Acknowledgement

I would like to express my sincere gratitude to Shri Pramod Kumar Tiwari, Director General Bureau of Indian Standards for providing me the opportunity to prepare this Handbook on Artificial Intelligence. This has enabled me to learn about the subject in more depth and bring out the importance of standardization in the field of Artificial Intelligence.

I would also like to thank my colleague Mr Kshitij Bathla, Scientist-C, BIS and member secretary of BIS Technical Committee on Artificial Intelligence for his support in preparing this Handbook.

I believe that this endeavour has prepared me for taking up new challenging projects for standardization in the area of Artificial Intelligence.

Reena Garg

Scientist- G & Head

Electronics & IT Department

Bureau of Indian Standards

New Delhi

reena.garg@bis.gov.in

About the Author

Reena Garg, Scientist G

Reena Garg is B.E. (Electronics & communication) from Netaji Subhas Institute of Technology (NSIT), New Delhi and MBA. She has 30 years of experience in the field of Electronics and IT standardization activities at BIS.

She has handled the standardization work in various important areas including Information System Security, Biometrics, Electromagnetic Compatibility, Identification Cards, Data management systems, Computer Hardware and peripherals, Indian Language Technologies and products, Safety of Audio, Video and IT products, Artificial Intelligence etc. She has represented India in various IEC, ISO and JTC1 meetings related to international IT standardization activities.

She has also worked in conformity assessment activities of BIS including Compulsory Registration Scheme (CRS) for safety of electronics and IT Goods. She is also the Committee Manager of ISO/IEC/JTC1/SC7 Software and Systems Engineering subcommittee, responsible for formulating international standards in this area.

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INTRODUCTION

INTRODUCTION

- Information Technology (IT) has become an integral part of our lives and has been touching and transforming almost every aspect of our lives. As technology continues to evolve at a rapid pace, the establishment and adherence to standards have become crucial in ensuring compatibility, interoperability, Information interchange, life cycle management, privacy and security. IT standards serve as the foundation for a reliable and efficient IT infrastructure.

- In the field of Information Technology, BIS formulates Indian Standards (IS) covering broad range of areas, including Software development and software Quality Assurance, Cybersecurity, Data protection, Blockchain, Biometrics, Internet of Things (IoT), E-learning, Artificial Intelligence, Brain Computer Interface, Metaverse, Quantum Technologies etc. More details on BIS technical committees working in emerging technology areas are given in Annex 1.

- Artificial Intelligence (AI) has gained increased attention from various industries and governments across nations. The prospect of AI solving some of society's most challenging issues has fascinated many. Big multinationals across industries are investing in implementing AI. The growth projected for AI and data science technology is $15.7 trillion by 2030. AI has disrupted the global techno-political regime quite significantly in the recent past. From industrial automation to self-driving cars, from medical drug discovery to space exploration, there is a little that the AI revolution has left untouched.

- Traditionally, AI has been focused on large scale problems that were either too hard and complex to solve with traditional compute methods or were in specialized emerging areas. This is no longer the case now. Machine learning has widened the applicability of AI. Focus on the digital transformation has created a demand for services and more intelligent analytics. For Examples:

  - AI expert systems are helping healthcare professionals make better decisions for patients with proper trustworthiness measures designed into the system,

  - AI deployment in the smart manufacturing sector is driving higher efficiencies by allowing robots to work alongside human workers with the proper safety measures designed into the system,

  - AI deployment in the financial ecosystem is enabling applications that range from asset management that takes into account factors such as the clients risk to fraud detection that reduces false-positives.

- Emerging AI applications are numerous and diverse e.g. consumer, retail, digital assistants, expert systems such as smart grid, marketing intelligence tools, enterprise etc. Thus, it is not surprising that IDC estimates that 75% of enterprise applications will use AI. The market is forecast to accelerate further in 2024 to break the $500 billion mark.

- The rapidly evolving AI Ecosystem requires standards for successful and responsible AI development and deployment while addressing societal challenges and advancing human well-being.

- It is pertinent to mention that understanding AI standards is crucial for engineering students to develop AI systems that are ethical, reliable, compliant, and innovative. It prepares them for successful careers in a rapidly evolving field and ensures they contribute positively to the development and deployment of AI Systems.
- This handbook is being prepared with an intent to provide guidance and information regarding basic concepts of Artificial Intelligence, national and global landscape for standardization and regulatory framework in the field of artificial intelligence. The aim is to provide information related to standards developed and under development to the students and faculty, which they must know while studying course of Artificial Intelligence. An effort has also been made to map the existing national and International standards with AI courses taught to the students in the colleges.
- There are 61 standards and a number of subjects under considerations for developing standards mentioned in this handbook. The details are given in Clause 6 of the handbook. Readers of this handbook are encouraged to contribute to standardization efforts at national and International level through BIS. Those who are interested to participate may contact at litd30@bis.gov.in.

CHAPTER I

OVERVIEW OF ARTIFICIAL INTELLIGENCE

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OVERVIEW OF ARTIFICIAL INTELLIGENCE

1.1 What is Artificial Intelligence (AI)

Artificial Intelligence (AI) is an evolving technology that enables machines to act with higher levels of intelligence and emulate the human capabilities of sense, comprehension and act. In other words, it refers to a machine or computer system's ability to perform tasks that would typically require human intelligence.

From the technical perspective, Artificial intelligence is defined as "an engineered system that generates outputs such as content, forecasts, recommendations or decisions for a given set of human-defined objectives" [IS/ISO/IEC 22989:2022 - Artificial Intelligence Concepts and Terminology].

AI is one of the most talked about technology. Artificial Intelligence has been rapidly transforming various aspects of our lives, from healthcare and finance to transportation and entertainment.

AI encompasses various subfields, including machine learning (ML) and deep learning, which allow systems to learn and adapt in novel ways from training data. It involves programming systems to analyse data, learn from experiences, and make smart decisions – guided by human input. AI has been successful in developing virtual assistants like Alexa and Siri applications supporting humans in various ways and making life easy. ChatGPT, Gemini and Krutrim are the latest AI tools which can mimic just like humans and can be put to use in various useful tasks.

The machine learning has become so "competent" as to generate everything from software code to images, articles, videos and music. This is the next level of AI, the so-called generative AI, which differs from traditional AI in its capabilities and application. While traditional AI systems are primarily used to analyse data and make predictions, generative AI goes a step further by creating new data similar to its training data.

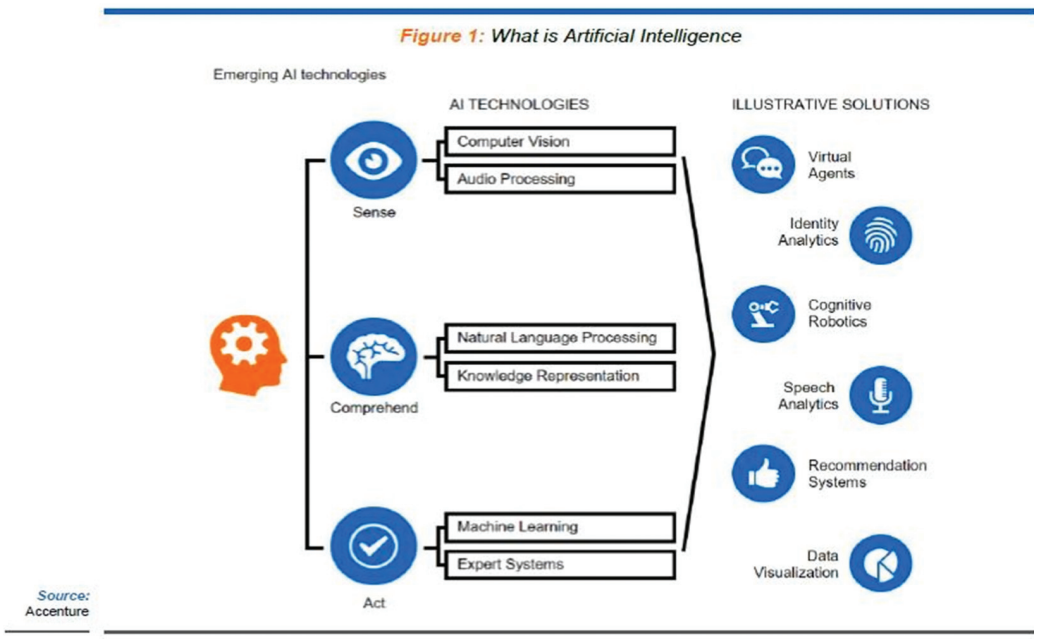

Figure 1: What is Artificial Intelligence

1.2 Evolution of Artificial intelligence (AI)

Artificial intelligence (AI) is not a new scientific discipline, as its origins can be traced back to the 1950s. The evolution of Artificial Intelligence (AI) has been marked by significant advancements in technology, leading to its integration into various industries and applications. An overview of the key milestones in the evolution of AI and its integration into diverse sectors is as follows:

Early Foundations (1950s-1960s):

- The field of AI originated in the 1950s with the pioneering work of researchers such as Alan Turing, John McCarthy, Marvin Minsky, and others.
- Early AI systems focused on symbolic reasoning, logic, and rule-based approaches, culminating in the development of expert systems capable of emulating human expertise in specific domains.
- Applications included rule-based systems for automated reasoning, natural language processing (NLP) systems, and early forms of machine learning.

Growth of Machine Learning (1980s-1990s):

- The 1980s witnessed the resurgence of interest in neural networks and machine learning techniques, fuelled by advances in computational power and algorithms.
- Supervised learning algorithms, such as backpropagation, gained prominence, enabling the training of neural networks for pattern recognition, classification, and regression tasks.
- Applications expanded to include handwriting recognition, speech recognition, and early forms of computer vision.

Rise of Data-driven Approaches (2000s-2010s):

- The proliferation of digital data and the internet fuelled the rise of data-driven approaches to AI, including statistical machine learning, data mining, and big data analytics.
- Breakthroughs in deep learning, a subset of machine learning focused on neural networks with multiple layers, revolutionized AI by achieving unprecedented performance in tasks such as image recognition, speech recognition, and natural language processing.
- AI applications proliferated across industries, including healthcare (medical imaging, drug discovery), finance (algorithmic trading, fraud detection), retail (recommendation systems, customer segmentation), and transportation (autonomous vehicles, route optimization).

Current Trends and Future Directions:

- AI continues to advance rapidly, driven by innovations in deep learning, reinforcement learning, and other AI techniques.

