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लोकहितार्थं सत्यमिच्छा
Dedicated to Truth in Public Interest



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Artificial Intelligence & Machine Learning

International Centre for Information Systems & Audit (iCISA)



International Centre for Information Systems and Audit



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About the Journal

PursuIT, the e-Journal, is a platform for sharing of experience and inculcating professional excellence in the emerging areas in the domain of Information Technology. The e-Journal aims at having features on emerging areas of Information Technology viz. cybersecurity, Data Security, e-Governance etc. It also looks into the technological developments, future of technology, national policies and standards, as well as articles on IT Audit conducted by SAI India.

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We strive for constant improvement and encourage our readers to provide their valuable feedback/suggestions to make the endeavor successful. Send us your suggestions, comments, and questions about the e-Journal to icisa@cag.gov.in

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Director General's Message

Welcome to iCISA's e-Journal *PursuIT*. Incorporating contributions from eight SAls for the very first time, this edition of the e-journal is special indeed. Over the years, *PursuIT* has emerged as a valuable platform for sharing knowledge, exchanging ideas, and promoting excellence in the field of Information Systems Auditing and emerging technologies. We are delighted that in line with iCISA's **Strategic Plan (2025–30)**, our e-Journal is now being partnered by the international fraternity of SAls, members of iCISA's alumni network, guest and in-house faculty as well as staff and officers of SAI India.

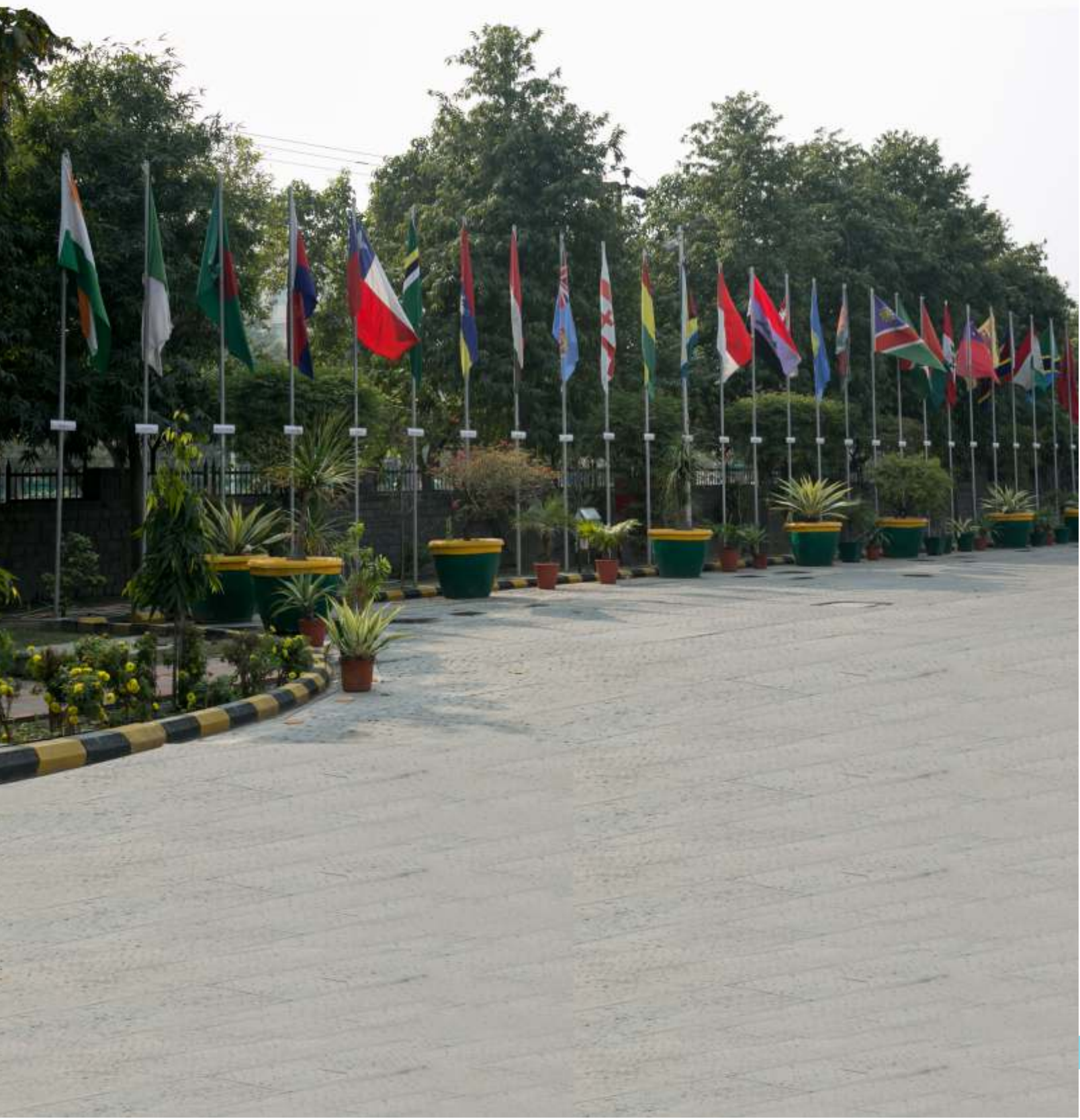
The theme of this edition - '**Artificial Intelligence and Machine Learning**,' - is closely aligned with SAI India's commitment to explore and enhance the use of AI and ML in auditing. However, at the same time, the international collaboration in this edition, has helped us foreground the shared challenges faced by SAls worldwide and their diverse responses and experiences. With an interesting mix of theory and practice, the articles in our tenth issue have been carefully grouped under themes such as **Frameworks, policies and governance; Practical applications in auditing; Understanding technical domains; Cross-sectoral application as well as a summary of the commemorative lecture organized in March, 2025 to mark the foundation of iCISA.**

I would like to express my sincere appreciation to all the authors, reviewers, and members of the Editorial Board for their valuable efforts and contributions. Your support helps *PursuIT* remain a trusted and insightful publication for professionals in the audit and IT fields.

As we celebrate this **tenth edition**, I invite our readers to explore the ideas shared in these pages and continue to contribute new thoughts and ideas.

Thank you for your continued support and engagement.

Ms. Geeta Menon
Additional Deputy CAG & Director General, iCISA



Frameworks, Policies & Governance





Harnessing Artificial Intelligence and Machine Learning to Elevate Modern Auditing

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The Case for Change in Auditing

Auditing, as a fundamental mechanism for accountability, has long relied on traditional techniques such as sample testing, retrospective verification, and standardized checklists. While effective in the past, these approaches are increasingly challenged by the speed, scale, and complexity of today's organizational data environments. The expectations of stakeholders—ranging from senior management to regulators—are rising. There is a growing demand not only for accuracy and compliance but also for insights, foresight, and value addition.

Artificial Intelligence (AI) and Machine Learning (ML) offer auditors new capabilities to address these demands. AI refers to a broad range of technologies that enable machines to simulate human intelligence—interpreting language, recognizing patterns, and making decisions. ML, a subset of AI, focuses on developing models that improve their accuracy by learning from historical data. When effectively integrated into the audit process, these tools can elevate the auditor's role from data examiner to strategic risk assessor.

This shift is not a matter of choice but a

necessity. With data volumes expanding exponentially and fraud mechanisms becoming more sophisticated, traditional manual reviews are no longer adequate. Audit institutions must modernize their methodologies and technology infrastructure or risk obsolescence.

Enhancing Audit Processes through Intelligent Technologies

AI and ML are not futuristic concepts—they are already in use across leading audit organizations globally. Their impact is evident across multiple stages of the audit lifecycle.

Data classification is often the first step in audit preparation. AI-driven tools can ingest and organize unstructured data, such as scanned documents or emails, into logical categories. This process, which previously required significant manual effort, can now be completed in a fraction of the time, allowing auditors to focus on analysis and judgment.

Another key advancement lies in **anomaly and fraud detection**. ML algorithms, trained on historical data, can identify transactions that deviate from established norms—whether due to data entry errors,

control lapses, or fraudulent activity. These alerts enable auditors to perform targeted investigations, increasing audit effectiveness while minimizing disruption.

Risk assessment, traditionally conducted at the start of the audit cycle, can be transformed through predictive modeling. ML systems can evaluate past audit outcomes, control weaknesses, and financial patterns to anticipate risk areas with greater accuracy. This allows for dynamic audit planning that adapts as new data becomes available.

Continuous auditing, enabled by AI, marks a departure from periodic reviews. Real-time monitoring of financial and operational data streams makes it possible to detect and respond to issues as they occur, significantly enhancing the value of the audit function.

Natural Language Processing (NLP) is also finding increasing utility in auditing. By extracting relevant information from legal contracts, internal policies, or compliance reports, NLP tools support a more comprehensive audit scope without requiring line-by-line manual review.

In particular, AI and ML enable a more advanced analytical function known as **causal knowledge discovery**. Rather than merely identifying correlations or anomalies, advanced ML models can detect cause-and-effect relationships within datasets. This capability allows auditors not only to flag symptoms of risk but also to uncover their root causes—whether they stem from operational inefficiencies, control failures, or systemic process flaws. According to the literature, causal modeling

approaches significantly enhance audit accuracy, prioritization, and risk mitigation.

These improvements are summarized in Figure 1, illustrating the full cycle of AI-enabled auditing—from initial data capture to final reporting.



Figure 1 : AI-Driven Audit Lifecycle

Rethinking Methodologies: A Comparative Perspective

To better understand the transformation that AI and ML bring to auditing, it is helpful to compare traditional practices with their AI-enhanced counterparts.

One fundamental shift is in the area of risk assessment. In traditional audits, **risk identification** typically relies on predefined checklists and qualitative judgment made at the planning stage. These assessments often remain static throughout the audit cycle, even as new data or insights emerge. AI and ML enable a more dynamic approach—leveraging historical data and predictive modeling to continually refine risk prioritization as the audit progresses. This

results in more focused testing and resource allocation.

For instance, in traditional audits, **data sampling** is often used due to the impracticality of reviewing all transactions. This introduces the risk that material errors or fraud may go undetected. AI systems, however, can process entire datasets, identifying anomalies across all transactions and reducing audit risk.

Similarly, **fraud detection** under conventional methods often relies on predefined rules—such as flagging transactions above a certain threshold or involving specific vendors. These rules, while helpful, are inherently limited. ML models improve upon this by learning complex fraud patterns and adapting over time, even identifying previously unknown schemes.

Causal discovery techniques—enabled by ML—can also add a dimension not available through traditional means. While traditional audits may stop at identifying what went wrong, AI techniques can pinpoint why it occurred, offering a clearer path to control remediation and performance improvement.

In the **reporting phase**, human-authored findings may vary in structure and tone. AI tools can assist in drafting standardized, evidence-based reports, saving time and ensuring consistency across engagements.

A detailed comparison is presented in Figure 2, which contrasts selected audit functions across both methodologies (Traditional and AI-Powered).

Audit Function	Traditional Method	AI/ML-Enhanced Method
Risk Assessment	Static planning at audit start	Dynamic risk scoring with ML models
Data Sampling	Manual sample testing	Full-population analysis
Fraud Detection	Rule-based checks	Pattern recognition via ML
Causal Analysis	Often not performed	Root cause detection using causal models
Reporting	Narrative reports manually drafted	Automated drafting with analytics summaries

Figure 2 : Traditional vs. AI-Powered Auditing

Implementation Considerations and Risks

Despite the benefits, the integration of AI and ML into auditing is not without its challenges. One of the foremost concerns is **data quality**. AI applications depend heavily on clean, relevant, and comprehensive data. Inconsistent datasets can lead to incorrect conclusions and undermine audit credibility.

Another issue is the **interpretability of AI models**. Many ML systems, especially those based on deep learning, operate as “black boxes,” offering limited transparency into how conclusions are reached. For auditors, who must justify findings to clients and regulators, this lack of explainability can be problematic.

System integration is also a technical challenge. Legacy audit software may not be compatible with modern AI platforms, requiring significant upgrades or replacements. These infrastructure

investments must be planned strategically and aligned with long-term audit modernization goals.

Cultural and organizational readiness must not be overlooked. Resistance to change, fear of obsolescence, and limited digital fluency among audit teams can hinder adoption. Addressing these concerns through communication, training, and leadership engagement is essential.

Finally, **ethical considerations** must guide AI implementation. Issues such as algorithmic bias, data privacy, and automated decision-making must be carefully managed. Governance frameworks, including oversight committees and ethical AI policies, are key to responsible use.

Importantly, many of these challenges can be addressed by applying the appropriate ML techniques. For instance, data quality issues—such as missing values or small datasets—can be managed through advanced imputation methods or robust algorithms designed to perform reliably with limited data. Concerns over model interpretability can be resolved using shallow learning methods integrated with causal analysis, which provide both transparency and explanatory power. Likewise, system integration can be streamlined with modular, API-compatible AI tools, and ethical risks can be proactively mitigated using fairness-aware model selection and audit trails.

However, the effectiveness of these solutions hinges on the auditor's ability to understand and leverage them appropriately. This underscores the critical importance of training. Auditors must be equipped with both

domain expertise and a working knowledge of AI and ML concepts to choose the right models, interpret outputs correctly, and ensure that implementation aligns with regulatory and ethical standards. Continuous professional development is essential to ensure that auditors can derive meaningful, trustworthy, and actionable insights from these technologies.

The Enabling Role of iCISA

The International Centre for Information Systems and Audit (iCISA) is a vital institution supporting audit professionals in adapting to emerging technologies. As a premier training and knowledge-sharing center, iCISA equips auditors with the tools and frameworks necessary for digital transformation.

Through its educational programs, iCISA has introduced courses and seminars on IT auditing, data analytics, and the fundamentals of AI. These initiatives are particularly important for Supreme Audit Institutions (SAIs) seeking to modernize practices without compromising audit integrity. iCISA also curates thought leadership through its publications, such as the PursUIT e-journal, providing a platform for global professionals to exchange insights.

Moreover, iCISA actively advocates for ethical innovation in auditing. It supports the development of regionally appropriate standards and encourages responsible adoption practices through seminars, technical papers, and cooperative initiatives. iCISA emphasizes that building audit readiness in the digital era requires a combination of technical acumen, ethical grounding, and strategic foresight.

By fostering a community of practice and advancing training standards, iCISA helps ensure that AI and ML are leveraged not just as tools—but as enablers of accountability and good governance.

Strategic Roadmap for Audit Institutions

Audit organizations at various stages of technological maturity can take practical steps toward AI integration. First, conducting a **readiness assessment** helps identify gaps in infrastructure, skills, and processes. This diagnostic approach provides a foundation for phased implementation.

Starting with **pilot projects** is advisable. These may focus on discrete use cases—such as fraud detection in procurement or automated review of expense claims. Successful pilots help build internal confidence and provide data to support broader investment.

Cross-functional collaboration is also critical. Auditors should engage with IT, legal, compliance, and external partners to ensure AI solutions are secure, scalable, and aligned with institutional objectives.

Education and training are ongoing requirements. Whether through internal workshops or external certifications, auditors must continuously upgrade their capabilities in data analytics, AI/ML principles, and digital ethics.

Finally, **embedding governance** from the outset helps mitigate risk. Institutions should establish protocols for data access, model validation, and bias monitoring. Regular evaluations and independent reviews should be part of the audit strategy.

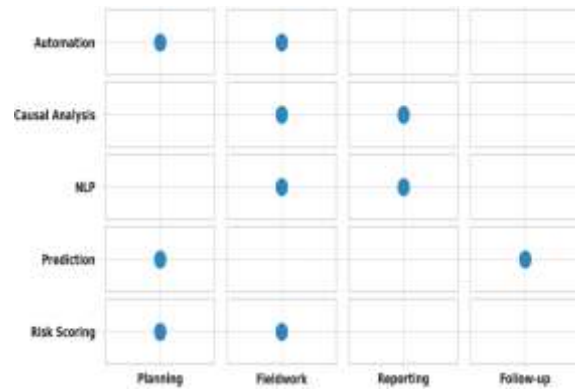


Figure 3: Mapping AI/ML Capabilities across Audit Stages

The above diagram (Figure 3) provides a mapping of key AI and ML capabilities across the main stages of the audit lifecycle, offering a visual reference for institutions planning their adoption strategies.

Conclusion

AI and ML are reshaping the future of auditing—not by replacing human judgment but by amplifying it. These technologies enable auditors to provide deeper insights, faster assurance, and broader coverage, all while upholding professional standards.

Successful adoption, however, depends on more than technology. It requires vision, investment, and institutional readiness. By following a structured approach and engaging in continuous learning, audit institutions can responsibly integrate AI and ML into their practices.

The support of knowledge hubs like iCISA reinforces this transition. By equipping auditors with skills, standards, and a shared platform for innovation, iCISA ensures that the future of auditing remains both technologically advanced and professionally grounded.

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Realizing the Value of AI in Public Sector Auditing: Challenges and Opportunities for SAs

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Introduction

The adoption of Artificial Intelligence (AI) has significantly impacted a wide range of sectors globally, spanning both private and public domains. Ongoing technological advancements have further facilitated the ease of implementing AI solutions across various industries. Although the private sector, driven by revenue-oriented objectives, is often perceived as the primary adopter of AI technologies, public sector

organizations are increasingly recognizing its potential to improve efficiency, service delivery, and decision-making.

A recent report by Capgemini¹ on data foundations in government, based on a survey of 700 respondents from 350 public sector organizations worldwide, reveals that 64% of these organizations are already engaged in or actively pursuing generative AI initiatives, and 90% are planning to explore, pilot or implement agentic AI within the next 2–3 years. These government organizations see data and AI as a key enabler in pursuing greater efficiency and further seek to open opportunities in delivering citizen-centric services, drive economic growth, and foster innovation.

Supreme Audit Institutions (SAIs), which have leveraged Information and Communication Technology (ICT) to enhance their audit processes, are now exploring the integration of Artificial Intelligence (AI) into their methodologies. This growing interest signifies a broader transformation—not only in the modernization of audit practices but also in recognizing the potential of AI to strengthen public accountability, improve oversight, and foster institutional learning.

¹ Capgemini Research Institute. (2024). Data powered government: Unlocking the value of data and AI in the public sector. Capgemini. Retrieved May 28, 2025, from https://www.capgemini.com/wp-content/uploads/2025/05/Capgemini-Research-Institute-report_Data-foundations-for-government_From-AI-ambition-to-execution-3.pdf

AI utilization in public sector auditing

As institutions entrusted with oversight mandates, SAIs generally aim to fulfill their mission of ensuring transparency, accountability, and good governance in the use of public resources. Accordingly, decisions regarding the adoption of ICT are guided by the extent to which such technologies support and enhance the achievement of these objectives. In line with this mandate, ICT implementation and emerging technologies adoption such as AI are typically related to improving audit efficiency, expanding audit coverage, improving detection of irregularities and fraud, and supporting risk-based audit planning². While no cases of full AI integration into SAI methodologies can be presented in this article, several SAIs have begun incorporating AI-powered tools and approaches into their audit functions. These initiatives reflect a growing interest in leveraging AI to enhance audit effectiveness and efficiency.

One example is SHAMEL 2.0 developed by SAI Saudi Arabia³—a digital audit platform featuring an AI-powered Smart Auditor Assistant that supports the audit team by providing instant responses, recommendations, and access to knowledge base. SHAMEL also employs AI and machine learning algorithm in its advanced analytics capabilities to detect anomalies, identify

patterns, and uncover potential irregularities or violations.

Since 2019, SAI USA has established Innovation Lab and launched a Science, Technology Assessment, and Analytics (STAA) team. Through this initiative, SAI USA created a dedicated environment for exploring advanced analytics and emerging technologies, including AI and machine learning, aimed at transforming the work of auditors and other government professionals⁴. Recently, SAI USA began deploying a large language model to synthesize past reports, support editorial reviews, and analyze congressional documents, while continuing to explore additional use cases to further leverage AI's potential.

Earlier in 2017, SAI Brazil deployed ALICE (Analysis of Public Tenders and Calls of Tender) —an AI-based tool designed to review public procurement notices published by federal and state institutions on daily basis⁵. Together with this tool are SOFIA and MONICA designed to support the auditing process. SOFIA performs automated cross-check on identification data, while MONICA used to integrate monitoring of public acquisitions that were not captured by ALICE.

One research in South Africa on object directly related to public sector audit⁶ was conducted to predict audit comes, based on municipal financial statements analyzed

² U.S. Government Accountability Office. (2024). Science & tech spotter: Artificial intelligence in financial statement audits (GAO-24-107237). GAO.gov. Retrieved May 28, 2025, from <https://www.gao.gov/products/gao-24-107237>

³ Argaam. (2024, December 28). Saudi Arabia launches digital platform for government tenders. Argaam. Retrieved May 28, 2025, from <https://www.argaam.com/en/article/articledetail/id/1787677>

⁴ U.S. Government Accountability Office. (2019, October 29). Our Innovation Lab: Building a sandbox for audit tech. GAO.gov. Retrieved May 28, 2025, from <https://www.gao.gov/blog/2019/10/29/our-innovation-lab-building-a-sandbox-for-audit-tech>

⁵ Observatory of Public Sector Innovation (OPSI). (n.d.). Robot ALICE: Bid, contract and notice analyser. OECD. Retrieved May 28, 2025, from <https://oecd-opsi.org/innovations/robot-alice-bid-contract-and-notice-analyser/>

⁶ Mabelane, K. L., Mongwe, W. T., Mbuva, R., & Marwala, T. (2022). An analysis of local government financial statement audit outcomes in a developing economy using machine learning. *Sustainability*, 15(1), Article 12. <https://doi.org/10.3390/su15010012>

using machine learning algorithms. The researchers used training models such as decision trees, logistic regression, and artificial neural networks (ANN) on historical audit data. The result returned that ANN showed strong performance in classifying audit results based on financial ratios. This result demonstrated that AI can be leveraged to support audit functions, especially for identifying patterns linked to audit opinions.

In SAI Indonesia, the integration of AI to support audit activities is still in its early stages. Currently, SAI Indonesia is actively developing domain-specific AI agents designed to assist auditors through conversational interfaces (chatbots). These intelligent agents can be embedded within various digital platforms to enhance accessibility and usability.

To date, three distinct AI agents have been developed:

1. Performance Audit Agent – trained to provide guidance on performance audit methodologies and procedures.
2. Big Data Navigation Agent – designed to assist auditors in navigating and utilizing the SAI's big data analytics portal.
3. SDG Audit Knowledge Agent – focused on delivering insights related to audit findings concerning the achievement of the Sustainable Development Goals (SDGs).

These agents are powered by a Large Language Model (LLM) that has been fine-tuned using curated documents relevant to their respective domain. The Performance Audit Agent is integrated into SAI Indonesia's electronic working paper system, SIAP. Meanwhile, the Big Data Navigation Agent

and the SDG Audit Knowledge Agent are deployed within the BIDICS platform and the Knowledge Management System, respectively.

In addition to these developments, SAI Indonesia is also exploring prototype use cases for AI, including automated transcription of recorded interviews and facial verification for personnel management within the Human Resource Information System (HRIS).

Navigating Effective AI Adoption

It is reasonable to infer that the current development of AI adoption in public sector auditing involves diverse approaches, employing a range of tools and use cases. Early applications suggest that AI is being strategically adopted with the intention of complementing and enhancing existing audit practices including broadening audit scope, improving accuracy, and bettering efficiency.

AI adoption in public sector organizations is often undertaken as part of a broader digital transformation initiatives. Hence, the measurement of value delivered is usually framed within the impact of digital transformation, rather than being evaluated as AI implementation specifically. Given the early stage of AI adoption in public sector, available information on the value gained remains limited and tends to be partial, focusing on specific aspects of audit practices.

Despite limited visibility into AI-specific value, SAIs may take proactive measures to ensure that AI adoption leads to a meaningful and sustainable improvements. The measures include addressing key challenges and considering critical factors in AI adoption journey. Several important aspects of AI adoption, that are relevant to SAIs, are

pertaining to data, system integration, regulation, sovereignty, and the impact of AI on audit processes.

Data and Systems

AI algorithm works on large volume and high quality data to produce accurate and meaningful outputs. Therefore, SAIs need to have access to large volume datasets that available, consistent and trustworthy. These datasets could be stored by SAIs or stayed in the data owner's system. Regardless of which opted by SAIs, it is imperative to ensure that the system where data resides support interoperability, providing real-time or updated information, and well-maintained.

Interestingly, the Capgemini report on government organizations¹ reveal that less than 25% public sector organizations report high maturity in any aspect of data readiness. Only 35% have rolled out or fully deployed data sharing initiatives, and crucially no more than 8% have fully deployed the initiatives. Without reliable data inputs, AI tools risks generating misleading insights, which could potentially undermine credibility of audit outcomes.

Sovereignty and Regulatory Compliance

As government organizations, SAI naturally work predominantly with government data and systems, which are often classified as confidential or at least sensitive. With technology ownerships increasingly shifting to third parties, government organizations considering AI solutions are growing increasingly concerned about maintaining agency and control in the digital domain. This

is in line with the survey results in the Capgemini report¹, where 64% of public sector organizations express concern about data sovereignty, 58% about cloud sovereignty, and 52% about AI sovereignty.

To keep up with AI rapid development and growing eagerness to adopt this technology, many countries have issued regulations and policies to ensure that AI implementation aligns with national strategies and operates within defined boundaries. As a result, many countries have published specific policies and regulatory frameworks related to AI. However, beyond AI-specific regulations, countries generally also issue broader policies governing the wider domains of digital or information technology.

In Indonesia, for example, Government Regulation No. 71 of 2019 on the Operation of Electronic Systems and Transactions encourages the placement of data centers and disaster recovery centers within Indonesia for strategic or public service data. Although the relocation of the national capital has yet to be fully realized, the governance for the new capital in Law No. 3 of 2022 on the National Capital includes provisions that promote the use of domestic technology and platforms in government systems. Additionally, Law No. 27 of 2022 on Personal Data Protection contain several articles that, among other things, regulates national control over personal data processing, require data controllers to have a representative in Indonesia, and encourage data localization —especially for public sector data. Similar regulatory requirements are likely to be found in other countries as well.

¹ Capgemini Research Institute. (2024). Data powered government: Unlocking the value of data and AI in the public sector. Capgemini. Retrieved May 28, 2025, from https://www.capgemini.com/wp-content/uploads/2025/05/Capgemini-Research-Institute-report_Data-foundations-for-government_From-AI-ambition-to-execution-3.pdf

Sovereignty concerns and regulatory compliance are significant factors influencing public sector organizations' decisions regarding AI adoption. These considerations shape choices across various aspects of technology selection, including infrastructure, operations, algorithms, and the use of experts.

