Addressing Timely AI Technology Standardization Challenges through a Hierarchical Analysis Approach

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***Abstract*— In this paper, the reasons why AI requires more standardization compared to other ICT technologies are studied. Furthermore, using the hierarchical analysis approach, AI technologies are classified into four categories from a standardization perspective, and each detailed sub-level items is extracted. Subsequently, through standards mapping and gap analysis is carried out, the areas where standardization is currently in progress and those that are not in progress. The areas where standardization is not progressing or progressing slowly are presented as examples in the final outcome, verifying the importance of standardization as a means to drive early market penetration for AI.**

Keywords— AI Standardization, Hierarchical Analysis, Standards Mapping, Gap Analysis, Interoperability, AI Governance, Lightweight AI Models

I. INTRODUCTION

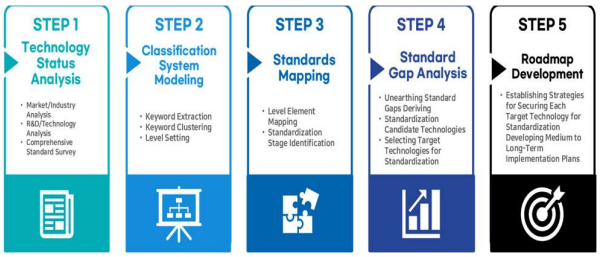
Standardization in the field of artificial intelligence (AI) is more crucial technology in the viewpoint of the following 4 key perspectives than the other ICT technologies. Firstly, it is important to ensure interoperability and interconnectivity. AI systems need to operate across various platforms, devices, and environments. However, if different manufacturers or developers implement AI in their own proprietary ways, it may hinder interoperability between systems. Standardized interfaces and protocols can enhance interconnectivity among AI systems, facilitating data and service sharing and integration. Secondly, it is important to ensure reliability and safety. In fields where AI systems are employed, such as healthcare, reliability and safety are of utmost importance. For instance, inaccurate results from AI diagnostic systems in the medical domain could lead to serious consequences. AI systems that adhere to standardized procedures and criteria can ensure reliability and safety while reinforcing quality management through testing and certification processes. Thirdly, it is important to ensure ethics and fairness. As AI has a profound impact on society, it must reflect social and ethical considerations. Standardization can provide guidelines addressing ethical principles, personal data protection, and fairness in AI systems. This way, the development and use of AI technology can respect and safeguard societal values and rights. Lastly, it is important to ensure collaboration and innovation. Standardization promotes collaboration and knowledge sharing among various stakeholders. In the advancement and application of AI technology, standardization encourages innovation and openness, fostering a better AI ecosystem through cooperation among companies, research institutions, and governments. Thus, standardization is essential for the development and application of AI technology, as it plays a pivotal role in fostering interoperability, reliability, ethics, and collaboration. To determine the specific domains requiring standardization, A method based on the IEC system approach and hierarchical analysis is employed to classify and deduce the necessity of standardization and its integration with R&D for the identified sub-items.

II. CLASSIFICATION OF AI TECHNOLOGIES

A. Analysis based on IEC System Approach

When developing the AI Standardization Strategy, it traditionally were formulated based on an analysis of domestic and international ICT trends (policies, standards, and expert opinions) and SWOT analysis of ongoing international standardization activities. However, a new analysis approach was introduced in this study, which is based on the IEC 'System Approach' [1]. and utilizes future standardization demand predictions for effective planning.

Fig. 1. Analysis based on IEC System Approach



B. Hierarchical analysis for AI technologies

The hierarchical analysis of AI technologies was conducted as shown in the Step1 and Step2 of Fig.1. The study results areas summarized in Table 1. “AI basis" includes the technologies and standards related to cognition, learning, inference, and understanding, which are the fundamental skills underlying the development process of AI systems. "AI Governance" encompasses technologies and standards related to the trustworthiness, ethics, governance, and evaluation of AI component technologies. “AI Systems" comprises the technologies and standards related to models, data, and operations, where AI element technologies are structurally

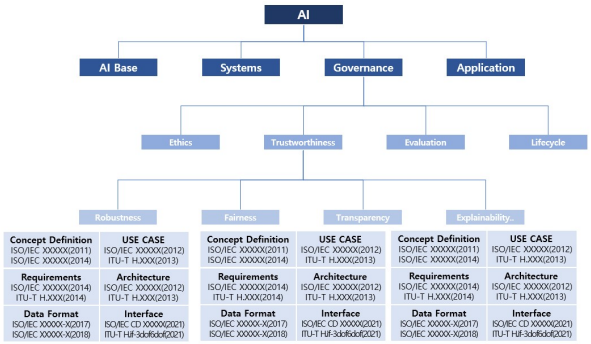
combined or integrated to form a unified system. “AI Application Services" includes the technologies and standards used in the fields of infrastructure services and converged services, where AI element technologies are configured into systems and applied in various industries.

