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QUANTUM TECHNOLOGIES AND ARTIFICIAL INTELLIGENCE. (Practical Applications of Quantum Technologies in Combination with Artificial Intelligence)

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Abstract

This article examines the practical application of artificial intelligence technologies in combination with machine learning algorithms, artificial neural networks, and emerging quantum technologies for solving complex engineering, analytical, and decision-support tasks. Particular attention is devoted to the interaction between artificial intelligence and human expertise, demonstrating that modern AI systems function most effectively as intelligent decision-support tools under professional supervision rather than as complete substitutes for highly qualified specialists.

The publication analyzes contemporary machine learning models capable of predicting human decision-making under conditions of uncertainty and risk. Special emphasis is placed on behavioral prediction models that integrate established behavioral science theories with machine learning techniques to improve the accuracy of forecasting human choices and optimize decision-support systems in engineering, economics, management, and other applied fields.

Keywords: *Artificial Intelligence; Artificial Neural Networks; Quantum Technologies and Solutions; Fields of Application; Machine Learning Algorithm; Artificial Intelligence Mechanism; Conventional Information Storage Systems; Documents for Instant Access; Machine Learning Model; Capability to Predict Human Decision-Making; Mathematical Formula; Engineering Design of Quantum Dots*

Introduction

Although artificial intelligence is currently unable to fully replace qualified specialists in any field of application, it is already capable of displacing entry-level professionals who perform preliminary or routine work, provided that the final refinement, supervision, and quality control remain the responsibility of an experienced specialist.

For example, a modern chatbot can already perform many tasks typically assigned to a junior programmer by generating code in a specified programming language and for a defined technical purpose. However, a qualified professional is still required to design the overall project architecture, supervise and guide the AI during task execution, coordinate files and functions within the project, separate backend and frontend components, and ensure the integrity of the final software system.

Therefore, in order to remain competitive with artificial intelligence in creative and intellectual professions, people will need to develop precisely those skills that still distinguish human specialists from machines: the ability to build abstractions, integrate separate components into a coherent whole, test solutions, identify and correct errors, introduce stylistic diversity, and enrich creative work with originality and contextual meaning.

The artificial intelligence system Grok, integrated into the social network X, has recently received a function for animating images. At the present stage, this feature is operating in a test mode and is available only to paid subscribers of the former Twitter platform.

Since the number of such subscribers is significant, the first examples of generated content have already begun to appear online. Some of the most impressive results have been shared by Elon Musk, the American entrepreneur and owner of the social network.

Grok has learned to animate various types of images, including photographs of people. This is not the first technology of its kind, as similar tools already exist, including services such as Midjourney and Google's video generation system Veo 3. However, such services are relatively expensive, and the ability to generate video directly from images within the social media ecosystem may become an important additional advantage for users.

The rapid development of artificial intelligence has significantly accelerated the transition from text-based information to visual content. Today, the generation of high-quality images from textual descriptions and the creation of realistic videos based on still images are becoming increasingly widespread and are transforming the way digital information is produced and consumed.

Digital platforms capable of providing such services on a large scale are expected to gain substantial competitive advantages by attracting new users and expanding their technological ecosystems. Although this trend will inevitably evolve as new technologies emerge, visual artificial intelligence currently represents one of the most dynamic directions in the development of modern information technologies.

While considerable public attention remains focused on large language models such as ChatGPT and similar systems, a fundamental technological transformation is simultaneously taking place within the infrastructure supporting artificial intelligence. Modern approaches to storing, indexing, and processing unstructured information – including documents, images, video, and multimedia datasets – are undergoing a profound evolution. One of the leading technological developments in this field is represented by intelligent semantic data storage systems that enable artificial intelligence platforms to process extremely large volumes of heterogeneous information with unprecedented speed and efficiency.

Unlike conventional information storage systems that rely primarily on file names, directory structures, and keyword indexing, modern intelligent storage architectures automatically analyze the semantic content of stored information and generate vector representations describing its meaning. As a result, information retrieval is performed according to semantic similarity rather than exact textual coincidence, allowing intelligent systems to locate relevant documents and datasets even when identical keywords are absent.

An equally important direction in the practical application of artificial intelligence involves the prediction of human decision-making under conditions of uncertainty and risk. Understanding the mechanisms governing human decisions remains one of the principal challenges of contemporary behavioral science and has significant implications for economics, engineering, management, healthcare, and public policy.

