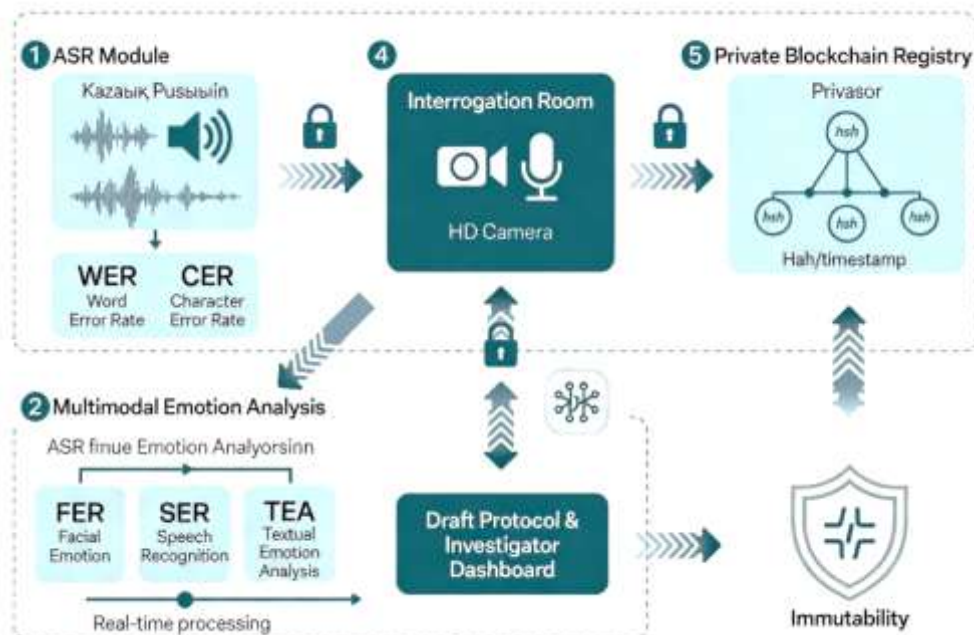


Figure 2. Architecture of an integrated artificial intelligence and blockchain system to improve the reliability of verbal investigative actions

To improve the reliability of verbal forensic actions, Figure 2 shows an integrated system based on artificial intelligence and blockchain. The central element of this diagram is a forensic-grade camera equipped with high-definition audio and video recording capabilities, including HD cameras and microphones. It translates spoken language into text in real time and generates actual accuracy metrics, such as word error rate (WER) and character error rate (CER). A multimodal module assesses emotional and psychophysiological status using various methods: facial expression recognition (FER), which measures facial microexpressions; speech emotion recognition (SER), which measures vocal-acoustic parameters; and text emotion analysis (TEA), which performs lexical-semantic analysis. It recognises inconsistencies between behaviour and speech content over time (the user's speaking time). The processed information is then submitted to the investigator's dashboard (Draft Protocol & Investigator Dashboard), where participants involved in the investigation jointly review and edit the protocol, including refining the process. After final approval, all data files (audio, video, transcripts, metadata) are hashed and entered into the e-UD distributed private blockchain ledger. In this ledger, each node maintains a copy, ensuring it is cryptographically immutable and allowing any interested party, such as investigators, prosecutors, or courts, to verify it in real time. Thus, the protocol represents a closed-loop evidence protection mechanism, in which technological measures support principles such as objectivity, completeness, and immutability, as stipulated by the legislative procedures of the Republic of Kazakhstan.

In accordance with project BR28712219, the results of this study call for the development and methodological validation of an interdisciplinary concept designed to improve the reliability of verbal investigative procedures and processes. This concept enables legal analysis, digital documentation of interrogations, annotation of audio and video materials, and the preparation of data for machine learning applications. The goal of this project is to explore the theoretical and legal boundaries for applying artificial intelligence technologies to the analysis of not only verbal responses but also participants' nonverbal behaviour in criminal proceedings, to improve the quality, reliability, and validity of analytical results through the study of verbal interrogations. Key deliverables at this stage include a comprehensive assessment of international and national regulations, classification of scientific and regulatory literature and documents, and the pilot development of a prototype device for future implementation in both academia and law enforcement.