TABLE I. CLASSIFICATION FOR AI TECHNOLOGIES STANDARDIZATION

1st Level	2nd Level	3rd Level
AI Basis	Cognition	Visual Intelligence
		Language Intelligence
		Auditory Intelligence
		Olfactory Intelligence
		Gustatory Intelligence
		Tactile Intelligence
		Brain Intelligence
		Multi-Sensory Intelligence
	Learning	Supervised Learning
		Unsupervised Learning
		Reinforcement Learning
		Self-supervised Learning
		Meta Learning
		Multi-modal Learning
		Lifelong Learning
		Transfer Learning
	Inference	Knowledge Processing
		Knowledge Representation
		Knowledge Inference
		Knowledge Generation
		Commonsense Reasoning
	Situation Awareness	Emotion Intelligence
		Spatial Intelligence
		Behavioral Understanding
		Situation Judgment
	Social	Multi-turn Conversation Intelligence
		Collaborative Intelligence
AI Governance	Trustworthiness	Robustness
		Fairness
		Transparency
		Explainability
	Ethics	Ethical Reference Model
		Ethical Policy Platform
		Ethical Standards
		Ethical Implementation Measures
	Governance	Technical Governance
		Ethical Governance
		Socio-legal Governance
		Privacy Governance
		Data Governance
	Evaluation	Evaluation Process
		Evaluation Metrics
	Lifecycle	Data Preprocessing
		Model Training
		Model Evaluation
		Model Serving
	App. Analysis	Industry Classification
		Standardization Trends Analysis
AI Systems	Models	Model Lightweighting
		Model Compatibility
		Computational Model
		Federated Learning Model
	Data	Training Data
		Evaluation Data
		Image/Language Anonymization
	Production	Single Inference System
		Federated Inference System
AI Applicat-ion	Brain Com.	Brain-Computer Interface
	Infra Service Intelligence	Cloud Computing Intelligence
		Communication/Network Intelligence
		Security Intelligence
	Converged Service Intelligence	Healthcare, Multimedia, Autonomous Vehicle, Robot, Semiconductor, Drone, Smart City/IoT, Smart Factory, Smart Farm, Environment/Energy, Smart Education, Financial

The standards mapping and gap analysis of AI technologies was conducted as shown in the Step3 and Step4 of Fig.1. The study results are summarized as shown in Fig 2.

Fig. 2. Example for AI standards Gap Analsys



Due to the vastness of AI-related standardization items and standards being globally pursued, study results on examples of appropriately and well-progressed standardization items in each field are explained in Table 2 as the examples.

TABLE II. CLASSIFICATION FOR AI TECHNOLOGIES STANDARDIZATION

1st Level	AI standardization of appropriate progress
AI Basis	AI-based Document Summarization Technology
	Advanced Reward Methods in Reinforcement learning
AI Governance	Ethical Compliance Tracking Tech. for Training Data
AI Systems	Data Extraction/Evaluation Automation for AI Evaluation
AI Application	Implicit Neural Visual Representation/Compression Tech.

Regarding the AI-based Document Summarization Technology, the standardization efforts for improving the performance of artificial intelligence deep learning models in document summarization and document structure design, led by ITU-T SG16 and JTC1 SC42, are currently in their initial stages. Within these groups, the pursuit of standardization involves both extractive and abstractive summarization approaches. Extractive summarization offers fast processing speed but may compromise accuracy, whereas abstractive summarization can achieve higher accuracy at the cost of slower processing and the need for deep learning training. Regarding the Advanced Reward Methods, In ITU-T SG13 FG-AN, there has been an attempt to utilize reinforcement learning techniques and reward/policy learning techniques for network slicing and network resource optimization in the IoT domain. In relation to this topic, it is crucial for the relevant standardization groups to collect use cases and prioritize standardization efforts to address these challenges effectively. Regarding Ethical Compliance Tracking Technology, Labeling of training data, ethical use, appropriate privacy protection, and bias removal are critical factors for enhancing the reliability and success of artificial intelligence systems. Therefore, standardization of traceability technologies to verify compliance with ethical criteria for training data is essential. To address this, there is a pressing need for the development of standards related to ethical criteria for each type of training data (e.g., text, images, videos) and interfaces for tracking compliance with ethical standards. Swift progress in these standardization endeavors is imperative. Regarding the Data Extraction and Evaluation Automation for AI Evaluation, Unlike the model creation and training process, which is engineering-centric, the performance evaluation of artificial intelligence models requires the establishment of objective performance metrics, clear procedures, and the availability of appropriate data for evaluation. To achieve this, it is essential to develop agreed-upon procedures and components that ensure the validity of each step in the evaluation process. Regarding the Implicit Neural Visual

Representation and Compression Technology, R&D on Implicit Neural Visual Representation (INR) for spatial image rendering is actively underway, and potential possibilities for 2D/3D image/video representation and compression are being presented [2]. Therefore, to secure a foothold in media encoding, there is a need for new compression standards to take advantage of the emerging potentials.