AI Impact on Audit Processes

When asked about SAIs' expectation from implementing AI, generally cite goals such as improving audit accuracy, increasing efficiency, and enhancing audit quality. While these objectives may seem straightforward, understanding how AI adoption will impact the audit process is arguably the most critical factor in realizing its potential benefits for SAIs.

Since auditing is the core function of SAIs, selecting audit-related objectives for AI implementation inevitably raises questions about accountability for the outcomes produced by AI. As a result, organizations must be prepared to take responsibility for how AI-generated results are used in their work, including addressing ethical considerations and ensuring trustworthiness of the generated outputs used.

Realizing the AI value in Public Sector Auditing

Even without the current global enthusiasm in adopting emerging technologies such as AI, willingly or not, SAI will eventually embrace this advancement even if only to a limited extent. Like other technologies, AI will continue to evolve and influence public sector. While specific value AI may bring to public sector auditing cannot yet be precisely determined, the strategic importance of

preparing the adoption is evident. A critical opportunity of benefit from AI adoption in SAI lies in integrating AI into audit practices to enhance efficiency, accuracy, and public accountability.

However, realizing the potential benefits of AI requires more than just a willingness to adopt new technologies. SAIs must also address a range of foundational issues, including data readiness, system integration, regulatory compliance, sovereignty concerns, and the impact on audit processes. In pursuing the value AI can offer to public auditing, SAI should consider tackling challenges pertaining to data and system, AI implementation approach, work automation, and determine the strategic objective.

Build data foundation and system interoperability

AI algorithm rely on data, therefore having a strong data foundation is imperative for successful AI adoption. A strong data foundation includes ensuring data availability, accessibility, quality, and governance. Data proficiency will enable SAI to better understand and leverage data to ultimately support an effective AI implementation. This means, SAI need to have essential tools and technologies to identify, collect, process, and utilize data, supported by skills, process, and process to drive data usage for decision making.

As SAI works on data sourced from external entities, interoperability is crucial in enabling applications, systems, and data sources to communicate. Unconnected systems may lead to prolonged processing times and hinders information reuse and sharing between entities.

Use Starts small approach

When adopting AI, SAI should consider to start with small scale approach, focusing on implementations with measurable impact and efficiency. It is better for SAI to target a specific audit areas or process where AI can deliver immediate value, for instance detecting anomalies in procurement data. In an innovation adoption process, Diffusion of Innovations Theory by Everett Rogers⁷ which support the use of pilot projects could be adopted by SAIs. A pilot project allows SAIs to tests AI models, refine the algorithms, and build internal capacity while using reasonable resources within a controlled environment.

By starting small, SAI users will have reasonable time to get familiar with AI tools, learn its limitations, and adapt accordingly. The success of initial pilots can help gain trust and increase confidence in expanding AI initiatives. Through phased and focused implementation, SAI can execute AI integration to strengthen audit functions in a sustainable manner with minimum disruption.

Appropriate automation

Targeting audit activities for AI automation should be carefully considered by SAIs. In the early stages of AI adoption, it is advisable for SAIs to focus on automating repetitive and time-consuming audit tasks. Tasks that are rule-based and data-intensive are particularly well-suited for AI automation projects. Core audit activities such as reviewing procurement documents, extracting data from reports, verifying compliance, and matching transactions are examples of

routine processes commonly performed by auditors that fit the criteria of being data intensive and rule based.

Automating these routine tasks allow SAIs to reduce manual workloads, minimize human error, and enable auditors to focus on higher-value activities that require expert judgment, such as risk assessment and audit planning. Focusing on automation in early phase of AI adoption will more likely return a tangible result and will have positive impact on SAI's confidence in their journey with AI implementation, while building groundwork for a more advanced capability in the future.

Selecting strategic objectives

Selecting strategic objectives for AI adoption means identifying the most valuable features that AI can contribute to public sector auditing. So far, one of the most recognized capabilities that encourages the adoption of AI is its ability to analyze large volumes of data and detect irregularities using appropriate algorithms. For example, machine learning models can be trained to recognize deviations or anomalies from normal patterns.

Such AI abilities can be integrated into the audit process for anomaly detection and fraud identification. SAIs can benefit from improved audit timelines and enhanced audit findings. However, to ensure the results reliability, it is essential for SAIs to ensure that models used are trained on reliable and diverse datasets, followed by review of AI outputs conducted by proficient auditors.

⁷ Rogers, E. M. (2003). Diffusion of innovations (5th ed.). Free Press. Retrieved May 28, 2025, from <https://teddykw2.files.wordpress.com/2012/07/everett-m-rogers-diffusion-of-innovations.pdf>

Conclusion

In line with general development in public sector organizations, SAIs are showing growing interest in adopting AI to improve efficiency, enhance accuracy and eventually produce high quality audits. To ensure a successful AI adoption in audit, SAI should consider building strong data foundation,

improving system interoperability, addressing regulatory compliance and sovereignty concerns, starting with manageable projects, and selecting strategic objectives wisely. With careful planning and clear goals, AI can support SAIs in strengthening their role in promoting accountability and good governance.



Reimagining TAP in the Age of AI: Introducing the TAPAI Framework for Supreme Audit Institutions

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Introduction

In today's rapidly evolving digital landscape, Supreme Audit Institutions (SAIs) are facing unprecedented challenges and opportunities. The traditional governance pillars of **Transparency, Accountability, and Participation (TAP)** are under pressure to adapt. As Artificial Intelligence (AI) and Machine Learning (ML) become embedded into the public sector, SAIs must rethink their roles not only as overseers of public finance, but as architects of intelligent, inclusive, and impact-driven governance.

This article introduces the **TAPAI Framework**, which expands the classical TAP model by integrating **Artificial Intelligence (AI)**. The framework provides a strategic lens through which SAIs can leverage emerging technologies to enhance not only audit effectiveness, but also trust and engagement with stakeholders.

From TAP to TAPAI: A Strategic Shift

The original TAP framework has guided democratic governance for decades:

- **Transparency:** ensuring access to information
- **Accountability:** holding institutions responsible
- **Participation:** encouraging stakeholder engagement

However, in the digital era, data overload, algorithmic complexity, and the speed of information flow demand more responsive and intelligent systems. The addition of **AI** and **Impact orientation transforms** TAP into **TAPAI**, defined as:

- Transparency
- Accountability
- Participation
- Artificial Intelligence
- Impact-Oriented Governance

TAPAI is both a framework and a mindset—one that calls on SAIs to actively shape how AI is applied within public accountability systems.

How AI Enhances the TAP Dimensions

1. Transparency through AI

- Real-time audit dashboards
- Open government data platforms

- NLP-based tools for translating complex findings into citizen-friendly formats

2. Accountability through AI

- Predictive analytics for fraud and risk detection
- AI-enabled compliance tracking systems
- Smart contracts in public procurement

3. Participation through AI

- Digital citizen feedback platforms using AI sentiment analysis
- Crowdsourced audit initiatives enhanced by machine classification
- Voice-to-text AI tools for inclusive stakeholder consultation

These AI-enhanced mechanisms not only improve efficiency but also rebuild public trust through greater visibility, responsiveness, and inclusion.

Challenges and Ethical Reflections

Despite its promise, integrating AI into public audit systems is not without risks. SAls must be aware of:

- **Bias and fairness:** Addressing inherent biases in algorithms and datasets
- **Explainability:** Ensuring transparency of AI decisions
- **Data ethics and privacy:** Protecting sensitive public information

To manage these risks, SAls must invest in **AI literacy**, cross-sector collaboration, and updated audit standards that include algorithmic accountability.

SAls as AI Governance Stewards

By adopting TAPAI, SAls can position themselves as credible stewards of AI governance in the public sector. This includes:

- Auditing AI systems deployed by governments
- Assessing algorithmic impacts on equity and access
- Advocating for responsible AI procurement and deployment practices

SAls can become both watchdogs and thought leaders in ensuring AI is a force for inclusive governance.

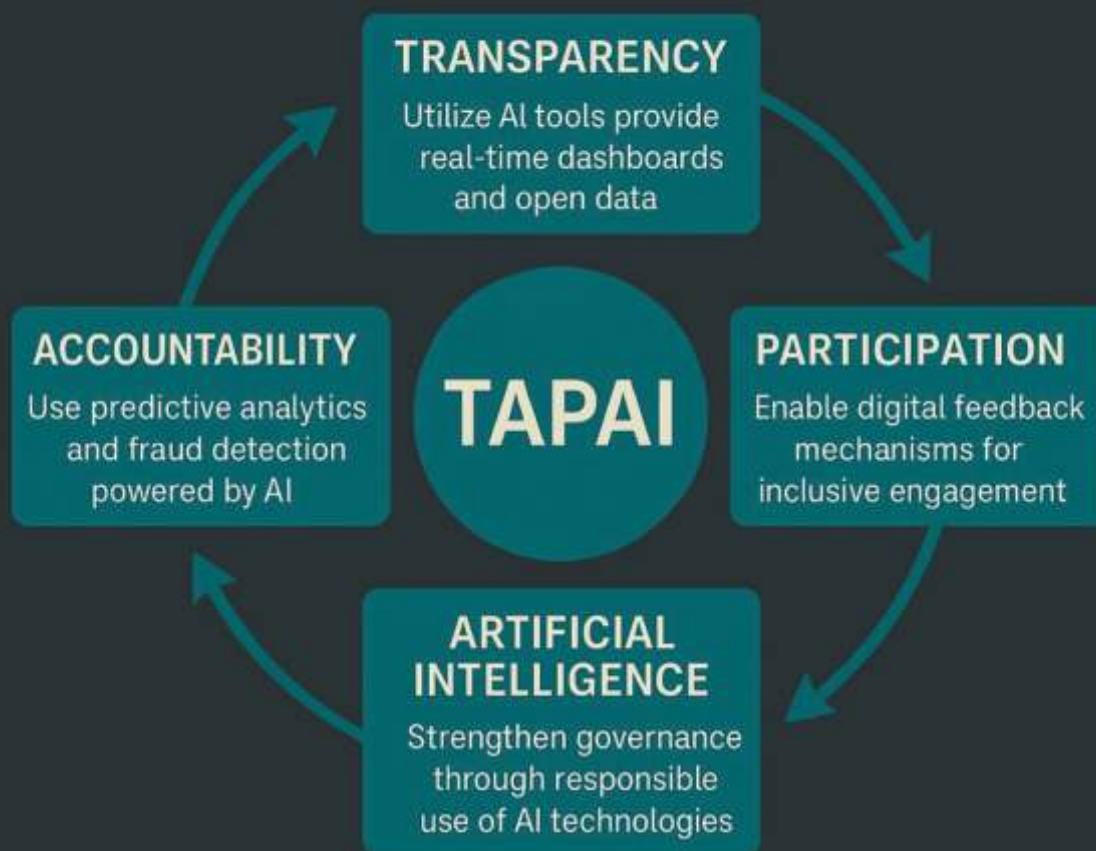
Conclusion

The TAPAI Framework offers more than a technical upgrade; it proposes a normative shift. As AI reshapes the public sector, SAls must evolve from reactive oversight bodies to **proactive, strategic actors** that guide how AI intersects with democratic values.

TAPAI reminds us that technology must serve people, not replace principles. In this transformation, SAls are not just adapting to the future—they are helping to design it.

Reimagining TAP in the Age of AI: Introducing the TAPAI Framework for Supreme Audit Institutions

The traditional governance pillars of Transparency, Accountability, and Participation (TAP) must be re-envisioned for the digital era. The TAPAI Framework incorporates Artificial intelligence (AI) to enhance public auditing practices



SAIs must develop AI literacy and governance oversight capabilities to address challenges and foster democratic trust

Content by Dr. Sutthi Suntharanurak
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Infographic by Kairos, AI

Artificial intelligence and Machine Learning in the State Audit Office of the Republic of Croatia: A Look into the Present and Future



*Tomislav Saić and
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On December 16, 2022, the Croatian Parliament adopted the Digital Croatia Strategy for the period until 2032¹. The Digital Croatia Strategy was published in the Official Gazette of the Republic of Croatia on January 4, 2023.



Picture 1 – Digital Croatia Strategy (head page)

The key goal of the Digital Croatia Strategy is to accelerate the digital transformation of the Republic of Croatia, especially through the digitalization of public administration, the economy and society as a whole, i.e., strengthening the digital competencies of citizens and institutions. Regarding artificial

intelligence (AI), the Strategy recognizes AI as a key technology for the modernization and digitalization of public administration and for economic development. The application of AI is planned in various sectors, including smart governance, healthcare, education, and security, with an emphasis on ethical standards and privacy protection. The Digital Transformation Strategy also envisages investments in the development of AI infrastructure and encouraging research and innovation in this area so that the Republic of Croatia can better integrate into global and European initiatives related to AI. The Digital Croatia Strategy relies on European guidelines, such as the EU's Digital Decade, and sets a framework for cooperation between the public and private sectors in the implementation of digital solutions, including AI. Croatia is also part of the Cooperation Initiative in the field of AI within the European Union, which provides access to funds and cooperation on projects involving the application of AI.

¹ https://mpudt.gov.hr/UserDocsImages//RDD/SDURDD-dokumenti//Strategija_Digitalne_Hrvatske_final_v1_EN.pdf?lang=de

The application of AI in public administration and state institutions in Croatia is only in the initial phase, but there are examples of use and plans for further implementation.

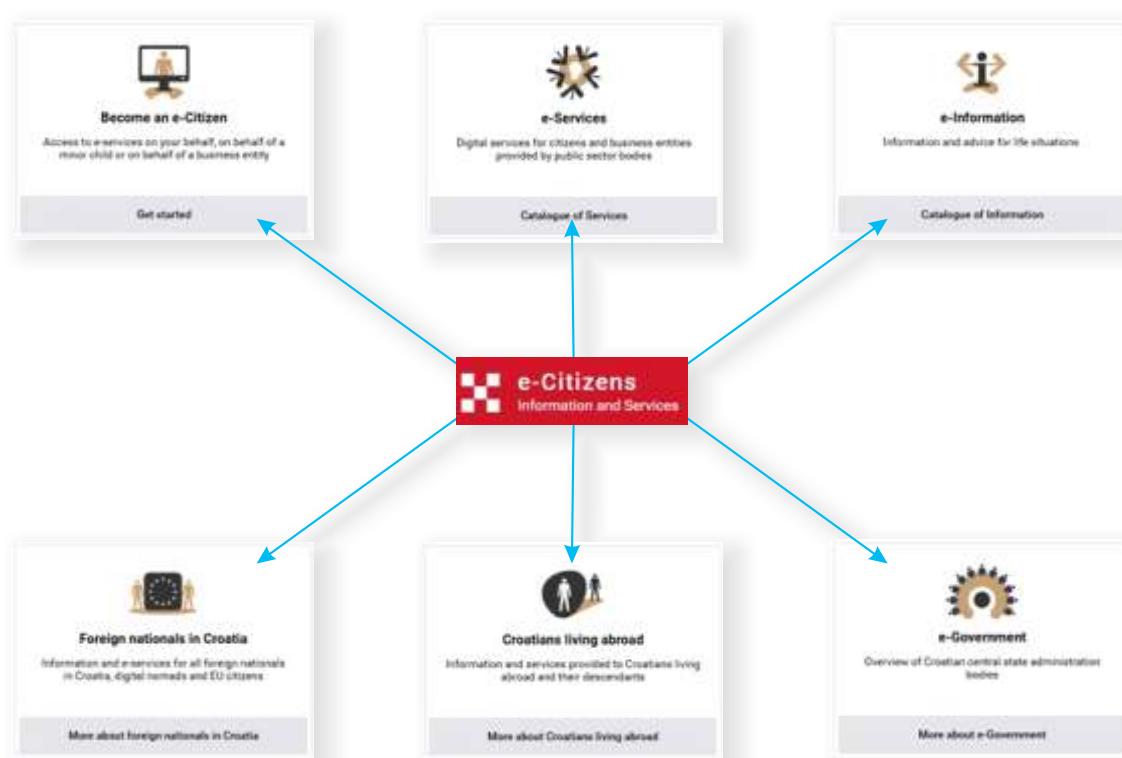
Here are some examples:

♦ **APIS IT and UI Data Processing Tools:**

APIS IT², as a key IT support for government institutions, is working on the development of tools that use AI to process large amounts of data. These tools are used to optimize administrative processes and to automate

repetitive tasks in government services. They are currently in the development phase of AI solutions for monitoring data on public services and optimizing the e-Citizens system³.

♦ **The eCitizens system**, which provides citizens of the Republic of Croatia with access to various digital services, is one of the main projects of digitalization of public administration. (see picture 2) The integration of AI is planned in several key areas to improve efficiency, adaptability and user experience.



Picture 2 – Digital services provided by eCitizens system

Current application of artificial intelligence in eCitizens

• **Chatbots:**

Currently, AI technology is being used in the form of chatbots and digital assistants to provide basic information to citizens. These systems automate communication, make it

easier for citizens to access information about different services, and help to solve problems.

• **Process automation:**

Using AI tools to automate repetitive tasks, such as requesting documents, tracking the status of requests, and issuing specific

² <https://www.apis-it.hr/web/naslovnica>

³ <https://gov.hr/en/become-an-e-citizen-2091/2090>

certificates. These processes allow faster data processing and reducing administrative errors.

Planned improvements

- **Personalization of services:**

It is planned to use AI to analyze user data to enable personalization of services. This means that the system will be able to identify the specific needs of users and offer them customized services, thus improving the user experience.

- **Advanced chatbots and virtual assistants:**

Introducing more advanced versions of chatbots and virtual assistants with greater natural language recognition capabilities. These assistants will be able to answer more complex questions from citizens and provide more detailed information on legal, administrative and health services.

- **AI for data analysis:**

It is planned to implement an AI system that will analyze data in real time to optimize processes, reduce system downtime, and suggest improvements for the efficiency of the entire eCitizens platform.

- **Pattern recognition systems:**

AI could be used to identify patterns in citizens' data, which will help solve administrative barriers and approve requests and processes faster.

- **Cybersecurity:**

Introducing AI technologies to improve

security within the eCitizens system, including identifying security threats and detecting potential security breaches or system abuse faster.

In accordance with the Digital Croatia Strategy until 2032, a comprehensive introduction of AI in public services, including eCitizens, is planned. Key strategic objectives include the development of interoperable systems, increasing the number of digital services and further reducing the administrative burden on citizens. AI will play a key role in this transformation through automation, predictive analytics, and personalization. These initiatives aim to increase the efficiency of the eCitizens system, improve the user experience and ensure that public services are as accessible and efficient as possible for citizens⁴.

Ministry of Finance and Tax Administration

The Ministry of Finance uses AI in the fight against tax fraud. AI-based systems are used to analyze large data sets to identify behavioral patterns that may indicate fraud or irregularities. There are plans to expand these systems to improve tax collection and reduce manipulation⁵.

Healthcare – AI in Patient Data Analysis

The Croatian healthcare system uses AI in analyzing medical data. There are plans to expand the use of AI systems in diagnostics, predictive health analytics, and personalized medicine, which would improve the efficiency of healthcare services and shorten waiting time⁶.

⁴ Source: National Plan for the Development of Public Administration for the period from 2022 to 2027, Digital Croatia Strategy for the period until 2032 - https://mpudt.gov.hr/UserDocsImages//RDD/SDURDD-dokumenti//Strategija_Digitalne_Hrvatske_final_v1_EN.pdf?lang=de

⁵ Source: <https://mfin.gov.hr/en>

⁶ Source: <https://hzzo.hr/projekti/novosti/projekt-umjetna-inteligencija-za-pametno-zdravstvo-i-medicinu>

Local, regional and regional self-government units – Smart cities and counties

Some municipalities and cities are introducing solutions that use AI to digitize administrative processes, such as issuing permits and communicating with citizens through chatbots. For example, the City of Rijeka has implemented smart waste management systems that use AI to optimize waste collection routes and analyze efficiency.

To use AI properly, it is necessary to implement digital services. Examples of various applications in other local government units for which chatbots (AI) are planned to be introduced in the future for creating queries from materials are, for example:

- e-Information is a center for informing citizens by the local government,
- e-Government allows citizens to send

inquiries to individual services, send and receive documents, as well as access documents,

- e-Waste offers an overview of the collection schedule, sending coupons for the removal of bulky waste with access to various related documents,
- e-Warden is a connection with the utility service through which numerous city problems can be solved,
- The e-kindergarten offers easier communication between parents and the kindergarten management, sending requests and various documents,
- e-Health provides the possibility of sending chronic therapy to family doctors, sending findings and other documents,
- e-Ecology gives an insight into the air quality in the centers of a municipality or city, as well as a display of daily measurements of various parameters.

Examples of chatbot and AI usage by local government units

Example No. 1:

Through chatbot queries, citizens simply type into the chatbot on the local government units' website: "How to enroll a child in kindergarten? What is required for enrollment? *How do children spend their time in kindergarten?*" After the inquiry, they should get all the relevant answers without searching the web and asking questions to the kindergarten. They should directly get all the necessary information that leads them to the e-kindergarten application and the enrollment procedure.

Example No. 2:

The City of Zagreb uses AI as part of its smart city solutions, especially in traffic and infrastructure management. Further integration of AI-based systems to optimize public transport, monitor congestion, and introduce smart parking is planned⁷.

⁷ Source: <https://www.zagreb.hr/UserDocImages/smart%20city/doga%C4%91anja/izlo%C5%BEba/Zagreb%20Smart%20City.pdf>

AI and Machine Learning in the State Audit Office of the Republic of Croatia: Current situation

Although the current level of application of AI in the public administration of the Republic of Croatia is limited, there are plans and strategies for its wider implementation in the future. Efforts are focused on modernizing infrastructure, educating staff, and integrating AI into various sectors of state administration in order to improve the efficiency and quality of service delivery to citizens.



The State Audit Office of the Republic of Croatia (Office) recognizes the growing importance of AI and machine learning (ML) in performing audit procedures. Currently, AI and ML tools are not implemented in the Office. However, the Office is actively considering and preparing for the integration of AI and ML into audit processes. Specifically, the Office is negotiating with an international IT company on implementing AI and ML in daily audit work.

Key aspects and considerations:

Awareness and strategic orientation:

The Office is aware of the potential that AI and ML offer for improving the efficiency, effectiveness, and scope of audits. The Report on the Work of the State Audit Office for 2024 explicitly mentions "AI in auditing," signaling that this topic is part of the Office's strategic considerations.

International cooperation and trend monitoring

The Office participates in international discussions on the application of AI in auditing. For example, at a bilateral meeting with the Auditor General of the United States, AI in auditing was one of the topics of discussion.

Future needs and challenges:

The Office anticipates that auditees will increasingly use AI-based systems. This will create a new need – auditing the AI systems themselves to ensure their reliability, transparency, and compliance with regulations.

Human resources development:

The Office emphasizes the importance of developing human potential as a key prerequisite for facing new challenges, including those brought by the implementation of advanced technologies such as AI and ML.

Ethical considerations:

The Office is considering the ethical issues and challenges posed by AI and ML, which are an important prerequisite for the responsible application of these technologies.

Potential areas of application for AI and ML in the State Audit Office:

Although specific applications of AI and ML have not yet been introduced in the Office's work, the Office is aware that in the audit profession, AI and ML can be used for, analysis of large amounts of data (Big Data); automated recognition of anomalies, patterns, and potential risks in financial and non-financial data.

Risk assessment:

More precise identification of high-risk areas that require more detailed auditing.

Automation of repetitive tasks:

This will allow auditors, through the introduction of AI, to have more time for more complex analyses and judgments.

Fraud detection:

Identifying suspicious transactions and activities that could indicate irregularities.

Predictive analytics:

Predicting future trends and potential problems based on historical data.

AI and ML in the State Audit Office of the Republic of Croatia: Future plans

The integration of AI tools within the State Audit Office of Croatia represents a strategic initiative to enhance audit processes by streamlining document analysis, collaboration, and reporting. The State Audit Office of Croatia plans to leverage AI in the following key areas:

- 1. Audit Planning Phase:** Analyzing available data with AI tools to identify and prioritize risk areas for auditing.
- 2. Audit Execution Phase:** Performing standardized audit procedures using AI tools, which includes:
 - o Analyzing available data to detect anomalies and inconsistencies.
 - o Automating repetitive audit tasks to improve overall efficiency.
- 3. Reporting Phase:** Utilizing AI to create a more efficient reporting process, for instance, by improving data visualization for clearer insights.
- 4. Follow-up Audit Phase:** In this stage, AI can be instrumental in monitoring corrective actions (implementation status of audit recommendations), as well as automating follow-up reporting.
- 5. Collaboration with Legal Authorities:** When audit findings suggest potential illegal activities and necessitate engagement with legal authorities, AI can offer powerful support through enhanced evidence collection and analysis, sophisticated fraud and anomaly detection, and secure information sharing.

Given the rapid development of technologies and their increasing impact on various sectors, there is a growing need for integrating IT auditing and using AI and ML in standard audit practices. Possible trends in this area and the required level of knowledge and expertise that will be needed for auditors in the future:

Basic understanding of IT: Although it is not necessary for all auditors to become IT auditors, a basic understanding of IT systems, infrastructure, and general concepts such as databases, networks, and security practices will be extremely important. This knowledge will enable auditors to recognize basic risks and challenges associated with AI and ML in auditees.

Specialized IT auditors: With the development of technology, it is expected that auditors specialized in IT auditing, cybersecurity, and big data analysis will be crucial for a deeper evaluation of complex systems. This includes understanding specific technologies, such as cloud computing, AI, and blockchain, and the ability to conduct IT audits.

Education and training: Audit offices can offer training and certifications for their auditors to ensure basic knowledge of IT systems and technologies, including AI and ML. This may include seminars, workshops, and formal educational programs in cooperation with educational institutions or professional organizations.

Specialized external experts: In many cases, engaging external experts will be useful, especially for specific areas such as cybersecurity, big data analysis, and complex IT systems. External experts will provide deep understanding, due to possessing technical skills that are certainly not present within the internal audit team.

Access to expert resources: External experts can bring knowledge of the latest technologies and threats that can change rapidly, which is important for keeping audit practices up-to-date and relevant. In conclusion, although not all auditors will

become specialists in IT auditing, basic knowledge of technologies and the ability to cooperate with external experts will be key for effective auditing in the future. The integration of technology experts and continuous education of auditors will help maintain high audit standards in a rapidly changing technological environment. In today's digital environment, a quality audit of financial statements cannot be imagined without including an audit of the administrative and accounting IT system. IT systems manage key data and processes that are crucial for the accuracy and integrity of financial statements. Auditing IT systems helps identify risks, weaknesses, and potential errors that can affect financial statements, thereby ensuring a comprehensive and reliable audit.