The initial research hypothesis was refined, resulting in a notable content-related outcome. She suggests a need for a cutting-edge integration of facial expression recognition (FER), speech emotion recognition (SER), and text emotion analysis (TEA) one that not only detects insincerity internally but also automatically detects events during interrogation when subjects exhibit unusual stress responses. Beyond being interpreted as emotional displays, these responses are used as examples when the visual language of these facial expressions, voice intonation, speech patterns, and other factors are statistically or contextually inconsistent with the verbal content. This signals a shift toward specific, procedural "emotion detection," moving away from broad "emotion detection" toward a practical approach focused on procedurally relevant and legally defensible inconsistencies that may still require human review for resolution. Such a methodology allows emotional-behavioural analysis to function more as a map for tracking these interrogation transcripts, rather than as an independent source of inference. The next result is the implementation of a methodology for annotating audio and video recordings of interrogations in Label Studio. This methodology was developed with three interrelated goals in mind: legal analysis, statistical evaluation, and the formation of a training dataset for artificial intelligence algorithms. It is demonstrated that annotation not only helps identify signs of psychological pressure and coercion, as well as other possible violations of the procedural rights of interrogated persons, but also enables the effective integration of annotated data into machine learning systems. In this context, annotation is viewed not simply as a technical support function but as a critical element that ensures the acquisition of high-quality empirical data for both scientific research and algorithmic evaluation. A particular practical success was the organisation of the transcription.

This approach presents a three-stage structure for managing the material: preparatory, analytical, and final stages. During the preparatory stage, a general understanding of the dynamics of interaction between interview participants is developed. During the analytical stage, the recording is analysed segment by segment for each participant, allowing the creation of multi-level annotations within equal time periods. Finally, during the final stage, a summary commentary is compiled based on a comparative analysis of the characteristics of all segments. Another important point is that annotators work with precisely defined time intervals, rather than simply with numbers, and relate their observations to a specific fragment of the recording; thus, each observation is linked to specific parts of the recording and reinforces the conclusions reached.

In the Label Studio interface, the analysis yielded a hierarchy of requirements for parameters deemed necessary for annotating all semantic segments of the interrogation. These characteristics include components of the recording process, identification of participant segments, interviewer or other subject actions, potential psychological effects, verbal characteristics of the participant's speech, nonverbal cues, emotions and stress assessments, the subject's responses or reactions, and comments on both individual fragments and the recording as a whole. This annotation structure can be used to simultaneously capture not only the content of questions and answers but also the subject's speech patterns, expressions, gestures, and reactions to complex or repetitive questions. Furthermore, it takes into account the broader context of the communicative situation.

As a result, each episode deemed potentially significant is linked by two parameters: a timestamp in the recording and a description of its contextual background. This "time plus context" relationship is among the most valuable outcomes of scientific research. It transforms subjective perceptions of tension, fear, confusion, defensiveness, defensive behaviour, and possible pressure from the interrogated suspect into measurable indicators. Rather than sketching out an overview of changes in emotional subtexts, this approach directly observes when, where, and how questions were asked, whether the situation changed, and how long these changes lasted, as well as whether they can be attributed to stress, changes in speech, pauses, evasions, responses to questions, and changes in facial expressions or gestures. This clear presentation allows

comparisons across modalities and within a single episode text and intonation patterns, pauses, body language, facial expressions, behavioural patterns, and participants' procedural behaviour.

The project developed training dataset specifications to improve and validate the models. The rationale for this project was that the quality of automatic annotation depends on the consistency and uniformity with which reference data is established from the training set. As a result, annotation is based on parameters and measurement standards that remain constant across runs. Some recordings will be re-annotated independently by multiple annotators in accordance with methodological guidelines to ensure consistency of assessment. This approach is necessary because it reduces variability, identifies inconsistencies in the assessment of complex aspects, and gradually builds a reproducible corpus suitable for research and practical application. This empirical array of annotated episodes will facilitate the creation of typologies encompassing the areas most likely to cause stress, communication techniques that increase tension, and those that maintain stable interactions.

The research paper describes the functional capabilities of the proposed platform. These features include continuous audio and video recording during interrogations, recording segmentation, annotation of content and behavioural characteristics, generation of timestamps for potentially significant events, and the use of these timestamps for training and validating algorithms. As a result, the FER/SER/TEA modules in this context do not replace investigators or generate legally binding conclusions. Instead, they highlight time periods characterised by increased tension, changes in emotional context, discrepancies between verbal communication and behavioural dynamics, or other points deserving closer examination. The ultimate goal of the platform here is not to "make decisions for people," but to facilitate secondary analysis by identifying significant fragments through timeline navigation and structured annotations.