- Applications of AI are expanding to new domains, including robotics, virtual assistants, augmented reality, and personalized medicine.
- Ethical considerations, such as bias mitigation, fairness, transparency, and accountability, are becoming increasingly important as AI systems play a larger role in decision-making processes.
- Collaborative efforts are underway to standardize AI technologies, develop regulatory frameworks, and address societal challenges related to AI deployment.

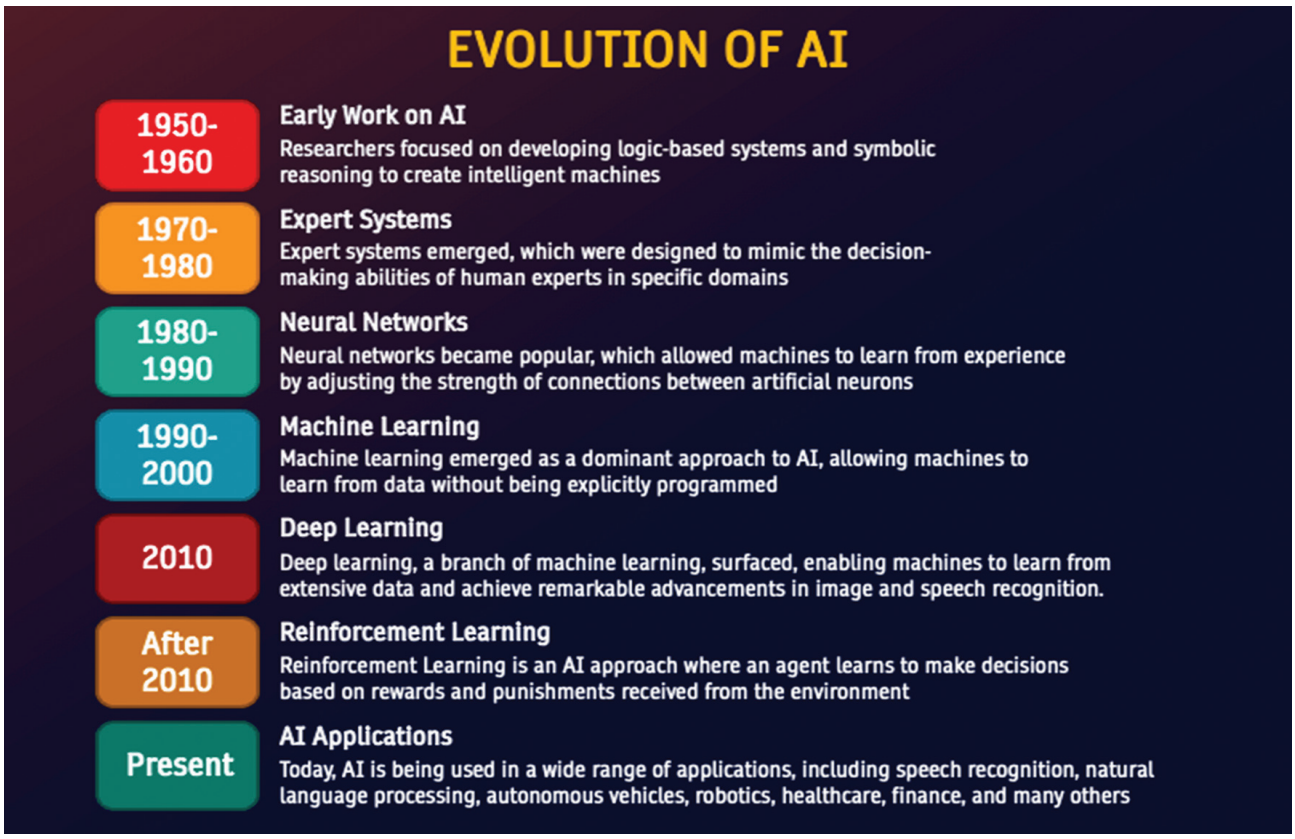

Figure 2: Evolution of AI

1.3 Categorization of AI

AI gets categorised in different ways.

a) Weak AI vs. Strong AI:

Weak AI describes "simulated" thinking. That is, a system which appears to behave intelligently, but doesn't have any kind of consciousness about what it's doing. For example, a chatbot might appear to hold a natural conversation, but it has no sense of who it is or why it's talking to you.

Strong AI describes "actual" thinking. That is, behaving intelligently, thinking as human does, with a conscious, subjective mind. For example, when two humans converse, they most likely know exactly who they are, what they're doing, and why.

b) Narrow AI vs. General AI:

Narrow AI describes an AI that is limited to a single task or a set number of

tasks. For example, the capabilities of IBM's Deep Blue, the chess playing computer that beat world champion Gary Kasparov in 1997, were limited to playing chess. It wouldn't have been able to win a game of tic-tac-toe - or even know how to play.

General AI describes an AI which can be used to complete a wide range of tasks in a wide range of environments. As such, it's much closer to human intelligence.

c) Superintelligence:

The term "superintelligence" is often used to refer to general and strong AI at the point at which it surpasses human intelligence, if it ever does.

CHAPTER II
HOW DOES AI WORK?

CHAPTER II

HOW DOES AI WORK?

AI analyses data to extract patterns and make predictions. It does this by combining large datasets with intelligent AI algorithms/ – or sets of rules/ – that allow the software to learn from patterns in the data. The way the system accomplishes this is through a neural network/ – an array of interconnected nodes that relay information between various layers to find connections and derive meaning from data. The concepts need to be known for better understanding are:

- **Machine Learning and Deep Learning:**

  Machine learning enables machines to learn from data, identify patterns and make decisions without explicit programming. **Deep learning** empowers to understand more complex patterns using millions of data points.

- **Reasoning:**

  The ability to reason is crucial to AI because it allows computers to mimic the human brain. AI can make inferences based on commands it is given, or other available information, to form hypotheses or develop strategies for addressing a problem.

- **Problem solving:**

  AI's problem-solving capability is based on the manipulation of data through trial-and-error techniques. It involves using algorithms to explore various possible paths to find the most optimal solution to complex problems.

- **Natural Language Processing (NLP):**

  AI uses natural language processing to analyse human language data in a way that is meaningful to computers. NLP It refers to the ability of computers to understand, interpret and generate human language, using text analysis, sentiment analysis and machine translation.

- **Perception:**

  I scans the environment through various types of sensors and cameras. This field of AI enables machines to interpret and understand visual data and is used in image recognition, facial recognition and object detection.

CHAPTER III

AI INTEGRATION INTO VARIOUS INDUSTRIES

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AI INTEGRATION INTO VARIOUS INDUSTRIES

The evolution of AI has led to its integration into various industries, driving innovation, efficiency, and new opportunities for growth and improvement across sectors.

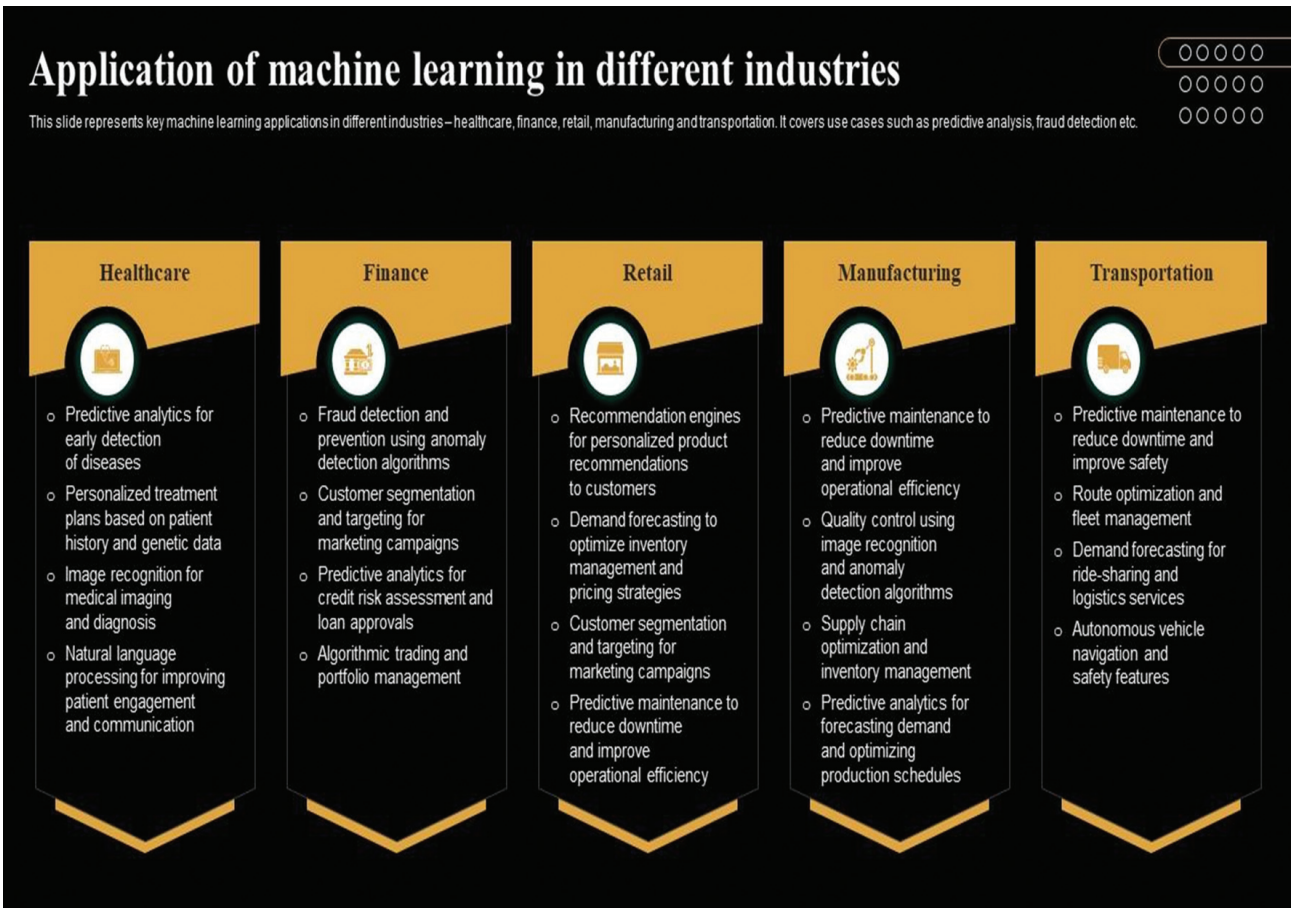

Figure 3: Application of machine learning in different industries

3.1 **Healthcare:** AI is being used for medical imaging analysis, disease diagnosis, personalized treatment planning, and drug discovery.

3.2 **Finance:** AI powers algorithmic trading, fraud detection, risk assessment, and customer service automation in banking and financial services.