Conclusion

The Republic of Croatia is advancing its digital transformation through the Digital Croatia Strategy 2032, which emphasizes Artificial Intelligence (AI) as a key technology for modernizing public administration and fostering economic development. While AI adoption across the Croatian public sector is still in its initial stages, there are notable examples of its application and planned implementation in various areas.

The State Audit Office of the Republic of Croatia (Office) recognizes the significant potential of AI and Machine Learning (ML) to enhance audit procedures, even though these tools are not yet implemented. The Office is actively preparing for their integration, including negotiating with an international IT company. Strategic considerations include improving audit efficiency and scope, as highlighted in the

Office's 2024 Work Report and discussions with international counterparts like the US Auditor General. A key future challenge will be auditing AI systems used by auditees. The Office emphasizes developing human resources and addressing ethical considerations as prerequisites for responsible AI adoption. Potential AI/ML applications in the Office include analyzing large datasets, enhancing risk assessment, automating repetitive tasks, detecting fraud, and utilizing predictive analytics. Future auditors will require a basic understanding of IT, while

specialized IT auditors and external experts will be crucial for complex systems. The Office plans to provide training to ensure staff possess necessary IT knowledge. Key next steps involve finalizing AI tool license procurement, training auditors, conducting a pilot audit project, evaluating its outcomes, and then gradually scaling AI integration across all audits. This proactive and strategic approach aims to position the State Audit Office to maintain audit integrity and relevance in an evolving digital landscape.

Artificial Intelligence and Machine Learning Introduction: The Dawn of Intelligent Machines



*Ashish Kumar Shukla
and Sameer Asif,*

*O/o The Comptroller &
Auditor General of India*

In the tapestry of modern technological advancements, few threads shine as brightly as Artificial Intelligence (AI) and Machine Learning (ML). AI & ML stand at the forefront of technological innovation, transforming industries, reshaping societies, and redefining human potential. These



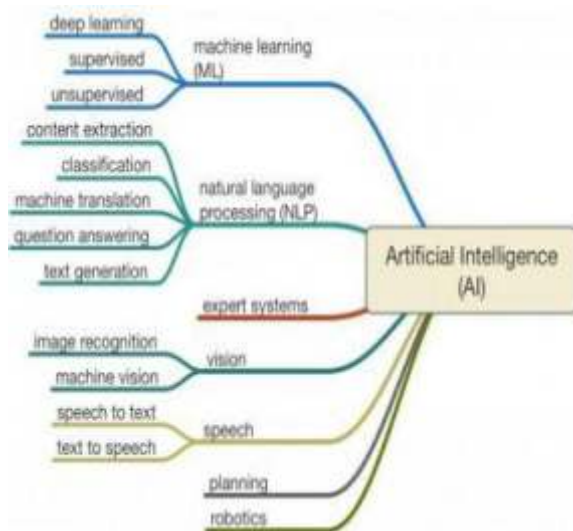
intertwined disciplines have transcended academic curiosity to become the backbone of innovations that define the 21st century. From voice assistants that anticipate our needs to algorithms that predict global market trends, AI and ML are reshaping the way we live, work, and think. This article delves into the essence of AI and ML, tracing their evolution, examining their transformative applications, grappling with their ethical dilemmas, and envisioning their

future trajectory. As we stand on the cusp of an AI-driven era, understanding these technologies is not just an academic, professional exercise but a societal imperative.

Defining Artificial Intelligence and Machine Learning

At its core, **Artificial Intelligence** refers to the development of computer systems that can perform tasks typically requiring human intelligence, such as reasoning, problem-solving, perception, and learning. AI is a broad field encompassing various subdomains, including natural language processing (NLP), computer vision, robotics, and expert systems. The goal of AI is to create machines that can mimic or surpass human cognitive abilities in specific contexts.

Machine Learning, a subset of AI, focuses on enabling computers to learn from data without being explicitly programmed. ML algorithms identify patterns, make predictions, and improve their performance over time as they process more data. ML is the engine behind many AI applications,



powering everything from recommendation systems to autonomous vehicles. It can be categorized into supervised learning (using labeled data), unsupervised learning (finding patterns in unlabeled data), and reinforcement learning (learning through trial and error).

While AI is the overarching vision of intelligent systems, ML provides the practical tools to realize that vision. Together, they form a symbiotic relationship that drives innovation across industries.

A Brief History of AI and ML

The roots of AI can be traced back to ancient myths of automatons and mechanical beings, but its formal journey began in the mid-20th century. In 1950, Alan Turing posed the question, "Can machines think?" in his seminal paper *Computing Machinery and Intelligence*, introducing the Turing Test as a measure of machine intelligence. The term "Artificial Intelligence" was coined in 1956 at the Dartmouth Conference, where pioneers like John McCarthy and Marvin Minsky laid the foundation for the field.

Early AI research focused on symbolic AI, where systems used predefined rules to solve problems. However, these systems struggled with complexity and scalability. The 1980s saw the rise of ML, particularly with the development of neural networks inspired by the human brain. Despite initial excitement, progress was hampered by limited computational power and data, leading to the "AI winter" of reduced funding and interest.

The 21st century marked a renaissance for AI and ML, fuelled by three key factors:

Big Data: The explosion of digital data provided the raw material for ML algorithms.

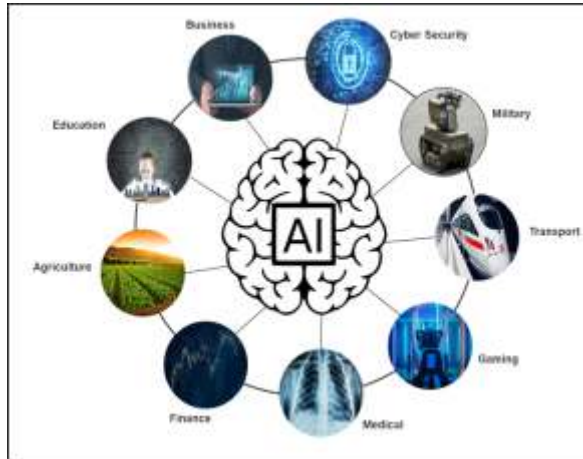
Computational Power: Advances in GPUs and cloud computing enabled the training of complex models.

Algorithmic Breakthroughs: Innovations like deep learning, a subset of ML using multi-layered neural networks, unlocked new possibilities.

By the 2010s, AI and ML were no longer confined to research labs. Milestones like IBM Watson's victory on *Jeopardy!* (2011), Google's AlphaGo defeating world champion Go player Lee Sedol (2016), and the rise of generative AI models like ChatGPT (2022) showcased their transformative potential.

Applications of AI and ML Across Domains

AI and ML are reshaping industries by driving efficiency, enabling innovation, solving complex challenges, and new possibilities. Below are some key domains where these technologies are making a profound impact:



1. Medical and Healthcare

AI and ML are revolutionizing healthcare by enhancing diagnostics, personalizing treatments, and streamlining operations. ML algorithms analyze medical images to detect disease conditions with accuracy rivaling human experts. Predictive models identify patients at risk of chronic diseases, enabling preventive care. AI-powered Chatbots provide mental health support, while robotic surgery systems assist surgeons with precision. For example, Google's DeepMind has developed models to predict acute kidney injury up to 48 hours in advance, potentially saving lives. Neuralink, a neurotechnology company founded by Elon Musk, has successfully implanted its brain-computer interface (BCI) device in three human patients, with all showing positive results. The company plans to perform 20-30 more implants in 2025 and is also working on "Blindsight," an artificial visual prosthesis, with the aim of restoring sight, according to BioTecNika.

2. Finance

In finance, ML algorithms detect fraudulent transactions by analysing large dataset and identifying patterns and risks with enhanced accuracy in real-time. AI-driven robo-advisors

offer personalized investment advice, democratizing wealth management. High-frequency trading systems leverage ML to predict market trends, executing trades in milliseconds. Additionally, AI enhances credit scoring by incorporating non-traditional data, improving access to loans for underserved populations.

3. Transportation

Autonomous vehicles, powered by AI and ML, promise to redefine mobility. Companies like Tesla and Waymo use deep learning to process sensor data, enabling cars to navigate complex environments. AI optimizes traffic flow in smart cities, reducing congestion and emissions. In logistics, ML algorithms streamline supply chains by predicting demand and optimizing routes.

4. Retail and E-Commerce

Retailers use AI to personalize customer experiences, from product recommendations to dynamic pricing. ML models analyze consumer behavior to forecast trends, while chatbots handle customer inquiries 24/7. Computer vision enables cashier-less stores, like Amazon Go, where shoppers can walk out without checking out. AI also enhances inventory management, reducing waste and costs.

5. Education

AI-driven platforms like Duolingo and Coursera adapt learning content to individual student needs, improving engagement and outcomes. ML algorithms identify at-risk students, enabling timely interventions. AI tutors provide personalized feedback, while automated grading systems free up educators' time. In research, AI accelerates

discoveries by analyzing vast datasets, as seen in protein folding predictions by DeepMind's AlphaFold.

6. Entertainment and Media

Streaming platforms like Netflix, Amazon Prime and Spotify rely on ML to recommend content tailored to user preferences based on history, likes and dislikes. AI-generated art, music, and literature are pushing creative boundaries, with tools like OpenAI's DALL·E creating stunning visuals from text prompts. In gaming, AI enhances non-player characters' realism and adapts difficulty levels to player skill.

7. Security and Defense

AI strengthens cybersecurity by detecting threats like malware and phishing attacks. Facial recognition systems, though controversial, are used for surveillance and authentication. In defence, AI and ML are revolutionizing modern defence warfare by enhancing decision-making, improving surveillance and security, and optimizing logistics. AI-powered systems can process vast amounts of data from various sources, like satellites and drones, to identify patterns, detect threats, and provide actionable intelligence, leading to faster, more accurate decision-making on the battlefield, and even targeted strikes, reducing risk to human personnel.

8. Auditing and Accounting

AI and ML are revolutionizing auditing and accounting by automating repetitive tasks, enhancing accuracy, and uncovering insights that human auditors might miss. ML algorithms analyze vast datasets—such as

financial transactions, invoices, and ledgers—to detect anomalies, fraud, and errors in real-time. For example, tools like Deloitte's Argus use NLP (Natural Language Processing) and domain-specific Large Language Models (LLM) to review contracts and financial documents, identifying discrepancies with unprecedented speed. AI-driven predictive models assess financial risks by analysing historical data and trends, aiding in compliance with regulations.

In auditing, AI enhances continuous auditing, allowing firms to monitor transactions dynamically rather than relying on periodic reviews. This reduces audit times and improves reliability. For instance, PwC's GL.ai for anomaly detection scans general ledgers to flag unusual entries, ensuring transparency. In accounting, AI automates tasks like invoice processing, expense categorization, and tax preparation, freeing professionals to focus on strategic advisory roles.

The audit system in India, governed by the Comptroller and Auditor General (CAG) of India, where various initiatives of using AI and ML enhances auditing by managing large volumes of data beyond traditional methods. Key areas of application includes monitoring and anomaly detection for improving fraud detection and oversight, analysis of tax data, e-procurement data scrutiny, auditing social welfare schemes for cross-verification of beneficiary data to help identify fraud and ghost beneficiaries.

These applications underscore AI and ML's transformative potential, particularly in auditing and accounting, where they enhance precision, efficiency, and trust.

9. Changing Governance through AI and ML in India

The call of the hour is to address the dynamic needs of India's diverse, growing population. At such a point an urgent need is for reshaping governmental operations through



e-governance initiatives that streamline long, tedious processes, enhance accessibility, and reinforce accountability by harnessing the transformative power of AI and ML. It is in the spirit of such transformation that digital initiatives such as the Digital India program was brought in July 2015 by the Government of India with the vision of transforming India into a digitally empowered society and a knowledge-based economy, by ensuring digital access, digital inclusion, digital empowerment and bridging the digital divide. These programs have evidently digitized a wide-range of public services and enhanced the distribution of crucial information.

AI Projects Undertaken for governance in India.

i. Bengaluru Adaptive Traffic Control System (BATCS): The Bengaluru Traffic Police has implemented the BATCS, which utilizes AI to adjust traffic signal timings based on real-

time data from camera sensors, reducing congestion and travel times. ASTRAM (Actionable Intelligence for Sustainable Traffic Management), launched by the government, further enhances this by providing a comprehensive traffic management app that integrates various data sources for efficient monitoring and response. The police also run a priority ambulance service, where emergency vehicles can request green corridor support via an app-based system called E-Path.

ii. BHASHa INterface (Bhashini): Bhashini, for India, was launched to provide technological translation services in 22 Indian languages using AI. The Bhasha Daan initiative crowdsources linguistic data for training AI models. By March 2025, Bhashini supported over one hundred diverse use cases with over 300 AI-based language models and had achieved over one hundred million monthly inferences. A significant achievement was seen during the Maha Kumbh. The Digital Lost & Found Solution, used during the Maha Kumbh 2025, facilitated registration of lost items via voice input in native languages with real-time translation. Bhashini supports applications like PM Kisan Chatbot and educational material translation.

iii. National Institution for Transforming India (NITI) Aayog AI Initiatives:

- NITI Aayog, the Indian government's think tank, has produced key document, National Strategy for Artificial Intelligence (NSAI), which promotes AI adoption in sectors like Healthcare, Education, Infrastructure, Agriculture, and Transportation.

- Model International Center for Transformative Artificial Intelligence (ICTAI) for AI research collaboration.
- "NITI For States" platform integrates Bhashini for multilingual governance knowledge dissemination.
- AIRAWAT supercomputing infrastructure enables AI-based research.

These examples illustrate the versatility of AI and ML, but their impact extends far beyond these domains.

However, these applications of AI & ML raise ethical concerns about privacy and autonomy.

Ethical Considerations: Prioritizing Responsible AI

The rise of AI and ML brings profound ethical challenges, necessitating a commitment to Responsible AI—the development and deployment of AI systems that are ethical, transparent, and aligned with societal values. Responsible AI is not a buzzword but a framework to ensure technology serves humanity without causing harm. Below are key ethical considerations, with a focus on responsible practices:

1. Bias Mitigation and Fairness

AI systems can inherit biases from training data, leading to unfair outcomes. For example, biased hiring algorithms have favored certain demographics, perpetuating inequality. Responsible AI demands diverse, representative datasets and regular audits to identify and correct biases. Techniques like fairness-aware ML and adversarial debiasing are emerging to ensure equitable outcomes.

2. Transparency and Explainability

Opaque AI models, often called “black boxes,” erode trust, especially in critical domains like auditing or healthcare. Responsible AI prioritizes explainable AI, enabling users to understand how decisions are made. For instance, in financial audits, explainable models clarify why a transaction was flagged, ensuring accountability.

3. Privacy Protection

AI's reliance on personal data raises privacy concerns. Responsible AI incorporates privacy-preserving techniques like federated learning, where models train on decentralized data, and differential privacy, which adds noise to protect individual identities. These methods balance innovation with user rights, aligning with regulations.

4. Accountability and Governance

Responsible AI requires clear accountability for AI decisions. In auditing, if an AI system flags a false positive, who is liable—the developer, firm, or auditor? Governance frameworks and organizations must adopt ethical AI policies and independent oversight boards.

5. Minimizing Harm of Misuse and Weaponization

AI's potential for misuse is significant, from deepfakes that spread misinformation to autonomous weapons that could escalate conflicts. Responsible AI seeks to prevent misuse.

6. Inclusive Development

Responsible AI involves diverse stakeholders—technologists, ethicists,

policymakers, and communities—to ensure systems reflect varied perspectives. Initiatives like AI4All promote inclusivity by training underrepresented groups in AI development, fostering equitable innovation.

By embedding Responsible AI principles, we can build systems that are trustworthy, fair, and beneficial. This requires global collaboration, robust regulations, and a culture of ethical stewardship to navigate AI's societal impact.

The Future of AI and ML

The future of AI and ML is poised to redefine industries and societies. Below are key trends shaping their trajectory, with expanded focus on their role in these fields:

1. AI in Auditing and Accounting

The future of auditing and accounting will see AI and ML become indispensable. Real-time auditing will replace traditional sampling, with AI systems continuously monitoring transactions to detect fraud and ensure compliance. ML models viz. LLMs will integrate unstructured data—like emails and contracts—with structured financial data, providing holistic insights.

In accounting, AI will automate complex tasks like multi-jurisdictional tax compliance and ESG (Environmental, Social, Governance) reporting, which require analyzing diverse datasets. Blockchain-integrated AI will enhance audit trails, ensuring tamper-proof records. The importance of AI lies in its ability to transform auditing from a reactive process to a predictive, strategic one, fostering trust in financial systems.

2. General AI

Current AI systems are narrow, excelling at specific tasks but lacking general intelligence. The pursuit of Artificial General Intelligence (AGI)—machines with human-like cognitive abilities—remains a holy grail. While AGI is likely decades away, breakthroughs in areas like transfer learning and neurosymbolic AI could bring us closer.

3. Explainable AI

As AI systems become more complex, understanding their decision-making processes is critical, especially in high-stakes domains like healthcare and law. Explainable AI aims to make models transparent, fostering trust and accountability.

4. Edge AI

Running AI models on edge devices, like smartphones and Internet of Things (IoT) sensors, reduces latency and enhances privacy. Advances in hardware and model compression are driving the adoption of Edge AI, enabling real-time applications in remote areas.

5. Human-AI Collaboration

Rather than replacing humans, AI is increasingly seen as a collaborator. Augmented intelligence tools enhance human capabilities, through AI-assisted tools. This collaboration will redefine the profession, emphasizing creativity and ethics.

6. Sustainable AI

The computational demands of AI training contribute to significant carbon emissions.

Researchers are exploring energy-efficient algorithms and hardware to create sustainable AI, aligning with global climate goals. Firms will leverage AI to track and report sustainability metrics, meeting stakeholder demands.

7. Democratization of AI

Python (a high-level, general-purpose programming language known for its readability and versatility) significantly contributes to the democratization of AI by making it more accessible, understandable, and approachable for a wider range of users, including those without extensive programming expertise. Its ease of learning, rich ecosystem of libraries, and open-source nature foster a collaborative environment that accelerates innovation and makes AI solutions more readily available. Through open-source libraries and frameworks such as TensorFlow, PyTorch, and Scikit-Learn, Python enables developers and researchers to build and deploy sophisticated AI models, thereby making AI accessible to businesses and individuals. This democratization fosters innovation but also raises concerns about misuse.

8. AI in Space Exploration

In space, AI is poised to play a key role in space exploration, from autonomous rovers on Mars to predictive models for exoplanet discovery. AI mission to accelerate human scientific discovery aligns with this vision, leveraging AI to unlock cosmic mysteries.

These trends suggest a future where AI and ML are deeply integrated into society, driving progress while posing new challenges.

Preparing for this future requires proactive governance, education, and ethical stewardship.

Personal Reflections

Writing this article has deepened our appreciation for AI and ML's transformative power. Growing up in a world shaped by rapid technological change, we have witnessed AI evolve from a sci-fi fantasy to a tangible force. Our interactions with AI-powered tools—like voice assistants (e.g., Alexa, Siri, Google Assistant etc.) and recommendation systems—highlight their seamless integration into daily life. We are inspired by AI's ability to streamline complex processes but sobered by the ethical responsibilities it entails. In auditing, AI's promise of real-time insights excites us, but we recognize the need for human judgment to ensure ethical outcomes. Our hope is for a future where AI amplifies human potential while upholding our values, and we are committed to advocating for education and dialogue to achieve this balance.

Conclusion: Shaping an AI-Driven Future

Artificial Intelligence and Machine Learning are catalysts for a new era of human progress. Their applications span every facet of life, from saving lives in hospitals to sparking creativity in art studios. Yet, their rise demands a steadfast commitment to Responsible AI, ensuring systems are fair, transparent, and accountable.

By fostering a future where AI serves humanity's highest aspirations, we can ensure that these intelligent machines amplify our potential rather than diminish it.

In the words of Alan Turing, “We can only see a short distance ahead, but we can see plenty there that needs to be done.” Let us step

boldly into this future, guided by knowledge, ethics, and a shared vision for a better world.

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Future Auditing Begins Today: How Can Egypt Benefit from Artificial Intelligence?

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Introduction

In light of the vast developments in information technology, artificial intelligence (AI) has become a vital tool that is radically changing many fields, most prominent is auditing. AI will help audit teams improve their efficiency and effectiveness by streamlining processes, analyzing data quickly and accurately, and providing proactive insights that contribute to strengthening governance and audit. It is a new and constantly evolving field that attracts everyone's attention. The use of AI systems and modern information technology is essential for the future of data processing in auditing to complete audit work efficiently and effectively.

Artificial Intelligence (AI)

Is the ability of digital systems to simulate human behavior in terms of thinking, analysis, and decision-making? It is the technology that enables machines to exhibit human-like logic and capabilities, such as independent decision-making. By absorbing massive amounts of training data, AI learns to recognize speech and patterns, proactively solve problems, and predict future situations and incidents.

Benefits of Using AI in Auditing

1. Benefiting from the Use of Expert Systems in Auditing: Expert systems are computer systems that can mimic the decision-making ability of a human expert in auditing. Expert systems can achieve several advantages:
 - o They can improve the efficiency of the audit process, reduce costs, reduce the audit workload, and provide audit results in a timely manner.
 - o Expert systems can serve as a documentary reference for auditors.
2. Automating Repetitive Processes
 - o Analyzing invoices and transactions in real-time.
 - o Reducing human error and increasing operational efficiency.
3. Detecting Fraud and Abnormal Patterns
 - o Using Predictive Models to Analyze Unusual Financial Behavior.
 - o Enhancing Proactive Auditing Capabilities.

4. Analyzing Big Data

- o The ability to process millions of records in seconds.
- o Providing detailed reports supported by predictive analytics.

5. Detecting Unusual Activities

- o AI-based algorithms can identify unusual behaviors or transactions that may indicate fraud or weak audit.
- o AI systems can compare financial transactions with historical patterns to detect any inconsistencies.

6. Intelligent Compliance Audit

- o AI can track organizational performance and compliance with laws and regulations.
- o It can also generate automatic alerts in the event of violations.

Artificial Intelligence in Egypt from Planning to Implementation

Egypt is witnessing a rapid digital transformation, and artificial intelligence (AI) is a key pillar of this transformation. Through ambitious projects and a national strategy, the government seeks to enhance its digital capabilities, improve services, and empower AI through the implementation of strategic projects aimed at improving government services, promoting the digital economy, and developing human capabilities. President Abdel Fattah El-Sisi launched the National Strategy for Artificial Intelligence in its first edition (2021-2024) and then the second edition (2025-2030). Among the most important strategic goals of the National Strategy in its second edition are the following:

- Increasing the contribution of the information and communications technology (ICT) sector to the GDP to 7.7% by 2030.
- Enable and support the establishment of more than 250 companies.
- The number of AI professionals and experts will reach 30,000 by 2030.
- Develop a national model for generative AI to support applications in the public and private sectors.

The President emphasized the importance of developing AI applications responsibly and ethically, in line with human values and international standards, protecting individual rights, and promoting sustainable development efforts.

There are many prominent applied projects in Egypt:

1. Diagnosis of Diabetic Retinopathy:

An application using artificial intelligence was developed to diagnose diabetic retinopathy with an accuracy rate exceeding 95%. It is currently being used in 10 university hospitals to screen one million citizens.

2. Applied Innovation Center:

Established by the Ministry of Communications and Information Technology, the center aims to utilize the most appropriate technological methods to develop innovative solutions for the sake of key national challenges. The center seeks to contribute to accelerating the growth of the Egyptian ICT sector by supporting the establishment of local high-tech companies that can participate in the implementation of major government projects and serve the private

sector, both locally and internationally.

3. Information and Decision Support Center IDSC Projects:

The Information and Decision Support Center IDSC is using AI technologies as part of the Egyptian government's vision for localization of these advanced technologies. The IDSC has been able to integrate AI technologies to enhance the quality of its outputs, including, for example, the Legal Portal for Egyptian Legislation (ELPAI), which is the first Egyptian, Arab, and African government legislation database to incorporate AI and machine learning as the basis for its search mechanism. The portal also features an AI Chatbot, which relies on generative AI technologies to develop the Legal Portal for Egyptian Legislation and enable researchers to search the content of legislation, provisions, and fatwas.

The center also prepares simulation models to predict a number of priority economic and social variables using AI technologies, develops an expert and customer relationship management system, analyzes expert contributions, and extracts insights using AI technologies. Furthermore, the center provides several smart applications based on AI technologies to analyze the knowledge content of the "Hiwar" (Dialogue) community engagement platform and enhance communication mechanisms with experts and citizens. Additionally, a smart employee assistant (GENIE – AI Chatbot) is being developed to respond to all informational inquiries from Center employees regarding the Center's internal regulations and human resources manuals, saving time and effort and ensuring a smart work environment that facilitates easy,

creative, and efficient business conduct.

Towards Smart Audit: Accountability State Authority's Role in Adopting Artificial Intelligence

As part of its efforts to keep pace with rapid technological developments, the Accountability State Authority (ASA) is making tangible efforts to integrate AI technologies into auditing and control processes, enhancing performance efficiency and keeping pace with the digital transformation led by the Egyptian government. These efforts have included training ASA staff on the use of AI in auditing, in collaboration with local institutions such as the Egyptian Banking Institute (EBI) and international institutions such as the Center for Finance, Technology and Entrepreneurship (CFTE), to build professional capacities capable of handling modern AI tools.

These efforts culminated in Egypt hosting the International Conference of Supreme Audit Institutions (INCOSAI XXV) in 2025. The ASA chaired the conference's second technical theme; "**The Use of Artificial Intelligence in Auditing**", which underscores the ASA's commitment to supporting the exchange of expertise and knowledge on AI applications in auditing.

Lessons Learned:

1. The Importance of Integration Between Government and Private Sector:

Cooperation with local and international technology companies has proven highly effective in speeding up the accuracy of implementation.

2. The Necessity of Building Human Capacity:

Investing in trained personnel is a critical

component of any project's success.

3. Data is the Foundation:

Linking government databases is a fundamental step to achieving the effectiveness of smart applications.

4. Gradual Implementation:

Piloting on a limited scale before generalization helps improve models and reduce errors.

Summary

AI represents a promising future for the field of auditing and governance, providing powerful tools for understanding data and making informed decisions in record time. Institutions that adopt these technologies today will be at the forefront of tomorrow's leadership.

AI and machine learning are not just technical tools; they are a strategic means to enhance the effectiveness and efficiency of Supreme Audit Institutions (SAIs), and a means to strengthen bridges of cooperation and knowledge exchange between these institutions around the world. These technologies can be the cornerstone of a smart, collaborative audit model that meets

future challenges with confidence and transparency.

