

LARGE LANGUAGE MODELS AS A NEW STAGE IN THE DEVELOPMENT OF ARTIFICIAL INTELLIGENCE

Daria Yaskulko¹

Nataliia Dubovyk²

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Over the past decades, artificial intelligence (AI) has evolved into one of the most dynamic and important realms of modern science and technology. Its applications cover a wide range of industries – from healthcare, education, finance, manufacturing to many others. Among all areas of AI development, natural language processing (NLP) plays a special role, as it bridges the gap between human communication and machine intelligence. Natural language is not just a set of words and grammatical rules, but a complex system that includes context, emotions, subtext, and cultural features. Teaching a machine to “understand” and “generate” human language has proven to be one of the greatest challenges in the history of computer science. Overcoming this challenge requires not only computational power but also advanced models capable of capturing the richness and ambiguity of human speech. For decades, researchers relied on linguistic rules and statistical methods, yet these approaches often failed to fully reflect the depth of natural language. One of the earliest programs was **ELIZA**, which used a set of predefined rules to simulate human conversation [5]. Subsequent developments aimed to move beyond traditional approaches. The real breakthrough came with the advent of machine learning and deep learning, which enabled systems to independently detect language patterns by analyzing massive datasets. A pivotal milestone in this evolution was the emergence of *Large Language Models* (LLMs) – systems capable of processing vast amounts of text data and performing tasks that once seemed impossible. Modern LLMs, such as **GPT** and **BERT**, appeared in 2018 [9]. LLMs have not only transformed the field of NLP but also marked a new stage in the development of AI, impacting science, business, education, and everyday life. Their rise should be seen not as a mere technical achievement but as a paradigm shift in human-machine interaction. In this paper, we will review their theoretical foundations, key characteristics, practical applications, and future prospects in modern artificial intelligence systems.

LLMs represent a new stage in the development of AI, which has significantly changed the approach to NLP. They are not only powerful computational systems but also an example of how theoretical advancements in

¹ V.N. Karazin Kharkiv National University, Ukraine

² V.N. Karazin Kharkiv National University, Ukraine

deep learning can lead to transformative applications across multiple domains. **LLMs** are advanced AI systems built on the **Transformer** architecture that has gained immense popularity in the field of NLP [6]. Unlike earlier recurrent or convolutional models, this architecture relies on the self-attention mechanism, which allows them to efficiently process long data sequences [8]. LLMs are trained on large volumes of text and contain billions of parameters, enabling them to capture complex linguistic patterns, semantic relationships, and even stylistic nuances. A distinguishing feature of LLMs is their capability to perform a wide range of language tasks without task-specific training [3]. Such an approach, known as **zero-shot** and **few-shot learning**, enables the models to adapt to new tasks based on solely instructions or a few examples [7]. This universality makes them flexible and powerful tools in modern information technologies.

The essential features of LLMs can be summarized as follows:

- flexibility: ability to handle diverse tasks without pretraining;
- scalability: can be expanded by increasing parameters, data, or compute, while still solving large-scale tasks efficiently;
- adaptability: can adjust to new conditions, domains or tasks through fine-tuning, zero-shot, or few-shot learning;
- efficiency: optimize computational resources and deliver fast, relevant outputs;
- accuracy: produce contextually correct and factually reliable results;
- performance: provide high operational quality, including speed, precision, and consistency across tasks;
- versatility: work across multiple domains, languages, styles, genres, and formats, supporting both technical and creative applications;
- contextuality: understand and maintain context across long sequences, capturing semantics and discourse relations;
- creativity: generate new, creative and original content, going beyond simple reproduction of training data [4].

The most widely known LLMs include **OpenAI's GPT series** (e.g., GPT-3, GPT-4, GPT-5); **Google's T5, Gemini, BERT**; **Meta's LLaMA** and **Anthropic's Claude** [1]. These models differ in size, speed, training data and purposes of use. The applications of LLMs are extremely broad and diverse. In practice, they are applied in many fields, including *sentiment analysis, machine translation, content generation, text summarization, development of chatbots and virtual assistants, healthcare decision support*, and more [2].

The rapid development of information technologies and AI has led to the emergence of new approaches to NLP. At the core of these advances are LLMs, which have fundamentally changed the way machines process, generate, and understand human language, opening new possibilities across multiple sectors.

Despite their remarkable capabilities, LLMs face a number of challenges. One of the main concerns is *ethical responsibility*: models may reproduce biases present in the training data or generate misleading or inaccurate information. Another challenge is the *environmental cost*, as training large-scale models requires vast computational and energy resources. In addition, questions of data privacy and intellectual property remain unresolved, highlighting the need for responsible development and deployment of these technologies.

To our mind, the prospects for LLMs are highly promising. Upcoming generations of models are expected to become more efficient and accessible, requiring less computational power and energy. Ongoing research is focused on improving model transparency, explainability, and controllability. These improvements are crucial to ensure that the outputs of LLMs align with ethical principles, societal expectations, and human values. Another key direction is the integration of multimodality. Modern AI is no longer limited to text: it increasingly integrates images, audio, video, and other modalities. Multimodal LLMs are capable of understanding and generating information across different forms of data, enabling richer, more natural, and human-like interaction. Such systems hold immense potential for application in education, healthcare, creative industries, and human-computer collaboration. The future of LLMs is also closely tied to personalization. By adapting models to individual needs, preferences, and cultural contexts, it will be possible to create AI systems that better reflect human diversity. However, this requires careful attention to ethical issues, including the prevention of biases, respect for privacy, and protection of intellectual property.

Ultimately, the emergence of LLMs represents a significant milestone in the evolution of AI. They not only bridge the gap between human communication and machine intelligence but also expand the boundaries of what AI can achieve. Their future impact will depend on society's ability to balance technological progress with ethical considerations, ensuring that these systems contribute to a more innovative, inclusive, and human-centered digital era.

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