3.3 **Retail:** AI-driven recommendation systems, demand forecasting, inventory management, and supply chain optimization enhance customer experience and operational efficiency.

3.4 **Transportation:** Autonomous vehicles, traffic management systems, and predictive maintenance solutions are transforming the automotive and transportation industries.

3.5 **Manufacturing:** AI-enabled robotics, predictive maintenance, quality control, and supply chain optimization improve productivity, quality, and safety in manufacturing processes.

CHAPTER IV

NEED FOR STANDARDIZATION IN THE FIELD OF ARTIFICIAL INTELLIGENCE

CHAPTER IV

Need for Standardization in the field of Artificial Intelligence

As AI technologies continue to advance, their impact on society and the economy is expected to grow, shaping the future of work, healthcare, transportation, and beyond. There are significant challenges and potential risks to the widespread adoption and responsible deployment of AI. Standardization in AI is THE SOLUTION for overcoming various challenges and potential risks enumerated below:

4.1 Challenges to adoption of AI

4.1.1 Interoperability Issues: Without standardized formats, protocols, and interfaces, AI systems may struggle to communicate and work together seamlessly. This can hinder data exchange, integration, and collaboration across different platforms and applications.

4.1.2 Quality and Reliability: The lack of standardized evaluation criteria and benchmarks makes it difficult to assess the quality, performance, and reliability of AI systems. This can result in variability in system capabilities and outcomes, impacting user experience and trust.

4.1.3 Ethical Concerns: In the absence of standardized ethical guidelines and principles, AI developers may face challenges in addressing ethical considerations such as fairness, transparency, accountability, and bias mitigation. This can lead to ethical dilemmas and societal harm, including discrimination and privacy violations.

4.1.4 Regulatory Uncertainty: Without clear regulatory standards and compliance requirements, AI developers and users may face uncertainty and ambiguity regarding legal obligations and liabilities. This can impede innovation, investment, and adoption of AI technologies, leading to regulatory fragmentation and jurisdictional conflicts.

4.2 Potential Risks to adoption of AI

4.2.1 Bias and Discrimination:

Unstandardized AI systems may exhibit bias and discrimination in decision-making processes, resulting in unfair treatment and unequal opportunities for certain groups. This can reinforce existing societal inequalities and undermine trust in AI technologies.

Some common types of biases that have come under the lens of researchers and regulators include algorithm bias, sample bias, prejudice bias, measurement bias, and exclusion bias.

Algorithm bias - The algorithm produces a systematically prejudiced result due to erroneous assumptions in the ML process.

Sample bias - The training data does not accurately reflect the real-world usage of the model. Usually, one population is either heavily overrepresented or underrepresented.

Prejudice bias - The data used to train the system reflects existing prejudices, stereotypes and/or faulty societal assumptions, thereby introducing those same real-world biases into the machine learning algorithm itself.

Measurement bias -The bias arises due to underlying problems with the accuracy of the data and how it was measured or assessed.

Exclusion bias - This bias in artificial intelligence occurs when one excludes some features from the training dataset.

A widely cited case of a biased AI algorithm is Amazon's AI recruitment tool. Amazon had to kill its AI-powered recruitment tool after it was found to be biased against female candidates. The Amazon tool failed to rate candidates for a technical job gender-neutral way. The algorithm used was trained on past ten-year data when the tech industry was male-dominated. Poor selection of data sets can result in gender, ethnic and cultural biases and discrimination.

The autonomous vehicle is a widely debated concept among researchers and policymakers. It raises questions such as if an autonomous vehicle kills a pedestrian, who should be held accountable? Who is to be held liable by the legal machinery? Is it the owner of the vehicle or the manufacturer? What are the damages?

4.2.2 Privacy Violations:

Without standardized privacy safeguards and data protection mechanisms, AI systems may pose risks to individuals' privacy and personal data. This can lead to unauthorized access, misuse, and unauthorized disclosure of sensitive information, infringing on individuals' rights and freedoms.

4.2.3 Safety Concerns:

Unstandardized AI systems deployed in safety-critical applications, such as autonomous vehicles and medical devices, may pose risks to human safety and well-being. This can result in accidents, injuries, and fatalities, as well as legal and reputational consequences for responsible parties.

4.2.4 Lack of Accountability:

In the absence of standardized accountability mechanisms, it may be challenging to attribute responsibility and liability for the actions and decisions of AI systems. This can create accountability gaps and legal challenges in addressing harms and seeking redress for affected parties.

4.2.5 Market Fragmentation:

Without standardized frameworks and guidelines, the AI market may experience fragmentation, with incompatible technologies and proprietary solutions hindering interoperability and competition. This can limit choice, innovation, and market access for stakeholders, impeding the development and adoption of AI technologies.

4.2.6 Security Risks:

Unstandardized AI systems may be vulnerable to security threats such as data breaches, cyberattacks, and adversarial manipulation. This can compromise the confidentiality,

integrity, and availability of data and systems, posing risks to individuals, organizations, and society.

In summary, the absence of standards in AI poses significant challenges and potential risks. Addressing these challenges and mitigating these risks requires collaborative efforts from stakeholders across sectors to develop and adopt standardized frameworks, guidelines, and best practices for responsible AI development and deployment while addressing societal challenges and advancing human well-being.

CHAPTER V

AI STANDARDIZATION-NATIONAL AND GLOBAL EFFORTS

CHAPTER V

AI Standardization-National and global efforts

In India, Technical committee on "Artificial Intelligence", LITD 30 set up by Bureau of Indian Standards in year 2018, deals with the Standardization in the area of Artificial Intelligence and Big Data.

The LITD 30 committee comprises of members from various stakeholders' groups coming from Government organization, industry, Academia, R&D institutes, Consumer organizations etc. The institutions like IIT Bombay, IIT Kanpur, IIT Madras, TCS, Infosys, Ministry of Electronics & IT, CDAC, IISc Bangalore, ISGF, ABB India, CII, NASSCOM, NITI Aayog etc. are active participants on this Committee. LITD 30 identifies the areas for AI standardization based on National priorities in line with the NITI Aayog National Strategy for AI and directives issued from Government from time to time and also pursues these at International level. More details on BIS committee on AI (LITD 30) are provided in Annex 2.

Artificial Intelligence being a technology which transcends boundaries, the LITD 30 committee works in sync with the International standardization work of ISO/IEC JTC 1/SC 42, committee of International Organization for Standardization (ISO) and International Electro technical Commission (IEC). Experts from 62 countries, including India participate in the work of this AI committee. The committee also has liaison with UNESCO, WTO, World economic forum, ITU, European Commission etc. More details about ISO/IEC JTC 1/SC 42 committee on AI are provided in Annex 3.

BIS Committee, LITD 30 on AI is the national Mirror Committee of this important international AI Committee (ISO/IEC JTC 1/SC 42). Only the members represented on BIS committee are eligible to participate and contribute towards international standardization efforts in SC 42. BIS's endeavour is to have strong presence and participation of Indian experts in JTC 1/SC 42 so as to ensure that national priorities and requirements are incorporated while bringing out international standards. This ensures seamless adoption and implementation of the international standards within the country.

AIM of AI Standardization:

- Common concepts and terminology
- Enabling meaningful and Intelligent insights from large amount of data sets
- Defining Characteristics of Quality of Data
- To tackle Governance issues
- To ensure Trustworthiness: security, privacy, ethical and societal consideration aspects

CHAPTER VI

ARTIFICIAL INTELLIGENCE–KEY TOPICS OF STANDARDIZATIONS

CHAPTER VI

ARTIFICIAL INTELLIGENCE–KEY TOPICS OF STANDARDIZATIONS

- Foundational Standards
- Data – AI, Big Data Analytics
- Trustworthiness of AI Systems including Governance
- Societal Concerns and Ethics
- Use Cases and Applications
- Computational Methods, Algorithms
- Testing of AI Based System
- Sustainability

6.1 Artificial Intelligence - Foundational Standards

Overview

AI has generated interest across a very diverse and growing set of stakeholders. It is, therefore, required to introduce a common language that can be used across stakeholder groups. There is a need to address unique AI requirements to enable certification and audit via Management System Standards.

Standards Published

1. AI Concepts and Terminology (IS/ISO/IEC 22989:2022)

   This document establishes terminology for AI and describes concepts like Strong AI, Weak AI, Supervised machine learning, Unsupervised machine learning, Semi-supervised machine learning, Reinforcement learning, machine learning algorithms, roles of AI stakeholders, AI System Life cycle etc.

2. Framework for AI Systems Using Machine learning (IS/ISO/IEC 23053:2022)

   This document provides an Artificial Intelligence (AI) and Machine Learning (ML) framework for describing a generic AI system using ML technology. This framework describes the system components and their functions in the AI ecosystem.

3. AI - Management System Standard (IS/ISO/IEC 42001:2023)

   This document specifies requirements for establishing, implementing, maintaining, and continually improving an Artificial Intelligence Management System (AIMS) within organizations. It is designed for entities providing or utilizing AI-based products or services, ensuring responsible development and use of AI systems.

Standards under development

4. AI system impact assessment (ISO/IEC 42005)

   The document provides guidance for organizations on performing AI system impact assessments to address potential impacts on individuals and society. It outlines how to integrate these assessments into an organization's AI risk management and overall management system. Key aspects include documenting the process, determining the scope, and analyzing results.

5. Requirements for bodies providing audit and certification of AI management systems (ISO/IEC 42006)

   This document specifies additional requirements for ISO/IEC 17021-1 in order to enable accredited and or peer assessed certification bodies to reliably audit the management system for organizations that develop or use AI systems or both according to ISO/IEC 42001 and to make an evaluation and decision for certification.

6. Taxonomy of AI system methods and capabilities (ISO/IEC 42102)

   This document proposes a taxonomy for classifying AI systems, aiming to provide a common understanding among stakeholders across various stages of AI system lifecycles. It addresses the need for coherence and interoperability in describing AI applications, supporting development, operation, conformity assessment, and market surveillance..

7. Amendments of base documents, ISO/IEC 22989 and 23053, to add generative AI concepts

   These amendments intend to add concepts and terminology related to Generative AI.

6.2 Data – AI, Big Data Analytics

Overview

Big Data deals with extensive datasets by considering characteristics, such as volume, variety, velocity, variability, which allows scalable technology to efficiently store, manipulate, manage and analyse these datasets. AI systems acquire, process and apply knowledge, which relies on data, its properties and quality. Analytics derives insights from data, which requires data acquisition, collection, validation and processing. Standards are, therefore, required for Data ecosystem, characteristics, properties and quality essential to AI, Big Data and analytics work.