Recommendations

- SAIs should develop their infrastructure, invest in developing information systems, and provide an integrated digital environment capable of accommodating AI technologies.
- SAIs should establish specialized training programs in AI and big data analysis to ensure a deep understanding of modern digital tools and build human capacity.
- Strengthen cooperation among SAIs by exchanging expertise and best practices in the use of AI in auditing, as well as in auditing AI tools used by auditees.
- Promote efforts to leverage AI in predicting risks, combating corruption, and detecting abnormal patterns using AI tools to analyze financial data.
- Encourage research and development on the use of AI applications in auditing, in partnership with universities and specialized centers.

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Practical Applications in Auditing



AI Applied to Public Auditing: The TCU's Experience with ChatTCU and GABI

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importance of exploring AI's potential to improve efficiency and transparency in the use of public resources. A key example is ChatTCU, a generative AI tool developed to assist auditors with tasks ranging from quick queries to language standardization and increased productivity in audits.

More than just a technical solution, ChatTCU represents an institutional and cultural milestone, symbolizing a paradigm shift in TCU's operations, where innovation, ethics, and digital governance are articulated to enhance public sector oversight. This article shares TCU's experience with ChatTCU, its challenges, lessons learned, and the next steps the institution is taking in utilizing AI to strengthen public auditing in Brazil and internationally.

Introduction: AI as a Frontier of Institutional Innovation

Artificial intelligence (AI) has become a crucial tool in various fields, including public auditing, where innovative technologies can radically transform auditing and oversight practices. The Brazilian Federal Court of Accounts (TCU) has led the application of these technologies in Brazil, adopting AI in a responsible and effective manner to optimize its internal processes and public/government auditing.

In a global context of accelerated digital transformation, TCU, as Brazil's Supreme Audit Institution (SAI), has demonstrated the

ChatTCU: A Generative AI Solution for Institutional Support

ChatTCU was developed from a robust architecture based on large language models (LLMs), such as OpenAI's GPT-3, adapted to the specific context of public auditing. Its initial goal was to provide a quick and efficient solution for answering technical questions, drafting documents, and assisting with repetitive tasks that consume much of auditors' time, enabling them to dedicate more time on analytical and strategic activities.

The launch of ChatTCU in March 2023 was a major milestone in TCU's history. The tool was initially introduced as a pilot project, aimed at evaluating its feasibility and assessing positive impact on the day to day working of auditors. Since then, ChatTCU has been gradually integrated into the work environment of more than 2,700 TCU staff members, representing about 90% of TCU's workforce. By May 2025, ChatTCU had processed over 650,000 messages, demonstrating its widespread adoption and the trust auditors have placed in the tool.

This initial success was the result of careful development and continuous adaptation of the tool to meet the institution's needs, including technical adjustments to ensure terminological accuracy and alignment with

TCU's normative framework. Additionally, the integration of ChatTCU into the internal audit system facilitated its use by all auditors, allowing documents and working papers to be automatically included in ChatTCU's context window, leading to greater clarity and efficiency in audit stages and decision-making.

Figure 1 illustrates ChatTCU's context window displaying a summarized assistant response to the question “How can you help me in my work as a TCU auditor?” The assistant outlines key support functions, including access to TCU normative framework and jurisprudence, document summarization, administrative guidance, and research assistance — highlighting its potential to streamline audit-related tasks.

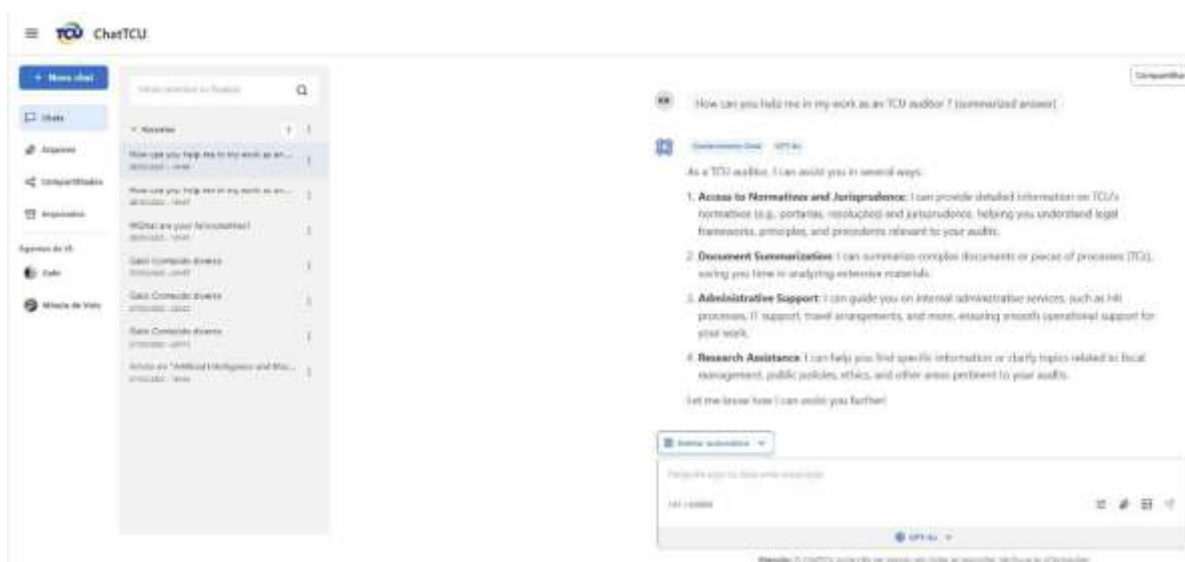


Figure 1 – ChatTCU context window showing auditor support capabilities

Sharing with Other Institutions and External Impact

Recognizing the positive impact of the tool within TCU, the institution decided to adopt an open and collaborative stance by making ChatTCU's source code available to other public entities. This decision aims to promote interinstitutional cooperation and extend the

benefits of AI usage to other government organizations, such as state audit courts, regulatory agencies, public defenders' offices, and universities. To date, 99 institutions have signed agreements to use ChatTCU's code, demonstrating its effectiveness and appeal across different sectors of government.

In addition to sharing the code, TCU has provided technical support, documentation, and training to institutions that adopted the tool, ensuring that ChatTCU is implemented efficiently and responsibly. This open and collaborative approach has been internationally recognized by the OECD (Organization for Economic Cooperation and Development), which, in 2024, highlighted TCU as the only public agency to achieve an advanced level of maturity in using generative AI in public administration. This recognition reinforces TCU's role as a leader in technological innovation within the public sector.

GABI: Automating Audit Minutes with AI

Another significant advancement in AI use at TCU was the creation of GABI (Automated Office of Good Ideas), a feature integrated into ChatTCU that uses AI to automate the transcription, summarization, and drafting of audit meeting minutes. During auditing processes, meetings with public managers often generate large amounts of information that need to be recorded and analyzed. Manual note-taking during these meetings

often hinders the flow of discussions and makes documentation labor-intensive.

With GABI, TCU transformed this process. The tool uses advanced AI models to convert audios, videos, and links (including from YouTube) into editable documents that include participant lists, meeting objectives, key discussion points, and conclusions. As a result, auditors can focus on more analytical aspects, while the documentation process becomes faster and standardized.

The productivity gains with GABI's implementation are significant, as the time spent on drafting meeting minutes has been drastically reduced, allowing auditors to focus on activities that demand critical thinking. Furthermore, GABI strengthens information governance at TCU, ensuring greater transparency and traceability of meeting records.

Figure 2 shows the GABI virtual assistant interface within ChatTCU, demonstrating how users can upload audio or video files to automatically generate structured meeting summaries.

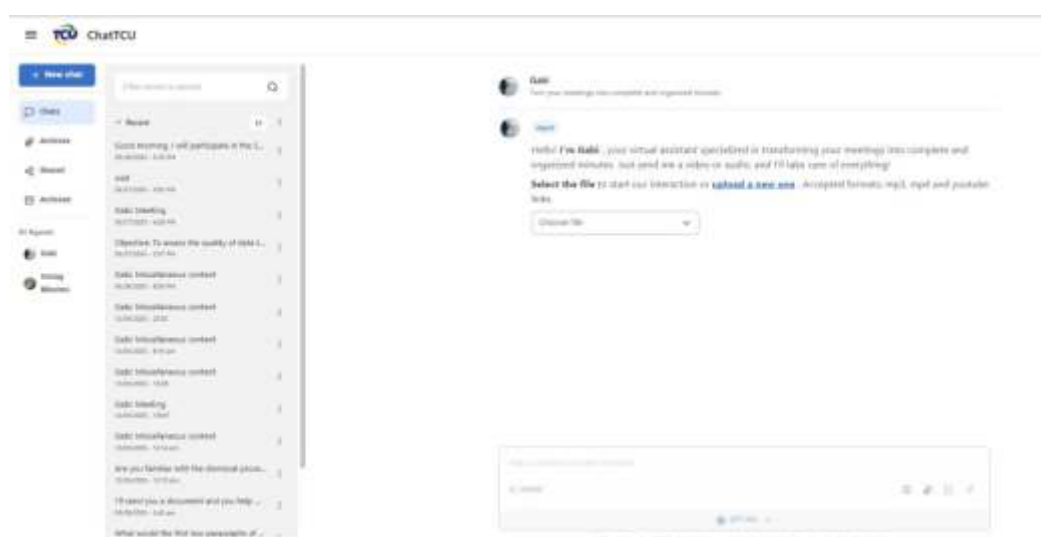


Figure 2 – GABI assistant integrated into ChatTCU

Challenges Faced: Technical, Institutional, and Ethical

Despite the progress, the implementation of ChatTCU and GABI was not without challenges. On the technical side, one of the biggest obstacles was ensuring that the AI models could accurately understand and respond within the specific normative and technical context of public auditing. This required continuous refinement of the models and adjustments to ensure terminological precision and alignment with TCU's guidelines.

From an institutional perspective, introducing AI at TCU required a significant cultural shift. Many auditors had to adapt to the new tool, which required investments in training and developing a digital mindset within the institution. While acceptance of ChatTCU has been gradual, it has been supported by a clear institutional commitment and ongoing efforts to demonstrate the benefits of AI for public auditing.

On the ethical front, the development of ChatTCU involved defining safeguards to prevent issues such as hallucinated responses and the leakage of sensitive data. The tool was designed to ensure transparency and auditability, with continuous feedback mechanisms to monitor and adjust the AI's performance as needed.

Lessons Learned and Recommendations

The experience with ChatTCU provided TCU with valuable lessons that can be applied by other public entities adopting AI. Key lessons include:

- Start with well-defined pilot projects, with clear planning and institutional support.
- Ensure technical governance from the outset, with active participation from IT, legal, and operational areas of the institution.
- Keep human oversight at the center of decision-making, using AI as a support tool rather than a replacement for auditors.
- Promote continuous training and create feedback channels to adjust the tool to users' real needs.
- Foster knowledge sharing with other institutions and encourage responsible reuse of technology.

Next Steps: Integration and Expansion

TCU is exploring new possibilities for expanding AI use across its operations. This includes analyzing large data volumes in audits, automating generation of audit reports, and integrating AI with risk dashboards. The lessons learned from ChatTCU have prepared the institution to incorporate machine learning (ML) into more specialized tasks, such as risk prediction and pattern detection in complex processes.

Conclusion

TCU's experience with ChatTCU and GABI demonstrates that AI can be applied pragmatically and responsibly in the public sector, delivering gains in efficiency, transparency, and governance. TCU stands as a reference point for technological innovation

in public administration, showing that it is possible to transform public auditing through the intelligent use of AI.

More than just a technological tool, ChatTCU represents a cultural shift within TCU,

embracing AI-assisted auditing. This project, which started as a simple solution, has the potential to transform the way SAIs operate for the benefit of society, making auditing processes faster, more efficient, and more accessible.

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SAI India's Initiatives on Artificial Intelligence in Public Auditing

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Introduction

The Supreme Audit Institution (SAI) of India has been at the forefront of integrating Artificial Intelligence (AI) into public auditing to enhance accountability, efficiency, and evidence-based decision-making. Recognizing that the scale and complexity of government programmes demand new analytical approaches, SAI India has pursued a systematic strategy to leverage AI for smarter audits. From fraud detection and beneficiary analytics to knowledge management and capacity building, these initiatives collectively mark a transition from traditional auditing to an era of data-driven, technology-enabled public oversight.

AI Initiatives

SAI India has been actively exploring and deploying Artificial Intelligence across multiple audit domains to enhance analytical depth, operational efficiency, and institutional learning. One of the key innovations is the use of **AI-driven image analytics** to detect ghost and duplicate beneficiaries in welfare schemes.

- By applying computer vision and facial similarity algorithms, auditors can automatically flag suspicious entries in beneficiary databases, enabling targeted

field verification and reducing leakages in public spending.

- This approach has already shown promise in social sector audits and is being extended to other schemes such as housing and subsidies.
- To ensure accessibility, SAI India has developed an AI tool called “*Artificial Intelligence*” which is a user-friendly application, allowing auditors to perform image-based verification without writing any code.

Another initiative involves the use of network analytics for **detecting collusion in public procurement**. This methodology combines graph theory, the Apriori algorithm (an unsupervised machine learning algorithm), and entity resolution to identify patterns of coordinated bidding behaviour across tenders. AI models analyze co-bidding networks, shared identifiers, and transactional overlaps to flag potential cartels.

- Beyond detection, SAI India is now integrating these analytics into its risk assessment frameworks, enabling field offices to identify high-risk entities during audit planning.

- This marks a shift from reactive to proactive auditing, where AI helps prioritize audit targets based on systemic risk indicators.
- The entire workflow is being converted into a no-code application, empowering auditors to conduct complex network analysis through intuitive interfaces.
- The chatbot interface will be fully no-code, ensuring that auditors across field formations can access and utilize its capabilities without any technical barriers.
- This initiative not only enhances audit productivity and standardization but also lays the foundation for future innovations such as predictive risk modeling and AI-assisted fraud detection.

In collaboration with Indian Institute of Technology (IIT) Madras, SAI India is developing a domain-specific **Large Language Model (LLM)** tailored to the unique requirements of public sector auditing. Unlike generic AI models, this LLM is being custom-trained on internal audit documents such as Inspection Reports, Draft Paragraphs, Separate Audit Reports, and procedural guidelines, enabling it to understand audit-specific terminology, workflows, and compliance logic.

- The model will power an AI-based audit assistant chatbot that provides auditors with real-time access to similar content from past audit reports, helps in drafting memos and paras, and offers contextual references from Public Accounts Committee decisions, manuals, and circulars.
- Designed with a secure, self-hosted architecture, the system ensures confidentiality while supporting semantic search, editorial guidance, and interactive document querying.
- A knowledge graph is also being developed to interlink audit entities, rules, and precedents, allowing deeper contextual reasoning and structured insights.
- In parallel with these technological deployments, SAI India has also prioritized **capacity building** to ensure that auditors are equipped to engage meaningfully with AI tools and methodologies.
- In collaboration with premier institutions such as IIT Madras and IIT Delhi, customized training programs have been developed specifically for SAI India, focusing on real audit use cases involving AI and machine learning.
- These programs combine conceptual grounding with hands-on exposure to AI applications in public auditing, such as anomaly detection, predictive analytics, and natural language processing, ensuring that auditors can interpret, apply, and critically assess AI outputs in their day-to-day work.
- This strategic investment in human capital complements the development of no-code applications, creating a robust ecosystem where both tools and users evolve together to meet the demands of modern auditing.

Conclusion

Through these initiatives, SAI India is steadily integrating Artificial Intelligence into its audit ecosystem in a practical and purposeful manner. The collaboration with academic institutions, combined with in-house development and user-friendly tools, reflects

a measured approach to innovation, one that strengthens audit quality, consistency, and efficiency. By embedding AI into its audit workflows, SAI India aims to enhance evidence-based decision-making and contribute to more transparent and effective public financial management.

Artificial Intelligence and Machine Learning in National Projects Audit



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Keywords

DFOG (Duplication, Fragmentation, Overlap, and Gap), BERT (Bidirectional Encoder Representations from Transformers), ML (Machine Learning), RF (Random Forest), KNN (K-nearest Neighbors), PLSA (Probabilistic Latent Semantic Analysis), ROC analysis.

Following international standards (ISSAI 130; ISSAI 300) the Accounts Chamber of the Russian Federation is open to the new and strives to introduce innovations in its audit activities, along with the basic principles of critical approach, objectivity and professional skepticism. One of the key innovations in the work of the Accounts Chamber is the use of algorithms based on artificial intelligence (AI), including machine learning (ML).

External government audit of national projects has been recently developed; however, it was considered to be mainly focused on non-typical tasks, where algorithmic optimization does not give the

necessary effect in terms of scale or carries unacceptable consequences of errors. At the same time, considering that the data analyzed in the course of national projects audits has already reached the big data scale, and considering the growing lack of resources for their processing, using AI algorithms becomes almost inevitable.

Among specific examples of the application of AI and ML over the last year in the Accounts Chamber within the framework of the audit of national projects, let us highlight the following.

Portfolio analysis for duplicate entities

When handling a significant portfolio of projects that does not have any standardized work decomposition structures (events/results/goals handbook), there is a possibility of duplication of these categories within a single project (vertical duplication) or across projects (horizontal duplication).

A good chunk of an auditor's work is focused

on finding and analyzing those duplications, in particular, under the DFOG concept (Duplication, Fragmentation, Overlap, and Gap)¹.

In some cases, duplication is not a negative practice: for example, it can reflect standard project activities applied to different objects (such as “engineering surveys” at unrelated construction projects) or decomposition of an aggregate indicator (such as “revenue growth”).

In general, duplication should be a point for close attention because it violates the MECE² principle and can lead to deviations, like parallel financing of the same job, clone activities, accounting misstatements (redundant information, entities not in line with their hierarchy levels, etc.). All these phenomena carry risks of unsubstantiated expenditures and incorrect management decisions.

The issue of finding duplicates can be solved by various applied methods. Perhaps, the easiest approach to implement is tokenization (breaking down into constituent elements) of work/events/results/goals names into alphabetical symbols with subsequent comparison based on the principle of “everything against everything”. The similarity metric in this case is the difference between numbers of specific symbols in names being compared. The advantages of this algorithm are the simplicity and interpretability, as well as the fact that it can be done in Excel with no extra costs. The disadvantages include sensitivity to synonyms, abbreviations, dilution of the

meaning by extraneous words and amphibology (double meaning, see, “Eats shoots and leaves”).

More complex and advanced algorithms for searching duplications are based on other metrics, including the Levenshtein distance, known in information theory. As an example of practical implementation of more complex algorithms, let us take a look at the Excel “Fuzzy lookup” module based on Fuzzy Logic. The search for duplicates can be organized in a more convenient way by using Excel “Power Query”, a fuzzy comparison query merge tool. Even more powerful tool for duplicate analysis is the AI-based language models like BERT (Bidirectional Encoder Representations from Transformers) which eliminate many of the weaknesses of simpler algorithms, in particular concerning the search for synonyms.

If multiple duplication is expected (in particular, both vertical and horizontal duplication), clustering is recommended for detecting unique entities. If relying on the single metric (e.g. Levenshtein distance), clustering can be performed by identifying connected graphs. For example, if duplication is detected between events A and B and also (independently) between events B and C, then, by representing the letters as points on a graph, we can say that the A-B-C graph is connected. In this way, a transition is made from detecting duplicating pairs to detecting groups (or clusters) with a certain degree of similarity in all entities within them. Then, a managerial question is posed about the causes for duplication and, possibly, about their elimination. If we have to cluster using

¹ <https://asosai.org/asosai/upload/file/202308/62322.pdf>

² Mutually Exclusive, Collectively Exhaustive is a managerial principle requiring that the totality of elements should be exhaustive and not overlap.

multiple metrics (for example, correlation between planned or actual indicator values on top of the Levenshtein distance), specialized clustering algorithms may be applied, including those using the ML – K-means, Probabilistic Latent Semantic Analysis (PLSA), etc.

Admittedly, no algorithms listed above can fully eliminate the subsequent need for “manual” analysis, but, according to the experience of the Accounts Chamber, they reduce the labor intensity by several times due to the decrease in the amount of analyzed information.

Key risk indicator system for national projects implementation

An important stage in operational analysis of national projects is the assessment of probability that the events included in them will be implemented on time, which ultimately determines the success of the project implementation as a whole. In order to solve that problem, we have developed a set of indicators calculated on the basis of credible data taken from periodic project status reports, such as the share of milestones achieved on the federal and regional levels, trends for their achievements, implementation issues encountered in previous years, etc. In this regard, firstly, there is the task of assessing the importance (weight, significance) of each of the indicators, and secondly, the task of predicting the probability of implementation of an activity (or, conversely, the risk of its non-implementation).

A possible way to solve the first issue is to analyze retrospective data on successful implementation of measures in connection with relevant indicators, using various approaches, such as the construction of regressions. The second issue can be solved using the Random Forest (RF) ML algorithm³. The method consists of developing an array of decision trees and using them to calculate a number of metrics, including MDI⁴ (mean decrease impurity) that can be interpreted as improving the model quality when adding a certain factor to decision trees.

Once the list of risk indicators has been identified and relevant information on them has been obtained via periodical monitoring, the task of forecasting the risk of events failure arises. Qualitative assessment can be done using a scoring model that calculates the number of “triggered” indicators. For quantitative assessment of the probability of the events' success, more advanced algorithms have to be used, such as K-nearest neighbors, or KNN, a ML algorithm used predominantly for classification purposes and built around the following principle. If in a factor space, among KNN of an unclassified point, there are more points of one class than another (more “red” points than “purple” points, for example), then the unclassified point is likely to be “red”.

Using the algorithms described in the context of the risk-oriented approach adopted by the Accounts Chamber, a system of key risk indicators has been created, which enables to detect the problematic events within national projects in advance and assess

³ Breiman, L. Random Forests. Machine Learning 45, 5–32 (2001). <https://doi.org/10.1023/A:1010933404324>

⁴ https://scikit-learn.org/1.5/auto_examples/inspection/plot_permutation_importance.html

adequate response measures. A dashboard is used to visualize risk indicator data in the context of projects and relevant events.

The first results of the key risk indicator system analysis, based on the ROC-analysis methodology⁵ for 2024, indicate good predictive capabilities of the model. At the same time, the model needs improvement in a number of parameters, in particular, increase of selectivity, which can be achieved by improving the list of risk indicators used.

The development of the key risk indicator system is focused on expanding the range of its application, in particular, within the audit materiality criteria, and includes tasks related to improving accuracy and timeliness of detection of project events at risk of failure: development of new, science-based indicators, including those that account for events' specifics (construction, procurement, etc.), increasing the frequency of assessments and operationalization of follow-up audit.

⁵ See, e.g., Davis, Jesse & Goadrich, Mark. (2006). The Relationship Between Precision-Recall and ROC Curves. Proceedings of the 23rd International Conference on Machine Learning, ACM. 06. 10.1145/1143844.1143874.



Transforming Auditing with Artificial Intelligence

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Introduction:

Artificial intelligence (AI) has become a general-purpose technology (GPT) in the current era. AI is a pervasive technology and being used in nearly all fields of industry, society, and governance, and auditing is not an exception. Traditionally, auditing is considered a labour-intensive, monotonous, and repetitive task. Traditional auditing has relied on statistical sampling techniques and manual verification, analysis, and interpretation of records. The increasing use of digitalization and internet is contributing to exponential growth in data. However, the humans are limited by capacity to interpret and analyse a huge volume, which creates a challenge in uncovering deeper insights. AI proves to be highly beneficial in efficient analysis and interpretation of such a huge data. Thus, auditors leverage advanced AI tools and algorithms to analyse large volumes of data more accurately and efficiently. These AI and Machine Learning (ML) algorithms can detect violations in compliance with regulatory requirements, detect anomalies, and flag potential frauds. AI is enhancing the reliability and speed of audits, allowing auditors to focus on higher-value tasks such as strategic analysis and risk assessment.

Use of AI in auditing raises concerns about data security, ethical use, and model transparency. Thus, a careful selection of an

AI model, relevant data, and well-thought-out interpretation with human experts is essential. Despite these above concerns, AI offers significant benefits such as deeper insights, anomaly and trend detection, risk mitigation, and more informed decision-making. Many firms identified the opportunity and potential of AI in auditing and started using it. The lead has been taken by the big four Deloitte, PwC, EY, and KPMG to develop AI-based platforms for auditing. The smaller firms are not untouched and internal audit teams have started exploring and adopting AI. Moving from traditional auditing to AI-based auditing is a challenging process. It requires a strategic transformation with thoughtful planning, skill development, and process reengineering. The article provides an overview of AI technologies for core audit functions, a practical roadmap for transitioning from traditional to AI-empowered auditing. To set the context, we first review the evolution of AI practices in both global and Indian private audit firms.

Evolution of AI use in Auditing:

Auditing firms started exploring the use of AI and ML to overcome the challenges and ease the process of audit. In early applications, firms like PwC applied machine learning to solve basic audit tasks. Journal entry auditing is one such task, which has traditionally been performed manually through sampling.

PwC's Halo analyses all journal entries for audit using clustering learning and principal component analysis¹. Thus, the use of AI tools helps in two ways: improving performance by scanning all entries and saving time by reducing manual work. It helps auditors to focus on high-risk entries thus improves efficiency of audit. Deloitte developed an AI-powered audit platform Argus to enhance the audit process by automated document review. It uses natural language processing (NLP) and ML algorithms to analyse and extract key insights from electronic documents like invoices, contracts and agreements². Argus leverages AI algorithms to detect potential anomalies in financial data and performs prediction analysis to anticipate potential areas of high risk. The complexity of financial reports is increasing with requirements of standards like International Financial Reporting Standard (IFRS) 16. The ever-growing volume of data with complex financial reports is making traditional auditing even harder to effectively identify risk and ensure compliance. The increasing data with high complexity compelling the development of sophisticated AI models for audit. EY developed an AI-based platform called Document Intelligence to extract critical insights for a wide variety of electronic documents, include PDFs, Word documents, scanned images, and other OCR-compatible formats. EY's Document Intelligence handles structured and unstructured data using optical character recognition (OCR), and advanced NLP models such as BERT to exact key insights.