Recent advances in machine learning have demonstrated that behavioral prediction models combining artificial intelligence algorithms with established theories of behavioral science can achieve exceptionally high prediction accuracy. Models based on integrated behavioral characteristics transform psychological decision-making strategies into mathematical representations suitable for machine learning algorithms. Such approaches allow artificial intelligence systems to identify stable behavioral patterns and predict human decisions even when operating with previously unseen datasets, demonstrating a high degree of generalization.

The practical significance of these technologies extends far beyond behavioral analysis. Predictive artificial intelligence systems are increasingly applied to decision-support systems, intelligent control platforms, adaptive engineering solutions, financial forecasting, medical diagnostics, autonomous transportation, and complex industrial processes where reliable prediction of human behavior substantially improves the effectiveness of operational and strategic decision-making.

Artificial intelligence technologies are also becoming increasingly important in solving global engineering and environmental challenges. One example is the development of advanced membrane technologies for water desalination. Recent scientific investigations have demonstrated that the structural and transport properties of desalination membranes under fully hydrated operating conditions differ significantly from those observed in conventional dry-state laboratory testing. These findings provide new opportunities for improving membrane performance, increasing freshwater production efficiency, and reducing the energy consumption of desalination systems.

Considering that approximately one-quarter of the world's population continues to lack reliable access to safe drinking water, the integration of artificial intelligence, advanced materials science, intelligent process control, and modern engineering technologies represents one of the most promising directions for achieving sustainable water management and supporting the global objectives of environmental protection and sustainable development.

Israel is currently recognized as one of the world's leading countries in both water purification and seawater desalination technologies. The country's five large-scale desalination plants provide approximately 70% of Israel's domestic water supply, while nearly 85% of municipal wastewater is treated and subsequently reused for agricultural irrigation.

The principal technology employed for both desalination and water purification is reverse osmosis. During this process, saline water or water requiring purification is forced through ultra-thin membranes whose pore sizes are smaller than one nanometer. To achieve effective separation, the feed water must be supplied under extremely high pressure, making reverse osmosis a highly energy-intensive process. A single large desalination facility may consume an amount of electrical energy sufficient to supply a small city.

Researchers working on reverse osmosis technologies have long recognized that membrane performance should be evaluated under actual hydrated operating conditions. However, because both the membrane pores and their internal structures are at the nanometer scale, direct observation had remained technically impossible for many years. This limitation has recently been overcome by freezing the water contained within the membrane structure and examining the hydrated membrane using cryogenic transmission electron microscopy (cryo-TEM), allowing its operational microstructure to be investigated under realistic working conditions.

Practical investigations have further demonstrated that the integration of membrane filtration systems with electrochemical reactors into a single treatment module, combined with an upward parallel-flow water treatment system functionally connected through automatic mechanical filtration units, provides significantly higher water purification efficiency and improved treatment performance compared with conventional water treatment technologies.

The figure illustrates such integrated comprehensive water-treatment modules, which demonstrate superior water regeneration quality, higher processing efficiency, and substantially faster regeneration rates than traditional water treatment systems.

Researchers demonstrated that water fundamentally alters the internal structure of reverse osmosis membranes. Under operating conditions, hydrated membranes expand by approximately one-third or more, resulting in significant changes to their three-dimensional architecture, including the size and geometry of nanopores. These findings provide engineers with a new scientific basis for improving reverse osmosis systems. Considering the global importance of water desalination and purification technologies, even modest improvements in membrane efficiency or reductions in operating pressure may result in substantial energy savings and significant economic benefits.

Figure 1.

Researchers at the Hebrew University of Jerusalem have proposed new quantum cryptography protocols capable of operating reliably even with imperfect hardware. Quantum cryptography has long been regarded as one of the most promising approaches for achieving theoretically unbreakable secure communications. However, its widespread implementation has been limited by the requirement for highly stable single-photon sources, which remain technically complex and expensive.

Instead of relying on ideal photon emitters, the researchers developed a protocol compatible with currently available quantum-dot-based light sources that behave similarly to artificial atoms. Engineering optimization of quantum dots, combined with specially designed nanoscale optical antennas, enabled precise control of emitted light pulses. The proposed approach is based on the purification of an initially "noisy" optical signal, whereby multiple emitted photons are filtered in real time, allowing only high-quality single photons suitable for quantum key distribution to enter the communication channel.