Standards Published

1. Foundational Big Data work: IS/ISO/IEC 20546 and IS/ISO/IEC 20547 series Big Data Reference Architecture

   This document provides an overview and vocabulary for big data, focusing on key data characteristics (volume, velocity, variety, and variability) and processing characteristics (data science, volatility, veracity, visualization, and scaling). It addresses the significance of structured and unstructured data, distributed file

systems, distributed data processing, and non-relational (NoSQL) databases, emphasizing horizontal scaling and the handling of diverse data types.

2. Process management framework for Big Data analytics to leverage across the organization irrespective of industry (IS/ ISO/IEC 24668)

   This document provides a framework for implementing big data analytics (BDA) across diverse organizational functions. It introduces a Process Reference Model (PRM) and Process Assessment Model (PAM) structured around five key process categories: organization stakeholder, competency development, data management, analytics development, and technology integration. The framework aims to optimize BDA processes by providing process descriptions, performance indicators, and capability assessments aligned with international standards, facilitating improved decision-making, competitive advantages, and operational efficiencies through BDA automation and enhancement.

3. AI – Data lifecycle framework (IS/ISO/IEC 8183)

   This document defines the stages and identifies associated actions for data processing throughout the artificial intelligence (AI) system life cycle, including acquisition, creation, development, deployment, maintenance and decommissioning. This document does not define specific services, platforms or tools. This document is applicable to all organizations, regardless of type, size or nature, that use data in the development and use of AI systems.

Standards under development

4. Data quality for analytics and Machine Learning (ISO/IEC 5259) -6 parts covering terminology, measures, requirements, guidelines, process framework, governance framework and visualization

   These documents provide guidance and requirements to maintain data quality for analytics and machine learning (ML). Part 1 of this series describes the data quality terminology and concepts used in this series. Part 2 describes the data quality model and data quality measures. Part 3 specifies requirements and provides guidance for establishing, implementing, maintaining and continually improving the quality of data used in the areas of analytics and machine learning. Part 4 describes the data quality process framework. Part 5 provides a data quality governance framework as guidance for governing bodies. Part 6 describes a visualization framework for data quality in analytics and ML.

5. Overview of synthetic data in the context of AI systems (ISO/IEC 42103)

   This document provides an overview of synthetic data concepts, methods, uses and considerations in the context of AI systems.

6. De-identification of training data for ML(ISO/IEC 47559)

   This document intends to provide methods and mechanisms for de-identification of training data (both for personal and non-personal data) before it is used for training of ML models.

6.3 Trustworthiness of AI Systems

Overview

Standards are required looking at a wide range of issues related to AI trustworthiness, security and privacy to enable responsible adoption. Standards are built on the robust and widely adopted portfolio of existing standards related to trustworthiness and extends for AI. These standards are essential for stakeholders across application domains to enable broad adoption and provide key for regulatory landscape.

Standards Published

1. AI risk management framework (IS/ISO/IEC 23894 -based on IS/ISO 31000*)

   This document provides guidance to organizations that develop, produce, deploy or use products, systems and services that utilize artificial intelligence (AI) for managing risk specifically related to AI. The guidance also aims to assist organizations to integrate risk management into their AI-related activities and functions. It moreover describes processes for the effective implementation and integration of AI risk management.

2. AI trustworthiness overview (IS/ISO/IEC 24028)

   This document surveys topics related to trustworthiness in AI systems such as approaches to establish trust in AI systems through transparency, explainability, controllability; engineering pitfalls and typical associated threats and risks to AI systems, along with possible mitigation techniques and methods; and approaches to assess and achieve availability, resiliency, reliability, accuracy, safety, security and privacy of AI systems.

3. Overview and formal methods of robustness of neural networks (IS/ISO/IEC 24029 Series)

   This is series of documents related to robustness of neural networks. These documents provide background about existing methods to assess the robustness of neural networks. These documents describe methodology for use of formal and statistical methods.

4. Overview of bias in AI systems (IS/ISO/IEC TR 24027)

   This document addresses bias in relation to AI systems, especially with regards to AI-aided decision-making. Measurement techniques and methods for assessing bias are described, with the aim to address and treat bias-related vulnerabilities. All AI system lifecycle phases are in scope, including but not limited to data collection, training, continual learning, design, testing, evaluation and use.

5. Governance implications of the use of artificial intelligence by organizations (IS/ISO/IEC 38507)

   This document provides guidance to governing bodies of organizations on effectively governing the use of Artificial Intelligence (AI). It emphasizes the role of governance in managing AI's opportunities, risks, and responsibilities, focusing on human oversight rather than technical aspects. This document aims to ensure the effective, efficient, and ethical use of AI across various sectors.

6. Quality Model for AI systems (IS/ ISO/IEC 25059)

This document outlines a quality model for AI systems and is an application-specific extension to the standards on Systems and software Quality Requirements and Evaluation (SQuaRE). The characteristics and sub-characteristics detailed in the model provide consistent terminology for specifying, measuring and evaluating AI system quality. The characteristics and sub-characteristics detailed in the model also provide a set of quality characteristics against which stated quality requirements can be compared for completeness.

7. Controllability of automated artificial intelligence systems (IS/ISO/IEC TS 8200)

This document specifies a basic framework with principles, characteristics and approaches for the realization and enhancement for automated artificial intelligence (AI) systems' controllability.

8. Functional Safety and AI Systems (IS/ISO/IEC TR 5469)

This document describes the properties, related risk factors, available methods and processes relating to use of AI inside a safety related function to realize the functionality; use of non-AI safety related functions to ensure safety for an AI controlled equipment; use of AI systems to design and develop safety related functions.

9. Guidance for quality evaluation of AI systems (IS/ISO/IEC TS 25058)

This document provides guidance for evaluation of artificial intelligence (AI) systems using an AI system quality model. this document is to guide AI developers performing a quality evaluation of their AI systems. This document does not state exact measurements and thresholds, as these vary depending on the nature of each system. Instead, it specifies comprehensive guidance that covers the relevant facets of an AI system's quality for successful quality evaluation.

Standards under development

10. Benchmarking of AI system quality characteristics (ISO/IEC TR 42106)

This document provides an overview of conceptual frameworks for graded benchmarking of AI system quality characteristics. The aim is to examine the feasibility of using differentiated benchmarking of quality characteristics based on the complexity and context of use of an AI system.

11. Objectives and approaches for explainability and interpretability of ML models and AI systems (ISO/IEC TS 6254)

This document provides a comprehensive framework for achieving explainability in ML models and AI systems. It outlines various approaches such as empirical analysis, post-hoc interpretation (local and global), inherently interpretable components, architecture- and task-driven methods, and data explanation.

12. Treatment of unwanted bias in classification and regression machine learning tasks (ISO/IEC 12791)

This document describes how to address unwanted bias in AI systems that use machine learning to conduct classification and regression tasks. This document

describes good practises for treating unwanted bias and can help an organization with the treatment of unwanted bias in machine learning (ML) systems that conduct classification and regression tasks. The techniques in this document are applicable to classification and regression ML tasks. This document does not address applicability of the described methods outside of the defined ML tasks.

13. Transparency taxonomy of AI systems (ISO/IEC 12792)

    The document establishes a taxonomy for transparency in AI systems, aimed at improving trust, accountability, and communication among stakeholders by standardizing terminology and information elements. It addresses various aspects of transparency, including the system's context, internal functioning, and dataset documentation, to aid stakeholders in understanding and evaluating AI systems.

14. Guidance for human oversight of AI systems (ISO/IEC 42105)

    This document provides guidance for human oversight of AI systems, emphasizing the importance of human operators and developers in controlling and monitoring AI throughout its lifecycle. It builds upon ISO/IEC TS 8200 to ensure AI systems remain controllable, providing frameworks for effective policy implementation, information exchange clarity, and appropriate system reactions.

15. Assessment of the robustness of neural networks part 3: methodology for the use of statistical methods (ISO/IEC 24029-3)

16. AI-enhanced nudging (ISO/IEC 25029)

    This document aims to define and guide the implementation of AI-enhanced nudging mechanisms, ensuring they align with existing AI standards.

17. Guidance for addressing security threats and failures in artificial intelligence systems (ISO/IEC 27090)

    This document provides guidance to address security and privacy concerns in AI systems.

18. Reliability of AI systems (ISO/IEC 42118)

    This document intends to provide methods and mechanisms to evaluate the reliability of an AI system. It describes the metrics of reliability and the procedure for reliability assessment from a statistical perspective

19. Artificial Intelligence — Privacy protection (ISO/IEC 27091)

    This document provides guidance to address privacy concerns in AI systems. The guidance in this document helps organizations identify privacy risks throughout the AI system lifecycle, and establishes mechanisms to evaluate the consequences of and treat such risks

6.4 Societal Concerns and Ethics

Overview

Adoption of transformative technologies like AI have impacts that go beyond the technology. There are AI-specific trustworthiness issues e.g. reliability, privacy, security,

explainability, controllability. And there are Emerging issues related to the context of use of the technology – e.g. algorithmic bias, safety directives in industrial AI, eavesdropping etc. Standards can mitigate ethical issues allowing for broad responsible adoption.

Standards Published

1. Artificial Intelligence - Overview of ethical and societal concerns (IS/ISO/IEC TR 24368:2022)

   This document provides a high-level overview of AI ethical and societal concerns such as; Accountability, Fairness and non-discrimination, Transparency and explainability, Privacy, Safety, Security, Human centred design, respect for the rule of law, environmental sustainability etc.

Standards under development

2. Guidance on addressing societal concerns and ethical considerations (ISO/IEC AWI TS 22443)

   The document proposes guidance for organizations to identify and address societal concerns and ethical considerations throughout the life cycle of AI systems, aiming to enhance trustworthiness and compliance with emerging regulations. It covers diverse impacts such as autonomy, privacy, accountability, and effects on sectors like healthcare and education.

3. Beneficial AI Systems (ISO/IEC AWI TR 21221)

   This document describes the development of a conceptual framework to articulate the benefits of AI systems as perceived by a variety of stakeholders based on value and impact. The dimensions of benefits of AI systems include but are not limited to functional, economic, environmental, social, societal, cultural.

6.5 AI- Computational Methods, Algorithms

Standards Published

1. Overview of the state of the art of computational approaches for AI systems (IS/ ISO/IEC TR 24372)

   This document provides an overview of the state of the art of computational approaches for AI systems, by describing main computational characteristics of AI systems and main algorithms and approaches used in AI systems

2. Assessment of classification performance for machine learning models and algorithms (IS/ ISO/IEC TS 4213)

   This document specifies methodologies for measuring classification performance of machine learning models, systems and algorithm such as Confusion matrix, F_1 score, Kullback-Leibler divergence, Receiver operating characteristic curve, Precision recall curve etc.