EY developed Document Intelligence to handle lease audits. This platform combines advanced NLP models such as BERT with optical character recognition (OCR) to extract key terms and conditions from thousands of lease contracts, including scanned paper documents. The platform improves accuracy of audit and speeds up document analysis and reduces document review time by 80%. KPMG developed Clara; a cloud-based platform built on Microsoft's Azure. It provides a real-time interaction with audit team and client. Clara utilizes transformer-based QA models, generative AI and other ML-based models to automate the routine audit tasks³. It focuses on predictive audit scoping to identify high-risk areas in audits. Bindr Dijker Otte (BDO) has been developing AI platforms to enhance data analytics, anomaly detection and compliance testing. It developed BDO ADVANTAGE, a digital suite to empower high quality audit experience⁴. The platform uses NLP techniques for smart summarization, ML models for anomaly detection and risk prediction. BDO ADVANTAGE uses robotic process automation (RPA) tools like UiPath and Blue Prism. It is powered by generative AI models like GPT-4⁵. Protiviti developed AI solutions to provide end-to-end professional services related to blockchain-based digital assets⁶. Protiviti formed a strategic partnership with ConsenSys to provide efficient audits of blockchain and digital assets.

¹ PwC, Halo for Journals: Data-Driven Risk Assessment, 2023. [Online]. Available: <https://www.pwc.com>

² Deloitte, Argus AI: The Future of Real-Time Auditing, 2023. [Online]. Available: <https://www2.deloitte.com>

³ KPMG, Clara: Transforming the Audit with Predictive Analytics, 2023. [Online]. Available: <https://home.kpmg>

⁴ BDO Global, AI and RPA in Compliance Audits, 2022. [Online]. Available: <https://www.bdo.global>

⁵ Protiviti and ConsenSys, Blockchain Assurance: Smart Contract Auditing Framework, 2023. [Online]. Available: <https://www.protiviti.com>

⁶ Institute of Chartered Accountants of India (ICAI), CAQ Annual Report 2022–2023, Centre for Audit Quality, ICAI, 2023. [Online]. Available: <https://caq.icai.org>

AI Technologies for Core Audit Functions:

As discussed in the earlier section, AI is reshaping the future of auditing. It is improving the efficiency, accuracy by

transforming core audit functions. However, Transforming traditional auditing to AI-powered auditing is not just using another technology.

Audit Task	AI Tools / Models
Data & Anomaly Analytics	Python, Power BI, Tableau, Scikit-learn
Fraud Detection & Monitoring	IBM Watson, SAS, Autoencoders, ACL Robotics
Audit Planning & Risk Scoring	Decision Trees, Oracle EPM, RiskLens
Document & Journal Review	Textract, ABBYY, Alteryx, SQL-based engines
Reporting & Decision Support	ChatGPT, BloombergGPT, Power BI
Internal Controls Testing	SAP GRC, Splunk, Exabeam, NLP-based control analytics
Compliance & Regulatory Mapping	BERT, RoBERTa, LogicManager, Deloitte RegHub
Tax Auditing	Wolters Kluwer CCH Axcess, Alteryx, NLP for tax laws
Audit Trail Integrity	EY OpsChain (blockchain), Azure Sentinel, Elasticsearch
Client Collaboration & Workflow Automation	UiPath, Power Automate, Teams/Slack Bots

Table-I

It needs well-thought strategic road map. A sound understanding of these AI tools and techniques is required to develop an AI ecosystem in audit firms. To get a familiarity with AI tools, core audit tasks and corresponding AI tools/models are presented in Table I. These AI and machine learning algorithms includes various technologies, including machine learning algorithms like decision trees and clustering, natural language processing models such as BERT and RoBERTa, RPA tools like UiPath, and data analytics platforms like Power BI. The core audit tasks include audit planning, anomaly/fraud detection, risk scoring, journal review, internal control testing,

compliance and regulatory mapping, auditing reporting etc.

Adopting AI in Auditing:

As discussed in earlier section, AI has emerged as a crucial technology in auditing, still adopting it in traditional audit firms is a challenge. This article provides a roadmap to adopt AI in a traditional audit firm.

i. Strategic Alignment:

Adopting AI in auditing requires organizations to begin with strategic alignment. This involves establishing a clear vision for how AI will contribute to audit objectives, such as increasing operational efficiency, enhancing

fraud detection, or achieving compliance with evolving regulatory standards. This vision must be supported by top management and well rooted within the broader strategy of the organization. Complete change from a traditional auditing firm to AI-powered audit firm in one go is not advisable. The firms should identify the main pain points in auditing. This will help in selecting the use cases that resonate with core audit challenges. It helps in prioritizing investment and demonstrating return on innovation. With a well-thought strategic alignment and clear starting use cases, the organization can avoid fragmented pilot projects.

ii. Building a Cross-Functional Team:

A dedicated in-house team is vital to drive the transformation towards an AI-powered audit firm. Although AI knowledge is essential for the team, domain knowledge is equally important. The organization must form a multidisciplinary team to combine the expertise of auditors with the AI expertise required to lead the transformation. In addition to the core and AI expertise, key managers of relevant operations may be included for smooth transition. This cross-functional team plays a pivotal role in aligning the adoption and development of AI platforms for auditing.

iii. Pilot Implementation:

As discussed under the heading "strategic alignment", selecting a pilot project aligned with broad objective of the audit firm is key to its successful transformation. The pilot project implementation is critical step towards full-scale AI adoption. It gives a mechanism to validate the effectiveness, scalability and adoptability in the organization. The controlled environment of pilot project provides understanding of the

implications of AI in auditing. One or two small parts of the audit process like checking invoices or spotting unusual transactions can be picked up as pilot project. Once a pilot is selected, cross-functional team can prepare a plan to execute the pilot. Auditors present in the team ensures the practical relevance, transparency and trust of AI model used in the process. Pilot implementation reduces risk and builds foundation to full-scale adoption to AI.

iv. Technology Selection:

Selecting appropriate AI technology is one of the critical phases in the adoption. It involves identifying the right AI tools, platforms aligning with requirements of the selected pilot projects. The choice depends on audit challenges like analysing contracts, anomaly detection, risk assessment, compliance etc. Once the objective and challenges are fixed, the team needs to select from the range of AI, ML technologies as listed in Table-I. The team should ensure the compatibility of AI technology with existing technology in the firm. It facilitates the smooth integration with existing audit, ERP, and data formats. The following check list may be followed in selecting suitable AI tools and platforms:

- i • Strategic Alignment
- ii • Building Cross-Functional Teams
- iii • Pilot Implementation
- iv • Technology Selection
- v • Workforce Upskilling
- vi • Process Reengineering
- vii • Governance and Compliance
- viii • Scaling and Automation
- ix • Continuous Improvement

- Define objectives of the audit
- Identify capabilities of AI technologies
- Assess the compatibility with existing technologies
- Set the expected accuracy, reliability and explainability
- Ensure technology compliance with data protection laws and regulations
- Check the scalability of AI technologies across audits and adaptability to various audit environments.
- Perform cost-benefit analysis of licensing, training and implementation cost verses value added through AI.
- Frame a strategy to deploy AI in the workflow and train the audit teams.
- Fundamental training on data analysis for understanding of data types, data quality and data governance.
- Familiarization with core concepts of AI and ML to understand how AI systems identify patterns, anomaly, and risk in audit.
- Develop proficiency in AI audit tools and platforms. Hands on training on these tools is key in this process.
- Developing critical thinking and analytical skills to interpret AI-powered audit results and ensure relevancy and accuracy.
- Developing the understanding of ethical use of AI, audit transparency, and compliance implications.

The management needs to decide whether to develop AI capabilities in-house or adopt commercially available AI platforms. The big firms like KPMG developed in-house solutions like Clara platform with capabilities such as predictive analytics, audit scoring, and interactive dashboard. Smaller firms normally prefer to adopt commercially available AI tools and platforms like Caseware IDEA, MindBridge AI, and TeamMate Analytics. In addition, other useful technologies include ML frameworks like PyTorch, TensorFlow, NLP models like BERT, GPT for contextual understanding.

v. Workforce Upskilling:

In transition to AI-powered auditing, upskilling of existing workforce is essential, especially for audit teams. Key areas for upskilling are as follows:

Audit firms are increasingly collaborating with academic and research institutions for such kind of upskilling for their workforce and bridging the skill gaps.

vi. Process Reengineering:

AI tools should not be considered just as an add-on to audit firms. It should be embedded to the lifecycle of audit. There should be rethinking about how audit tasks are performed and redesign them to take full advantage of AI capabilities. In other words, it is transforming the audit workflow into more data driven and automated processes. A structured approach to process reengineering is as follows:

- Identify and eliminate manual and repetitive tasks
- Redesign audit tasks for better integration and adoption of AI tools and techniques

- Redefine the role of auditors from low value tasks like data collectors to high value tasks like insight interpreters and risk advisors.

A thoughtful process reengineering helps in effective and reliable transformation to AI-powered auditing. Finally, the process engineering enables a firm to perform real-time, risk-focused auditing.

vii. Governance and Compliance:

Transformation from traditional auditing to AI-powered auditing requires a strict governance and compliance framework to ensure the responsible and ethical use of AI in auditing. This mechanism develops trust, ensure transparency, accountability and regulatory alignment by:

- Establishing a governance framework with clear roles and responsibilities for using AI in the audit firm
- Identifying the regulatory and audit standards applicable to the audit firms and ensure compliance with them.
- Documenting the working of AI model used to maintain the transparency and explainability.
- Implementing the risk control mechanism to detect and mitigate bias, irregularities and avoid over dependence on AI models.

Firms are encouraged to constitute ethics committees to review the process on time-to-time basis.

viii. Scaling and Automation:

After successful completion of pilots, the next step is to scale the AI solutions across the

audit functions of the organization. Remember, scaling is not just a replication of pilots across the all-audit functions. A systematic approach is required to identify and integrate what could work for broader audit functions. For efficient scaling, the firm need to advance from successful pilots to standardised modular components, which can be generalized to other audit functions. These reusable and configurable AI modules can ensure consistent audit performance and reduce the duplicate efforts. The scaling should involve a balanced mix of central governance and local flexibility. The central governance ensures the consistency in foundation AI models, architectures, data security and other policies and compliances. On the other hand, local flexibility is important to cater the need of specific functionality required for a industry or regulatory.

In addition, the firms should focus the automatization of repetitive tasks such as documentation validation, compliance testing, data extraction and formatting. In other words, robotic process automation (RPA) may be used to reduce digital labour along with AI modules, which are used to add digital intelligence.

ix. Continuous Improvement:

Transformation of traditional audit firm to AI-powered audit firm is not one-time process. It is a continuous improvement and needs regular updates. The audit firms should keep checking accuracy in various audit tasks, processing speed, client satisfaction, and false positives reported. AI is fast growing field and task that seems impossible today, may become reality in future. The firms should be continuously exploring and

adopting new AI tools and technologies. Feedback from auditor is very critical for such continuous improvements.

Conclusion:

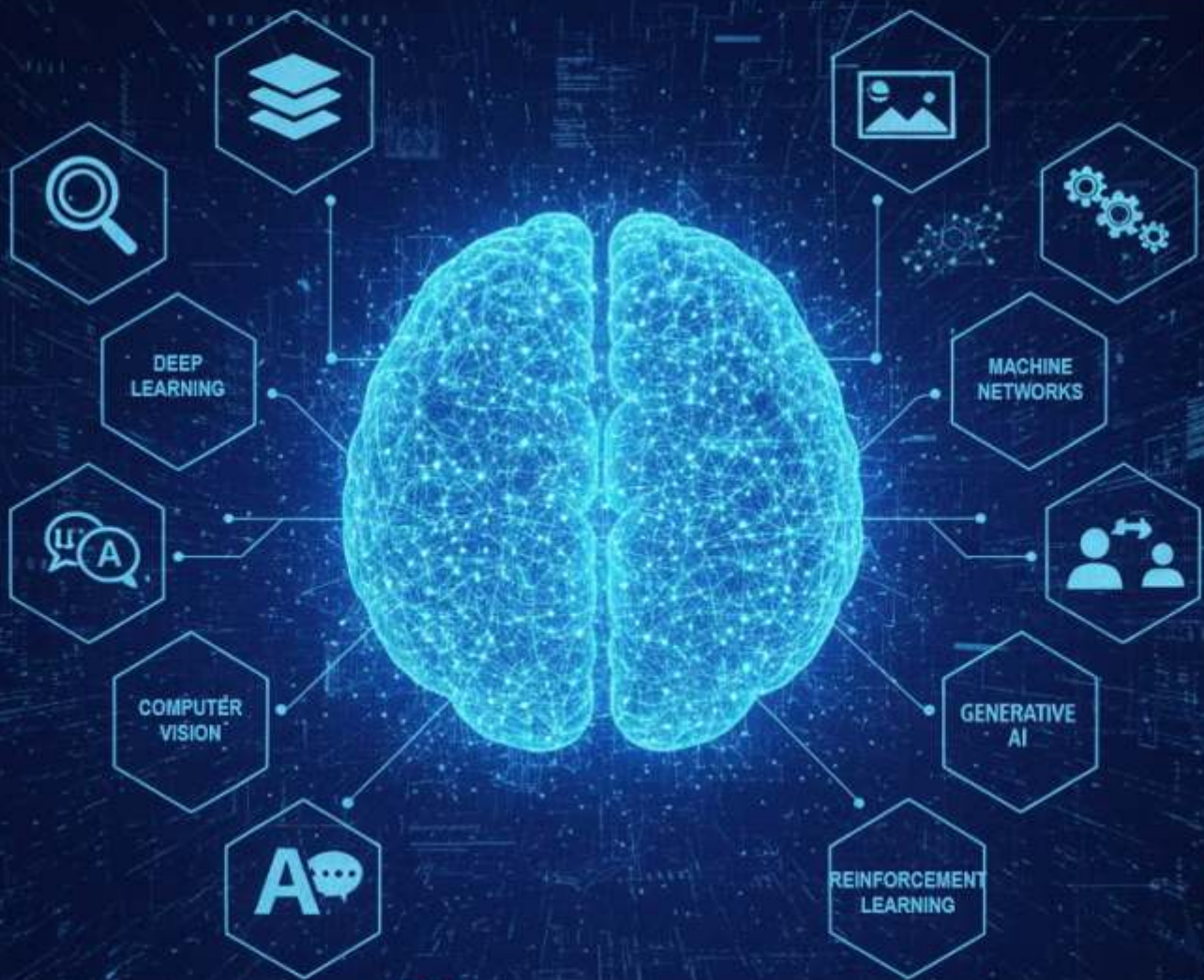
Artificial intelligence provides an opportunity to enhance the efficiency and effectiveness of the process across the key areas of audit. The big audit firms have taken a lead in utilizing AI for audit process and developed automated

platforms. Smaller firms are also moving in the same direction, but relatively with lower pace. This article presented a practical road map to transform a traditional audit into an AI-powered audit firm. The article focused on key steps like strategic alignment, AI tool selection, process reengineering and implementation. A well-planned and phase-wise approach can help the firm to become leader in AI-powered auditing.

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Understanding Technical Domains





Scaling and Emergence in Artificial Intelligence - Path ahead for auditing

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Extrapolating the spectacular performance of GPT-3 into the future suggests that the answer to life, the universe and everything is just 4.398 trillion parameters¹.

Geoffrey Hinton, Nobel Prize Winner 2024

In the winter of 2017, barely six months after Google scientists had unveiled the now famous "transformer" architecture, in a now popular paper called "Attention is all you need"², a young junior engineer at OpenAI named Alec Radford set himself a quiet weekend project. Rather than translating text from one language to another, Radford asked the model to guess the next word in seven thousand out of print English novels: romances, detective books, speculative adventures, covering the full domain of human knowledge. He coded and gave no grammar rules, no style guide, only stories. The network obliged, and with one word, then another, then whole paragraphs that seemed to have a rhythm, that it had never

been taught. It showed sparks of something new, something faintly spooky, that had emerged. Radford's tinkering lit the fuse that would become GPT-2, GPT-3, and eventually ChatGPT, along with a growing suspicion that large models don't merely scale in size but acquire unexpected abilities³. It did something that it was never programmed to do.

Emergence and Scaling - "Emergence is when quantitative changes in a system result in qualitative changes in behavior⁴." Emergence is a concept deeply rooted in AI now, describes how intricate, higher-level properties manifest when a model is trained beyond a threshold. The incredible power unleashed by scaling AI models to unprecedented sizes is the primary catalyst for these emergent abilities. However, this power comes with inherent unpredictability and new categories of risk.

¹ <https://x.com/geoffreyhinton/status/1270814602931187715>

² <https://arxiv.org/abs/1706.03762> paper "Attention is All you need" paper

³ <https://www.newyorker.com/books/under-review/can-sam-altman-be-trusted-with-the-future>

⁴ 1972 essay called "More Is Different" by Nobel prize-winning physicist Philip Anderson

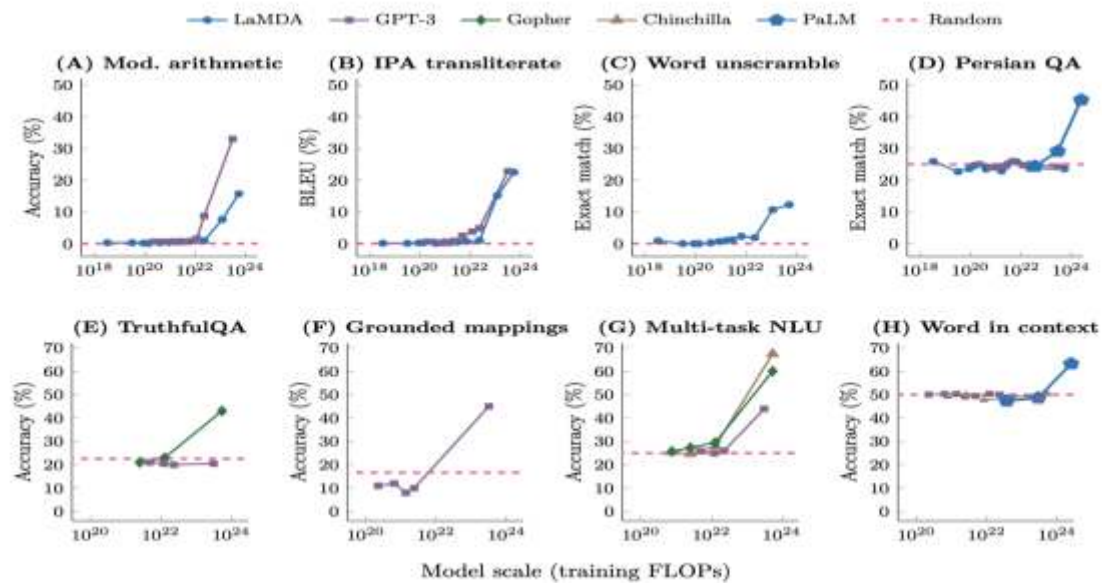


Figure1⁵: As model scale increases linearly (on X Axis), new abilities suddenly emerge at thresholds in leaps (Y Axis). From unscrambling words to acing multilingual QA, models like PaLM, Chinchilla, GPT- 3 cross invisible thresholds and gain intelligence.

The postulates for their emergence rest on a concept known as Scaling. A surprisingly predictable relationship (also referred as Scaling Laws)⁶ has been found: if one massively increases the scale of three key ingredients, the model's performance and emergent abilities skyrocket.

1. Model Size (The Brain): This refers to the number of "parameters"⁷ in the model, which are like the knobs and dials that the AI adjusts during training. It is estimated that GPT-2 in 2019 had 1.5 billion parameters and the very popular GPT-3 in 2020 had 175 billion. The models of today are estimated to have over a trillion.

2. Data Size (The Library): The volume of text, images, or code the model learns from. We've gone from curated datasets to scraping huge swathes of the public internet which is an unprecedented amount of information (like Common Crawl).

3. Compute Power (The Engine): The raw processing power which is used for training. This is one of the most significant investment areas for tech companies, involving massive centers of specialized computer chips running for weeks or months, which is called as training.

⁵ <https://arxiv.org/pdf/2206.07682>. For more, may read about the debate of usage of continuous and non-continuous variables usage on measuring the performance of the models.

⁶ <https://arxiv.org/abs/2001.08361> Kaplan. Further reading, see the Chinchilla Paper <https://arxiv.org/abs/2203.15556>

⁷ Parameters in an AI model are like knobs the model adjusts while learning, so it can make better guesses or decisions over time.

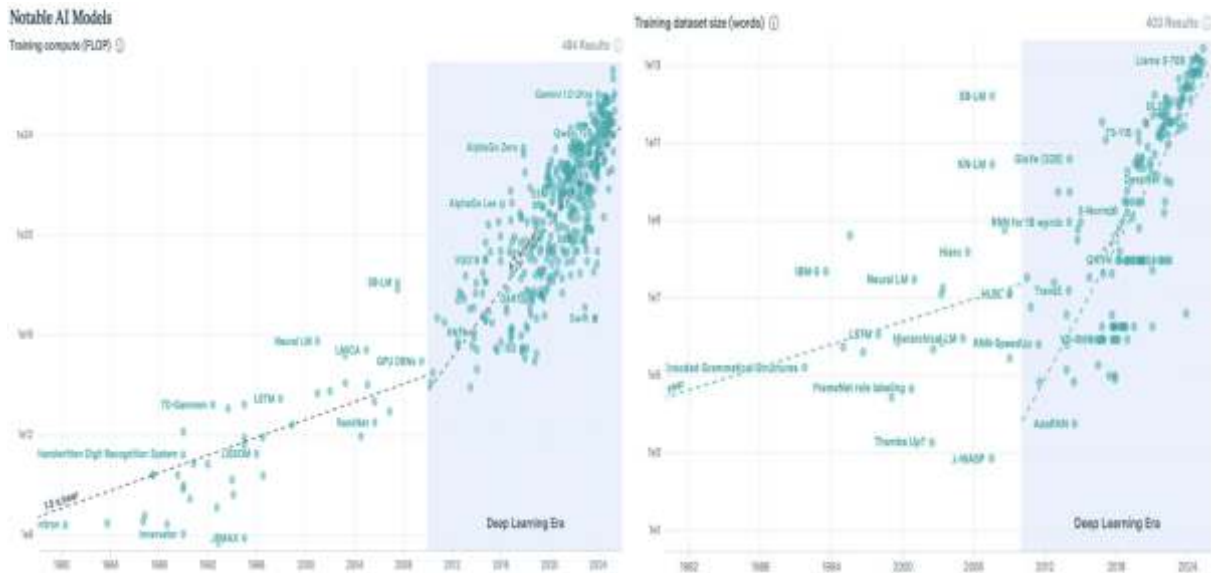
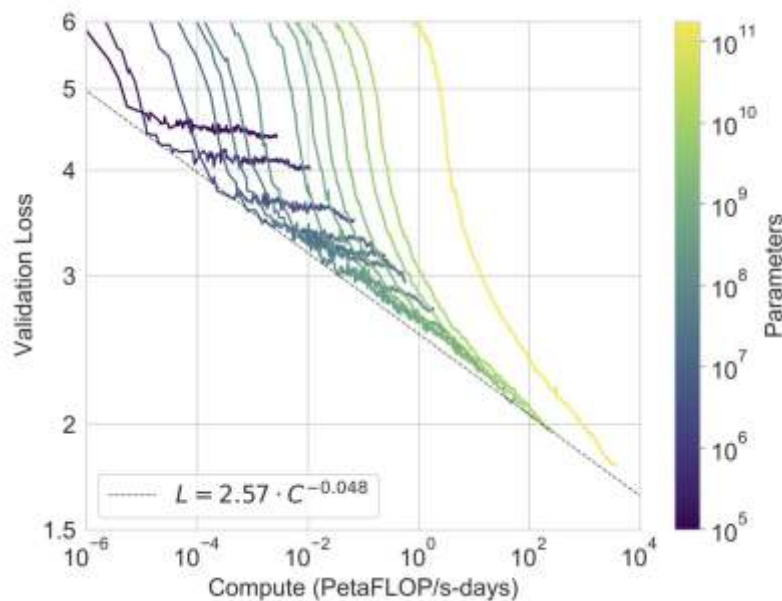


Figure 2 and 3⁸ show the trend of the increase of the Compute and Datasets over the years, in what is often described as 'exponential' growth.

But is this all approach a random chance, or is there a method to this AI madness? In 2020 OpenAI scientists, Jared Kaplan, Sam McCandlish and the enigmatic Ilya Sutskever⁹ plotted the error rate of dozens of transformer models against three inputs:

parameters, data tokens, and compute time. The result looked very strangely aligned, and a graceful power-law curve emerged (The graph below). It was found that a predictable improvement of performance based on these components/inputs was discernable.



Figure¹⁰ : This figure demonstrates the fundamental "scaling laws" in machine learning, showing how model performance (measured by validation loss on the y-axis) improves predictably as computational resources increase (x-axis shows compute in PetaFLOP/s-days).

⁸ <https://epoch.ai/data/notable-ai-models>.

⁹ <https://arxiv.org/abs/2005.14165> Language models are few shot learners

¹⁰ <https://arxiv.org/abs/2005.14165>

The Vertical Axis (Validation Loss): It can be thought of as "**Error Score**" on the test. A lower score is better, meaning the AI is making fewer mistakes.

The Horizontal Axis (Compute): This is the "**Amount of Time**" or computer power used to train the AI. The further to the right, the more time and energy were spent training.

The Colorful Wiggly Lines: Each line represents a different AI model being trained. The color tells you the size of the model's 'brain'. Therefore, the **Dark purple/blue lines** are smaller AI models. **Bright green/yellow lines** are very Large AI models.

What the Graph Shows: and why does it matter: The main point is very simple, that the more you train an AI (moving right), the better it gets (the lines go down), and therefore predictability of increasing the model trainings and making new mega data centers for the same. This gave the reassurance to the big technological players and researchers to start investing heavily in the AI models and trainings¹¹.

However, scale does not give only positive benefits. As the models grow, they also pick up capabilities which are inaccurate as well as dangerous. A phenomenon which is discussed mostly, in context of recent LLM based models, is called 'hallucinations', where the false information is presented with seemingly accurate demeanor and citations. The problem is a double-edged sword, where these incredibly powerful systems, give outputs that require enhanced verification and cannot be directly applied to critical systems and sub systems.

Auditing AI Systems:

Earlier, when an IT System or Platform was used by the government or a business, the methods for auditing were standard and gave the required assurance. The auditors could use the Rules, also test it to make sure it worked as expected. Most importantly, the creators of the Systems usually understood exactly how it behaved, and its actions could be traced back to specific lines of code.

However, modern AI is different where this classical approach faces problems. The powerful AI models are like 'black boxes' and its difficult to see why they make certain decisions. In this scenario it is unclear how can we truly know if these systems are safe? How do we ensure they are fair and doing what they're supposed to do? Emergence makes AI behavior **less predictable**, which in turn makes oversight much harder. This is exactly why a new field called "AI auditing and assurance"¹² is now becoming so vital. A robust framework of AI auditing will also allow the deployment of AI systems more trustworthy, and in turn lead it to be used widespread.