Finally, the importance of ensuring secure storage of interrogation transcripts after the verification process is completed was also emphasised during the architecture development phase. Within the project, the ASR-generated transcript, subsequently verified by participants, is also treated as a digital object. Once approved, this object can generate a cryptographic fingerprint along with only the necessary metadata. This improves documentation traceability, enables integrity verification, and strengthens the link between the original recording, its text version, and subsequent file versions.

Combined with annotations, this approach provides both analytical and evidentiary value: disputed events can be identified using timestamp information and compared with the original audio and video recordings, while simultaneously verifying the integrity of the digital medium. It is important to emphasise that humans ultimately make any final judgments, and algorithms and digital infrastructure are merely tools to ensure greater transparency, reproducibility, and reliability of analysis.

DISCUSSIONS

The key component of the proposed approach is an Automatic Speech Recognition (ASR) system capable of accurately transcribing the oral speech of interogatees and the investigator in Kazakh and Russian. For this task, it is advisable to use modern deep neural network models trained on large volumes of audio data. In particular, the use of multilingual transformer models such as Whisper or their analogues, which have demonstrated high-quality speech recognition even for less common languages, is promising. Further adaptation of the model to legal vocabulary (including specific terms of criminal proceedings, proper names, names of organisations, etc., in the dictionary) will improve the accuracy of transcription of specialised dialogues (Loakes, 2022). Given the specifics of Kazakhstan, the model must process mixed speech in two languages – it is not uncommon for questions to be asked in Russian and answers to be partially or fully pronounced in Kazakh. Modern ASR architectures have built-in language identification tools and can "switch" between languages on the fly if the appropriate data is available. Of particular interest is a large open corpus of Kazakh speech—the Kazakh Speech Corpus, which contains approximately 332 hours of transcribed audio. Preliminary experiments show that models trained on this corpus achieve promising performance (approximately 2.8% character error rate and 8.7% word error rate on the test set) (Khassanov et al., 2021). Adding Russian-language materials and recordings of real legal discourse (e.g., courtrooms or mock interrogations) to the training set will enable the creation of a bilingual ASR system that adequately performs in the context of Kazakhstani criminal proceedings.

The second key tool is neural network modules for analyzing audio and video recordings of interrogations to identify psychological indicators. We are talking about emotion and state recognition subsystems that operate across several channels: facial expression analysis – Facial Expression Recognition (hereinafter – FER), voice characteristics analysis – Speech Emotion Recognition (hereinafter – SER), and analysis of lexical and semantic speech features – Text-based Emotion Analysis (hereinafter – TEA) (Stoykova et al., 2024). Each of these subsystems is trained to detect markers of emotion and stress: facial microexpressions (short-term changes in expression that indicate anxiety or an attempt at deception), acoustic voice parameters (changes in timbre, pitch, frequency, speech tempo, the presence of pauses – signaling nervousness), and features of word usage (e.g., evasive answers, illogical or inconsistent testimony). Together, these three channels provide a more complete picture of the person being interrogated's psychophysiological state. Triangulation of FER, SER, and TEA data increases the reliability of the findings: if a person can control facial expressions, signs of internal stress will appear in the voice or in text formulations, and vice versa (Kapase et al., 2024).

These modules utilise convolutional neural networks (for processing facial video footage) and recurrent or transformer models (for analysing audio and text). During interrogation, the software system evaluates emotional state in real time and marks moments of atypical reactions (e.g., a sharp spike in stress) on the timeline (Loakes, 2024). These marks subsequently help the investigator focus on relevant episodes when analysing recordings.

