

# **Human-AI Collaboration Frameworks in Cloud Computing for Enhanced Productivity**

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## **Abstract:**

Cloud computing has revolutionized the way businesses operate, providing scalable and flexible computing resources on-demand. With the integration of Artificial Intelligence (AI), cloud computing has reached new heights, enabling enhanced productivity through human-AI collaboration. This research paper investigates the evolving landscape of human-AI collaboration frameworks in cloud computing and their impact on productivity. By analyzing existing frameworks, methodologies, and case studies, this paper aims to provide insights into the opportunities, challenges, and future directions of human-AI collaboration in cloud computing environments.

**Keywords:** Human-AI collaboration, cloud computing, productivity, frameworks, AI integration.

## **I. Introduction:**

In recent years, the convergence of cloud computing and artificial intelligence (AI) has catalyzed a paradigm shift in how organizations harness technology to drive productivity and innovation. Cloud computing, with its promise of scalable and accessible computing resources over the internet, has become the cornerstone of modern IT infrastructure. Simultaneously, AI technologies have demonstrated remarkable capabilities in automating tasks, analyzing data, and augmenting human decision-making processes.

The rapid advancements in cloud computing and artificial intelligence (AI) have significantly reshaped the technological landscape, revolutionizing how businesses and organizations operate. Cloud computing, with its promise of on-demand access to computing resources over the internet, has become the backbone of modern IT infrastructure. Meanwhile, AI technologies, encompassing machine learning, natural language processing, computer vision, and robotics,

have demonstrated unprecedented capabilities in automating tasks, analyzing data, and making intelligent decisions. The convergence of these two transformative technologies presents an exciting opportunity for synergistic collaboration, where humans and AI systems work together to achieve common goals[1].

The motivation behind exploring human-AI collaboration in cloud computing stems from the recognition of its potential to enhance productivity, innovation, and efficiency across various domains. By combining the cognitive abilities of humans with the computational power and scalability of AI algorithms, organizations can unlock new opportunities for optimizing processes, improving decision-making, and delivering personalized experiences to users. However, realizing the full potential of human-AI collaboration requires a deep understanding of the underlying frameworks, methodologies, challenges, and ethical considerations involved. Hence, this research paper aims to delve into the evolving landscape of human-AI collaboration frameworks within the context of cloud computing, shedding light on its implications for productivity and innovation[2].

The primary objective of this research paper is to provide a comprehensive overview of human-AI collaboration frameworks in cloud computing and their impact on productivity. To examine the evolution of cloud computing and the integration of AI technologies, highlighting the synergies between these two paradigms and their implications for human-AI collaboration. To explore existing frameworks and methodologies for facilitating effective collaboration between humans and AI systems within cloud computing environments, including task allocation, data management, decision support, automation, and security considerations. To analyze real-world case studies and applications of human-AI collaboration across various industries, showcasing examples of enhanced productivity, innovation, and competitive advantage. To identify the challenges, ethical considerations, and future directions of human-AI collaboration in cloud computing, offering insights into potential strategies and best practices for addressing them. By addressing these objectives, this research paper aims to contribute to the understanding of how human-AI collaboration frameworks can be leveraged to drive productivity and innovation in the era of cloud computing.

The remainder of this paper is organized as follows: Section 2 provides an overview of human-AI collaboration in cloud computing, highlighting its evolution, importance, benefits, and challenges. Section 3 explores existing frameworks for human-AI collaboration, focusing on task allocation, data management, decision support, automation, and security considerations. Section 4 discusses methodologies and approaches employed in human-AI collaboration, including machine learning techniques, natural language processing, deep learning, reinforcement learning, and human-centered design principles. Section 5 presents case studies and applications of human-AI collaboration in various industries, showcasing real-world examples of enhanced productivity and innovation. Section 6 examines the challenges and future directions of human-AI collaboration in cloud computing, addressing ethical, technical, and regulatory considerations. Finally, Section 7 summarizes the key findings and concludes the paper.