To validate the proposed concept, the research team constructed a room-temperature quantum-dot system and successfully tested an adapted quantum cryptographic protocol. Experimental results demonstrated reliable quantum key exchange despite the use of non-ideal photon sources. According to the authors, the proposed technology is compatible with a broad range of quantum light sources and therefore represents a practical pathway toward the large-scale deployment of secure quantum communication networks.

Another significant achievement has been reported by researchers from the Technion – Israel Institute of Technology, who developed the BEAST-GB machine learning model capable of predicting human decision-making under conditions of uncertainty and risk with an accuracy approaching 96%.

Understanding human decision-making remains one of the central challenges of behavioral science. Accurate prediction of human choices has important applications in economics, engineering, healthcare, public administration, and intelligent decision-support systems.

The BEAST-GB model integrates machine learning algorithms with established theories of behavioral science. It is based on the BEAST (Best Estimate and Sampling Tools) behavioral framework, which combines psychological theories describing how individuals evaluate uncertain alternatives. Human behavioral strategies were transformed into mathematical behavioral characteristics representing sensitivity to specific decision variables. These mathematically defined characteristics, supplemented by objective descriptions of decision-making tasks, were subsequently incorporated into machine learning algorithms.

The resulting model demonstrated the ability to explain and accurately predict human decisions across a wide range of previously unseen scenarios with approximately 96% prediction accuracy, substantially outperforming conventional behavioral models that typically achieve prediction rates of only 30–50%. The model's ability to generalize beyond its training data indicates that it successfully captures universal behavioral patterns governing human decision-making.

The continuing expansion of artificial intelligence infrastructure is further illustrated by the development of SDS-AI, a new national supercomputing platform being deployed by Shonfeld Data Services (SDS). Built on NVIDIA Blackwell B200 processors, the system incorporates 2,032 next-generation processors and is expected to achieve computational performance approximately 6.5–6.8 times greater than the existing Israel-1 supercomputer.

Unlike previous high-performance computing systems designed primarily for internal corporate applications, SDS-AI has been developed as an open computational platform intended to support Israel's innovation ecosystem. The supercomputer will provide advanced computational resources to startups, universities, research institutions, and technology companies, enabling the domestic development of next-generation artificial intelligence systems without reliance on foreign computing infrastructure.

One of the most promising practical applications of artificial intelligence is the development of the Smart Specialist's Office concept. This integrated digital environment combines intelligent clinical management software, electronic medical records, mobile applications, diagnostic support systems, and artificial intelligence algorithms into a unified platform. Such systems assist medical specialists in diagnostics, treatment planning, workflow optimization, clinical decision support, and healthcare resource management, thereby improving both the quality of patient care and the overall efficiency of modern medical institutions.

One of the most promising practical applications of artificial intelligence is the development of the Smart Physician's Office concept, which represents an integrated digital environment designed to improve the efficiency of medical diagnostics, treatment planning, and healthcare management. Rather than replacing physicians, artificial intelligence functions as an intelligent clinical assistant, supporting medical professionals in data analysis, image interpretation, clinical decision-making, and workflow optimization.

A modern smart physician's office integrates several complementary technological components into a unified information ecosystem.

The first component consists of intelligent medical information systems. Specialized software platforms enable healthcare institutions to manage patient databases, electronic medical records, appointment scheduling, clinical documentation, treatment planning, and administrative processes. Such systems substantially improve operational efficiency while reducing the probability of human error.

The second component includes mobile medical applications developed for both physicians and patients. These applications support clinical diagnostics, treatment planning, educational activities, remote consultation, and professional communication. Specialized software can also assist physicians in analyzing clinical findings, monitoring patient conditions, and developing individualized preventive recommendations.

A third essential component is the integration of artificial intelligence technologies into clinical practice. AI systems are capable of analyzing medical images, identifying pathological changes, supporting differential diagnosis, evaluating treatment outcomes, and assisting physicians in preparing individualized treatment strategies. Although these systems significantly improve diagnostic accuracy and decision support, they complement rather than replace professional medical judgment.

The fourth technological component comprises advanced digital medical equipment. Modern digital radiographic systems, intraoral scanners, three-dimensional imaging systems, high-resolution optical cameras, and computer-controlled therapeutic equipment provide highly accurate diagnostic information while improving patient comfort and reducing examination time.