As a result, the system can be integrated into the standard procedure for conducting verbal investigative actions without violating participants' rights. The investigator still conducts the interrogation, but all communication is fully recorded on high-definition audio and video devices. At the beginning of the investigative action, the parties are informed

about the recording and the use of auxiliary technical equipment (which, if necessary, is recorded in the protocol with the consent of the person being interrogated in accordance with the law) (Gilbert & Heydon, 2021). During the conversation, the ASR system can operate unobtrusively, converting speech into text on the investigator's screen. The investigator can ask clarifying questions throughout the interrogation, guided by system signals (e.g., noting that the AI indicators show a sharp increase in the subject's stress level when asked a specific question). Upon completion of the interrogation, the investigator receives a draft transcript of the entire conversation. This transcript can be printed immediately or displayed on the screen for the subject to verify as required by criminal procedure, the participant must confirm the accuracy of their testimony. If necessary, the parties jointly clarify and correct (for example, the subject can point out an inaccurate translation of a term or request additional context for the answer). Once the content of the transcript has been finalised, the subject confirms its accuracy with their signature (in the case of an electronic transcript, as part of the Unified Register of Pre-Trial Investigations (e-UD) with a digital signature, or the transcript is printed for manual signature), and the investigator also signs the document.

At the final stage, a blockchain system records the results. The verified and signed electronic interrogation protocol, along with associated files (full audio recording, video recording), is uploaded to a secure departmental blockchain registry. The system automatically generates a unique cryptographic hash (digital identifier) for each file and assigns a timestamp. This data is then distributed among the nodes of the Unified Register of Pre-Trial Investigations network.

A private blockchain with a limited number of trusted participants is used; each network node stores a copy of the ledger and participates in validating new records. Adding a new interrogation record requires consensus among nodes, eliminating the possibility of undetected data tampering by a single participant. Records stored in the blockchain are securely protected: changing even a single byte of information will cause a hash discrepancy, and any attempt to tamper will become obvious to all nodes (Lai, 2023). This ensures the immutability and verifiability of the materials each stage of the protocol (collection, storage, status change) is transparently reflected in a digital trace, accessible to authorised persons.

Confidentiality is protected by encryption: only those with the necessary keys (investigator, prosecutor, court) have access to the contents of the records. Personal data in the electronic protocol can be anonymised (with subsequent disclosure upon request of the court) to comply with information protection laws (Fu-Ching, 2021). As a result, this aspect of integration allows, without violating participants' rights (on the contrary, strengthening their protection), the introduction of new technologies into the interrogation procedure that increase the reliability and security of the evidence collected.

CONCLUSIONS

The study demonstrates that the integrated use of artificial intelligence and blockchain offers real potential for improving the reliability and objectivity of verbal investigative processes. The use of modern automatic speech recognition systems virtually eliminates distortions and gaps in interrogation transcripts testimony is recorded fully, accurately, and in the interviewee's own words.

Parallel neural network analysis of emotional and behavioural factors serves as an additional verification of the veracity and correctness of the process, alerting to hidden problems that a human observer might miss. Blockchain technology provides a fundamentally new level of security for this process: it makes the resulting digital evidence immutable and transparently verifiable in origin, significantly increasing its persuasiveness in court.

The combination of these solutions creates a "digital standard" of reliability, where the quality of evidence is guaranteed not only by human professionalism but also by technology. For Kazakhstan, which is implementing a large-scale digital transformation program, the integration of AI and blockchain into criminal proceedings means not only increased efficiency and speed in investigations, but also strengthened rule of law and increased public trust in the judiciary.

Notably, declaring 2026 as the Year of Digitalisation and AI in Kazakhstan creates favourable conditions for testing these innovations: pilot implementations of such systems in pre-trial investigation bodies in the near future would allow for refining practical aspects and developing a regulatory framework for wider application. Of course, implementing such innovations will require further testing, algorithm refinement, and improvements to the regulatory framework, taking into account the aforementioned ethical aspects.

Nevertheless, the development vector is clear: the synergy of AI and distributed ledger technology sets a new standard for the transparency and reliability of investigative actions, bringing criminal proceedings closer to the realities of the digital age, where no participant's word will be lost or distorted, and no procedural violation will go unnoticed.

However, several limitations must be acknowledged. The study is mainly conceptual and lacks large-scale empirical validation in real investigative settings. In addition, the effectiveness of AI tools may vary depending on language, data quality, and contextual conditions, while legal and ethical constraints may affect practical implementation.

Future research should empirically test the proposed framework in real-world settings and improve AI model performance in multilingual legal contexts. Further studies are also needed to develop standardised legal and ethical guidelines and to assess the long-term impact of these technologies on judicial efficiency and reliability.

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