## **II. Human-AI Collaboration in Cloud Computing: An Overview:**

The evolution of cloud computing has been marked by a transformative journey from a novel concept to a ubiquitous and indispensable technology in the modern digital era. Initially conceived as a means to provide scalable and on-demand access to computing resources over the internet, cloud computing has democratized access to IT infrastructure, software applications, and development platforms. Over time, cloud computing has evolved from basic infrastructure services (IaaS) to encompass platform services (PaaS) and software-as-a-service (SaaS) offerings, catering to diverse needs ranging from storage and computing power to application development and deployment. The proliferation of cloud providers, coupled with advancements in virtualization, networking, and distributed computing technologies, has fueled the adoption of cloud solutions across industries, driving efficiency, agility, and cost-effectiveness[3].

The integration of artificial intelligence (AI) technologies into cloud computing has ushered in a new era of intelligent computing, where machines can emulate human cognitive functions and perform complex tasks autonomously. Cloud providers have embraced AI as a core component of their service offerings, integrating AI capabilities such as machine learning, natural language processing (NLP), computer vision, and robotics into their platforms. This integration enables organizations to leverage AI algorithms and models for tasks such as predictive analytics, data classification, image recognition, language translation, and robotic process automation. By embedding AI services within cloud environments, organizations can harness the scalability, reliability, and accessibility of cloud infrastructure to develop and deploy intelligent applications and services rapidly[4].

While AI systems excel at processing data and performing repetitive tasks with speed and accuracy, they often lack the contextual understanding, creativity, and ethical reasoning capabilities inherent in human cognition. Human-AI collaboration harnesses the complementary strengths of humans and machines, enabling them to work synergistically towards common goals. In the context of cloud computing, human-AI collaboration enhances the effectiveness of AI algorithms by incorporating human domain expertise, intuition, and judgment into decision-making processes. By involving humans in the loop, organizations can ensure that AI systems operate ethically, transparently, and in alignment with organizational objectives. Moreover, human-AI collaboration fosters innovation, as humans provide the creativity and insight necessary to conceive novel solutions and applications of AI technology[5].

The integration of human-AI collaboration frameworks in cloud computing offers a multitude of benefits, including enhanced decision-making, increased efficiency and productivity, personalized user experiences, and scalability. By leveraging the complementary strengths of humans and AI systems, organizations can achieve better outcomes, drive innovation, and gain a competitive edge in the marketplace. However, the adoption of human-AI collaboration in cloud computing also presents challenges and considerations, such as ethical and societal implications, integration complexity, scalability and performance concerns, and issues related to human-AI

interaction and trust. Addressing these challenges requires careful planning, collaboration, and a holistic approach that encompasses technical, ethical, and regulatory considerations. Despite these challenges, the potential of human-AI collaboration in cloud computing to transform industries and drive productivity remains immense, making it a compelling area of research and innovation[6].

### **III. Frameworks for Human-AI Collaboration in Cloud Computing:**

Task allocation and coordination are critical aspects of human-AI collaboration in cloud computing, ensuring that both humans and AI systems work seamlessly together to achieve common objectives. Frameworks for task allocation and coordination involve dividing tasks between humans and AI systems based on their respective strengths and capabilities, as well as orchestrating the interaction and communication between them. This may involve defining roles and responsibilities, establishing workflows and protocols, and implementing mechanisms for monitoring and feedback. By effectively allocating tasks and coordinating activities, organizations can optimize resource utilization, enhance productivity, and mitigate potential conflicts or redundancies between humans and AI systems[7].

Data management and analysis play a pivotal role in human-AI collaboration frameworks in cloud computing, as they enable organizations to leverage data-driven insights to inform decision-making and drive innovation. These frameworks encompass the collection, storage, processing, and analysis of data from various sources, including structured and unstructured data, sensor data, and user-generated content. AI algorithms are employed to extract meaningful patterns, trends, and correlations from large datasets, empowering organizations to derive actionable insights and make informed decisions. Human involvement in data management and analysis may include data annotation, validation, and interpretation, as well as feedback loop refinement to improve AI models over time[8].