The implementation of smart medical technologies provides numerous practical advantages. Digital diagnostic systems improve the accuracy and reliability of clinical examinations, while intelligent information systems optimize medical workflows, automate routine administrative operations, and reduce the likelihood of procedural errors. Integrated communication platforms facilitate interaction between healthcare professionals and patients, improving treatment coordination and continuity of care. Furthermore, the adoption of advanced digital technologies contributes to the establishment of a modern, technologically advanced healthcare environment capable of delivering higher-quality medical services.

The continuing integration of artificial intelligence, advanced medical software, intelligent diagnostic equipment, and automated clinical management systems demonstrates the ongoing transformation of healthcare toward comprehensive digital ecosystems in which engineering technologies, information systems, and medical expertise operate as a unified intelligent platform for improving clinical effectiveness and patient outcomes.

Quantum dots are ultra-small semiconductor particles whose dimensions are tens of thousands of times smaller than the diameter of a human hair. Since their introduction, their unique physical properties – providing the highest levels of color accuracy, brightness, and spectral purity among currently available display materials – have transformed modern display technologies.

When incorporated into display panels, quantum dots provide an exceptionally wide color gamut corresponding closely to the full spectrum perceived by the human eye. They also enable highly accurate pixel-level light control, resulting in improved black-level reproduction, greater contrast, and superior overall image quality.

Because quantum dots emit light uniformly in all directions, they ensure consistent brightness and stable color reproduction regardless of viewing angle while simultaneously minimizing blue-light emission, thereby improving visual comfort during prolonged viewing.

The commercial performance of quantum-dot displays is determined by several important engineering parameters, including the concentration of active quantum-dot material, the quality and structural uniformity of the quantum-dot film, and the application of environmentally safe cadmium-free quantum-dot technologies. High-performance displays generally require quantum-dot concentrations exceeding approximately 3,000 parts per million (ppm) in order to achieve the characteristic brightness, color saturation, and image fidelity associated with this technology.

The year 2025 has become a significant milestone in technological development, marking the transition of numerous long-term scientific achievements from laboratory research to practical industrial implementation. Major advances have occurred simultaneously in artificial intelligence, quantum technologies, advanced computing, robotics, energy systems, and space technologies, substantially influencing global industrial competitiveness and economic development.

Artificial intelligence has emerged as one of the principal driving forces behind this technological transformation. Generative AI technologies have evolved beyond experimental systems and are now being integrated into governmental institutions, industrial enterprises, healthcare systems, engineering platforms, and commercial organizations, where they automate complex workflows while creating entirely new categories of products and services.

At the same time, the United Nations designated 2025 as the International Year of Quantum Science and Technology, emphasizing the strategic importance of quantum research worldwide. Commercial and academic organizations continue to demonstrate steady progress in quantum computing, including the development of topological quantum processor architectures and advanced quantum simulation systems, bringing practical quantum computing significantly closer to industrial deployment.

Another major technological breakthrough has occurred in controlled nuclear fusion research. Several research laboratories have successfully demonstrated fusion systems capable of producing energy outputs exceeding the energy required to sustain the fusion reaction while maintaining stable operating conditions for longer durations than previously achieved. These advances represent important milestones toward the future commercialization of fusion power generation.

Rapid progress is likewise being observed in intelligent robotics and autonomous systems. Advanced computing platforms integrating artificial intelligence into autonomous robotic systems are enabling industrial robots to perform increasingly complex operations independently across manufacturing, logistics, transportation, mining, and infrastructure management.

Space technologies continue to demonstrate remarkable advances through increasing launch frequencies, lunar exploration programs, on-orbit satellite servicing technologies, and autonomous spacecraft operations, illustrating the growing maturity of modern aerospace engineering.

Collectively, these developments demonstrate that artificial intelligence, quantum technologies, advanced semiconductor materials such as quantum dots, intelligent robotics, high-performance computing, sustainable energy technologies, and space engineering are becoming mutually integrated components of a new global technological ecosystem. Their convergence is expected to establish the technological foundation for future industrial infrastructures, intelligent manufacturing systems, secure communication networks, advanced healthcare platforms, and next-generation digital economies.

The modern world can no longer be imagined without artificial intelligence, which has rapidly become an integral component of everyday life. AI technologies are now widely used to optimize professional activities, automate routine operations, support scientific research, and solve numerous everyday tasks. Moreover, many people interact with artificial intelligence systems on a daily basis without even realizing it. Nevertheless, the full extent to which artificial intelligence is transforming the technological, economic, and social foundations of modern civilization has yet to be fully appreciated.