3. Reference architecture of knowledge engineering (KE) (ISO/IEC 5392)

   This document defines a reference architecture of knowledge engineering (KE)

in artificial intelligence (AI). The reference architecture describes KE roles, activities, constructional layers, components and their relationships amongst themselves and other systems from systemic user and functional views. This document also provides a common KE vocabulary.

4. Overview of machine learning computing devices (ISO/IEC TR 17903)

   This document surveys machine learning (ML) computing devices, including ML computing device terminology and characteristics and existing approaches to the setting and use of characteristics for optimizing ML computing device performance.

Standards under development

5. Guidance on model training efficiency optimization of machine learning system (ISO/IEC NP 42112)

   The proposal aims to provide guidance on optimizing machine learning model training efficiency by addressing key characteristics such as communication, storage, and recovery processes. It targets AI providers and producers, offering methodologies like parallelism, resource utilization, and checkpoint mechanisms to enhance training speed and reduce resource consumption.

6. Evaluation methods for accurate natural language processing systems (ISO/IEC 23282)

   This proposal aims to develop a standard specifically for evaluating natural language processing (NLP) systems, addressing gaps in existing standards like ISO/IEC 23053 and ISO/IEC TS 4213. It focuses on defining and implementing evaluation metrics tailored to NLP tasks such as machine translation, speech recognition, and information extraction. The standard will provide guidelines on selecting appropriate metrics, ensuring their correct implementation for reproducible results, and specifying technical resource requirements for comprehensive NLP system evaluations across different languages and applications.

6.6 Testing of AI based Systems

As adoption and deployment across industry sectors of AI continues, a need to address testing of AI-based systems is key.

AI testing is similar to conventional software testing, but it also faces AI-specific challenges. These challenges are discussed and approaches to mitigate are introduced.

Standards Published

1. Guidelines on the testing of AI-based systems (IS/ISO/IEC TR 29119-11)

   This document presents the challenges of testing AI-based systems, the main challenge being the test oracle problem, whereby testers find it difficult to determine expected results for testing and therefore whether tests have passed or failed. It covers testing of these systems across the life cycle and gives guidelines on how AI-based systems in general can be tested using black-box approaches and introduces white-box testing specifically for neural networks. It

describes options for the test environments and test scenarios used for testing AI-based systems.

Standards Under development

2. Testing of AI systems (ISO/IEC TS 29119-11)

   This document provides requirements and guidance on the application of the ISO/IEC/IEEE 29119 series to the testing of AI systems.

3. Verification and validation analysis of AI systems (ISO/IEC TS 17847)

   This document describes approaches and provides guidance on processes for the verification and validation analysis of AI systems including formal methods, simulation and evaluation. This document describes techniques used in V&V analysis approaches for AI systems and provides overview of V&V analysis approaches for non-functional requirements. It also provides guidance for the use of metrics in V&V analysis.

6.7 Sustainability

Standards Under development

Environmental sustainability aspects of AI systems (ISO/IEC TR 20226)

This document outlines the environmental sustainability aspects of AI systems throughout their lifecycle. It covers significant topics such as energy consumption, including the use of power-intensive GPUs and their impact on carbon emissions. Geographic considerations, including location, distribution, and transportation of AI infrastructure, are highlighted. The document addresses water use, cooling methods, carbon footprint, and waste management, emphasizing the potential environmental impacts and providing metrics for measurement. Strategies for reducing these impacts are suggested, including ecosystem, lifecycle, and supply chain approaches, aiming to mitigate environmental degradation caused by AI technologies.

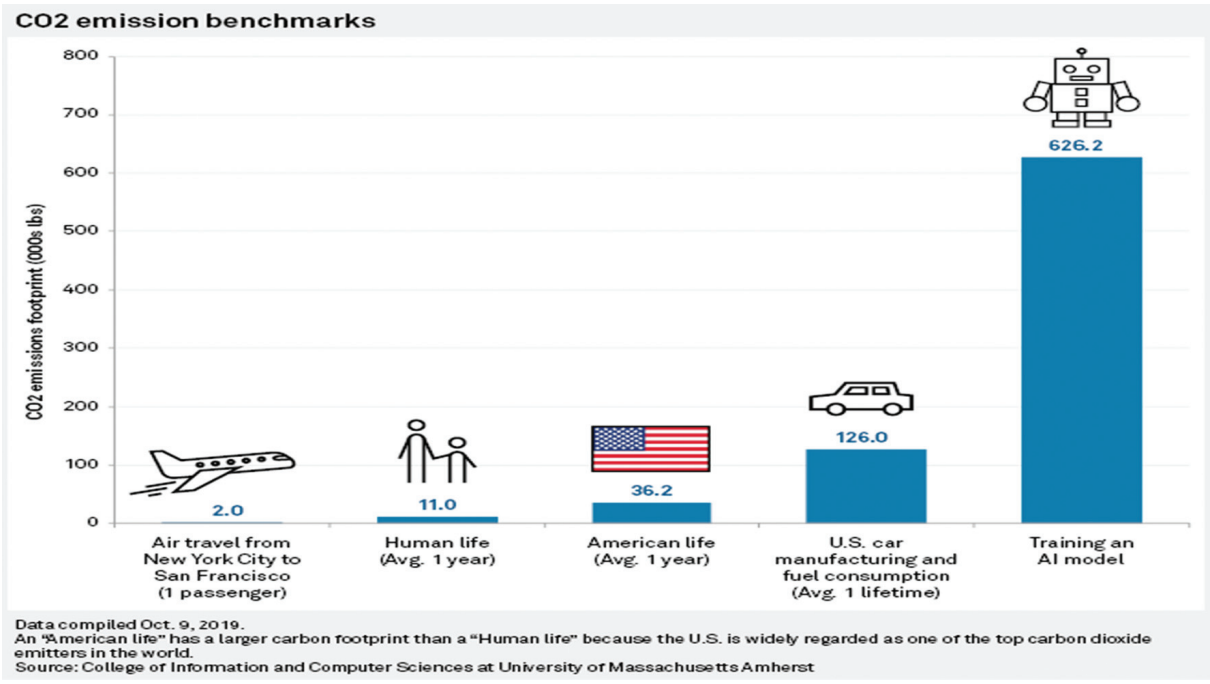

Figure 4: Co2 emission benchmarks

6.8 Artificial intelligence - Use Cases and Applications

Interest in AI continues to grow across application domains and use cases. By looking at different domains, standards prepared are expected to be "broad enough to be horizontal". It is required to identify AI application domains, context of AI use in those domains and develop guidance for AI applications. Thereafter, collect representative use cases and analyze for derived requirements.

Standards Published

1. Artificial intelligence - Use Cases (IS/ISO/IEC TR 24030)

   This document providing a collection of artificial intelligence (AI) use cases across various domains.

2. Guidance for AI applications (IS/ISO/IEC 5339)

   This document provides guidance on artificial intelligence (AI) applications, emphasizing stakeholder engagement and the AI application life cycle. It aims to enhance multi-stakeholder communication and acceptance by offering a framework that includes the make, use, and impact perspectives of AI systems. This document provides guidance to consider AI Application with stakeholder perspective.

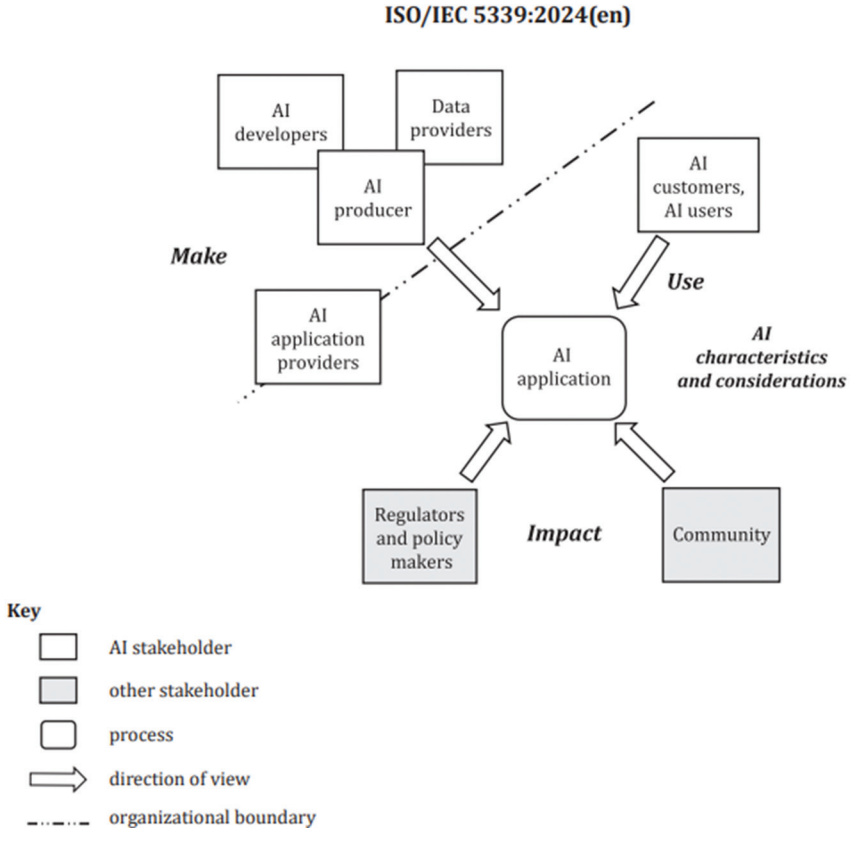

Figure 5: AI application – stakeholders' perspectives

3. AI System Life cycle process (IS/ISO/IEC 5338)

   This document defines a set of processes and associated concepts for describing the life cycle of AI systems based on machine learning and heuristic systems.

This document provides processes that support the definition, control, management, execution and improvement of the AI system in its life cycle stages.

Standards under development

4. Human-machine teaming (ISO/IEC 42109)

   This document intends to provide concepts and guidance for usage of Human-machine teaming in AI systems.

5. Guidance for Generative AI Applications

   This document intends to provide guidance for generative AI applications. Guidance is primarily aimed related to output data quality.

