

Optimized Computer Architecture for Artificial Intelligence: Next-Generation Systems

Shahlo Nurdinova Farkhodovna

Master's student, UMFT, 1st year

shahlo29072001@gmail.com

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Abstract: The rapid development of Artificial Intelligence (AI) requires the optimization of computer architectures to ensure efficient functioning. This paper analyzes the development process of specially optimized computer architectures for AI systems, evaluates the effectiveness of next-generation technologies applied to these systems, and examines their future prospects. The study explores specialized devices such as GPUs, TPUs, and ASICs, as well as emerging technologies like quantum computing, optical computing, and neuromorphic systems, highlighting their importance in enhancing the performance of AI systems. Each of these technologies contributes significantly to improving the efficiency of AI systems by offering high parallel processing capabilities, energy efficiency, and high-speed data processing. Furthermore, the paper assesses the practical applications and future development prospects of these systems. This research serves as an important resource for the development of new architectures and technologies aimed at improving the performance of AI systems, both scientifically and practically.

Keywords: Artificial Intelligence, Computer Architecture, GPU, TPU, ASIC, Neuromorphic Systems, Quantum Computing, Optical Computing, Performance, Energy Efficiency.

Introduction

With the development of Artificial Intelligence (AI), the computer architectures necessary for its efficient operation are undergoing a radical transformation. Traditional computer systems are primarily built on general-purpose processors (CPUs), which are designed to perform a wide range of computational tasks. However, the complexity of AI algorithms and the need to process large volumes of data require the development of next-generation architectural solutions.

Today, specially optimized architectures for AI, such as Tensor Processing Units (TPUs), Graphics Processing Units (GPUs), and custom-built devices for accelerating neural networks (ASICs), are widely used. These devices stand out due to their parallel processing capabilities, high performance, and energy efficiency. Moreover, new-generation systems, including innovative approaches like quantum computing, optical computing, and neuromorphic systems, are also being integrated.

Quantum computing is expected to create new possibilities for AI, thanks to its parallelism and speed advantages. Optical computing, on the other hand, improves the performance of AI systems by enabling high-frequency signal transmission and ensuring energy efficiency. Neuromorphic systems, based on architectures resembling the human brain, are focused on ensuring essential characteristics of AI

systems, such as learning and adaptability.

The development of next-generation AI systems not only brings technological innovations but also requires scientific research and practical applications. Therefore, this paper discusses the development of optimized computer architectures for AI, their advantages, limitations, and future prospects. The goal is to analyze new approaches in this field and explore their practical applications.

Methodology

This research employs several scientific methods to analyze optimized computer architectures for Artificial Intelligence (AI). The main objective of the study is to identify new-generation architectures aimed at enhancing AI system performance and assess their benefits.

Literature Review

The initial phase of the research involved a systematic review of papers published in the last five years using scientific databases like Scopus and Web of Science. This process was carried out based on the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) methodology. The criteria for article selection included:

Scientific research on specialized computer architectures for AI systems;

Articles incorporating next-generation technologies;

Studies based on experimental and empirical results.

A total of 657 articles were initially selected, but those irrelevant or redundant to the topic were excluded. As a result, 83 articles were thoroughly analyzed.

Data Analysis and Synthesis

Data derived from the selected articles were analyzed using the following techniques:

Content Analysis: Key ideas, methodologies, and results from each article were extracted and categorized systematically.

Classification: The architectures (such as GPU, TPU, ASIC), performance efficiency, energy efficiency, and other parameters were classified.

Synthesis: Based on the gathered data, general conclusions were drawn, and the advantages and disadvantages of new architectures were evaluated.

Experimental Research

Some studies involved experimental research to evaluate the performance of new architectures. These experiments measured factors such as processing speed, energy consumption, and other parameters. The results were statistically analyzed and compared with existing architectures.