Although the fundamental concepts underlying artificial neural networks were proposed more than fifty years ago, practical implementation became possible only after the emergence of sufficiently powerful computing systems capable of processing enormous volumes of information. The operation of modern artificial intelligence systems relies primarily on computationally intensive mathematical processing, pattern recognition, statistical optimization, and large-scale machine learning algorithms. Consequently, further progress in artificial intelligence remains closely linked to advances in high-performance computing technologies.

The continuing development of artificial intelligence is increasingly constrained by the availability of computational resources and electrical energy. The performance of advanced language models and intelligent systems depends directly on the computational capacity of modern data centers equipped with next-generation processors. These facilities consume substantial quantities of electrical power, and projections indicate that artificial intelligence infrastructure will become one of the largest industrial consumers of energy over the coming decade.

An equally important strategic factor is the availability of advanced engineering materials required for manufacturing high-performance computing equipment. Semiconductor devices, graphics processors, memory systems, and data-center infrastructure require significant quantities of silicon, copper, rare-earth elements, cobalt, neodymium, praseodymium, manganese, and numerous other critical materials. Consequently, the availability of these resources has become an essential determinant of technological competitiveness and national economic security.

Artificial intelligence is simultaneously transforming modern healthcare. One notable example is the development of intelligent diagnostic systems capable of evaluating coronary artery disease using conventional X-ray angiographic images. Recent advances in machine learning have enabled artificial intelligence models to estimate the physiological severity of arterial stenosis without requiring invasive diagnostic procedures involving pressure-sensing guidewires and pharmacological stimulation.

Such intelligent diagnostic systems significantly reduce procedural risks while providing physicians with reliable clinical information in real time. By integrating artificial intelligence into routine cardiological practice, healthcare providers can improve diagnostic accuracy, optimize therapeutic decision-making, personalize treatment strategies, and enhance overall patient safety. These technologies have already been successfully applied in the clinical evaluation of more than one hundred thousand patients, demonstrating their practical effectiveness and medical value.

Another rapidly developing research area concerns the creative capabilities of generative artificial intelligence. Recent comparative investigations involving large language models – including ChatGPT, Claude, Gemini, and other advanced systems – have demonstrated that modern AI models are capable of outperforming the average human participant in standardized assessments of divergent linguistic creativity.

These studies indicate that contemporary generative artificial intelligence has achieved a level of creative performance exceeding the average results obtained from large human populations. Nevertheless, the highest levels of originality, conceptual abstraction, and creative diversity remain uniquely associated with exceptionally creative individuals. Psychological testing based on Divergent Association Tasks has confirmed that although artificial intelligence can successfully generate diverse and innovative ideas, the most outstanding human creative abilities continue to surpass those of even the most advanced large language models.

The convergence of artificial intelligence, high-performance computing, advanced semiconductor technologies, intelligent medical systems, and computational creativity demonstrates the emergence of a new technological paradigm in which engineering, information technologies, and machine intelligence operate as an integrated ecosystem. Continued advances in computational infrastructure, energy technologies, critical materials engineering, and intelligent algorithms will determine the future pace of innovation and the practical implementation of next-generation artificial intelligence systems across science, medicine, industry, and society.

One widely used assessment of creative thinking is the Divergent Association Task (DAT), in which participants – whether humans or artificial intelligence systems – are asked to generate ten words that are as semantically unrelated as possible. A highly creative response might include words such as *galaxy, fork, freedom, algae, harmonica, quantum, nostalgia, velvet, hurricane,* and *photosynthesis*. The DAT has demonstrated strong consistency with other validated methods used to evaluate creativity in idea generation, creative writing, and problem-solving. Although the test is language-based, it measures not merely vocabulary but a broad range of cognitive processes underlying divergent thinking. An additional advantage of the DAT is its simplicity and accessibility, requiring only two to four minutes to complete and being readily available online.

Building upon these findings, researchers investigated whether the ability of artificial intelligence to perform well on relatively simple word-association tasks could be transferred to more complex creative activities. Large language models were directly compared with human participants in creative writing exercises, including the composition of haiku poetry, short film plot summaries, and original short stories. The results confirmed the same general tendency observed in the DAT assessment. While artificial intelligence occasionally outperformed average human participants, the most experienced and highly creative authors consistently maintained a substantial advantage.