CHAPTER VII

INTERNATIONAL STANDARDIZATION -UNDER INDIA'S LEADERSHIP

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INTERNATIONAL STANDARDIZATION -UNDER INDIA'S LEADERSHIP

Indian experts which are part of the BIS committee on AI have been actively contributing in the activities of ISO/IEC JTC 1/SC 42 in bringing out International Standards on "Artificial Intelligence". Some of the International Standards have been conceptualized with in BIS committee and Indian experts have taken these further to International committee. Such projects have been developed/are being developed as ISO/IEC documents under the leadership of Indian experts. Some of these are as listed below:

1. **ISO/IEC 24668:2022 'Information technology — Artificial intelligence — Process management framework for Big data analytics'**

   This standard provides comprehensive framework for identifying and assessing key tenets for successful implementation of Big Data Analytics projects within the organization. This document specifies process management for big data analytics with its various process categories taken into account along with their interconnectivities. These process categories are organization stakeholder processes, competency development processes, data management processes, analytics development processes and technology integration processes. This document describes processes to acquire, describe, store and process data at an organization level which provides big data analytics services.

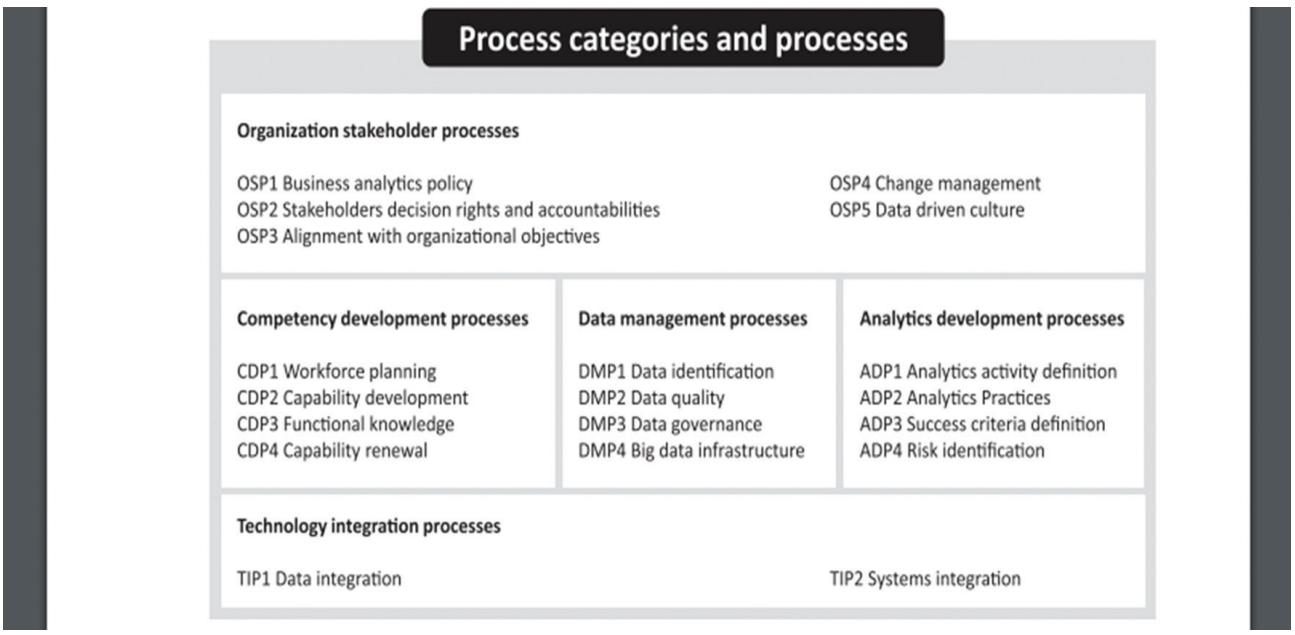

Figure 6: Big data process categories and processes:

2. ISO/IEC 5339:2024 'Information Technology — Artificial Intelligence — Guidelines for AI applications'

This standard provides guidelines for identifying the context, opportunities, and processes for developing and applying AI Applications. The document provides a macro level view of an AI Application and a common framework to stakeholders to answer the question: "What is an AI Application?"

3. ISO/IEC AWI TS 17847 'Verification and validation Analysis of AI systems'– *Under development*

This document describes approaches for verification and validation of AI systems against their stated requirements and specifications.

4. ISO/IEC AWI TR 42106 Overview of differentiated benchmarking of AI system quality characteristics – *Under development*

This document provides an overview of conceptual frameworks for graded benchmarking of AI system quality characteristics. The aim is to examine the feasibility of using differentiated benchmarking of quality characteristics based on the complexity and context of use of an AI system

5. Guidance for Generative AI Applications

This document intends to provide guidance to identify value contribution and value realization for each stakeholder when developing or using a generative AI application. This document also provides guidance for governance mechanism to manage use of an existing generative AI application as a service

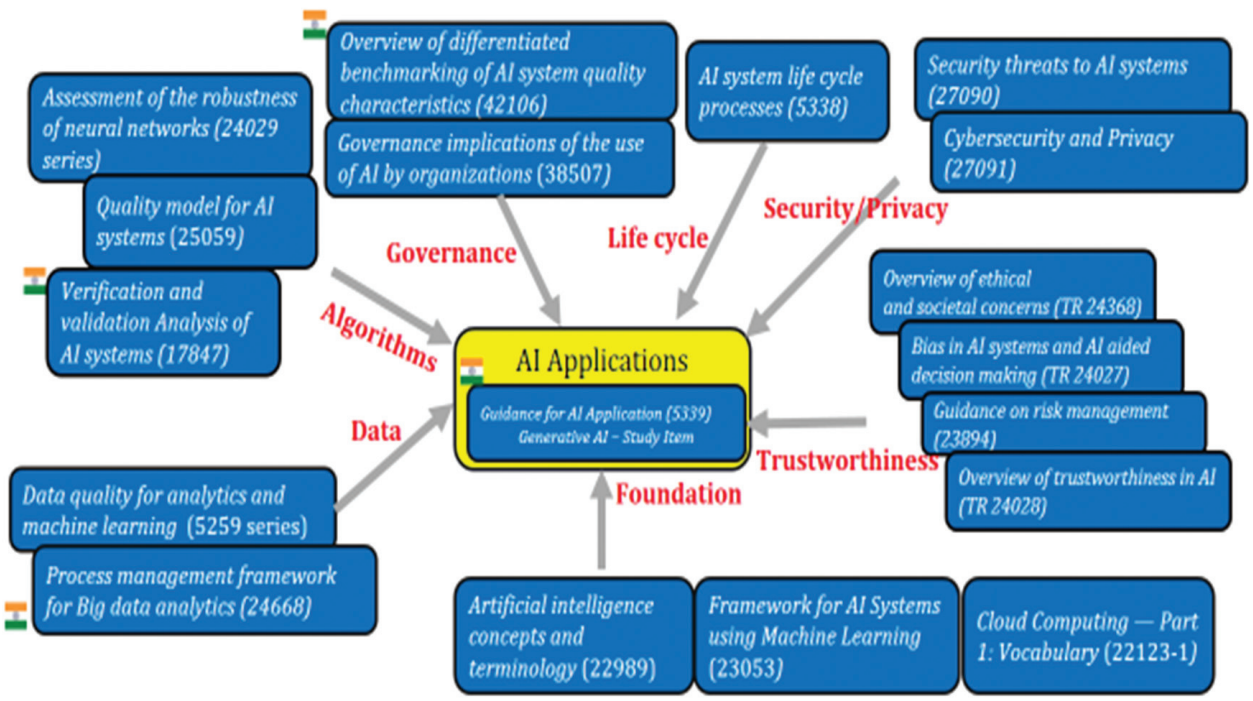

Figure 5: Relation of AI Applications standard with other standards

6. Reliability of AI Systems – *Under development*

This document intends to provide methods and mechanisms to evaluate the reliability of an AI system. It describes the metrics of reliability and the procedure for reliability assessment from a statistical perspective

7. De-identification of training data for ML

This document intends to provide methods and mechanisms for de-identification of training data (both for personal and non-personal data) before it is used for training of ML models.

CHAPTER VIII

ARTIFICIAL INTELLIGENCE REGULATORY FRAMEWORK ACROSS THE GLOBE

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ARTIFICIAL INTELLIGENCE REGULATORY FRAMEWORK ACROSS THE GLOBE

The legal framework for AI governance varies widely across different countries and regions, reflecting diverse approaches to regulating AI technologies. The legal frameworks for AI governance are evolving, with many countries and regions emphasizing ethical principles, transparency, data protection, and innovation. While the approaches differ, there is a common goal to harness the benefits of AI while mitigating risks and ensuring public trust. A summary of the frameworks in several key jurisdictions:

SL NO	REGULATION/ PROPOSAL	REGION	KEY POINTS
1.	Artificial Intelligence (AI) Ethics Principles Framework	Australia	Australia's 8 Artificial Intelligence (AI) Ethics Principles are designed to ensure AI is safe, secure and reliable.They will help: • achieve safer, more reliable and fairer outcomes for all Australians • reduce the risk of negative impact on those affected by AI applications • businesses and governments to practice the highest ethical standards when designing, developing and implementing AI The principles: 1. Human, societal and environmental wellbeing 2. Human-centred values 3. Fairness 4. Privacy protection and security 5. Reliability and safety 6. Transparency and explainability 7. Contestability 8. Accountability
2.	Bill 2338/2023	Brazil	Mandates entities to ensure transparency and mitigate biases, particularly in high-risk AI systems. It also requires detailed public impact assessments that outline the system's purpose, risk mitigations, and stakeholder involvement, where entities will be held strictly liable for any damages caused. Takes a risk-based approach similar to the EU.
3.	The Artificial Intelligence and Data Act (AIDA)	Canada	Contains few details about the specific types of AI uses on which the Federal Government intends to impose the strictest requirements: the so-called "high-impact systems".