Decision support systems (DSS) form an integral part of human-AI collaboration frameworks in cloud computing, providing users with intelligent tools and interfaces to assist in decision-making processes. These systems leverage AI algorithms to analyze data, generate recommendations, and simulate scenarios to help users make more informed and effective decisions. DSS frameworks may incorporate machine learning models, optimization techniques, and predictive analytics to enhance decision quality and facilitate real-time decision-making. Human users interact with decision support systems through intuitive interfaces, where they can explore alternative options, evaluate trade-offs, and incorporate domain knowledge and preferences into the decision-making process.

Intelligent automation frameworks in cloud computing leverage AI technologies to automate repetitive and routine tasks, freeing up human resources to focus on higher-value activities. These frameworks encompass the design, deployment, and management of intelligent automation solutions, such as robotic process automation (RPA), cognitive automation, and

autonomous agents. AI algorithms are trained to mimic human behavior and cognitive functions, enabling them to perform tasks such as data entry, document processing, customer service, and IT operations autonomously. Human-AI collaboration in intelligent automation involves defining automation workflows, setting decision thresholds, and handling exceptions or edge cases that require human intervention[9].

Security and privacy considerations are paramount in human-AI collaboration frameworks in cloud computing, as they involve handling sensitive data and ensuring the integrity, confidentiality, and availability of information assets. These frameworks encompass the implementation of security controls, encryption mechanisms, access management policies, and audit trails to protect data and mitigate cybersecurity risks. AI technologies can be leveraged to enhance security and privacy through anomaly detection, threat intelligence, and behavior analysis. Human involvement in security and privacy considerations may include defining data governance policies, conducting risk assessments, and responding to security incidents or breaches in a timely manner. Additionally, frameworks for security and privacy in human-AI collaboration emphasize transparency, accountability, and ethical use of AI systems to maintain trust and confidence among stakeholders[10].

#### **IV. Methodologies and Approaches:**

In the realm of human-AI collaboration in cloud computing, various methodologies and approaches are employed to facilitate seamless interaction and cooperation between humans and AI systems. These methodologies leverage cutting-edge technologies and design principles to enhance productivity, decision-making, and user experience.

Machine learning techniques form the foundation of many human-AI collaboration frameworks in cloud computing, enabling AI systems to learn from data and make predictions or decisions without explicit programming. Supervised learning algorithms are commonly used to train models on labeled datasets, while unsupervised learning techniques uncover hidden patterns and structures in unlabeled data. Reinforcement learning algorithms enable AI agents to learn optimal behavior through trial and error interactions with the environment. Human involvement in machine learning encompasses data preprocessing, feature engineering, model selection, and validation, as well as interpreting and refining model outputs to ensure alignment with domain knowledge and objectives[11].

Natural Language Processing (NLP) plays a crucial role in human-AI collaboration frameworks, enabling AI systems to understand, interpret, and generate human language. In cloud computing environments, NLP techniques are employed to facilitate human-computer interaction through chatbots, virtual assistants, and conversational interfaces. These systems leverage techniques such as sentiment analysis, named entity recognition, and text summarization to extract insights from unstructured text data and provide contextually relevant responses to user queries. Human involvement in NLP may include data annotation, corpus creation, and model evaluation, as well

as refining language models to improve accuracy, fluency, and naturalness of AI-generated text[12].

Deep learning models have emerged as powerful tools for human-AI collaboration in cloud computing, capable of learning intricate patterns and representations from large-scale data. Deep neural networks, with their hierarchical architecture and multiple layers of abstraction, excel at tasks such as image recognition, speech recognition, and sequence prediction. In cloud computing environments, deep learning models are employed for various applications, including image classification, object detection, speech synthesis, and recommendation systems. Human involvement in deep learning encompasses model architecture design, hyperparameter tuning, and dataset curation, as well as interpreting model outputs and troubleshooting performance issues[13].

