

A Comprehensive Timeline Review of Artificial Intelligence, Machine Learning, Deep Learning and Explainable AI based Models and Methods

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Abstract- We are witnessing transitioning from rule-based systems to complex deep neural architectures in the way Artificial Intelligence (AI), Machine Learning (ML), Deep Learning (DL) and Explainable AI (XAI) that have evolved over the past decades and keep on growing. This paper presents a comprehensive and detailed literature review in a timeline sequence while highlighting key models and the important methods that have been developed from year 1950 to year 2025. The study categorizes all the major developments done into AI, ML, DL and XAI providing a detailed comparative and logical analysis of their working principles and their limitations. Here in this proposed review paper it identifies the research gaps and the major emerging trends such as hybrid XAI systems along with human centered AI systems.

Keywords: Artificial Intelligence, Machine Learning, Deep Learning, XAI, Timeline Review, Models, Methods.

I. INTRODUCTION

Alan Turing, a well-known researcher, father of modern computer science termed Artificial Intelligence in 1950 with his original work [1]. Nowadays AI has evolved in such a way for data-driven paradigms like Machine Learning and Deep Learning [2]. However, these innovations in field of ai enhanced prediction accuracy but it causes a loss of interpretability, which leads to the development of Explainable AI (XAI) that peaks inside the black box models to find out that actually working of the models. [12][20].



Fig.1.: Taxonomy of AI, ML, DL and Explainable AI Methods

Fig.1. Represents the hierarchical taxonomy of AI, showing the relationship between AI, Machine Learning, Deep Learning and Explainable AI.

II. TAXONOMY OF AI, ML, DL AND EXPLAINABLE AI

III. TIMELINE LITERATURE REVIEW

Table 1: Timeline of AI, ML, DL Models and Methods

Year	Domain	Model/Method	Key Contributor	Type	Working Principle	Limitation
1950	AI	Turing Test	Alan Turing	Concept	Intelligence evaluation	Not practical [1]
1957	AI/ML	Perceptron	Frank Rosenblatt	Model	Linear classification	Non-linear failure [2]
1967	ML	k-NN	Cover & Hart	Algorithm	Distance-based	Slow [3]
1986	ML	Decision Tree	Ross Quinlan	Model	Rule-based splitting	Overfitting [3]
1986	DL	Backpropagation	Geoffrey Hinton	Method	Gradient descent	Vanishing gradient [4]

1995	ML	SVM	Vladimir Vapnik	Model	Hyperplane optimization	Complex [5]
1997	DL	LSTM	Sepp Hochreiter	Model	Memory cell	Heavy [7]
2001	ML	Random Forest	Leo Breiman	Model	Ensemble trees	Black-box [8]
2006	DL	DBN	Geoffrey Hinton	Model	Layer-wise training	Complex [8]
2009	DL	CNN	Yann LeCun	Model	Convolution	Low interpretability [9]
2014	DL	Seq2Seq	Ilya Sutskever	Model	Encoder-decoder	Data heavy [10]
2015	DL	GAN	Ian Goodfellow	Model	Generator-discriminator	Unstable [10]
2015	DL	ResNet	Kaiming He	Model	Residual learning	Complex [9]
2016	XAI	LIME	Marco Tulio Ribeiro	Method	Local surrogate	Approximation [12]
2017	DL	Transformer	Ashish Vaswani	Model	Self-attention	Resource heavy [11]
2017	XAI	SHAP	Scott Lundberg	Method	Shapley values	Expensive [13]
2017	XAI	Grad-CAM	Ramprasaath Selvaraju	Method	Heatmap visualization	Limited [14]
2018	ML	XGBoost	Chen & Guestrin	Model	Boosting	Black-box [15]
2019	XAI	EBM	Cynthia Rudin	Model	Interpretable boosting	Slower [16]
2020	DL	BERT	Jacob Devlin	Model	Bidirectional transformer	Heavy [15]
2021	XAI	Counterfactuals	Wachter	Method	What-if explanations	Complex
2022	DL	Vision Transformer	Dosovitskiy	Model	Transformer vision	Data hungry [17]
2023	DL	GPT Models	OpenAI	Model	Large language model	Black-box [18]
2024	AI	Hybrid XAI	–	Framework	Combine ML + XAI	Complex
2025	AI	Human-Centered AI	–	Concept	Trust & fairness	Emerging

IV. COMPARATIVE ANALYSIS

Aspect	Models	Methods
Purpose	Prediction	Explanation
Examples	CNN [5], SVM [9]	SHAP [12], LIME [13]
Accuracy	High (DL)	Depends on model
Interpretability	Low	High

V. RESEARCH GAPS

- Evaluation metrics is still lacking for standardization to worldwide [13].
- Still limited implementation of explainability methods in deep learning models [9], [11].

- Computational cost is still high after so much evolutions in AI era [13].

- XAI needs to be implemented for domain specific [12].

VI. FUTURE DIRECTIONS

- Toward Human centered AI framework to be worked on [16].
- Reliable AI framework to be implemented [19].
- Interpretable deep learning models to be implemented[20].
- Hybrid XAI system still needs to be implemented [12], [13].

VII. CONCLUSION

The fast-growing evolution of AI demonstrates a great shift from symbolic reasoning to deep learning and nowadays towards explainability of black box models. It is fact that upcoming future systems have to make a balance between accuracy, interpretability, and trust, making XAI [12],[13] a critical and serious research direction.

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