			Principles that will guide the development of the obligations: • Human Oversight & Monitoring • Transparency • Fairness and Equity • Safety • Accountability • Validity & Robustness
4.	Plan of Next Generation AI Development 2017 Guidelines to the Construction of the National New-Generation AI Standard System 2020	China	Responsible AI Through Four Governance Dimensions: 1. Data Governance: New civil rights for individuals and obligations for processors ensure accountability and protect personal information. 2. Algorithm Governance: Principles of transparency, fairness, controllability, and accountability guide algorithm use, addressing issues like bias and differential treatment. 3. Platform Governance: Online platforms, which often lead AI innovation, must follow rules to ensure fairness and competition. 4. Specific Application Scenarios: Sector-specific regulations address unique risks in areas such as labor, facial recognition, and financial services.
5.	EU AI Act,2024	The European Union	This is AI law based on a risk-based approach. Reliability of AI systems is mentioned as an important aspect. Sets out a risk-based approach, where the obligations for a system are proportionate to the level of risk that it poses. The Act outlines four levels of risk: 1. Low-risk systems 2. Limited or minimal risk systems 3. High-risk systems 4. Systems with unacceptable risk
6.	National Strategy for Artificial Intelligence Responsible AI for All	India	NITI Aayog has identified five sectors — healthcare, agriculture, education, smart cities and infrastructure and transportation — to focus its efforts towards implementation of AI.A part of this strategy was to ensure the safe and responsible use of AI (RAI), including the following principles: • Safety and Reliability • Equality

			• Inclusivity and Non-Discrimination • Privacy and Security • Principle of Transparency • Principle of Accountability • Protection and Reinforcement of Positive Human Values
7.	Principles of Policy, Regulation and Ethics in AI	Israel	A series of 6 ethics principles: 1. AI for growth, sustainable development and Israeli innovation leadership 2. Human-centered AI 3. Fairness 4. Transparency and explainability 5. Reliability, robustness, security and safety 6. Accountability
8.	Social Principles of Human-Centric AIGovernance Guidelines for Implementation of AI Principles	Japan	AI regulations can be classified into two categories: • Regulation on AIÏ • Regulation for AISet forth seven principles surrounding AI: 1. Human-centric 2. Education/literacy 3. Privacy protection 4. Ensuring security 5. Fair competition 6. Fairness, accountability, and transparency 7. Innovation
9.	National Artificial Intelligence Strategy 2.0	Singapore	Focus on 3 key research areas: 1. Responsible AI 2. Resource-Efficient AI 3. Reasoning AI
10.	National Guidelines for Artificial Intelligence (AI) Ethics	South Korea	Three Basic Principles 1. Respect for human dignity 2. Common good of society 3. Proper use of technology Ten Key Requirements: 1. Safeguarding Human Right 2. Protection of Privacy 3. Respect for Diversity 4. Prevention of Harm 5. Public Good 6. Solidarity 7. Data Management 8. Accountability 9. Safety 10. Transparency

11.	A pro-innovation approach to AI regulation-March 2023	The United Kingdom	The framework is underpinned by the following five principles that are intended to guide how regulators approach AI risks: 1. Safety, security and robustness; 2. Appropriate transparency and explainability; 3. Fairness; 4. Accountability and governance; and 5. Contestability and redress.The regulatory framework is designed to achieve the following three objectives: • Drive growth and prosperity • Increase public trust in AI • Strengthen the UK's position as a global leader in AI
12.	Executive Order on the Safe, Secure, and Trust worthy Development and Use of Artificial Intelligence	The United States of America	Ensuring the Safety and Security of AI Technology by • Reporting requirements related to dual-use foundation models • Reporting requirements for IaaS service providers on foreign users • Strengthening of cyber security for critical infrastructure • Consideration of watermarking for AI-generated contents

Standards play crucial role in implementation of the regulations. Therefore, regulators across the world are also active participants in Standardization community.

CHAPTER IX

AI COURSES TAUGHT IN INDIAN UNIVERSITIES/COLLEGES AND STANDARDIZATION

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AI COURSES TAUGHT IN INDIAN UNIVERSITIES/ COLLEGES AND STANDARDIZATION

Mastering AI Technology includes learning foundation courses of computer science such as Basics of Programming, Data Structures, Algorithm Design, Database Management, Computer Architecture, and Basics of Probability and Statistics. The advanced topics such as convex optimization, Image processing, computer vision etc may help in building a complex AI system for real time applications.

AI courses provide students with the foundational knowledge and skills necessary to develop AI systems. This includes understanding AI models, algorithms, and their practical applications. These courses cover topics like machine learning, neural networks, natural language processing etc. AI courses equip students with the technical knowledge and skills necessary to develop AI systems and standards on AI provide a framework to ensure AI systems are effective, reliable, and ethical.

Standardization of AI ensures that AI systems adhere to established guidelines and best practices, such as performance, accuracy, and security etc. Thus, knowledge gained in AI courses helps students to align their work to ensure AI systems are effective, reliable, and ethical. Standards on artificial intelligence provides comprehensive guidelines that cover all aspects of the AI system lifecycle from development to decommissioning. Standards cover various aspects like performance, accuracy, reliability, security, risk management, processes to identify threats, ethical and social considerations etc.

This section tries to map AI standards to the theme of the course that is being taught in the AI courses at reputed Universities.

A. Course Name: Introduction to AI

Relevant Standard:

i) IS/ISO/IEC 22989 Artificial intelligence concepts and terminology

This document establishes terminology for AI and describes concepts like Strong AI, Weak AI, Supervised machine learning, Unsupervised machine learning, Semi-supervised machine learning, Reinforcement learning, machine learning algorithms, roles of AI stakeholders, AI System Life cycle etc.

B. Course Name: Artificial Intelligence – Basic Concepts

Relevant Standard:

i) IS/ISO/IEC 5338 Information technology — Artificial intelligence — AI system life cycle processes

This document defines a set of processes and associated concepts for describing the life cycle of AI systems based on machine learning and heuristic systems.

ii) IS/ISO/IEC TR 24028 Artificial intelligence — Overview of trustworthiness in artificial intelligence

This document surveys topics related to trustworthiness in AI systems, It mentions approaches to establish trust in AI systems through transparency, explainability, controllability,

iii) IS/ISO/IEC TR 24368 Overview of ethical and societal concerns

This document provides a high-level overview of AI ethical and societal concerns.

iv) ISO/IEC TR 24372 Overview of computational approaches for AI systems

This document provides an overview of the computational approaches for AI systems. It describes main computational characteristics of AI systems and main algorithms and approaches used in AI systems,

v) IS/ISO/IEC TR 24027:2021 Bias in AI systems and AI aided decision making

This document addresses bias in relation to AI systems, especially with regards to AI-aided decision-making. Measurement techniques and methods for assessing bias are described, with the aim to address and treat bias-related vulnerabilities. All AI system lifecycle phases are in scope, including but not limited to data collection, training, continual learning, design, testing, evaluation and use.

vi) IS/ ISO/IEC TR 24028:2020 Overview of trustworthiness in artificial intelligence

This document surveys topics related to trustworthiness in AI systems, including approaches to establish trust in AI systems through transparency, explainability, controllability, etc.; engineering pitfalls and typical associated threats and risks to AI systems, along with possible mitigation techniques and methods; and approaches to assess and achieve availability, resiliency, reliability, accuracy, safety, security and privacy of AI systems. The specification of levels of trustworthiness for AI systems is out of the scope of this document.

vii) IS/ISO/IEC TR 24372:2021 Information technology — Artificial intelligence (AI) — Overview of computational approaches for AI systems

This document provides an overview of the state of the art of computational approaches for AI systems, by describing: a) main computational characteristics of AI systems; b) main algorithms and approaches used in AI systems, referencing use cases contained in ISO/IEC TR 24030.

C. Course Name: Data Structures

Relevant Standard:

i) IS/ ISO/IEC 5392:2024 Reference architecture of knowledge engineering

This document defines a reference architecture of knowledge engineering (KE) in artificial intelligence (AI). The reference architecture describes KE roles, activities, constructional layers, components and their relationships amongst

themselves and other systems from systemic user and functional views. This document also provides a common KE vocabulary by defining KE terms.

ii) IS/ ISO/IEC 8183:2023 Data life cycle framework

This document defines the stages and identifies associated actions for data processing throughout the artificial intelligence (AI) system life cycle, including acquisition, creation, development, deployment, maintenance and decommissioning. This document does not define specific services, platforms or tools. This document is applicable to all organizations, regardless of type, size or nature, that use data in the development and use of AI systems.

D. Course Name: Foundations of Machine Learning

Relevant Standard:

i) IS/ISO/IEC 23053 Framework for Artificial Intelligence (AI) Systems Using Machine Learning (ML)

This document provides an Artificial Intelligence (AI) and Machine Learning (ML) framework for describing a generic AI system using ML technology. This framework describes the system components and their functions in the AI ecosystem.

ii) IS/ISO/IEC 23053:2022 Framework for Artificial Intelligence (AI) Systems Using Machine Learning (ML)

This document establishes an Artificial Intelligence (AI) and Machine Learning (ML) framework for describing a generic AI system using ML technology. The framework describes the system components and their functions in the AI ecosystem. This document is applicable to all types and sizes of organizations, including public and private companies, government entities, and not-for-profit organizations, that are implementing or using AI systems.

E. Course Name: Deep Learning

Relevant Standard:

i) IS/ISO/IEC TR 24029-1:2021 Artificial Intelligence (AI) — Assessment of the robustness of neural networks — Part 1: Overview

This document provides background about existing methods to assess the robustness of neural networks.

ii) IS/ISO/IEC 24029-2:2023 Artificial intelligence (AI) — Assessment of the robustness of neural networks — Part 2: Methodology for the use of formal methods

This document provides methodology for the use of formal methods to assess robustness properties of neural networks. The document focuses on how to select, apply and manage formal methods to prove robustness properties.

F. Course Name: Advanced Topics in Machine Learning

Relevant Standard:

i) IS/ISO/IEC TS 4213:2022 Information technology — Artificial intelligence — Assessment of machine learning classification performance

This document specifies methodologies for measuring classification performance of machine learning models, systems and algorithms.

ii) IS/ISO/IEC 5339:2024 Information technology — Artificial intelligence — Guidance for AI applications

IS/ISO/IEC 5339 provides guidance on artificial intelligence (AI) applications, emphasizing stakeholder engagement and the AI application life cycle. It aims to enhance multi-stakeholder communication and acceptance by offering a framework that includes the make, use, and impact perspectives of AI systems.

iii) IS/ISO/IEC TR 5469:2024 Artificial intelligence — Functional safety and AI systems

This document describes the properties, related risk factors, available methods and processes relating to: use of AI inside a safety related function to realize the functionality; use of non-AI safety related functions to ensure safety for an AI controlled equipment use of AI systems to design and develop safety related functions.

iv) IS/ISO/IEC TR 17903:2024 Information technology Artificial intelligence Overview of machine learning computing devices

This document surveys machine learning (ML) computing devices, including the following: ML computing device terminology and characteristics; existing approaches to the setting and use of characteristics for optimizing ML computing device performance. The information provided in this document is relevant for organizations of all types and sizes.

v) IS/ISO/IEC TR 24030:2024 Information technology — Artificial intelligence (AI) — Use cases

ISO/IEC TR 24030 is a comprehensive document providing a collection of artificial intelligence (AI) use cases across various domains. It encompasses an extensive range of applications, illustrating the applicability and potential of AI in different sectors and contributing significantly to the field of AI standardization.

vi) IS/ISO/IEC TR 24368:2022 Information technology — Artificial intelligence — Overview of ethical and societal concerns

This document provides a high-level overview of AI ethical and societal concerns. In addition, this document: provides information in relation to principles, processes and methods in this area; is intended for technologists, regulators, interest groups, and society at large;is not intended to advocate for any specific set of values (value systems). This document includes an overview of International Standards that address issues arising from AI ethical and societal concerns.

vii) IS/ISO/IEC 30122-2 Information technology — User interfaces — Voice commands — Part 2: Constructing and testing

This document provides the technical criterions and test methods of voice commands and its speech recognition engine.