An AI audit, broadly speaking, is a systematic evaluation of an AI system's design, implementation, and effects. As stated by the GAO, the rapidly evolving pace of AI makes it necessary to establish a framework to independently verify AI systems¹³. An AI audit framework provides a toolkit for evaluators (be they government inspectors, external auditors, or internal compliance teams) to *ask the right questions and gather evidence* about an AI system's behavior. Auditing

¹¹ <https://www.forbes.com/sites/chriswestfall/2025/06/24/ai-investment-represents-new-gold-rush-for-investors-entrepreneurs/>

¹² <https://cag.gov.in/uploads/media/Artificial-Intelligence-Strategy-Framework-issued-by-CAG-of-India-068515070c7da65-91395536.pdf>

¹³ <https://intosaijournal.org/journal-entry/gao-groundbreaking-framework-for-ai-accountability>

forces a closer look at *outcomes* and *impacts*, not just intentions. For example, a public agency might deploy an AI system to help determine eligibility for a social program. The code isn't a simple set of rules; it's a machine learning model that emerged from training on historical data. Emergent behavior also means AI can change or "learn" new tricks even post-deployment (for instance, through online learning, or simply by being used in a new context). This makes **continuous monitoring** crucial. A one-time approval of an AI system isn't enough; ongoing audits or evaluations need to catch emerging issues early.

There are various frameworks of AI auditing, however for comprehensive understanding of the AI auditing ecosystem, one can look in life cycle approach, wherein, first, the training data itself can be examined by scanning through trillions of data to catch biases, copyrighted material, toxic content, and private information that shouldn't be there in the training data set. Then comes behavioral testing, where you try to break the trained model through red teaming (attempts to bypass safety measures) and (structured benchmarking against standards to see how it performs on those standards)¹⁴. The third stage then looks at how the model gets into real products. This can be done by checking whether there are appropriate content filters, human oversight for critical decision systems, and safety features that can't be easily manipulated by users. Finally, the last

layer for analysis is of the societal layer, which brings methods to assess the broader effects: environmental costs, job market impacts, power concentration, and potential for misuse like disinformation campaigns. These layers feed into each other constantly so a societal problem might reveal a system flaw or a design flaw that traces back to behavioral issues rooted in the original training data, making this more of a continuous loop.

It is also crucial to understand that all aspects of these audits cannot be done just by the traditional 'Auditors'. It will require deployment of technical teams by external auditors, transparency norms and internal audits and red teaming etc.

SAI Audits of AI :

Globally, various SAIs are assessing the Auditing Framework for AI. The Netherlands led the way with its 2021 Audit Framework for Algorithms¹⁵, which they applied to audit nine government AI systems in 2022, finding that only three met basic requirements while six had significant issues with bias, data handling, or performance monitoring¹⁶. The UK's National Audit Office has focused on building auditor expertise and created an international "audit catalogue" with five other countries¹⁷. This catalogue¹⁸ covers the lifecycle of an AI project and includes checklist also. Canada is taking a regulatory approach with its proposed Artificial Intelligence and Data Act, which would mandate independent audits of high-impact

¹⁴ <https://openai.com/index/advancing-red-teaming-with-people-and-ai/>

¹⁵ <https://english.rekenkamer.nl/publications/reports/2021/01/26/understanding-algorithms>

¹⁶ <https://intosaijournal.org/journal-entry/experiences-on-auditing-algorithms-and-artificial-intelligence-in-the-dutch-government/> #:~:text=Process%20of%20auditing%20algorithms

¹⁷ <https://www.nao.org.uk/insights/how-to-audit-artificial-intelligence-models>

¹⁸ <https://www.nao.org.uk/insights/how-to-audit-artificial-intelligence-models>

AI systems, while the US Government Accountability Office published an AI Accountability Framework in 2021¹⁹ with four key pillars: governance, data, performance, and monitoring.

SAI India has brought out a comprehensive document on AI Strategy Framework²⁰ which provides structured guidance on the adoption and on integration of AI tools and techniques across the audit lifecycle. The framework also underscores key considerations related to ethical use, data privacy, model governance, and capacity building. Also, in tandem, a massive capacity building initiative to upskill the workforce in cooperation with the leading institutions of AI, is being done on a large scale. This would enable an AI skilled workforce which can deploy the strengths of AI in auditing as well as be competent to conduct audits of AI systems.

Conclusion :

In 2025 the debate around AI swings between the “existential risk”²¹ and the “unlimited²² boon²³”. However the debates on emergence should invite a quieter, more empirical stance that the technology is still charting its own space, and neither enthusiasts nor sceptics can predict every turn. Therefore, the safest strategy is to insist on continuous evaluation and assessment, by the plot of curves, watching for steps, and treating each new leap as both an appreciation as well as an audit trigger. Our institutional response must be equally scalable and flexible enough to stretch with the next billion parameters.

The machines will keep climbing their staircase. The auditor's task is perhaps to keep the searching, light pointed upward, to prevent any stumbles.

¹⁹ <https://www.gao.gov/products/gao-21-519sp>

²⁰ <https://cag.gov.in/uploads/media/Artificial-Intelligence-Strategy-Framework-issued-by-CAG-of-India-068515070c7da65-91395536.pdf>

²¹ <https://www.youtube.com/watch?v=Yd0yQ9yxSYY> Please read further on by Eliezer Yudkowsky

²² <https://www.darioamodei.com/essay/machines-of-loving-grace>

²³ <https://blog.samaltman.com/the-gentle-singularity>



The Face of the Machine: How Computers Recognize Us

*Anil Goyal,
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When I started earning in the late 1990s, one of my earliest dreams was to own a digital camera. It felt like the height of modern living — capturing moments not on film, but as data. I finally bought one in the early 2000s and treated it like a prized possession. But within a few years, smartphones took over. What was once a luxury gadget soon became just another feature in every pocket. The digital camera faded quietly, but the technology behind it — digital imaging — became part of almost everything we use today, from phones and laptops to security systems and even doorbells.

That simple act of taking a photo has since grown into something far more powerful. The same technology that helped us store memories now helps machines identify people, verify identities, and even understand emotions. Artificial Intelligence (AI) and Machine Learning (ML) drive this change. They enable computers not just to record what they see, but to interpret it — deciding whether the person in front of them is you, a stranger, or someone on a watchlist. From airports and offices to social media and shopping apps, AI quietly runs in the background, connecting the physical and digital worlds in ways we barely notice.

But with such progress comes new worries. Every time a face is scanned or stored,

questions arise — who owns this data, how securely is it kept, and what else might it be used for? The same tools that make travel smoother or phones safer can also blur the line between convenience and intrusion. As AI continues to learn and adapt, we must find a careful balance between using technology for good and protecting personal privacy. The real challenge is not just how smart our machines becomes, but how wisely we use them.



Figure 1: Digi Yatra signboard at airport

How Machines First Learned to See

To understand how computers reached this stage, it helps to recall how they first learned to “see.” In the early days, computers were blind — they could only process numbers and text. The idea of digital vision began when scientists started representing images as grids of tiny dots, or pixels, each carrying a

value for brightness or color. From simple black-and-white shapes to full-color digital photos, machines gradually learned to handle images the way we see the world. Techniques like color processing and compression helped store and share huge amounts of visual data efficiently. These developments laid the foundation for what we now call computer vision — the science that allows machines not just to capture an image, but to understand it. And it's on this foundation that facial recognition was built — where computers moved from seeing faces to recognizing who those faces belong to.

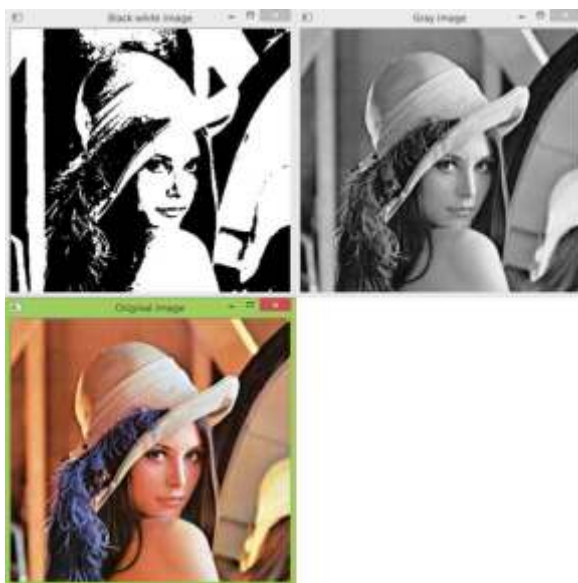


Figure 2 : Binary, Grayscale and colored versions of same image.

When Machines Started Recognizing Us

As this technology matured, it began to slip quietly into our everyday lives. What started as a technical challenge in laboratories is now part of ordinary experience — when we unlock our phones with a glance, pass through airport gates without showing a ticket, or get automatically tagged in a photo on social media. These things feel effortless, almost magical. Yet behind that magic lies a fascinating mix of mathematics, computer

vision, and artificial intelligence working together to make sense of visual data in real time.

Even though computers had learned to store and display images, that alone didn't mean they could understand them. To a machine, an image is still just a grid of numbers — millions of pixels arranged in rows and columns. It can tell the brightness or color value of each pixel but has no idea whether those values together form a tree, a cat, or a human face. Teaching a computer to detect what's inside an image requires another layer of intelligence — one built on mathematical models that can identify patterns, shapes, and relationships among pixels. This is where computer vision truly begins: when numbers start turning into meaning.

Step 1: Object Detection – Teaching a Computer to Spot Things

Before a machine can recognize a face, it must first detect it as an object within an image. Think of object detection as a game of “I Spy” for machines. Just as a child looks for familiar objects in a cluttered room, computers scan images to locate items of interest.

Imagine standing at a crowded railway station and trying to spot your friend in the crowd. Your brain does not check every detail; instead, it looks for patterns—maybe the bright red jacket your friend is wearing or their height compared to others. Computers work in a similar way, but instead of jackets or hairstyles, they look for visual patterns made up of pixels.

Computers achieve this, using feature extraction. A feature is simply a distinct, measurable pattern—like an edge, corner, or texture. For instance:

- A football can be recognized by its round shape and pentagonal patches.
- A stop sign is recognized by its octagonal outline and red color.
- A face is recognized by its unique arrangement of eyes, nose, and mouth.

Over time, with enough examples, algorithms learn to detect objects even when they are rotated, partially hidden, or seen in different lighting. Object detection is not limited to faces—it powers everything from converting handwritten notes to text to detecting vehicles in traffic/overspeed detection cameras.

Step 2: The Viola–Jones Breakthrough – The First Practical Face Detector

Detecting faces was once one of the toughest problems in computer vision. In 2001, Paul Viola and Michael Jones introduced a breakthrough algorithm that changed everything. Their method relied on Haar-like features—patterns of light and dark areas.

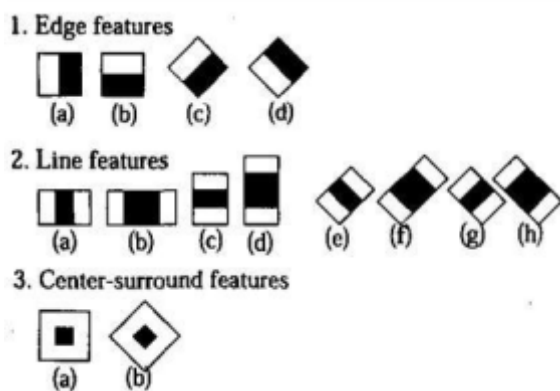


Figure 3 : Image source-Edge detection in Cassini astronomy image using Extreme Learning Machine

For example:

- The eye region tends to be darker than the cheeks.
- The bridge of the nose is usually lighter than the surrounding areas.

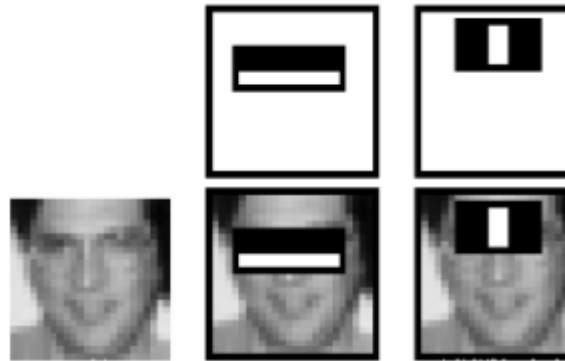


Figure 4 : Haar like features in Human face

The algorithm scanned the image with small rectangular filters to detect these contrasts. But here's the challenge: analyzing every possible region in an image would have been painfully slow. Imagine checking every square inch of a football stadium for a friend—it is impractical.

This is where the cascade classifier came in—a clever idea that worked like a security checkpoint:

- Quick, simple tests ruled out obvious non-faces (like flat walls).
- If a region passed, it went through more detailed tests.
- Only the most promising candidates reached the final stage.

This hierarchy allowed the system to detect faces in real time—even on ordinary computers of the early 2000s. Soon, digital cameras adopted it, enabling automatic face detection for better focus and exposure.

Think of a ticket checker at a stadium. They first glance at your ticket to see if it even resembles the correct format. If it looks wrong, you are waved away. If it looks fine, they check more carefully. This layered approach saves time—just like the cascade classifier.

The algorithm was so efficient that it became the backbone of early face detection in webcams, point-and-shoot cameras, and even early social media platforms. For the first time, machines could “see” faces fast enough to be useful in everyday life.

Step 3: HOG – Seeing the World Through Edges

While Viola–Jones was groundbreaking, it had limitations. It struggled with tilted heads, poor lighting, or side profiles. Enter the HOG (Histogram of Oriented Gradients) method—a technique that changed the game by focusing on edges and their directions rather than brightness or color.

Imagine tracing the outlines of facial features:

- Eyebrows form horizontal edges.
- The nose creates vertical edges.
- The chin forms a curved edge.

HOG divides an image into tiny cells and records which directions the edges point in each one. These are then combined into a “map” of the face.



*Figure 5 : 68 landmarks of human face-
by Brandon Amos*

This map acts like a fingerprint of the face's structure, making detection more reliable.



Figure 6 : HOG map from input image

It's like sketching a cartoon. Even if you draw only the outlines of the eyes, nose, and mouth, people can still recognize it as a face. HOG does the same by focusing on outlines instead of fine details.

Unlike Viola–Jones, which relied on brightness patterns, HOG could handle variations in lighting and pose better. It became popular in applications like pedestrian detection in self-driving cars and security systems.

Step 4: From Detection to Recognition – Putting a Name to the Face

Detecting a face is one thing. Recognizing who the face belongs to is another. This process is similar to how a human official verifies someone's identity using a photograph on an ID card. The machine does something similar, but with math.

This happens in three steps:

- **Face Encoding:** Once a face is detected, key landmarks are identified: the distance between the eyes, the curve of the jawline, the length of the nose, etc. Modern systems can measure 60–128 such features.
- **Vector Representation:** These features are turned into a mathematical vector (a list of numbers). This vector is unique to the individual, just like a digital fingerprint.
- **Comparison:** When a new face is scanned, its vector is compared to those in the database. If two vectors are close enough (using measures like Euclidean distance), it is a match.

Think of this like matching handwriting samples. Two signatures do not have to be identical, but if they share enough similarities in shape, size, and spacing, you can conclude they belong to the same person.

Step 5: Deep Learning – When Machines Teach Themselves

The real leap in facial recognition came with deep learning, especially convolutional neural networks (CNNs). Unlike HOG or Viola–Jones, which rely on human-designed rules, CNNs learn the features themselves.

Given thousands of labeled images, a neural network gradually learns what makes one face unique. It might detect subtle patterns we humans overlook, like tiny differences in skin texture or the way shadows fall across cheekbones. This has made facial recognition incredibly accurate—even under poor lighting, at different angles, or as people age.

Think of a passport control system at a busy international airport. Initially, it relied on human officers comparing photos with faces—a process easily tired and error. But modern systems use facial recognition powered by deep learning. Over time, these systems have scanned millions of faces, learning to distinguish subtle differences: the curve of a smile, the spacing of the eyes, or even how aging affects facial features. Just as an experienced immigration officer develops an instinct for spotting mismatches, convolutional neural networks (CNNs) build expertise by learning from vast datasets—becoming very accurate at identifying individuals across lighting conditions, angles, and expressions.

Conclusion: The Human Reflection in the Machine's Eye

Facial recognition is not just about teaching machines to see faces. It's about teaching them to recognize identity, uniqueness, and presence. From Viola–Jones' rectangles to today's deep learning advances, the journey reflects both human creativity and our hunger to make machines more like us. Yet, the technology also holds up a mirror: it forces us to ask how much recognition we are comfortable with, who gets recognized, and who controls the data.

Just as every face tells a story, every step in this technological journey tells us something about ourselves, our creativity, our values, and our vision of the future.

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Harness the Power of Voice AI: Practical Projects in Speech Recognition, Synthesis, and Control

*Piyush Tiwari,
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Introduction

Imagine stepping inside a classroom at the International Centre for Information Systems and Audit (iCISA). Curiosity fills the atmosphere as participants from Latin America, the Middle East, and Africa come together for a session on audit using the emerging technologies. As the faculty commences their presentation of insights, the real-time captions greet every learner in their own language, while the voice of a warm interpreter reads the content aloud for visually impaired participants.

The vision described so far should not be considered as a futuristic idea or a flashy tech showcase. This idea, though not yet a reality at iCISA, is single-handedly achievable through the TTS and automatic STT conversions made possible by Python. So these are Python-assisted developments that are quietly making their way forward.

Till now, human translators and Wordly, Zoom live translator, and Microsoft translator have been used to bridge language divides. These yielded wonderful results, especially with the Spanish and Arabic sessions, though scaling and customization remained a

challenge. With speech-to-text and text-to-speech being woven into our training workflows, we are now building e-learning modules that are multilingual, literally speaking! These modules, once born, can be read and heard, were also interact with a few; thereby keeping the learning environment more inclusive and accessible.

In an era where cross-border training and global collaboration are vital, these AI-powered technologies help ensure no participant feels left out due to language or accessibility barriers. They transform the learning experience into something more human, more inclusive, and more adaptable. At iCISA, we have seen these tools bringing transformational changes in terms of training worldwide. The tools not just break down the language barrier; they also humanize the learning experience. With the research expanding into regional languages like Marathi, Hindi, Telugu, Punjabi, and Kannada, the area of learning potential is further broadened.

So now let us take a tour of how these tools are engineered, with Python, and the tangible difference they are making in public sector capacity building.

Methodology

The use of voice processing tools is certainly not a one-time affair. Rather, it is a continuous adaptation process, facilitated through machine learning algorithms. Let us now look at the way Python paves the way for these intelligent implementations.

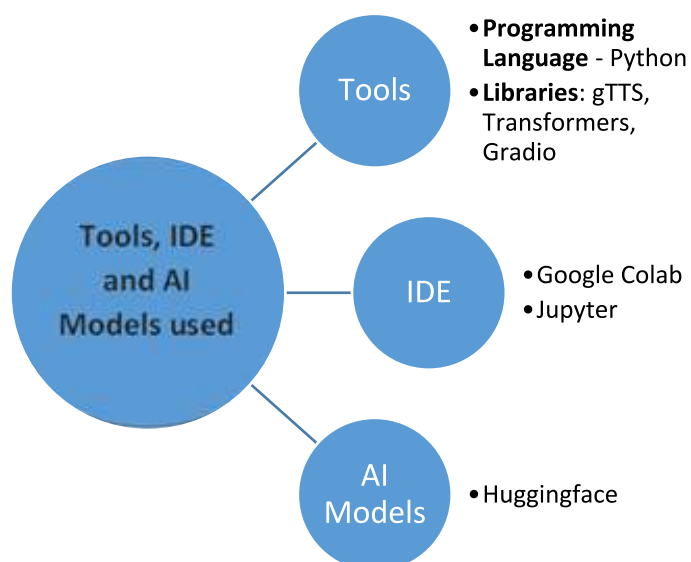
(i) TTS and STT?

Text-to-Speech (TTS): Converts written text into spoken audio. Useful for narrating documents, presentations, or notifications.

Speech-to-Text (STT): Converts spoken language into written text. Ideal for transcribing meetings, interviews, or lectures.

(ii) Tools, IDEs and AI Models used:

S. No.	Project	Tools Used	What It Does
1	Text-to-Speech (TTS)	gTTS, Gradio	Converts written text into spoken audio that can be played or downloaded.
2	Speech-to-Text (STT)	Speech Recognition, OpenAI Whisper	Handles real-time and recorded audio, converting it into text.
3	Speech-to-Speech Translation	Transformers, gradio, librosa,	Translates a language speech into spoken another language using AI-based speech synthesis.
4	Meeting Transcriber & Summarizer	DeepSeek	Generates written transcripts and concise summaries from recorded audio.
5	Voice Command Recognition	Gradio, Speech Recognition, transformers (by Hugging Face)	Used to load pre-trained models for automatic speech recognition (ASR). Enables voice-activated control of systems such as lighting and temperature.



(iii) Bringing Voice AI to Life: Real-World Projects in STT, TTS, and Beyond

(a) Converting Text into Voice-A Natural Voice for Words

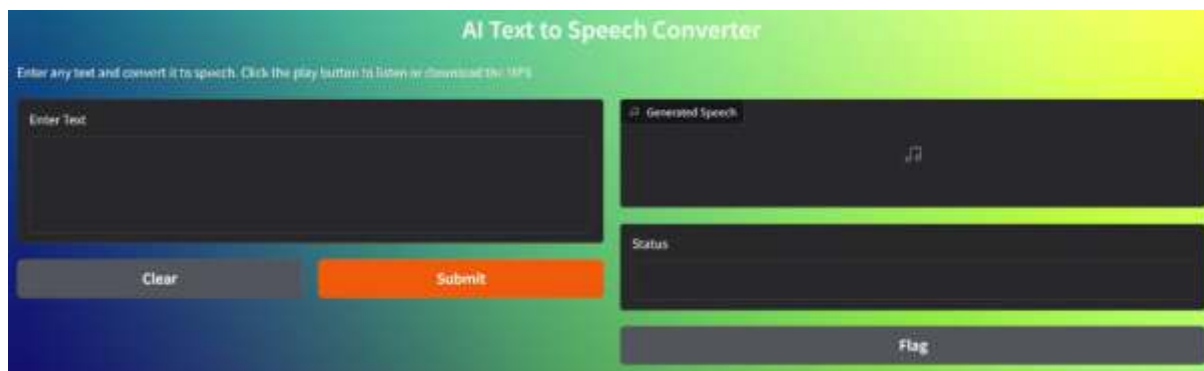
The Text-to-Speech System takes plain text as an input and processes it to generate spoken audio of a natural nature or voice. The evolution of this exercise starts when the user enters a phrase or paragraph via an interface. Raw input passes through preprocessing steps that remove noise such as unwanted punctuation, irregular capitalization, abbreviations, and inconsistent date formatting. Abbreviations are expanded, symbols are converted into words, and other conversions might be performed to aid in an accurate synthesis.

The preprocessed input text is used in linguistic analysis to separate word boundaries, syntax, and phonetics. Based on

this information, conversion into phonemes or a spectrogram is performed according to the model architecture being used. These spectrograms usually indicate a visual representation of sound frequency over time and are sent to a neural vocoder such as WaveGlow or Tacotron to generate the waveform. The sound output would be made available to the user for direct playback or to download for use-offline, thus offering a user-friendly solution of expressive voice outputs.

Use-cases:

1. Real Time Language Translation
2. Voice Command Recognition for IoT Devices
3. Medical Transcription
4. Virtual Assistants & Chatbots
5. Automatic Subtitle Generator



Result 1: AI Text to Speech Converter (Interface and Output)

(b) Speech to Writing : Making Interactive Transcripts

The speech-to-text or STT transcription system is by design made to generate highly accurate written transcripts from raw audio recordings. To start off, any user submits voice input in either recording mode or upload mode. This audio undergoes **initial preprocessing**, which includes noise reduction and Voice Activity Detection (VAD) to isolate the spoken segments and remove silence or background distractions.

During and after the preprocessing phase, acoustic features are extracted. In the generic manner of speech recognition, Mel-Frequency Cepstral Coefficients (MFCCs) are extracted, which carry spectral characteristics specific to the utterance. These utterance-specific features are then fed into the deep-learning-based acoustic model to

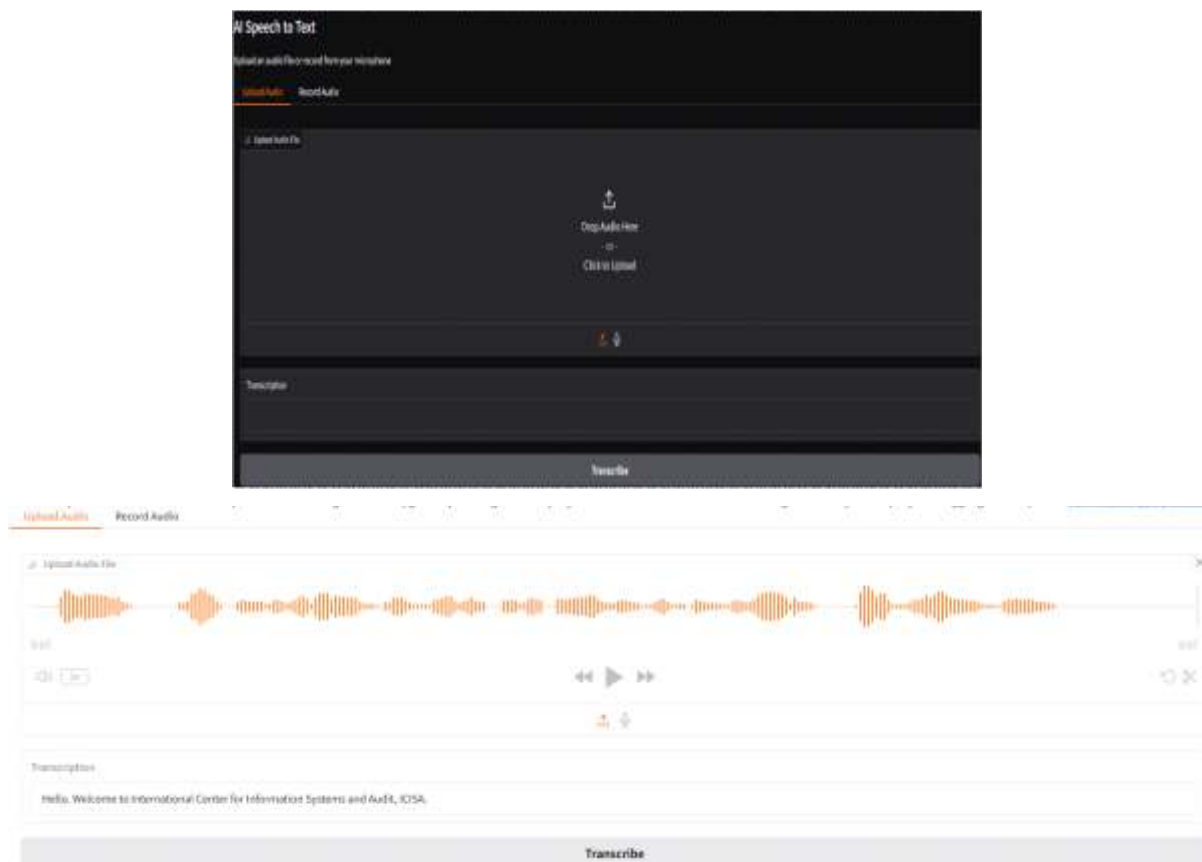
transform them into phonemes, which are basic sound units of a language. The language model then comes into play to basically bring in more context and grammar to the mix so it can polish the mapping from phonemes to words and generate a coherent transcription. Finally, this transcription is presented to the user in a complete and readable form, ready for export or further review.