Reinforcement learning is a branch of machine learning that enables AI agents to learn optimal decision-making strategies through interaction with an environment. In cloud computing, reinforcement learning algorithms are utilized for tasks such as resource allocation, dynamic pricing, and system optimization. These algorithms learn by receiving feedback in the form of rewards or penalties based on their actions, enabling them to improve performance over time. Human involvement in reinforcement learning frameworks may include defining reward functions, specifying exploration-exploitation trade-offs, and setting constraints or safety measures to ensure responsible AI behavior[13].

Human-centered design principles are essential for creating intuitive, user-friendly interfaces and experiences that foster effective collaboration between humans and AI systems. In cloud computing environments, human-centered design principles are applied to develop user interfaces, workflows, and interactions that accommodate diverse user needs and preferences. These principles emphasize user research, iterative prototyping, and usability testing to ensure that AI-driven applications and services meet the expectations and requirements of end-users. Human involvement in human-centered design encompasses gathering user feedback, iteratively refining design solutions, and incorporating user insights into the development process to create products that are intuitive, accessible, and inclusive[14].

## **V. Case Studies and Applications:**

In the healthcare industry, human-AI collaboration frameworks in cloud computing have been instrumental in improving patient care, diagnosis, and treatment. For example, AI-powered medical imaging systems leverage cloud computing resources to analyze radiological images and detect abnormalities with high accuracy. Human radiologists collaborate with AI systems to interpret images, validate diagnoses, and provide personalized treatment recommendations based on patient data and medical knowledge. Additionally, AI-driven predictive analytics models leverage patient data stored in cloud databases to identify individuals at risk of developing

chronic diseases and recommend preventive interventions, ultimately leading to better health outcomes and reduced healthcare costs[15].

In the financial services sector, human-AI collaboration frameworks in cloud computing have revolutionized various aspects of banking, insurance, and investment management. AI algorithms deployed on cloud platforms analyze vast amounts of financial data to detect fraudulent transactions, assess credit risk, and optimize investment portfolios. Human financial analysts collaborate with AI systems to validate model outputs, interpret risk factors, and make informed decisions regarding lending, underwriting, and investment strategies. Furthermore, AI-driven chatbots and virtual assistants deployed on cloud servers provide personalized financial advice, assist customers with account management, and streamline customer service interactions, enhancing user experience and engagement[16].

In the e-commerce and retail industry, human-AI collaboration frameworks in cloud computing have transformed the way businesses engage with customers, optimize operations, and drive sales. AI-powered recommendation engines deployed on cloud platforms analyze customer browsing behavior, purchase history, and demographic data to generate personalized product recommendations and promotions. Human merchandisers collaborate with AI systems to curate product assortments, optimize pricing strategies, and forecast demand based on market trends and customer preferences. Additionally, AI-driven chatbots deployed on cloud servers assist customers with product inquiries, order tracking, and post-purchase support, enhancing customer satisfaction and retention[17].

In the manufacturing and supply chain management domain, human-AI collaboration frameworks in cloud computing have streamlined production processes, optimized inventory management, and enhanced supply chain visibility. AI-powered predictive maintenance systems deployed on cloud platforms analyze sensor data from manufacturing equipment to detect anomalies, anticipate equipment failures, and schedule maintenance proactively. Human engineers collaborate with AI systems to interpret maintenance alerts, prioritize tasks, and optimize equipment performance based on real-time data and historical patterns. Furthermore, AI-driven demand forecasting models deployed on cloud servers analyze market data, consumer trends, and supply chain dynamics to optimize inventory levels, minimize stockouts, and reduce holding costs, ultimately improving operational efficiency and customer satisfaction[18].

In the education and research sector, human-AI collaboration frameworks in cloud computing have facilitated personalized learning experiences, advanced scientific discovery, and accelerated research progress. AI-powered adaptive learning platforms deployed on cloud servers analyze student performance data, learning preferences, and educational resources to personalize learning pathways and recommend tailored content and activities. Human educators collaborate with AI systems to monitor student progress, provide feedback, and adjust instructional strategies based on individual needs and learning outcomes. Additionally, AI-driven research assistants deployed on cloud platforms analyze scientific literature, experimental data, and computational models to

generate hypotheses, identify research gaps, and accelerate the discovery process in fields such as medicine, biology, and materials science[19].