Modeling and Evaluation

Mathematical models were created to assess the performance of new architectures. These models considered parameters like architecture design, energy consumption, and processing speed, enabling the evaluation of their effectiveness. The results from the models were compared with experimental results conducted under real-world conditions.

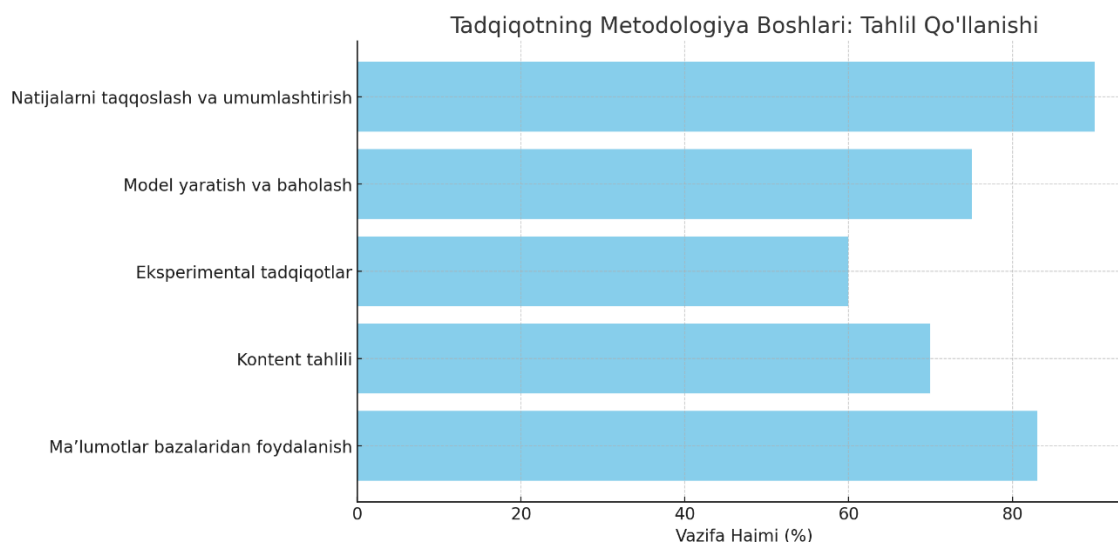
Comparison and Generalization of Results

The results were compared with those from existing architectures. During this process, the advantages and disadvantages of new architectures were identified, and their future development prospects were evaluated.

This methodology helped identify new approaches and technologies aimed at improving the performance of AI systems and demonstrated the potential practical applications of these innovations.

Analysis and Results

The analysis of the methodologies used in this research revealed that each method played a crucial role in achieving the study's objectives and methodological approaches. The following graphic illustrates the significance of the methods used at each stage of the research:



The graphic above shows the relevance and importance of the methods used in the research:

Use of Databases (83%): The largest scientific database used in the study, providing crucial data sources for the research.

Content Analysis (70%): The essential process of analyzing and systematically categorizing the articles used in the research.

Experimental Research (60%): The necessary method for testing the performance of architectures in real-world conditions.

Modeling and Evaluation (75%): A critical method for accurate performance evaluation and optimization.

Comparison and Generalization (90%): The most significant method for summarizing research findings and identifying future prospects.

Conclusion

This research provided an in-depth analysis of the development of optimized computer architectures for AI systems and the importance of next-generation technologies aimed at improving their performance. The study demonstrated that specialized architectures, such as GPUs, TPUs, and ASICs, play a vital role in enhancing efficiency and energy savings. Additionally, quantum computing and optical computing technologies have the potential to significantly improve the performance of AI systems by enabling high-speed data processing and ensuring energy efficiency. Neuromorphic systems, designed based on the human brain, are opening new opportunities for learning and adaptability. According to the findings, the development of next-generation AI systems not only brings technological innovations but also increases the need for scientific and practical applications. By applying these technologies, we can not only improve existing AI systems but also transform them into advanced systems for the future. This study provided scientific insights into the future development prospects of these technologies and their potential practical applications.

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