Upload Audio: Allows users to upload an existing audio file (e.g., MP3, WAV).

Record Audio: Enables users to record speech directly using their microphone.

Technical limitations:

1. Misinterpretation of Accents and Dialects
2. Lack of Emotional Tone
3. Background Noise



Result 2: AI Speech to Text Converter (Interface and Output)

(c) From Speech to Speech Seamlessly: The Breaking of Language Barriers

This speech-to-speech translation system begins when the user uploads or records audio, usually in MP3 file format, using the Gradio interface. After receiving the input, the system loads the audio using Librosa, which also resamples the audio to 16 kHz for standard processing. The next step then involves recognizing the speech, wherein the OpenAI Whisper ASR model is used to transcribe the English speech into text with very high accuracy.

This English text is then fed into a translation module using MarianMT that transforms the content into Spanish. The Spanish text is fed into a TTS-engine—the Google TTS—that converts it into spoken Spanish. The response is then given to the user as Spanish text and corresponding speech, along with an acknowledgment of successful execution. This translation-from-speech-to-speech pipeline elegantly fuses ASR, machine translation, and TTS in real time.

System Architecture and Workflow:

- **Automatic Speech Recognition (ASR):** The system begins by loading the input audio file using librosa. The Whisper-small ASR model (openai/whisper-small) is used to transcribe English speech into text.
- **Neural Machine Translation (NMT):** The transcribed English text is tokenized using MarianTokenizer and translated into Spanish using the Helsinki-NLP/opus-mt-es model from Hugging Face Transformers. The model generates a Spanish translation from the tokenized input.

- **Text-to-Speech (TTS):** The translated Spanish text is passed to gTTS, which synthesizes the speech and saves it as an MP3 file using a unique filename.

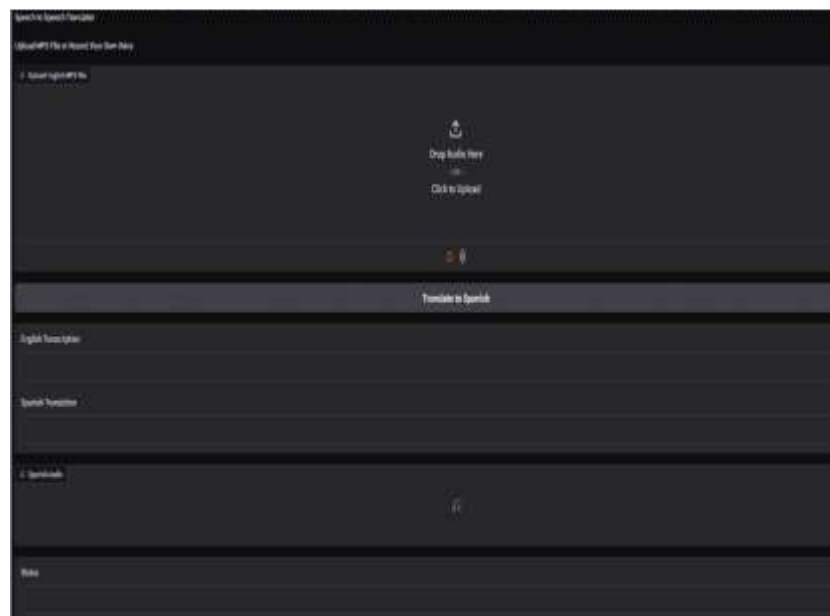
User Interface: Built with Gradio Blocks, the interface allows users to upload or record English audio, click a translate button, and receive:

- ✓ the transcribed English text,
- ✓ the Spanish translation,
- ✓ a playable/downloadable Spanish audio file,
- ✓ and a status message indicating success or failure.

Output and Applications: The system outputs:

- ✓ English transcription of the input audio,
- ✓ Spanish translation in textual format,
- ✓ Spanish audio generated from the translation.

Result 3: Speech to Speech Convertor (Interface and Output)



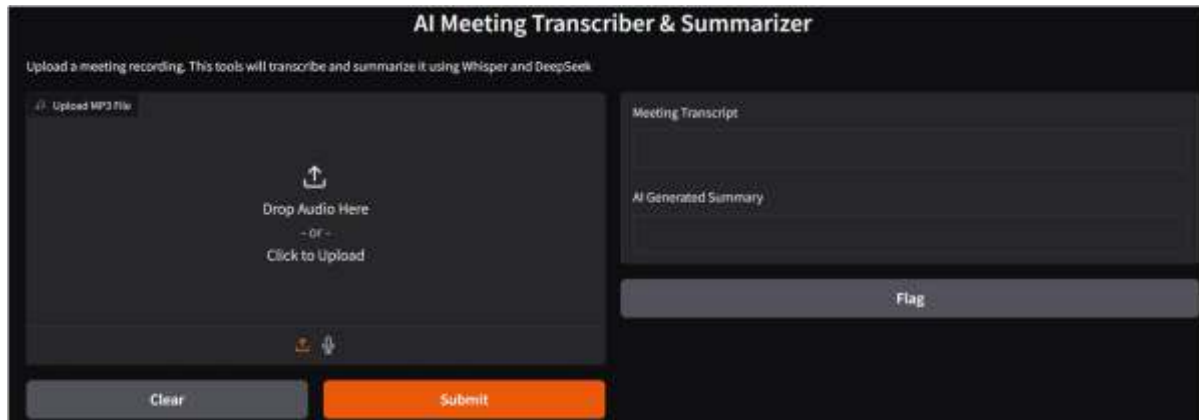
(d) AI-Powered Meeting Transcriber and Summarizer

This system captures, transcribes, and then summarizes meetings using speech recognition and natural language processing techniques. The process begins when the user records or uploads some audio from a meeting session. The audio is then prepared by applying noise reduction and Voice Activity Detection to remove any segment that does not contain speech, so as to analyze only the actual content that was spoken.

Once cleaned, the audio is passed into a speech-to-text engine like Whisper, which produces a word-by-word transcription. Post

transcription, a summarizing model takes the entire printer-ready text and extracts key points, action items, and topics discussed. The summarizer shortens the very long meeting transcript into a concise summary capturing all important issues. Finally, this summary is presented alongside the full transcription to the end user who can read it, save it, or export it into final documentation.

By automating both transcription and summarization, the tool reduces manual note-taking and ensures consistency in documenting discussions. It finds prime utility in environments where information needs to be delivered quickly.

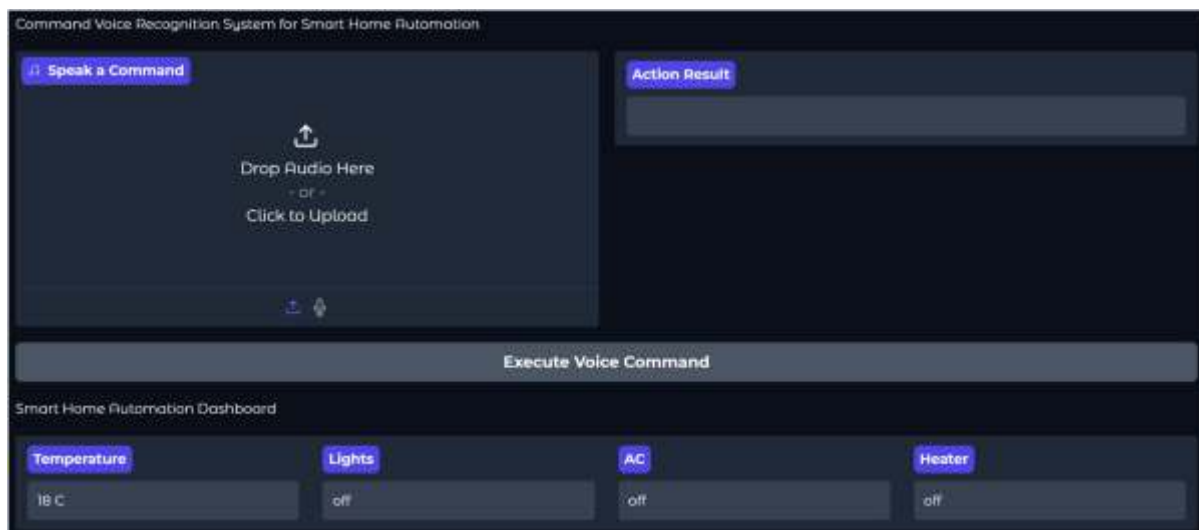


(e) AI-Based Voice Commanding System Recognition

In voice-controlled systems, speech-to-text is one of the most commonly used and recognized technologies. The integration of artificial intelligence enables devices to interpret human speech and convert it into actionable commands.

An AI pipeline attempts to analyze, interpret, and respond to voice commands in real time. It initiates when a user speaking a command into a microphone or uploading a recorded audio clip. Once the audio has been input to the system, it gets preprocessed by removing noise from the background and isolating human voice through Voice Activity Detection (VAD).

Features representing the key characteristics of input audio such as MFCCs are then extracted for interpretation. The feature sets are then analyzed through a pair of acoustic and language models. An acoustic model essentially transforms feature vectors into phonemes, whereas language models operate on higher-level units to infer the meaning of the spoken command through contextual cues. Once the spoken phrase is recognized and converted into text, it is decoded into a specific action or system response. A Text-to-Speech system can be invoked to generate a spoken reply, completing the voice interaction loop with the user.





Result 5: Command Voice Recognition System (Interface and Output)

Utility in Audit and Capacity Building Context:

- **Enhancing Inclusivity in Training**

Multilingual Transcription: STT tools can transcribe lectures delivered in English and translate them into Spanish, Arabic, and other languages in real time, supporting global participants.

Accessible Content Delivery: TTS can read documents aloud for participants with visual challenges or language comprehension difficulties.

- **Meeting Documentation and Review**

Convert audit exit meetings or training discussions into text transcripts using STT for documentation, review, and archival purposes.

Translate transcripts into multiple languages for use by foreign audit delegates.

- **E-learning Content Creation**

Use TTS to generate voice-over for presentation decks or e-modules.

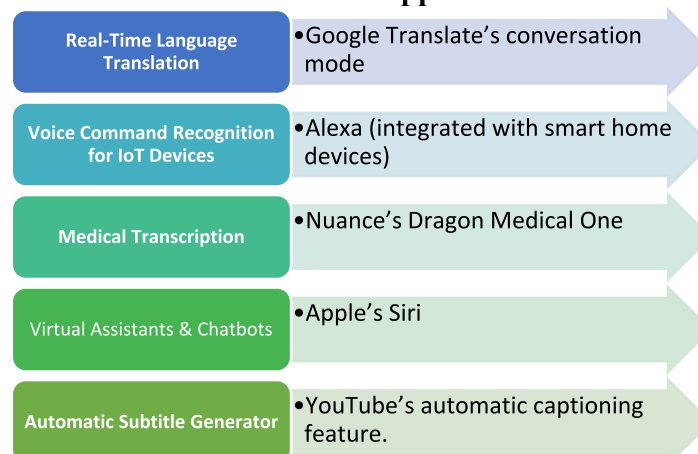
STT enables automatic captioning/subtitling for recorded sessions, aiding non-native English speakers.

- **Assistive Auditing in Field Environments**

Field auditors can dictate findings during site visits, and STT tools can transcribe them into structured reports.

TTS systems can read complex legal or policy documents aloud for quicker comprehension during audits.

Use-cases of Voice-based AI apps:



Challenges and Ethical Considerations

Data Privacy: Audio data, especially in an auditing environment, may contain sensitive information. Use of open-source or cloud-based services must ensure adequate data security protocols.

Language Accuracy: Errors may creep into automated translation and speech processing, especially for accents or dialects, and hence, should be subjected to manual verification.

Conclusion: Why This Matters in the AI Era

Scripting Python-based TTS and STT tools into audit training and operations is the kind of low-cost, high-impact applications that AI and ML offer. They remove linguistic and accessibility barriers while increasing productivity, documentation, and the effectiveness of training. As AI technology continues to develop, these tools will form the core of a modern, diverse, and technology-driven audit ecosystem.

These tools aren't just convenient—they're changing lives. . From assisting persons with disabilities to smart homes and virtual assistants, voice tools make technology human with the aid of Python software.

As the fields of AI and ML grow infinitely more sophisticated, so does a voice technology that is becoming more precise, timely in response, and emotionally intelligent. It is no longer simply about words. It is about intent, emotion, context.

Python in turn gives developers an accessible gateway to build these intelligent systems-if they so choose. The best part is, most of them are open-source, and they keep getting better, thanks to the global AI community.

Things to check:

- **Audio Quality:**

Good quality audio input signifies getting accurate results in voice AI projects; hence clear recordings from good microphones should be used in a silent environment. Before inputting the audio into any model, though, preprocessing should be applied, such as noise reduction, scrubbing silence, resampling-universally resample audio to 16 kHz-its volume normalization. At least implementing some or all of these will give one the cleanest input possible, thus positively affecting the accuracy of transcription, speech synthesis, or translation.

- **Language Detection:**

Modern multilingual voice-applications require the assessment for the accuracy of the language detection; that way, the correct model can be selected for transcription or translation. Training a machine learning system to detect the language spoken early in the pipeline is especially useful when one is faced with a myriad of different forms of user input. Consequently, the pipeline can route the audio accordingly, thereby enhancing the level of accuracy and efficiency of your whole system.

- **Segmenting Long Audio Inputs:**

Segmenting lengthy audio into smaller parts helps manage memory and processing efficiency under constrained resources. It also provides manageable chunks to the data, where the model is apt to apply itself and deal with processing for each segment individually correctly. Execution of preprocessing tasks, such as feature extraction and speech

enhancement, is then also improved when performed on consistent segments, thereby increasing overall performance.

Future Scope: Where AI Voice Tech Is Headed

The future is voice-first. Here's what we can expect:

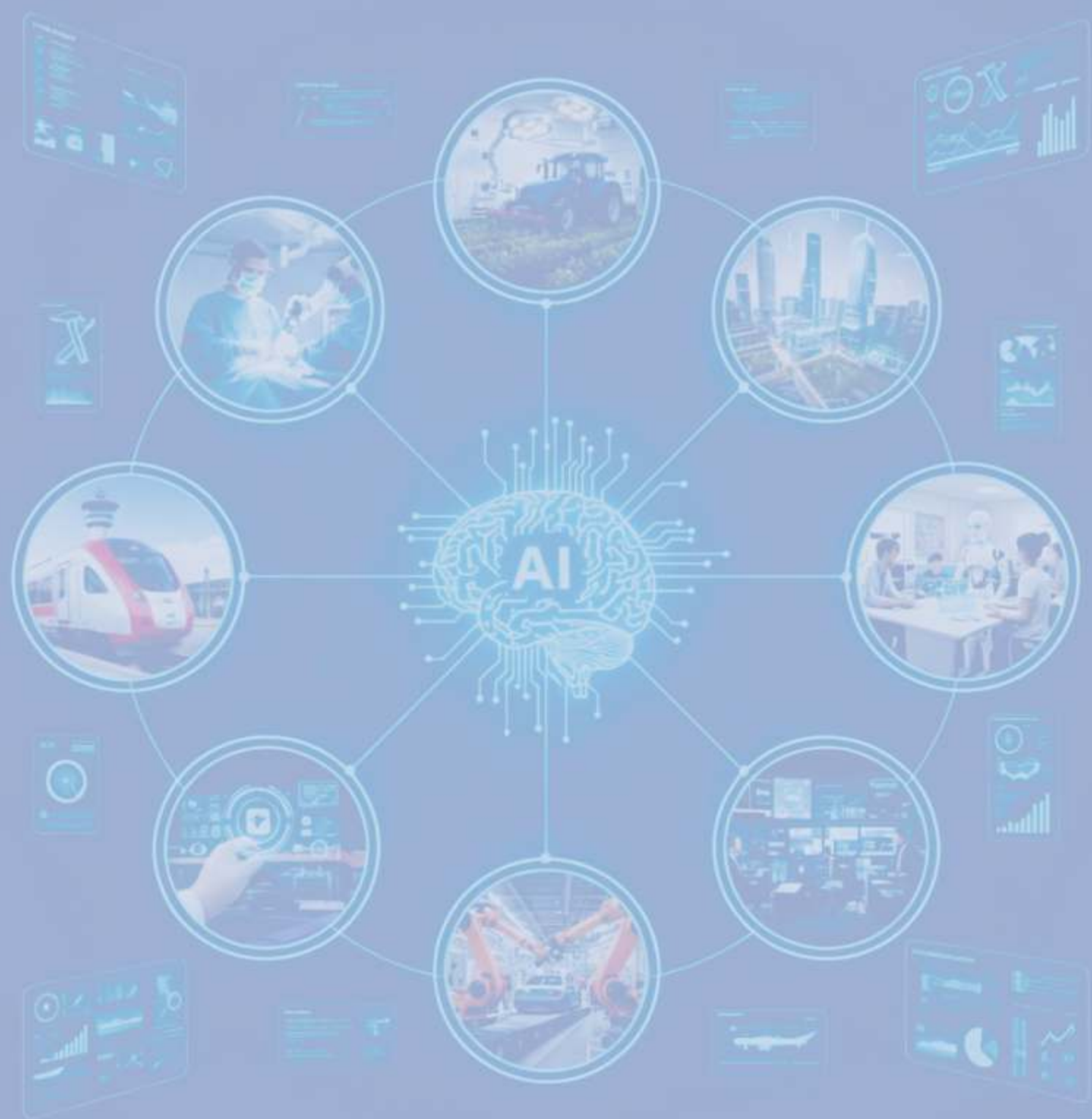
- **Smarter Interactions:** Voice tools will not only respond but anticipate and predict user needs.
- **Better Multilingual Support:** Regional language models are improving fast, enabling broader access.
- **Integration with AI Chatbots:** TTS and STT will power more natural conversations in customer service.
- **Real-Time Voice Translation:** Bridging language barriers in global communication.
- **Voice-Activated IoT:** Homes, cars, and even healthcare devices will respond intelligently to speech.

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Cross Sectoral Applications







Artificial Intelligence and Machine Learning: Pioneering the Future of Credit Insurance and Surety

*Le Cong Thien Dung,
State Audit of Vietnam*

Introduction

The tenth issue of *PursuIT* arrives at a moment when the global economy is rapidly digitizing. Emerging technologies such as Artificial Intelligence (AI) and Machine Learning (ML) are no longer confined to research laboratories—they are influencing decision-making across all levels of enterprises. For credit insurers and surety professionals, who must evaluate financial stability, predict risk, ensure compliance, and engage with clients efficiently, these technologies offer transformative opportunities.

AI and ML are ushering in a new era where human intelligence and machine capabilities can work hand-in-hand. This essay discusses their relevance in the credit insurance and surety industry, citing recent research, case studies, and global trends.

Understanding AI and ML: Definitions and Differentiation

Artificial Intelligence is defined as "the simulation of human intelligence processes by machines, especially computer systems" (Russell & Norvig, 2020). These processes include learning, reasoning, problem-solving, and language understanding.

Machine Learning, a subset of AI, involves algorithms that enable systems to learn from data and improve performance without being explicitly programmed (Mitchell, 1997).

Key ML techniques include:

Supervised learning (using labeled datasets)

Unsupervised learning (finding hidden patterns in data)

Reinforcement learning (learning by trial and error)

These techniques are increasingly being deployed in financial services, particularly in risk-heavy domains like credit insurance.

AI/ML in Credit Insurance and Surety: Real-World Applications

(i) Risk Assessment and Underwriting

Traditionally, underwriters relied on financial statements, credit ratings, and sectoral reports. AI now enhances this process through:

Predictive Analytics: ML models can forecast the probability of default based on financial, behavioral, and macroeconomic data.

Sentiment Analysis: AI tools can analyze news articles, press releases, or even social

media to gauge market sentiment about a company or sector (Choudhury et al., 2021).

Dynamic Risk Scoring: Instead of relying on static annual reviews, AI enables real-time risk monitoring and model recalibration based on new data inputs.

Example: Allianz Trade (formerly Euler Hermes) uses an AI-powered business intelligence platform to analyze the creditworthiness of over 80 million companies globally (Allianz Trade, 2022).

(ii) Claims Processing and Fraud Detection

ML algorithms are particularly effective in detecting patterns that might indicate fraudulent activity:

Anomaly Detection Algorithms: These identify outliers in claims data which may suggest fabricated or inflated losses.

Natural Language Processing (NLP): NLP is used to read and evaluate claims narratives, identifying inconsistencies or exaggerated descriptions.

Computer Vision: AI tools can assess the authenticity of scanned documents and photographic evidence.

Case in point: Lemonade Inc., a US-based insurtech, uses AI to process claims in as little as three seconds, reducing administrative costs and improving user experience (Lemonade, 2020).

(iii) Customer Experience and Engagement

AI-driven personalization is improving how insurers interact with clients:

Chatbots powered by NLP can handle routine queries 24/7.

Recommendation Engines tailor insurance products to client needs.

Voice Recognition Tools aid in verification and enhance accessibility.

These applications build stronger relationships between insurers and clients, offering rapid service and reducing friction in policy issuance or renewal.

Strategic Benefits of AI/ML Integration

Implementing AI and ML offers several advantages to insurers:

When deployed responsibly, AI can:

- Flag suspicious claims using dynamic, pattern-based systems.
- Offer tools for ethical underwriting and claim assessment.
- Prevent tragedies through early warning systems based on social and financial stressors.
- Protect the integrity of the credit insurance and surety ecosystem.

But as powerful as these technologies are, they must be guided by human wisdom, empathy, and a strong moral compass.

Benefit	Description
Efficiency Gains	Automates routine processes such as data entry, underwriting, and document verification.
Improved Accuracy	AI reduces human error and bias, leading to more consistent and accurate outcomes.
Real-Time Decisioning	Enables insurers to make near-instantaneous risk assessments, even in volatile markets.
Cost Reduction	Operational overheads drop as manual processes are replaced or augmented by automated workflows.
Scalability	AI solutions can be applied across global operations without proportional increases in human capital requirements.

Ethical and Regulatory Considerations

(i) Data Privacy and Protection

The deployment of AI requires large datasets, many of which include sensitive personal or financial information. Compliance with data protection laws such as the **General Data Protection Regulation (GDPR)** in the EU and the **Information Technology Act** in India is essential.

(ii) Bias and Fairness

AI systems may reflect or even amplify biases present in their training data. This can lead to

unfair discrimination in underwriting or claims assessment.

Solution: Adopt **Explainable AI (XAI)** models which allow human users to understand the logic behind automated decisions (Gunning & Aha, 2019).

(iii) Transparency and Accountability

Insurers must ensure transparency in decision-making and be able to audit AI-driven processes. Regulatory bodies such as the **Insurance Regulatory and Development Authority of India (IRDAI)** have begun evaluating AI usage in insurance to ensure compliance and consumer protection.

Challenges in AI/ML Adoption

Despite its potential, several challenges hinder the widespread adoption of AI/ML:

Data Silos: Many legacy systems are not designed for real-time data sharing.

Talent Shortage: There is a global shortage of professionals with dual expertise in insurance and data science.

High Implementation Costs: Developing custom AI solutions can be expensive and time-consuming.

These challenges require strategic investments in technology infrastructure, partnerships with insurtechs, and upskilling of existing staff.

Future Trends: What Lies Ahead?

(i) Integration with Blockchain

AI combined with blockchain could create **smart surety bonds**, enabling automatic verification and execution of contractual obligations.

(ii) Real-Time Economic Intelligence

Future AI models will integrate real-time economic indicators, geopolitical developments, and ESG metrics into credit scoring.

(iii) AI-Powered Ecosystems

Insurers will likely develop AI-enabled platforms that connect brokers, reinsurers, and clients in a seamless digital ecosystem.

(iv) Regulatory Sandboxes

Countries like India and Singapore are already launching **regulatory sandboxes** to test AI-based insurance solutions in controlled environments (IRDAI, 2023).

The Role of iCISA and the Alumni Network

Organizations like iCISA are pivotal in bridging the gap between innovation and implementation. The publication of *Pursuit* fosters cross-border knowledge exchange, showcases best practices, and strengthens the alumni network.

iCISA can further drive the AI/ML conversation by:

Hosting webinars and conferences on emerging tech in credit insurance

Encouraging co-authored research between alumni and academics

Promoting ethical AI adoption through policy dialogues

As alumni, we are custodians of industry wisdom and innovation ambassadors. Our collective efforts can shape a responsible and resilient AI-driven future.

Conclusion

Artificial Intelligence and Machine Learning are transforming the contours of the credit insurance and surety industry. From underwriting and fraud detection to customer engagement and beyond, these technologies offer tools to manage complexity and create value.

As we celebrate the tenth issue of *Pursuit*, let us reaffirm our commitment to learning, sharing, and collaborating. Through iCISA and its vibrant alumni network, we can continue to lead the industry into a smarter, more connected, and ethical digital future.

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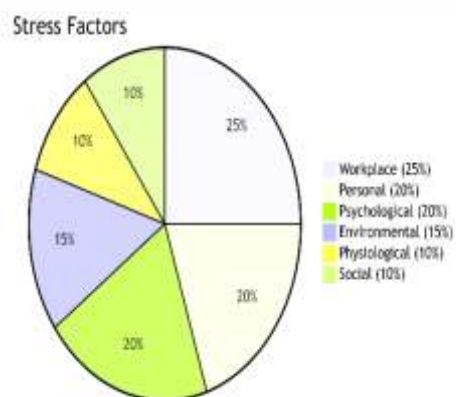


AI and Stress Management: A Medico perspective

*Dr Mohd Suhail Fazal,
O/o The Comptroller & Auditor General of India*

Stress has become a common issue affecting internal and physical health which in turn is a major cause of psychophysiological disorders. According to the American Psychological Association (APA, 2022), 77% of grown-ups report having stress-related physical symptoms, while 73% face psychological problems such as anxiety and depression¹.