## **VI. Challenges and Future Directions:**

The integration of human-AI collaboration frameworks in cloud computing presents various challenges and opportunities that shape the trajectory of innovation and adoption in this domain. Addressing these challenges and capitalizing on emerging trends are crucial for realizing the full potential of human-AI collaboration and driving meaningful advancements in productivity, efficiency, and user experience.

One of the foremost challenges in human-AI collaboration frameworks is addressing the ethical and societal implications of AI technologies. Concerns such as algorithmic bias, data privacy, accountability, and job displacement require careful consideration and mitigation strategies. Future directions in this area involve developing ethical frameworks, regulatory guidelines, and responsible AI practices to ensure that AI systems operate in a manner that aligns with societal values and human rights[20].

The integration of AI capabilities into cloud computing environments introduces complexity in terms of interoperability, scalability, and performance. Future directions in this area focus on developing standardized interfaces, interoperability protocols, and modular architectures that facilitate seamless integration and interoperability between diverse AI systems and cloud platforms. Additionally, advances in distributed computing, edge computing, and federated learning hold promise for addressing scalability and performance challenges in human-AI collaboration frameworks.

As the volume and complexity of data processed by AI systems continue to increase, scalability and performance become critical considerations. Future directions in this area involve optimizing AI algorithms for distributed computing architectures, leveraging parallel processing and hardware acceleration techniques to improve computational efficiency, and exploring novel approaches such as edge computing and federated learning to distribute AI workloads across heterogeneous computing resources[21].

Establishing trust and effective interaction between humans and AI systems is essential for fostering collaboration and user acceptance. Future directions in this area involve designing intuitive user interfaces, transparent explainable AI models, and interactive feedback mechanisms that enable users to understand and influence AI-driven decisions. Additionally, research into human-AI interaction paradigms, such as augmented reality, natural language interfaces, and gesture recognition, can enhance user experience and engagement in human-AI collaboration frameworks.

The regulatory landscape surrounding AI technologies and cloud computing is evolving rapidly, with policymakers grappling with issues such as data governance, algorithmic transparency,



liability, and intellectual property rights. Future directions in this area involve establishing clear regulatory frameworks, standards, and certification processes to ensure the responsible development, deployment, and use of AI systems in cloud computing environments. Collaborative efforts between industry stakeholders, policymakers, and academia are essential for shaping regulations that promote innovation while safeguarding ethical principles and societal values[22].

Looking ahead, several emerging trends and opportunities are poised to shape the future of human-AI collaboration in cloud computing. These include advancements in AI technologies such as explainable AI, federated learning, and AI-driven creativity, as well as the proliferation of edge computing and Internet of Things (IoT) devices. Additionally, interdisciplinary research initiatives that integrate insights from cognitive science, psychology, and human-computer interaction can inform the design of AI systems that are more human-centered, empathetic, and adaptable to diverse user needs and preferences. By embracing these trends and leveraging collaborative approaches, organizations can unlock new opportunities for innovation, productivity, and societal impact in the era of human-AI collaboration in cloud computing[23].

## **VII. Conclusion:**

In conclusion, the integration of human-AI collaboration frameworks in cloud computing represents a transformative approach to harnessing the synergies between human cognition and artificial intelligence to drive productivity and innovation. Through the examination of evolving frameworks, methodologies, case studies, and challenges, this paper has underscored the immense potential of human-AI collaboration in various industries, including healthcare, finance, e-commerce, manufacturing, education, and research. Despite the complexities and challenges associated with ethical considerations, integration complexity, scalability, trust, and regulatory frameworks, the future of human-AI collaboration holds promise for addressing societal needs, advancing technological capabilities, and shaping the digital landscape. By embracing emerging trends, fostering interdisciplinary collaboration, and prioritizing responsible AI practices, organizations can navigate the challenges and seize the opportunities presented by human-AI collaboration in cloud computing to create a future where humans and machines work synergistically to achieve common goals and drive positive societal impact.

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