The technical criterions include the phonetic requirements for spoken words or phrases that compose the voice command.

ANNEXS

Annex-1

BIS Technical Committees in Emerging Technology Area

In the field of Information Technology, BIS formulates Indian Standards (IS) covering broad range of areas, including:

a) Software development, Software Quality Assurance

b) Smart Cards and Computer peripherals,

c) Information System Security, Cybersecurity,

d) Data protection,

e) Block-Chain,

f) Biometrics,

g) Internet of Things (IoT),

h) Artificial Intelligence,

i) Data Centres,

j) Smart Infrastructure,

k) E-learning,

l) Indian Languages Technologies,

m) Brain Computer Interface,

n) Quantum technologies.

Some of the technical committees in the Emerging Technology Area are listed below:

Technical Committee Number	**Technical Committee Name**	**SCOPE**
LITD14	Software And System Engineering	To prepare Indian standards relating to: a) Processes, supporting tools and supporting technologies for the engineering of software products and systems. b) IT service management and IT governance
LITD15	Data Management System	To prepare Indian Standards relating to: a) Data Management and Interchange b) Document Description and Processing Languages c) Programming languages, their environments and system software interfaces
LITD16	Identification & Data capture techniques, Cards and Security	Standardization in the area of: a) Smart Cards, Identification cards, security devices and interface associated with their use in inter-industry applications and international interchange. b) Data formats, data syntax, data structures, data encoding, and technologies for the process of automatic identification and data

	Devices	capture and of associated devices utilized in inter-industry applications and international business interchanges and for mobile applications.
LITD17‘	Information Systems Security And Privacy	Standardization in Security and Privacy aspects of Information Systems
LITD19	E-Learning	To prepare Indian Standards relating to E-Learning
LITD20	Indian Language Technologies And Products	To prepare Indian Standards in the field of Language Technologies including Graphic character set and their characteristics (including string ordering and associated control functions and their coded representation for information interchanges Code extension techniques Linguistic resources (dictionary, annotated corpora, e-dictionaries, multilingual dictionaries etc.) Phonetic standards Keyboard layout
LITD22	Geospatial Information	To prepare Indian standards in the field of geospatial information including methods, tools, products, services for objects or phenomenon that are directly or indirectly associated with a location relative to the earth
LITD23	Coding and Processing Of Audio, Picture, Multimedia and Hypermedia Information	To prepare Indian Standards relating to: a) Coded representation of audio, picture, multimedia and Hypermedia information and sets of compression and control functions for use with such information, and b) Interfaces for information technology based applications relating to computer graphics and image processing
LITD25	Digital Governance	To prepare Indian standards related to Software applications for seamless sharing of data and services for e-Governance namely data, security, network, semantics, metadata and language and ensuring their integrity
LITD27	Internet of Things and & Digital Twin	To develop standards in the field of Internet of Things and related technologies including sensor networks.
LITD28	Smart Infrastructure	Standardization in the field of Smart Cities (Electro-technical and ICT aspects).
LITD29	Blockchain and Distributed Ledger Technologies	Standardization of blockchain technologies and distributed ledger technologies.
LITD30	Artificial Intelligence	Standardization in the area of Artificial Intelligence and Big Data
LITD31	Cloud	To establish Indian standards in the field of a) Cloud

	Computing, IT & Data Centres	Computing and Distributed Platforms including Foundational concepts and technologies, Operational issues, and Interactions among Cloud Computing systems and with other distributed systems b) Assessment methods, design practices, operation and management aspects to support resource efficiency, resilience and environmental sustainability for and by information, data centres and other facilities and infrastructure necessary for service provisioning
LITD32	Biometrics	Standardization of generic biometric technologies pertaining to human beings to support interoperability and data interchange among applications and systems.
LITD33	Wearable electronic devices and technologies	Standardization in the field of wearable electronic devices and technologies which include patchable materials and devices, implantable materials and devices, ingestible materials and devices, and electronic textile materials and devices
LITD34	Smart Manufacturing	Standardization in the field of Smart Manufacturing including systems level standardization.
LITD35	Active Assisted Living	Standardization in the area of accessibility, interoperability of AAL systems, services, products and components; and standardization of system level aspects of AAL such as safety, security and privacy
LITD36	Computer hardware, Peripherals, Office equipment and User Interfaces	Standardization in the field of - Computer hardware and peripherals, removable digital storage media (utilizing optical, holographic, and magnetic recording technologies) and flash memory technologies for digital information interchange; basic characteristics, test methods and other related aspects of office equipment such as Printers/Scanners, Copiers, Projectors, and Systems composed of their combinations. User-system interfaces in ICT environments and support for these interfaces to serve all users, including people having accessibility or other specific needs.
LITD37	Brain-Computer Interface	Standardization in the area of Brain-computer Interfaces for information technology to enable communication and interaction between brain and computers that are applicable across application areas.

Annex- 2

BIS TECHNICAL COMMITTEE LITD 30-ARTIFICIAL INTELLIGENCE

Committee Constituted in Dec 2017

First meeting of this committee was held in March 2018.

Scope of the LITD 30 Committee is "Standardization in the area of Artificial Intelligence and Big Data".

This committee also act as the National Mirror Committee of ISO/IEC JTC 1/SC 42 "Artificial Intelligence".

This committee is chaired by Dr. Pushpak Bhattacharya, Professor, IIT Bombay

The LITD 30 committee comprises of members from various institutions like IIT Kanpur, IIT Madras, TCS, Infosys, Ministry of Electronics & IT, Computer Society of India, CDAC, IISc Bangalore, Samsung, ISGF, Data Science foundation, ABB India, CII, NASSCOM, NITI Aayog etc.

LITD 30 has published 22 Standards. Working groups (WG) and Panels under LITD 30 are:

LITD 30/WG 01-Foundation standards

LITD 30/WG02-DATA

LITD 30/WG03-Trustworthiness

LITD 30/WG04-Use Cases and applications

LITD 30/WG05-Computational approaches and characteristics of artificial intelligence systems

LITD 30/WG06-Testing for AI Systems

LITD 30/WG07-AI enabled health informatics

LITD 30/ WG08-Functional Safety and AI systems

LITD 30/WG09-Natural language processing systems

LITD 30/Panel 3 - Levels of specifications for AI Systems

More details are at:

https://www.services.bis.gov.in/php/BIS_2.0/bisconnect/dgdashboard/committee_sso/composition/386/2

https://www.services.bis.gov.in/php/BIS_2.0/bisconnect/dgdashboard/committee_sso/workingGroupDetails/386

https://www.services.bis.gov.in/php/BIS_2.0/bisconnect/pow_new/

Annex-3

ISO/IEC JTC 1/SC 42 ARTIFICIAL INTELLIGENCE

First meeting of this committee was held in April 2018

ISO/IEC JTC 1/SC 42 "Artificial Intelligence" deals with International standards for Artificial Intelligence. 64 countries including India are members of this committee.

There are 11 sub-groups under ISO/IEC JTC 1/SC 42.

Two Plenary meetings of JTC 1/SC 42 along with sub-groups meetings are held in a year. Apart from the plenary meetings, virtual meetings of the sub-groups are held regularly throughout the year.

ISO/IEC JTC 1/SC 42 also liaison with 94 committees of ISO/IEC. Apart from other committees of ISO/IEC, JTC 1/SC 42 has also liaison with other organizations and Some of the major organizations are as follows:

a) European Commission
b) Organisation for Economic Co-operation and Development, OECD
c) Open Geospatial Consortium, Inc.
d) United Nations Educational, Scientific and Cultural Organization
e) World Trade Organization

India participates in ISO/IEC JTC 1/SC 42 thorough LITD 30 committee of BIS. Indian experts are actively contributing to the standardization activity of ISO/IEC JTC 1/SC 42.ISO/IEC JTC 1/SC 42 has published 28 standards and 33 standards are under development.

More details are at:

https://www.iso.org/committee/6794475.html

https://www.iso.org/committee/6794475/x/catalogue/p/1/u/0/w/0/d/0

References and Useful Links:

- https://www.services.bis.gov.in/php/BIS_2.0/bisconnect/dgdashboard/committee_sso/composition/386/2
- https://www.services.bis.gov.in/php/BIS_2.0/bisconnect/dgdashboard/committee_sso/workingGroupDetails/386
- https://www.services.bis.gov.in/php/BIS_2.0/bisconnect/pow_new/
- https://www.niti.gov.in/sites/default/files/2023-03/National-Strategy-for-Artificial-Intelligence.pdf
- https://www.iso.org/committee/6794475.html
- https://www.iso.org/committee/6794475/x/catalogue/p/1/u/0/w/0/d/0
- https://www.iso.org/committee/45306.html
- https://jtc1info.org/wp-content/uploads/2023/12/ISO_IEC5339_presentation_Shrikant_Bhat-Stephen_kwan.pdf

About BIS:

Bureau of Indian Standards (BIS), the National Standards Body (NSB) of India was established under the BIS Act, 1986 and came into existence on 1 April 1987 assuming the functions of the erstwhile Indian Standards Institution (ISI). The ISI came into being on 6 January 1947. The BIS Act, 2016 came into force on 12 October 2017 superseding BIS Act 1986. BIS Act, 2016 provides for the establishment of a national standards body for the harmonious development of the activities of standardization, conformity assessment and quality assurance of goods, articles, processes, systems and services in the country.

BIS through its core activities of standardization, conformity assessment and testing has been benefiting the national economy by providing safe, reliable and quality goods; minimizing health hazards to consumers; protecting the environment, promoting exports and imports substitutes; controlling over proliferation of varieties, etc. The standards and certification schemes of BIS apart from benefitting the consumers and industry also support various public policies especially in areas of product safety, consumer protection, food safety, environment protection, building and infrastructure development, etc.

There are 16 Technical Departments in BIS formulating standards in various subject areas. The standards cover important segments of economy and help the industry in upgrading the quality of their goods and services. One of the most important areas for defining standards being dealt by is Information Technology and emerging technology area.