India faces a growing mental health problem, with one in seven Indians suffering from psychological disorders² (WHO, 2022). India has only 0.75 psychiatrists per 100,000 people³ (NIMHANS, 2023).



It's also important to mention that a certain degree of stress is beneficial and required for coping, which is called "Eustress", but after a

certain level, it becomes distress. Hence, it is pertinent to use stress management rather than stress reduction.

AI-powered internal health chatbots to biofeedback wearables, technology is transforming how we can manage with stress as management involve coping, not merely suppressing stress.

How AI empowering the Stress Management

1. AI-Powered Mental Health Chatbots

AI-driven chatbots like Woebot etc., give 24/7 emotional support, using Natural Language Processing (NLP) to engage in remedial conversations. These bots use Cognitive Behavioural Therapy (CBT, a set of therapies affecting the thought process to produce modified behavioural output), offering management strategies and mood tracking. A Stanford University study (2021) found that users of Woebot endured a significant reduction in anxiety and depression within two weeks⁴.

Wysa (Bengaluru-based) Uses AI and CBT in Hindi, Tamil, and English, showing 38% stress reduction in TCS workers.

¹ American Psychological Association (APA)(2022). Stress in America: Mental health crisis.

² World Health Organization (WHO) (2022). Mental health in India: One in seven affected.

³ National Institute of Mental Health and Neurosciences (NIMHANS). (2023). Psychiatrist deficit in India: Annual report.

⁴ Stanford University (2021). Woebot efficacy study: AI chatbots for anxiety and depression reduction. Journal of Medical Internet Research (JMIR).

YourDOST (IIT-Madras spin-off) AI triage system directs users to counsellors after assessment as per their needs.

Government's "Manodarpan" chatbot handles examinations stress for more than 15 million students annually (NCERT, 2023)

2. Wearable AI Devices for Stress Monitoring

Smartwatches use AI to track heart rate variability (HRV), sleep patterns, and stress levels. Research in JMIR Mental Health (2023) found that these wearables reduced perceived stress by 23% in high-pressure professionals⁵. BeatO's diabetes- stress link AI cautions users whenever blood sugar shoots up, correlating with stress⁶ (Indian Journal of Endocrinology, 2023).

3. AI in Meditation and Awareness Apps

Apps like Headspace, Calm, and Muse use AI to provide meditation sessions grounded on personal needs. Muse's AI- powered headset provides real- time EEG feedback to enhance effectiveness of meditation sessions. A study published in Frontiers in Psychology (2022) showed that AI- guided meditation reduced cortisol⁷ (steroidal hormone produced by adrenal glands and directly correlated with stress) levels in blood by 20%. Art of Living's "Sanvello for India" adapts Western CBT to Ayurvedic principles.

4. Virtual Reality (VR) and AI for Stress Management

AI- enhanced VR surroundings (e.g., Tripp,

Healium) produce immersive relaxation experiences through visual illustrations and interactive commands. A Harvard Medical School (2023) trial found that VR reduced workplace stress⁸ by 40%.

5. AI in workplace Stress Management

Companies use AI tools like Microsoft Viva Insights to identify employee work exhaustion and suggest breaks. Deloitte (2023) reported that AI- driven workplace wellness programs increased productivity⁹ by 18%.

Further studies from medical journals

- A. Harvard Medical School & University of California (2020) trial with Woebot (AI chatbot) showed a 27% reduction in stress hormones (cortisol) among medical students¹⁰ over 4 weeks (Journal of Medical Internet Research).
- B. Johns Hopkins School of Medicine (2021) AI analysis of heart rate variability (HRV) from wearables (e.g., Fitbit) predicted stress spikes in nurses with 92% accuracy, enabling real- time interventions¹¹.
- C. Yale School of Medicine (2023) - AI- powered VR exposure remedy reduced Post traumatic stress disorder (PTSD) related stress by 50%, validated via MRI scans showing lowered amygdala hyperactivity¹².

⁵ JMIR Mental Health (2023). Wya's impact on stress reduction in TCS workers.

⁶ Indian Journal of Endocrinology(2023). BeatO's AI- driven stress- diabetes correlation alerts.

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Comparative Effectiveness¹³: AI vs Traditional Methods

Metric	AI Solutions	Traditional Therapy
Availability	24/7	Scheduled appointments
Cost	Cheaper	Costly
Response Time	Immediate	Days-weeks
Personalization	Algorithm-driven	Clinician-judged
Severe Cases	Supplemental	Primary treatment

Benefits of AI in Stress operation

- A. **Availability** – Available Anytime, anywhere (no therapist wait time).
- B. **Personalization** – Adapts to existent/ unique stress triggers.
- C. **Cost-Effective** – Cheaper than traditional curatives.
- D. **Data-Driven** – Tracks progress over time to be used in real- time.

Limitations and Ethical concerns

- A. **Lack of human Touch** – AI cannot completely replace human therapists, particularly in cases of delicate and resistant cases or multiple diagnoses. Lack of empathy is also a concern while using AI based solutions.

- B. **Data breach and privacy issues** – There's a possibility that sensitive internal health data could be misused.
- C. **Algorithm Bias** – There are chances that AI may not work well for all demographics. Most AI tools are designed for Western individualism, which need to be trained for more localized data.

Conclusion

AI has opened new avenues in stress management, offering tools that are accessible, substantiated, and effective. Though it cannot replace traditional therapy entirely, it serves as a complementary tool in stress management. Particularly for India, it provides the opportunity to bridge internal health gap, but success requires hyperlocalization (conforming to the local standards/norms/data), Public-private participation for affordable access and hybrid model of Human-AI.

¹³ HealthTech Monitor. (2023). relative efficacy of AI vs. traditional remedy. Annual Review of HealthTech.

Commemorative Lecture to mark the Foundation of iCISA- A Summary



DAMARU





Governing through AI, Governing AI (synopsis of speech)

*Dr. Lawrence Liang, Professor,
Dr B.R. Ambedkar University Delhi*

The Algorithmic Age: Navigating the Precipice of AI's Promise and Peril

We stand on a precipice, between the possibilities of enormous possibilities and potential that we see in AI. And at the same time, the attendant risks that accompany it. If there is one word that has transformed our lives in the last one year, it's the word ChatGPT.

AI has been around for a very long time, but it's only with the emergence of ChatGPT that it's really entered, in a way, the popular consciousness of people.

The Games that Changed the Game: Kasparov, Deep Blue, Sedol, and AlphaGo

In the 1970s, a philosopher, Herbert Dreyfus, wrote a book called ***"What Computers Can't Do"*** and concluded that computers were so primitive that they couldn't even beat the most novice of human chess players- an example of how computer intelligence is inherently limited.

In 1996, Garry Kasparov, regarded as one of the greatest chess players ever to have played the game, took on IBM's machine Deep Blue in a six match tournament. Kasparov saved the honor of human species by defeating

Deep Blue. A media commentator poetically declared this that the day of reckoning had been postponed.

On May 11th, 1997, there was a rematch between Kasparov and Deep Blue. Kasparov lost the tournament to Deep Blue. This game was a turning point in the development of AI. What did this event achieve?

It had cracked a formula that had evaded the computer industry for a long time. It combined the computational power with the brute force of algorithms, along with big data, combined with the machine's ability to learn. In other words, all the components that we associate with AI.

Far more than chess, the popular Asian game "Go", played on a 19 x 19 grid, was considered to have more elements that mimic human thought. Mathematicians had declared that Go was such a complex game that it required intuition and not merely rule.

In 2016, AlphaGo, developed by Google, had beaten the world's greatest Go player from South Korea, Lee Sedol. The DeepMind team that developed AlphaGo won the inaugural Marvin Minsky medal for the outstanding achievement in AI.



Beyond Games: The Rise of Image Recognition and its Double-Edged Sword

The ability of machines to recognize images has remained one of the holy grails of AI development.

An important milestone, in this regard, has been the ability of computers to recognize images through 'Convolutional Neural Networks'.

In 2012, a convolutional network called **AlexNet** won the ImageNet Visual Recognition Challenge by trawling through 12 million images to develop a program that would accurately recognize images.

When humans are asked to do Visual Recognition Challenge, out of 100 cat images 95 cat images were correctly identified.

In 2015, a Microsoft algorithm achieved 96% accuracy, surpassing the human ability to identify Cat images.

This technology allows Amazon to recommend products. It also allows a phone

to be unlocked by recognizing a face. But most importantly, AI development associated with this technology is responsible for the driverless car.

However, a majority of these technologies are also being put to use for surveillance, either by the state or by large corporations.

The Exponential Age: Confronting the Scale of Technological Change

A realistic assessment of what lies ahead has to be preconditioned on where we are. And where are we?

Jamie Susskind, in a book called *"Future Politics"*, argued that one cannot think about politics without thinking about technology.

He provided us with a very useful survey about technological transformation that we are witnessing. He argued that the exponential growth in computational power will have a profound implication on governance.

So from ChatGPT to DeepSeek, we are in an

era where the arms race of our time is AI and the two major countries with a huge stake in the pie are The US and China.

It means a lot to the world to think about what this new arms race, driven by the Nvidia chip, etc. is and how do we participate in it?

Utopia or Dystopia? Navigating the Extremes of the AI Narrative

There are two different ways of thinking about where we are.

There is, on the one hand, the techno utopian view of AI as an unprecedented force of progress, efficiency and human empowerment, and the dystopian that everything is going to change and be destroyed. The truth, of course, lies somewhere between the two.

While **techno utopianism** believes that AI is going to enhance creativity, eliminate tedious labor, and solve global challenges ranging from climate change to diseases and poverty, the **dystopian argument** says that AI is potentially leading in a way to human obsolescence or human extinction. It warns that AI driven misinformation, surveillance,

autonomous weapons will erode democracy and human rights, and super intelligent AI could become uncontrollable and ungovernable.

So, on the one hand, Jeff Bezos, on the optimistic side of things, argues that you have to learn to trust technology and things will sort themselves out.

Contrasting view is presented by Kai-fu Lee, one of the pioneers of text recognition in Apple, who in his book *"AI Superpowers"* says that - there is no doubt that there is going to be a churn and the churn is going to be felt. He predicts that almost 50% at a conservative estimate of jobs are going to be threatened by AI. He further says that we are going to be replacing white collar workers.

The business as usual argument would argue that there is nothing new about this. The history of modernity is a history of automation, and the history of automation is about the replacement of older jobs with newer jobs. But the other side of the argument is that history can only be trusted if it is a multiple recurrence of a similar event, not if it is a seismic or a paradigmatic shift.



Paradigm Shifts and the Limits of Historical Analogies

Thomas Kuhn, a philosopher of science and technology, argues that there are incremental changes, and then there are paradigmatic changes. The paradigmatic changes are the changes that completely transform all the rules of the game. For instance, the Industrial revolution fundamentally overcame even the limitations of human muscle power.

Something equally interesting is happening right now as we are overcoming the limitations of our minds.

Ray Kurzweil, in a book called *"The Singularity is Near"* states that singularity is the point at which the machine overtakes the human or the biological. He says that we are almost there today with AI & ML enabling us to surpass the limitations of human brain and cognition.

This will have a profound economic impact especially in terms of white collar work that will now be increasingly under threat. This will undoubtedly be one of the biggest challenges facing governments worldwide.

The Techno-Political Landscape: Reframing Classical Questions of Governance

Technology and governance have a considerable interface as pointed out by German media theorist Friedrich Kittler who says that political systems are created by technological systems. He looks at an instance of the emergence of Hitler, and he asks whether Hitler could have emerged without two technologies, the loudspeaker and the radio, which were crucial in the making of a leader like him.

In today's context, this raises a series of questions such as-

How does the rise of the algorithms transform governance and how does AI alter traditional conceptions of political authority and legitimacy?

How do digital identities, surveillance and class and datafication reshape what it means to be a citizen?

In what ways does technological infrastructure create new forms of control, freedom, coercion, dependence that challenge our traditional understandings?

How do digital platforms and algorithmic mediation transform the idea of democratic deliberation, Public reason and political representation?

How can state sovereignty be reconfigured in an era of global technological networks?

How does this technological AI era transform ideas of conflict, warfare, surveillance?

These are questions that are key to AI Governance.

AI Governance in India: The Need for Transparency, Accountability, and Equity

In the Indian context, if we look at the domain of AI governance, a well written document of 2019 by NITI Aayog, lays out the "National Strategy for AI". One of the important aspects under discussion would be - How governance is transformed through infrastructures of AI and the deployment of AI in the core functioning of governance and its implications.

In many ways, the role of AI in governance, particularly through some key areas at the

moment such as automated welfare systems, predictive policing, the domain of taxation, etc. goes beyond the question of efficiency and streamlining. There is a paradigmatic shift where governance is being embedded within opaque technological frameworks.

Governance has always been about rules and about laws. Algorithms are also about rules and laws. However, algorithms operate in ways that are invisible and very often unaccountable to the public. Decisions made by AI systems are shaped by values of those who design them. So technology is not a neutral system. It's designed with particular values.

But the question is how do you make that accountable?

Professor of law in Harvard called Larry Lessig argues that there are four major modes of regulation- Laws, norms, markets and code or architecture. He adds that today we have moved away from the domain of law to the domain of code, and says code is law.

We are now at a point where we really see code take on the function of the older modes as a way of regulation. Once code emerges as law, it is enforced not by human actors, but by digital systems. Very often it works on a preventive rather than a punitive logic, forcing compliance rather than punishing transgression.

So what is the relationship then between traditional ideas of governance and accountability and these new market technological forces that are opaque to us as consumers?

To cite an example, we are all familiar with the phenomenon of surge pricing. However, we

only see this as a matter of convenience, ignoring the fact that liberty is not going to be lost to an autocratic state. Liberty is going to be lost to convenience.

And all of us, in a way, are participants in that compromise of our own liberty. Algorithms now access essential resources from credit scores, housing applications, insurance premiums to job screening. And one of the questions that arises is what happens to algorithmic bias?

In the long run, in the societal context, when we are thinking about sharp differences that divide any country on the basis of gender, caste, religion, etc., what will algorithmic bias consist of? How then do we think about questions of accountability and transparency?

The Social Credit System: A Cautionary Tale

Social credit is an idea of accumulating the various data points of an individual as a citizen and creating an intelligible account of worthiness as a citizen.

There are countries which have a Social Credit System, a state led initiative to assess and regulate the trustworthiness of individuals, business and government entities. It's not a single unified system, but a collection of regional sectoral programs that can assess an individual and then mark them either as being credited or discredited.

This is a very dangerous scenario where algorithmic governance reshapes political power. Thus, the need to ensure transparency, accountability and public oversight becomes all the more urgent and critical.

Without democratic mechanisms to regulate these systems, the foundational principles, the constitutional commitments to justice, to liberty, and to civic freedom may be eroded, leaving governance in the hands of unaccountable algorithms rather than the people that they are meant to serve.

Case Study

John McCarthy, one of the leading computer scientists and a pioneer of AI, considered law to be the ideal test case and candidate for an AI approach.

This was because it was text and language based, rule bound, and with a vast archive of statutes and decided cases which are perfectly suitable for machine learning.

The pragmatic concern in the Indian context is that we have 50 million pending legal cases in the country and how we think about this in terms of AI as solution.

One of the structural problems of the legal system in India is that the Supreme Court of India is known as the Court of Residual Jurisdiction. Every single matter can go up to the Supreme Court of India. In contrast, the Supreme Court in the US delivers 80 to 120 judgments a year- all of them about constitutional questions.

So, should there be mechanization to overcome the uniqueness of every fact and every individual case demanding justice for that particular instance versus a kind of automation, where you also have the ability to create a routine solution?

Underlying all this is an interesting philosophical question- is law computable? At one level, it is also computing two different

kinds of claims and arriving at a balanced idea. Yet, law is also bound to give us something that's unmeasurable and cannot be reduced to a logic of computation, which is justice.

Coding Democracy: Towards a Civic Epistemology of AI

How do we inflict a democratic ethos within this domain of techno governance that is emerging?

Sheila Jasanoff, one of the world's leading science and technology scholars based in Harvard, talks about civic epistemologies. Civic epistemologies are - how societies construct but also participate in science, in technology, in knowledge, and in the design of technological systems so that it is not left to the technocrats, or to the corporations.

There is a public interest dimension that is so strong that it is far too important to leave it to the technologists and her argument is to ask - what are the ways in which we can think about our participation? **So classical ideas of democracy, representation, participation, equity, access- how do we encode these within the code?**

A study, again done at Harvard by the Berkman Center for Internet and Society, which has evaluated **approximately 40 AI policies** globally, including India, China, etc. have arrived at a **set of eight principles that are common and can be taken as the foundational principles towards governing AI.**

1. Privacy
2. Accountability
3. Safety and Security

4. **Transparency and Explainability**
5. **Fairness and Non-discrimination**
6. **Human Control**
7. **Professional Responsibility**
8. **Promotion of Human Values**

These principles offer a foundation for effective, ethical AI governance. Turning them into concrete practice requires ongoing dialogue, collaboration, and a commitment to democracy.

The Existential Question: What Does it Mean to be Human in the Age of AI?

Isaac Asimov in 1940 wrote The Laws of the robot.

They are as valid today as they were then.

- (1) A robot may not injure a human or, through inaction, allow a human to come to harm.
- (2) A robot must obey a robot must obey orders given to it by human beings. Unless such orders would conflict with the First law.
- (3) A robot must protect its own existence. As long as such protection does not conflict with the second or the first law.

This is a remarkable reaffirmation in a way, of the idea of the primacy of human values without being technophobic. It recognizes that robots are not merely inevitable, but that we may have to learn to live with robots. But in learning to live with robots, as a judge reminded us, we shouldn't become robots and we shouldn't forget human values.

Can AI be regulated, Regulating AI- role of Law, Governments, Global institutions:

The Life Cycle of law and the life cycle of technology are at loggerheads with each other. Law is constantly many steps behind technology. Law is too slow to deal with the technological transformations. Incorporation of standards in the regulation of technology to happen to overcome the problem of the temporal lag between law and regulation.

In the domain of internet governance, a lot of technologies have emerged primarily through the market and innovations in the market and it cannot be left to the market for it to create its own regulatory systems, because it won't.

As most of the supranational regulatory bodies in technology mimic the unequal structure of the political economy of the world, the AI regulations can neither be only a matter of national negotiation, nor can it only be a matter of private standards emerging.

The civil society organizations have to play a very important role. There should be a mutual cooperation across the global South in developing not merely technology, but standards of the regulation of technology, which address questions of equity, that address questions of access.

Historically, the dangerous technologies have always been regulated. And if AI is addressed from the point of global risk or from the perspective of access and equity, etc., there is a need of a global conversation on the regulation of AI, which should also be equitable. AI is a new configuration of power and politics, and the global community cannot afford to leave it undetermined.

Aspects of human life that AI cannot process

We surprise ourselves by our ability or our

capacity for tenderness and beauty as much as our irrationality. And there is something about that essential, unpredictable aspect of what it means to be human that remains our greatest fortitude against a technological and mechanical view of the world.

The reason why the law cannot be reduced to a mechanical application is because all problems of our disciplines emerge from life. And if life is to be encountered as the mysterious, we need to hold on to it and not abandon it.

Leveraging AI to promote equity and to build a more just society

The questions about equity is a deeply political question that's very urgent for all of us. And there's traditionally been a divide, a division of labor between people who think about technology and people who think about politics. However, technology has become too important to be left alone, to people who think about technology. It has to be thought by people who think about equality, about justice, about access.

Use of AI to build a thought process where equity becomes a central consideration.

We live in a very interesting paradoxical moment. There is on the one hand, the

avalanche of technology that threatens our conception of what it means to be human and the immediate temptation is to retreat into a classical idea of the human right.

At the same time, we live in a time of the Anthropocene, where it's precisely the centering of the human and the anthropomorphic conceit that has led us to all of the crises that we face by way of climate change and the ecological disasters around us.

Interestingly, over the last decade, we had a range of ways of thinking outside of the centrality of the human. What does it mean to learn from machines? Is there a possibility of learning what it means to be human from machines?

Pressing human creativity be preserved in the face of AI

We are now entering a time where we will have to consider our relationship even to the idea of creativity. How do we think about the idea of human machine collaborations in the domain of creativity? All forms of art respond to forms of life. And if the form of life is transforming rapidly, art has no choice but to also create and invent new forms to express ourselves. I'm excited by the possibility of what is going to emerge.

Our Contributors

Frameworks, Policies & Governance

I. Harnessing Artificial Intelligence and Machine Learning to Elevate Modern Auditing

Dr. Meshari Abdulmajid Al-Ebrahim (SAI, Kuwait) is a researcher specializing in Artificial Intelligence (AI), holding a Ph.D. in AI with a focus on Machine Learning (ML). He has extensive experience in developing advanced learning architectures, causal analytics, and intelligent decision- support systems applied across manufacturing, energy, and auditing sectors. Dr. Al-Ebrahim has authored several peer- reviewed publications and actively contributes to advancing AI methodologies for real-world problem solving and sustainable innovation. His broader research interests include Explainable AI, data-driven value engineering, and the integration of AI within governance frameworks.



II. Realizing the Value of AI in Public Sector Auditing: Challenges and Opportunities for SAIs

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III. Reimagining TAP in the Age of AI: Introducing the TAPAI Framework for Supreme Audit Institutions (SAIs)

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V. Artificial Intelligence and Machine Learning Introduction: The Dawn of Intelligent Machines

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VI. Future Auditing Begins Today: How Can Egypt Benefit from Artificial Intelligence?

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Practical Applications of Auditing

VII. AI Applied to Public Auditing: The TCU's Experience with ChatTCU and GABI

Pedro Coutinho Filho (SAI, Brazil) is a Federal External Control Auditor at the Brazilian Court of Accounts (Tribunal de Contas da União) since 2008, working in external oversight of information technology, particularly in performance audits. He served as a Finance and Control Analyst at the Brazilian Office of the Comptroller General (Controladoria-Geral da União). Currently serves as Director of Digital Transformation and IT Public Policy Evaluation in the Specialized Audit Unit for Information Technology. Holds degrees in Computer Science and Telematics with an emphasis on telecommunications.



Fernando Lima Gama Júnior (SAI, Brazil) is a Federal Auditor at Brazil's Federal Court of Accounts (TCU) and an innovator in applying Artificial Intelligence to public auditing. He developed two pioneering AI solutions—Gabi, an assistant that transcribes and summarizes meetings in real time, and GabiChecks, a tool that analyzes audit plans to generate checklists and highlight key risks.

Gabi's integration into ChatTCU, the Court's official AI platform, drove its widespread adoption, leading to over 200 partnerships with public organizations across Brazil.



Klauss Henry de Oliveira Nogueira (SAI, Brazil) is an Auditor at the Federal Court of Accounts of Brazil (TCU), specializing in IT auditing, transparency, and citizen engagement initiatives. He was part of the Segecex Working Group (2025) that authored the guide “Auditing with the Citizen in Focus,” promoting citizen perspectives in all audit stages. He coordinated the National Program for Public Transparency (PNTP) in 2023–2024, in collaboration with Atricon and various Courts of Accounts, to enhance social oversight and public information access. He has also authored articles in the INTOSAI Journal, including “Evaluation of Information Quality from the User's Perspective” (2023) and “Citizen Participation in Monitoring the Decisions of the Federal Court of Accounts: A Path to Transparency and Efficiency in Public Management” (2024).



VIII. SAI India's Initiatives on Artificial Intelligence in Public Auditing

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IX. Artificial intelligence and Machine Learning in National Project Audit

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Andrey Shishlin (SAI, Russia) is the Chief Inspector of the Accounts Chamber of the Russian Federation, a recognized expert in accounting and auditing. His areas of interest include database architecture; algorithms for processing and storing information. His recent key achievement is the collection and organization of information processing for the audit of the Russian Federation's national projects for 2018–2024.



X. Transforming Auditing with Artificial Intelligence

Prof. Anil Singh Parihar (Delhi Technological University) is an experienced Professor of Computer Science and Engineering, specializing in computer vision and deep learning. With over 15 years in academia, he is known for his research, impactful publications, and strong teaching skills. He holds a Ph.D. in Computer Vision and has collaborated with leading organizations like Adobe, Samsung, and AIIMS. He has held key administrative roles, including Associate Head of the Department at Delhi Technological University. He has led sponsored projects with ISRO and the Ministry of Electronics and Information Technology and has published notable research on autonomous vehicles, recommendation systems, and sketch recognition.



Understanding Technical Domains

XI. Scaling and Emergence in Artificial Intelligence - Path ahead for auditing

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XII. The Face of the Machine: How Computers Recognize Us

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XIII. Harness the Power of Voice AI: Practical Projects in Speech Recognition, Synthesis and Control

Piyush Tiwari (SAI, India) is an Assistant Administrative Officer (AAO) in the Research Wing at iCISA, Noida, with a background in Computer Science and Engineering and experience in IT auditing, data analytics, and visualization. A former System Engineer at Infosys Technologies Ltd. and IT Officer at the National Payments Corporation of India (NPCI), he has audited major Defence PSUs including HAL, BEL, BEML, GRSE, HSL, MDL, and ONGC, focusing on ERP systems, data verification, and system evaluations. He holds certifications in Cybersecurity (ISC2 CC), Ethical Hacking, and AI/ML using Python (SWAYAM-Plus), and is currently pursuing a PG Diploma in Data Science, AI, ML, and Cyber Security from IIT Madras under the CAG-IIT Madras MoU. An expert in Tableau, Power BI, Python and Adobe Captivate, he has developed structured training modules and e-learning modules and serves as a trainer in National and International Training Programmes on IT auditing, cybersecurity, emerging technologies, and data analytics & visualization.



Cross Sectoral Applications

XIV. Artificial Intelligence and Machine Learning: Pioneering the Future of Credit Insurance and Surety

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XV. AI and Stress Management: A Medico perspective

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Earlier he has worked in the office of the Principal Accountant General (G&SSA), Kerala as Deputy Accountant General (SGS-II) responsible for auditing various Government Departments, externally aided projects, autonomous bodies. He has also worked as Nodal Statistical officer and Nodal analytics officer.



Commemorative lecture to mark the foundation of iCISA - A Summary

XVI. Governing through AI, Governing AI

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A winner of the Infosys Prize for the social sciences in 2017, Liang was also awarded the Chevening, the Fubright scholar, the Rice and Hughes scholarship. He has taught, and been a research scholar at several institutions including Yale University, Columbia University, Michigan University, NLSIU, etc. He is also a co-founder of two digital archives pad.ma and indiancine.ma. He is the co-author of several books related to libraries including a book of speculative fiction titled “Invisible Libraries”

His latest publication on libraries is a book The Public Library Movement In India: Bedrock Of Democracy And Freedom published in 2024.



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