III. AI ITEMS THAT REQUIRE TIMELYSTANDARDIZATION

The reason for formulating a standardization strategy using hierarchical analysis, standards mapping, and gap analysis is to identify standardization items that need to be developed more appropriately in the future. This paper argues that the aim is to derive such items. Through the aforementioned methods, approximately 12 future standardization items were identified, and two representative examples are illustrated in Table 3 below.

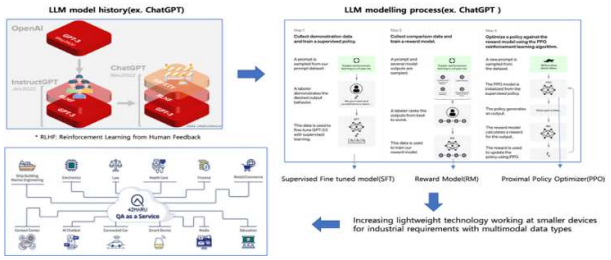
TABLE III. CLASSIFICATION FOR AI TECHNOLOGIES STANDARDIZATION

1st Level	Future standardization items (Example)
AI Systems	Lightweight Techniques for Large Language Models
AI Application	AIoT (Artificial Intelligence of Things) Technology

A. *Lightweight LLM Interface*

LLM technology necessitates lightweight LLM standards due to reasons such as resource limitations, distribution and propagation, and privacy protection. Particularly, when LLM is used in mobile and embedded systems, it becomes crucial to have lightweight LLM standards that can reduce the model size and efficiently execute under resource constraints. Standardization efforts in this regard require the development of LLM lightweight algorithms, compression techniques, and optimization algorithms, followed by testing to solidify the optimal algorithms and compression technologies into the LLM lightweight framework and architecture. As this standardization is currently not addressed by global standardization bodies, there is a need for proposals to create framework and architecture standards. Figure 3 illustrates the conceptual overview for addressing these requirements

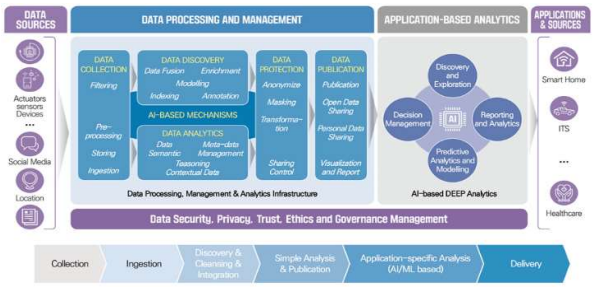
Fig. 3. Technical concept of lightweight LLM interface. (Source: Reconstitution of Referenced Figure from 42MARU & Overview of OpenAI)



B. *Mission-Centric Lightweight Deep Learning AI*

The integration of AI technology with Internet of Things (IoT) technology is being pursued independently without considering compatibility and interoperability, which poses a high risk of violating the fundamental principle of IoT, which is to connect all things. Therefore, it is imperative to develop autonomous IoT technology along with the related standard development to achieve the ultimate advancement model of IoT, which ensures the connection of all things. Figure 4 shows the concept of developing lightweight deep learning AI technology that supports system/network resource optimization to provide guaranteed-service level services even in resource-constrained environments [3].

Fig. 4. Concept of lightweight deep learning AI (Source: ISO/IEC 5392, "AI- Reference architecture of knowledge engineering")



It is necessary to promote the development of autonomous IoT framework and related standards for interconnection, where this type of intelligence is extended to things and intelligent services are implemented.

IV. CONCLUSION

To facilitate the commercialization and popularization of artificial intelligence technology, standardized and affordable solutions accessible to anyone in the market are more essential than high-level proprietary AI technologies of specific companies. As artificial intelligence technology has converged to various industries, the importance of utilizing standardized AI technology in the convergence of service domains becomes even more significant [4]. Currently, the number of standard development tasks in the field of artificial intelligence is relatively small compared to R&D projects. To enhance global economy of scale, excellent achievements from various AI R&D projects should be utilized to induce global standards. In this paper, the methods of hierarchical analysis, standards mapping, and gap analysis were employed to identify future standardization items that need to be appropriately developed. It is firmly believed that these methods, by providing a comprehensive view of the required standardization proposals, will greatly contribute to illuminating the future of the AI market. Furthermore, this approach will not only serve as a one-time research outcome but also be continuously updated and become a useful tool for researchers and standardization experts, ensuring its sustained usability.

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