According to the latest global survey conducted by McKinsey & Company, approximately 88% of organizations worldwide are expected to have implemented artificial intelligence in at least one business function by the end of 2025. However, recent research published in *Scientific Reports* indicates that the use of artificial intelligence in the workplace may produce not only organizational benefits but also important psychological consequences for employees.

The study demonstrated that passive use of artificial intelligence – where employees simply copy and paste AI-generated responses – may reduce confidence in their own professional abilities and diminish the perceived significance of their work. Approximately 270 professionals from various fields, including human resources, management, and communications, participated in the investigation. Participants completed writing tasks representative of their daily professional activities under three different conditions: independently, collaboratively with artificial intelligence, or by directly adopting AI-generated responses.

The results demonstrated that the manner in which artificial intelligence is utilized significantly influences employees' psychological state. Passive AI usage reduced personal responsibility for work outcomes by nearly 20%, while self-efficacy and perceived work meaningfulness declined by approximately 10%. In contrast, participants who actively collaborated with artificial intelligence as an intelligent assistant exhibited psychological indicators almost identical to those observed among individuals completing tasks independently.

Researchers evaluated three principal psychological variables: self-efficacy, defined as confidence in one's ability to perform tasks without artificial intelligence; perceived meaningfulness of work; and psychological responsibility for task outcomes. Additional measures included overall satisfaction with both the work process and the final results.

The experimental design consisted of two consecutive stages. During the first stage, participants completed tasks either independently, through active collaboration with artificial intelligence, or by passively copying AI-generated content. During the second stage, all participants performed similar tasks without any artificial intelligence assistance. This methodology enabled researchers to evaluate both immediate and longer-term psychological effects.

The findings revealed that the negative consequences associated with passive artificial intelligence usage persisted even after participants returned to independent work. Individuals continued to report lower confidence in their own abilities and reduced perceptions of the value of their professional contributions. Although passive AI usage initially increased task satisfaction by as much as 29% compared with completely manual work, this advantage disappeared over time. When participants resumed independent work, their satisfaction with both the work process and its outcomes declined below that observed among individuals who had never relied on artificial intelligence.

According to the researchers, these effects arise because employees rapidly become accustomed to the ease with which artificial intelligence completes complex tasks and subsequently begin to perceive their own expertise as less valuable. As AI systems demonstrate increasing competence, concerns regarding personal replaceability become more pronounced. The authors therefore emphasize that organizations should not merely deploy artificial intelligence technologies but should also train employees to interact with them actively and constructively, thereby preserving professional competence, motivation, and long-term engagement.

Another strategic direction in modern artificial intelligence research concerns the development of scalable quantum computing architectures. One of the principal engineering challenges in this field is the design of quantum computer architectures capable of supporting millions of stable qubits while maintaining reliable quantum coherence and efficient error correction.

An example of this approach is the start-up Q-Factor, founded by researchers from the Weizmann Institute of Science and the Technion – Israel Institute of Technology. The company is developing a neutral-atom quantum computing architecture designed to scale toward one million qubits and has already secured approximately US$24 million in seed investment.

Neutral-atom quantum computing employs individual atoms suspended in vacuum using optical laser tweezers. Unlike superconducting quantum computers, which require extremely low operating temperatures and highly complex cryogenic infrastructure, neutral atoms are naturally identical, free from manufacturing defects, and well isolated from external electromagnetic disturbances. These characteristics provide excellent conditions for preserving quantum information while allowing extremely high qubit densities within compact physical volumes.

The principal innovation introduced by Q-Factor addresses one of the fundamental bottlenecks in scalable quantum computing: laser control. Rather than employing millions of independent laser emitters, the proposed architecture utilizes a single high-power laser beam directed through a programmable spatial light modulator functioning as a dynamic holographic optical array. This device divides the original beam into hundreds of thousands of precisely controlled microscopic optical traps capable of simultaneously manipulating large arrays of neutral atoms.

Such an architecture substantially simplifies quantum control, improves error-correction capabilities, and enables future quantum computers to solve computational problems beyond the reach of even the world's most powerful classical supercomputers, including molecular simulation for pharmaceutical development, optimization of global logistics systems, advanced materials design, and large-scale engineering optimization.

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